Solar Air Heating and Ventilation in Classrooms

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Massey University

Project Background

Evidence that warm, dry homes improves health;

- less wheeze, doctor visits, reduced hospitalisation, improved IAQ, reduced school absenteeism

Does improving classrooms improve health,

IAQ and absenteeism?

NZ Classrooms

NZ has 30,000 classrooms on 8000 hectares of land - mixed stock & quality

Replacement value of $2.4 Billion.

Mostly;

single storey,

single glazed,

natural ventilation but built in a row of classrooms with only 1 or 2 exterior walls – cross ventilation challenging

.

Energy in Schools

2/3 of energy used for space heating, even with the windows closed.

Energy expenditure capped at 2010 levels.

Energy efficiency are measures required or ventilation problems will increase as a cost saving measure.

During winter classrooms

NZ Classrooms are under ventilated and too cold.

Classrooms have high winter bacteria levels.

Teachers typically don't open windows until lunchtime.

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$0.5B - $1.2B annual capital spend

$200M annual operational budget, including heat, water and light

Maintenance and Cap-ex budgets are tight

Clear evidence internal environment (acoustics, heating, ventilation and lighting) impacts on outcomes learning

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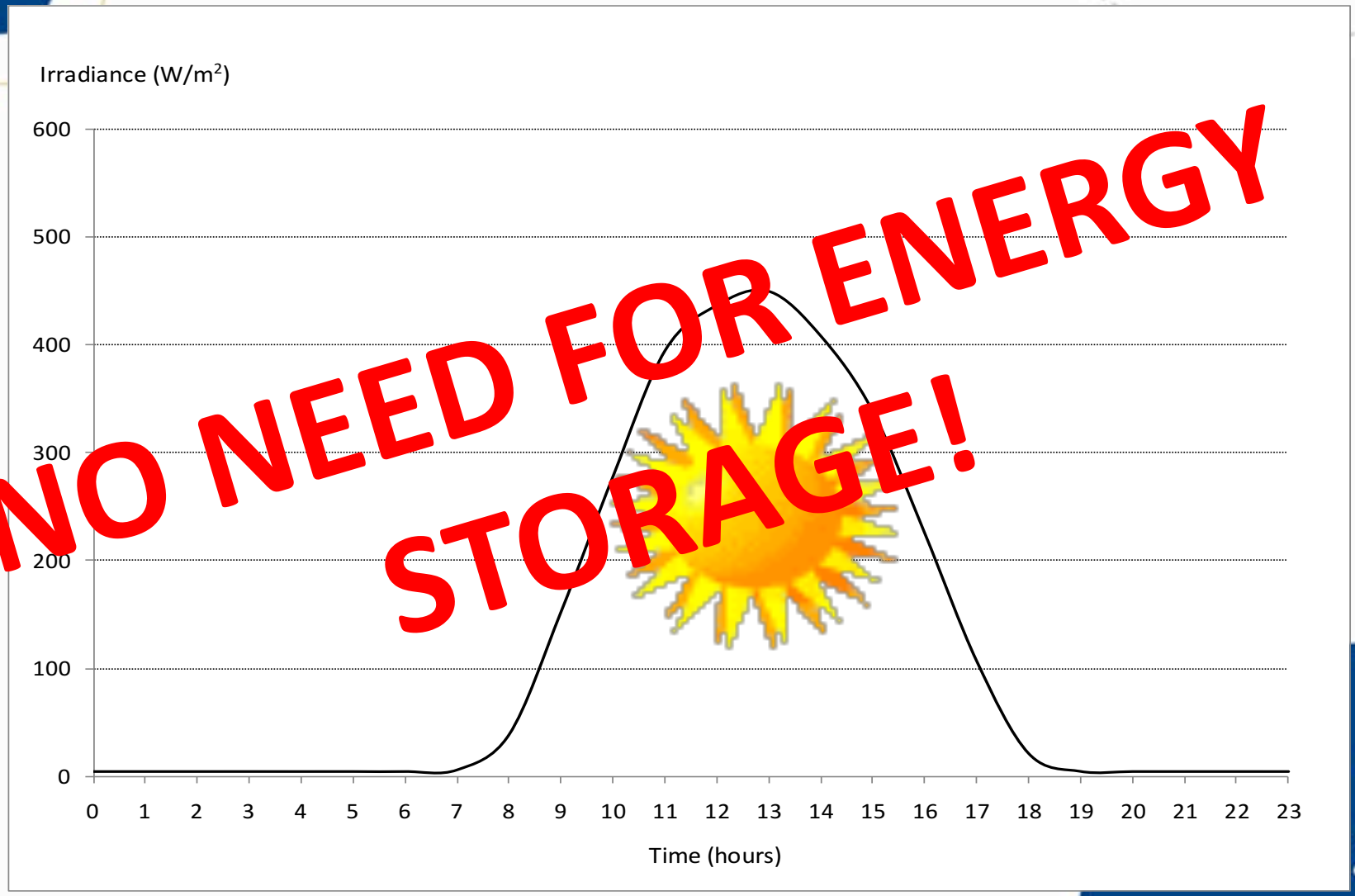
Solar energy at school ?



