

Resilient Design Thinking: How Can it be used to Improve Lifestyles?

Thinkpiece: Wellington

15th May 2014

CRESA,
Te Papa Museum, Wellington

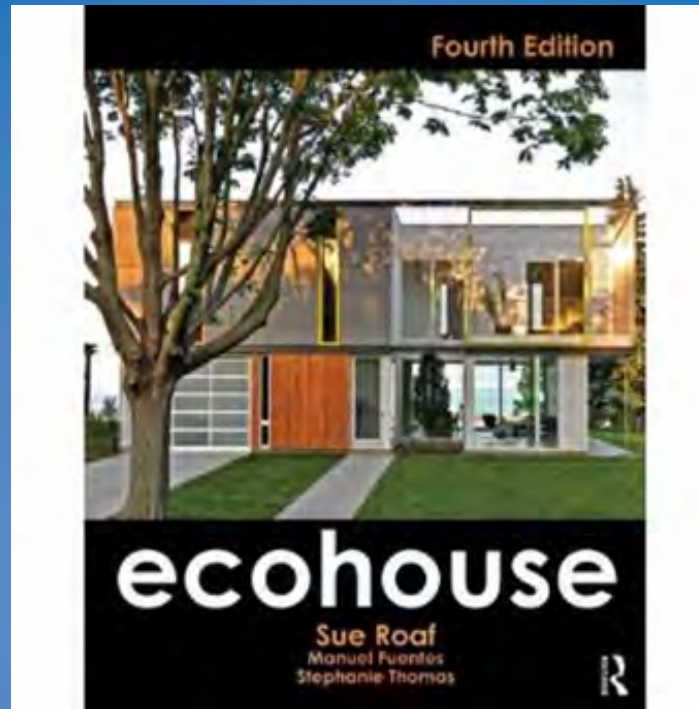
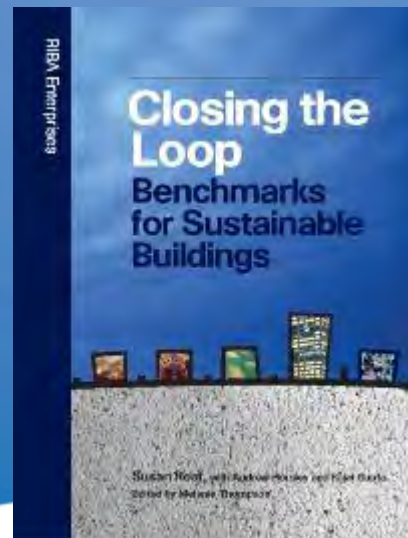
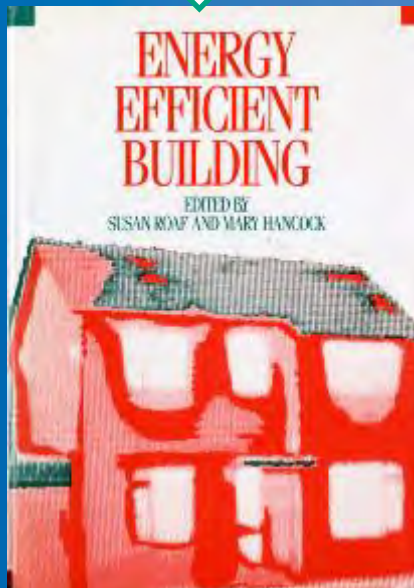
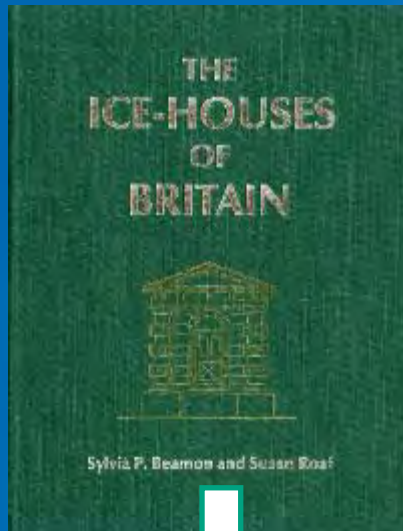
Professor Susan Roaf

Professor of Architectural Engineering at Heriot Watt University, Edinburgh,

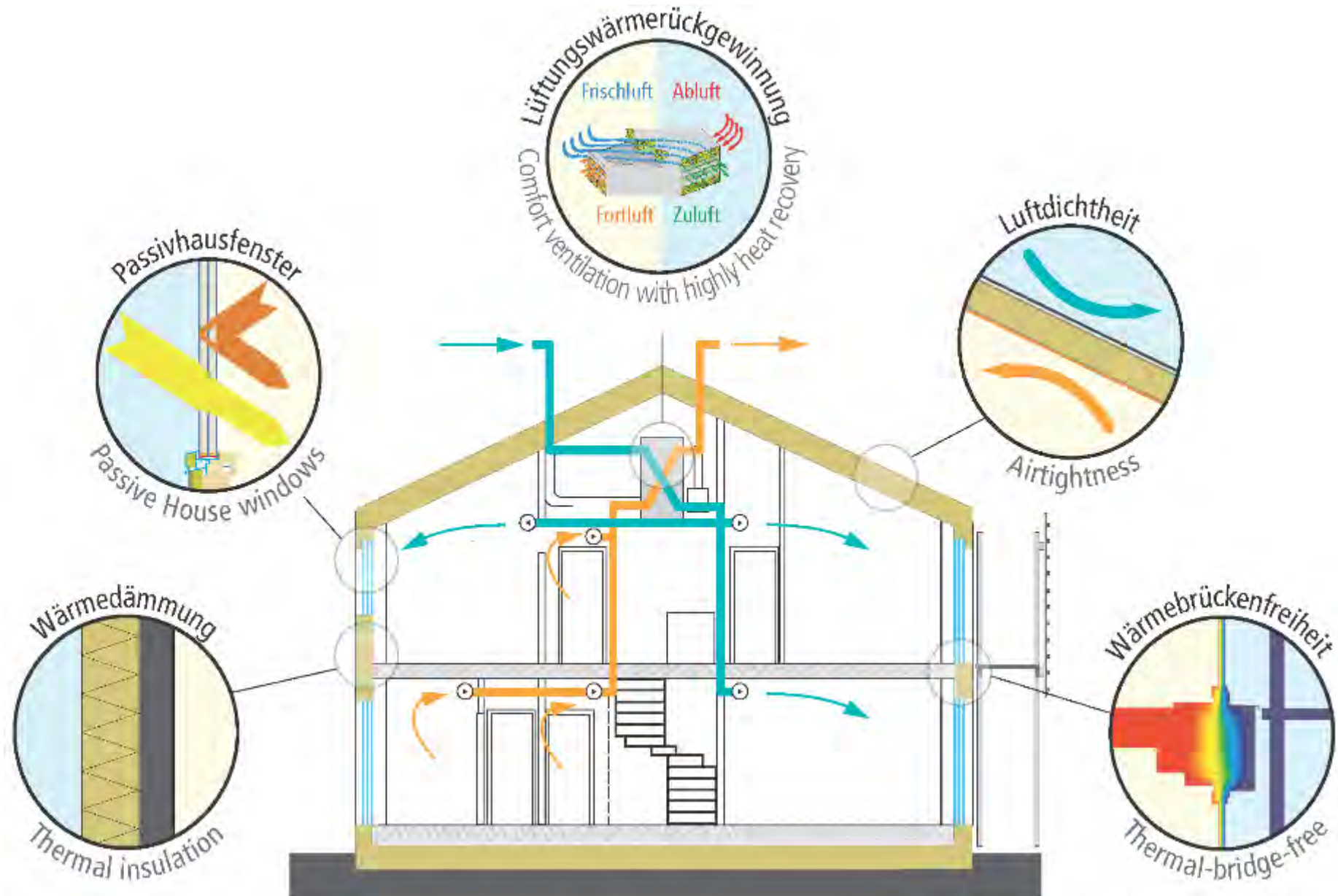
Email: s.roaf@hw.ac.uk

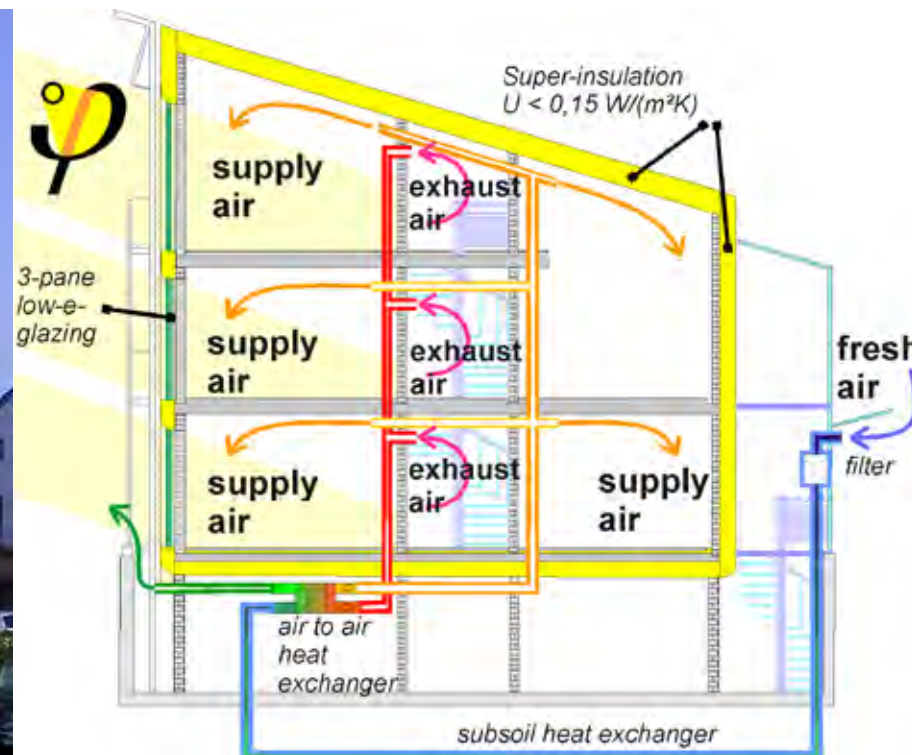
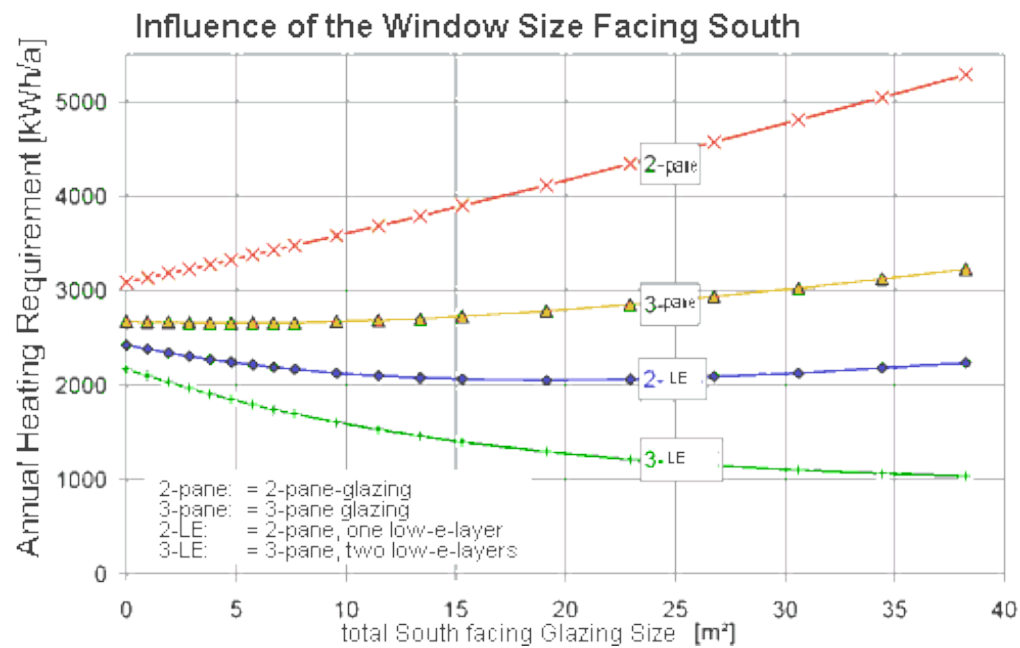


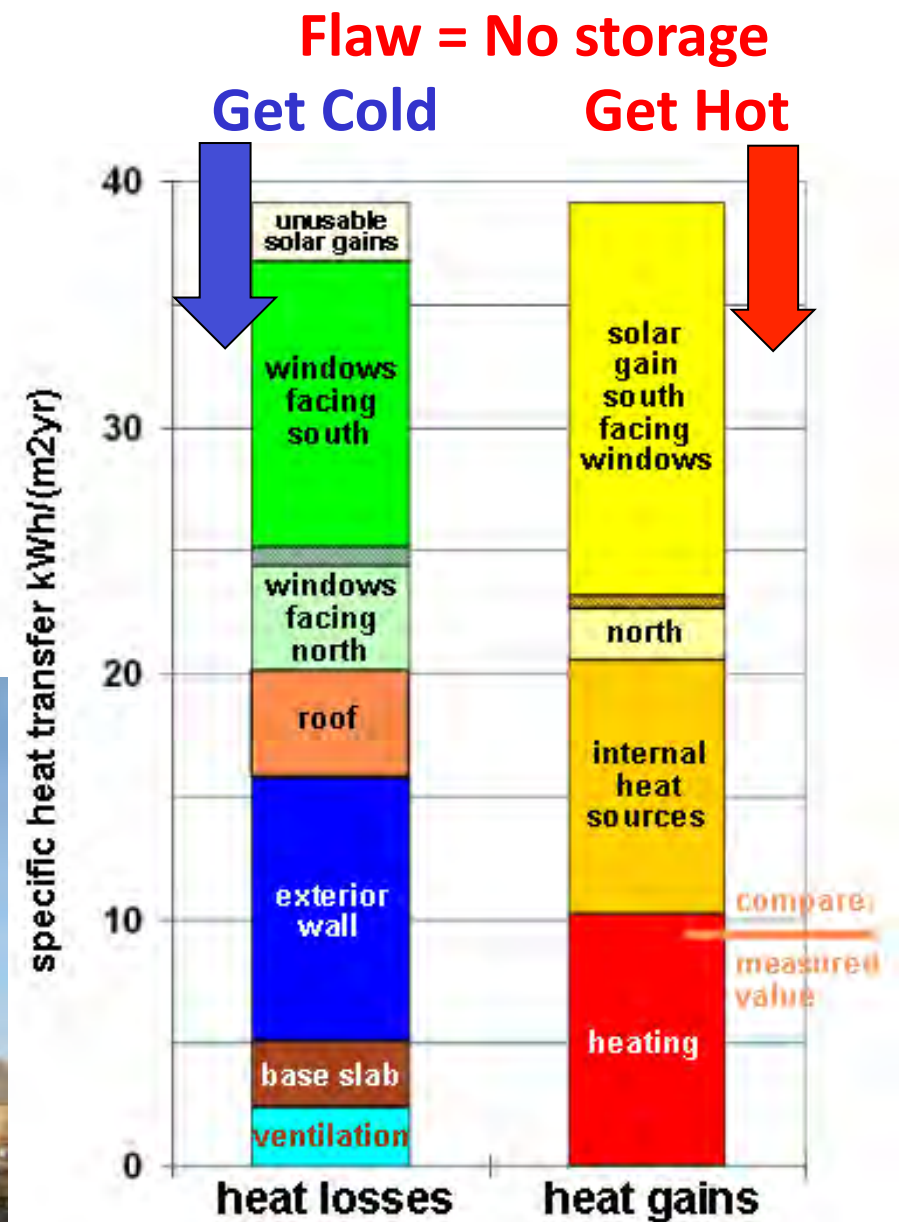
Is Resilient Design Sustainable /Green Design ?



Lets Think about this: PASSIVE HOUSES: 1990s

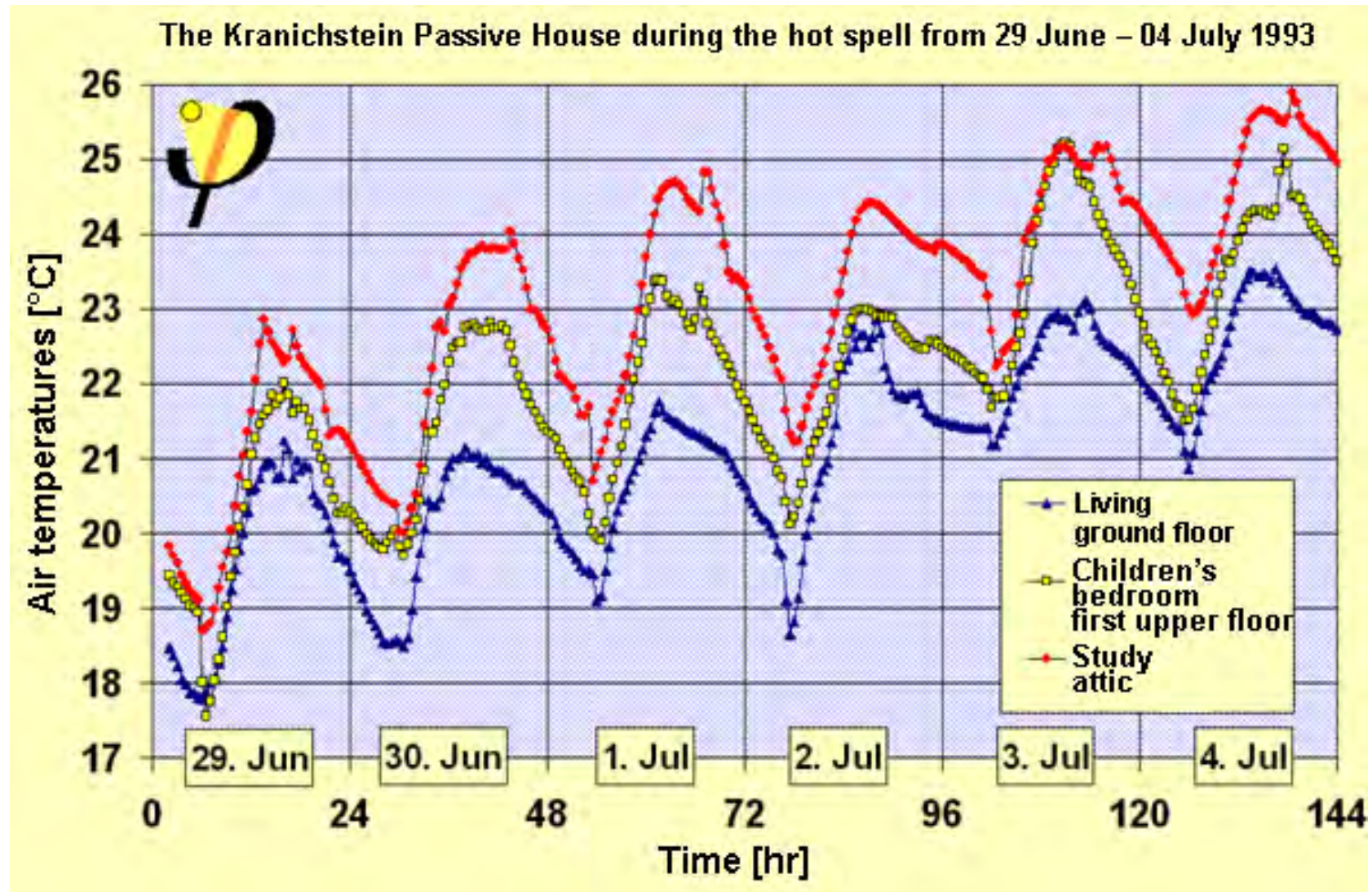






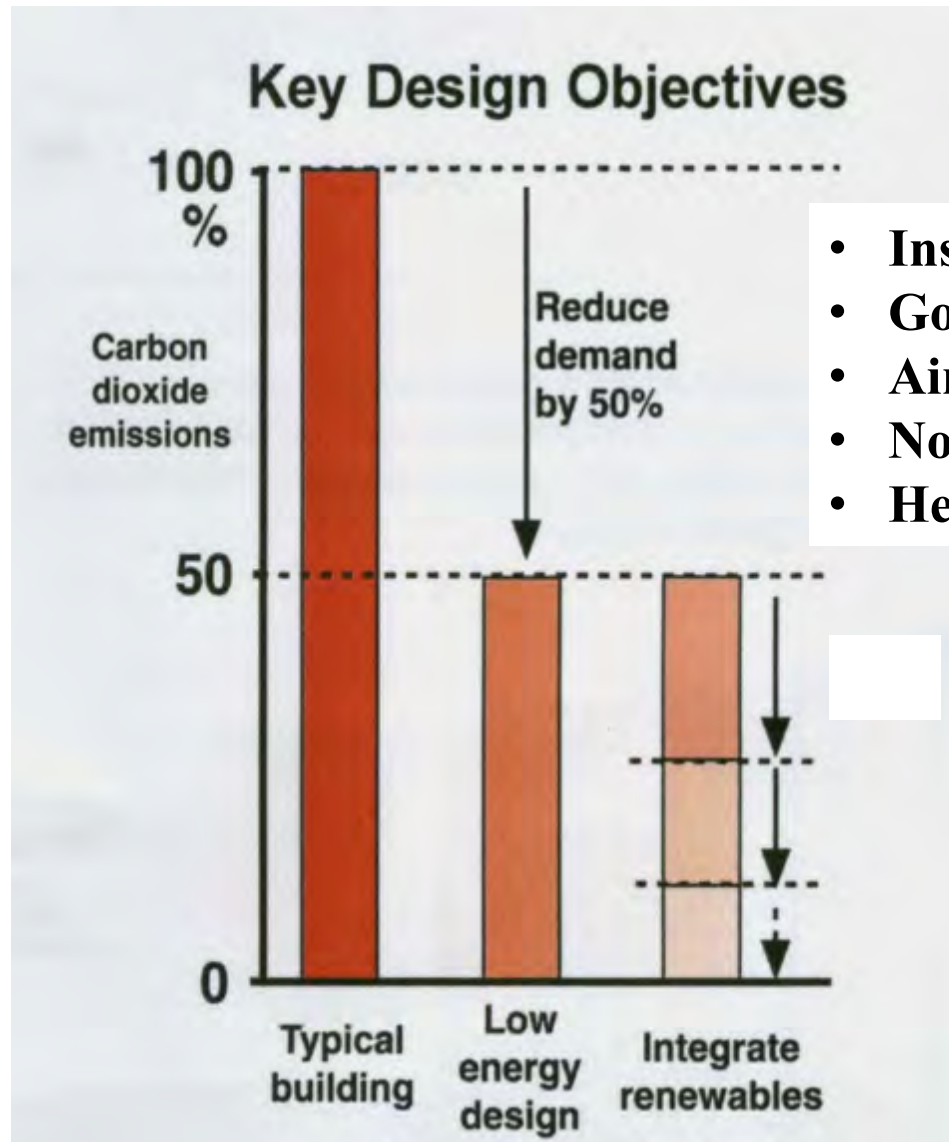
**The Kranichstein Passive House
(end-of-terrace house) / PHPP**

Passive Houses and Overheating



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

Passive House: An Energy Efficient Approach



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

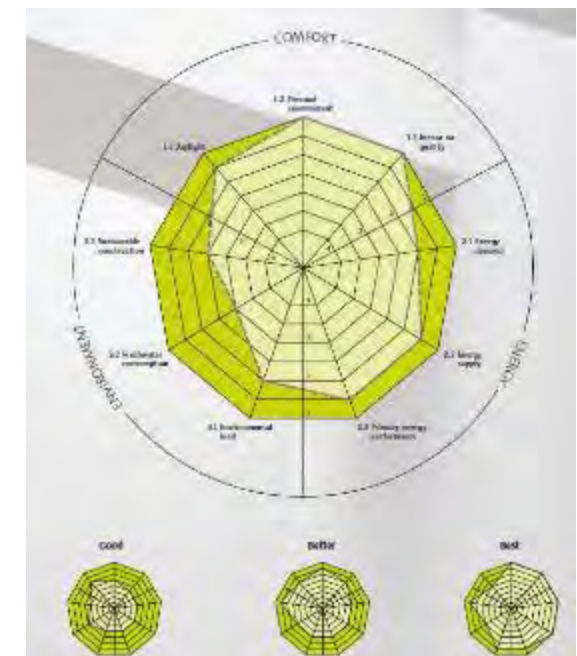
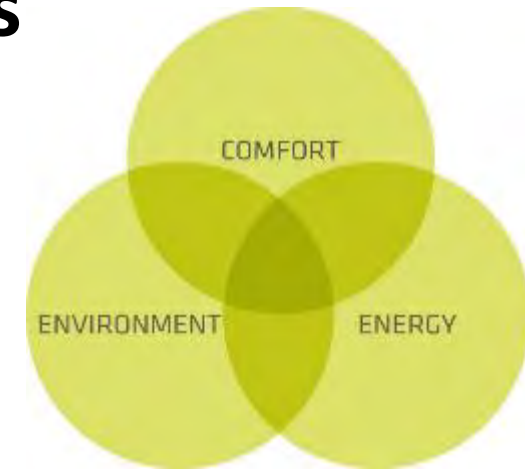
The Active House, yet another green building standard, comes to North America:

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*



[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.

