

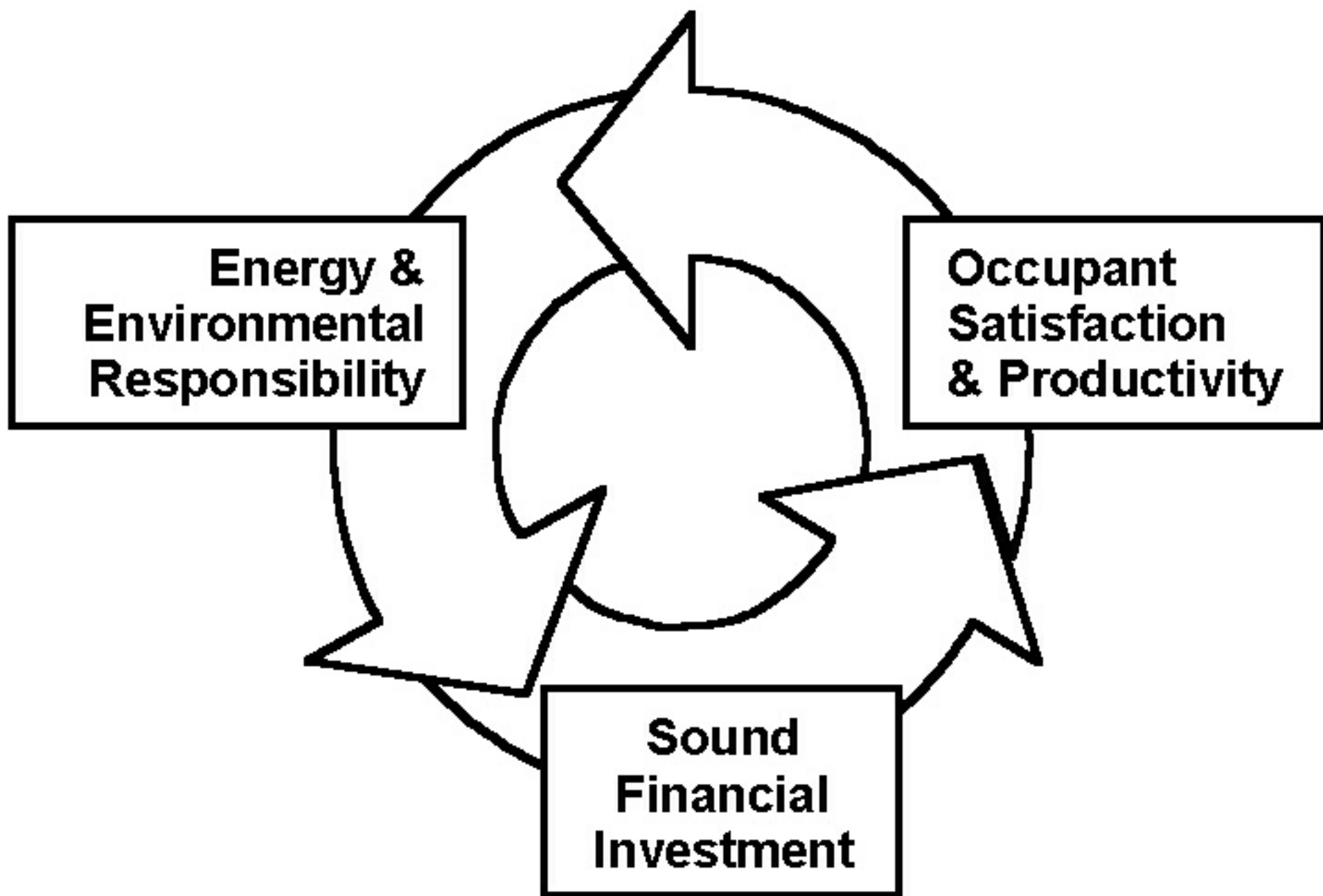
# PROBE & ITS ANTECEDENTS

## 1980s and early 1990s:

- DTI passive solar programme modelling and EPAs.
- DEn/DoE/BRECSU building energy analyses and case studies.
- Occupant health and comfort issues come to the fore.
- Major differences between predicted and actual performance.
- EnREI studies combine technical and occupant surveys.  
Confirm problems with controls and manageability, affecting energy performance and occupant satisfaction.
- Virtuous circles also identified for energy, comfort and control.

## Mid 1990s onwards:

- 1994 BSJ Editorial Committee – need for more feedback in *Building Services Journal* on performance in use. PiT sought.
- Probe 1: July 1995 – May 1997.
- 1997 Probe conference: *Buildings in Use 1997*.
- Probe 2: September 1997 – January 1999.
- 1998 Probe Team proposal for Strategic Review/Alliances.



# PoEs in the PUBLIC DOMAIN

(NB: speculative market under-represented)

- ***SEVEN OFFICES***  
*5 AC, 1 MM, 1 ANV*
- ***FIVE EDUCATIONAL BUILDINGS***  
*3 ANV, 1 MM, 1 ANV/MM*
- ***FOUR OTHER BUILDINGS***  
*NV Medical centre, ANV Training centre,  
MM Courthouse, NV Warehouse*

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Predominant HVAC type in areas in which occupants were surveyed:

AC= Air Conditioned, NV= Naturally-Ventilated, ANV= Advanced NV, MM= Mixed Mode

## The buildings investigated in Probe

Probe 1 Buildings investigated										
Sequ #	Full name	Location	Site	Short name	3-letter	Type	Gp	HVAC	Article	#
1	Tanfield House	Edinburgh	IC	Tanfield	TAN	Large administrative centre	O	AC/(MM)	Sep-95	1
2	1 Aldermanbury Square	London	CC	Aldermanbury	ALD	UK Head office (speculative)	O	AC	Dec-95	2
3	Cheltenham & Gloucester	Gloucester	BP	C&G	C&G	Large head office	O	AC	Feb-96	3
4	de Montfort Queens Building	Leicester	IC	de Montfort	DMQ	University teaching	E	ANV	Apr-96	4
5	Cable & Wireless	Coventry	BP	C&W	C&W	Company training college	M	ANV/NV	Jun-96	5
6	Woodhouse Medical Centre	Sheffield	IC	Woodhouse	WMC	Medical surgeries	M	NV/(MM)	Aug-96	6
7	HFS Gardner House	Harrogate	BP	HFS	HFS	Principal office	O	AC	Oct-96	7
8	APU Queens Building	Chelmsford	IC	APU	APU	Learning Resources Centre	E	ANV	Dec-96	8
Probe 2 Buildings investigated										
9	John Cabot CTC	Bristol	IC	Cabot	CAB	Secondary education	E	NV/ANV	Oct-97	11
10	Rotherham Magistrates Courts	Rotherham	IC	RMC	RMC	Courtrooms and offices	M	MM	Dec-97	12
11	Charities Aid Foundation	West Malling Kent	BP	CAF	CAF	Principal office (per-let)	O	MM	Feb-98	13
12	Elizabeth Fry Building	Norwich	UC	Elizabeth Fry	FRY	University teaching	E	MM	Apr-98	14
13	Marston Books Office	Abingdon	BP	MB Office	MBO	Principal office (per-let)	O	NV/(ANV)	Aug-98	16
14	Marston Books Warehouse	Abingdon	BP	MB Warehouse	MBW	Warehouse (pre-let)	M	NV	Aug-98	16
15	Co-operative Retail Services	Rochdale	BP	CRS	CRS	Large head office	O	AC/(MM)	Oct-98	17
16	The Portland Building	Portsmouth	IC	Portland	POR	University teaching	E	ANV/MM	Jan-99	18

