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UCL Centre for Sustainable Heritage
22 February 2024

Energy retrofits & traditional buildings:
Let's keep things in proportion

*Changing mindsets in our
climate and environmental emergency*

Bill Bordass

www.usablebuildings.co.uk

Outline

1. Some background
 2. Where is the UK now?
 3. What might we need to do?
 4. Or could we do other things?
 5. Principles of proportionate retrofit
 6. Possible future mindsets
 7. Postscript (*if time*). A people-first approach.
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PART 1: SOME BACKGROUND

using a few slides from 10-20 years ago

There was an imperative to cut energy use and carbon emissions across the building stock.

BUT:

Did we know what we needed to do, and what the unintended consequences might be?

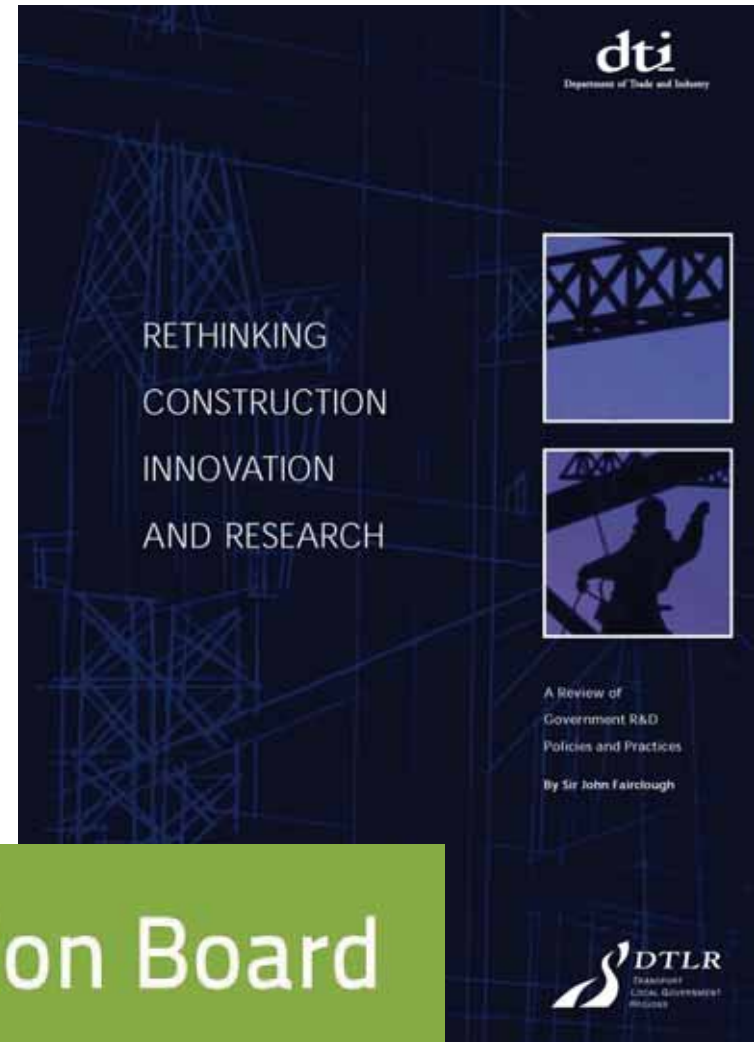
AND:

What might the implications be for heritage and traditional buildings?

Buildings policy has tended to focus on construction, *not performance in use*



REPORT OF THE CONSTRUCTION TASK FORCE



The Green Construction Board

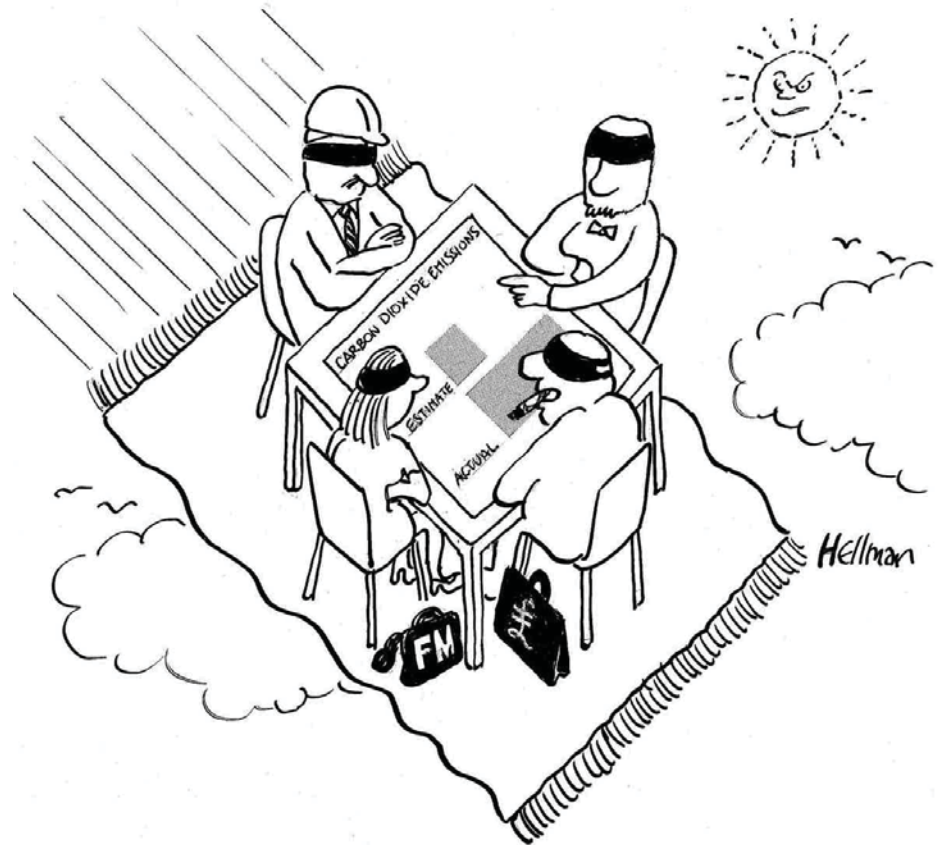
But many designers and builders know little about performance in use - *they're not paid to!*

"in theory, theory and practice are the same, in practice they aren't"
SANTA FE INSTITUTE

"designers seldom get feedback, and only notice problems when asked to investigate a failure"
ALASTAIR BLYTH
CRISP Commission 00/02

"I've seen many low-carbon designs, but hardly any low-carbon buildings"
ANDY SHEPPARD *Arup, 2009*

"unlike medicine, professions in construction have not developed a tradition of practice-based user research ... data about design performance are out there, in the field ... Our shame is that we don't make anything like enough use of it"
FRANK DUFFY, Past President RIBA *Building Research & Information, 2008*



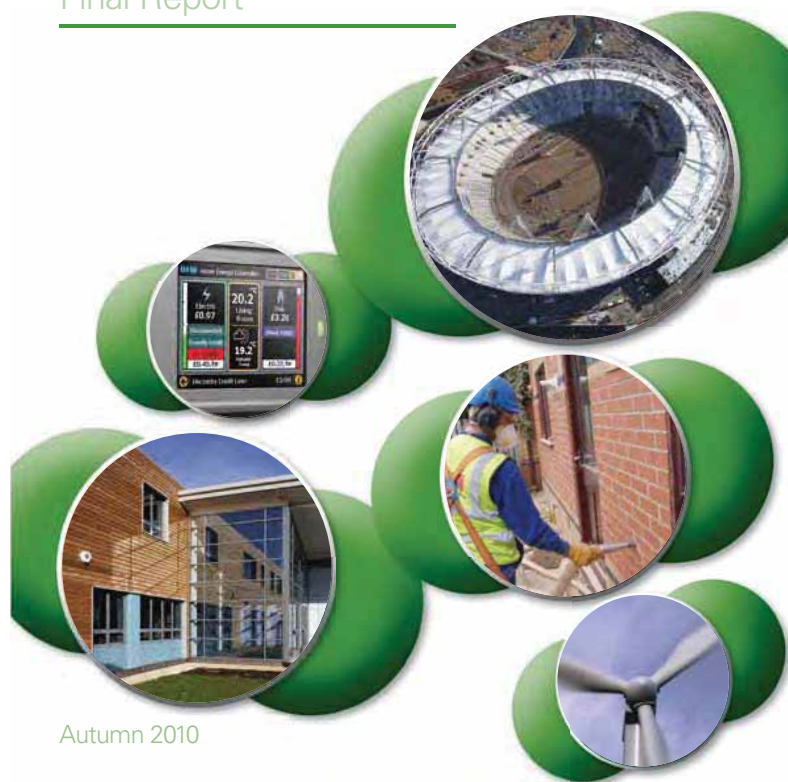
How might this blindness affect the approach to decarbonising traditional buildings?