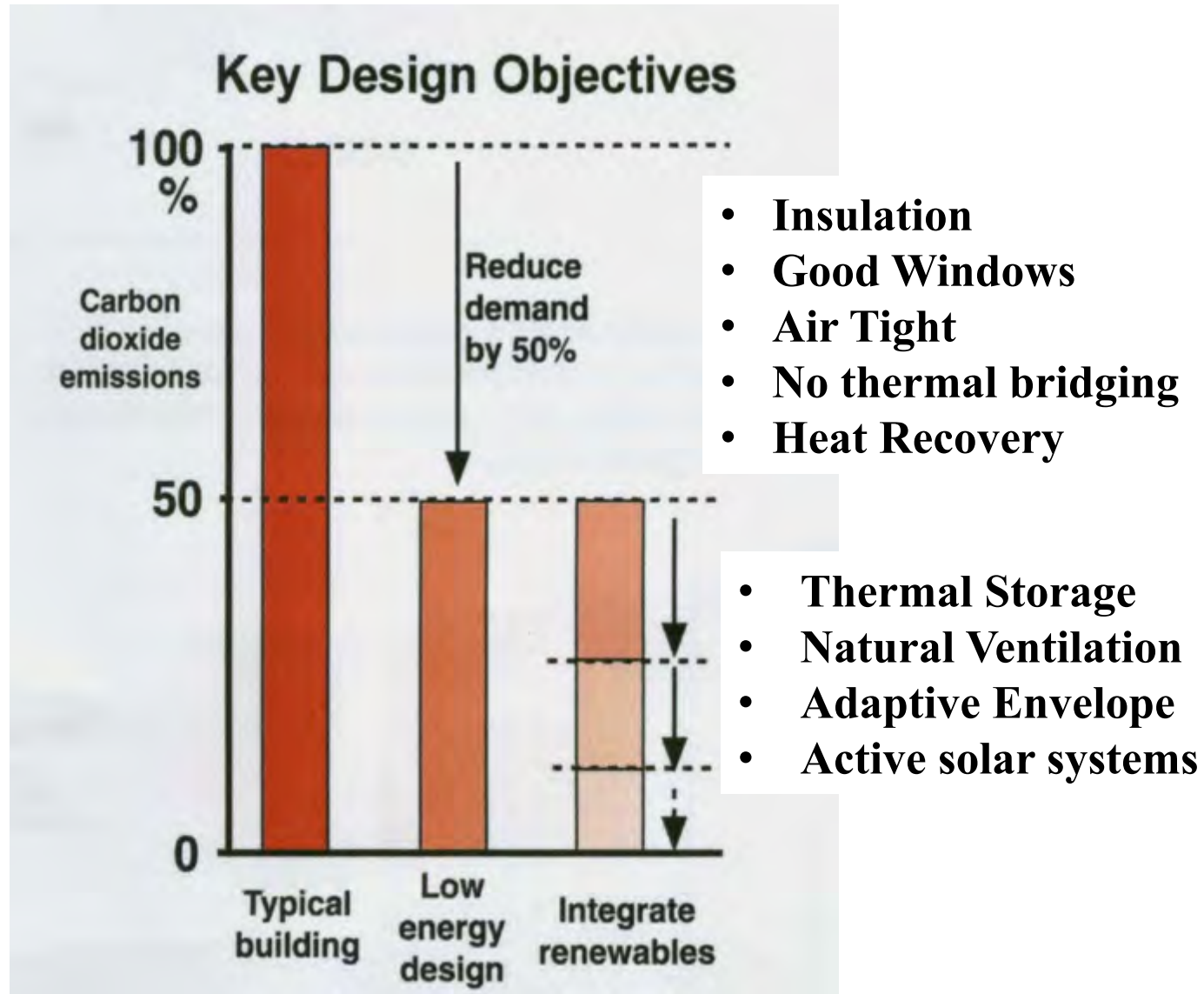
Andrew Purcell takes a tour of the world's first Active House

‘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’

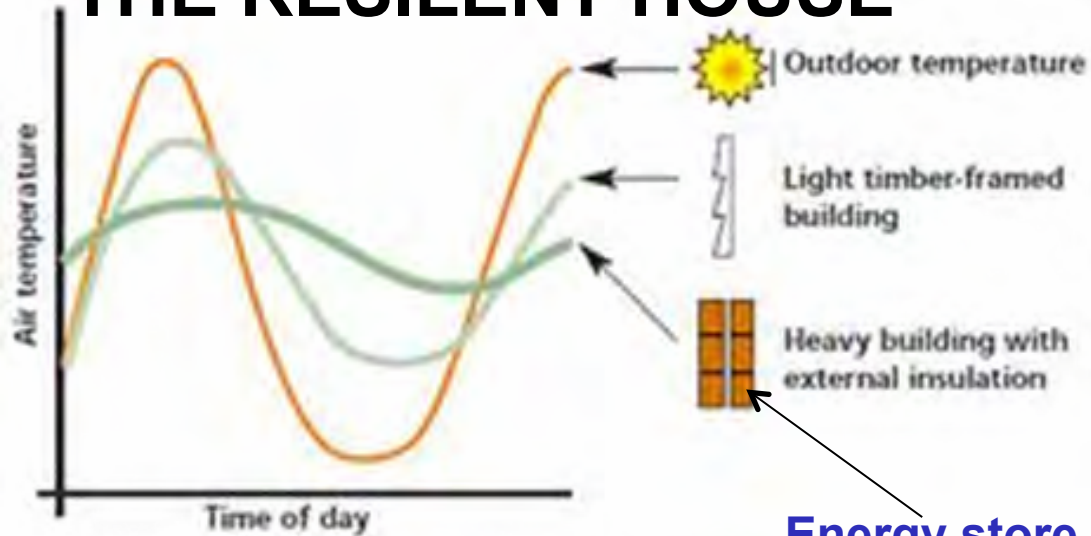
<http://www.theguardian.com/environment/2009/may/21/active-house-denmark-zero-carbon>



Active House: The Environmental Approach



THE RESILIENT HOUSE



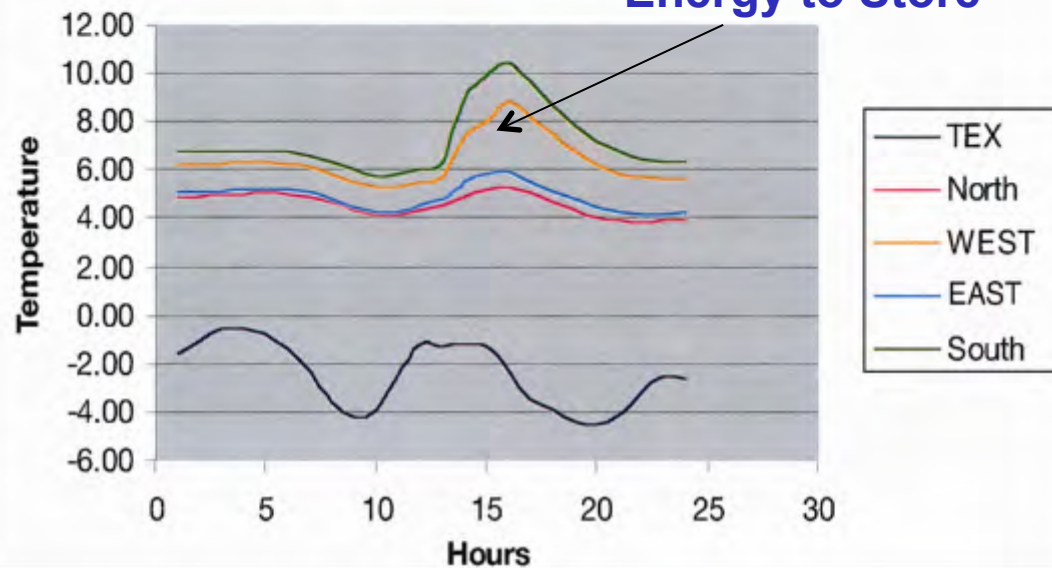
Energy store

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



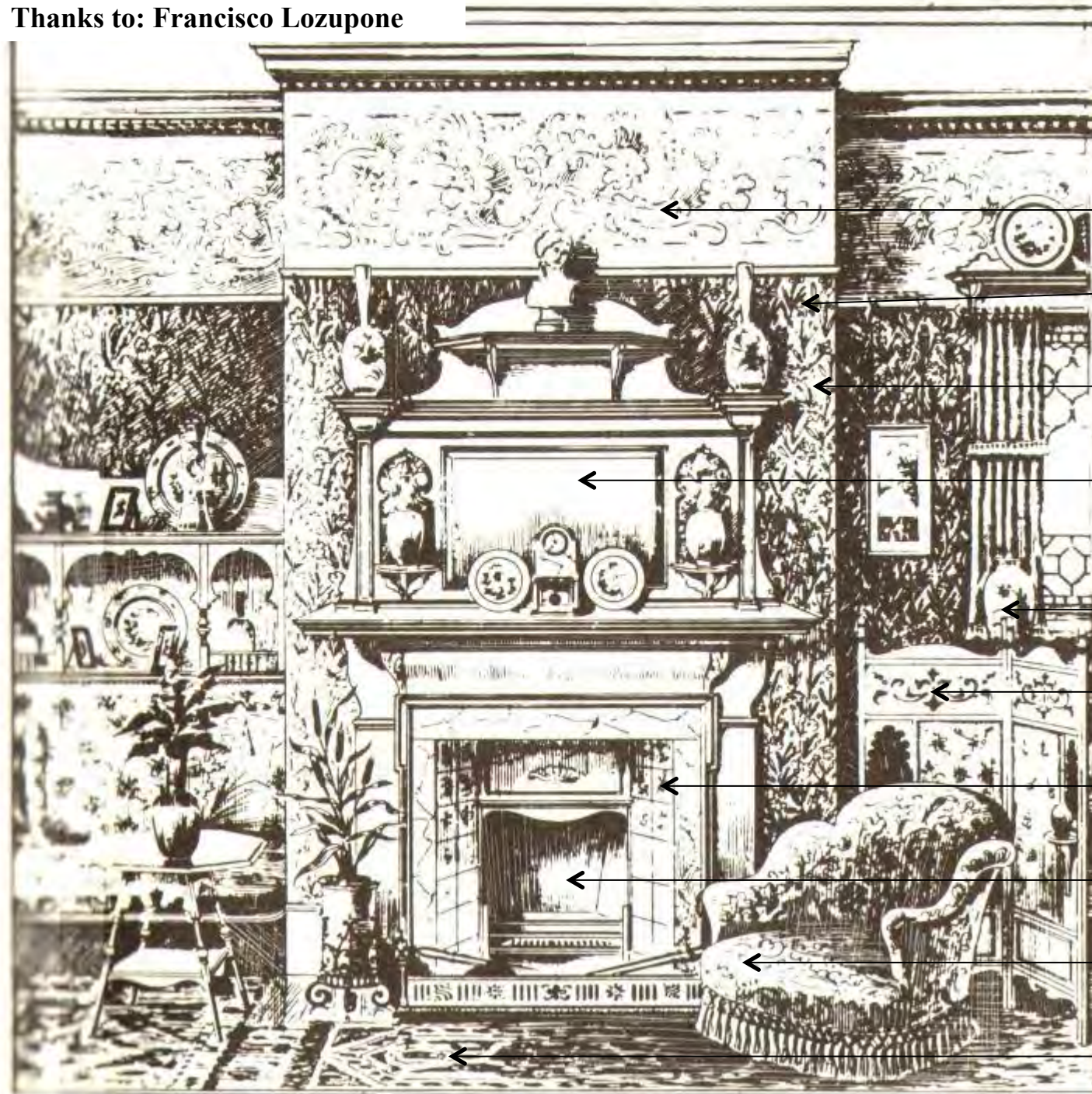
Sunspace Temperature – December 31st

Energy to Store



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

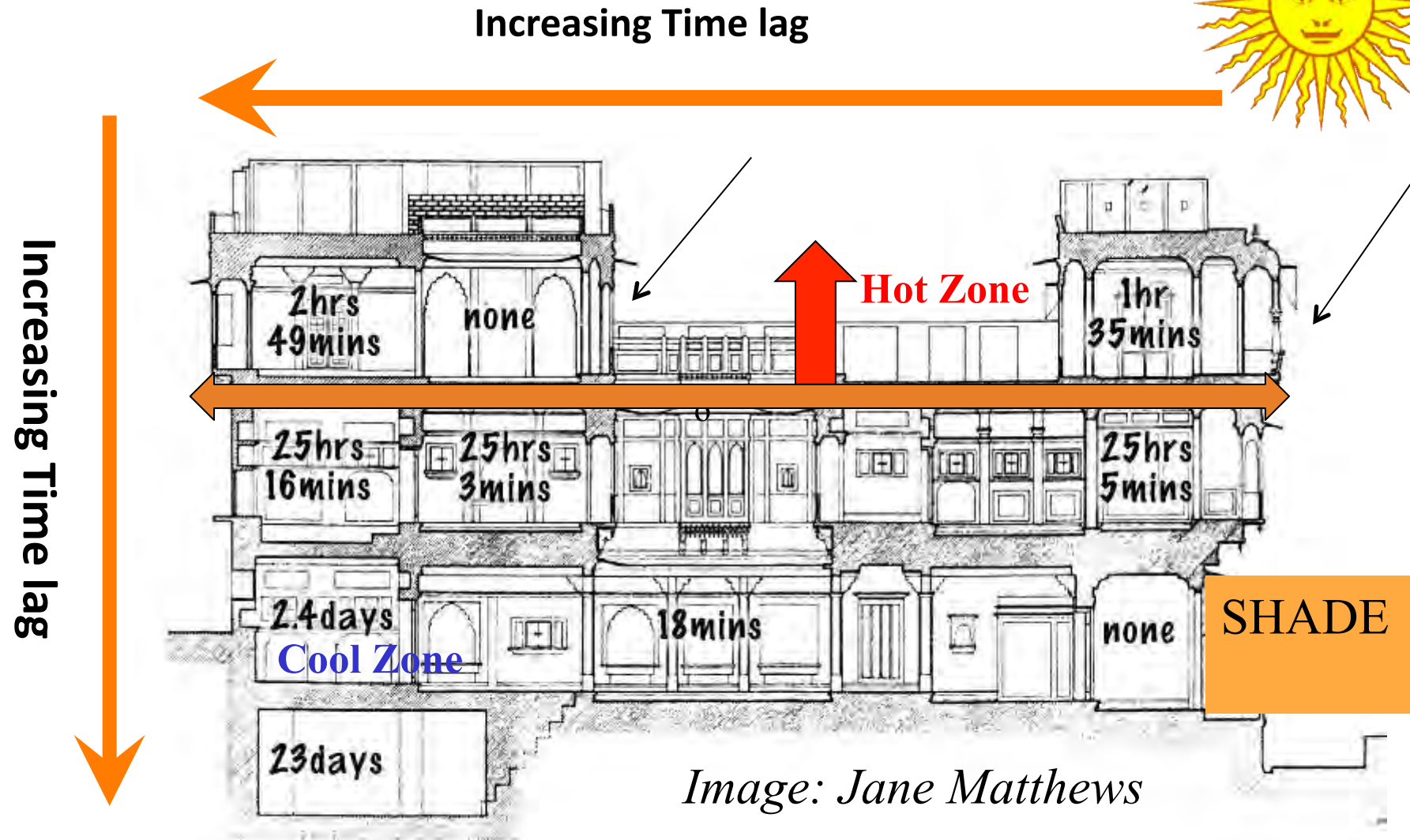
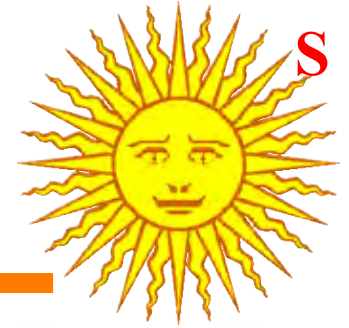
Wood / Coal

Expensive Chairs

Carpets

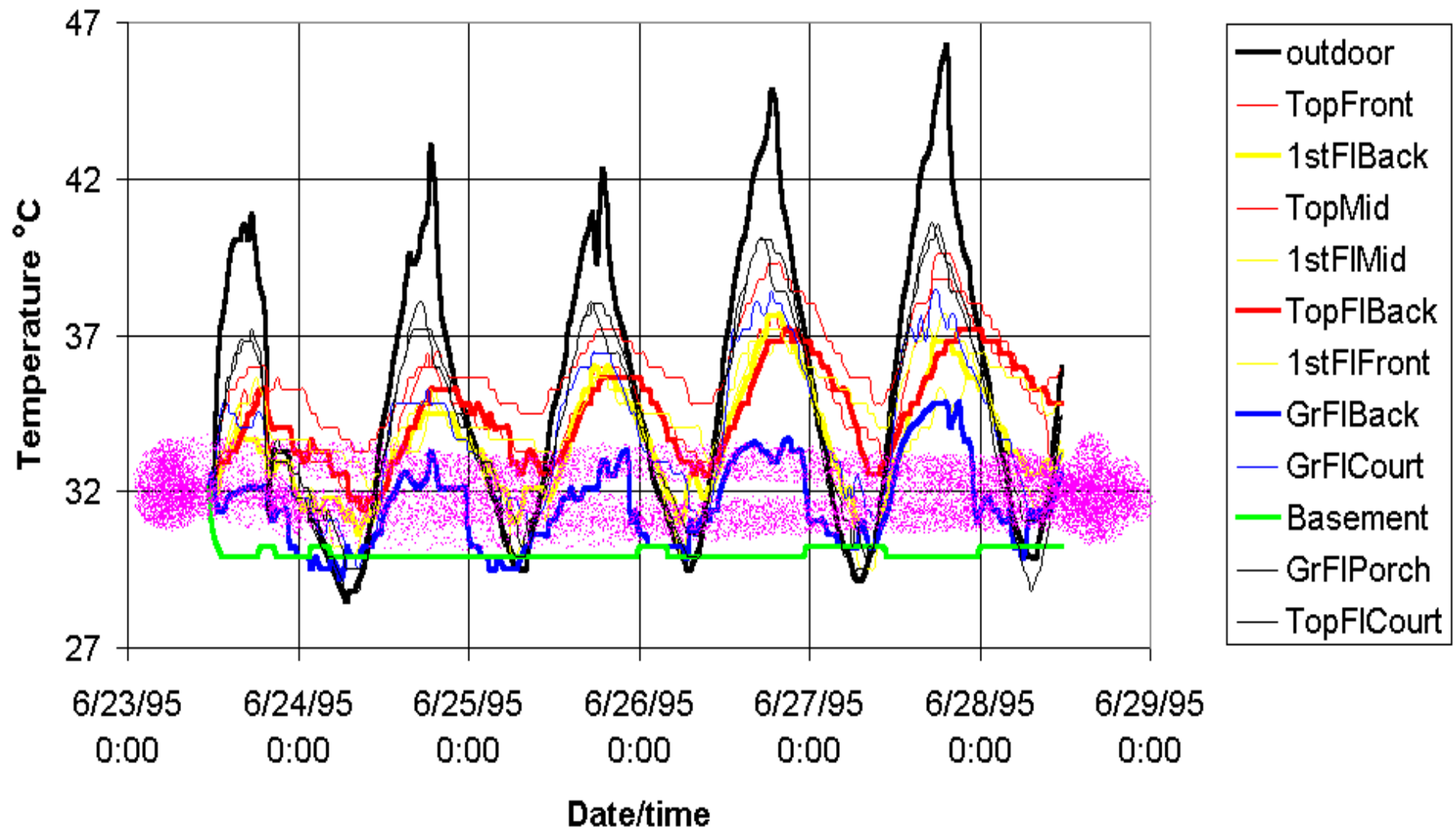
N

Sky or Earth - coupled rooms in the house



Buildings are more or less 'Coupled' or 'Exposed' to the climate around them through Form, Time, Place, Orientation and surroundings – and also through the opportunities they have built in to 'de-couple' through 'Adaptive Envelopes'.

Hotel Suraj indoor temperatures



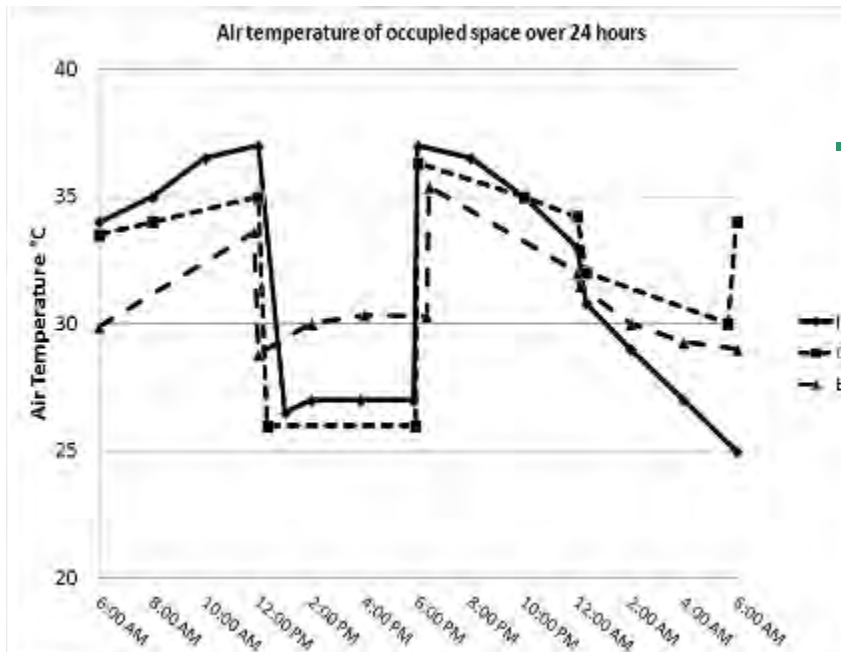
Each Room is Characterised by being more or less ‘PEAKY’¹⁴ in its thermal respon

CLIMATE CHANGE AND SHELTER & HOUSING:

1. Excessive Heat Waves

➤ Thermal Comfort

- ✓ Physiological aspects
- ✓ Cultural aspects



Temperature exposure of housewives
in three different houses in the
desert city of Yazd, Iran

People traditionally adapt
their behaviour to climate



HABITAT UNIVERSITIES

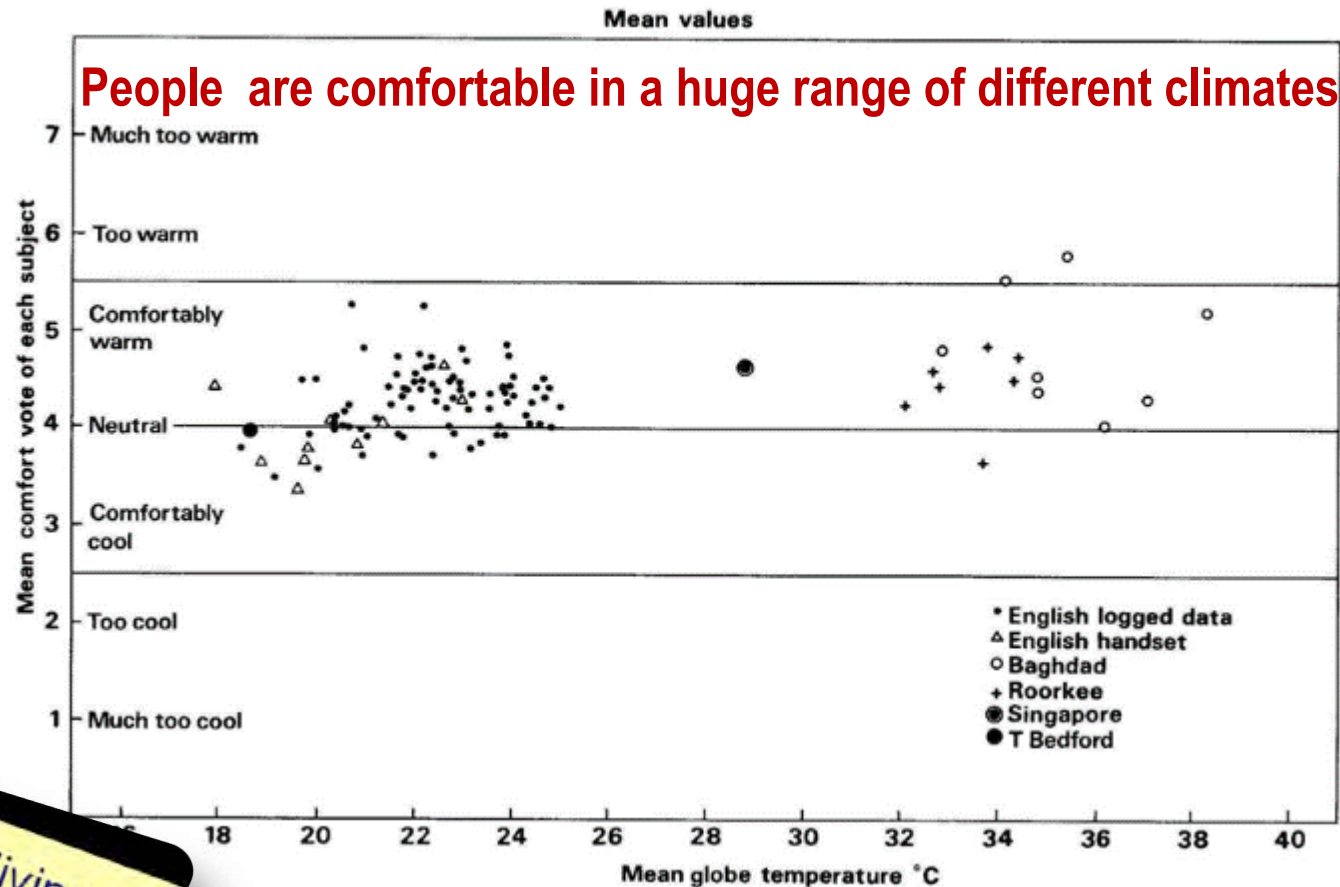
CLIMATE CHANGE AND SHELTER & HOUSING:

1. Excessive Heat Waves

➤ Thermal Comfort

- ✓ Physiological aspects
- ✓ Cultural aspects

Each dot on this diagram shows the comfort temperature from one comfort field survey – showing that different groups of people can be comfortable at very different temperatures.