**Site:** BP=Business Park or similar; CC=City Centre; IC=Inner City; UC=University campus  
**Group:** E=Educational; M=Miscellaneous; O=Office  
**HVAC:** AC=Air Conditioned; NV=Naturally Ventilated; ANV= Advanced NV; MM=Mixed Mode (Bracketed if minor influence)

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#1 TAN Tanfield House



#2 ALD I Aldermanbury Square



#3 C&G Cheltenham and Gloucester



#4 DMQ De Montfort Queen's Building



#5 C&W Cable and Wireless

Probe 1 and 2 buildings with article sequence numbers



#6 WMC Woodhouse Medical Centre



#7 HFS Homeowner's Friendly Society



#8 APU Anglia Polytechnic University Queen's Building



#11 CAB John Cabot CTC



#12 RMC Rotherham Magistrates' Courts



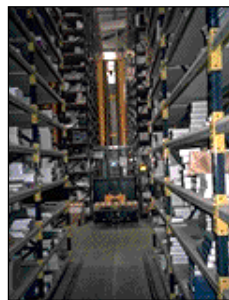
#13 CAF Charities Aid Foundation



#14 FRY The Elizabeth Fry Building



#16 MBO Marston Books Office



#16 MBW Marston Books Warehouse

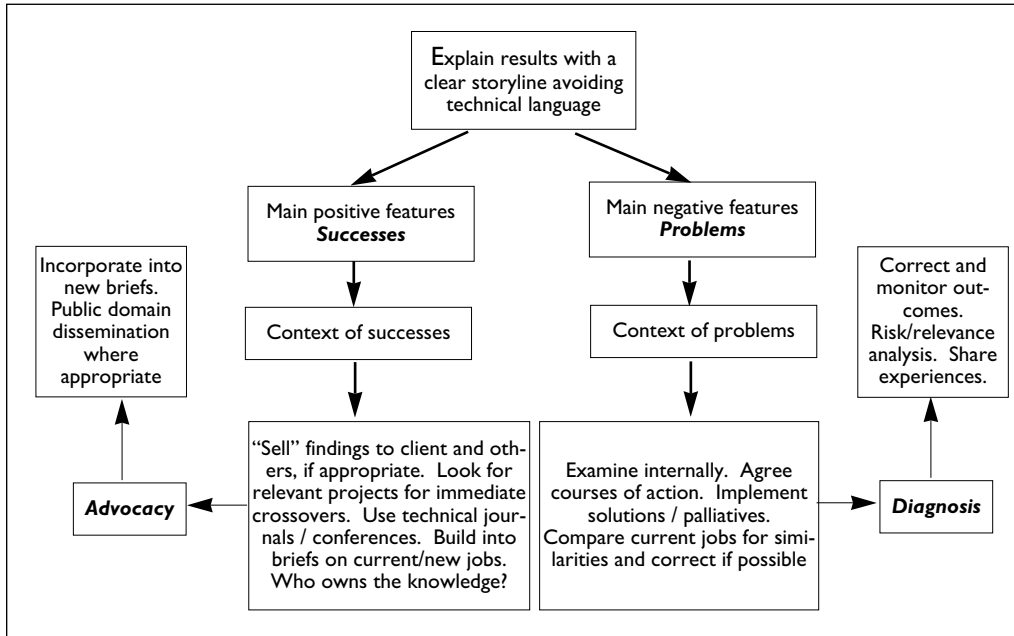


#17 CRS Co-operative Retail Society



#18 POR The Portland Building

## Feedback into the briefing process



# ISSUES and IMPLICATIONS

*The Probe buildings have many positive attributes. However, some chronic problems found in Probe 1 and other research and post-occupancy surveys persisted. How can we use the results to help break the vicious circle, and increase the importance of things not currently valued?*

- 1 CORE ISSUES**
- 2 FABRIC**
- 3 SERVICES**
- 4 ENERGY**
- 5 OCCUPANCY**
- 6 THE FEEDBACK PROCESS**

# 1. CORE ISSUES

*CONFUSION OF ENDS AND MEANS in briefing & design:*

- *Problems not always “owned “ by the right people.*
- *Contract conditions can overlook essential aspects.*
- *Important to identify and minimise the downsides.*

*CONSEQUENCES of technologies not clearly examined, e.g:*

- *Riskiness, vigilance, manageability, usability.*
- *Support costs, handover and sea trials requirements.*
- *Value of keeping things as simple to use as possible.*
- *Management and outsourcing is not always the answer.*

*FLEXIBILITY, ADAPTABILITY, VERSATILITY:*

- *Optima can be fragile. Flexibility demands vigilance.*
- *Poor system responsiveness to diverse usage.*

*MONITORING, BENCHMARKING AND FEEDBACK:*

- *Usually neglected, so chronic problems persist.*
- *Recognition of context is critical to interpretation.*
- *Clear common language from cradle to grave.*

*TRUE BASELINES: Added costs ... or essential features?*



# 2. FABRIC

## *ENVELOPE*

- *Persistent problems with airtightness.*
- *Good rewards from high insulation only if very well integrated with fabric, HVAC, control and management systems.*

## *STRUCTURE*

- *Potential for much better use of thermal capacity.*
- *Acoustic aspects need attention.*
- *In situ construction can assist airtightness by filling gaps.*

## *WINDOW DESIGN*

- *Widespread shortcomings, but this is a complex element.*
- *Use of daylight disappointing (glare, control).*
- *Shading systems can be troublesome.*

## *NATURAL VENTILATION DESIGN AND CONTROL*

- *Widespread difficulties, both manual and automated.*

## *SPACES*

- *Reception areas frequently uncomfortable.*
- *Maintenance access problems.*



# 3. SERVICES

## *HEATING & HWS*

- *No condensing boilers in the commercial buildings.*
- *Electric HWS needs more careful selection and use.*

## *VENTILATION and COOLING*

- *Wasteful full fresh air ventilation; also needs heat in summer.*
- *Humidification, if installed, often seems to be running wild.*
- *ANV tricky: needs consolidation using lessons learned.*
- *Promising mixed-mode developments, but also need care.*

