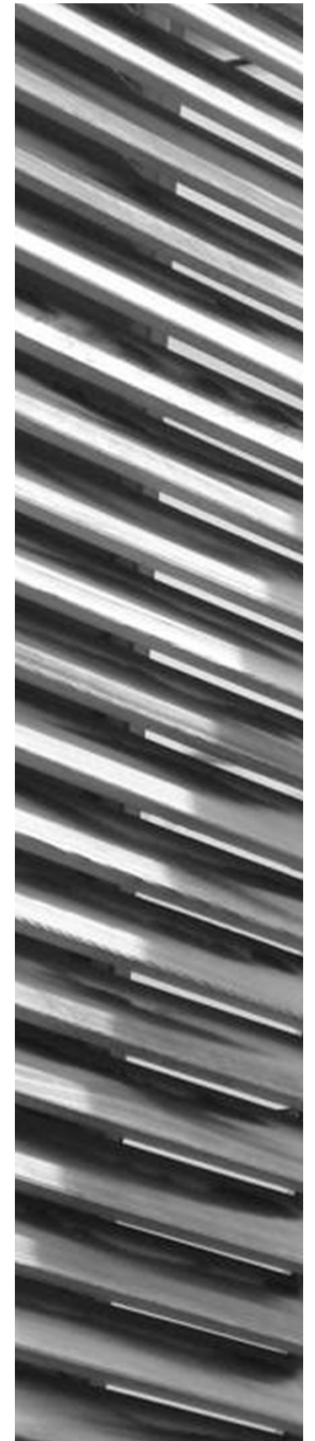


Practical assessment of window shutters for night insulation and solar shading for domestic buildings

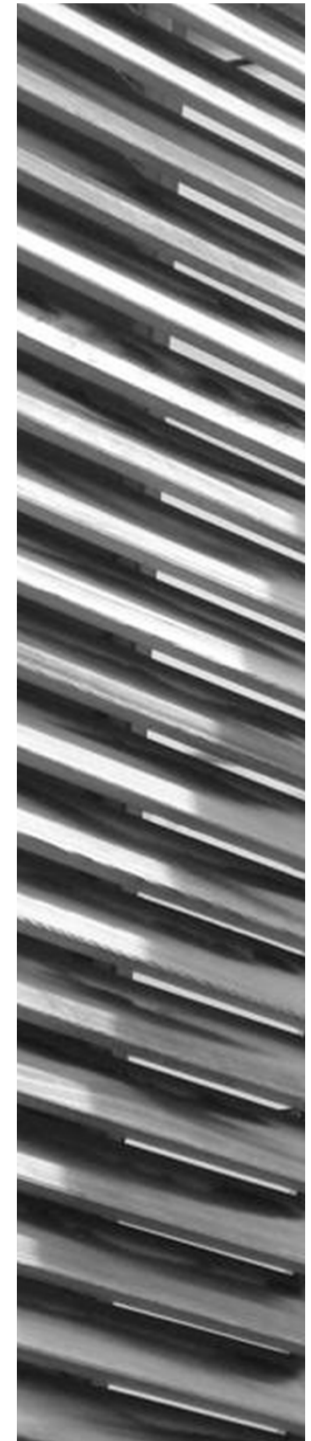
Jessica Winter

November 2007



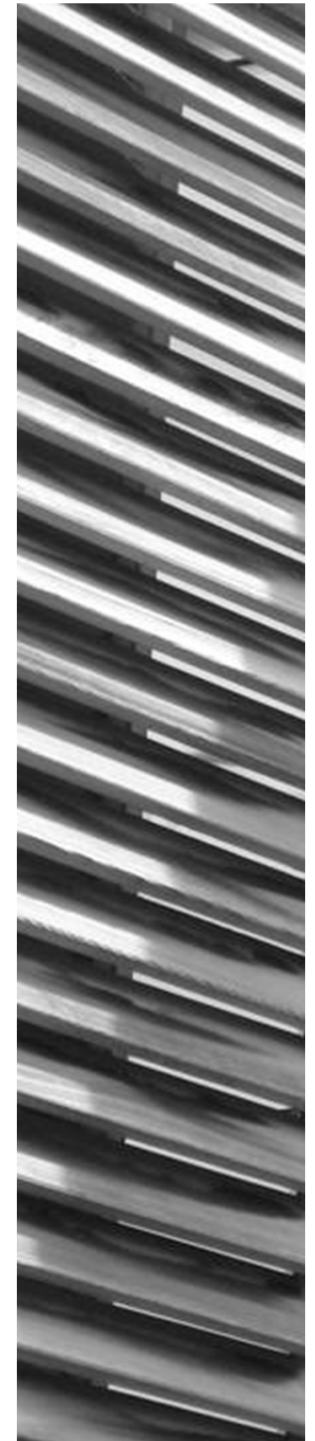
Motivation for study

- A technology that could potentially:
 - Help **mitigate** climate change through energy savings
 - Help **adapt** buildings to climate change by making them more robust to temperature changes
- A technology that can reduce heat gain in summer and heat loss in winter
- Could help improve comfort in existing NZ homes, particularly those with single glazing



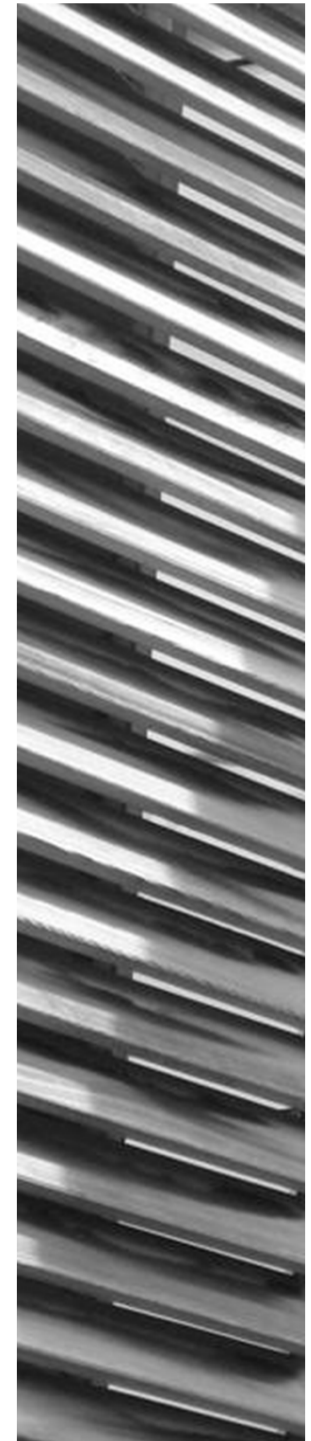
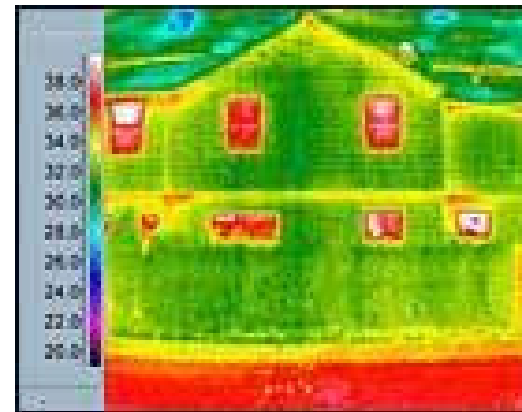
Format of talk

1. Background to the problem of windows
2. Hypothesis of a solution
3. Methodology of experiments
4. Results and analysis
5. Evaluation of solution