According to the living environment, people got used to different climates

New Zealand – A Unique Thermal Comfort Story

Recorded in **HEEP**

Household **E**nergy **E**nd-use **P**roject

- Understand hows, whys wheres & whens of residential sector energy use
- No change in behaviour or technologies
- Interested in all fuel types
 - Electricity, natural gas, LPG, solid fuel, solar water
- And the energy services they provide
 - e.g. space temperatures, hot water, television, radio, refrigeration, washing, drying, lighting, cooking, spa ...

Source: Nigel Isaacs

HEEP numbers

Year	Random Houses
1999	43
2000	17
2001	48
2002	100
2003	100
2004	100

~400 random houses

62 non-random houses

1,200 'temperature' locations

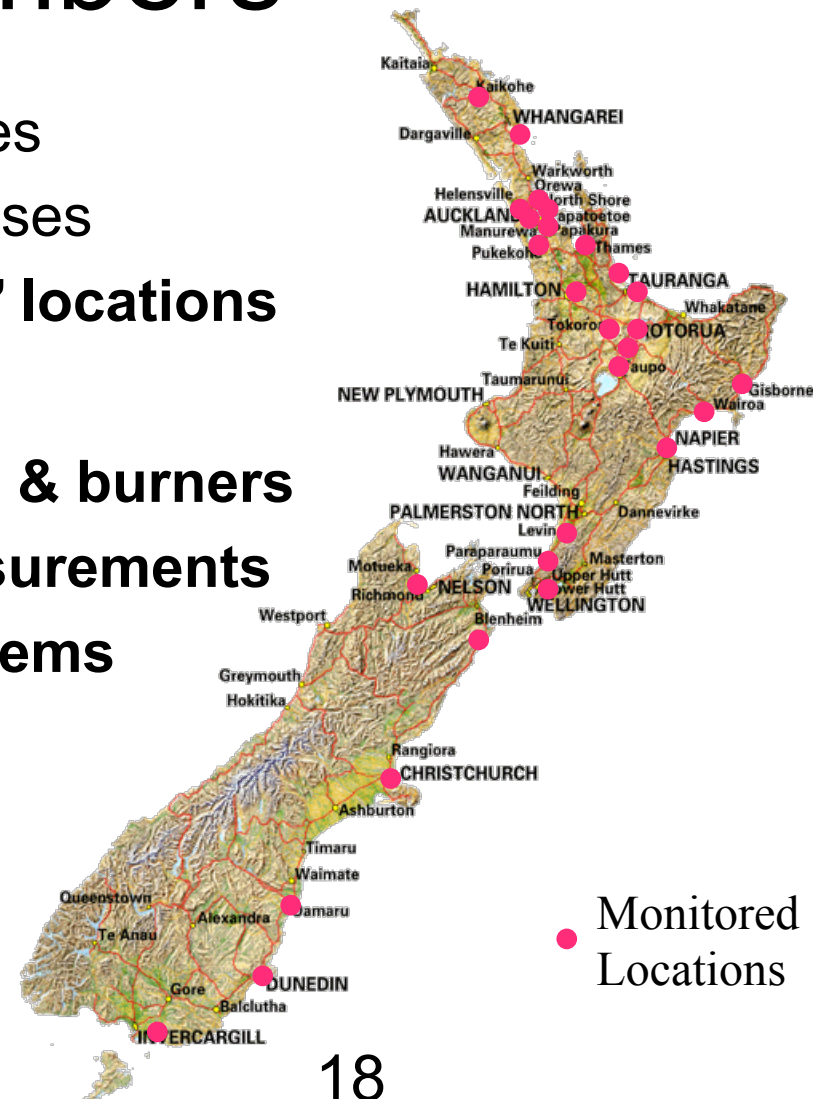
850 dataloggers

255 solid fuel fires & burners

14,000 power measurements

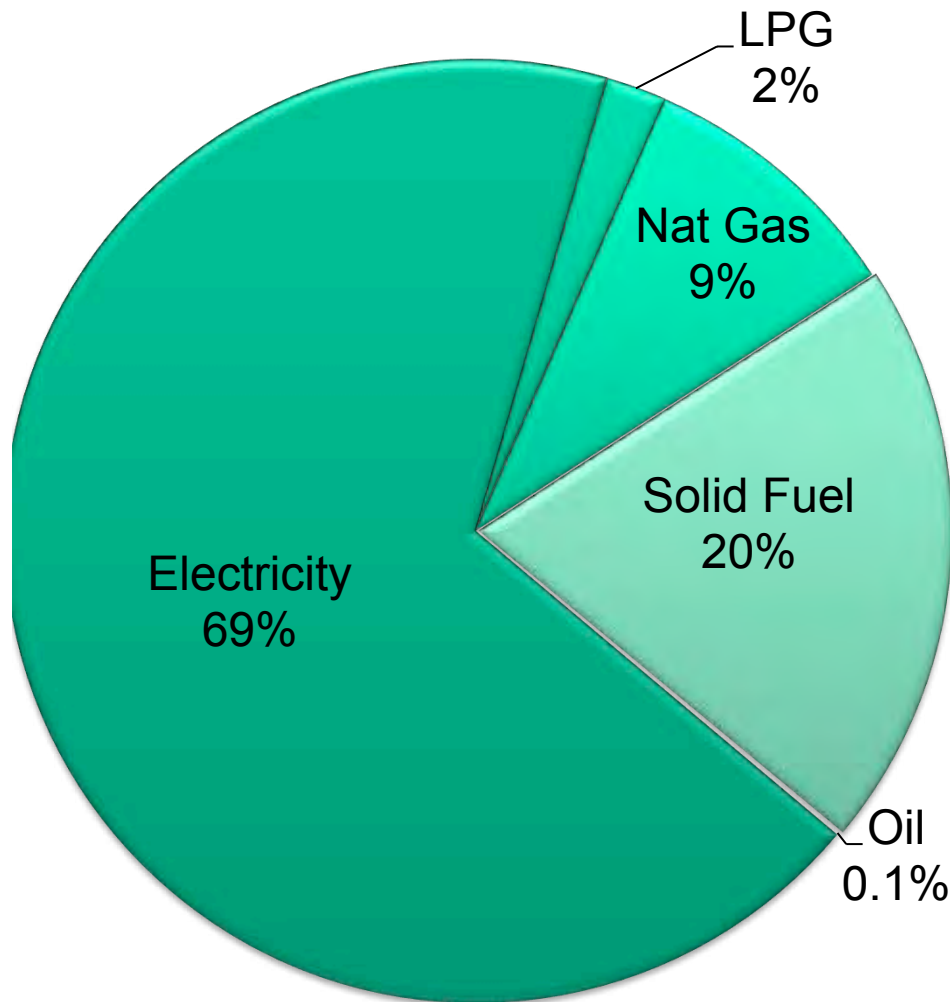
440 hot water systems

175 LPG heaters

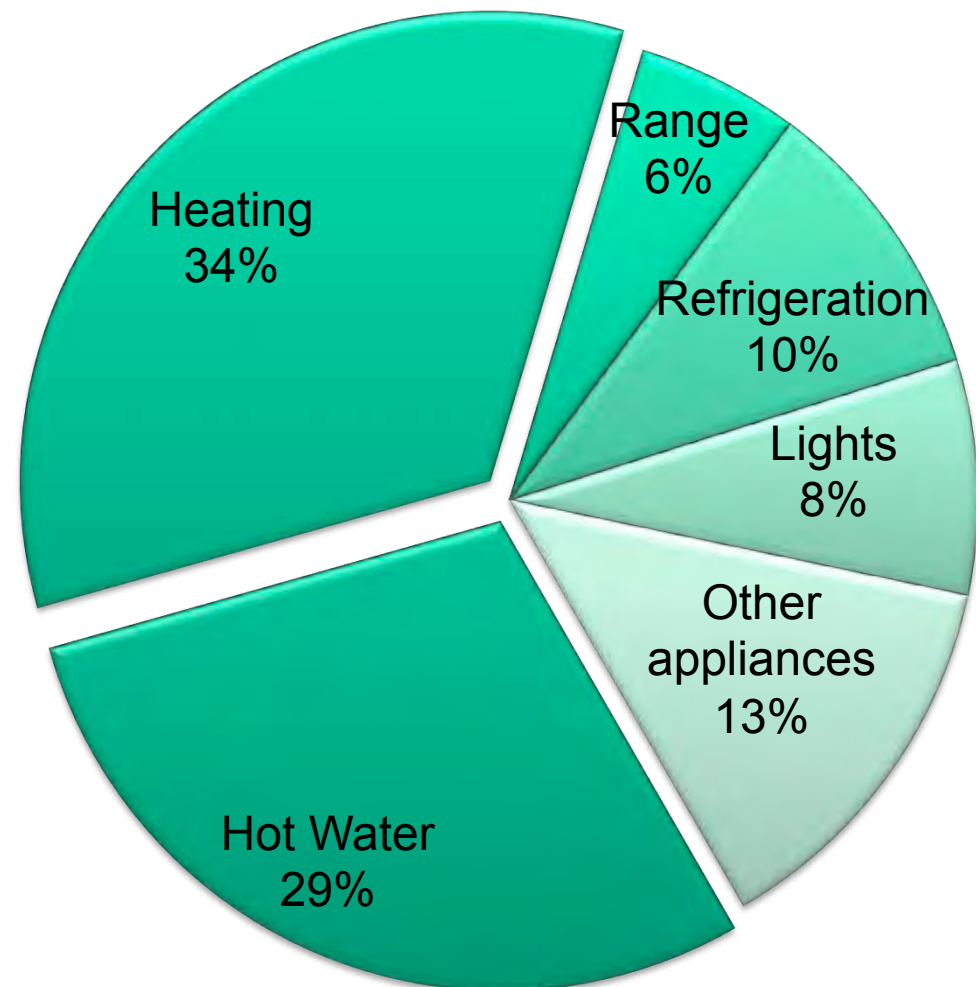


Source: Nigel Isaacs

NZ Stationary Fuels & End-uses

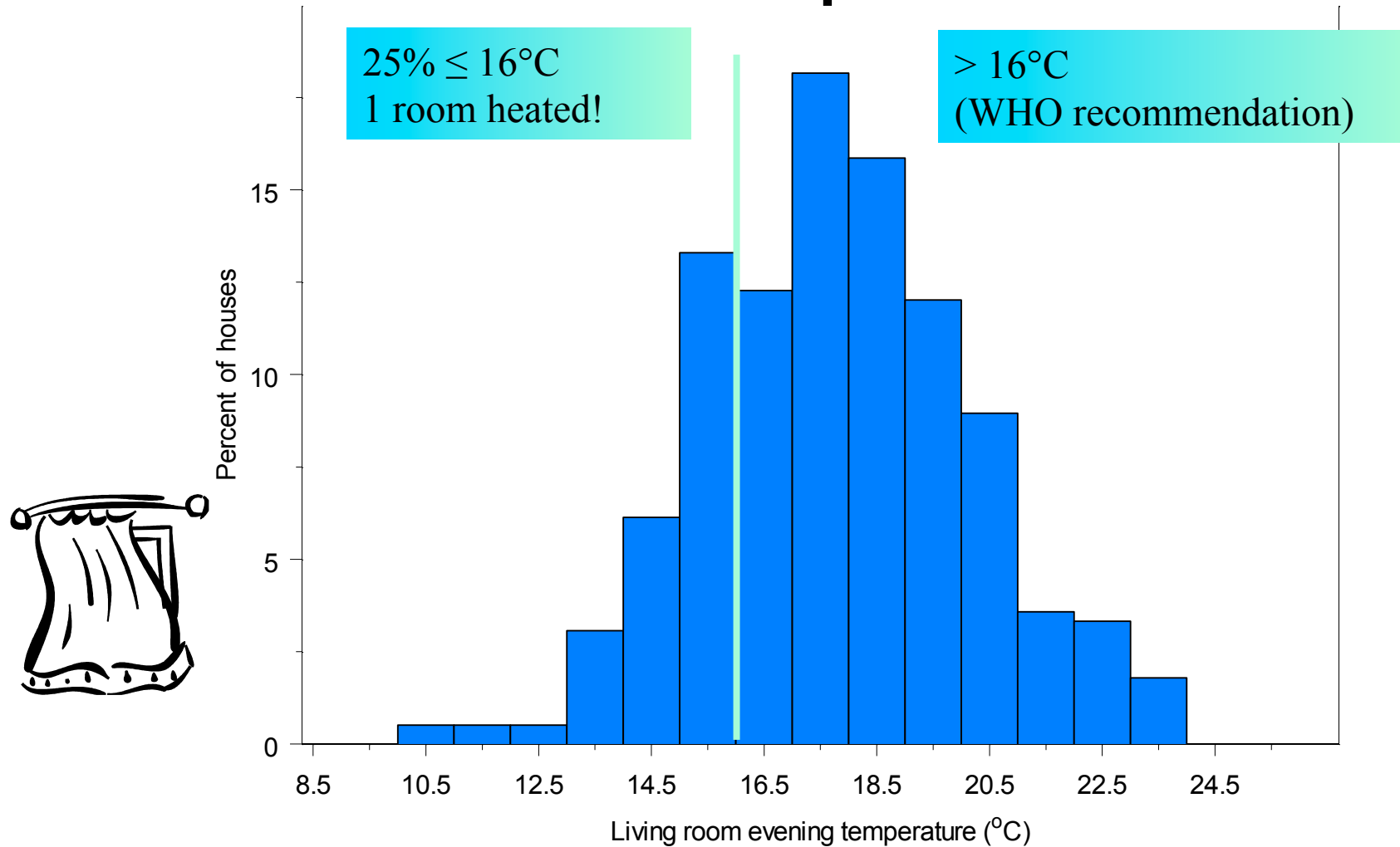


Includes Electricity, Natural Gas, LPG, Coal & Wood ('solid fuel')
Source: HEEP Year 10



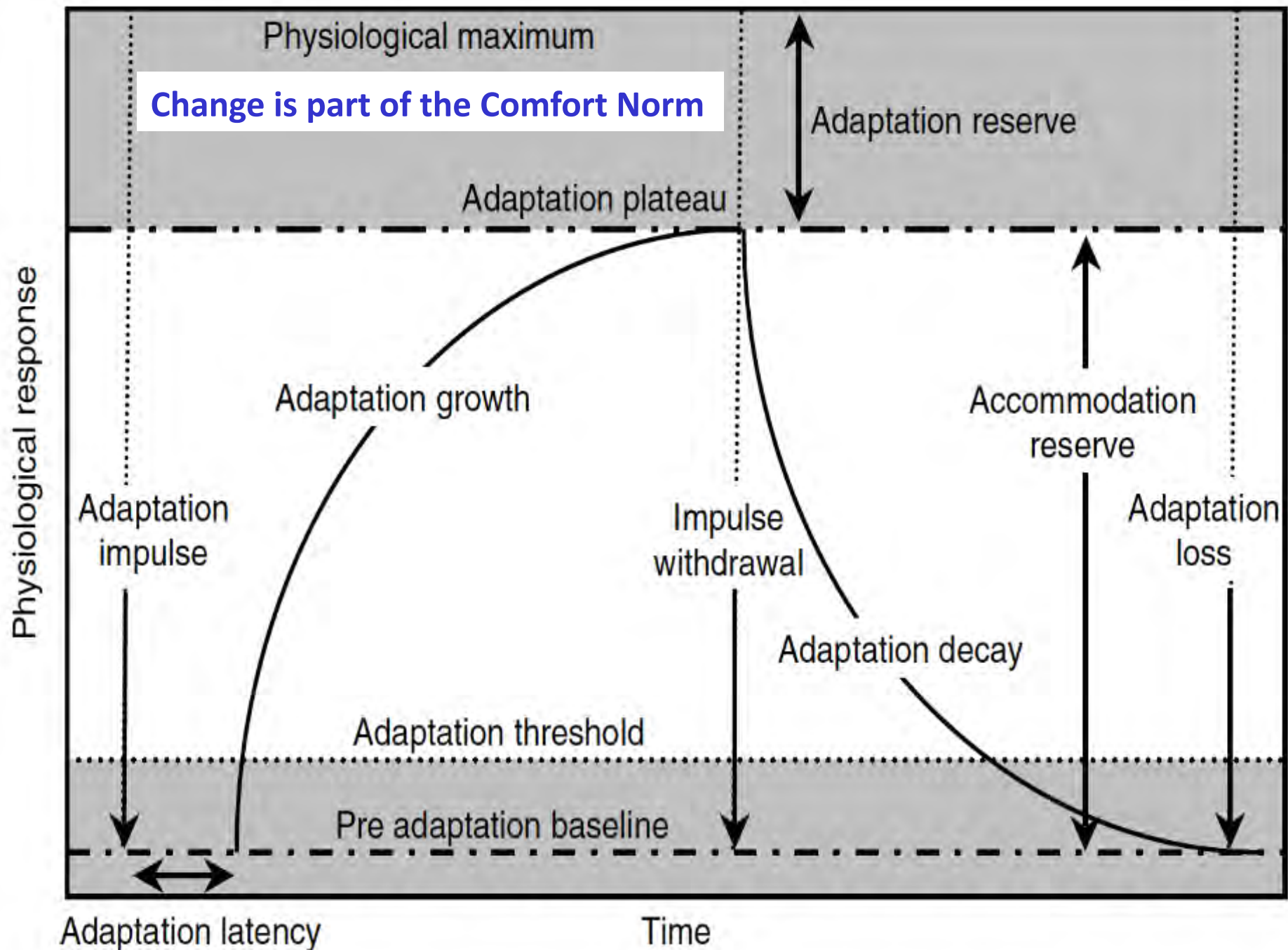
Source: Nigel Isaacs

Winter temperatures



Source: Nigel Isaacs

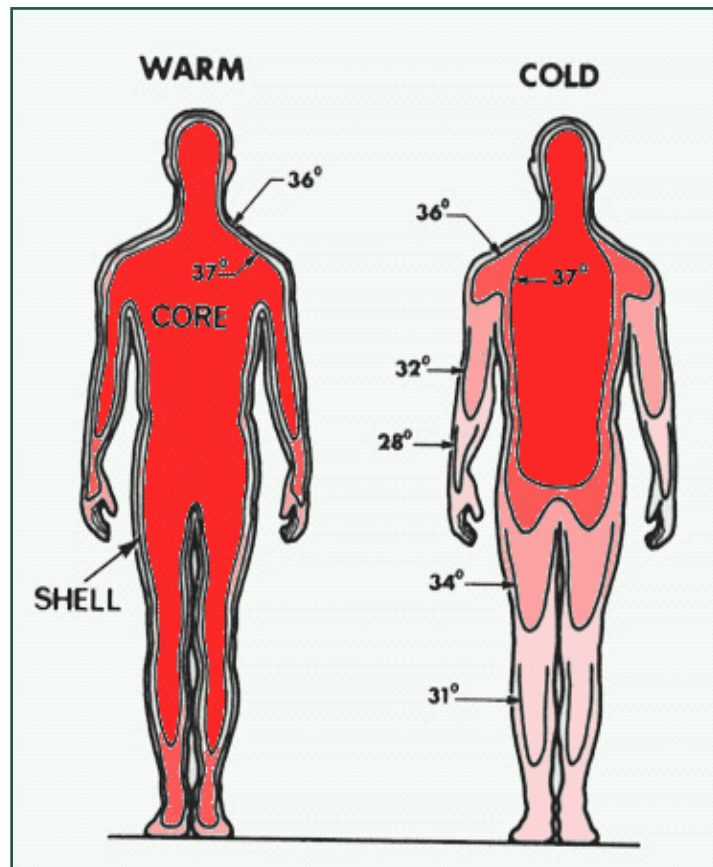
Winter = June to August; 5 pm to 11 pm



Source: Nigel Taylor, Human Heat Adaptation, Comprehensive Physiology, Volume 4, January 2014, pp. 325 - 365

