Case Study : ACNV Pig Building (farmref:blkuk)

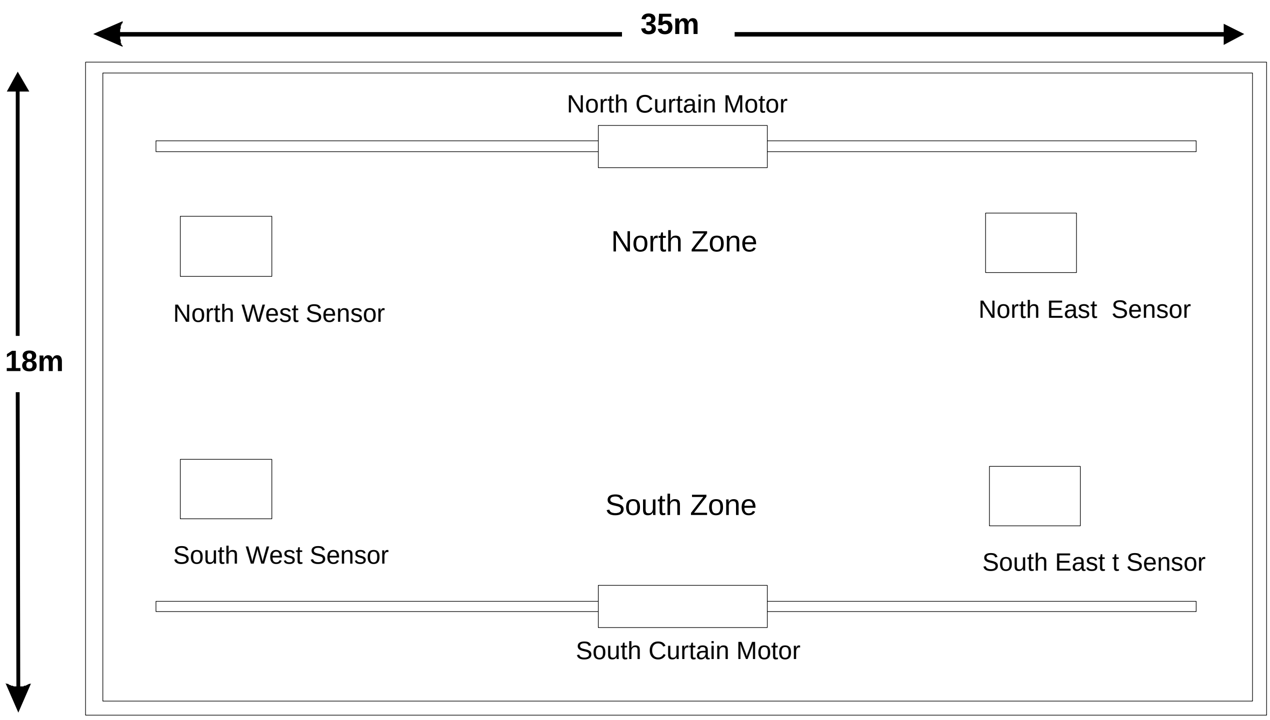
Introduction

This cases study covers a particular instance of an ACNV building for growers in the UK. Whilst the values measured apply to the individual building only, the general principles may be taken as representative.
This study investigates the actual values found, with illustrations of methods of analysis.
Data has been obtained from Barn Report data logging and data export (with post analysis).