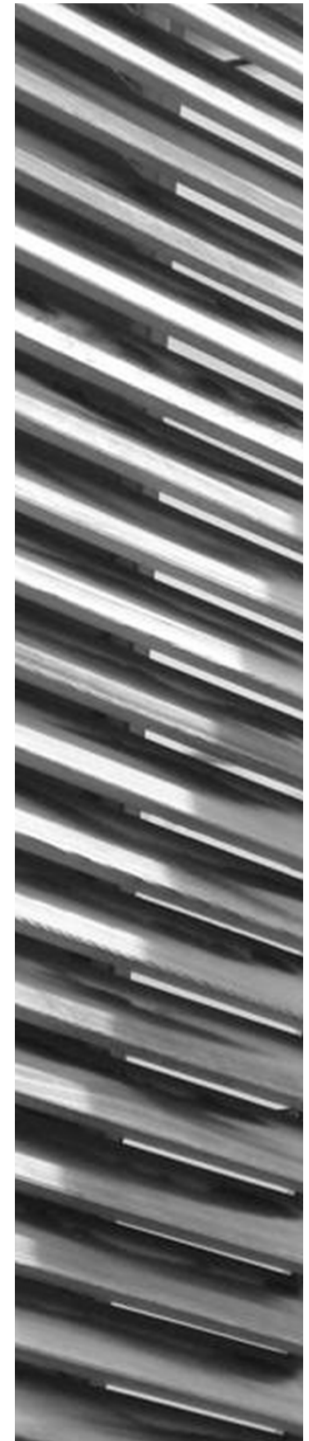
Windows

- Comprise 10% of total building envelope but 20% of heat loss occurs through windows
- weak point in terms of acoustics, security and ingress of water
- But critical for passive solar heating, daylighting, ventilation and visual contact with nature



Heat loss, thermal comfort and energy efficiency

- Reducing heat loss in winter should still be priority in New Zealand
- buildings in other countries with temperate climates are suffering from overheating as a result of higher internal gains and a higher ambient air temperature.
- The 'urban heat island' in cities can exacerbate this problem

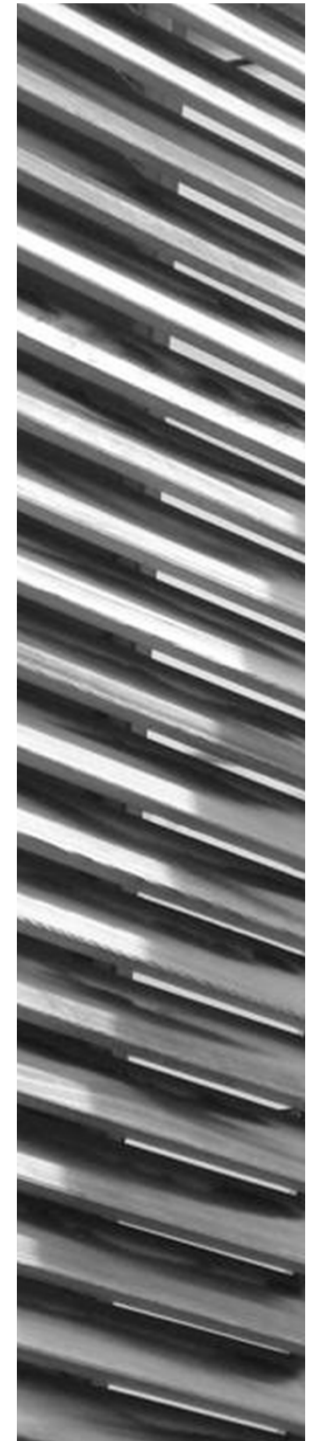


Adapting to climate change

'Warming of the climate is unequivocal, as is now evident from increases in global average air and ocean temperatures, widespread melting of snow and ice, and global mean sea level.'

(IPCC presentation to UN Climate Change Conference, Nairobi, 2007)

- **In New Zealand NIWA expect warming of average air temperature of between 1.5°C and 3°C by 2080**
(IPCC mid-range emissions scenario)(NIWA 2007)
- **An increase in the number of days above 25°C is expected, particularly at already warm northern locations, and potentially in the arid climate of central southern regions**



Conventional solution: air conditioning

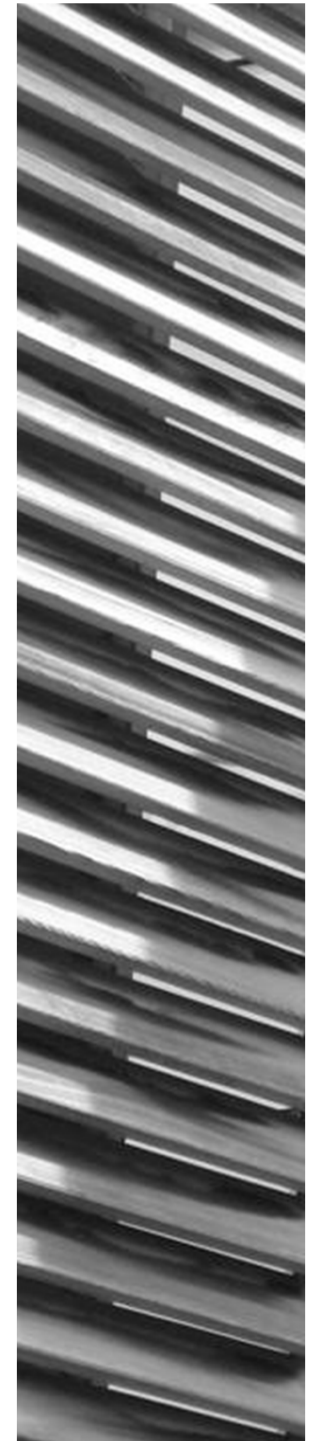
- increase in air conditioning markets around the world
- In the UK this is as a result of higher ambient air temperatures in summer and decreased costs and greater availability of domestic systems.
- In New Zealand the air conditioning market has doubled in the last decade.
- AC and heat pumps can contribute to peak electricity loads in New Zealand

'Air-conditioning can double the electricity consumption of a house and its associated carbon emissions...' (EST (UK) 2005)