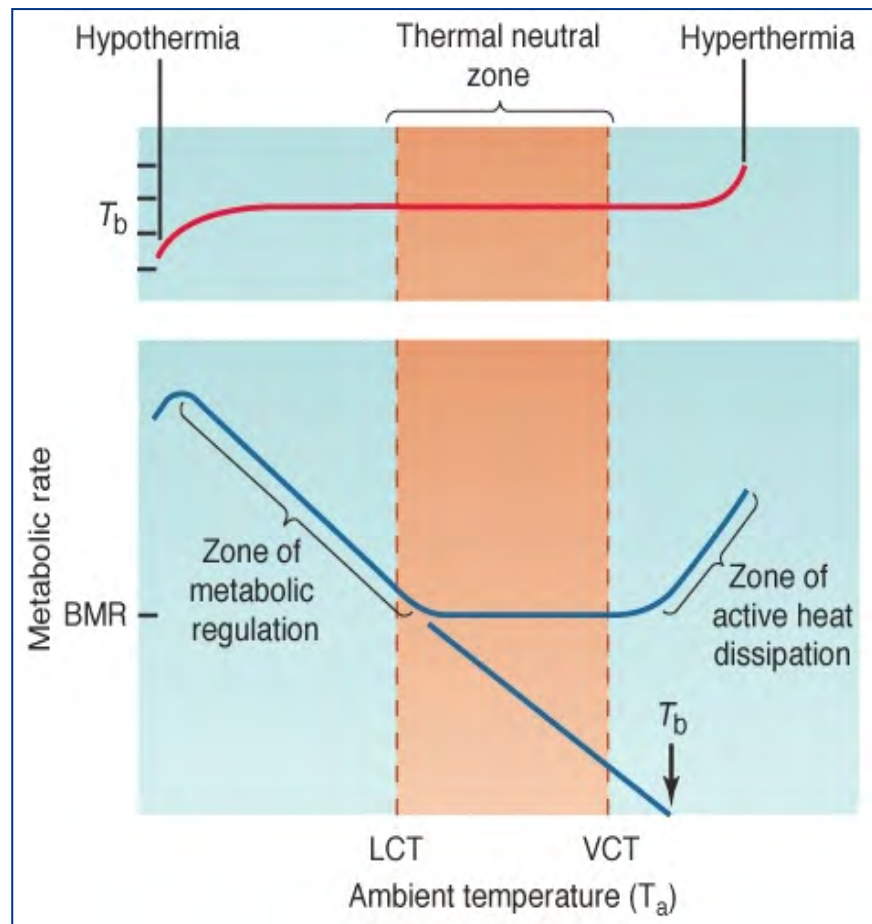
Thermoregulation

Heat loss

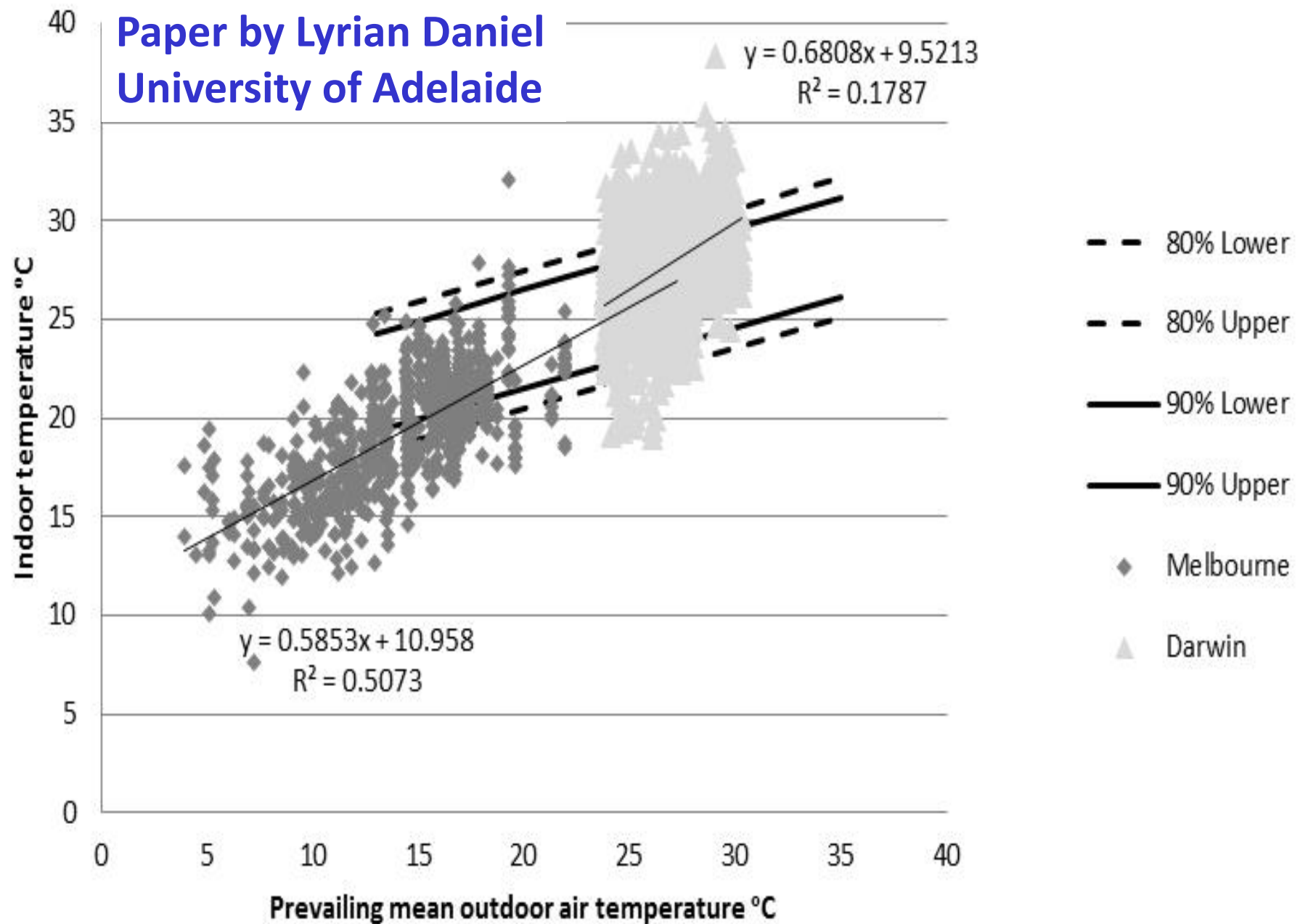


School of the Built Environment

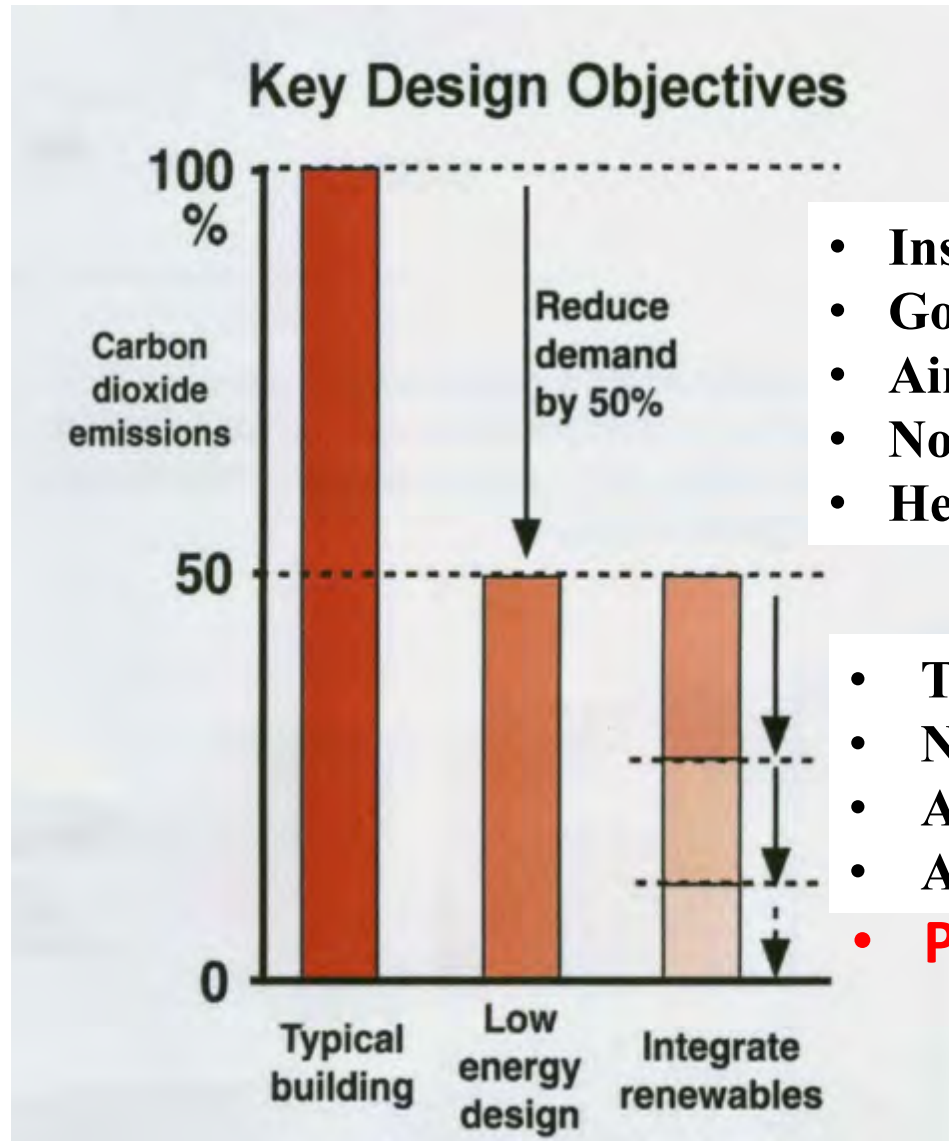
Heat production



Thermal Mavericks
Paper by Lyrian Daniel
University of Adelaide



Active House: The Environmental Approach



- Insulation
- Good Windows
- Air Tight
- No thermal bridging
- Heat Recovery
- Thermal Storage
- Natural Ventilation
- Adaptive Envelope
- Active solar systems
- **People / Controls**

Rising Temperatures: When Does the System Break ?



<400ppm

>750ppm

global temperature change (relative to pre-industrial times)

0°C

1°C

2°C

3°C

4°C

5°C

Buildings

increasingly fail to provide protection against more extreme climate

Increase in **building resilience**

High energy solutions unaffordable

Communities

Non-functional communities begin to disintegrate

Functional Communities **Resilient communities**

Tribal

Building Infrastructure

Systemic failures, temporary collapses

Permanent Collapse

Infra-structures fortified, **new paradigms developed** Local resilient fortified systems

System capacity

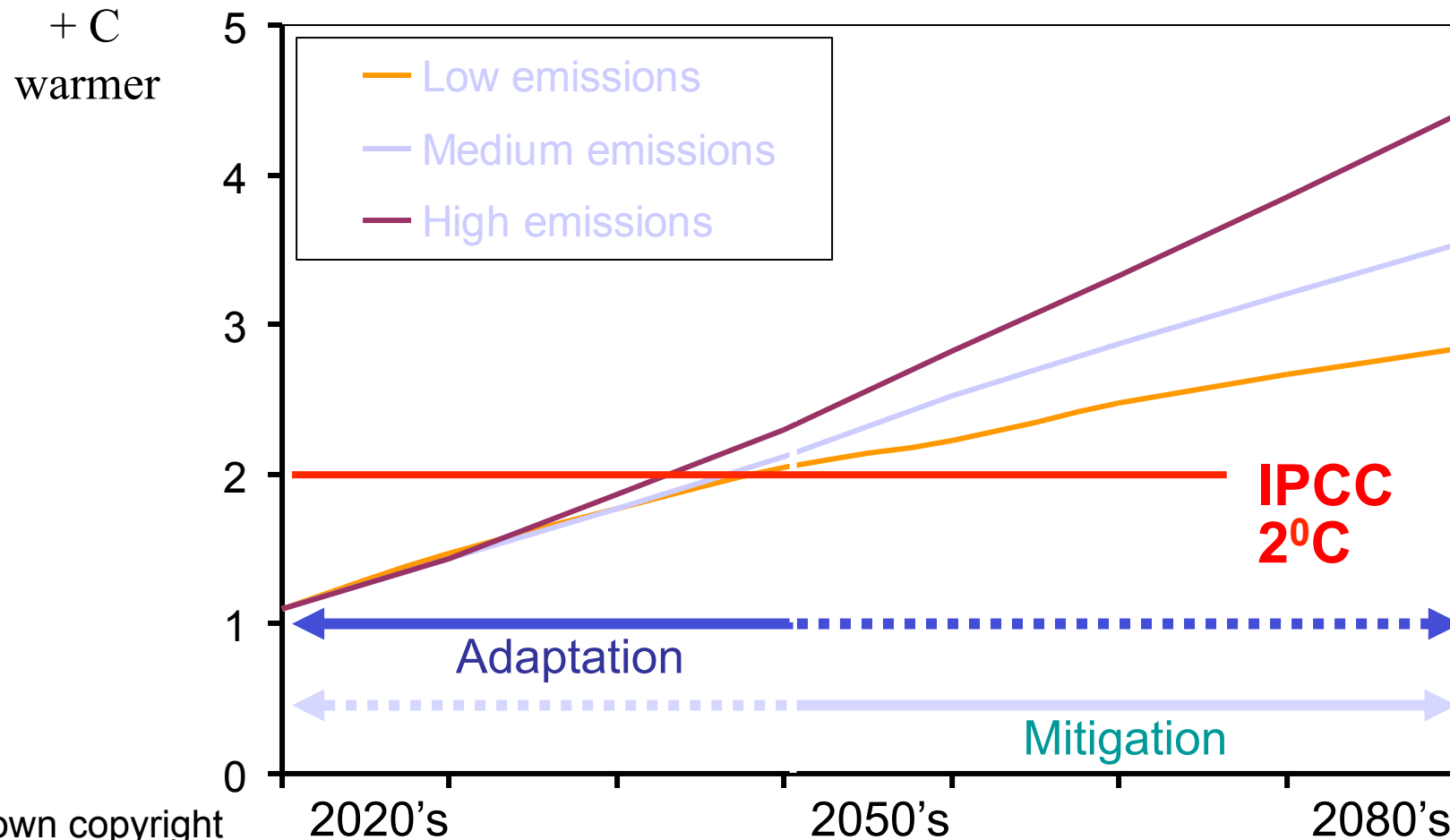
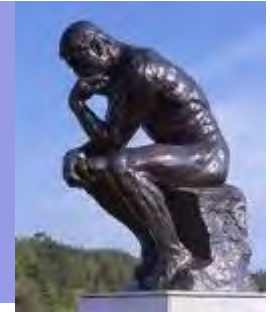
Inequality in societies magnified: system capacity is exceeded

Capacity planning and resource allocation systematised

Inequality in resources causes social breakdown

Sustainability - Adaptation and/or Mitigation ?

Resilience - Adaptation and/or Mitigation ?

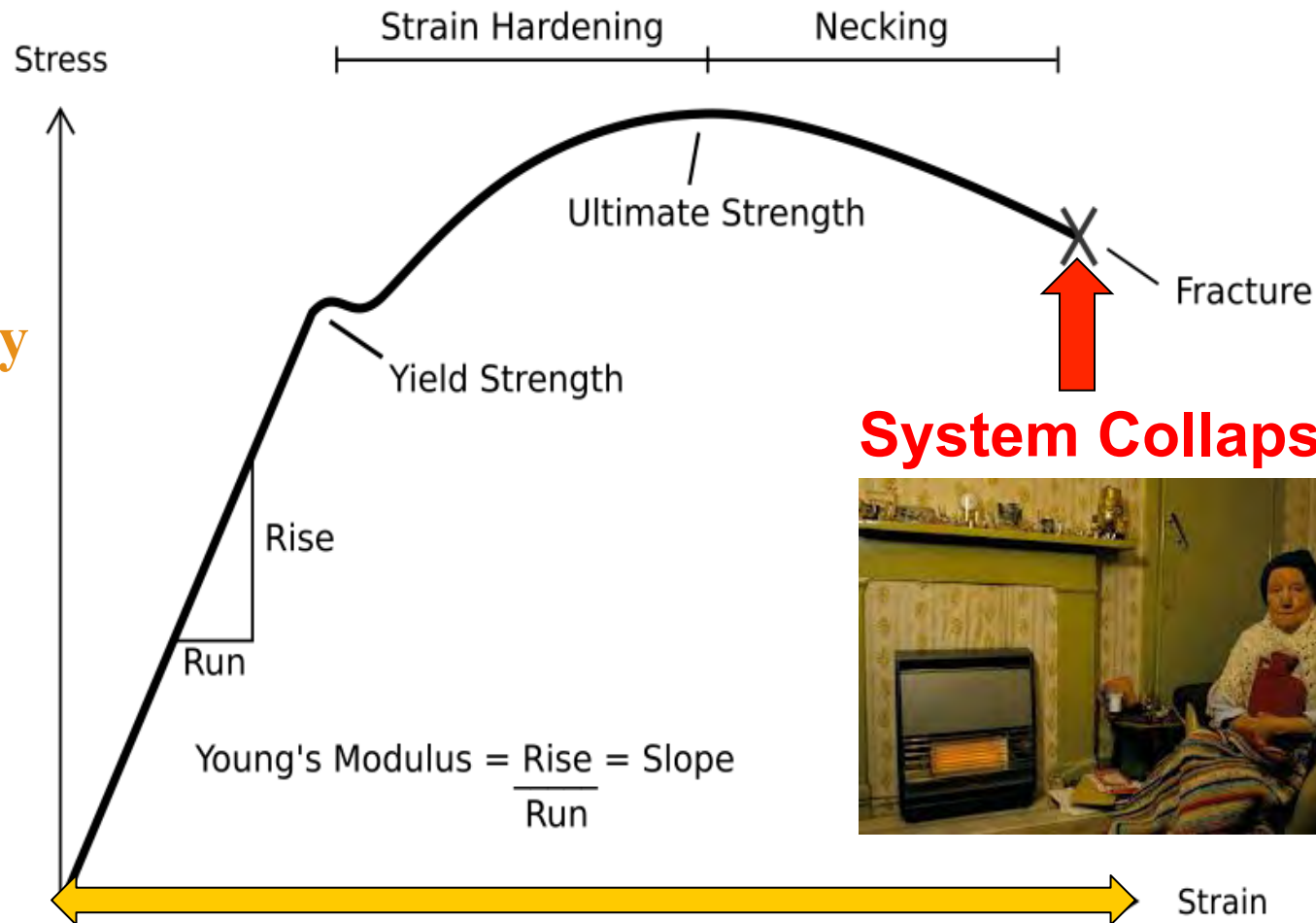


Social / Economic / Environmental Resilience: Is it about the Break Point – no more bouncing back ?



Eg. Ability to pay Energy Bills →

**Eg: ↑
Energy
Bills**



System Capacity



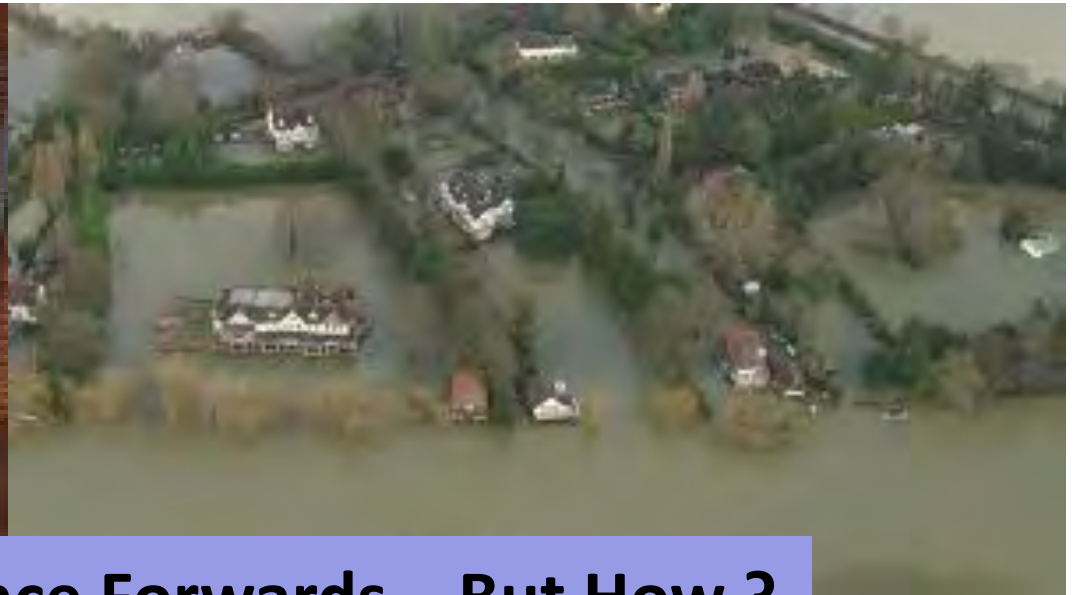
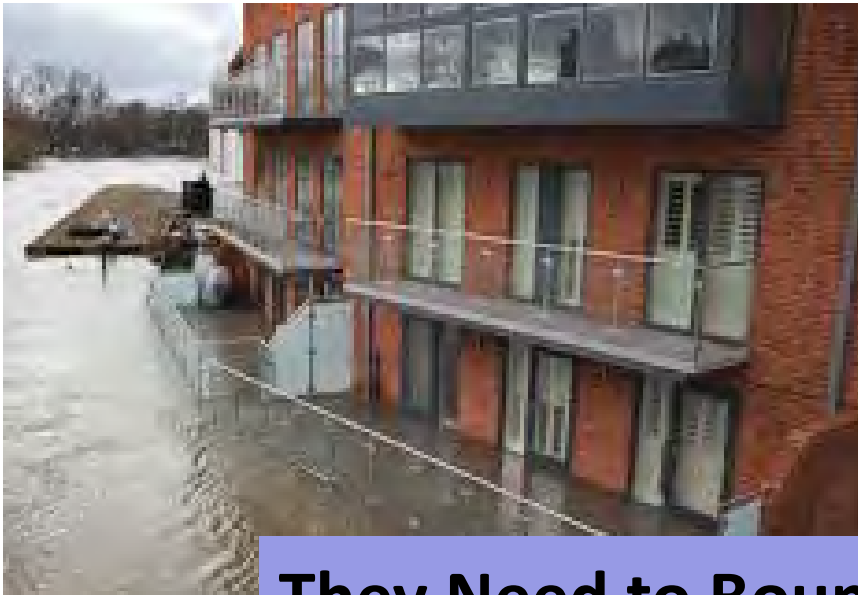
Passive House in the West of Scotland January 2012



How do you Regulate for Non-Linear increases eg. wind speeds?



**January 2014 UK Flooding : All house types affected : London Jan 14
Will they get Insurance again ? Many not ... Pre-empting such changes?**



They Need to Bounce Forwards – But How ?



**Resilience Thinking
requires:**

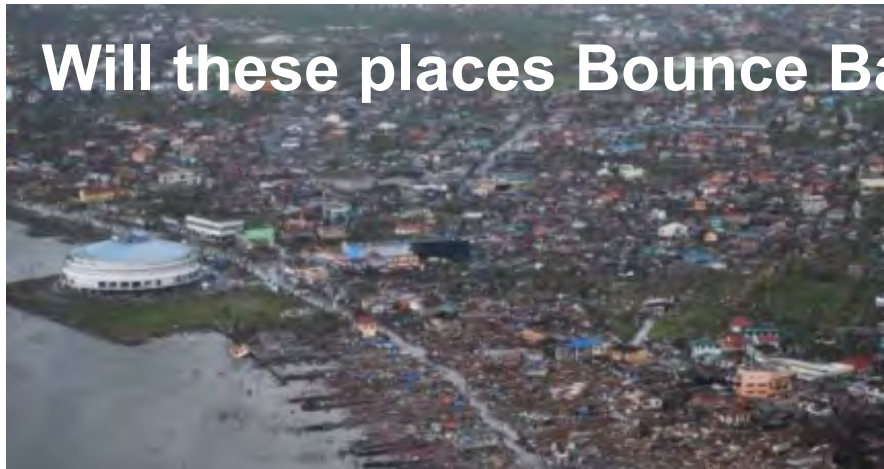
**Climate Ready Buildings ?
Climate Refuge Buildings ?
Pre-Emption ?**

Lots of Money ?

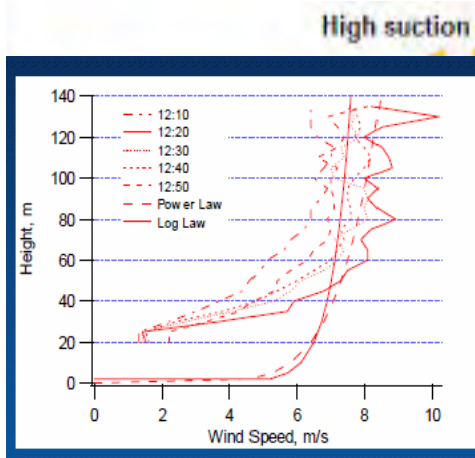


**Bandar Aceh
9 years after the
Tsunami**

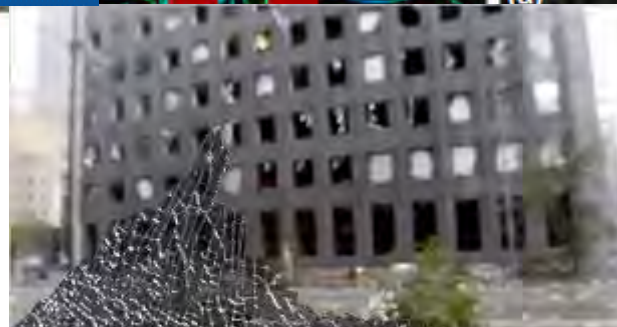
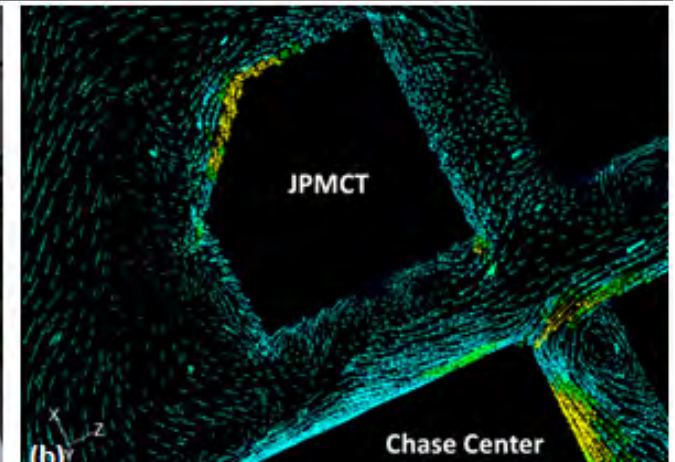
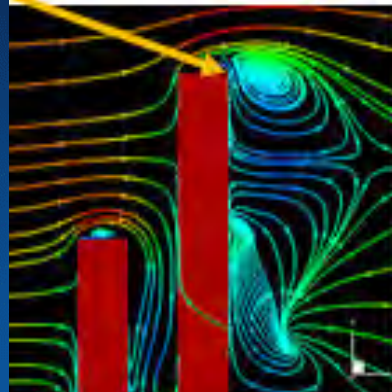
Will these places Bounce Back?



Tough decisions on Managed Retreat ?



High suction regions



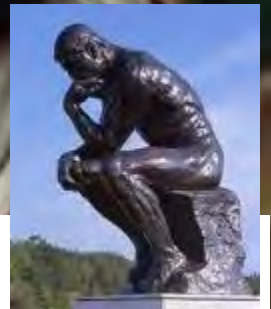
Identify and Remove Wrong Building Types ?

Better to Invest before the Event than to Blight?





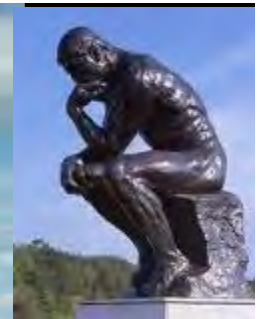
Would you gamble on a Broken System ?



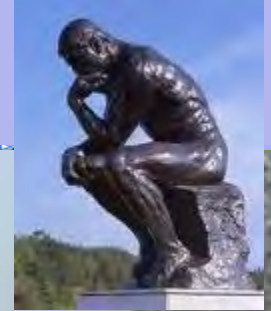
**Are there really some Sunny Uplands
We can engineer ?**



Image: J. Leggett



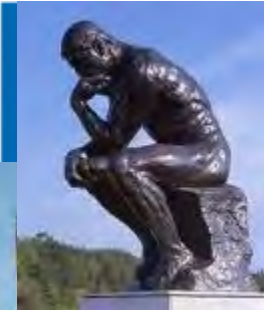
Dangerous Societies: Athens December 2008



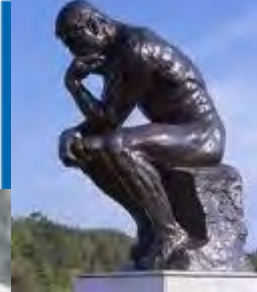
Disappointed Societies: Istanbul: 13th July 2013



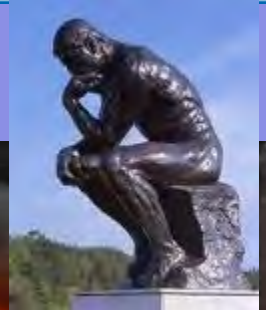
Angry Societies: San Paolo: June 18th / 19th 2013



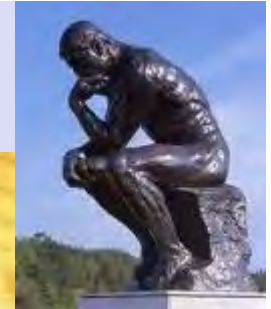
Angry Societies: Bangkok: December 2013



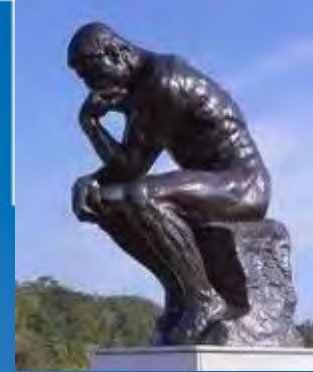
Revolutionary Societies: Kiev, February 20th 2014



Disaffected Societies: LONDON 6-10th August 2011



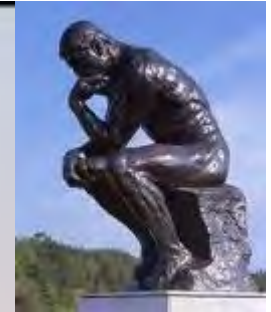
In the Energy Rich 20th Century



Aspirations centred on increasing the living standards and income of citizens

This model must fail at some time.....