## *LIGHTING*

- *Often over-supplied and over-used. Waste in common areas.*

## *INFORMATION AND COMMUNICATIONS TECHNOLOGY (ICT)*

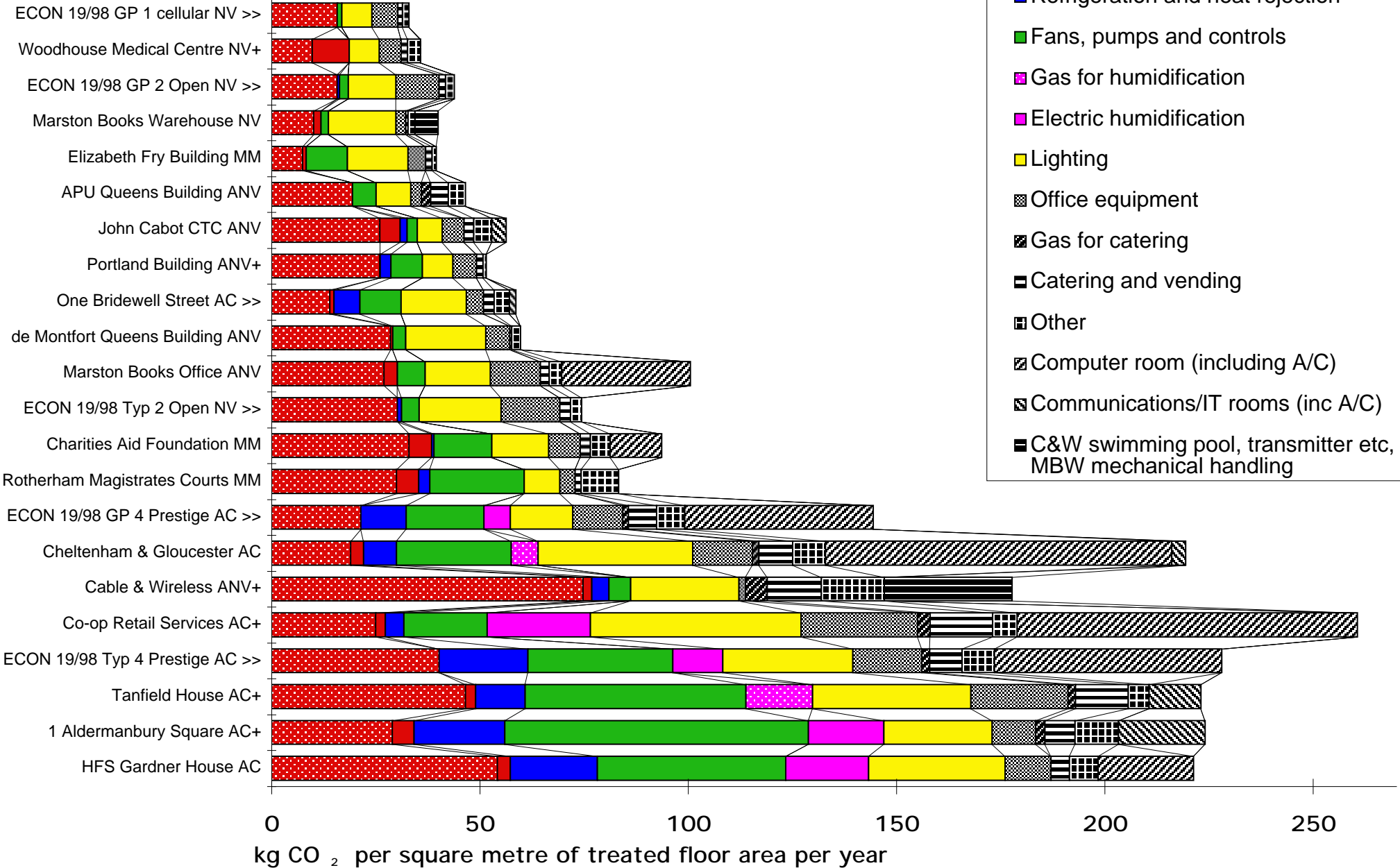
- *Equipment is very inclined to be left on.*
- *“Leaking electricity”. Some harmonics problems.*
- *AC for ICT rooms can often be extravagant in operation.*

## *CONTROLS AND BMS*

- *Widespread problems with performance, operation & usability.*
- *Poor demand-responsiveness, tendency to default to ON.*

# Annual carbon dioxide emissions

Benchmarks 1998 ECON 19. CO<sub>2</sub> factors kg/kWh: gas 0.20, electricity 0.52  
 Heating normalised to 2462 degree days except C&W and Marston warehouse



# 4. ENERGY and CO<sub>2</sub>

## *CLIENT-RELATED ISSUES*

- *Energy often poorly specified in briefing and design criteria.*
- *Little reality-checking and benchmarking of design or product.*

## *DESIGN ISSUES*

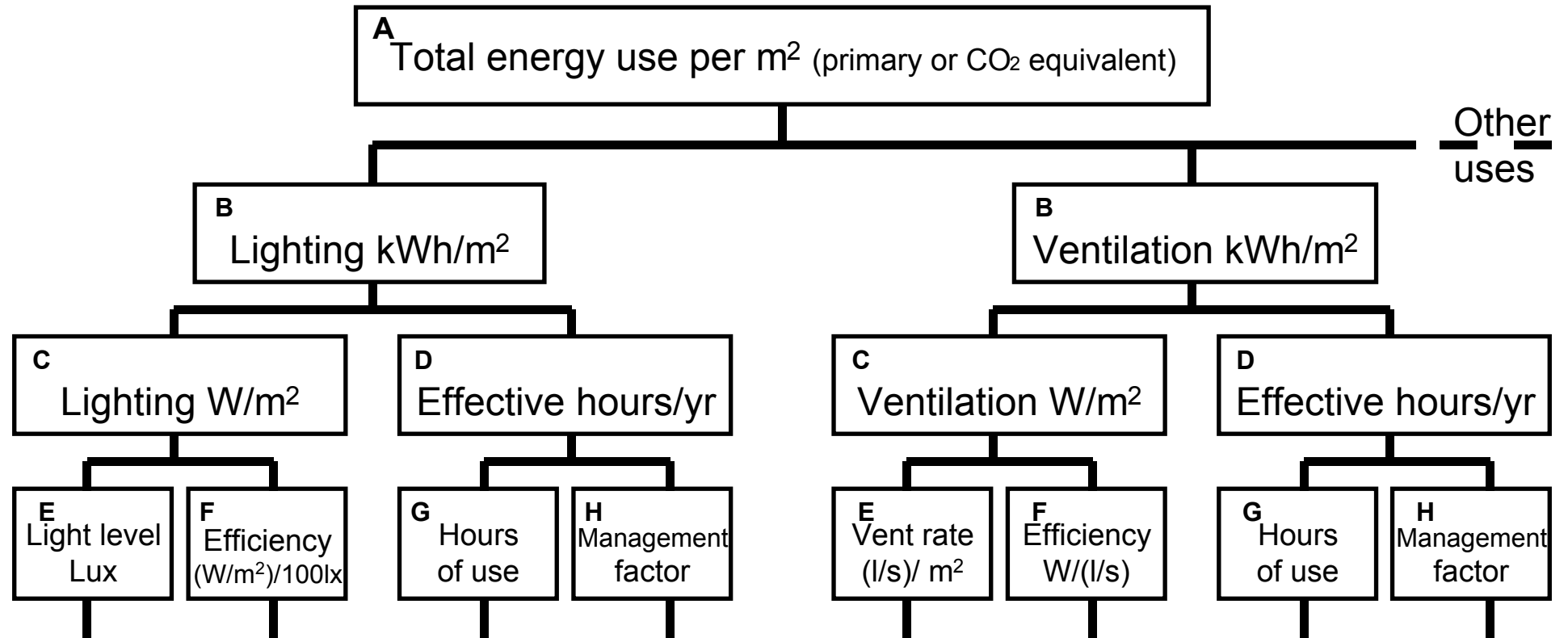
- *Designs often focus on a few items, typically passive systems.*
- *Little use of system and component benchmarking.*
- *Plant capacity large (but falling), specific fan power too high.*
- *Major shortfalls in performance, efficiency and control in AC.*
- *Internal gain allowances are more realistic, but some hot spots.*

## *IN USE*

- *Energy management rare, even in buildings with low-E briefs.*
- *Very little submetering, or meter reading.*
- *Fuel meter readings, especially gas, often poor.*
- *Poor management and use of often-unfriendly controls.*
- *Default to ON, especially fans, pumps, lighting, chillers & ICT.*
- *Electrical equipment is being added to and left on more.*
- *Computer rooms use lots of energy, often mostly in their AC.*

# “Tree diagram” analysis of building energy consumption and service provision

Each box can be considered as a benchmark



Source: J Field, J Soper, P Jones, W Bordass & P Grigg, Energy performance of occupied non-domestic buildings: assessment by analysing end-use energy consumptions, Building Services Engineering Research and Technology 18(1) 39-46 (1997).