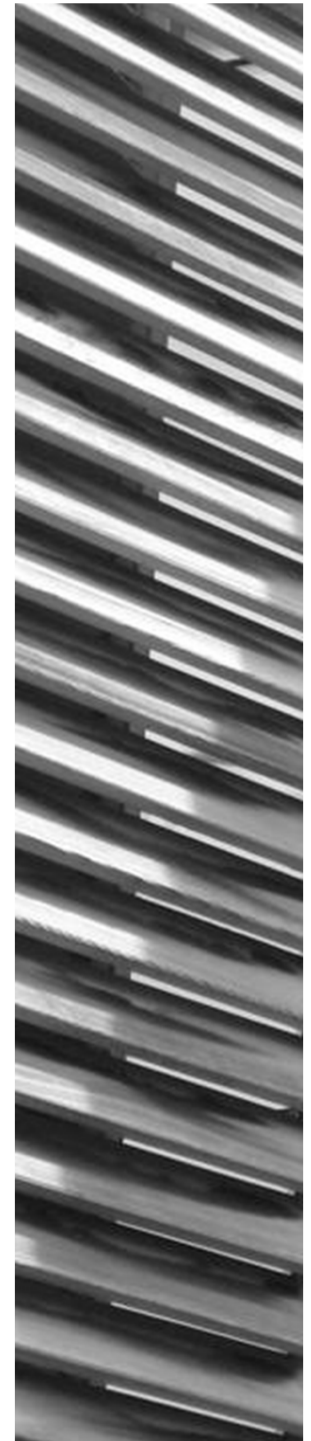
greenbuilding

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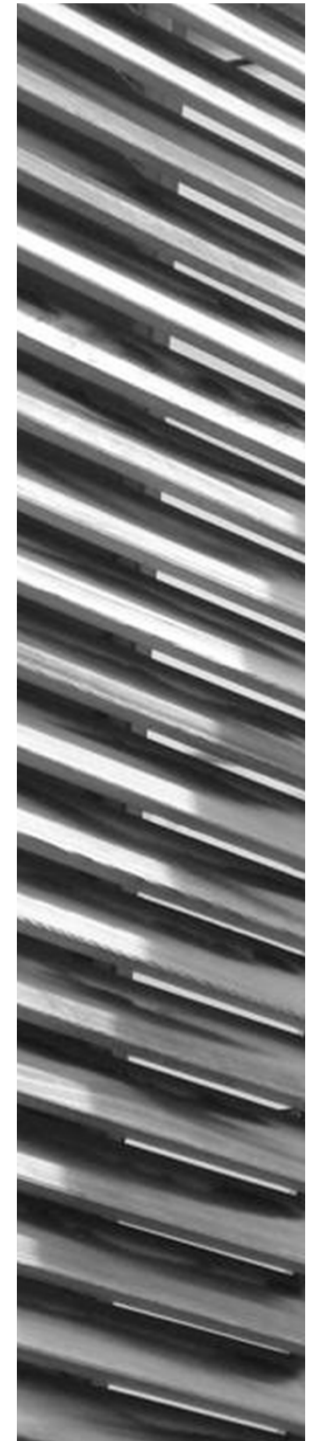
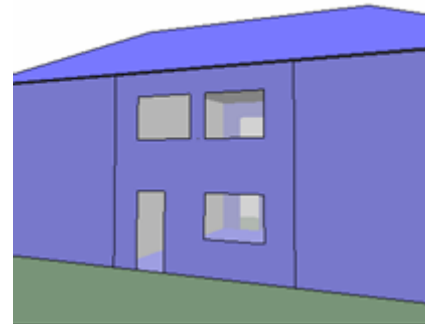
Hypothesis: Shutters can:

- **as night insulation, reduce heat loss**
- **As solar shading, reduce overheating**
- **Allow for secure ventilation**
- **Low tech, familiar**
- **Adjustable: to suit the season or the time of day**
- **In NZ, cheaper to install than retrofitting double glazing**



Experiment to measure effectiveness of shutters

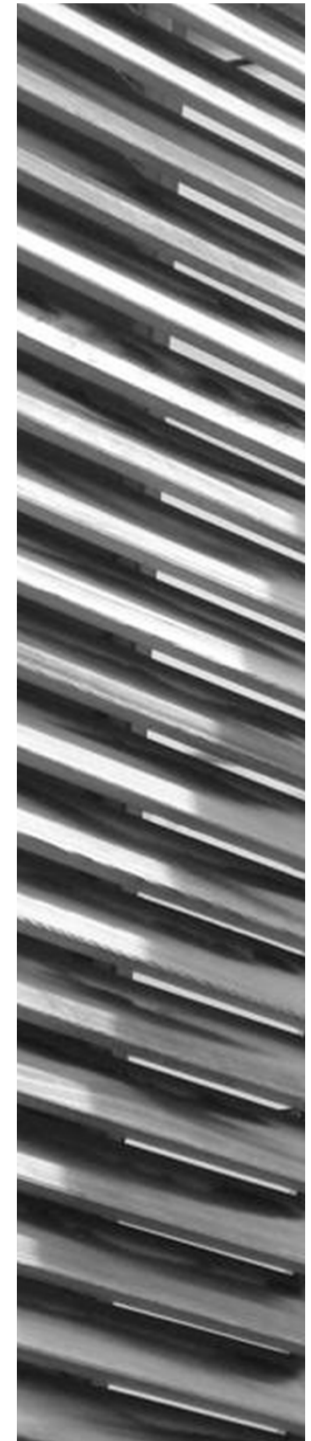
- test the R-values and shading coefficients of shutters and blinds using test cells
- apply data to a computer simulation of a 'real' dwelling
- assess energy saving potential of the systems in current and future climate



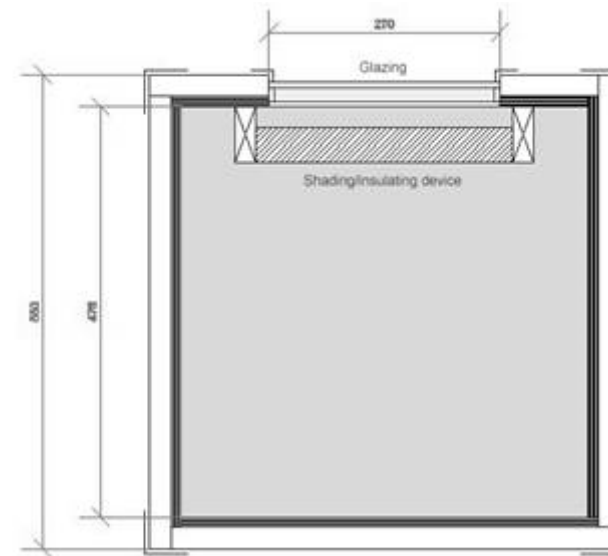
R-values and SHGCs of shutters

Window treatment	Theoretical R-value (m^2KW^{-1}) ¹	Approx. Solar Heat Gain Coefficient (SHGC) ²
Unshaded single glazed window (glazing only)	0.18	0.70
Unshaded double glazed window (IGU) (glazing only)	0.36	0.64
IGU with external louvred shutters	0.44	0.11
IGU with external Solid shutters	0.60	0.01
IGU with internal louvred shutters	0.44	0.46
IGU with internal solid shutters	0.60	0.09 ³

data implies that solid external shutter would perform the best (High R-value, low SHGC)