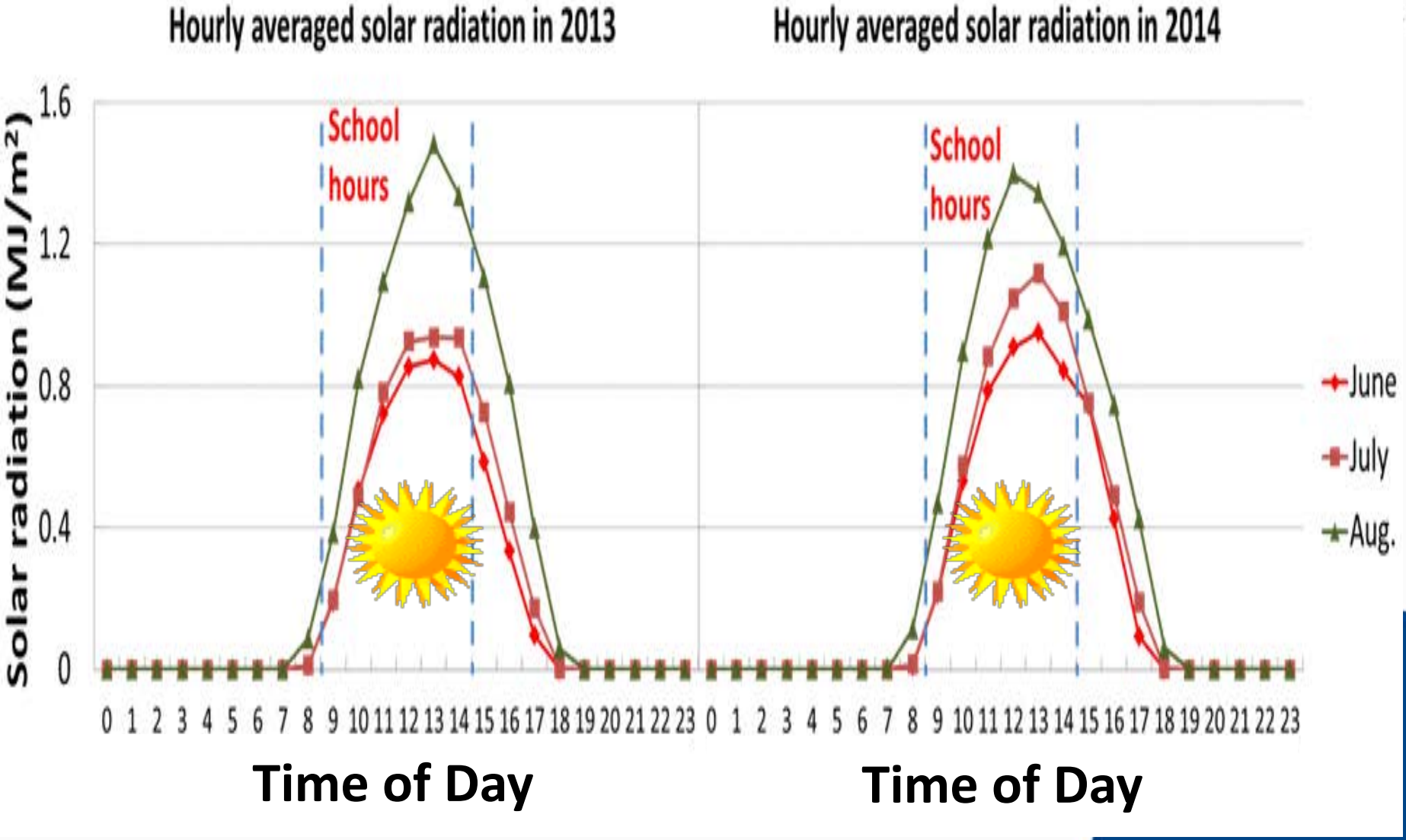
Possible solution

School day is closely aligned with solar availability.

The Team:

Prof Robyn Phipps, Dr Mikael Boulic, Yu Wang, Prof Chris Cunningham, (Massey University); School nurses (Midcentral Health); Bill Trumpetter (GNS), Prof Philippa Howden-Chapman and Prof Michael Baker (University of Otago)

The hourly averaged solar radiation in winter 2013 and winter 2014 in Palmerston North



Data from NIWA

Solar air heater

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Palmerston North School Trial

Palmerston North 40°S

6 pairs of classrooms with matched construction, orientation, heating, ventilation, solar access.