# 5. OCCUPANTS

*SAFETY, HEALTH, COMFORT, PRODUCTIVITY+ WELL-BEING*

- *Remember these are the ends and the buildings the means!*

*RESPONSES ARE HIGHEST WHEN:*

- *Absolute conditions are stable and reasonable.*
- *Relative conditions can be changed quickly if unacceptable.*
- *Conflicts can be resolved between occupants by themselves.*
- *Outcomes are not foisted upon them.*
- *The buildings, controls and/or management are responsive.*

*FEATURES LEADING TO GREATER SATISFACTION:*

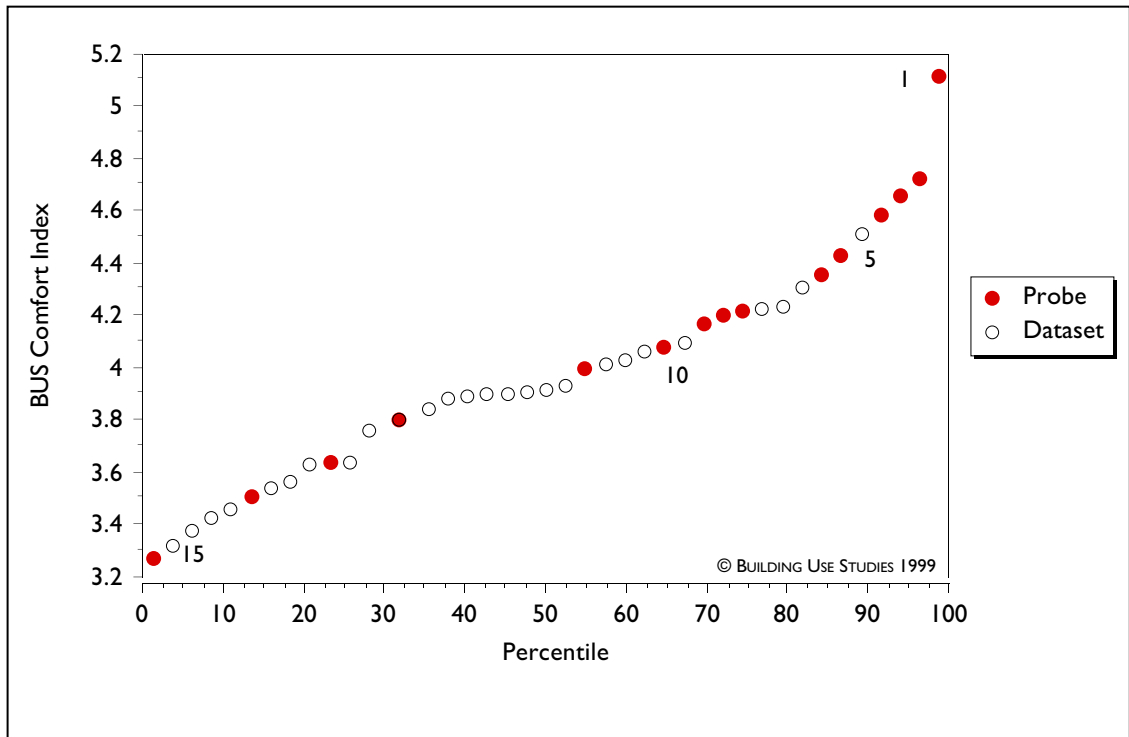
- *Shallow plans; cellular offices; stability with thermal mass; openable windows; not fixed to one workstation; usable controls; defined occupancy patterns; responsive management.*

*FEATURES MAKING SATISFACTION MORE DIFFICULT:*

- *Deeper plans; larger workgroups; higher densities; greater mixes of activities; higher dependencies on technology.*

*Good management can overcome the obstacles, but it is hard work!*

Comfort index showing Probe buildings and BUS dataset



**Comfort index score**

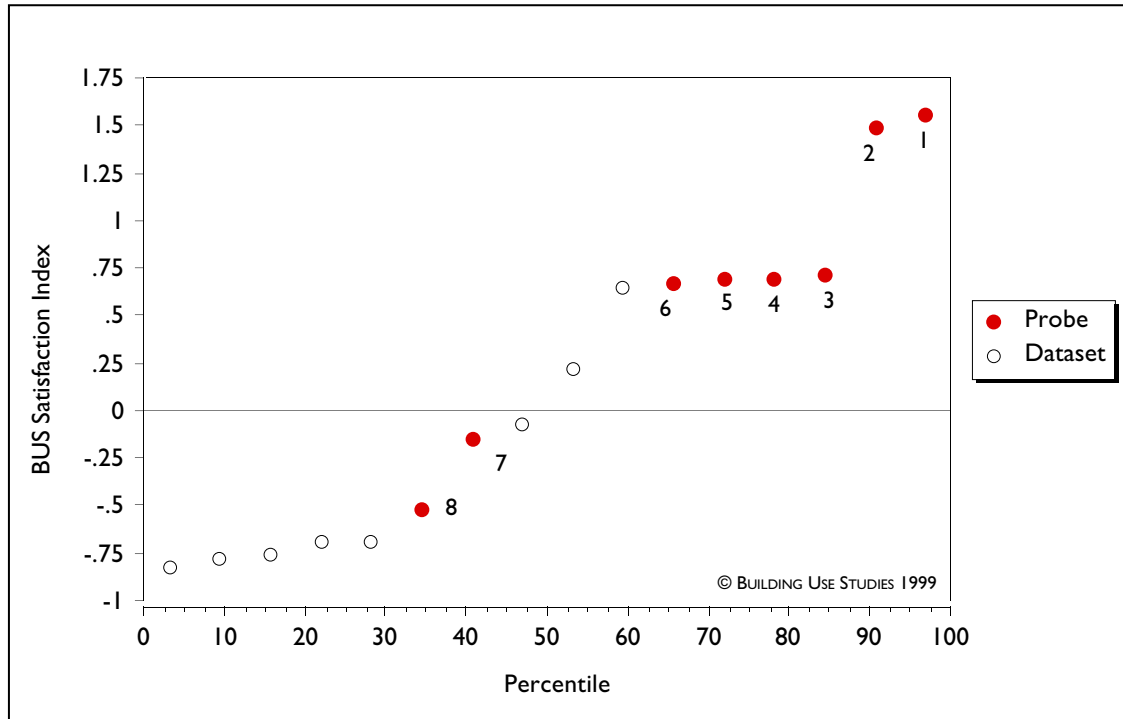
1	FRY	5.12
2	TAN	4.73
3	C&G	4.66
4	RMC	4.59
5	MBO	4.44
6	WMC	4.36
7	HFS	4.22
8	CAB	4.20
9	POR	4.17
10	CRS	4.08