Description

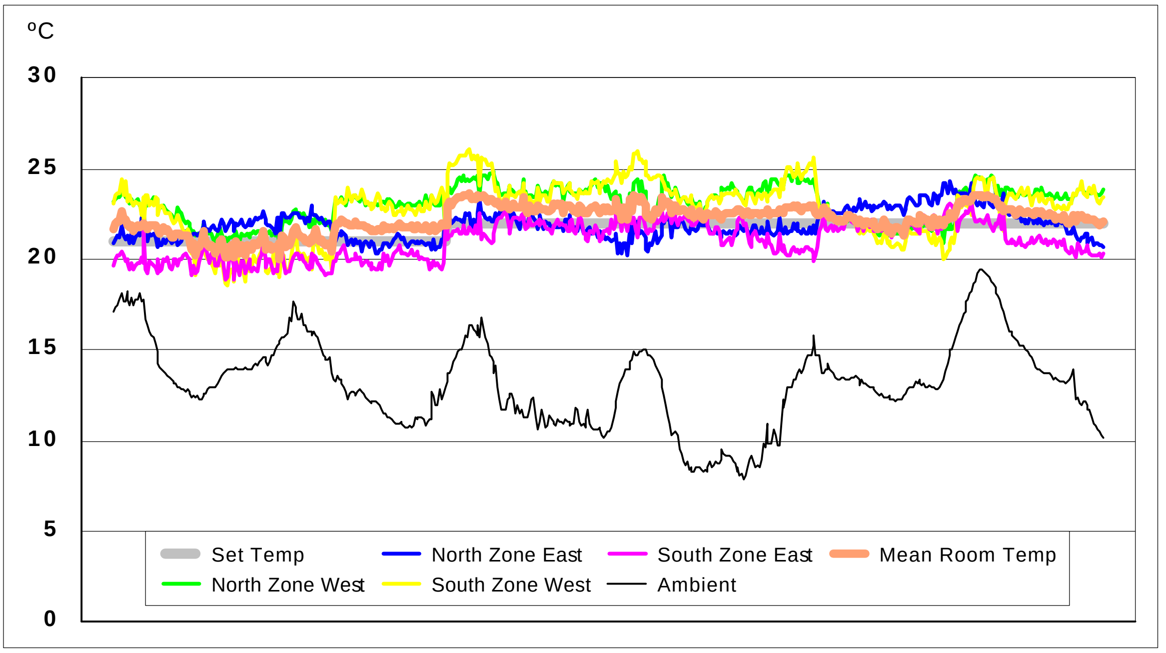
Building is approximately 35m by 18m in a single air space with an insulated flat ceiling at about 3m height. It houses about 1000 growers from 20kg.
The building is oriented with the ridge and longer axis East-West.
Note that the building is considerably wider than is typically recommended for ACNV

This study covers a period of approximately 6 days with relatively mild temperatures, but variable winds. (Wind speed has not been measured in this study.)



Ventilation is by two curtains - one running end to end on the North side, and the other end to end on the South side, and is controlled as two "Zones" using a Dicam NVZ1.2Z controller (single room, two zones with a single set temperature used for both zones).
The North zone motor is positioned according to the average of the North West and North East sensors , and the South zone motor using the South sensors.

Overall Results



This chart shows the individual sensor readings along with Set temp, ambient (outside) temperature and the calculated average room temperature.

It can be seen that overall, room temperature control is reasonably effective, and mean room temperature varies from about Set temp to slightly above.

Note : Curtains are positioned on the basis of comparing room and set temperature using a proportional control algorithm with a 3ºC band and a minimum position of 0%.
That is, when a zone is at or below Set temperature, the curtain is at 0% (fully closed). When the zone is 3ºC above set temperature, the curtain is 100% (fully open) and proportionately in between (e.g. at 1.5ºC over, it is as 50% - half open).

Therefore, when ventilation is "in control" of temperature, one would expect temperature to be between Set temperature and 3ºC above, with the curtains between fully closed and fully open.

When a curtain is fully closed (or at minimum position, if one is set), the system is no longer in control of temperature - temperature in the building is determined thereafter by rate of heat loss through the structure and air leakage.

Correspondingly, when a curtain is fully open, the system is no longer in control of temperature - temperature is determined by rate of heat loss due to wind speed.