Method

All classrooms fitted with a roof mounted Solar air heater (SAH) 3 x1m

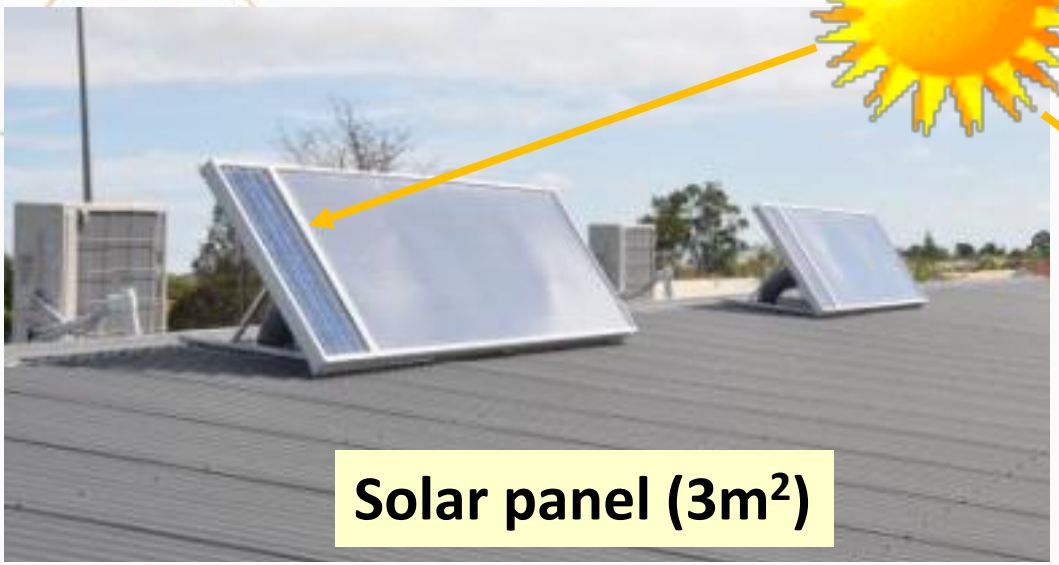
Control - SAH disabled

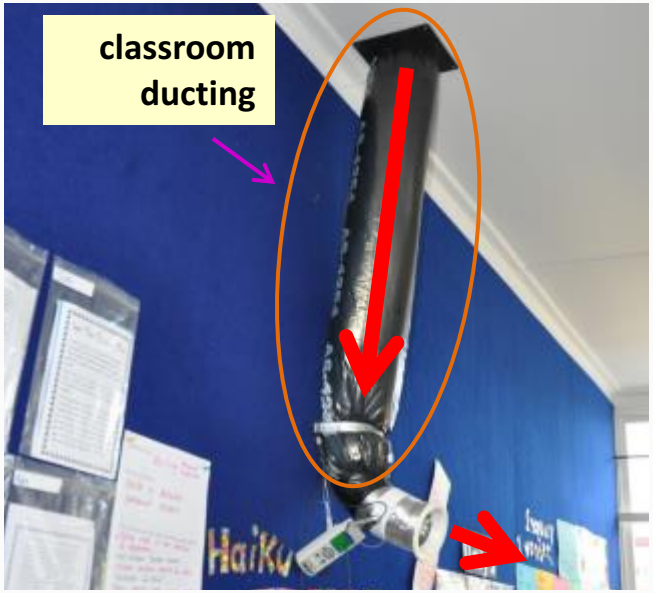
Treatment – SAH operational

Crossover design for two winters.

Measured temperature, relative humidity, CO2, particulates, air flow in supply duct, airborne bacteria, bacteria in child's throat, absenteeism for respiratory infection and heater use.