Low Carbon Construction

Innovation & Growth Team

Final Report



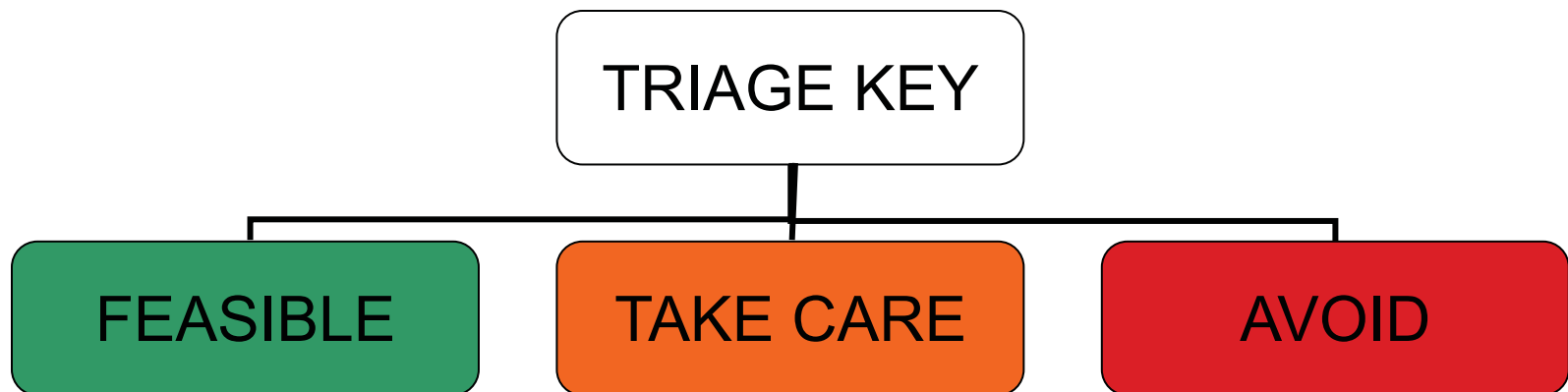
Autumn 2010

FOR CONSULTATION PURPOSES ONLY

Draft DECC Green Deal Code of Practice

Setting priorities and managing risks: *Triage process prototyped with English Heritage*

- Take a measure.
- Assess it for:
 - Energy (and carbon) saving opportunity and risk;
 - Technical opportunity and risk (*e.g. of damp and decay*);
 - Heritage opportunity and risk (*to substance or appearance*).
- Report each facet as traffic lights (*see below*).
- Reach an overall conclusion (*and report in the same way*).
- Assemble into packages, *ideally where everything is green*.



Triage case studies 2010: *six solid wall dwellings – 3 owner-occupied, 3 social*



Triage case studies 2010 findings

INSULATION AND MOISTURE All insulated internally to sidestep planning.

Technical risks: condensation, moisture and decay, e.g. joist ends. Needs research.

Heritage risks: appearance, details, cornices etc.

Heritage gains: potentially, e.g. external insulation of deteriorated rendered buildings.

WINDOWS and VENTILATION

Owner occupiers refurbished windows, Social landlords replaced them.

Owner occupiers used natural ventilation, with local mechanical. Social MVHR.

Technical risks: behavioural for owner-occupiers, equipment performance for social.

Heritage risks: social landlords felt a need to make bigger changes.

BUILDING SERVICES

Technical risk: over-complicated systems (particularly in social), costly to run.

Heritage risk: intrusive alterations, particularly in social, *but solar was done carefully.*

BEHAVIOUR AND PEOPLE

Major technical and heritage opportunity: Sheer interest and knowledge can make a success of a situation that might otherwise be risky; **but**

Major technical risk: lack of occupant interest or insight can scupper good intentions.

Assessing user involvement, knowledge and motivation is an important aspect of judging technical risk. Important to have robust designs with clarity

Letter to the Times, 1 August 2011

from SPAB and members of what became STBA

*We are seriously concerned that **the drive to promote the complete thermal upgrading of pre 1919 buildings could be storing up expensive future problems for both building fabric and human health.** Inappropriate forms of insulation and the sealing up of interiors take little account of the fact that these buildings, which number millions, perform differently from modern ones and need to 'breathe'. **They are likely to require a different approach, in particular over the movement of moisture within them.***

*While we strongly support the aim of reducing carbon emissions from the nation's building stock, **we call on the Government to involve bodies knowledgeable about old buildings in research and planning for The Green Deal.** Many of these bodies already have helpful research to contribute but to date have not been called on to do so.*

What was the UK Green Deal?

from DECC, the Department of Energy & Climate Change

- Policy for homeowners, landlords and tenants to make energy-saving improvements and pay through their fuel bills. *“The Golden Rule” was that the energy cost savings would at least cover the cost of the loan.*
- **A “shopping list”** of 45 eligible improvements, ranging from loft insulation to condensing boilers and solar thermal panels.
- **Nothing at all** related to the systemic performance of the building, e.g. condition of the fabric, and need to maintain good air quality. *These were seen to be a matter for others, e.g. building regulations.*

Introduced Oct 2012, *with loans at a high 6.5% APR.*

Revised Jun 2014 to include grants for some eligible households

Scrapped Jul 2015, *owing to poor uptake (only 15,000) and “frustration & confusion for both consumers and the supply chain.”* **PHEW!**

DECC itself was scrapped in July 2016

STBA was launched in November 2011

Sustainable Traditional Buildings Association stbauk.org

A TEAM LED BY NEIL MAY THEN GOT FUNDS FROM DECC FOR THIS >>>

SOME CONCLUSIONS:

Industry and policy lack understanding of the performance of traditional buildings.

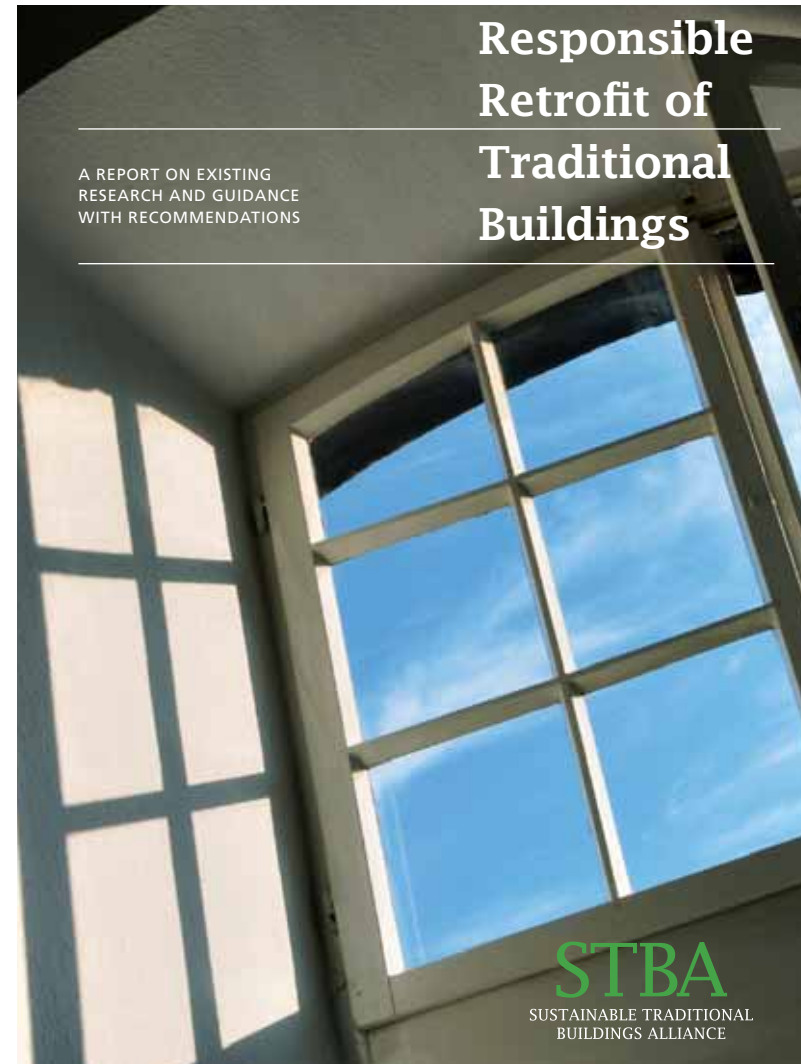
Lack of connection between research intelligence and guidance procedures.

Significant uncertainty in application of models and software.

Some methods used are inappropriate.

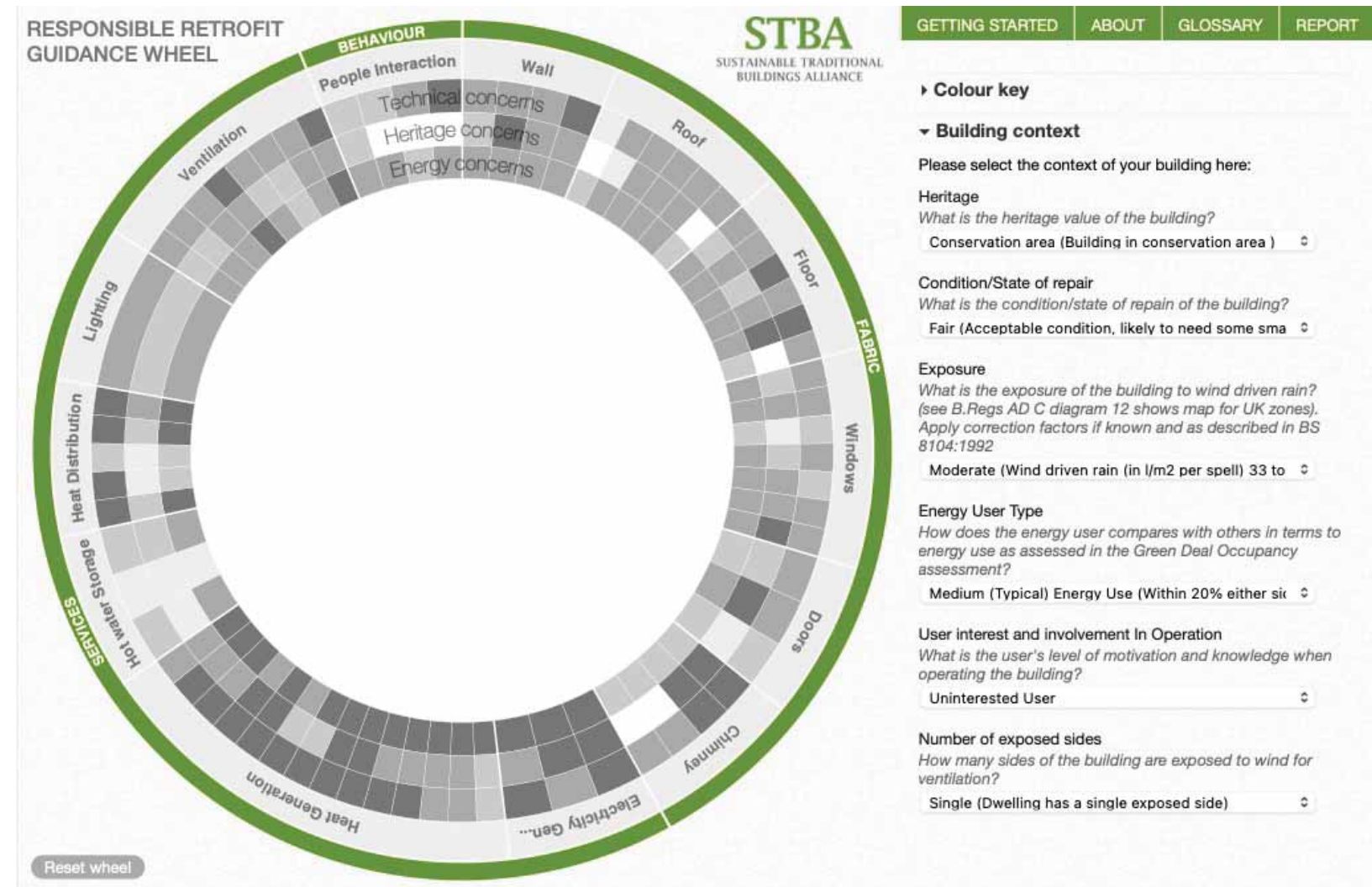
A systemic approach is necessary to avoid unintended consequences.