11	ALD	4.00
12	Benchmark	3.96
13	DMQ	3.81
14	CAF	3.64
15	APU	3.51
16	C&W	3.27

Based on seven variables using scale  
1=Uncomfortable; 7=Comfortable



**Satisfaction index showing Probe buildings and BUS dataset**



**Satisfaction index score**

1	MBO	1.56
2	FRY	1.49
3	RMC	0.72
4	CAB	0.70
5	CRS	0.69
6	POR	0.68
7	CAF	-0.15
8	APU	-0.52

*Based on standard z-scores*

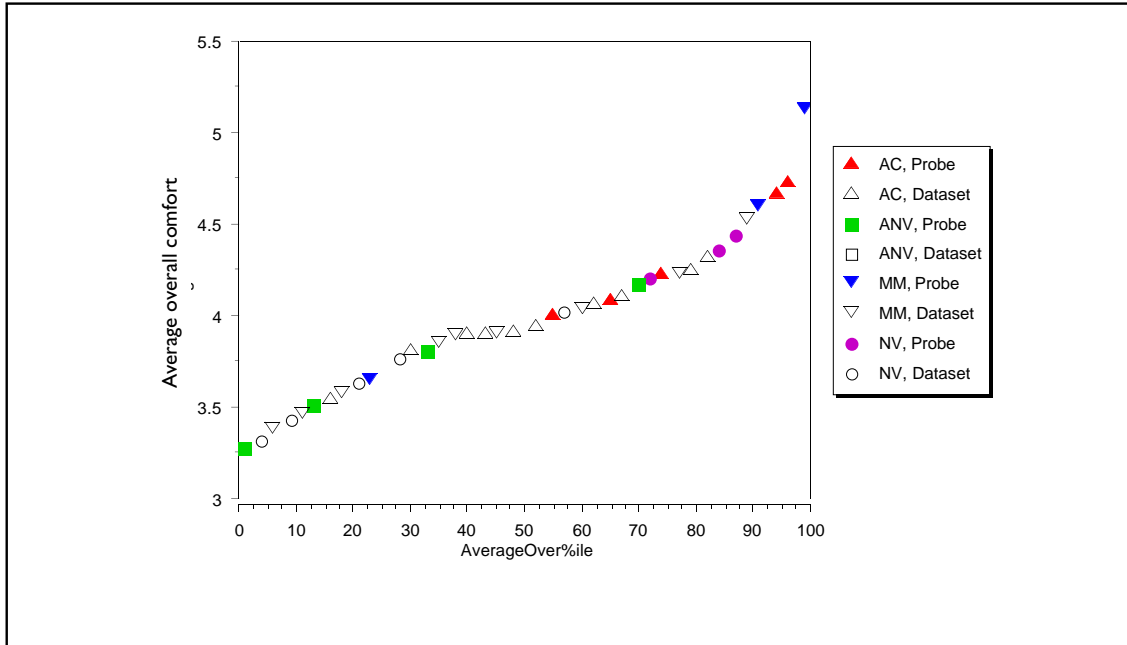
# Briefing strategies

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		<b>Technological complexity</b>	
		<b>More</b>	<b>Less</b>
<b>Building management input</b>	<b>More</b>	<i>Type A</i> Effective, but often costly	<i>Type D</i> Rare
	<b>Less</b>	Risky with performance penalties <i>Type C</i>	Effective, but often small-scale <i>Type B</i>

---

**Overall occupant survey scores for comfort by ventilation type**  
 Probe and BUS reference database



**Notes to Figure 7.1**

*Average Overall score*

A score based on the average scores of the following seven summary variables.

TSOver	Summer temperature
TWOver	Winter temperature
AirSOver	Summer air quality
AirWOver	Winter air quality
LtOver	Lighting
NseOver	Noise
ComfOver	Overall comfort

*Average Overall percentile*

A percentile based on the Average Overall score.

*Example*

TAN scores an average of 4.73 on the seven summary variables. When converted to a percentile this evaluates to 97. Thus TAN is in the top 5% of the dataset by this criterion.

*Scales*

Type A. Best on right

*Ventilation types*

NV	Natural
ANV	Advanced natural
MM	Mixed mode
AC	Air conditioned

*Interpretation*

For the average percentile variable, all dataset buildings have been a) ranked into order from worse to best (left to right on bottom axis); b) split into four ventilation types c) plotted showing rank against average percentile. The buildings in the top right of the graph are "best" by these criteria.

# 6. THE FEEDBACK PROCESS

## *REALLY IMPORTANT TO:*

- *Reduce the gap between intentions and results.*
- *Assist reality-checking, benchmarking and innovation.*
- *Nail the chronic problems, which otherwise pass unrecorded.*

## *WHAT HAS PROBE DONE?*

- *Made research results more tangible.*
- *Led to greater openness in discussing problems.*
- *Improved the speed and accuracy of survey techniques.*
- *So far avoided litigation!*

## *IS PROBE REPLICABLE?*

- *Initial article and contact by BSJ: not replicable.*
- *Techniques are replicable and largely codified.*
- *Experienced multidisciplinary team, not single-issue agenda.*
- *Avoid hitting corporate and design myths head-on!*

## *NEXT STEPS?*

- *Routine PoEs and feedback. Bootstrapping benchmarks.*

# ENDS

# LINKING TOOLS

# MEANS

## What are buildings for?

*The public interest: health, safety, social benefits.*

*The triple bottom line: people, business, environment.*

*Added value: joy, humanity, delight.*

## How can feedback make things better?

*Methods of linking clients, service providers and regulation to improve understanding, products and performance in an environment of socio-technical change.*

## Is the response realistic and practical?

*Agendas for:*

*- designers and providers of buildings and components;*

*- providers of outsourced services*

### STRATEGY FIRST

Don't confuse means and ends. Define what you are about as an organisation. Be clear in the brief about objectives, performance and risk levels. Beware of property criteria dominating too much.

### KEEP HOLD OF REALITY

Manage the brief. Prescription should not trump performance.  
Identify and minimise downsides.  
Question everything, undertake: reviews and reality checks.

### GET REAL ABOUT CONTEXT

Identify constraints (site, budget, culture ...).  
Consider requirements, risk, relevance.  
Work to the occupiers' true capacities.

### ESTABLISH THE ESSENTIALS

What do you want to forget about?  
Seek good quality baseline requirements - essentials not just desirables.  
Don't procure what you can't manage.

### SHARE YOUR EXPERIENCES

Essential to learn on the job.  
Feedback internally and more widely.  
Mechanisms for disseminating attributable and unattributable items.

### OWN PROBLEMS, DON'T HIDE THEM

Tasks for the professionals.  
Tasks for the occupier's management.  
What can be reasonably left to individual occupants?

### TARGETS ARE ALWAYS MOVING

Constantly review objectives and solutions. Consider change, volatility, and risk, and seek robust solutions.  
Avoid vicious circles: seek continuous improvement. Beware that the cure may be worse than the disease.

### ADOPT OPEN SOURCE DATA

Benchmarking: start with basics.  
Measurement is key to effective results, but must be sensitive to context. Tag data with likely status.  
Cradle to grave monitoring and reporting.

### LESS CAN BE MORE

Make essential features of intrinsically efficient options.  
Seek simplicity.  
Beware of unnecessary technological complexity creating unwanted management burdens.

# WHAT'S NEW?

## *CLEARER AGENDAS:*

- *Kyoto, Egan etc.. The triple bottom line.*
- *Planning for change.*
- *PoEs now more widely accepted.*

## *PROCESS AND PERFORMANCE, NOT JUST PRODUCT*

- *Briefing objectives and getting results. Context recognition.*
- *Industry performance, benchmarking, responsible innovation.*
- *Robust integration. Follow-through. Avoiding “revenge effects”*