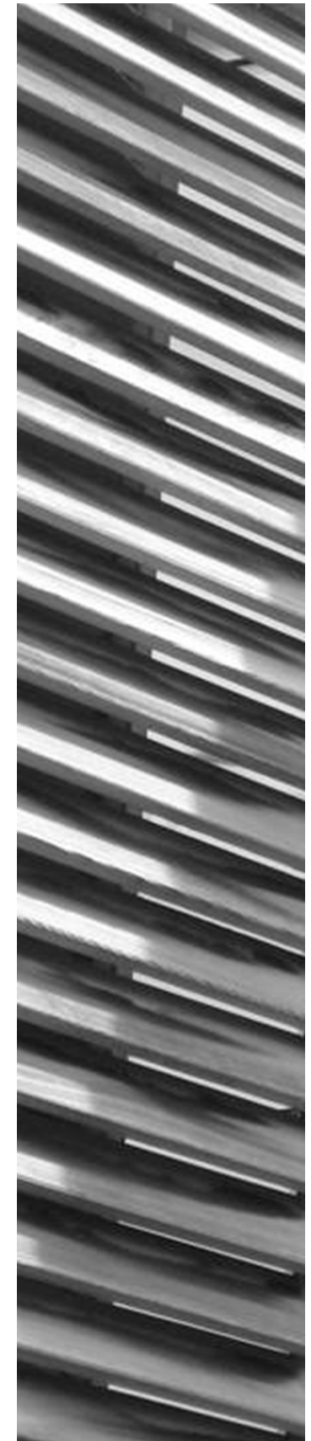


Test cells

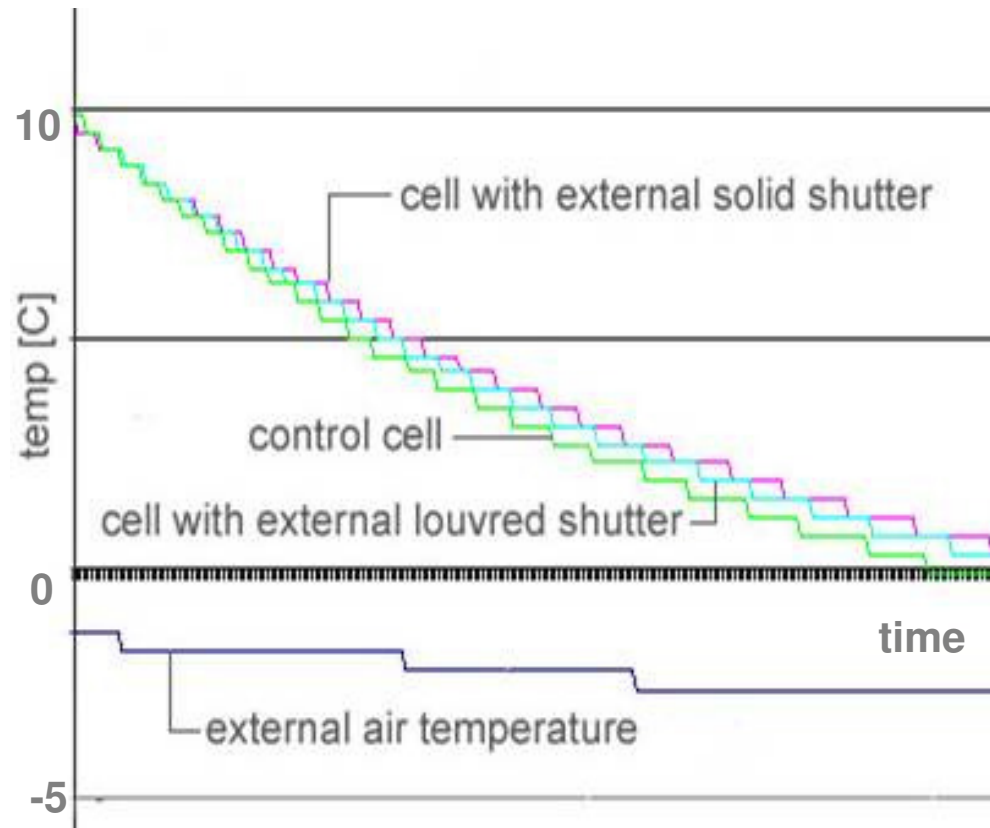


Plan of test cell

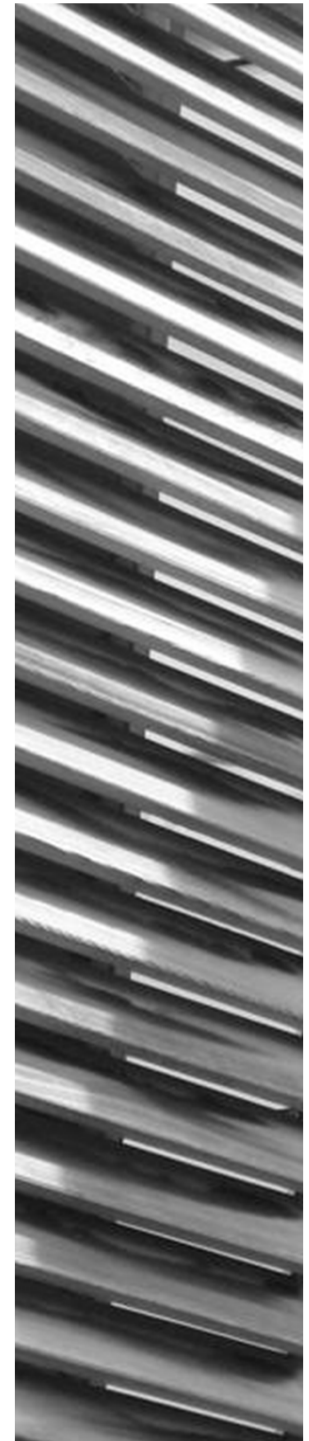
Data logger



Winter: Heat loss



- minor improvements in heat loss over winter nights
- even louvred shutter reduced heat loss