There are good opportunities, but some will need to be developed using a rather different basis and structure.



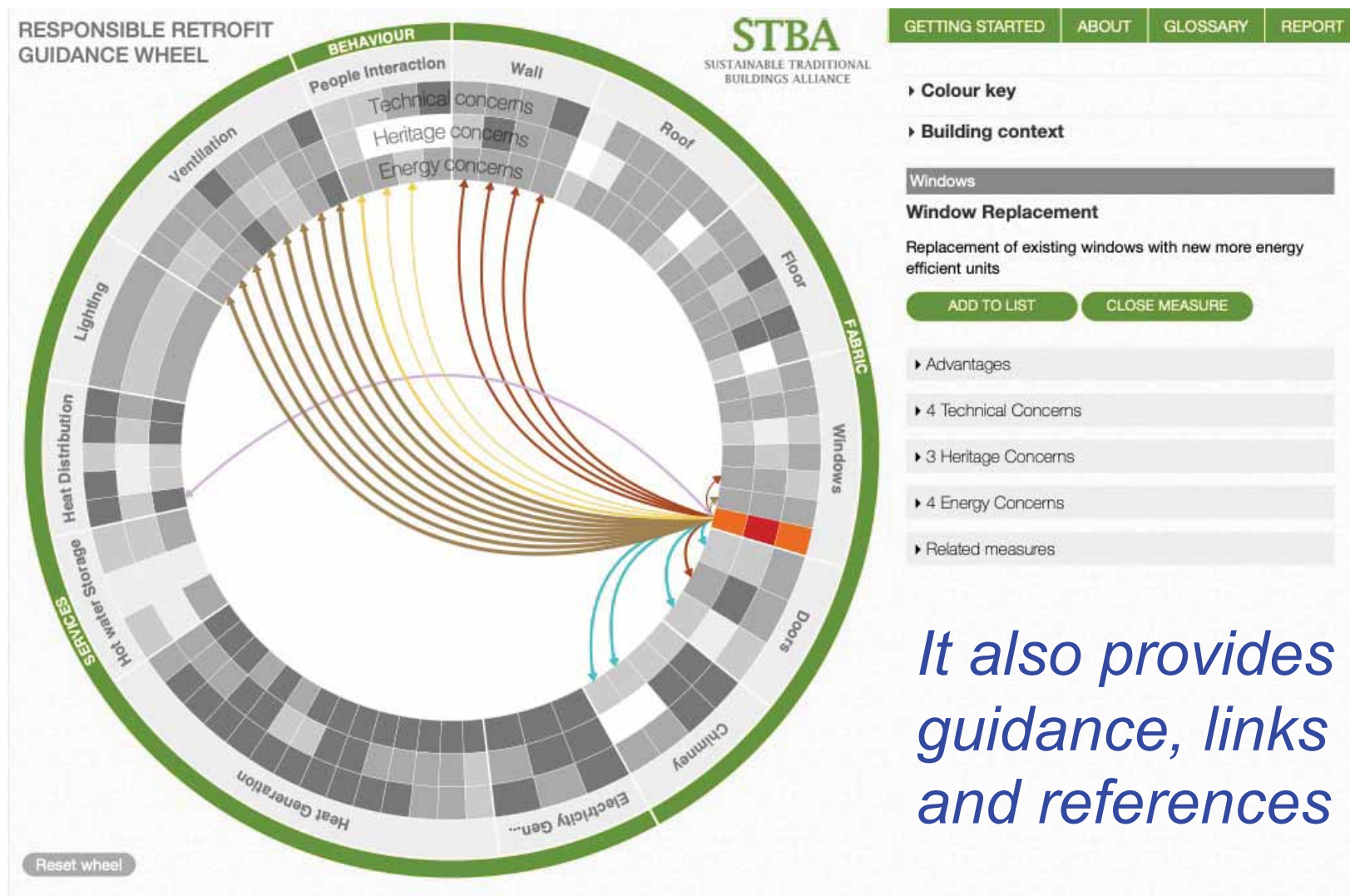
STBA's antidote to the Green Deal (2013)

the Green Wheel: to assist retrofit risk management



STBA's antidote to the Green Deal (2013)

Do one thing, and it exposes possible interactions



PART 2

Where is the UK now? 10-15 years later

We are now in an acknowledged climate and environmental emergency, *requiring urgent action, to mitigate **and to adapt**.*

BUT:

Much less progress has been made on tackling energy use in all buildings than might have been anticipated,
viz: the demise of domestic insulation schemes.

WHILST:

Renewable electricity has grown faster than expected, *now exposing bottlenecks in distribution & big needs for storage.*

AND:

Money is short, gas and electricity are much more expensive, *and our government continues to backtrack.*

“Altogether, we are failing to deliver. And I think the whole political system is responsible”

LORD DEBEN, *about to leave the Climate Change Committee (June 2023).*

STATUS OF “Responsible Retrofit”

*A decade after the STBA publication**

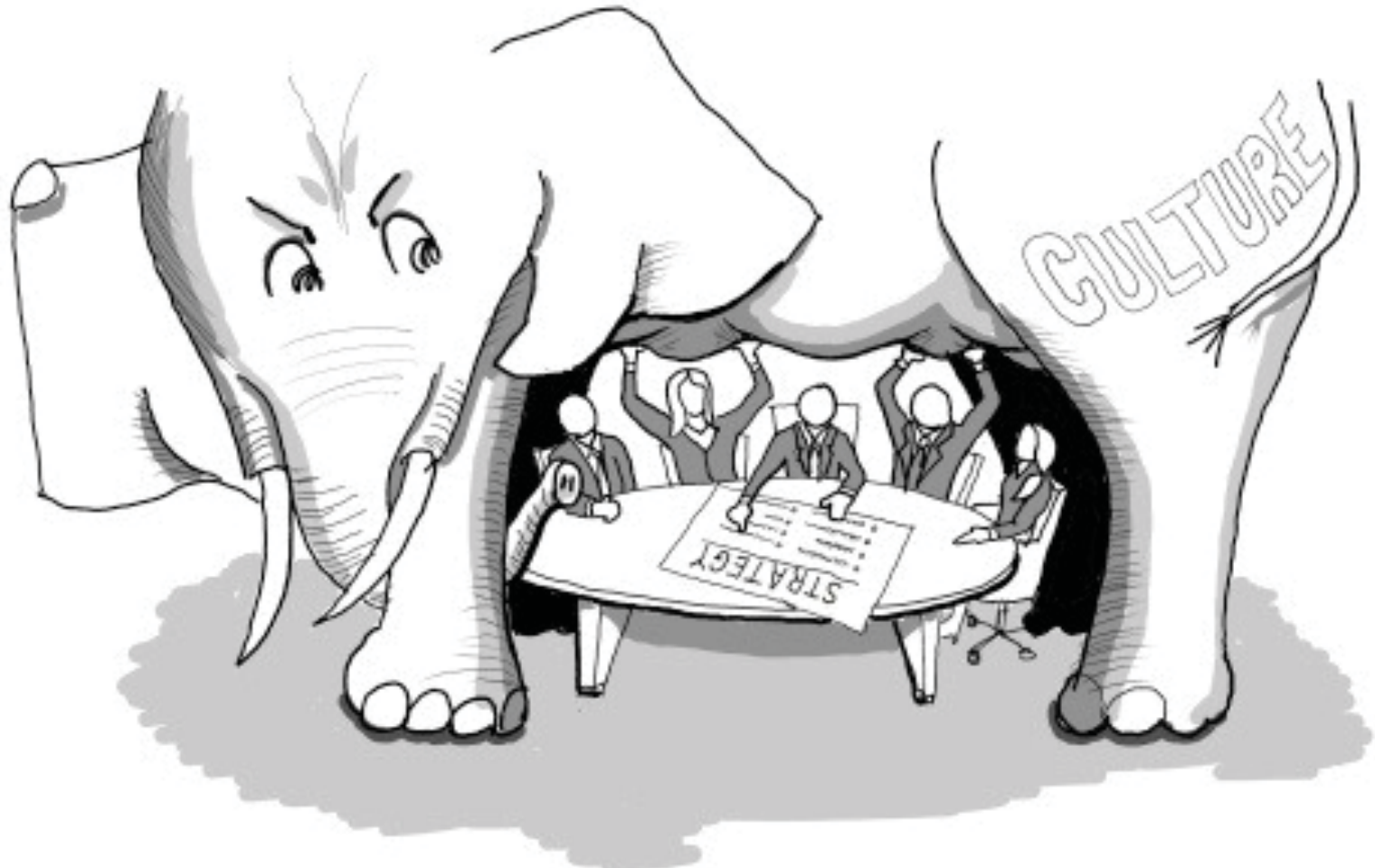
- Increased academic interest in real building performance, *e.g. with UCL’s own UK Centre for Moisture & Buildings, UKCMB**.
- Greater understanding of the different performance requirements of historic and traditional buildings, *in particular the role of moisture-permeable materials and the risk of water being trapped by modern impermeable layers.*
- Much revised British Standard BS 5250, on Moisture management*.
- Substantial work by heritage bodies on research, case studies and related research and guidance publications.
- British Standards’ PAS 2030, 2035 and 2038 on retrofit processes.
- National Retrofit Hub set up in 2023, to support domestic retrofit.
- Heritage included in development of the UK Net Zero Carbon standard.
- But we still have a long way to go
- *And not just for heritage buildings ...*