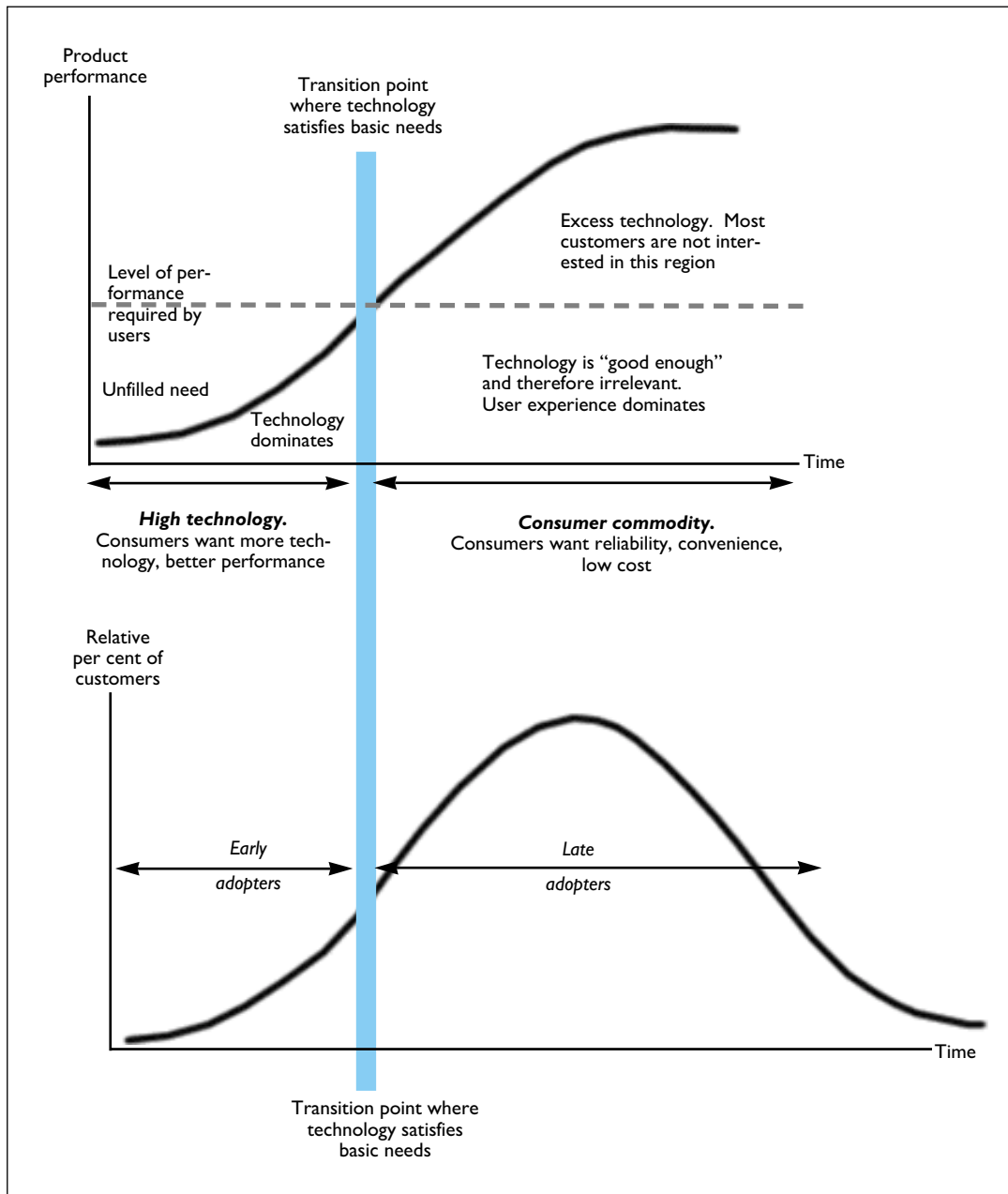
## *UNDERSTANDING AND INVOLVING THE USERS*

- *Occupant perceptions. Usability. Responsiveness.*
- *Adaptive opportunity (as end, not means).*
- *Management, manageability and maintainability.*

## *MEANS OF OF INFLUENCING DELIVERY SYSTEMS*

- *Incentives, e.g. competitive peer pressure.*
- *Guidance for all: tough points, not motherhood statements.*
- *Regulation: of various kinds; linked to benchmarks.*

### The transition in technology take-up



Source: D Norman, The Invisible Computer, p35, MIT Press (1999)

# SO WHAT?

## *EGAN*

- *Improving all-round performance and the triple bottom line.*
- *Agenda for items which add all-round value fast.*

## *KYOTO*

- *Better benchmarking of energy performance, e.g. tree diagrams*
- *Closing the gap between expectation and reality.*

## *BEST PRACTICE (via Strategic Alliances)*

- *Briefing and procurement: ends and reality-checks.*
- *Design: objectives, priorities, risk, robustness.*
- *Specification: essential features and acceptance procedures.*
- *Benchmarks: same language for briefing, review, & regulation.*
- *Contracts: to achieve the level of service requires.*
- *Overall: things that really add (or subtract) value.*

## *INNOVATION (nb: for solutions and convenience)*

- *Gentle engineering: intrinsic efficiency-usability-manageability*
- *True baselines: faster feedback to improve performance.*
- *Context: buildings not commodities, realism about 'fit+forget'.*



### Real-world research

Solving problems	... <i>rather than</i> ...	Just gaining knowledge
Predicting effects	... <i>rather than</i> ...	Finding causes
Looking for robust results and concern for actionable factors	... <i>rather than</i> ...	Statistical relationships between variables
Developing and testing services	... <i>rather than</i> ...	Developing and testing theories
Field	... <i>rather than</i> ...	Laboratory
Outside organisation (eg business)	... <i>rather than</i> ...	Research institution
Strict time and cost constraints	... <i>rather than</i> ...	R&D environment
Researchers with wide-ranging skills	... <i>rather than</i> ...	Highly specific skills
Multiple method	... <i>rather than</i> ...	Single method
Oriented to client	... <i>rather than</i> ...	Oriented to academic peers
Viewed as dubious by some academics	... <i>rather than</i> ...	High academic prestige

**Source:** Adapted from Box 1.2 of Robson R., *Real-world Research* London, Blackwell, 1993.

# IMPROVING THE PROCESS

## *BRIEFING*

- *Clearer definition of ends. Reality-checking.*
- *Usability issues: “don’t procure what you can’t manage”.*

## *DESIGN*

- *Keep things simple and do them well.*
- *Build users and management into the control loops.*
- *Get to the roots of energy consumption.*

## *CONSTRUCTION*

- *Make sure essential features are not treated as optional extras.*
- *Avoid nasty surprises with attention to detail, e.g. airtightness.*

## *AT AND BEYOND HANDOVER*

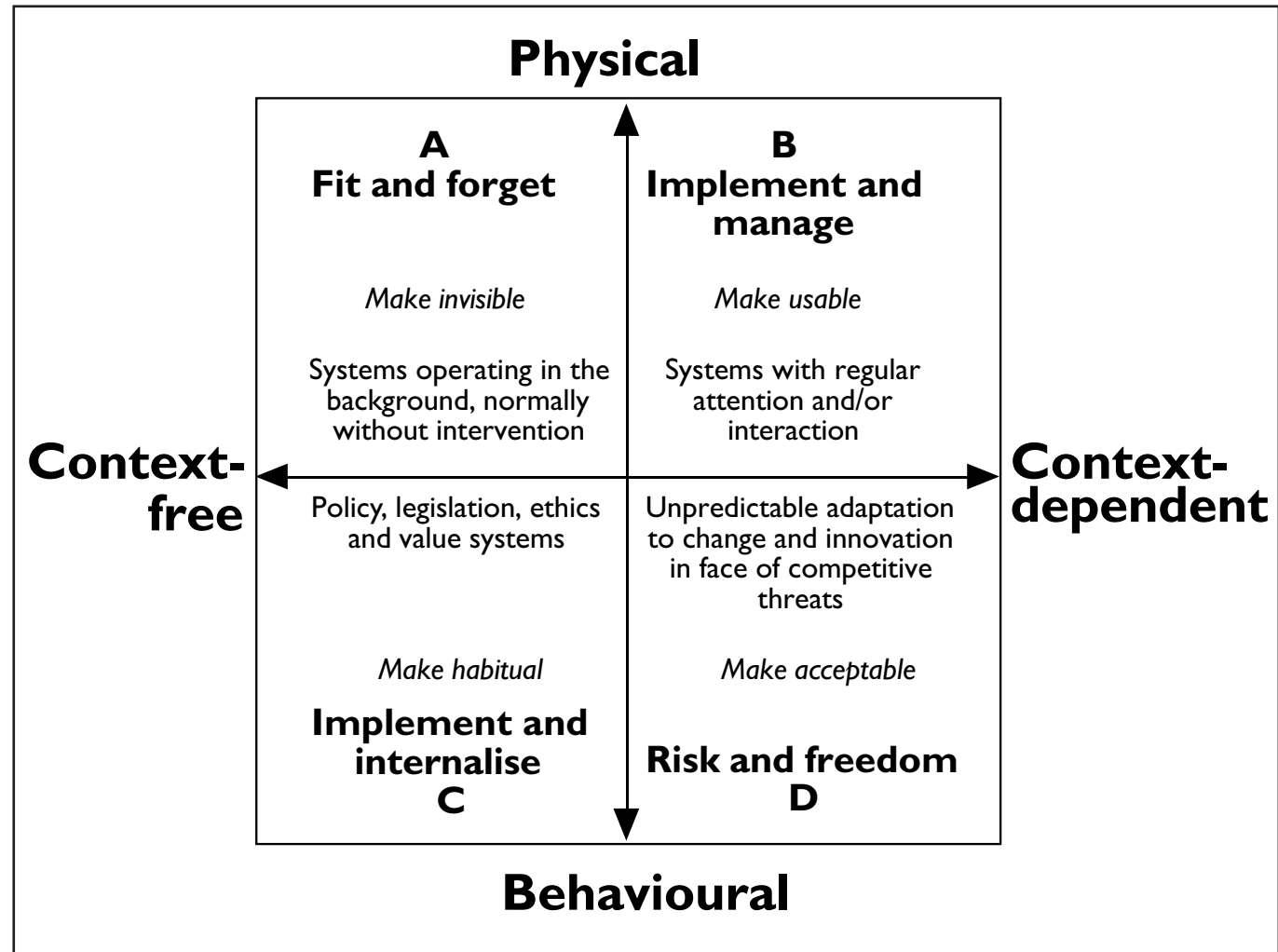
- *Get more right first time, but ...*
- *Also provide after sales support, e.g. “sea trials”.*