solar collector
control classroom
treatment classroom





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Results

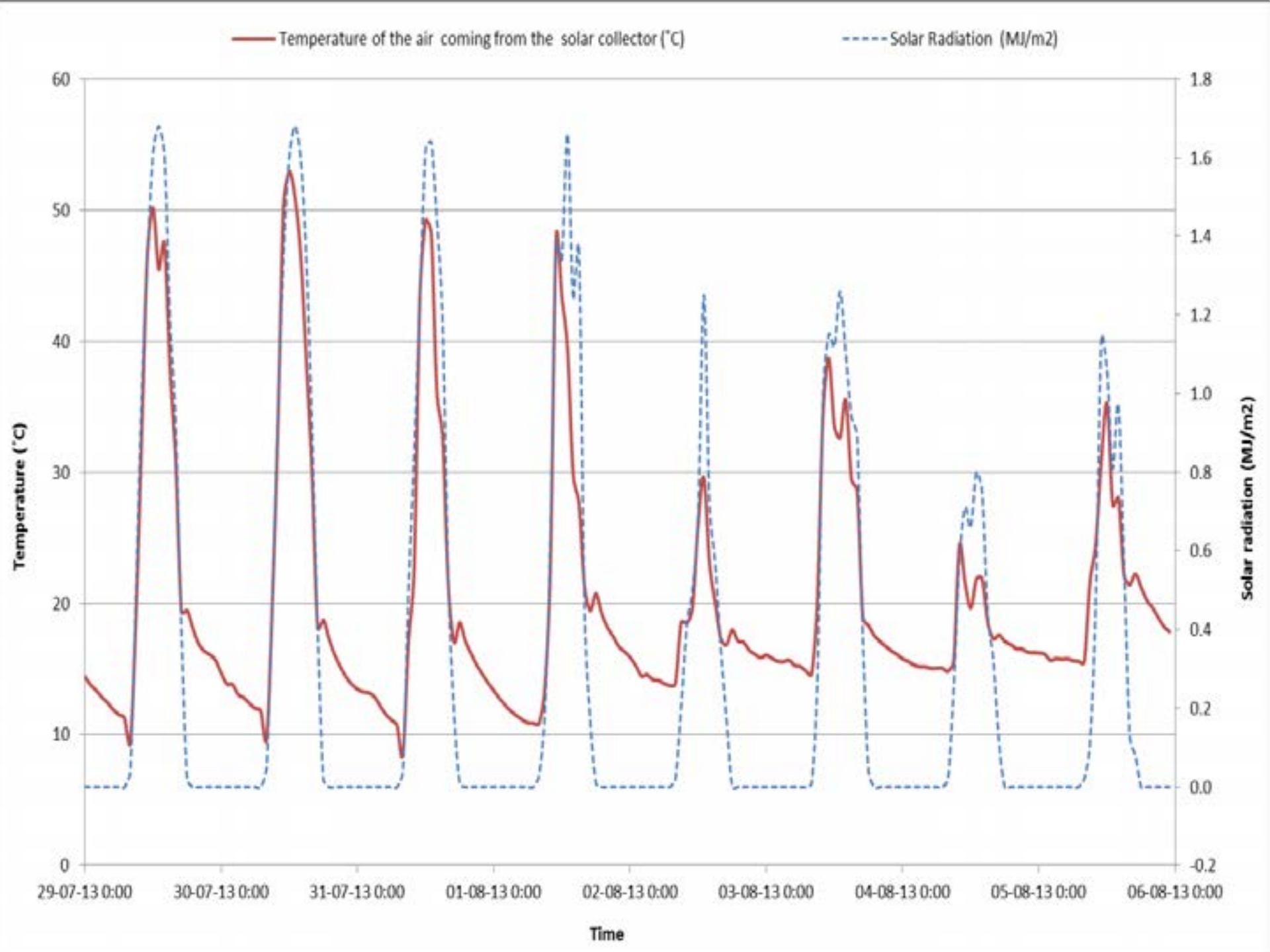
Treatment classrooms were warmer, yet used their heaters 2.3 times less than control classrooms