Apex of the American Dream: Phoenix Arizona
Most rapidly growing city in the USA 2007

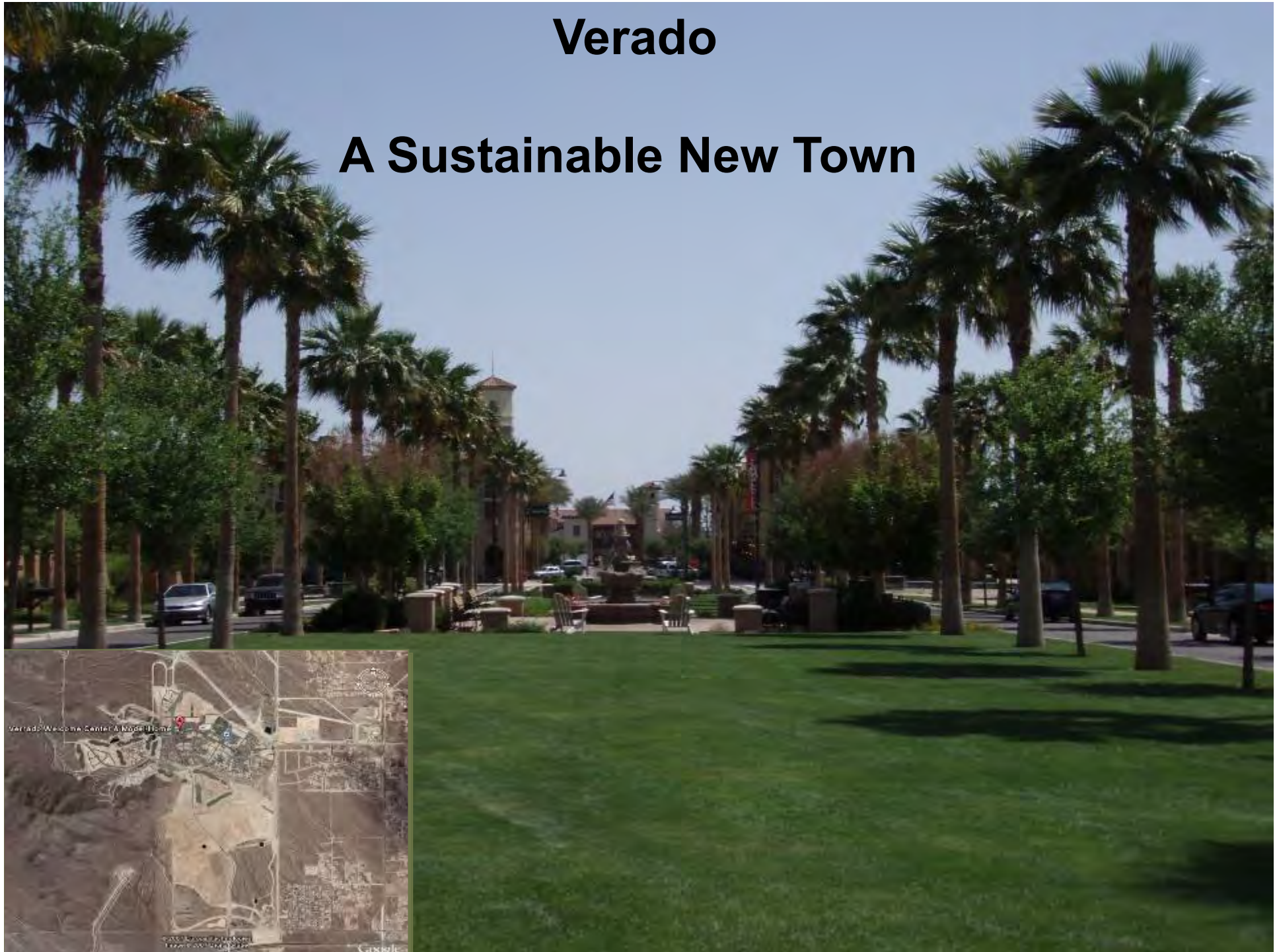


Mass Housing - Developers Dream – Developer's State



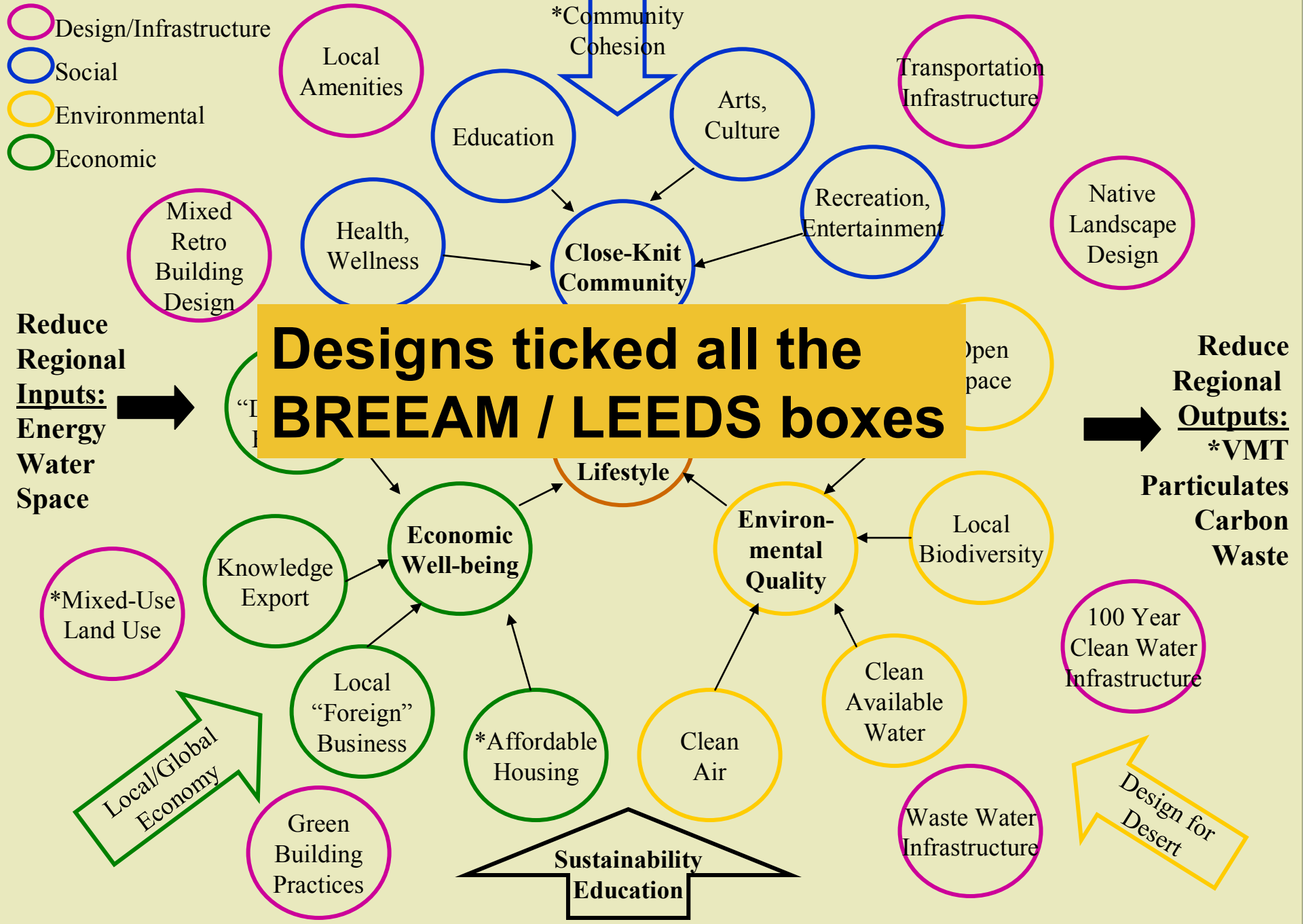
Verado

A Sustainable New Town



Sustainable Verrado System

* = Key System Levers



10

Process Management

11

WP1

9

Legislation
Adaptation Scotland
Professions
Other Stakeholders



WP 2
Scenarios 3
Risk - Options

WP 3

Ground Truthing 5

Costs Benefits 4

8

WP 4


Report to Policy Makers
6-7

Fit 4 Purpose?
6

7

Meta-analysis Framework

Sector Project Champion	Policy Driver	Criteria Policy Option Definition Metrics	Scenario	Risk Analysis	Policy Option Selection	Cost Benefits Analysis	Ground Truthing	Final criteria check + reporting	Strength, Weakness and Gaps Review	Uncertainty exercise
Farming Landuse K. Topp	SRDP	AM, SM, K. Topp and ET + Pol.	IB, MN, MC		(ET) Expert team – K. Topp	K. Topp team SAC	KB1, L. Poggio. AM, SM	K.Topp and ET, SM, AM + Pol		
Forestry Planting ? A, Moffat	Scot Adapt Comit?	KB2, AM, SM, BN + Pol.	Forestry Com team ? B. Nicol ?		A.Moffat, BN, + ET	Greg Valentine? JHI ?	KB1, KB2, SM, AM, BN, A. Moffatt	KB2, SM, AM, BN, A. Moffatt + Pol		
BioDiversity Species ? Chris Ellis	CCRA?	CE, SM, AM, and ET + Pol	IB, MN, MC ??		CE + ET	JHI M. Najink SAC?	CE, SM, KB1	CE, SM, AM, + Pol.		
Flooding		M, SM, JR, SR	IB		IB	?	KB1, JR, ?	JR, KB		
Additional OUTPUTS	Map of workable options V. policy drivers	Established evolving Indicator set and metrics	Sector and policy relevant scenario sets	Effective Risk Analysis Method for each sector	Range of tested policy options on the shelf	Effective CBA method for each sector. Costed Policy Options on shelf	Effective ground truthing two way network	Climate-proof policy options presented to politicians with costs.		

Single Person	VERRADDO 2007		VERRADO 2020	
2020 = x 2 energy prices Without water trucking prices	per month	per year	per month	per year
Mortgage	2000	24000	2800	33600
Property Tax	500	6000	500	6000
water + sewer	80	960	160	1920
Energy	300	3600	600	7200
Car purchase	300	3600	300	3600
Gas / petrol	250	3000	500	6000
House insurance	100	1200	100	1200
Car insurance	100	1200	100	1200
Telephone	100	1200	100	1200
Cable	50	600	50	600
Health Insurance	200	2400	200	2400
Extras	100	1200	100	1200
Groceries	300	3600	300	3600
Credit Cards	200	2400	200	2400
	4580	54960	6010	72120
& 30% TAX		16488		21636
ANNUAL SALARY		\$71.488		\$93.756



The **END** of **SUBURBIA**

Oil Depletion and The Collapse
of The American Dream



*"We're literally stuck up a cul-de-sac
in a cement SUV without a fill-up"*

-James Howard Kunstler



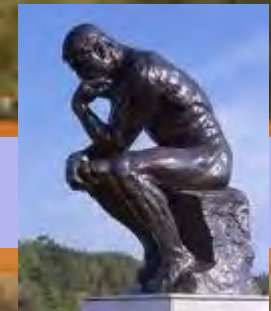
At the 2010 census there were over 261,000 vacant homes in the greater Phoenix / Maricopa area.



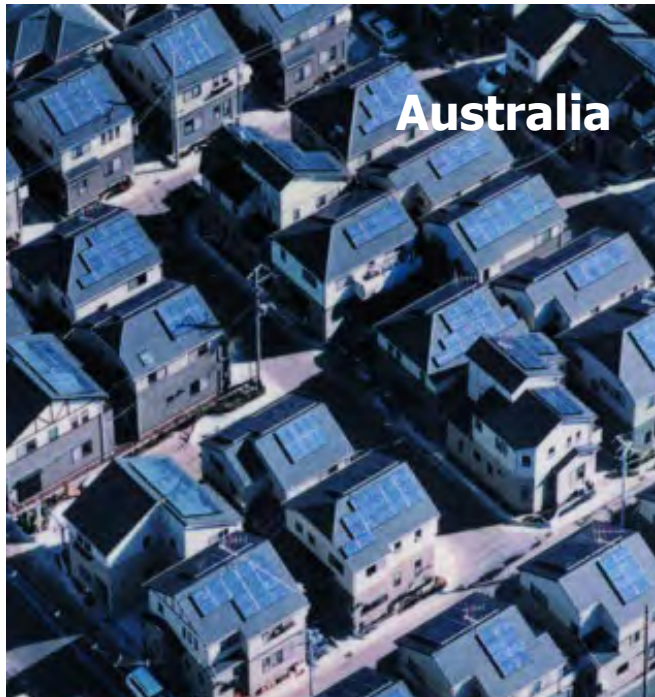
One in every 17
Arizona
households got a
foreclosure filing in
2010



Have / Will these properties Bounce Back ?



Single Person	GARFIELD 2007		SOLAR GARFIELD 2020		VERRADDO 2007		SOLAR VERRADO 2020	
	per month	per year	per month	per year	per month	per year	per month	per year
Mortgage	1400	14400.00	2000.00	24000	2000	24000.00	2800.00	33600
Property Tax	500	6000.00	500.00	6000	500	6000.00	500.00	6000
water + sewer	80	960.00	160.00	1920	80	960.00	160.00	1920
Energy	200	2400.00	0	0	300	3600.00	600.00	7200
Car purchase	300	3600.00	300.00	3600	300	3600.00	300.00	3600
Gas / petrol	100	1200.00	0	2400	250	3000.00	500.00	6000
House insurance	100	1200.00	100.00	1200	100	1200.00	100.00	1200
Car insurance	100	1200.00	100.00	1200	100	1200.00	100.00	1200
Telephone	100	1200.00	100.00	1200	100	1200.00	100.00	1200
Cable	50	600.00	50.00	600	50	600.00	50.00	600
Health Insurance	200	2400.00	200.00	2400	200	2400.00	200.00	2400
Extras	100	1200.00	100.00	1200	100	1200.00	100.00	1200
Groceries	300	3600.00	300.00	3600	300	3600.00	300.00	3600
Credit Cards	200	2400.00	200.00	2400	200	2400.00	200.00	2400
	3730	42360.00	4710.00	56520	4580	54960.00	6010.00	72120
& 30% TAX		12708.00		16956		16488.00		21636
ANNUAL SALARY		\$55068.00		(\$73,476) \$52468		\$71488.00		(\$93756) \$64888



Australia



USA



Japan



Brazil



China



Germany

6b) DESIGN AUTARKIC /SELF RELIANT BUILDINGS AND COMMUNITIES

A large flock of bats is captured in flight, forming a dense, dark, V-shaped column that stretches from the bottom center towards the top of the frame. The background is a dramatic sunset sky with warm orange and yellow hues. The sun is a bright, glowing orb positioned near the bottom center, partially obscured by the lower part of the bat flock. Wispy clouds are scattered across the sky, catching the low light of the setting sun. The overall scene conveys a sense of natural resilience and movement.

Roaf's 10 Top Tips for Designing Resilient Buildings For Heat Waves..

Migrating Bats during Adelaide January 2014 Heat Wave

1) Understand the Risk

Hazard:

- Climate Change
- Energy Prices
- Power Outages

Vulnerability:

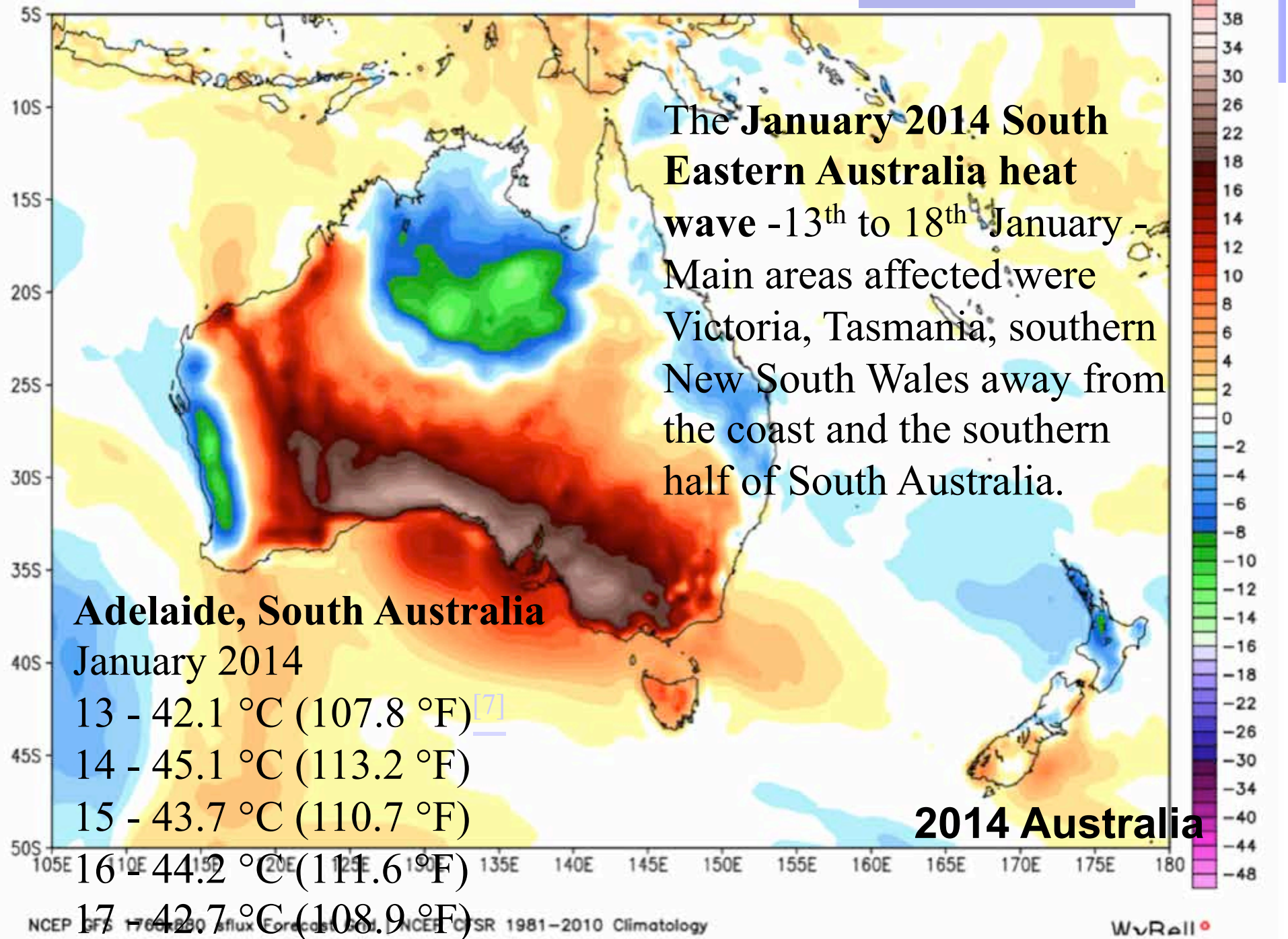
House ?
Car ?
Community ?
Health ?
Wealth ?
Age ?

RISK

Exposure: Where do you live ?

Temperature (°C)