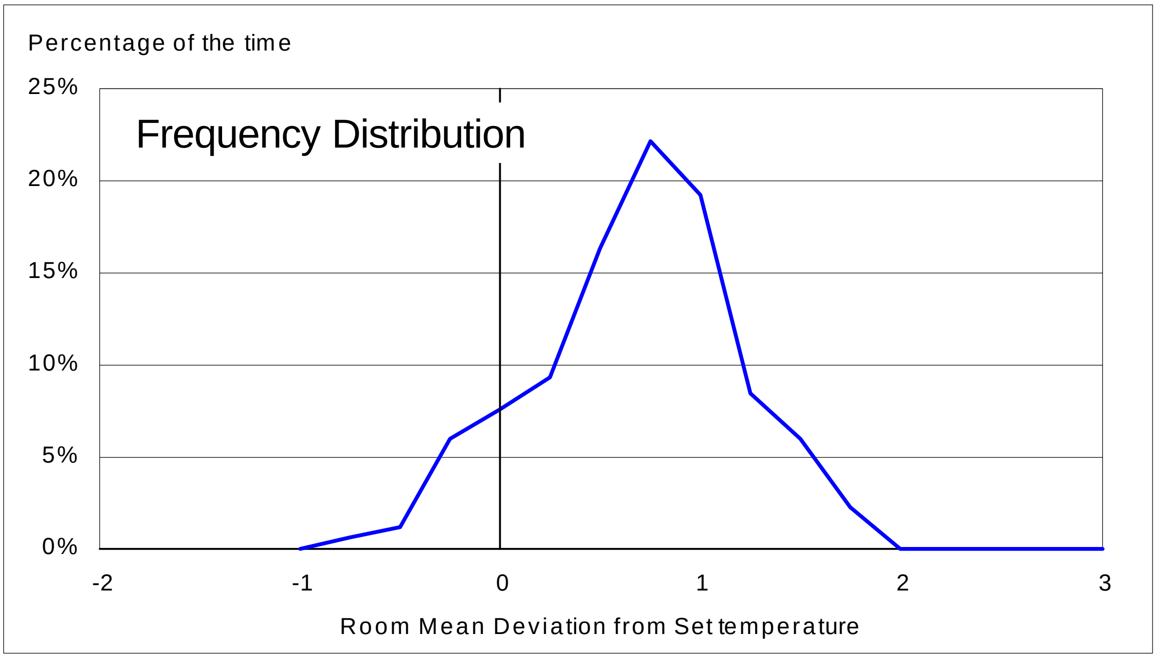
By these definitions, the system spent nearly all the time in control of temperature - that is, with curtains open at last partly.

North Zone spent only 2.7% of the time fully closed, and only 0.2% fully open (just one reading). However, there is reason to suppose the occasions may have been related to workers - such as during cleaning out.

South Zone spent 30% of the time fully closed, and was never fully open.

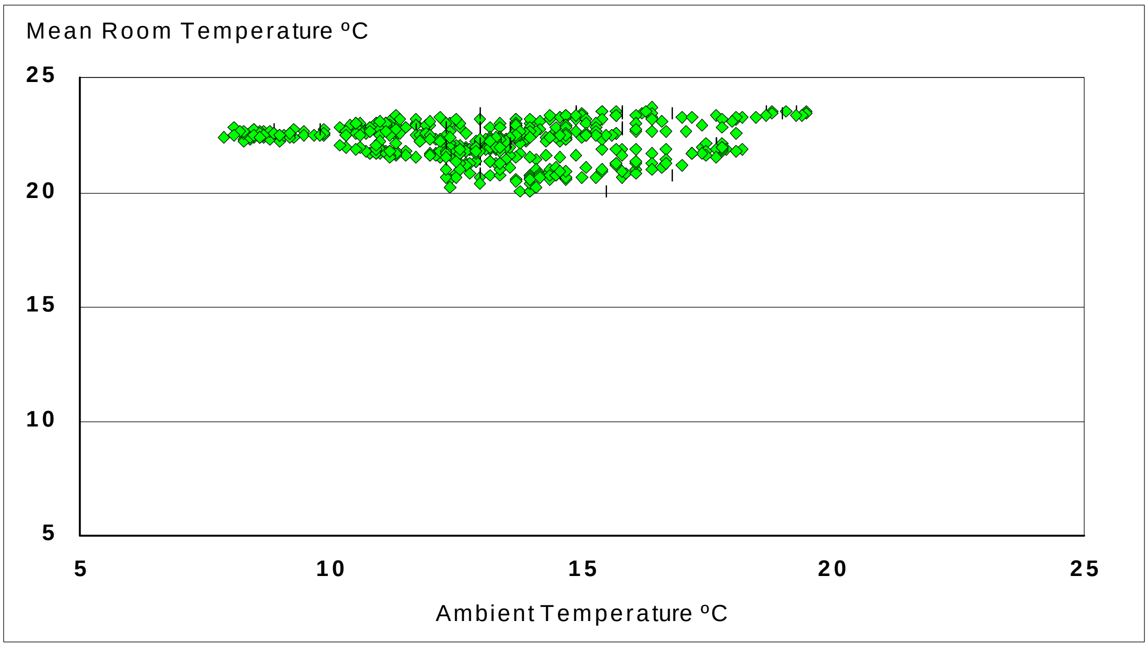
Combined, the system was fully closed (i.e. both curtains at 0%) for just 0.5% of the time - readings representing 45 minutes in 6 days, though these occasions were not continuous.