## *FACILITIES MANAGEMENT*

- *Make sure appropriate management systems are put in place.*
- *Don’t outsource your feedback loops.*

## *BENCHMARKING AND FEEDBACK THROUGHOUT*

# Dimensions of excellence in building performance



# WHERE TO START

## *TACKLE THE SIMPLE CHRONIC PROBLEMS*

- *e.g. Airtightness, Usability, Poor intrinsic efficiency, Handover.*

## *IMPROVE COMMUNICATION WITH CLIENTS & COLLEAGUES*

- *To create the contexts in which the simple things can happen.*

## *ROUTINE FEEDBACK*

- *On technical & energy performance & occupant satisfaction.*
- *With accessible, usable data.*

## *INDUSTRY BENCHMARKS*

- *Using a language which is intelligible to all parties at all stages of the process: briefing, design, standard-setting, regulation, construction, acceptance, management, research ...*

## *INSTITUTIONAL COLLABORATION*

- *To promote the embedding and improvement of essential, with good practice and aspirational benchmarks.*

## *A CULTURE OF CONTINUOUS IMPROVEMENT*

- *With a rolling agenda of priorities.*

# STRATEGIC ALLIANCES: 1

## *NEED FOR ALLIANCES*

- *Probe messages are highly relevant: Kyoto, Egan, etc..*
- *Up to now only BS Engineers – important, but not key players.*
- *Conventional dissemination often ignored/overlooked/buried.*
- *Probe lessons need to be tightly bound into other agendas.*

## *ALLIANCES WITH WHOM?*

### *Most influential:*

- *Developers, financial institutions, occupiers and owners.  
(but frequently Agent holds the key!).*
- *Government (in many forms).*

### *For new buildings:*

- *Mainly: client, QS, PM, architect.*
- *Less: other engineers and specialists.*

### *For existing buildings:*

- *Owners and their property/buildings departments.*
- *Facilities Managers and maintenance contractors.*

# STRATEGIC ALLIANCES: 2

## *TASKS:*

- *absorb main messages from Strategic Review*
- *identify and consider bodies to be contacted*
- *hold exploratory meetings*
- *present Probe findings and messages to representatives*
- *develop action plans with three sympathetic/influential bodies*
- *develop action plans with main professional bodies*
- *report to DETR on future actions required*

*~200 BUILDING INDUSTRY BODIES FROM ACE TO WWSMA!*

# STRATEGIC ALLIANCES: 3

## *CONTACTS MADE WITH:*

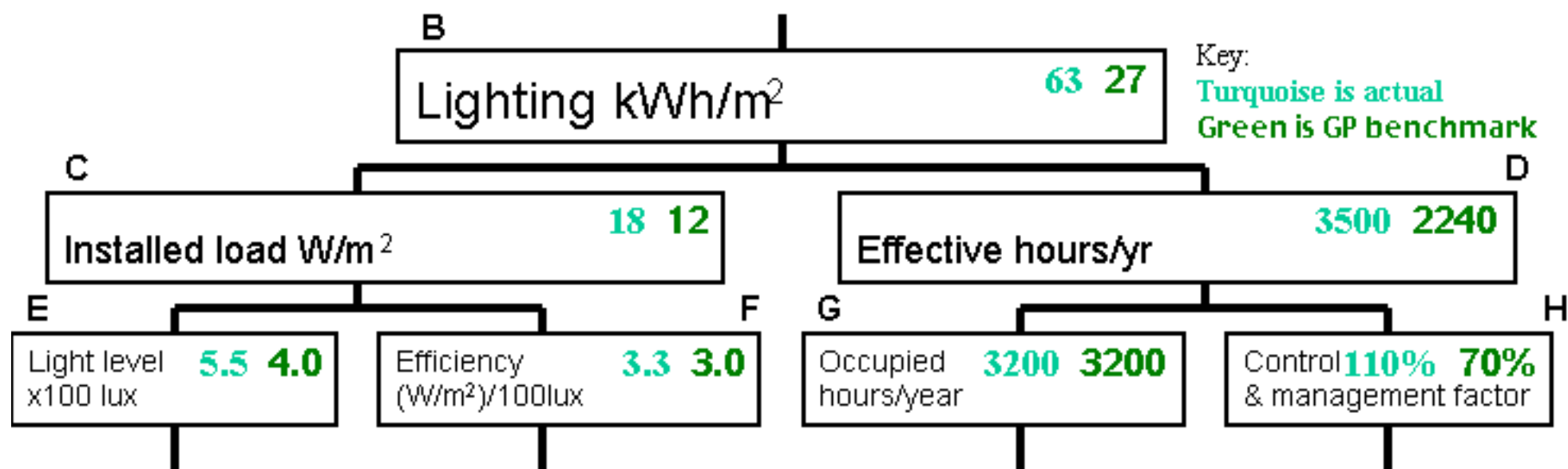
- *BCO, considering BPF too.*
- *CIC, Research and Innovation Committee.*
- *Construction Round Table.*
- *RIBA, CIBSE & ICE (presentations & Edge Debates).*
- *BIFM & maintenance contractors.*
- *DETR.*

## *CONTACTS TO BE MADE WITH:*

- *Construction Clients Forum.*
- *Construction Confederation – Sustainability Focus Group.*
- *RICS, Property Agents.*
- *ACE?*
- *Forum for the Future?*

# LIGHTING ENERGY CONSUMPTION IN AN AIR-CONDITIONED OFFICE

Each box can be considered as a benchmark



## Lighting benchmarks: typical

	Type1 Nat vent Cellular	Type2 Nat vent Open plan	Type3 Air cond Standard	Type4 Prestige HQ
C W/m <sup>2</sup>	15	18	20	20
G hrs/year	2500	3000	3200	3500
H % on	60%	70%	85%	85%
B kWh/m <sup>2</sup>	23	38	54	60