* The late Neil May MBE (1962-2018) was the moving spirit behind Responsible Retrofit, STBA, UKCMB, the revised BS5250 and many other things

... and the Grenfell fire exposed lethal flaws
in retrofit knowledge, process, practice and regulation



The elephant isn't in the room,
IT IS THE ROOM!



WE HAVE A SYSTEMIC PROBLEM: Blindness to performance in use
It's not just construction, it's the way society has gone about things

Heritage retrofit: my very recent observations

- People still often regard heritage buildings as unsustainable. *FAR FROM IT – THEY'VE LASTED.*
 - They are also regarded as inefficient. *In fact, they often use less energy than predicted. EPCs don't work well in traditional buildings.*
 - Retrofit plans tend to assume a need for fairly major interventions. *Quick wins can easily pass unacknowledged.*
 - Retrofit plans tend to regard a building as an object, *and take insufficient account of actual performance, owner and occupier preferences and budgets, and changes a future owner might make.*
 - We need better briefing process: *people too often jump to conclusions.*
 - And much better **local** advisers and installers for implementation.
 - Owner-occupiers, social & private landlords have different perceptions
 - There is a lot the industry and policymakers could learn from people who work on heritage buildings. For the most part, they don't: *Heritage is seen as fringe, rather than a laboratory for what works and what doesn't. INFORMATION NEEDS EXCHANGING MORE FREELY.*
-

PART 3

So what might we need to do?



"Fabric first" can help many new buildings do without much space heating and cooling

My ambition:

*"a building with
no heating,
no cooling,
and no lighting
while the Sun is
above the horizon"*

MAX FORDHAM
1933-2022

***In 2019, he very
nearly did it >>>***

Max Fordham House verified as net zero carbon



THE HOME OF DESIGN & ARCHITECTURE

APRIL 25, 2022 / INDUSTRY NEWS

The UK's first net zero carbon residential home has been verified in line with the UKGBC's framework

A private house in Camden, built for pioneering engineer Max Fordham, has become the first residential building in the UK to be verified a completely net zero. *[Including offsets for residual embodied C].*

The RIBA award-winning house sets an example of how net zero homes can become a key part of the UK's housing solution. During his lifetime, Max Fordham made great efforts to change the way architects think about heating, power, and light, and constantly championing sustainable design.

But what about our legacy?

Louis Hellman cartoon on cover of RIBA Journal Energy issue Feb 1976

And we now have another half century of energy dependent buildings.

HOW WRONG CAN WE AFFORD TO BE?



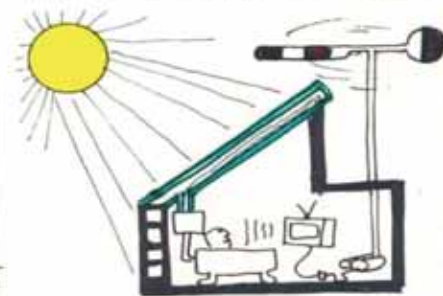
OLD BUILDINGS ARE HIGHLY FLEXIBLE IN USE, THEY CAN BE ADAPTED TO NEW FUNCTIONS CHEAPLY AND EASILY BY KNOCKING DOWN WALLS OR BY ADDING BATHROOMS OR STAIRCASES. IT HAS BEEN ESTIMATED THAT THE GREAT MAJORITY OF HUMAN ACTIVITIES CAN BE ACCOMMODATED IN A GEORGIAN TERRACE HOUSE.



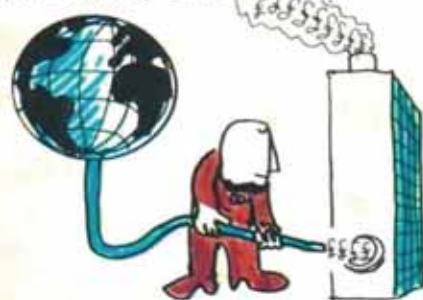
WHAT WE NEED IS A COMBINATION OF THE OLD EMPIRICAL EXPERTISE AND NEW TECHNIQUES TO PROVIDE REASONABLE BUILDINGS WITH THE MINIMUM COST AND ENERGY CONSUMPTION.



FOR EXAMPLE THE QUALITY OF DAYLIGHT IS MORE IMPORTANT THAN THE QUANTITY. SMALL WINDOWS FOR VIEWOUT CAN BE USED WITH ARTIFICIAL LIGHTING FOR WORK ETC.



MODERN MATERIALS CAN BE USED TO EXPLOIT SOLAR ENERGY MORE EFFICIENTLY TO HEAT WATER OR ROOMS, PLUS IMPROVED WINDMILLS TO DRIVE GENERATORS.



IT IS CLEAR THAT THE HIGHER THE BUILDING THE GREATER THE TECHNOLOGY REQUIRED TO COUNTERACT THE PROBLEMS CREATED BY BUILDING HIGH.



ENVIRONMENTAL DESIGN IS NOT AN EXACT SCIENCE - WE CAN NEVER BE RIGHT, THE QUESTION IS...



HOW WRONG CAN WE AFFORD TO BE?

Hellman

Current policy options for existing buildings,
driven largely by a need to save on heating (and increasingly cooling)

Deep Retrofit

Great if you have the chance,
but these are quite rare.

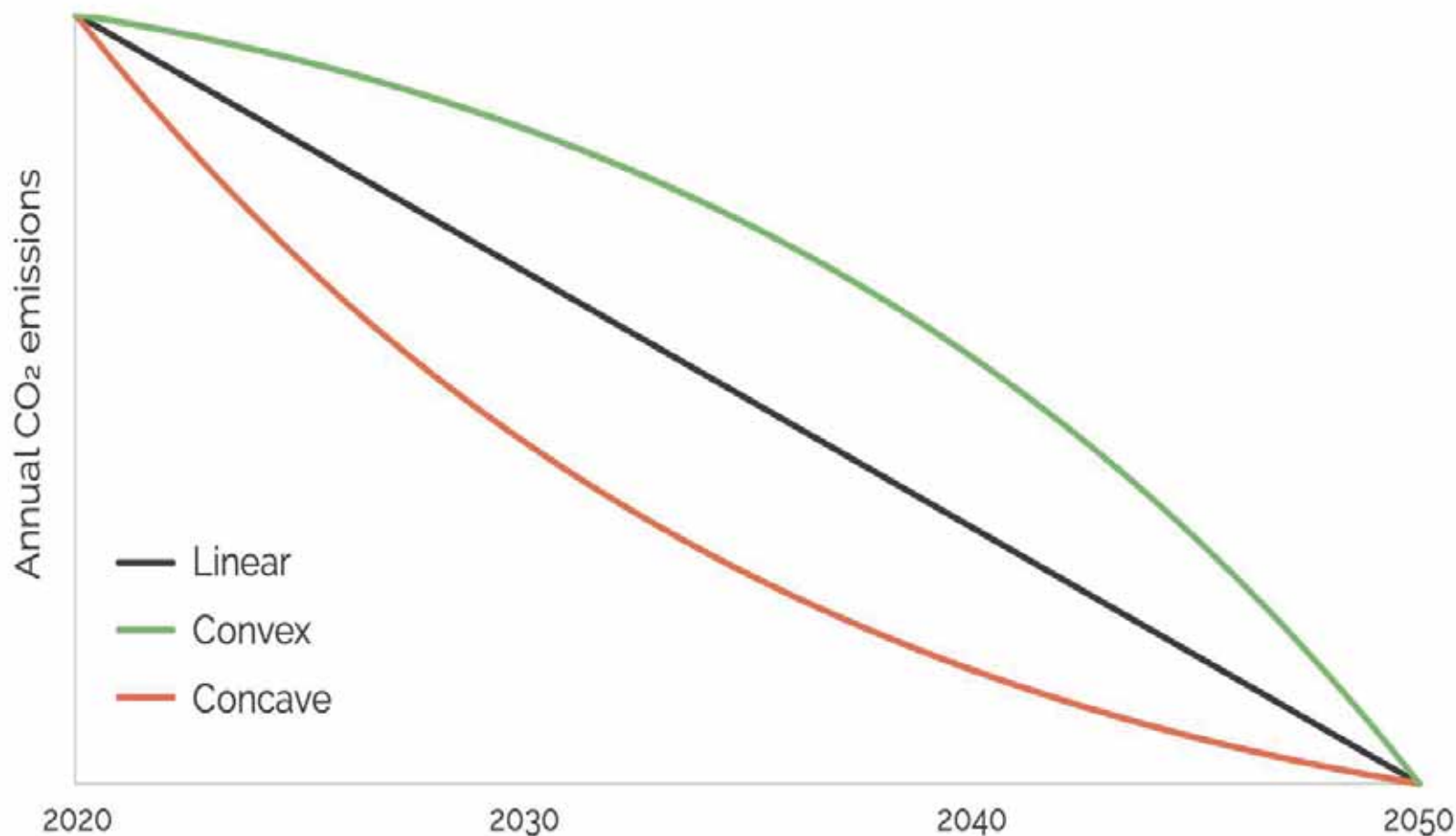
Substantial Renovation

Tends to be the most common policy, BUT
*the best UK and EU policymakers can see is
increasing rates from perhaps 1% to 2% p.a.*

*AND both come with supply chain problems and
technical risks (e.g. moisture and durability).*

Possible Decarbonisation Trajectories

A quick start minimises cumulative emissions



Every little helps: *use multiplier effects to save energy and carbon quickly*

ENGAGE PEOPLE to start with, **AND** for example ...