(But note : logging is at 15 minute intervals. It is possible that curtains could be - briefly - fully closed for a short time between logging occasions.)



This shows the frequency distribution of mean room temperature as compared to Set Temperature (with an interval of 0.25ºC). For example, it spent 22% of the time between 0.5 and 0.75ºC above set temperature.

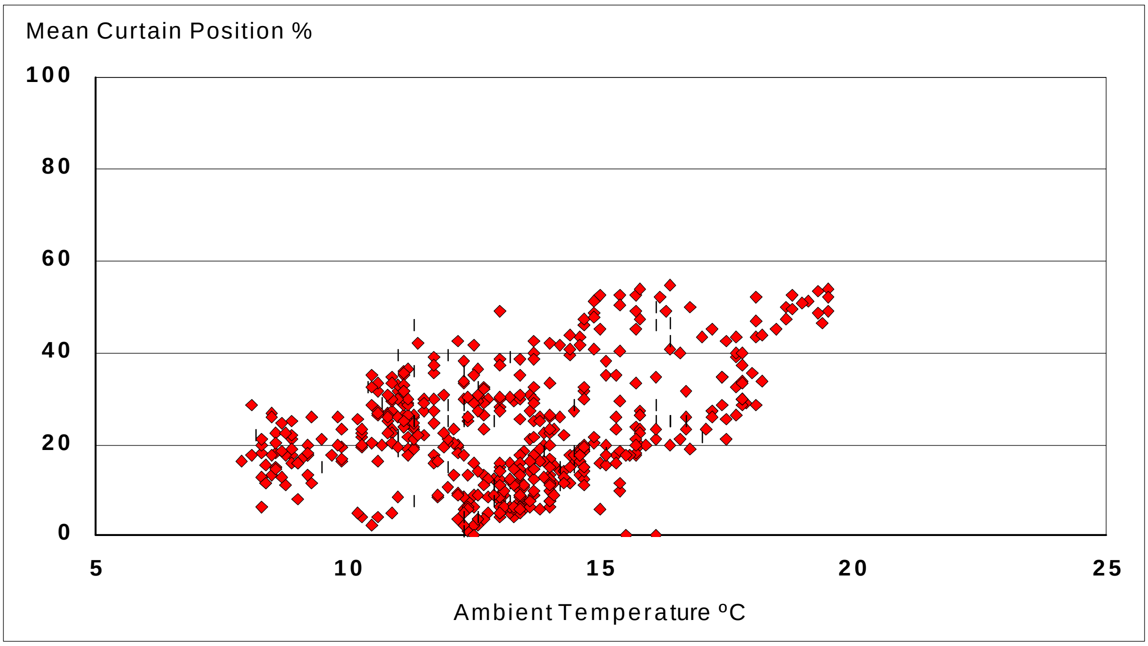
The majority of the points are between 0.25 and 1.25ºC above set temperature. It was never more than 1ºC below nor 2ºC above set temperature.



This chart shows correspondence between inside (mean room temperature) and outside (ambient). The upper grouping and the lower grouping are due to the change in set temperature part way through.

Essentially, this shows that the building has maintained mean temperature quite well over a range of outside temperatures (and wind speeds, though these have not been measured).