## Lighting benchmarks: good

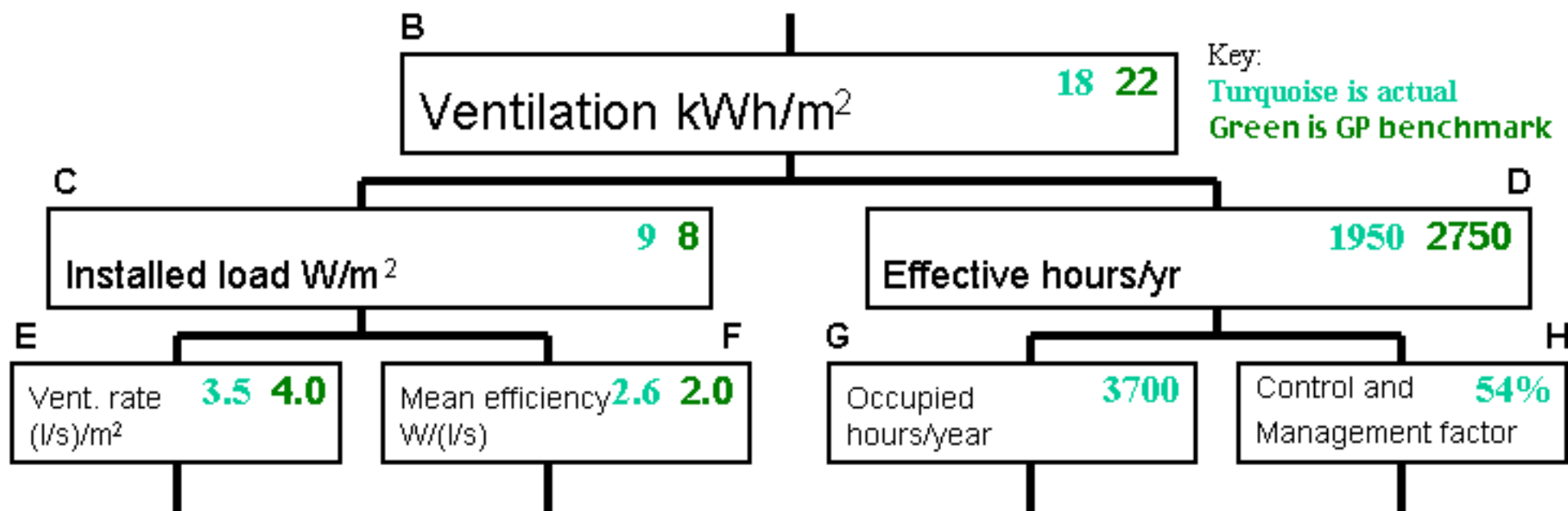
	Type1 Nat vent Cellular	Type2 Nat vent Open plan	Type3 Air cond Standard	Type4 Prestige HQ
C W/m <sup>2</sup>	12	12	12	12
G hrs/year	2500	3000	3200	3500
H % on	45%	60%	70%	70%
B kWh/m <sup>2</sup>	14	22	27	29

"Good" 12 W/m<sup>2</sup> is nominally 400lux & 3W/m<sup>2</sup> per 100 lux.



# VENTILATION ENERGY CONSUMPTION IN AN AIR-CONDITIONED OFFICE

Each box can be considered as a benchmark

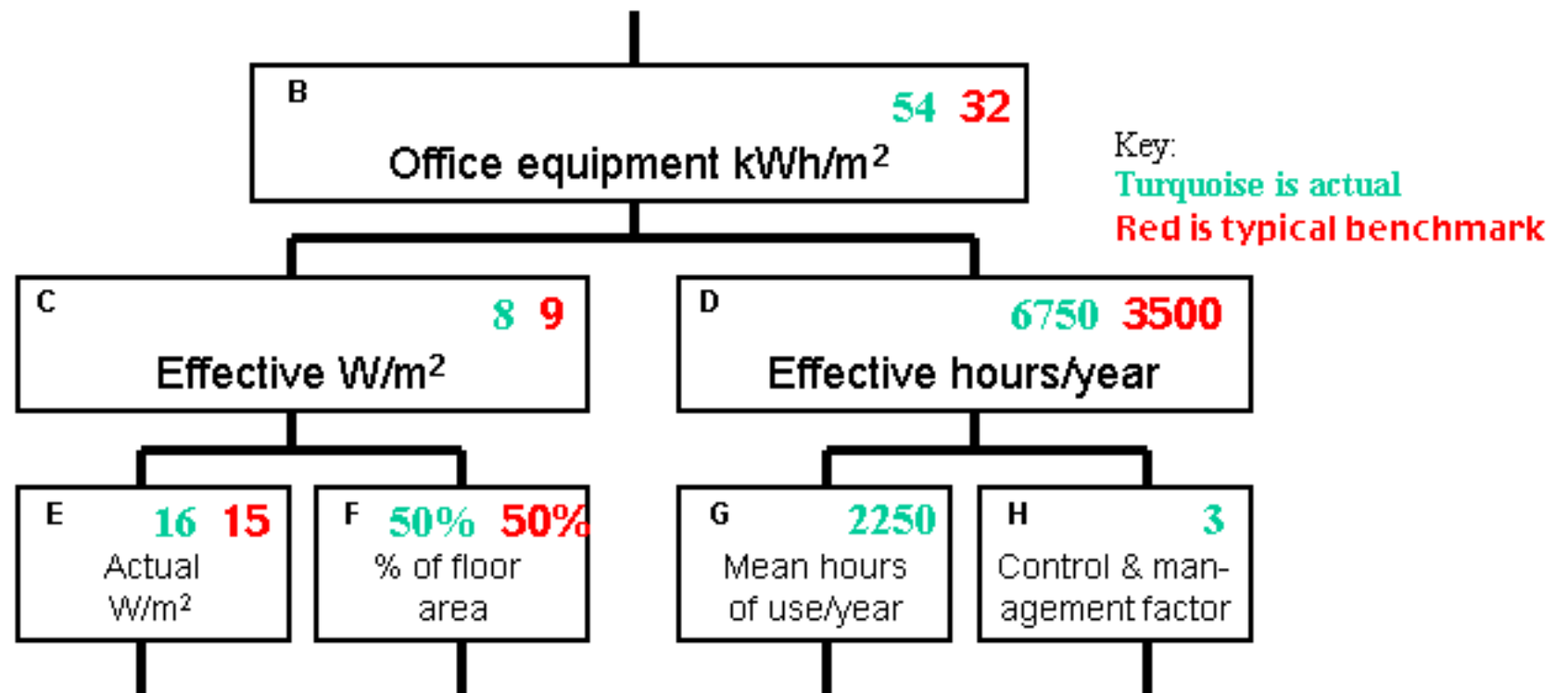


## Air handling benchmarks:

	GOOD:		TYPICAL:	
	Type3	Type4	Type3	Type4
	Air cond	Prestige	Air cond	Prestige
	Standard	HQ	Standard	HQ
E (l/s)/m <sup>2</sup>	4	4	4	4
F W/(l/s)	2	2	3	3
C W/m <sup>2</sup>	8	8	12	12
D hrs/year	2750	3000	3500	3700
B kWh/m <sup>2</sup>	22	24	42	44

# OFFICE EQUIPMENT ENERGY CONSUMPTION IN AN AIR-CONDITIONED HEAD OFFICE

*Not including separate print, computer and communications rooms*



### Office equipment benchmarks: good

	Type1 Nat vent Cellular	Type2 Nat vent Open plan	Type3 Air cond Standard	Type4 Prestige HQ
E W/m2	10	12	14	15
F % area	60%	65%	60%	50%
D hrs/year	2000	2500	2750	3000
B kWh/m2	12	20	23	23

### Office equipment benchmarks: typical

	Type1 Nat vent Cellular	Type2 Nat vent Open plan	Type3 Air cond Standard	Type4 Prestige HQ
E W/m2	12	14	16	18
F % area	60%	65%	60%	50%
D hrs/year	2500	3000	3250	3500
B kWh/m2	18	27	31	32