Lower carbon dioxide levels

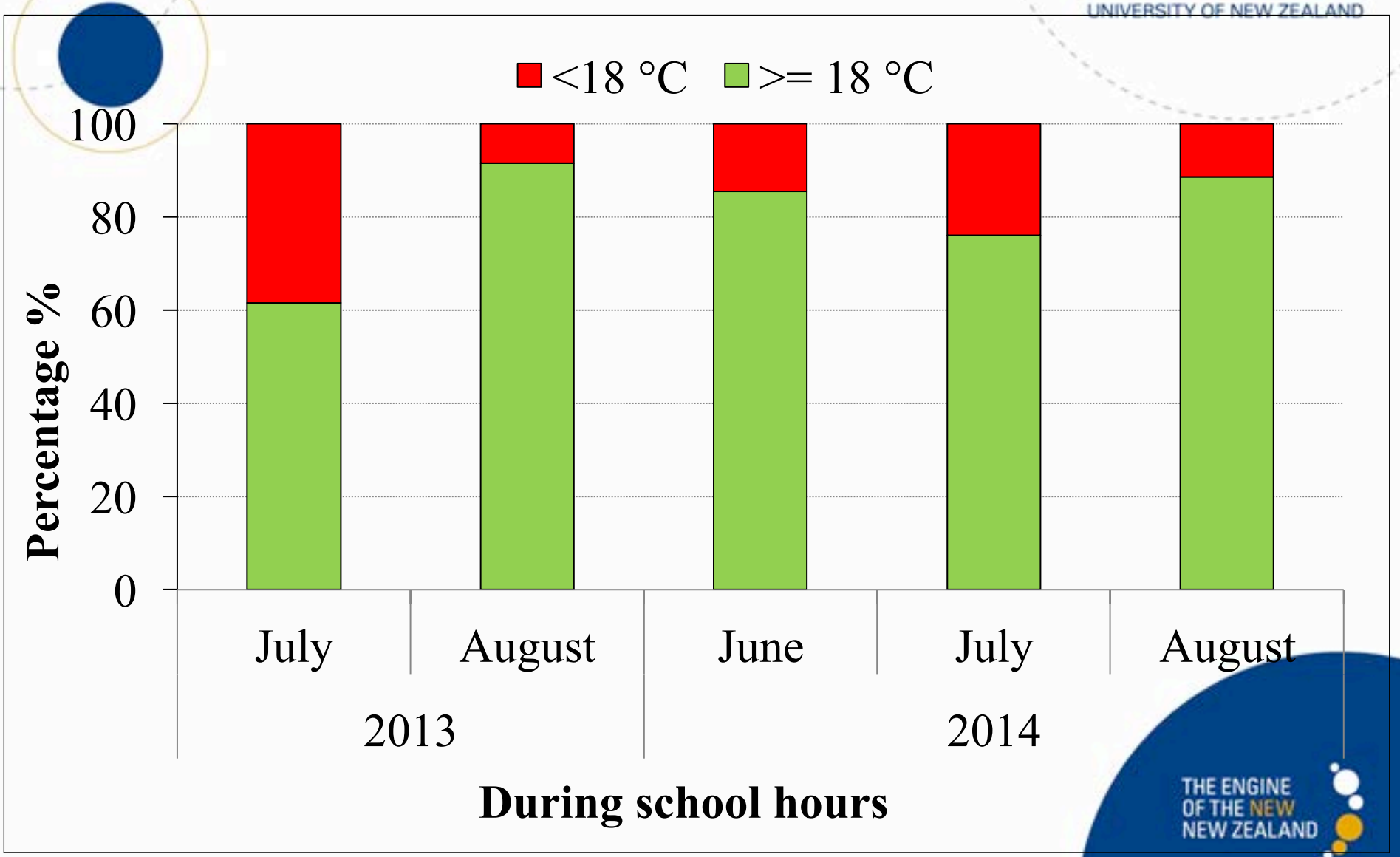
Lower relative humidity

Lower levels of respirable particulates

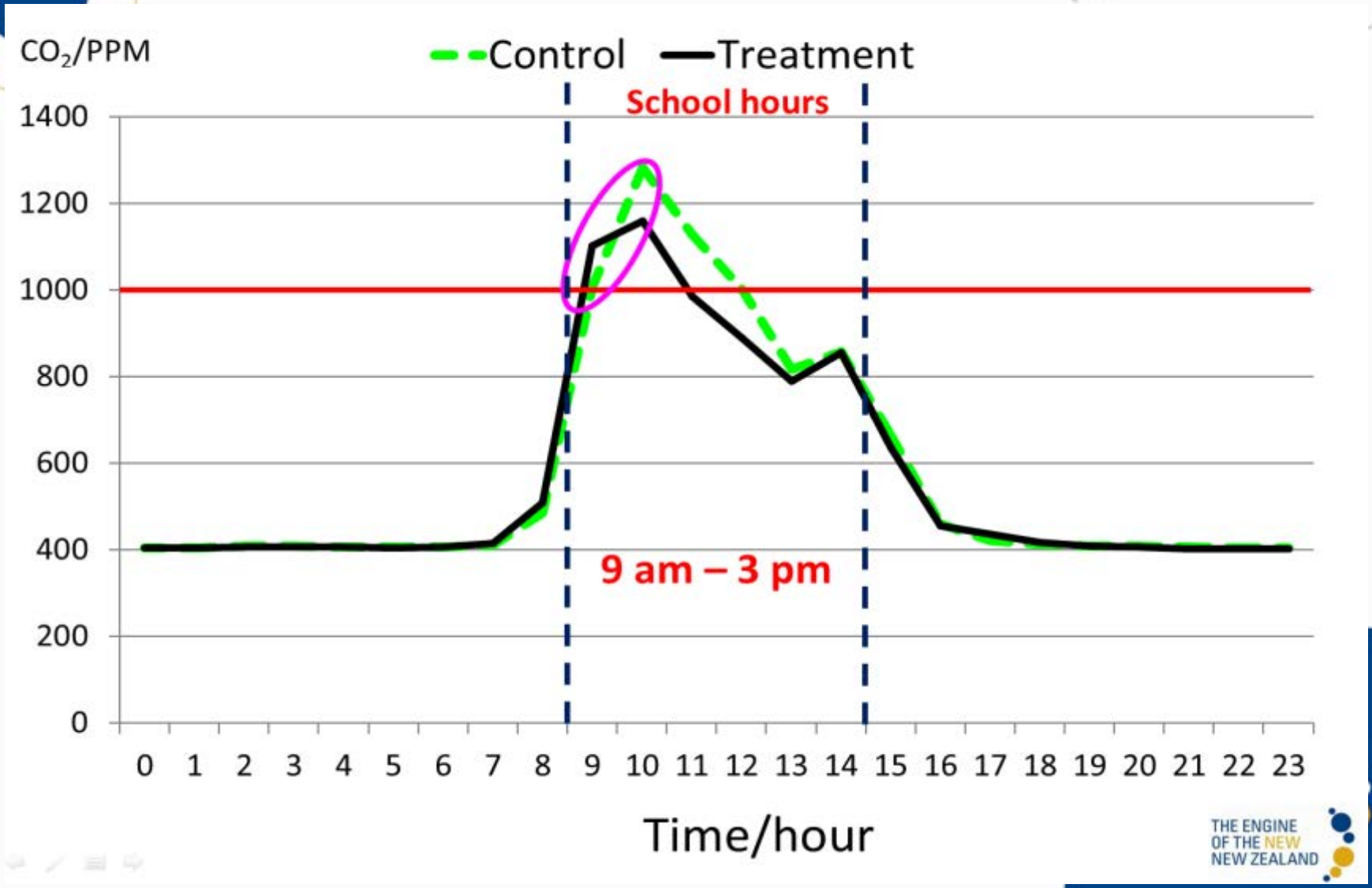
Health data and absenteeism still being analysed