There is no trace of a downturn in the trace at the left hand side (i.e. room temperature following ambient down), so it is not possible to predict the possible results for lower ambient temperatures.
Similarly, there is no significant upturn on the right hand side (it never loses control).

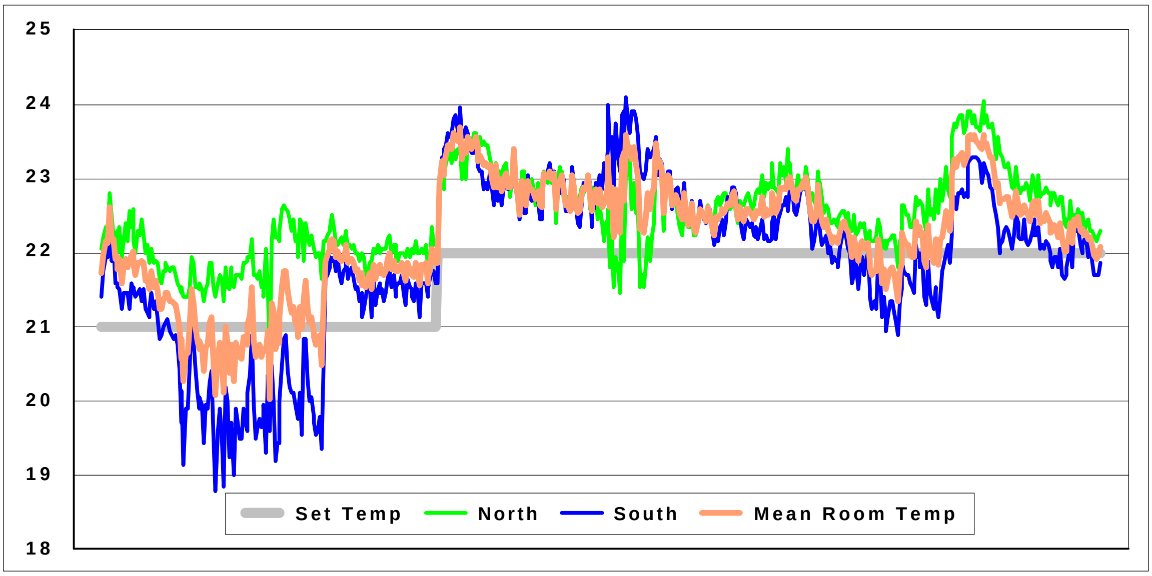


This chart shows, in a different form, the same result - mean curtain position against the range of ambient temperatures (similarly, with two groupings with moderately different slope).

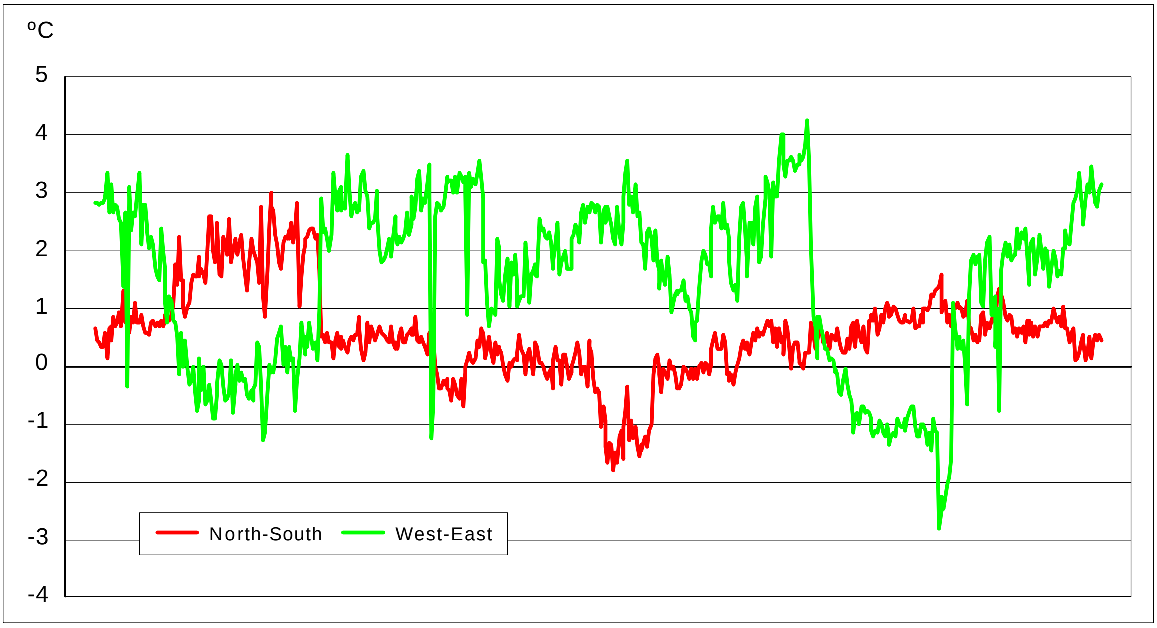
Since the system maintains only a modest lift over ambient at higher ambient temperatures, one would guess that wind speeds must have been relatively high at these times.
Note also that at lower ambient temperatures (7 or 8ºC) flap positions were around 15 to 30%, suggesting wind speeds were lower at these times.