Under the Beach Pier in Adelaide

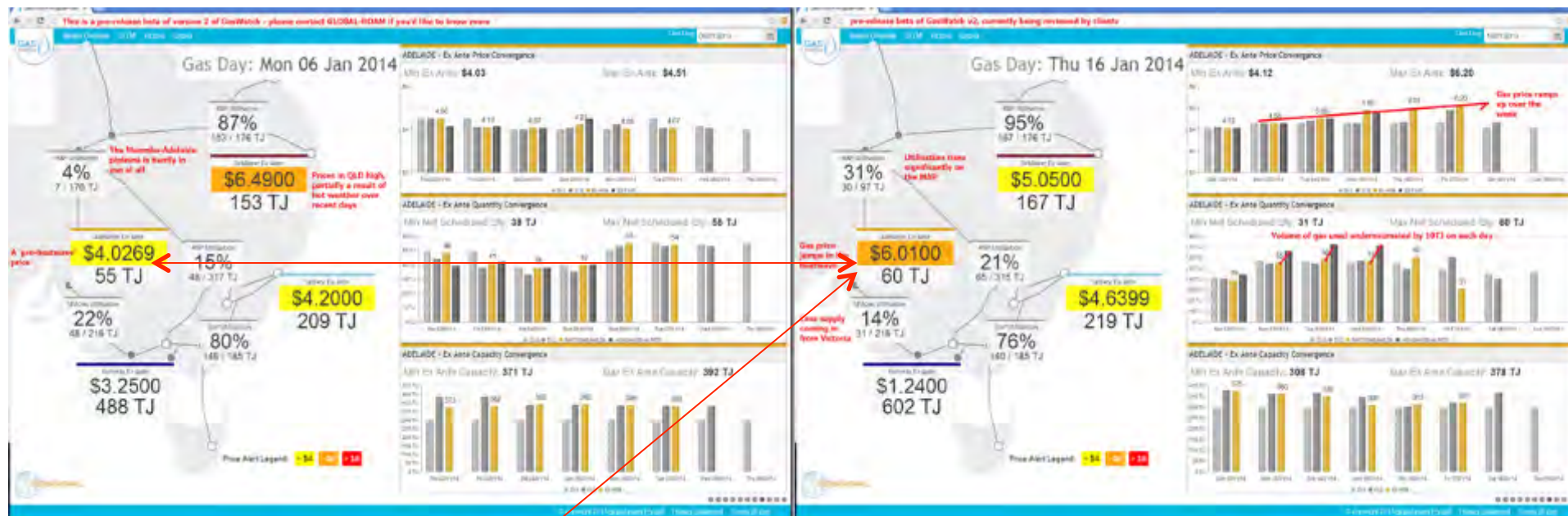


TRYING TO SURVIVE

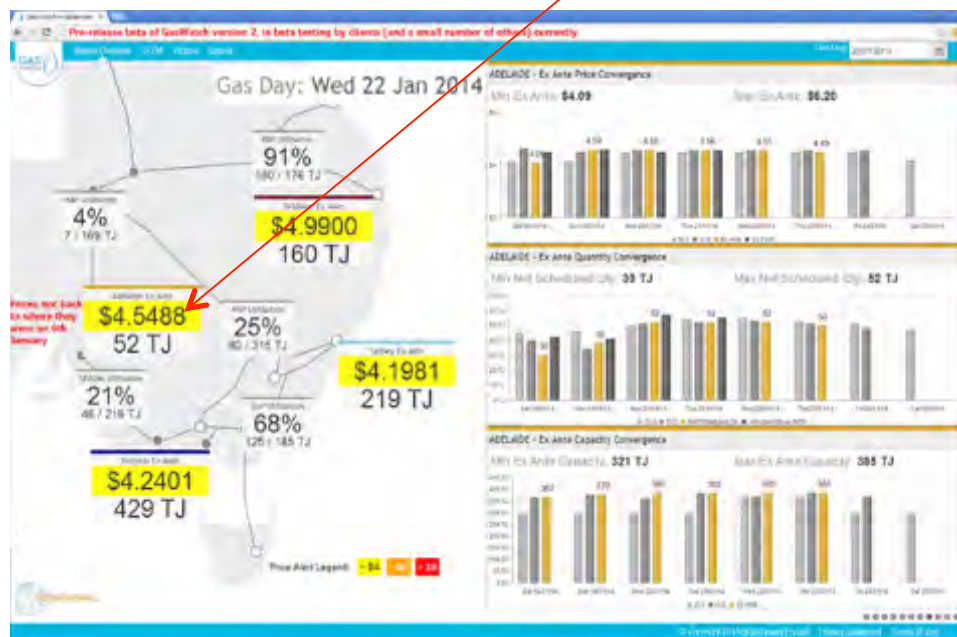


Trying to survive the Heat at home in Adelaide



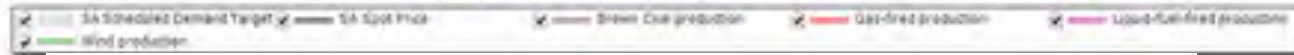


Energy Costs Soar during Heat Waves

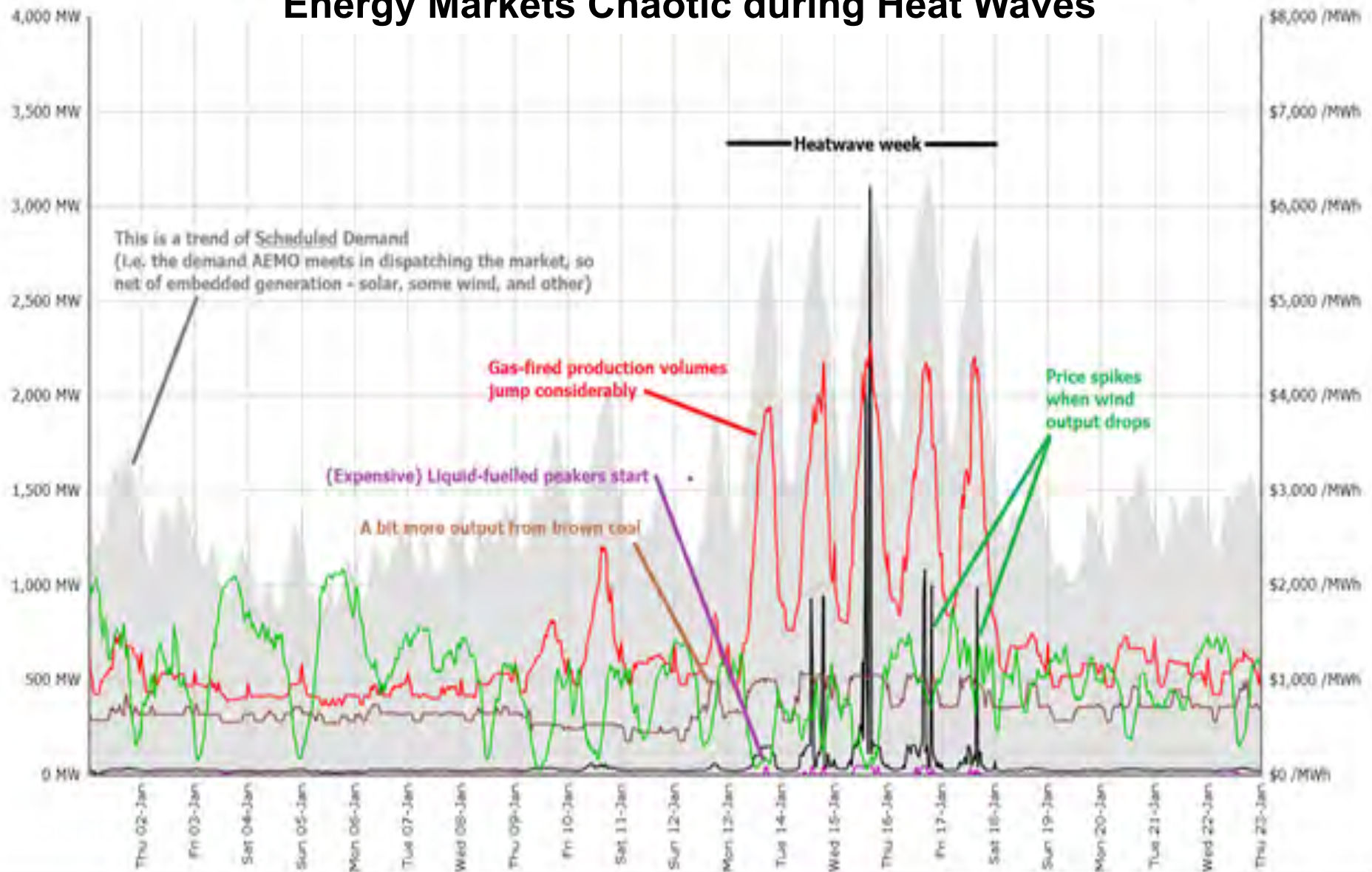


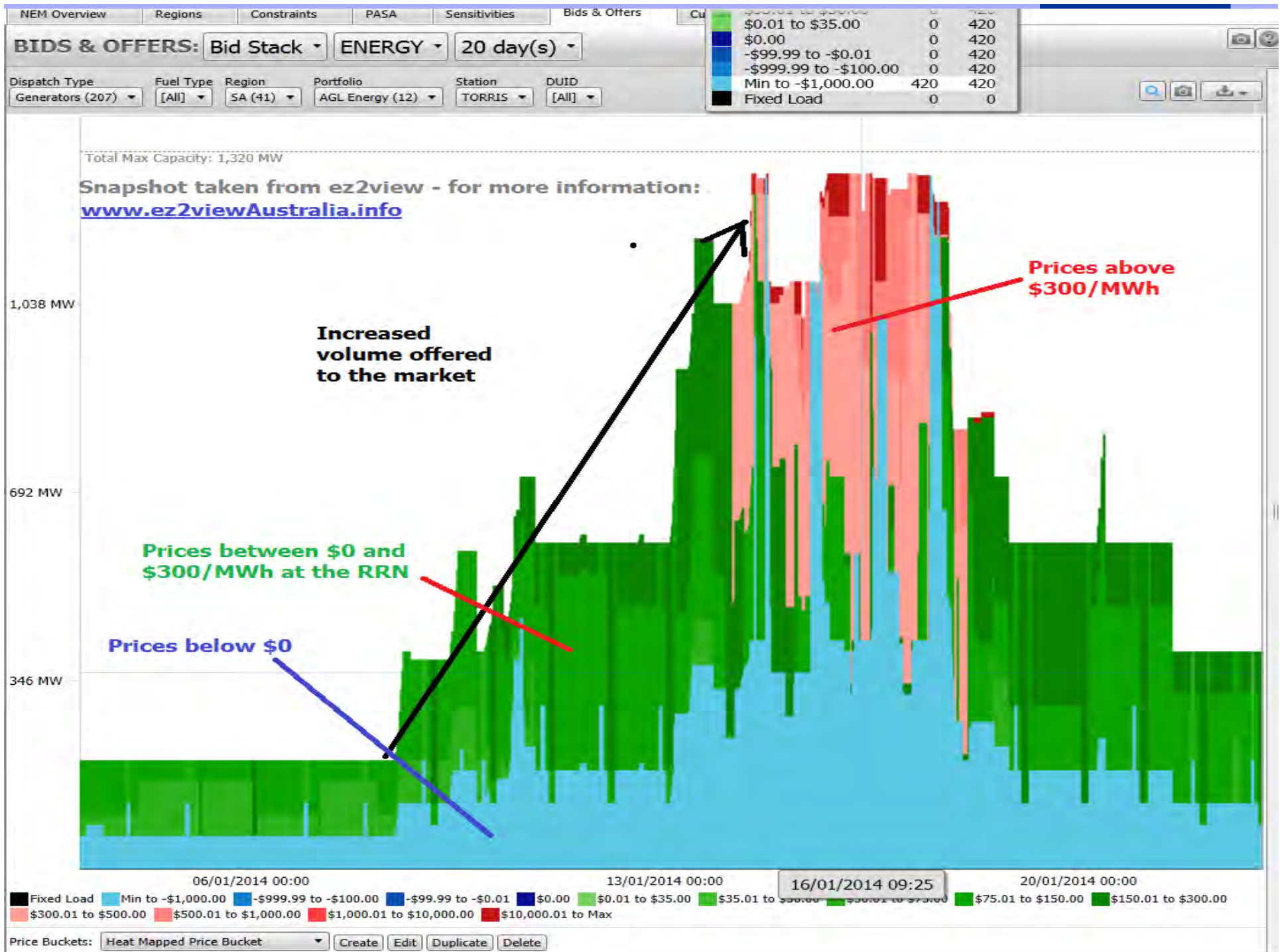
Trended Market Data for South Australia in the National Electricity Market January 2014, to Wednesday 23rd

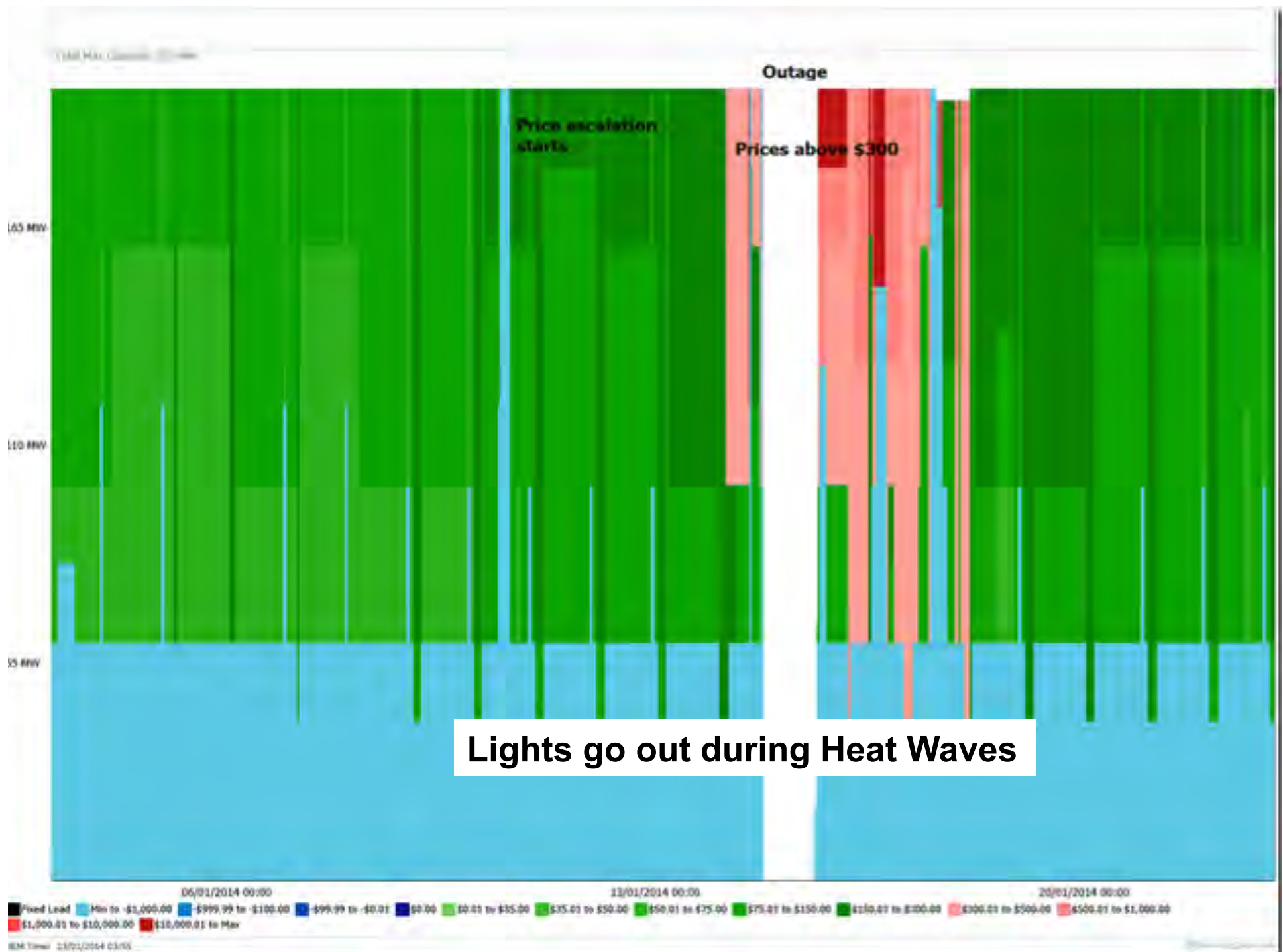
Created with NEM SA view (www.aemo.com.au/nem)



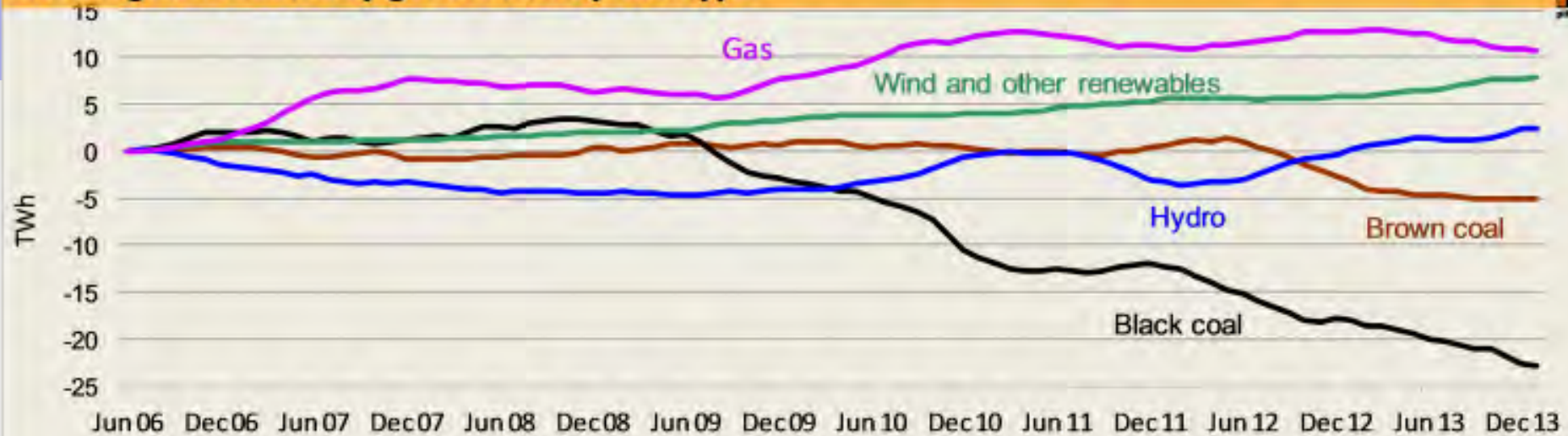
Energy Markets Chaotic during Heat Waves





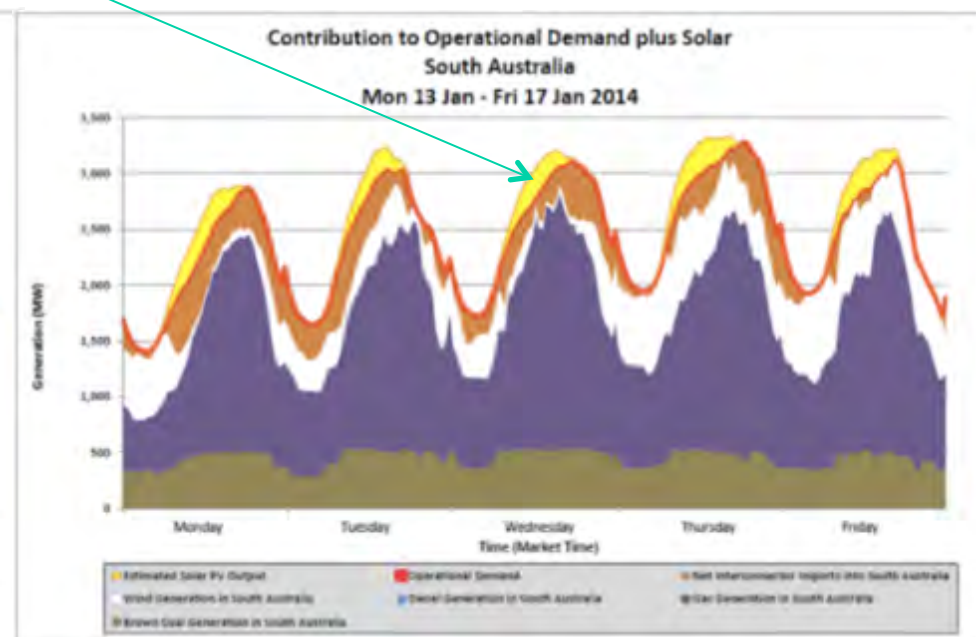
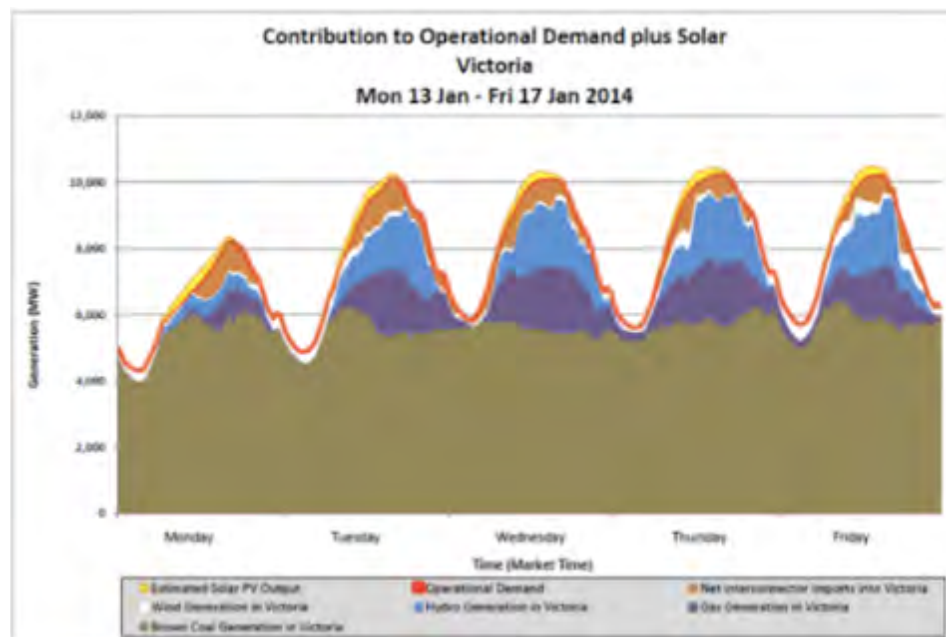


3. Changes in electricity generation by fuel type



PV energy shifts peaks during Heat Waves

Need for Long term / Large scale Demand / Supply / Storage Planning

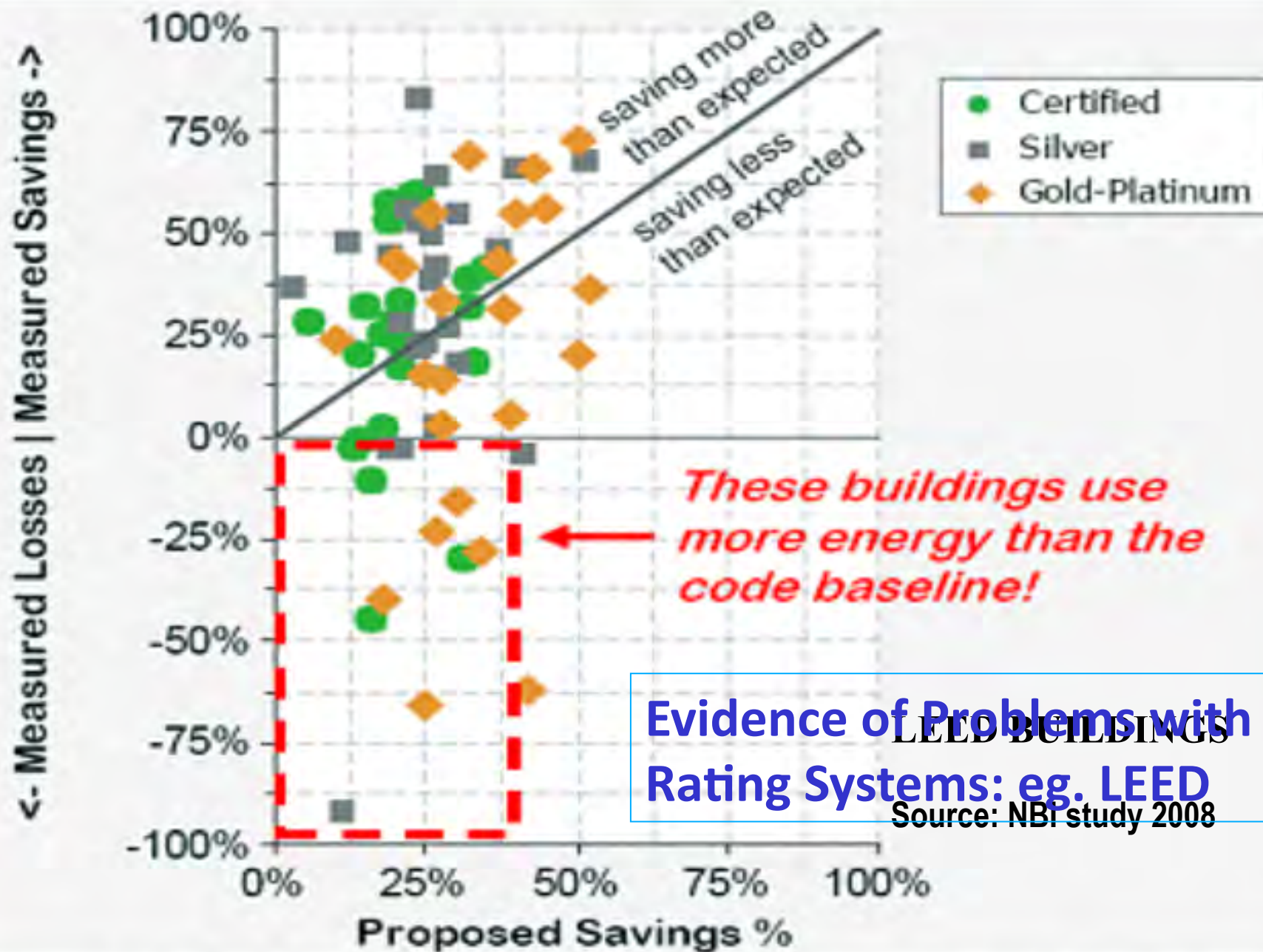




WAYS FORWARD ?



2) CHOOSE TO CHANGE



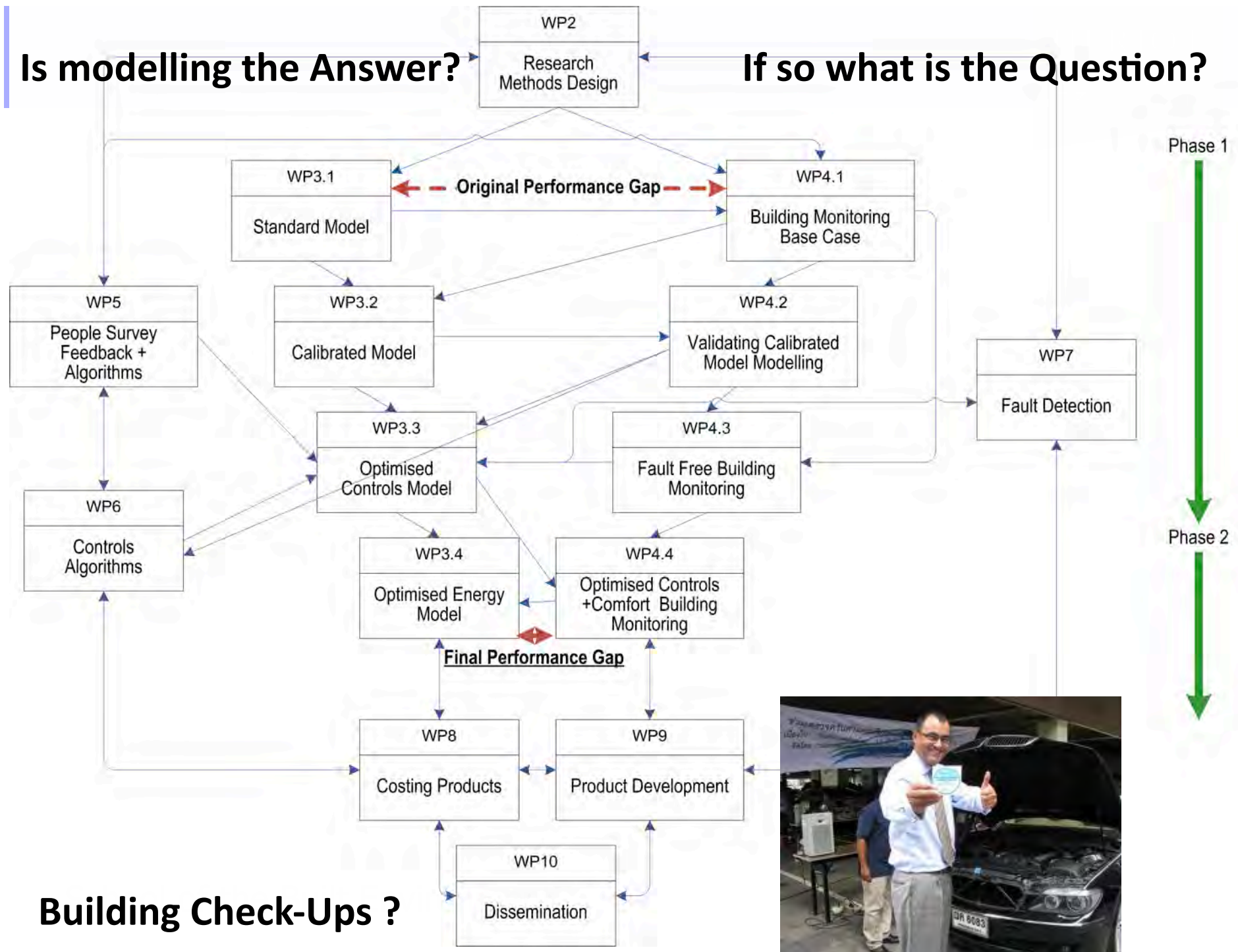
**Evidence of Problems with
Rating Systems: eg. LEED**

Source: NBI study 2008

Figure ES- 5: Measured versus Proposed Savings Percentages

Is modelling the Answer?

If so what is the Question?



Personal Actions:

- Climate-Proof homes
- De-couple from energy costs
- Climate Refuges
- Comfort Alternatives
- Have friends to visit



Municipal Actions:

- Climate-Proof the City
- Shading / Parks
- De-couple from energy costs - renewables
- Climate Refuges
- Comfort Alternatives
- Emergency response planning and strategies
- Store food/water/energy

Outside the UN Geneva The 3.5 Pillars of Sustainability

3) GET AN EQUITABLE PLAN



Business Actions:

- Climate-Proof Offices
- Shading / Nat Vent
- De-couple from energy costs - renewables
- Climate Refuges
- Comfort Alternatives
- Emergency working practices / flexibility

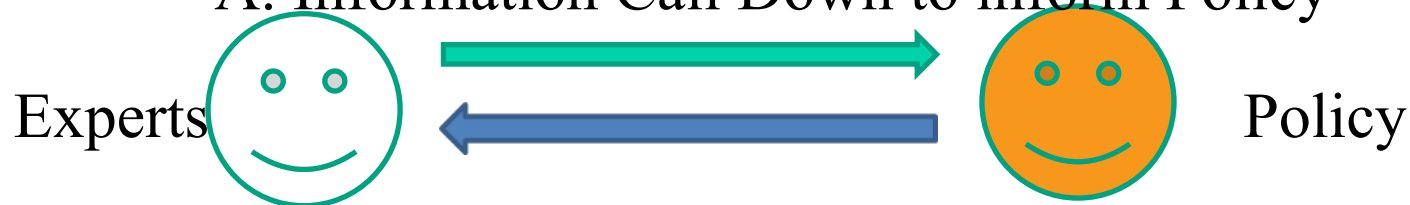


National Actions:

- Change Building Regulations to require Shading / Nat Vent
- Push load shifting and shaving + renewables
- Mandate Refuges
- Build in grid storage
- Fuel poverty relief

CxC Adaptation Workstream is not Just about:

A. Information Call Down to inform Policy



B. Provision of Information as it becomes available



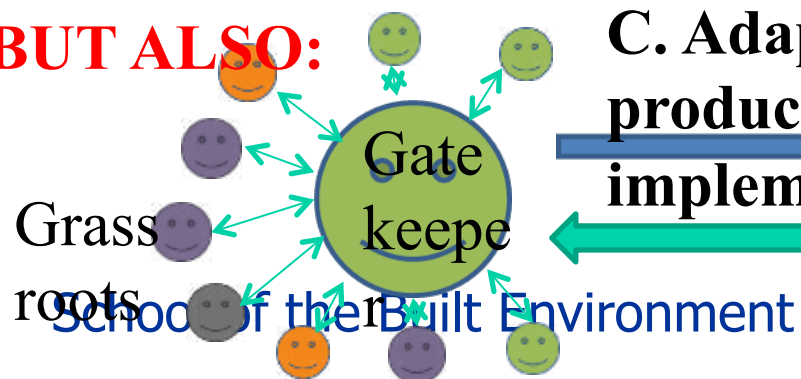
Weaknesses of this model:

1. Limited but the Knowledge and Attitudes of the individual Experts involved
2. Open to bias a manipulation if Experts have their own or other Agendas at heart
3. Not able to respond in time to unpredicted trends or events about which little is known.