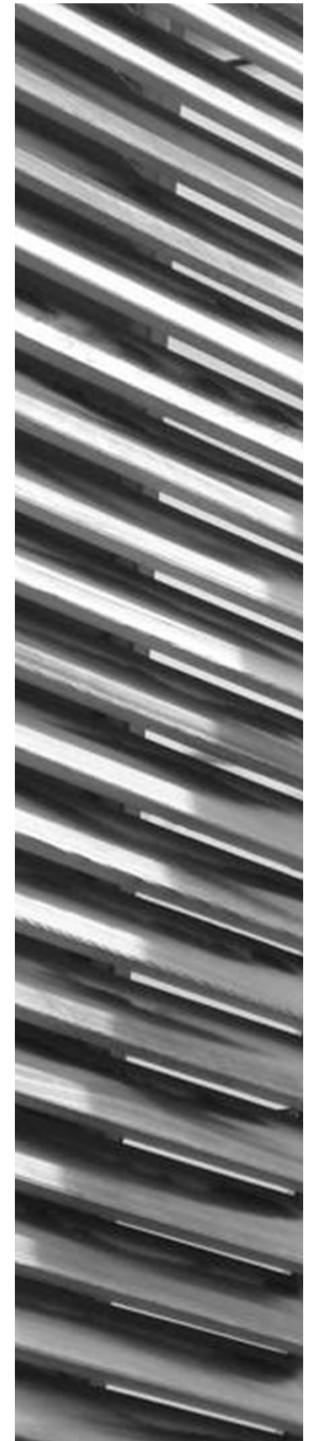
Reduction in condensation



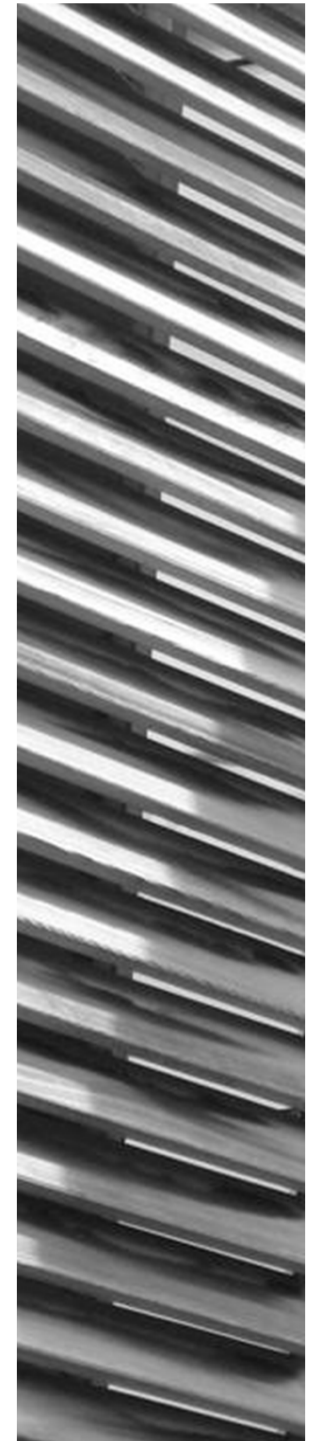
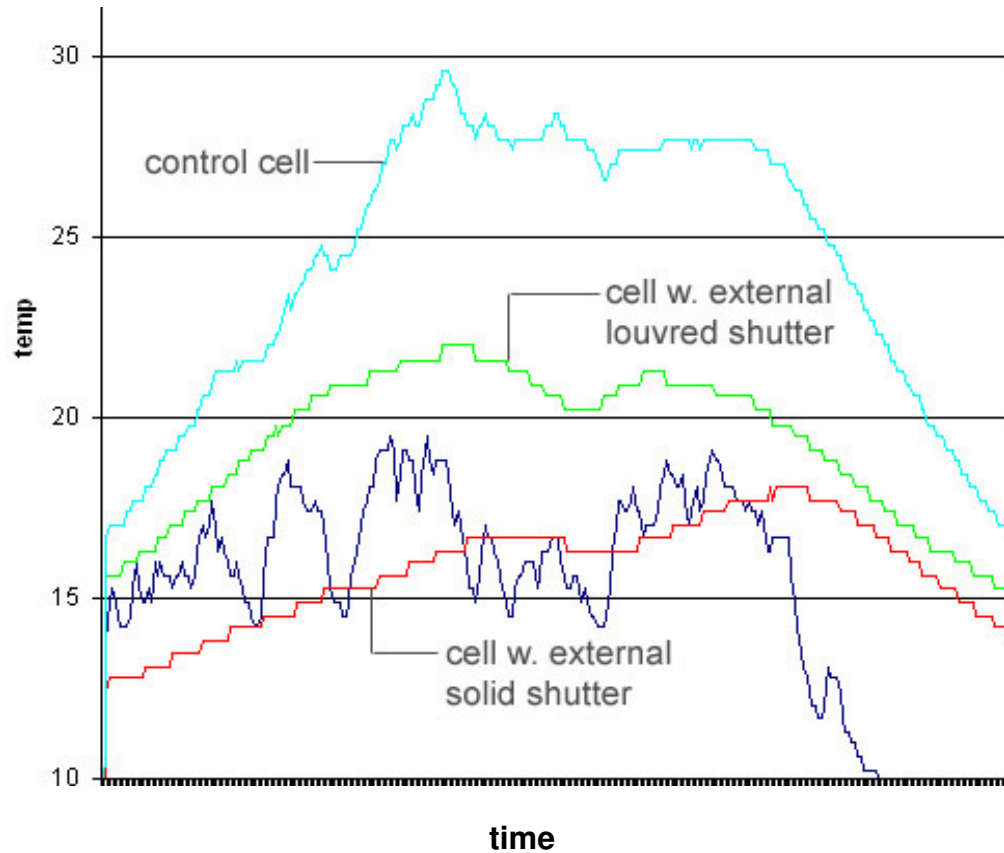
Uninsulated glazing



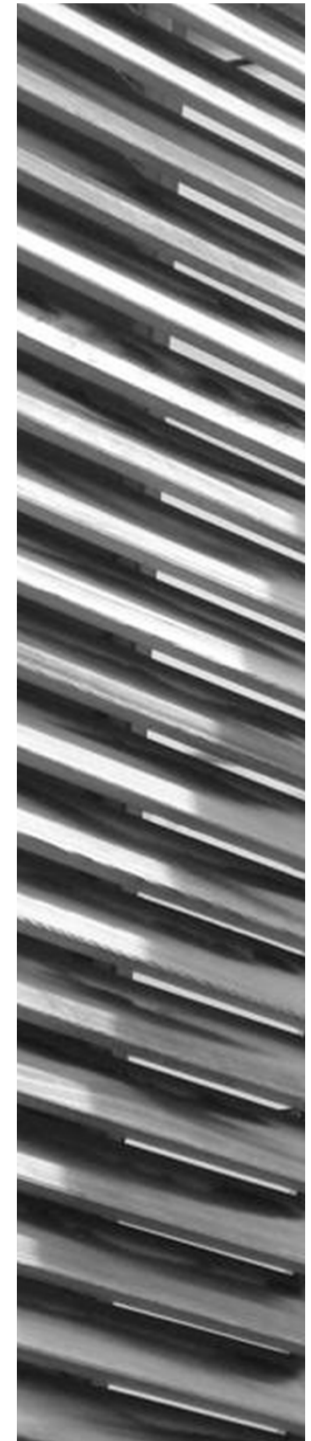
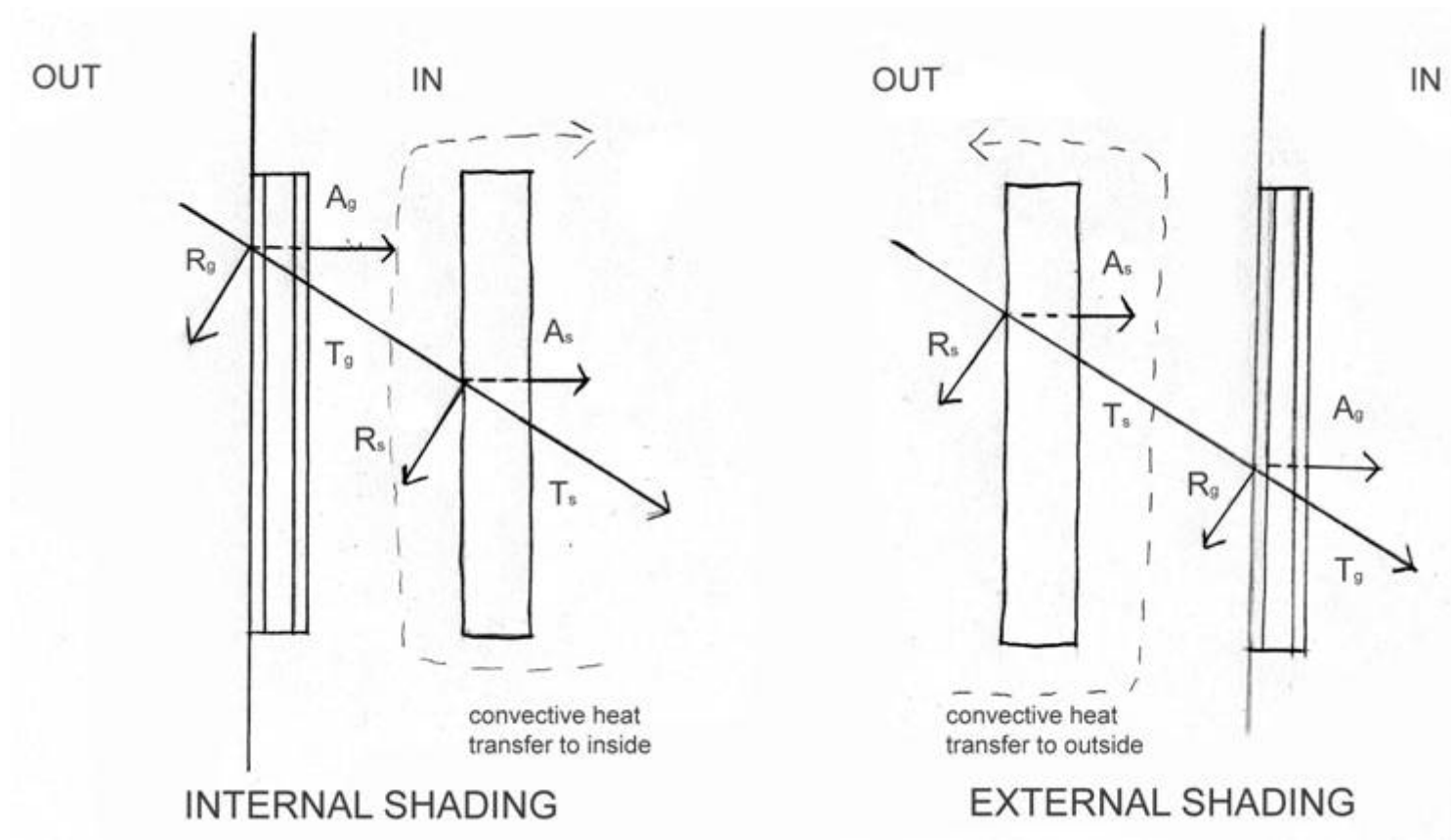
Glazing with Louvred shutter