BE LEAN - Halve the demand

Review standards, reduce losses, avoid waste.

times

BE MEAN - Double the efficiency

Buy efficient equipment, use it effectively, minimise system losses, tune it up.

times

BE GREEN - Halve the carbon in the supplies

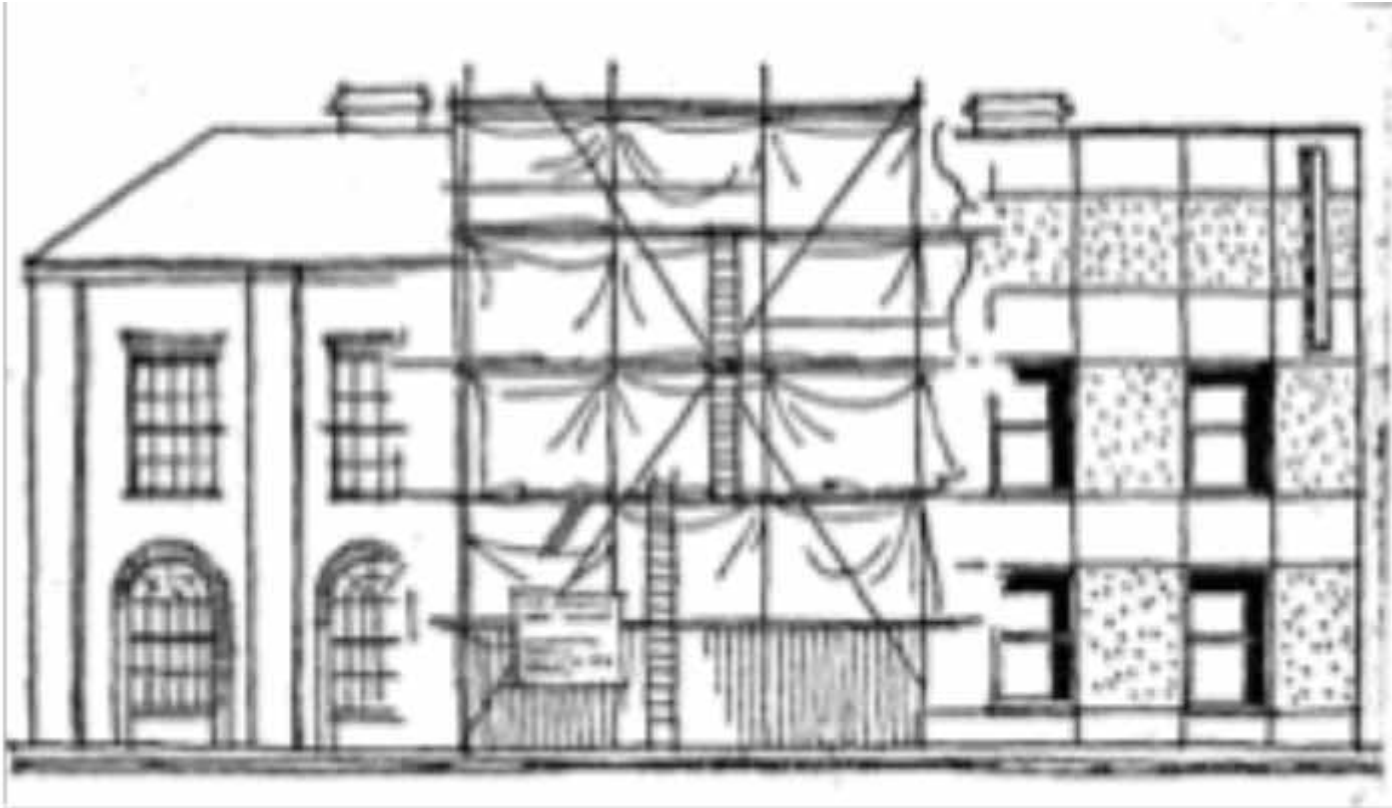
With on-and off-site measures

equals

You're down to one-eighth of the CO₂

“... prioritise heritage buildings within the energy efficiency and climate policy.” - POLICYMAKER

Is this a useful way of thinking ?



Or might policy have as much to learn from heritage as heritage from policy?

PART 4

Or could we do other things *and be healthy and comfortable enough whilst saving energy more rapidly?*



Should we be resolving our problems,
or re-examining our premises?

*“We can't solve problems
by using the same kind of thinking
we used when we created them”*

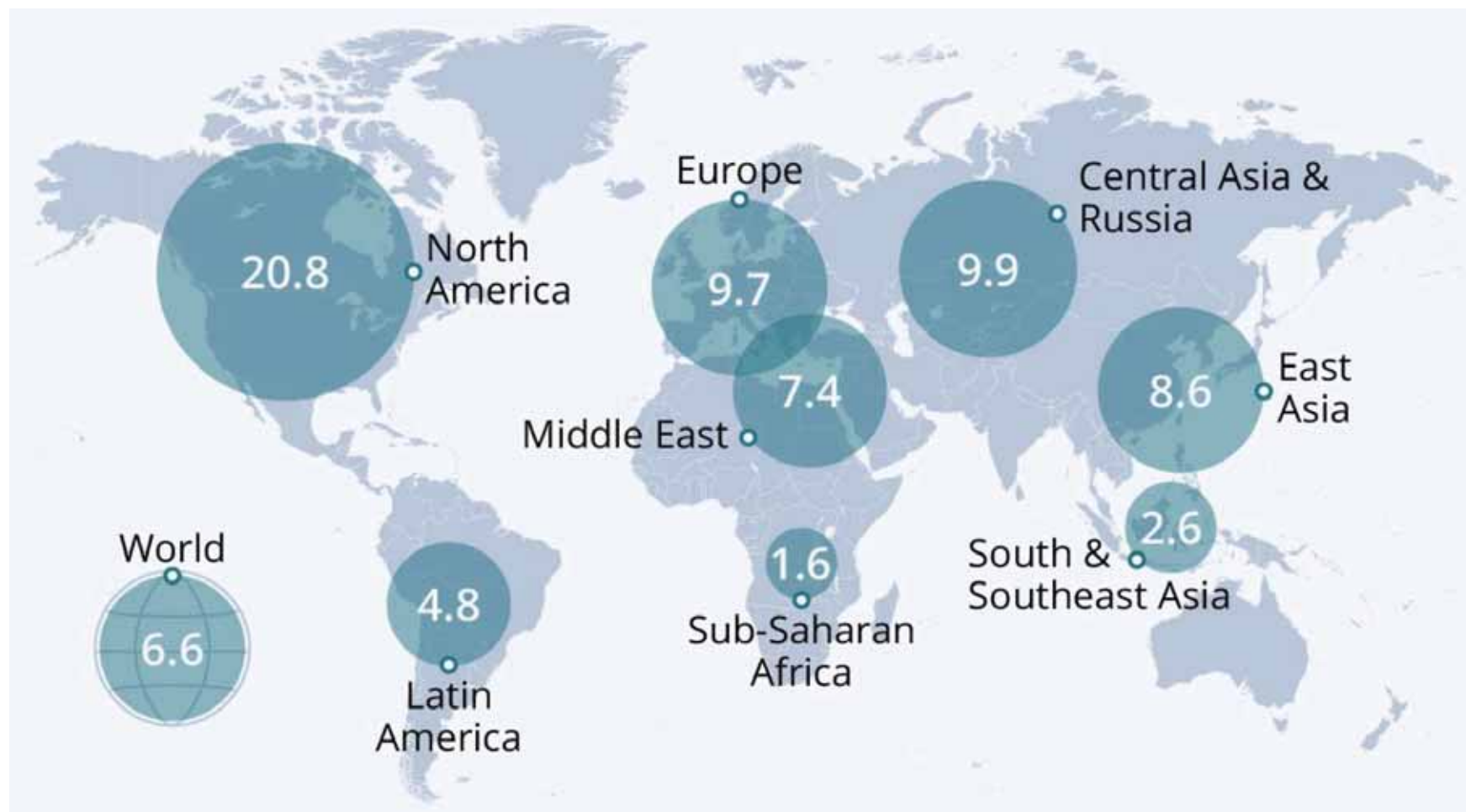
Attributed to A EINSTEIN

*“We are suffering from an attempt
to know our way into the future
instead of live our way”*

W SHARPE

Regional average CO₂ emissions (2019)

tonnes, including domestic and net imports



Global survey finds that Africa is happiest region of the world

09 JANUARY 2015

by **a staff reporter**



SOURCE: Church Times (9 January 2015), reporting the results of an international Gallup poll.