A flexible and Responsive Policy Support Process is required

As rates and magnitudes of change and events escalate flexible thinking is essential

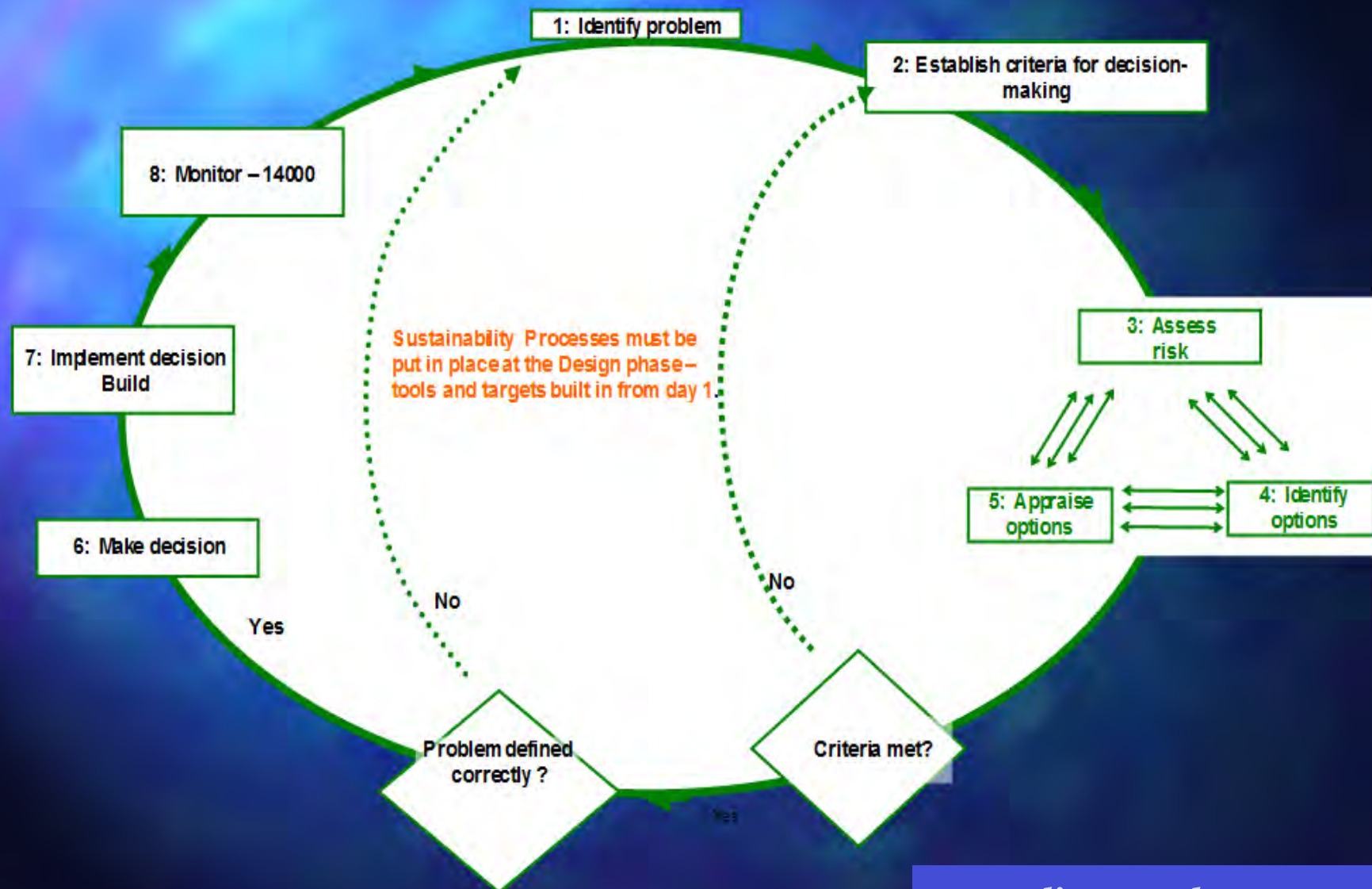
BUT ALSO:



C. Adaptation Policy Development Process to produce correct implementable solutions and

POLICY DEVELOPMENT PROCESS

Climate Ex Change Scottish Govt.



4) TURN THE PLAN INTO A REALITY / BUDGET / IMPLEMENT

2100 ?





Explore mixed mode building models

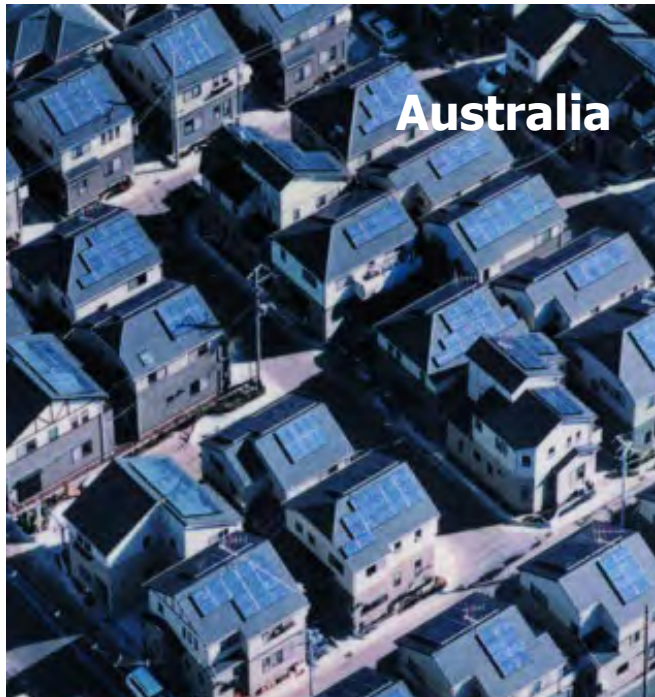
5) DESIGN FOR NATURAL VENTILATION BECAUSE LIGHTS WILL GO OUT



Lights Out, London!



**6) DESIGN FOR, AND WITH,
REGIONAL / COMMUNITY ENERGY
STORAGE**



Australia



USA



Japan



Brazil



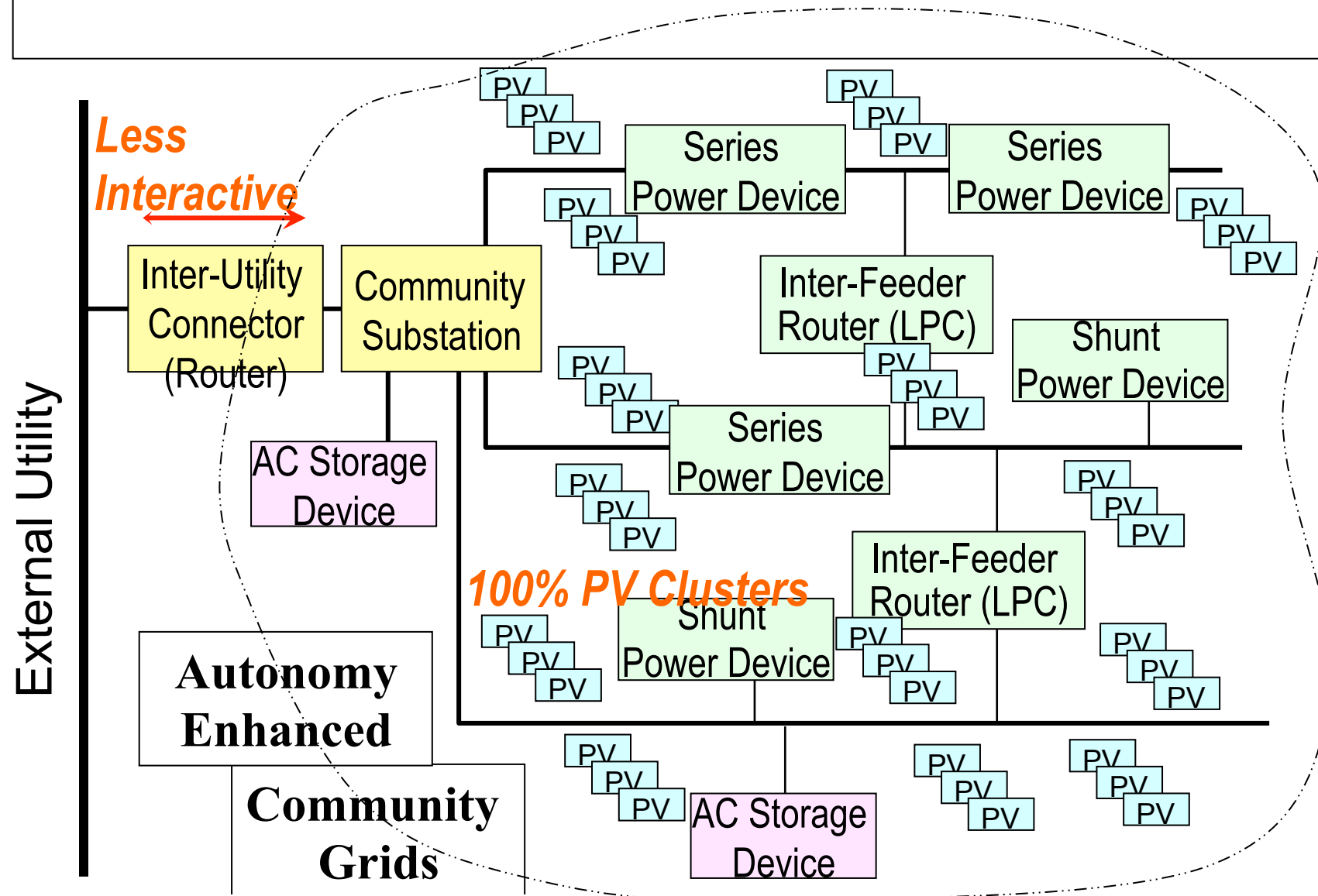
China



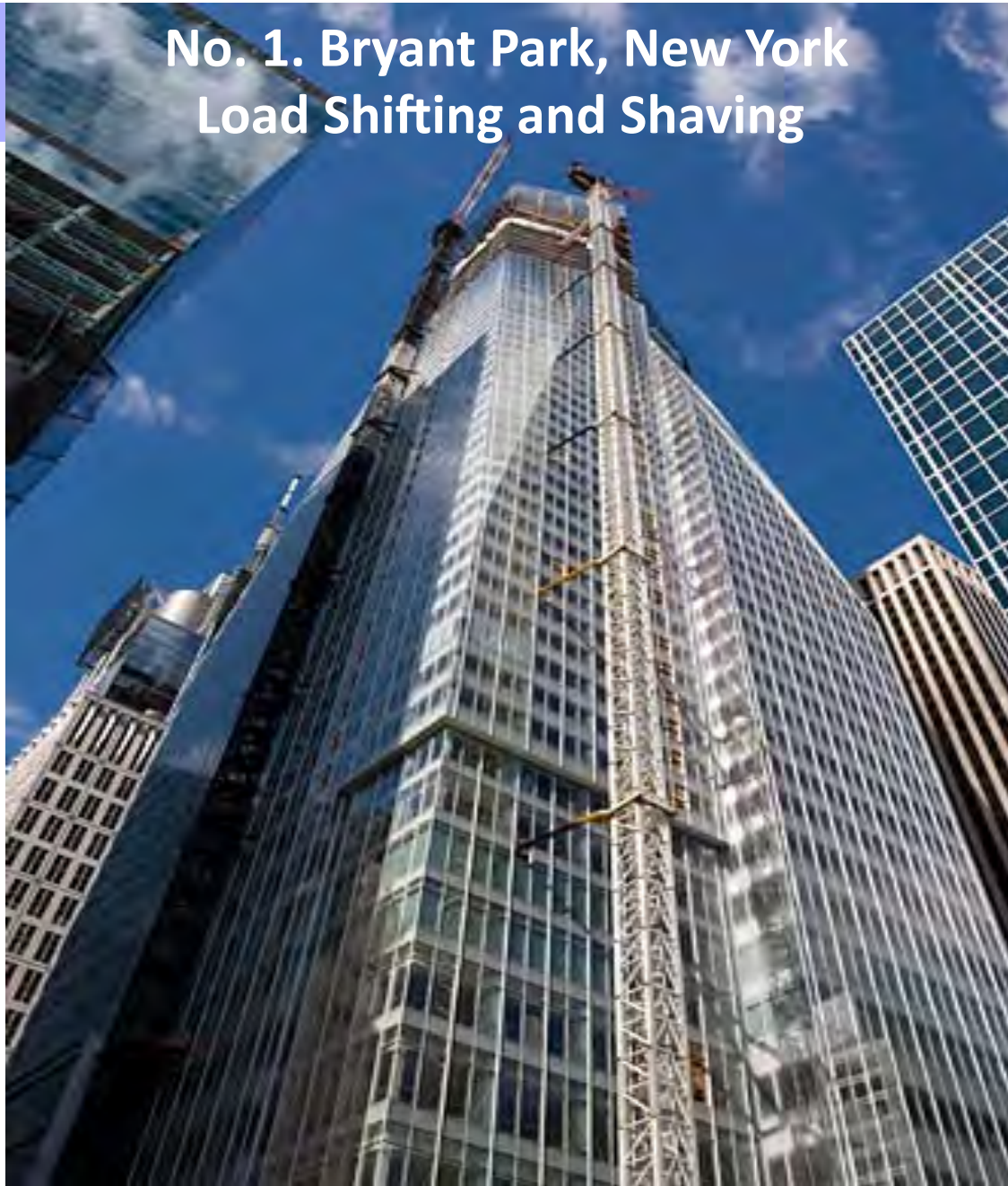
Germany

DESIGN AUTARKIC /SELF RELIANT BUILDINGS AND COMMUNITIES

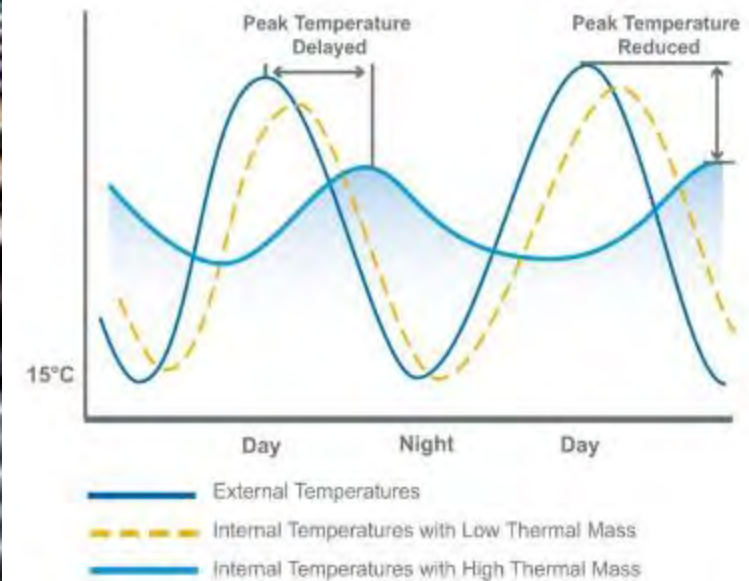
MICRO-GRIDS: Autonomy-Enhanced, Community-base PV Cluster Concept by introducing Active Control



No. 1. Bryant Park, New York Load Shifting and Shaving



Ice Thermal Energy Storage



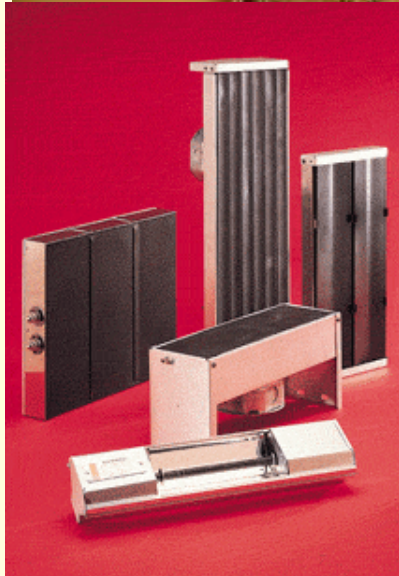
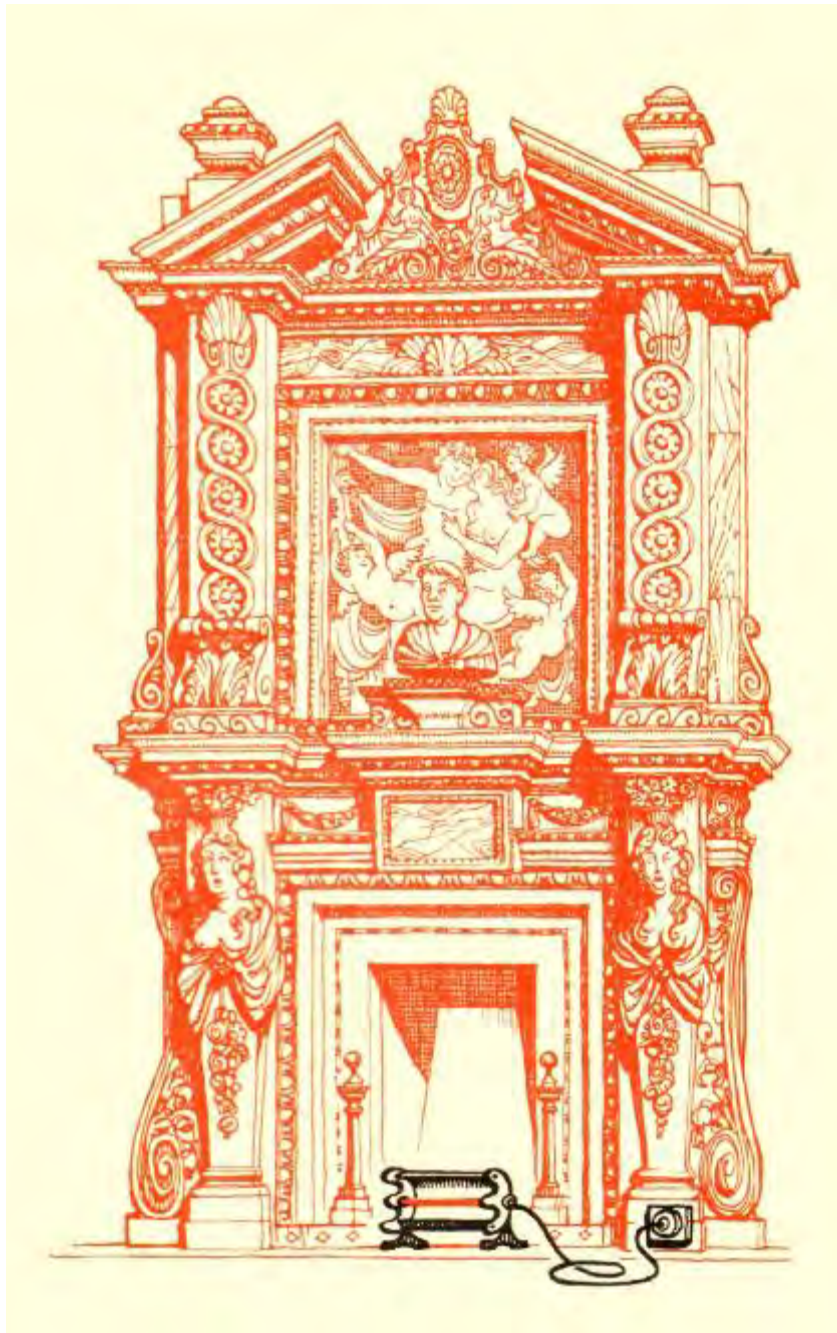
USE BUILDING THERMAL STORAGE

7. DESIGN SELF – REPAIRING COMMUNITIES



From left to right: Ken Sawyer Chief Exec Neath Port Talbot Council, Derek Vaughan Leader Neath Port Talbot Council, Ron Slater Welsh Assembly Government, and Sean Mayo considering plans for a major new industrial project on 300 acres in South Wales