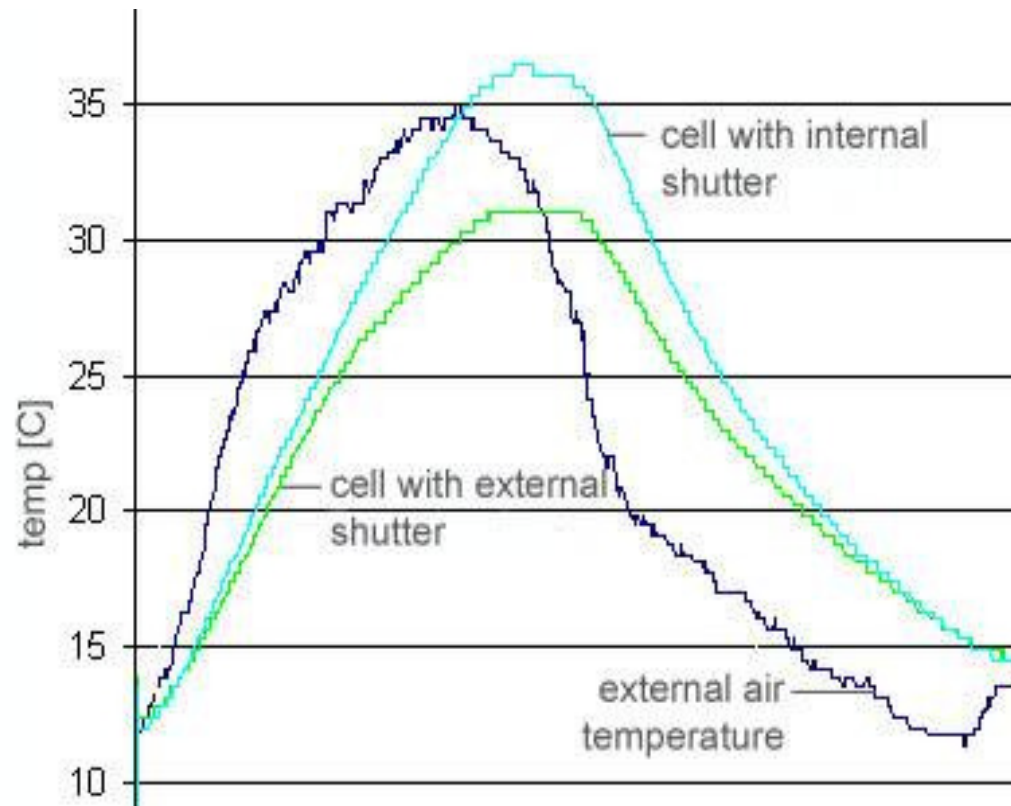
Summer: shutters for reducing heat gain



Internal versus external shading devices

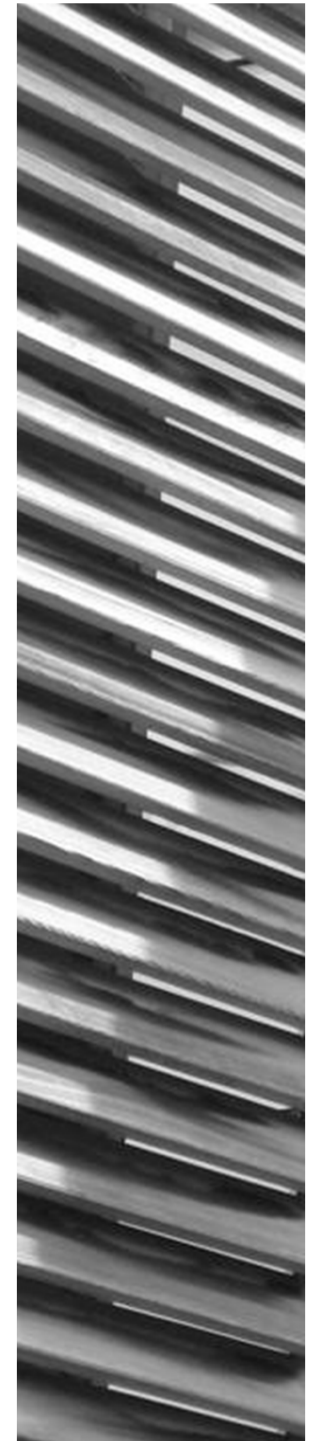


Is external shading better than internal?

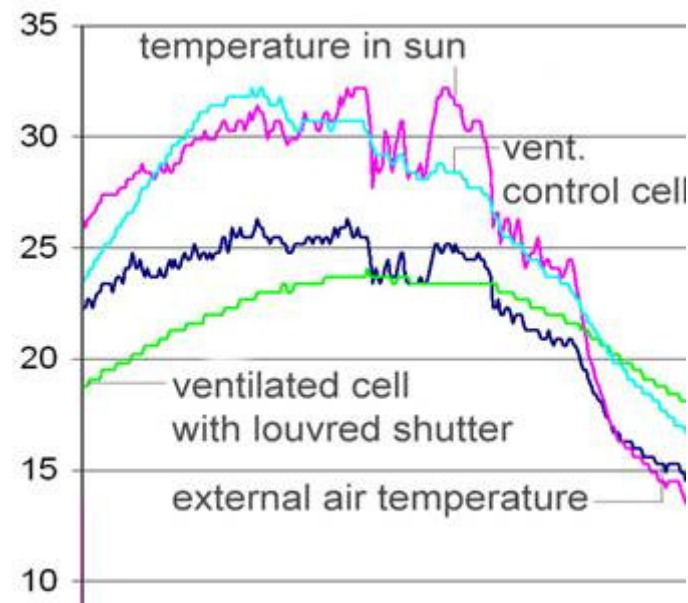
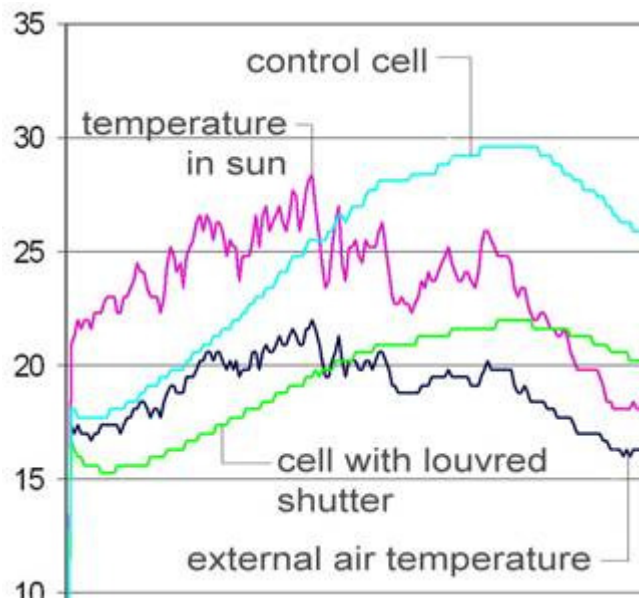