PEOPLE FIRST: Comfort standards are also socially and culturally determined

“If current understandings of comfort underpin escalating levels of energy demand, why persist with them?”

People’s needs... have social histories of their own ... The [mistaken] distinction between technology ... and behaviour.

“Sociology ... repeatedly demonstrates the extent to which things ... ‘script’ what people do ...

“[while] dominant paradigms remain ... there are fewer references to non-technical barriers and more to sociotechnical change, and ... practices not behaviours.”

Clothes like these would more than halve space heat demand:

Now to make them fashionable ...



Late medieval Burgundian coats – finally warm enough!



FRAMING COMFORT: *mindsets in earlier days*

Pre-Enlightenment, texts mentioning comfort tended to be about spiritual aspects, *not creature comforts*.

Fires were largely used for cooking: *heating welcome but often incidental*.

Expectations evolved alongside available resources and technologies, and following bursts of innovation. *viz UK Rumford fireplace, European ceramic stoves, American Franklin stoves ...*

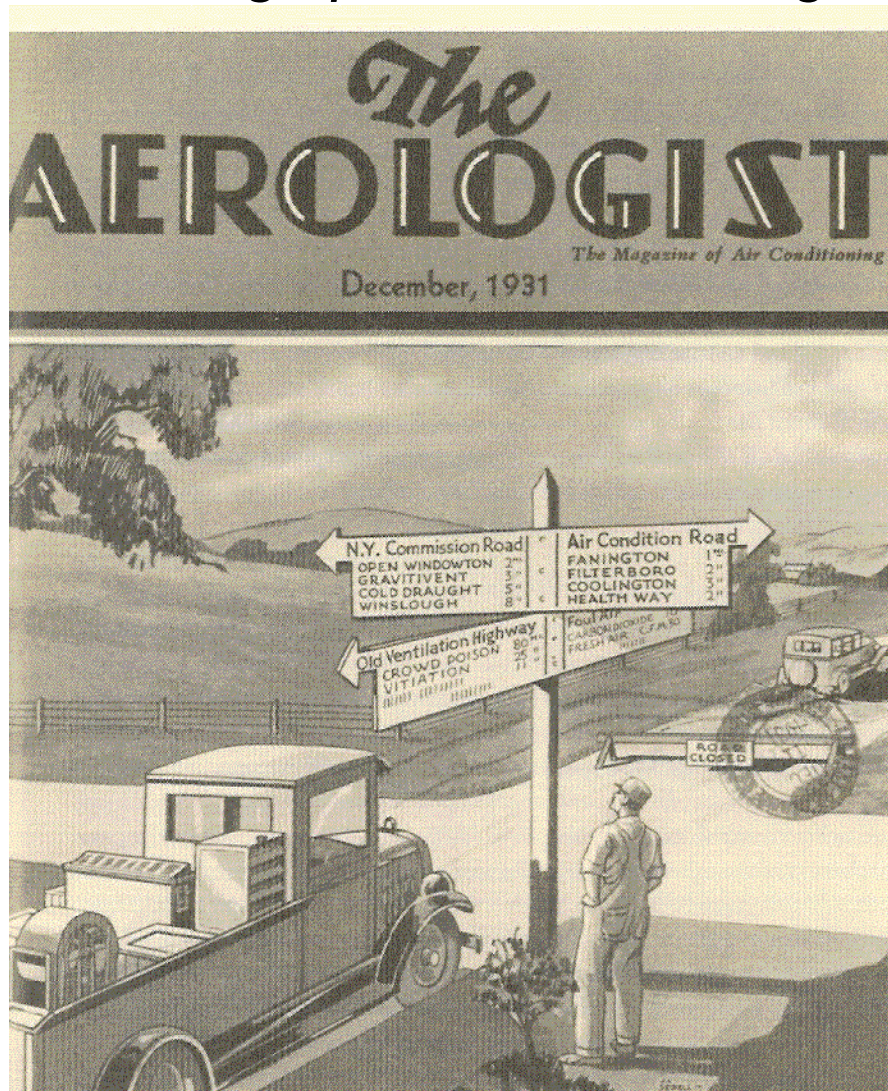
Mission creep over the years, enhanced by marketing, *so expectations for internal environments increased, while some past practices were overlooked, and even forgotten.*

BUT Ruling classes could regard physical discomfort as character-building, *viz British Public Schools*.



FRAMING COMFORT as controlled environment:

Making space conditioning into a marketable commodity



"In 1922, the New York State Commission ... advocated natural ventilation ... The engineering community seriously opposed ...

... *"The Aeroalogist journal ... argued physicians were stepping outside their [professional] boundaries.*

"When natural climate was the ideal, mechanical systems were found wanting, but when quantitative standards ... became the measure, natural climate was found wanting. When no town could deliver an ideal climate, all towns became potential markets."

AND AFTER WORLD WAR 2:

Climate-responsive features of buildings (verandahs, shutters, shade roofs etc.) were simplified or eliminated, in order to make air conditioning more affordable.

Lobbying Rules OK?

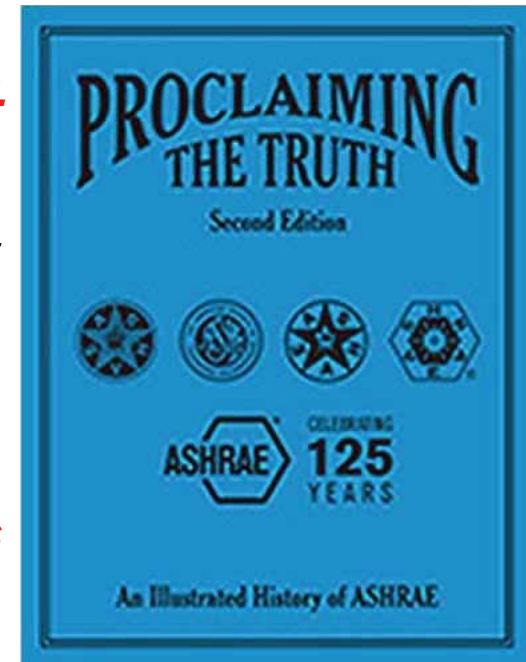
Constitution of American Society of H&V Engineers 1895

To establish a clearly defined minimum standard of heating and ventilation for all classes of buildings.

To favor legislation compelling ventilation of all public buildings in accordance with the standard of this society.

To encourage legislation favorable to improvement in the arts of heating and ventilation, and

to oppose legislation inimical to the business of the engineer.



FRAMING COMFORT IN THE PAST:

Some ideas from pre-fossil history



FRAMING COMFORT *in a Climate Emergency:*

*How about seeking to **escape Crises of discomfort****

HOW?

Use perceived control & adaptive opportunity, e.g:

- Adjust a passive system (*windows, blinds etc*).
- Adjust M&E services (*central, local or personal*).
- Contact the manager (*but rapid response is vital*).
- Adjust posture, clothing, activity etc. (*+ lap dogs and hot water bottles*)
- Move about, go somewhere else, go outside (*possible at home, in some modern work environments, in Australia! ...*).
- Eat or drink (*hot or cold*), take a shower, feet in bucket ...



Loose control with adaptive opportunity can give greater occupant satisfaction with less energy dependency ...

BUT achieving consensus in shared spaces can be tricky.

* SOURCE: D Haigh, *User response in environmental control*, in D Hawkes & J Owers (ed), *The architecture of energy* (1981).

ENERGY SUFFICIENCY: *Avoid unhealthy environments, allow escape from crises of discomfort*

MAIN METHODS:

1. Review appropriate standards *and promote adaptive comfort*
2. Control draughts, air movement and radiant heat gains and losses
3. Wear the right clothing and have suitable furniture etc.
4. Consider local and personal heating and cooling systems
5. Have accessible, responsive user-friendly controls
6. Improve thermoregulatory fitness where practicable
7. ADD thermal refuges, *both hot and cold, local and communal.*
8. *Plan to avoid health and moisture-related unintended consequences.*



"He gets so dramatic when I lower the thermostat."

These also save energy and carbon much more quickly and cheaply than heavy capital investment.

PART 5

Principles of Proportionate Retrofit

Should we consider a spectrum of approaches?

A spectrum of approaches to energy and carbon-saving retrofit

TYPE	COMMENT	TYPICAL COST (<i>per dwelling</i>)	SOME INGREDIENTS	NOTES
1. DEEP RETROFIT <i>LETI Exemplary</i>	The current mantra? e.g. EnerPHit	£ 100,000	Full suite of measures.	Nice work if you can get it, but rare.
2. GOOD PRACTICE <i>e.g. AECB</i>				
3. COST EFFECTIVE				
4. "SOFT" RETROFIT <i>People first</i>				
5. BASIC ENERGY SAVING				

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3. COST EFFECTIVE <i>Needs process and technical innovation</i>	Pareto optimum? <i>80% of the way with 20% of the money.</i>	£ 20,000	Pragmatic fabric <i>to halve annual heat requirement from current 130 kWh/m² median.</i>	Might include highly simplified MVHR an ASHP.
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5. BASIC ENERGY SAVING	Simple, <i>but too often still not done.</i>	£ 1,000 or less	Basic insulation, draughtproofing, equipment, control	Often absent from retrofit plans. <i>Advisers needed!</i>

Some possible implications of soft retrofits for heating in traditional buildings

Possible advantages	Caveats
Fewer alterations required to fabric, reducing associated risks too.	Some improvements may nevertheless be appropriate, depending on context.
Lower internal air temperatures.	Sometimes they are too low already, <i>increasingly so with recent price spikes</i> .
Less necessary to limit air infiltration if air temperatures are lower.	Some draughtproofing may also be helpful, depending on context.
Could help to reduce condensation and moisture problems that can occur after draughtproofing etc.	Cooler buildings can be more prone to problems from any internally-generated moisture - needs removal at source.
Potentially much faster, cheaper energy savings than deep fabric retrofits.	New technology is often electric and used at peak times. Storage needed?
Local electric systems simpler and less intrusive to install than traditional HVAC	Additional, dispersed electric heating equipment might increase fire risks.
Local systems could be particularly useful in lightly-occupied buildings.	Less energy-saving potential in heavily- or densely- occupied buildings.