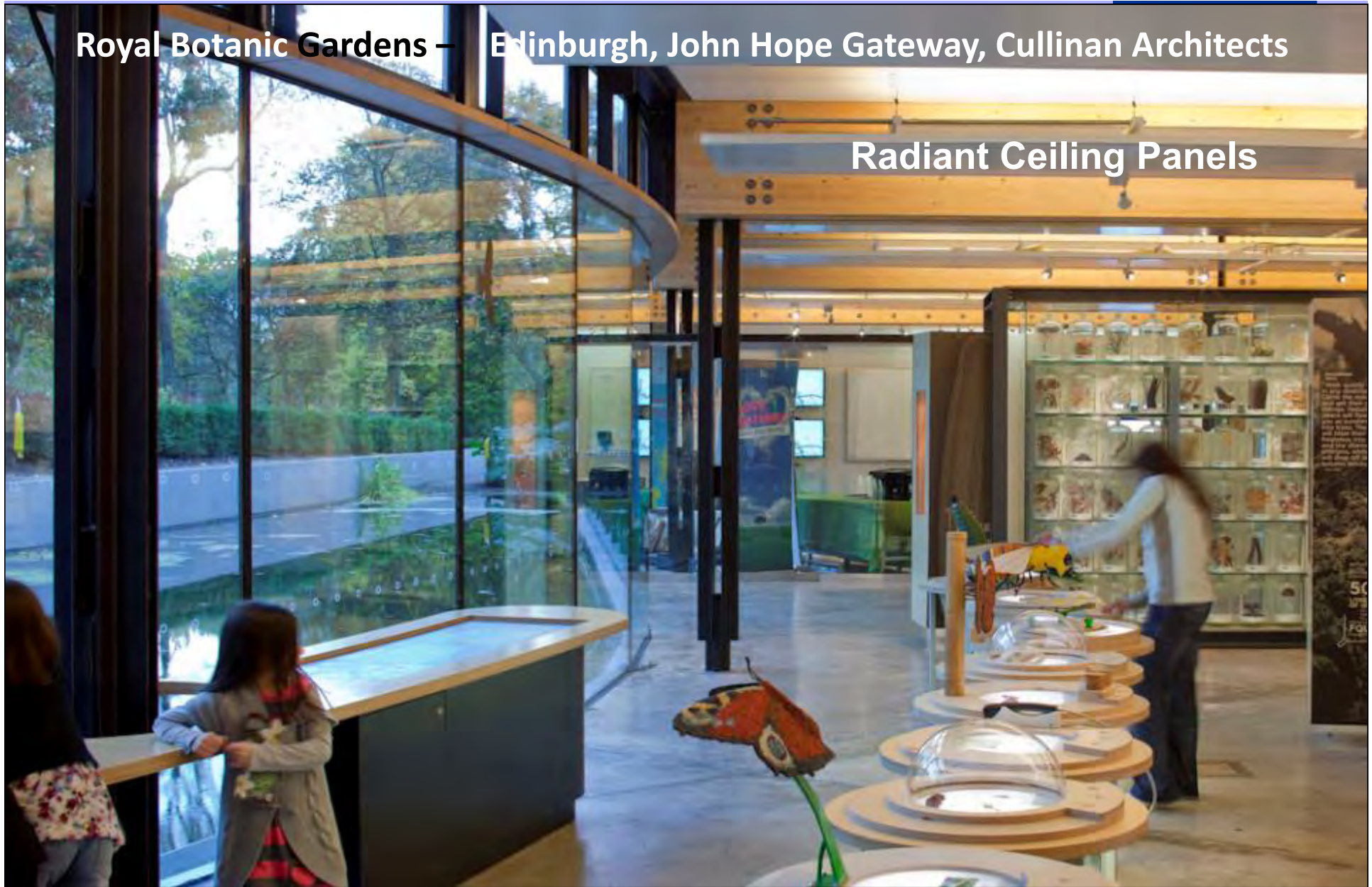




8) RE-THINK HOW PEOPLE HEAT AND COOL THEM SELVES

Royal Botanic Gardens – Edinburgh, John Hope Gateway, Cullinan Architects

Radiant Ceiling Panels



School of the Built Environment

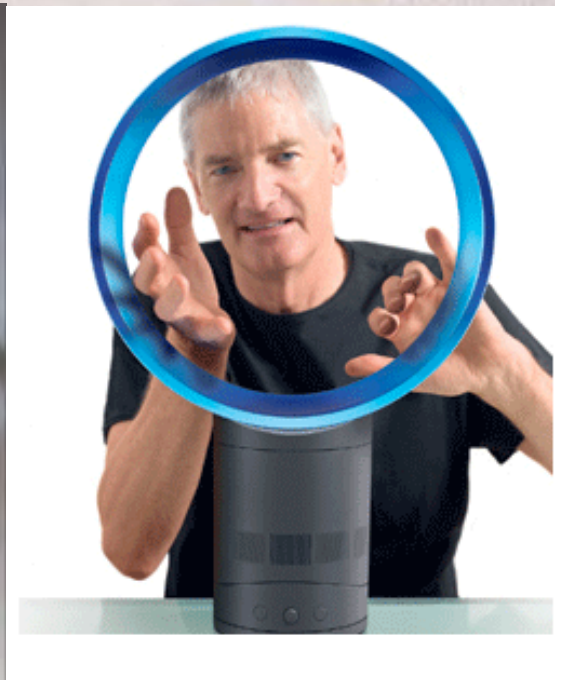
Personal Environmental Controls: PETs

4 Watt Fan

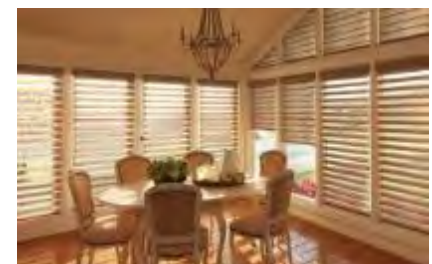
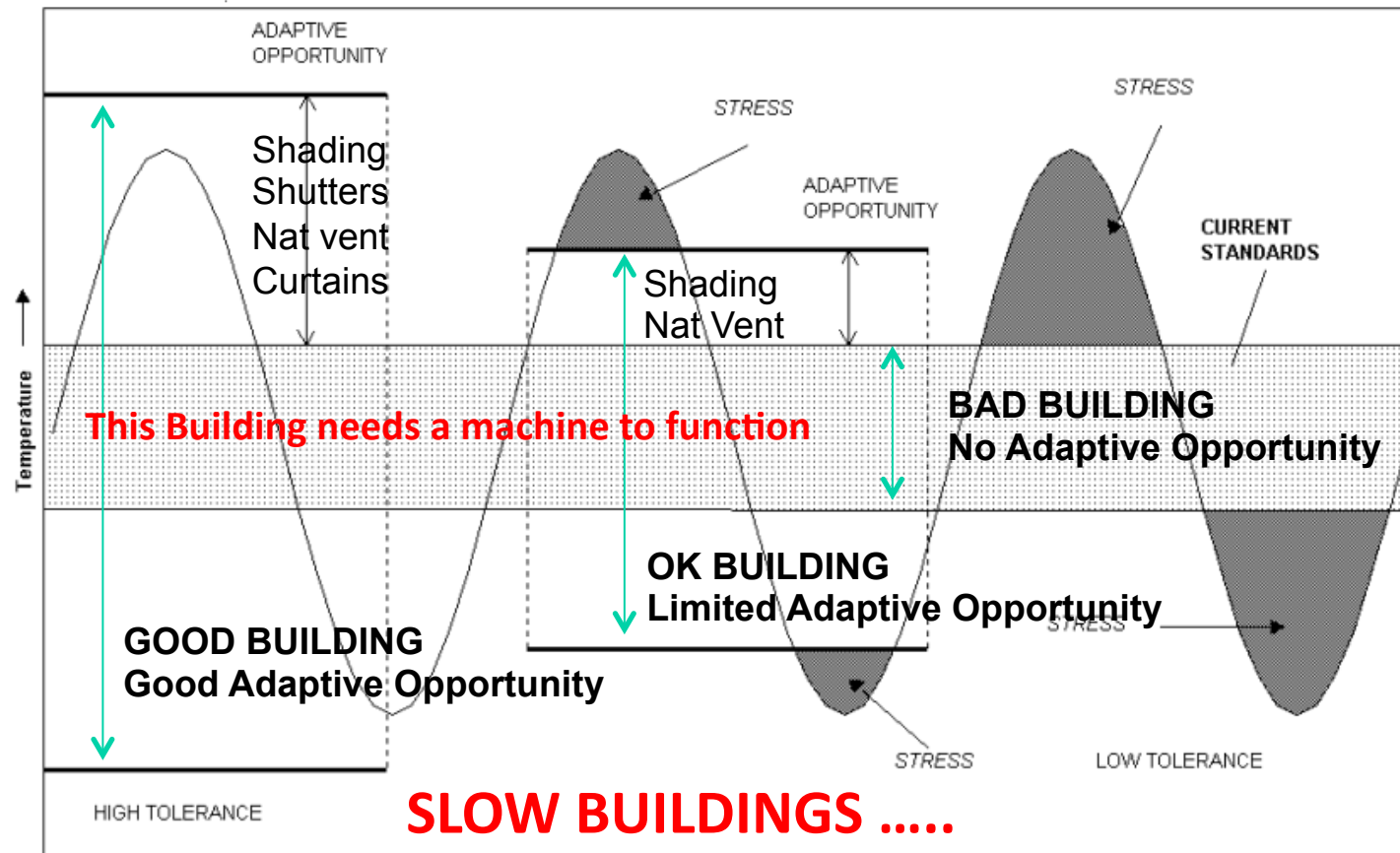
Source: Edward Arens, UC Berkeley, Windsor Conference 9-11 April 2010 on www.nceub.org .

image courtesy of haworth

PERSONAL LOCAL CONTROL - AS PRIMARY STRATEGY



9) DESIGN ADAPTIVE ENVELOPES





The Winter Snug



Cool Kitchen



Warm Sunny Kitchen



Cool Veranda

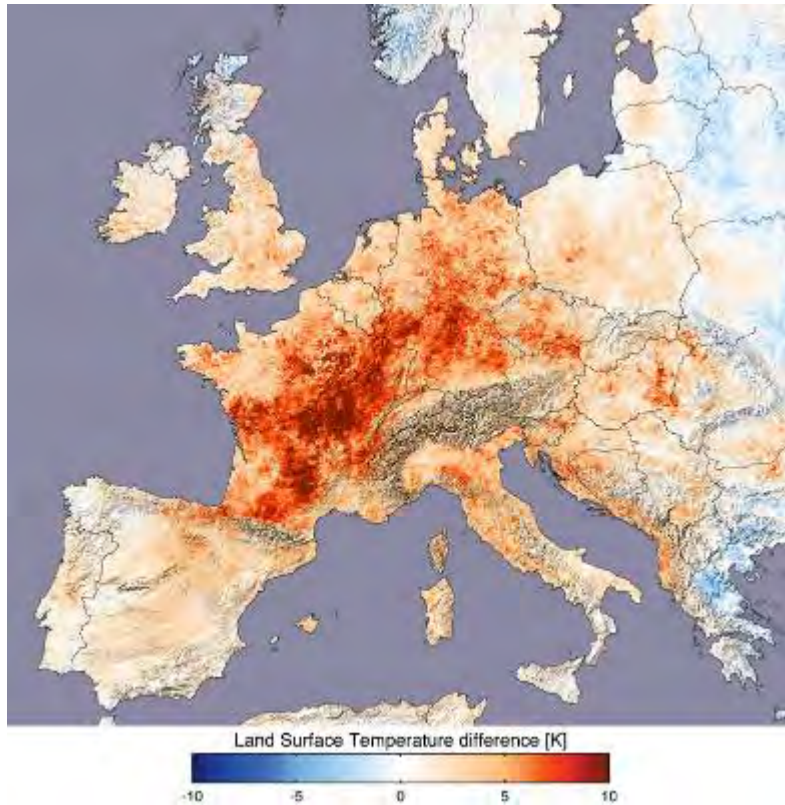
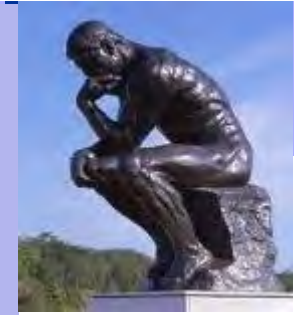
10) DESIGN BUILDINGS WITH CLIMATE REFUGES



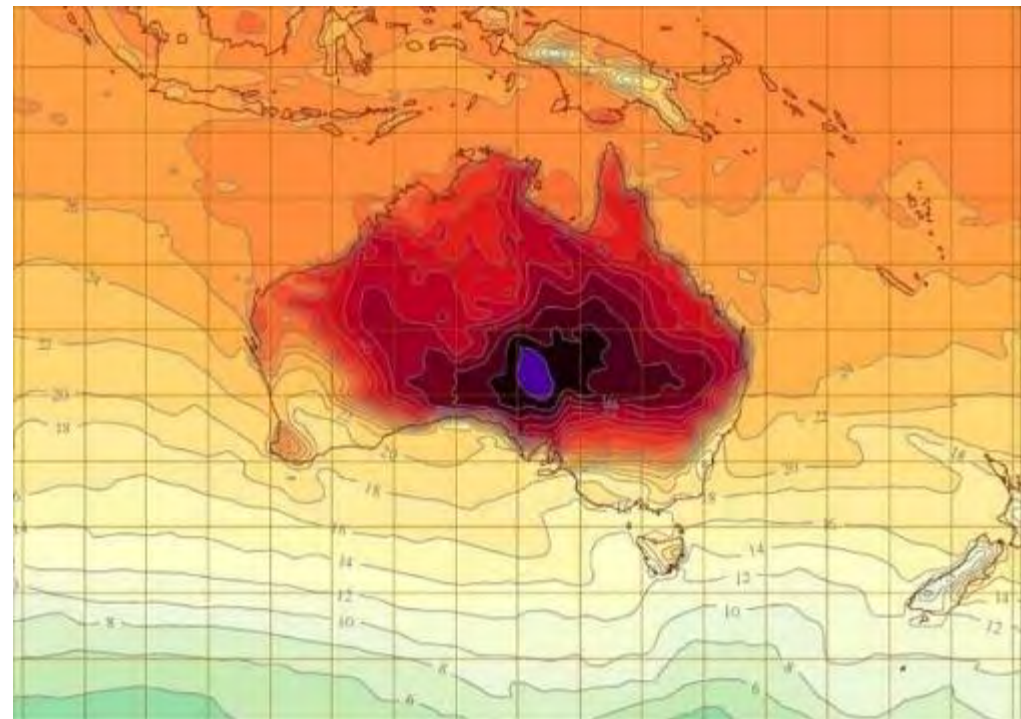
10) AND CITIES WITH CLIMATE REFUGES

Attribution statements can be made about individual climate events by examining the changed probability

Things are changing very fast – **Can We?**

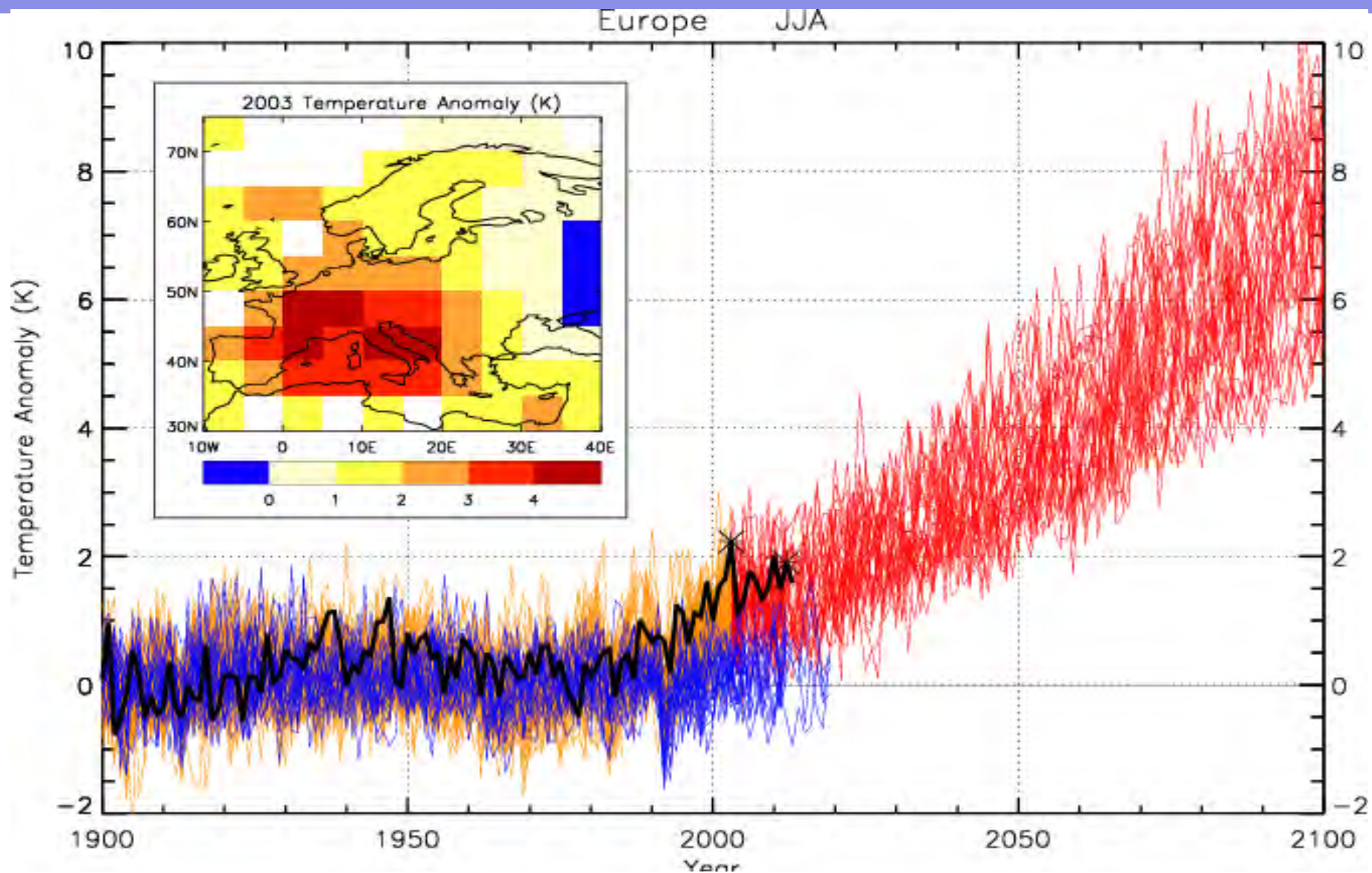


European heatwave, 2003
Very likely more than doubled
the probability (Stott et al)

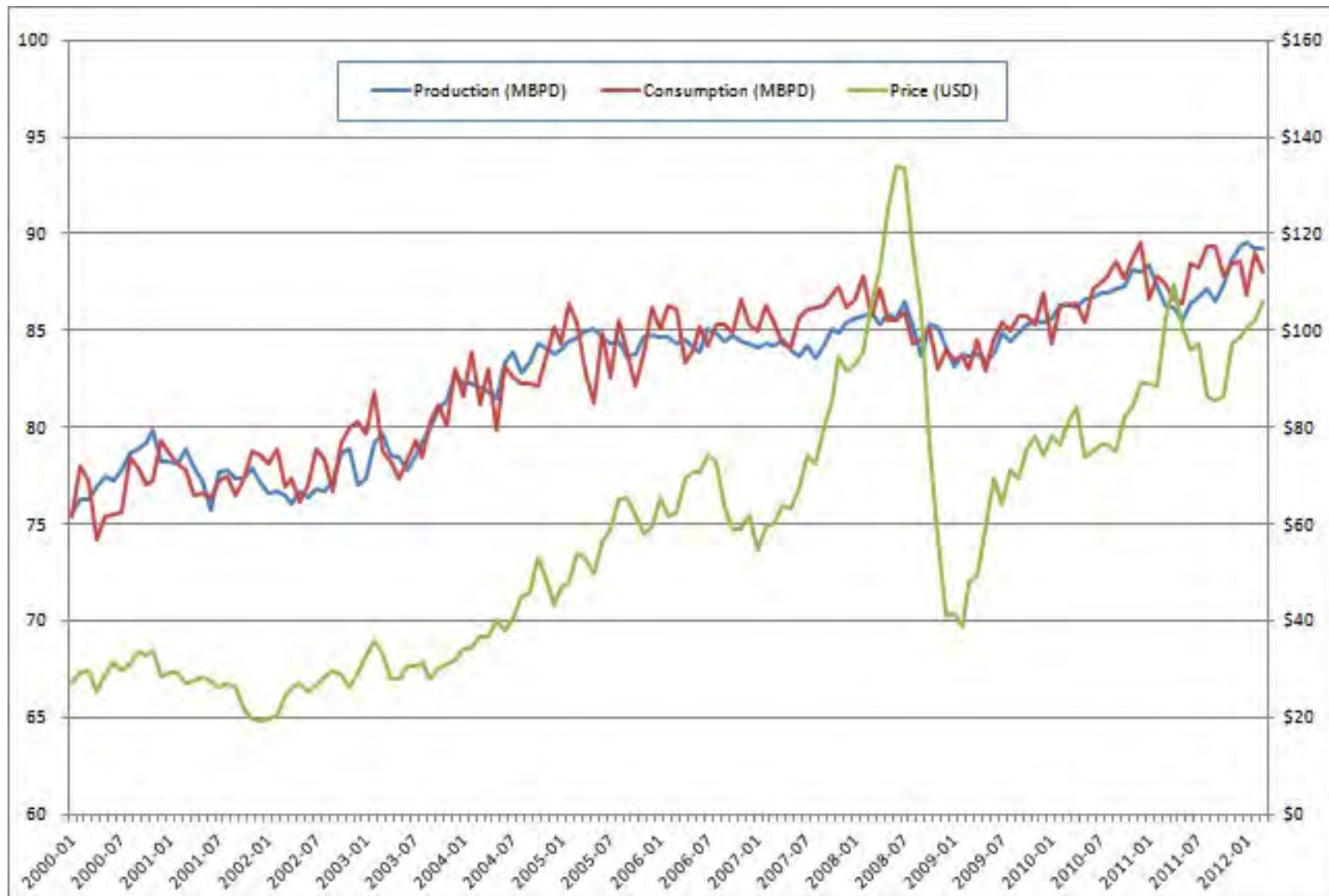


Australian heatwave, 2013
Very likely increased the
probability by more than 2.5
times (Lewis et al)

European summer temperatures on track for 2003 to become the norm by 2030s



Not for a Future of soaring energy costs?

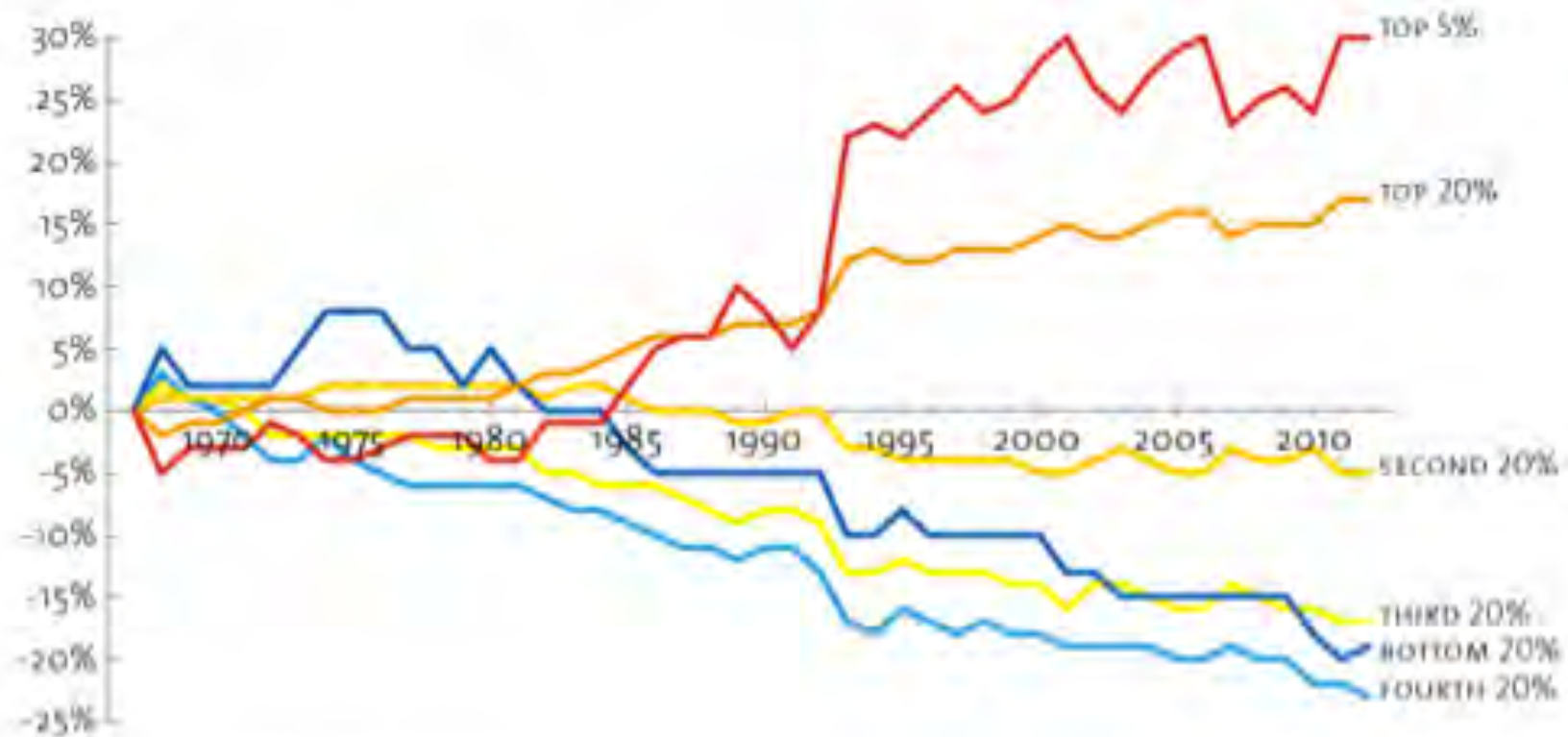


Global Oil Production, Consumption and Price 2001 - 2012
School of the Built Environment
<http://www.eia.gov/ers>

And Disappearing Middle Classes?

Change in Share of Total Income, 1967-2012

relative to 1967, by percentile



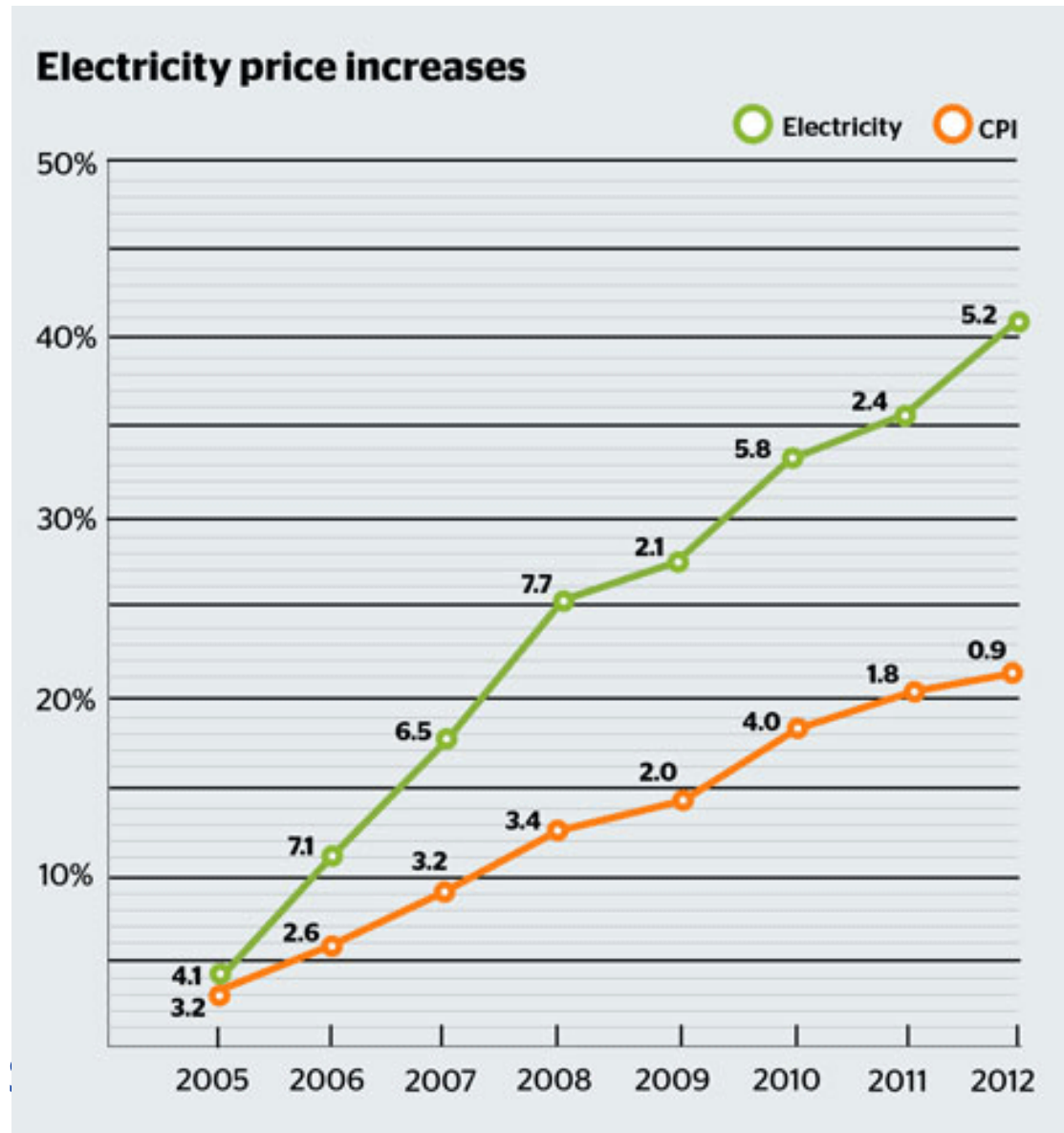
SOURCE: CENSUS BUREAU

Mother Jones

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>

- From Statistics NZ's Consumer Price Index (CPI) for years to December. Annual data points show the annual increase each year.

www.consumer.org.nz/reports/electricity-prices/rising-prices



Who Says New Zealanders don't Riot ?





Finally Thoughts from Scotland

**Building
Resilience
Matters**



WARM GRAN PLAN



KOOL GRAN PLAN



**New Zealand
Is perfectly
Situated for
People and
Climate Refuge
Centred Solutions**