Temperature of the air coming from the solar collector (°C)
Solar Radiation (MJ/m2)
Temperature (°C)
Solar radiation (MJ/m2)
Time
60
50
40
30
20
10
0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
29-07-13 0:00
30-07-13 0:00
31-07-13 0:00
01-08-13 0:00
02-08-13 0:00
03-08-13 0:00
04-08-13 0:00
05-08-13 0:00
06-08-13 0:00

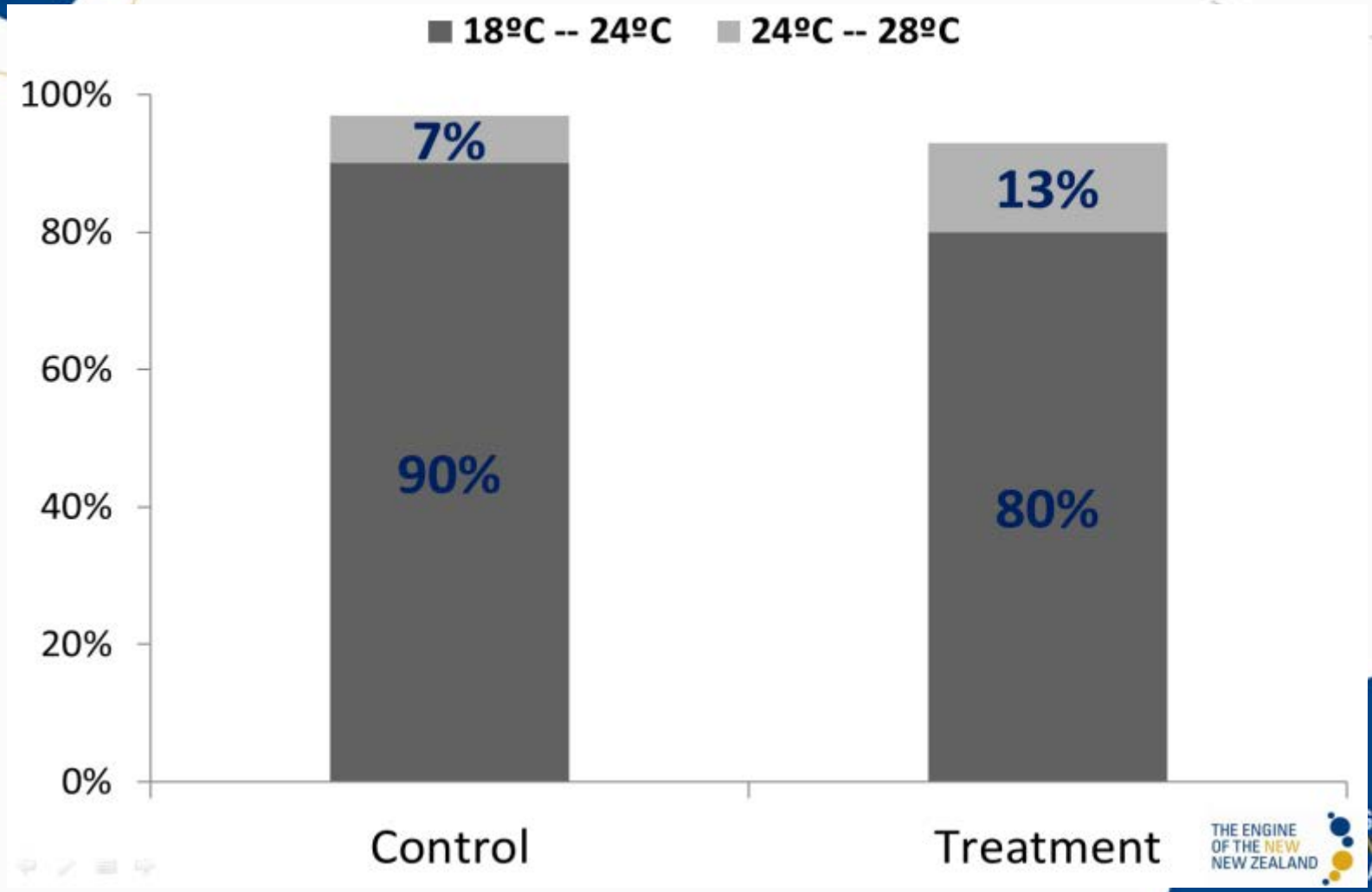
Incoming air temperature



CO_2 levels in control & treatment classrooms



Temperature and heater use levels in control & treatment classrooms