greenbuilding

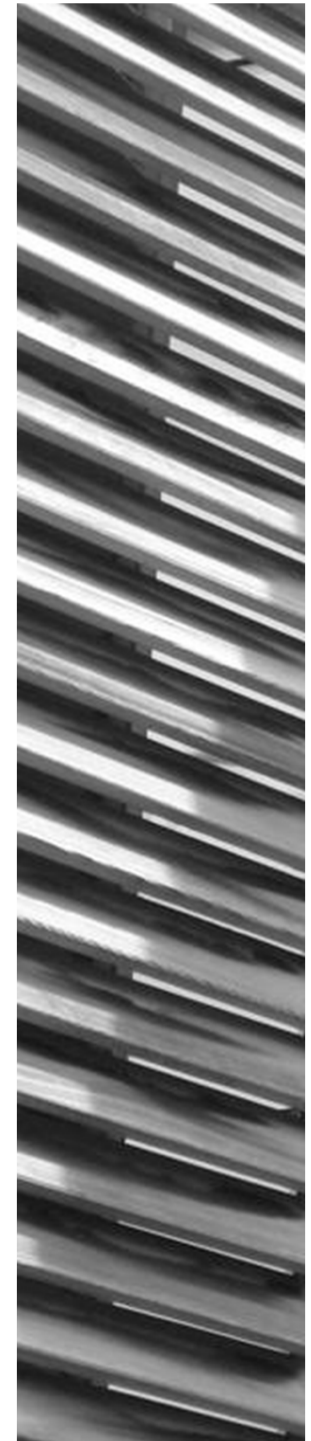
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Combining shading and ventilation



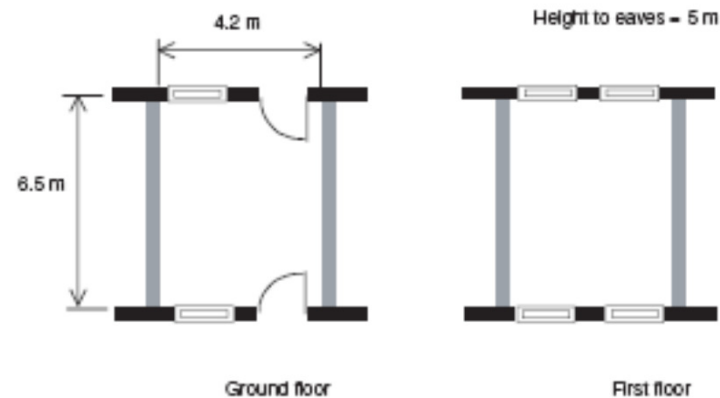
When combined with ventilation the best result was produced by an external louvred shutter



Simulated building

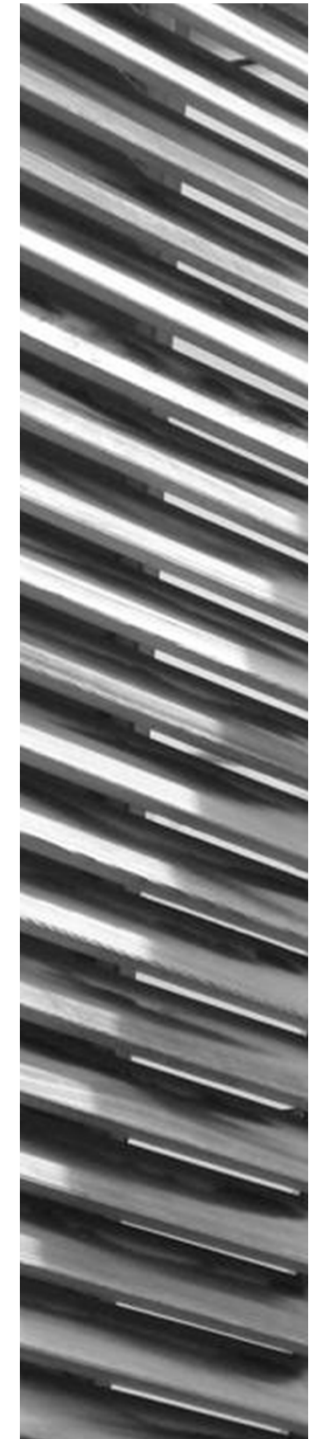
Table F1 Data for the two bedroom mid-terrace house with conventional gas boiler

Element	Description	Area	U-value
Wall	Brick/cavity/dense block with cavity insulation	26.4	0.35
Roof	Pitched roof, insulation between and above joists	27.3	0.16
Ground floor	Suspended timber, insulation between joists	27.3	0.25
Windows and doors	Double glazed low-E, wooden frame	13.6	2.0
Heating	Central heating with conventional gas boiler (efficiency 78%)		



- In winter the shutters are closed between 18:00 and 08:00

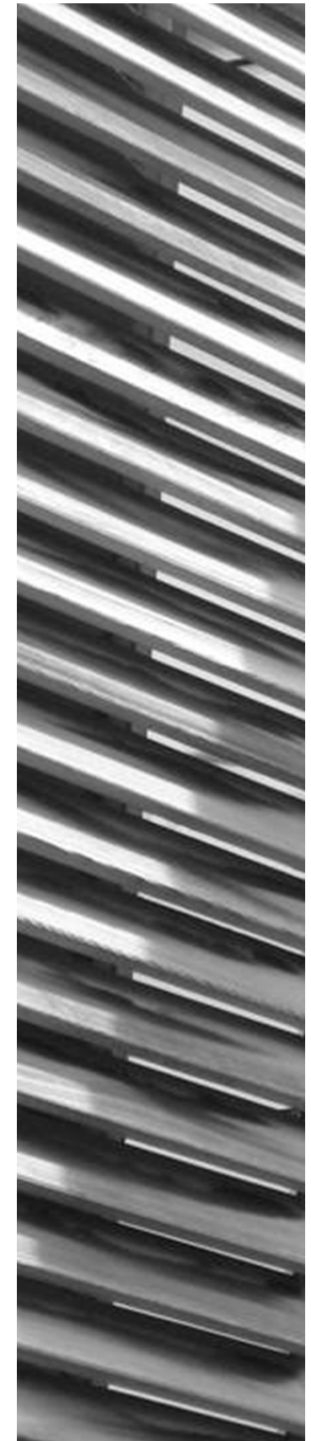
- In summer the shutters are closed between 08:00 and 18:00



Heating and cooling energy

	Heating energy (to 18°C) kWh	Cooling energy (to 23°C, using air conditioning) kWh	Total heating and cooling energy kWh
Base (IGUs with no window treatment)	1890	315	2205
Solid external shutters to all windows	2010	12	2022
Louvred external shutters to all windows	1960	29	1989
Solid internal shutters to all windows	1790	40	1830
Louvred internal shutters to all windows	1840	105	1945
Blinds to all windows	1900	53	1953

Unexpected outcome: external shading systems blocked some useful solar gain during the spring and autumn: more flexible operation in shoulder seasons needed