PART 6

POSSIBLE FUTURE MINDSETS



MOVING FORWARD: *Evolving Mindsets*

PAST <i>can persist, or revert</i>	PRESENT <i>C20-21</i>	FUTURE? <i>Later C21</i>
SUBJECT of a Chief, King, <i>Pope, Dictator, Putin ...</i>	CONSUMER <i>I spend, therefore I am</i>	CITIZEN + COMMUNITY <i>both local and wider scales</i>
PRIESTHOODS <i>+ Guilds Professions Unions</i>	MARKETS: <i>Invisible Hand,</i> <i>or Corporate Takeover?</i>	COLLABORATIVES <i>with diverse skills</i>

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BUILDINGS: BUILT TO LAST, Robust <i>With routine maintenance</i>	BUILT TO CONSUME <i>Demolish or retrofit old ones</i>	IMAGINATIVE RE-USE <i>Improving what we've got</i>
COMFORT: LOCAL PROVISION & <i>Thermoregulatory Fitness</i>	SPACE CONDITIONING <i>Commoditised comfort</i>	RESILIENCE, AVOIDING CRISES of DISCOMFORT plus Thermal Adaptation
ENERGY: CONSERVATION <i>Husbanding resources</i>	EFFICIENCY <i>But not necessarily saving</i>	SUFFICIENCY <i>Living within our means</i>

*“... we are living the end of what could have seemed an era of abundance
... of products of technologies that seemed always available ... of land
and materials including water” - EMMANUEL MACRON, 23 Aug 2022*

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PRIESTHOODS + <i>Guilds Professions Unions</i>	MARKETS: <i>Invisible Hand,</i> <i>or Corporate Takeover?</i>	COLLABORATIVES <i>with diverse skills</i>
BUILDINGS: BUILT TO LAST, Robust <i>With routine maintenance</i>	BUILT TO CONSUME <i>Demolish or retrofit old ones</i>	IMAGINATIVE RE-USE <i>Improving what we've got</i>
COMFORT: LOCAL PROVISION & <i>Thermoregulatory Fitness</i>	SPACE CONDITIONING <i>Commoditised comfort</i>	RESILIENCE, AVOIDING CRISES of DISCOMFORT plus Thermal Adaptation
ENERGY: CONSERVATION <i>Husbanding resources</i>	EFFICIENCY <i>But not necessarily saving</i>	SUFFICIENCY <i>Living within our means</i>
RESEARCH: BASIC <i>And on-the-job learning</i>	ACADEMIC <i>Distanced from practice</i>	REAL-WORLD <i>Closely</i> <i>integrated with practice</i>

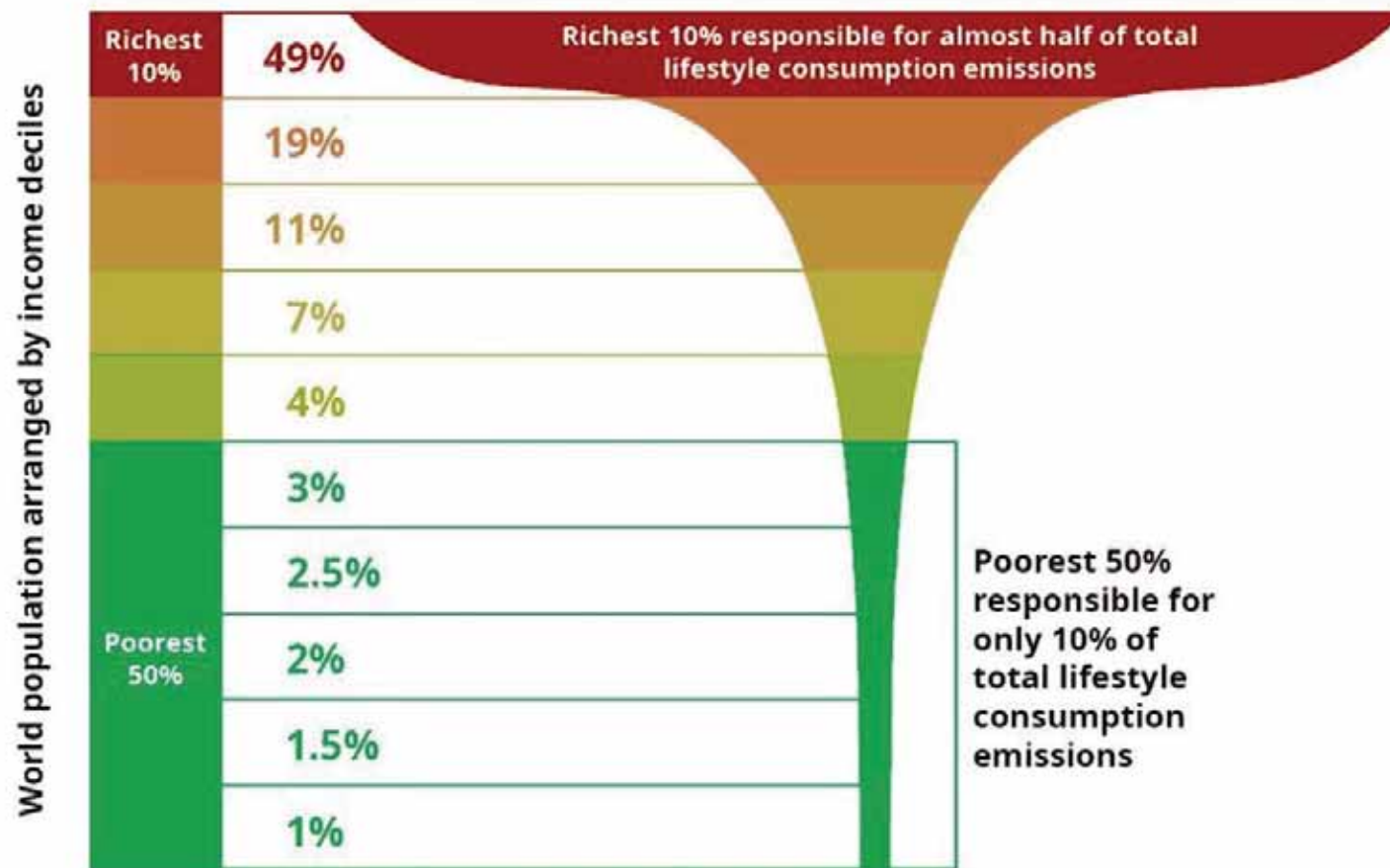
MOVING FORWARD: *Evolving Mindsets*

PAST <i>can persist, or revert</i>	PRESENT <i>C20-21</i>	FUTURE? <i>Later C21</i>
SUBJECT	CONSUMER	CITIZEN + COMMUNITY <i>both local and wider scales</i>
		COLLABORATIVES <i>with diverse skills</i>
		BUILDINGS: IMAGINATIVE RE-USE <i>Improving what we've got</i>
		COMFORT: AVOIDING CRISES of DISCOMFORT <i>plus Thermal Adaptation</i>
		ENERGY: SUFFICIENCY <i>Living within our means</i>
		RESEARCH: REAL-WORLD <i>Closely integrated with practice</i>

“You don’t waste time with reactionaries; rather you work with active change agents and with the vast middle-ground of people who are open minded” - DONELLA MEADOWS *