Incoming air flow rate

Max Flow rate = **163m³/h** at **21.1 ºC**.

1.2 hours for 1 air change (200 m^3 classroom).

Average flow rate = **65 m³/h** (over both winters).

13 times lower than the 850 m³/h than recommended value.

Increase the collector area or

Optimise for ventilation

Relative humidity levels in control & treatment classrooms

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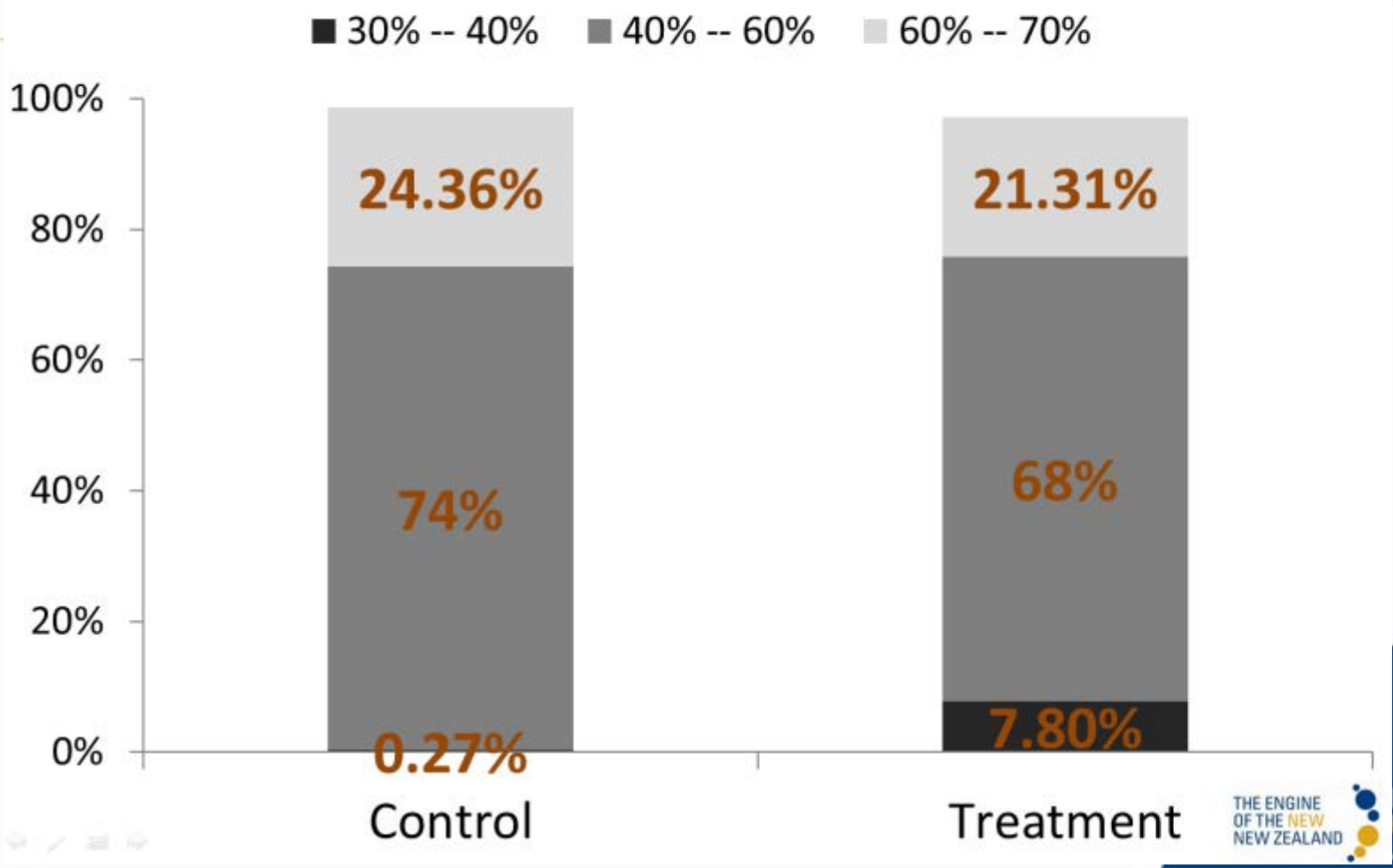
30% - 70% (Sterling *et al.*, 1985; Mendell and Heath, 2005; Koep *et al.*, 2013).