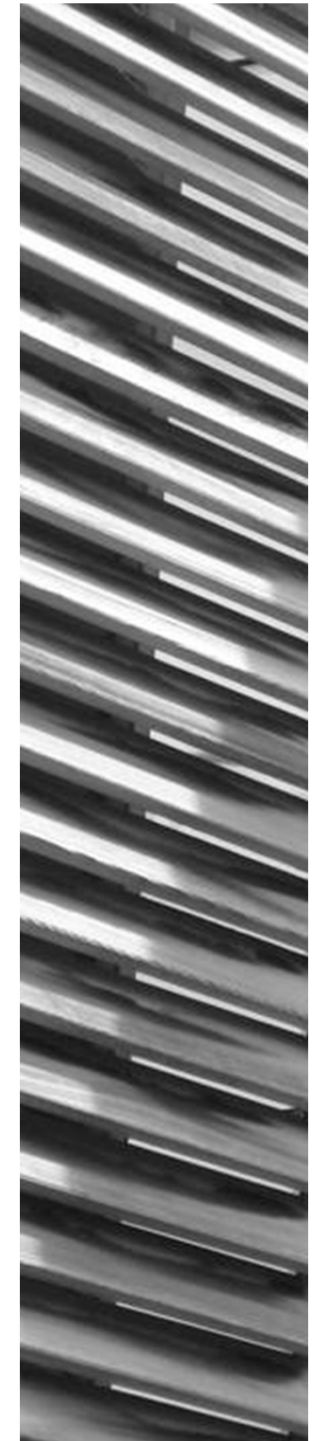


CO₂ emissions in current and future climate (UK)

	Current climate		2050 climate ¹	
	heat	cool (23°C)	heat	cool (23°C)
Base	359	135	351	528
Solid external shutter	384	4	351	102
Louvred external shutter	373	11	351	190
Solid internal shutter	341	19	323	217
Louvred internal shutter	351	46	337	327
Blind	362	23	344	251

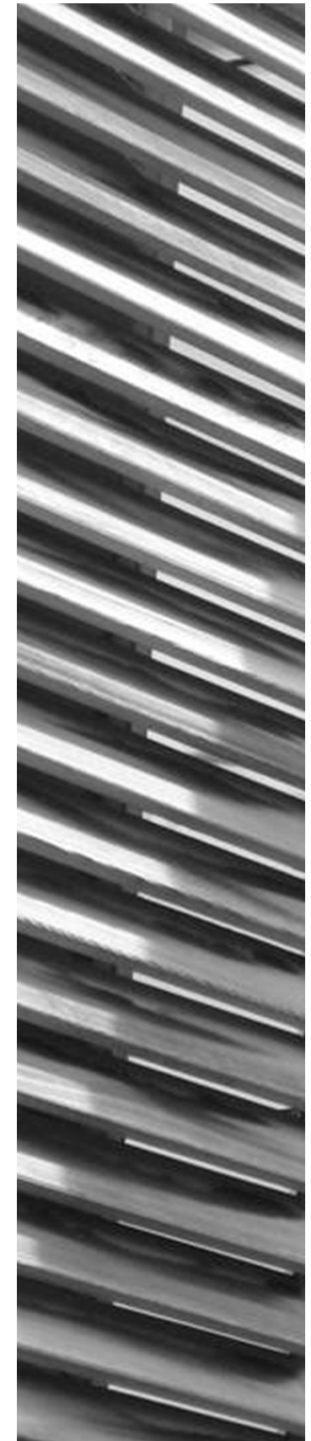
¹ Annual average temperature increase of 2.5 °C (UKCIP scenario for the southeast UK in 2050s based on medium-high (business as usual) emissions)

In a warmer climate the demand for heating decreases slightly while the demand for cooling increases fourfold: a 75% increase in energy consumption overall



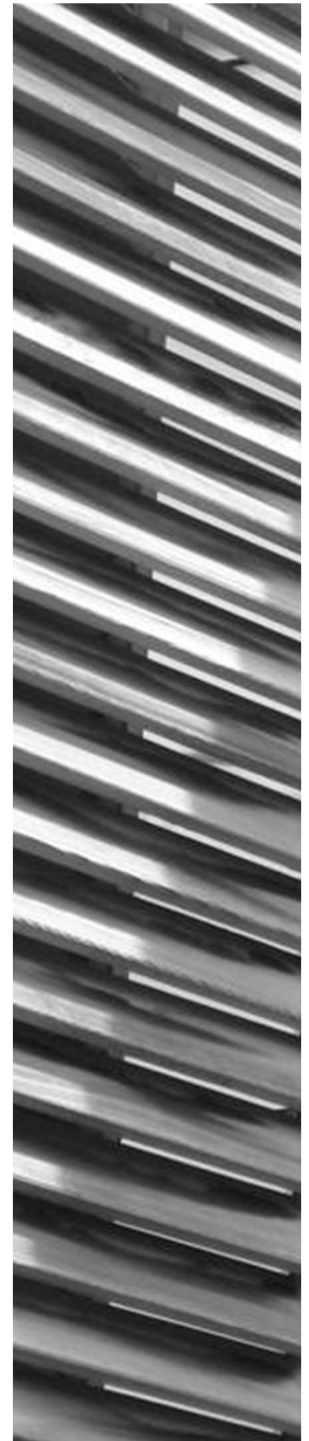
Technical Evaluation

- Require user interaction
- Window design: outward opening
- Internal shutters more user-friendly (less effective at cooling)
- For cooling, should be coupled with ventilation



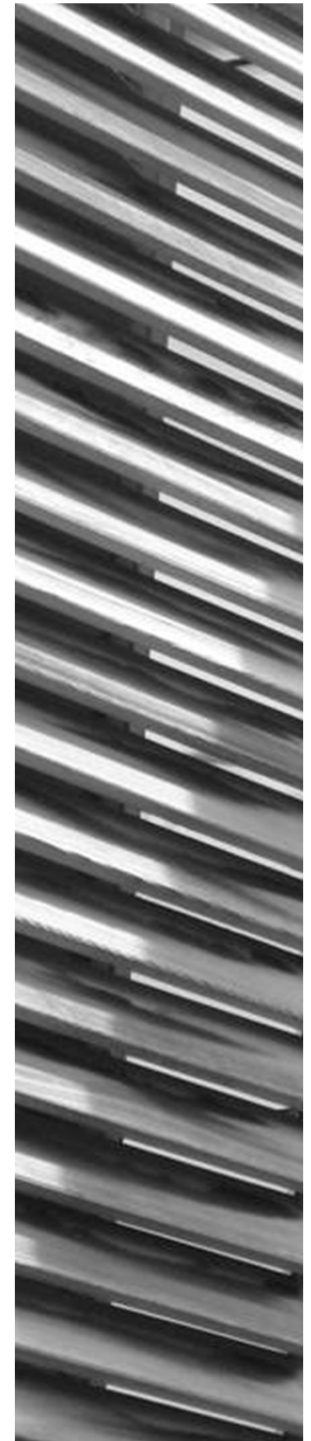
Economic evaluation

- Never pay back in terms of energy savings alone
- Can be an economic alternative to installing a new A/C or heat pump system



Conclusions

- Permeable (louvred) shutters can be just as efficient as solid systems if **combined with ventilation**.
- Internal systems are less effective than external systems, but perform adequately provided they are impermeable and are well sealed when closed.
- However, **internal shutters are more convenient to install and use** and are more likely to be used efficiently by occupants.



Further research

- More New Zealand based research
- Daylighting?
- Standards for overheating?
- Important to recognise the impact of AC devices on NZ's energy consumption – Learning from other countries mistakes
- Alternative to retrofitting double glazing in New Zealand?