“A constrained world cannot afford the rich ”
GEORGE MONBIOT

Percentage of CO₂ emissions by world population



Source: Oxfam

Thank you **DISCUSSION**



TIPPING POINT

www.usablebuildings.co.uk

PART 7

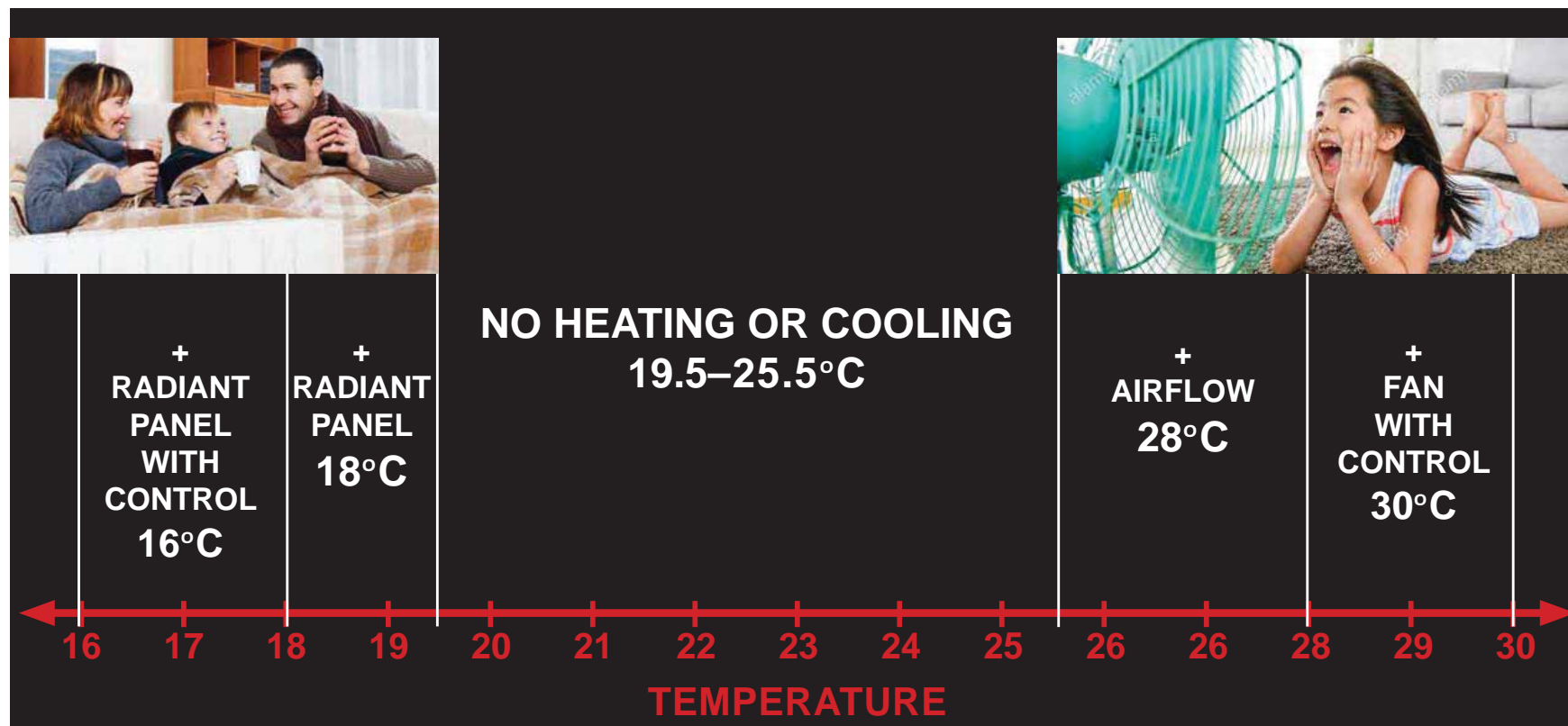
POSTSCRIPT *(if time)*

Ingredients of a People First Approach



1. STANDARDS: *Are they fit for today?*

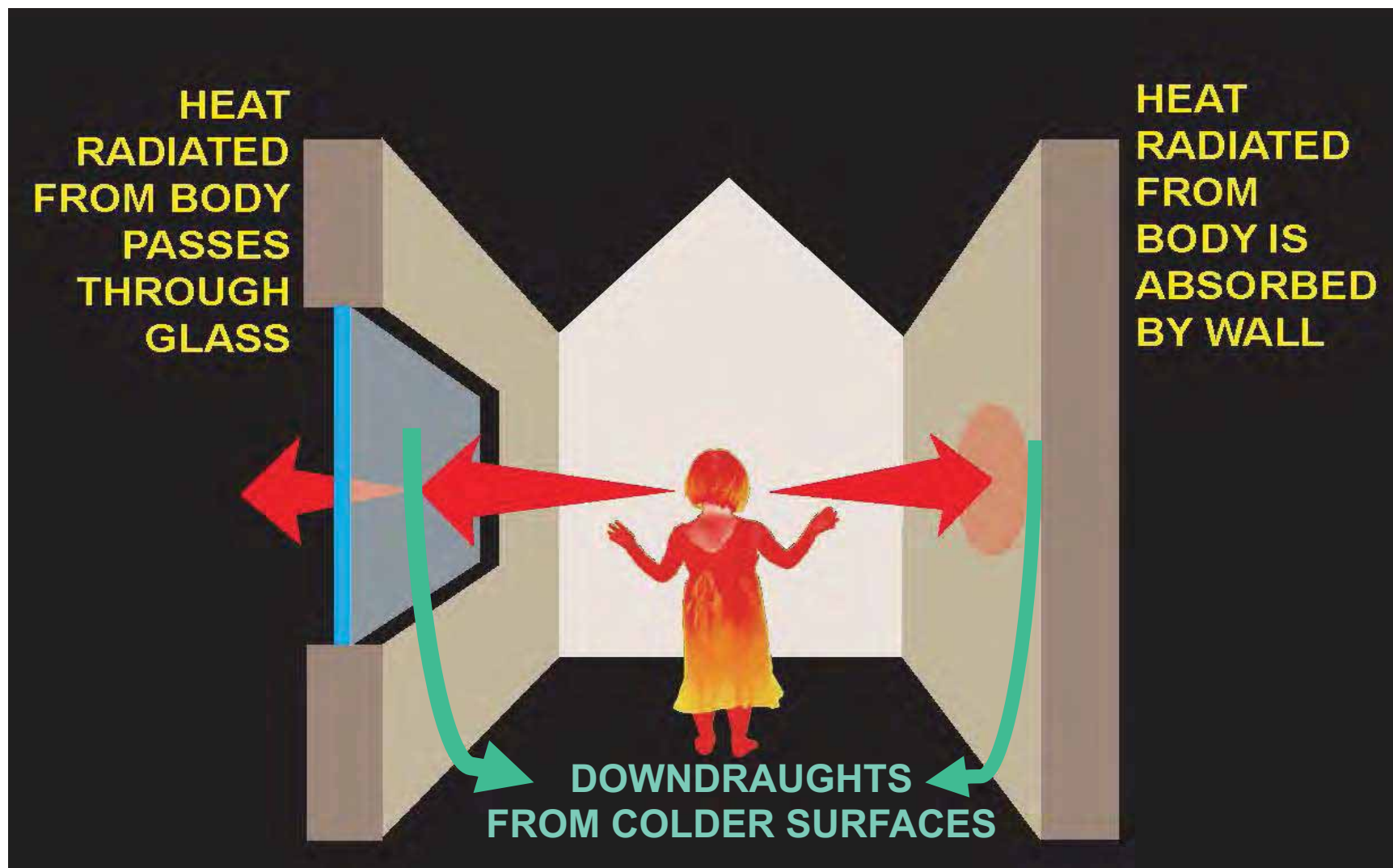
What do we really need to heat and cool spaces to?



What about UK's recommended minimum 18°C Health requirement?

In its Minimum Home Temperature Thresholds review (2014) Public Health England says it is a “*weak recommendation*” with little robust support, but *may be beneficial to the over-65s and those with pre-existing medical conditions.*

2. DRAUGHTS & RADIATION: *Effects of relatively cooler surfaces*



2. DRAUGHTS & “COLD” RADIATION: *Mediaeval hangings weren't just decorative*



2. DRAUGHTS & RADIATION:

Simple ways of countering losses and gains



Traditional Orkney high-backed chair with drawers for whisky and a Bible.



Ad hoc external shading by old linen sheets during 2022 London heatwave kept peak internal temperatures below 27 C.

3. CLOTHING: Back to the Future *in a chateau*



Modern winter layers – awkward indoors and ultimately not warm enough



An Erasmus-style hat is comfortable and warm



Late medieval Burgundian coats – finally warm enough!

Cone-shaped mediaeval garments proved to be the warmest and most controllable

Heating one 40 m² room to 10-15°C with a log fire needed less than 5% of the fuel required to heat the whole building to the high teens using modern wood burning stoves.

SOURCE: J Parker, *Returning to old ways of staying warm*, (2016), www.traditioninaction.org/Cultural/C042_Warm.htm

4. LOCAL AND PERSONAL HEATING: *Experiments with 16-zone thermal manikin*

Indicative Watts to increase personal comfort by 1°C:

250	Local convector heater
100	Local radiant panel
35	Local foot warming mat
<10	Heated chair or cushion



Max heating power 14 W
Max cooling power 3.6 W

5. USER-FRIENDLY ROOM CONTROLS

A few principles for both passive + active systems

- **Easy to reach**
from the point of need
- **Easy to use** and understand,
and preferably intuitively obvious
- **Acknowledge interventions**,
so you know things are going to happen
- **Default to off**, safe or standby,
so energy isn't wasted.

PLUS Rapid system response:

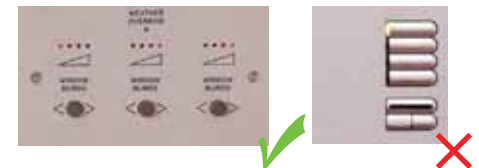
Widens thresholds of acceptability, by lessening any anxieties that conditions might continue to deteriorate. Conversely, slow or no response narrows thresholds for a “crisis of discomfort”.

BUT People are not good at anticipation: advice, decision support, or backup (e.g. mixed mode) systems may be needed.



Controls for End Users

a guide for good design and implementation



by Bill Bordass, Adrian Leaman and Roderic Bunn

Compiled for the BCIA by



Funded by



6. THERMOREGULATORY FITNESS

*Improving one's personal thermal physiology**

- **Habituation** to uniform thermal environments
has reduced our thermoregulatory capacity to cope with temperatures outside the range of conditions we normally experience.
- **We CAN be more resilient**
Acclimatisation has been shown to improve the ability to regulate body temperature in young, middle-aged and overweight individuals.
- **This will require “temperature training”**
More thermal variation in everyday life will improve cardiovascular and metabolic health, save energy, and help us adapt to climate change.

BUT We will still need to protect ourselves
(and particularly vulnerable individuals) from the hazardous effects of thermal extremes and other health issues, especially those related to moisture management.

7. REFUGES

both local and communal



JAPANESE KOTATSU HEATED TABLE.
Also used in Middle East and WW1 trenches.
Traditionally charcoal. Often electric today.



PUBLIC REFUGE IN PORTLAND, OREGON
During the "heat dome" temperature extreme
in late June 2021.

THANK YOU DISCUSSION