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Temperature and heater use in control and treatment classrooms

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NZ Ministry of Education: 18ºC (Ministry of Education, 2003).
WHO: 18ºC and 24ºC (WHO, 1987).

Temperature		Heater usage	
Classrooms	Mean	Average heater usage (hours)	Ratio of heater usage (C/T)
Control	21.4	81	2.3
Treatment	21.5	36	

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Conclusions

For 80 % of the time, the incoming air temperature above 18.0 ºC.

Classroom temperature up to 1.3 ºC higher in the treatment classroom

= free heating

Increase efficiency and the flow rate.


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What next ?

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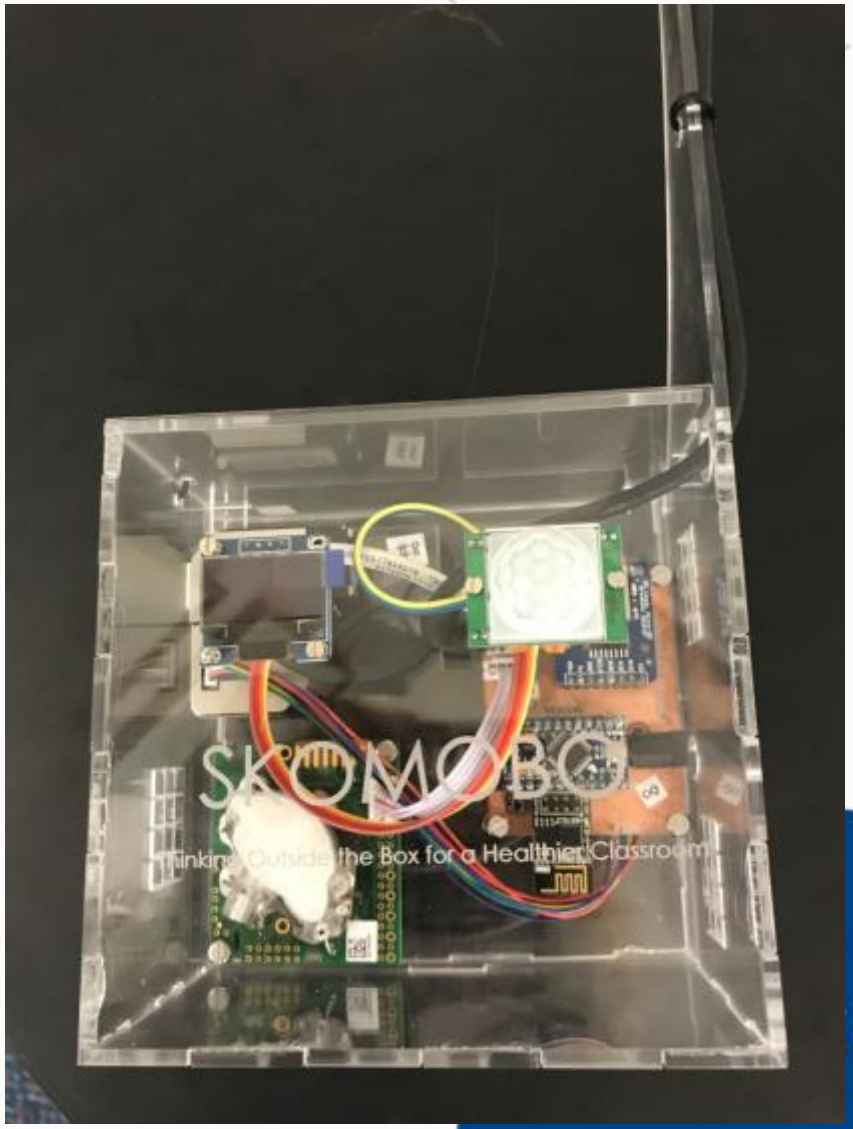
SKOMOBO and SKOMOBO plus

- Cheaper monitoring of CO2, temperature, RH, particulates, noise, occupancy and window use.

SKOMOBO's currently monitoring classrooms in 4 areas NZ.



Demo classrooms

- New prefab build classrooms in Auckland
- Renovated old prefab classrooms in Wellington
- Matched control and treatment conditions
- Treatments will be thermal insulation, noise absorption, solar air heating and ventilation, higher air tightness, passive cooling, high performance windows, interactive feedback

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Thank you

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