Temperature Differences

Whilst the overall results indicate adequate or good temperature control, there are temperature differences within the building.

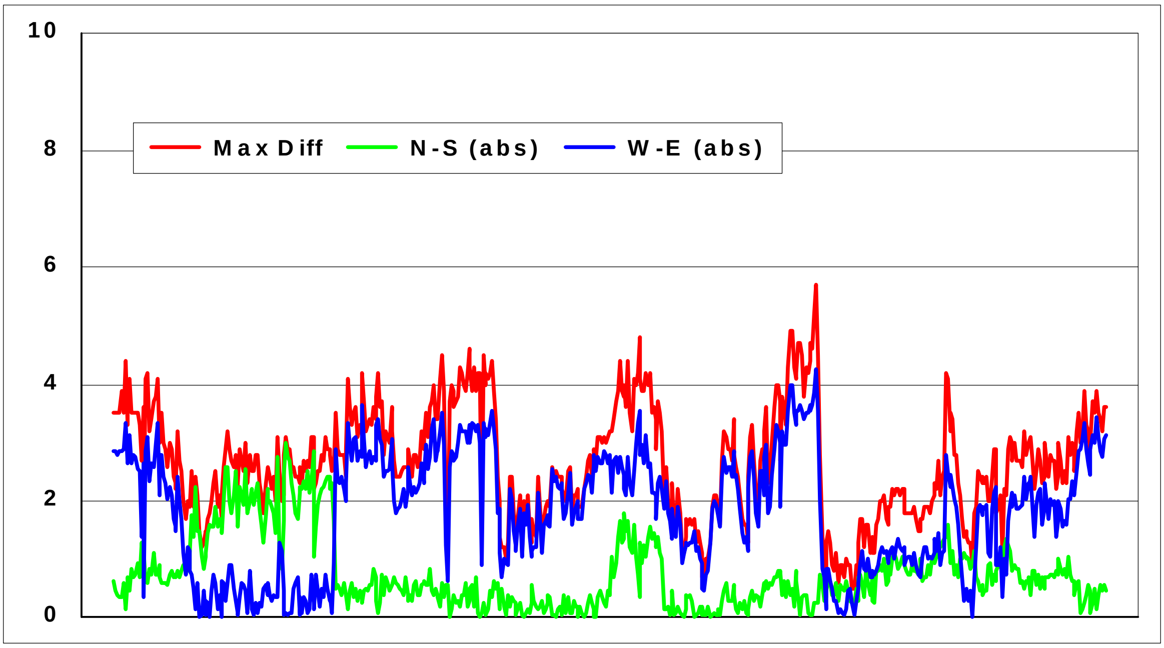


This shows zone temperatures (average within North or South zone) compared to Set Temp and Mean room temperature.
For most of the time, the South zone is marginally cooler, probably because wind is more southerly than northerly. Of somewhat greater significance, however, is the difference between East and West.



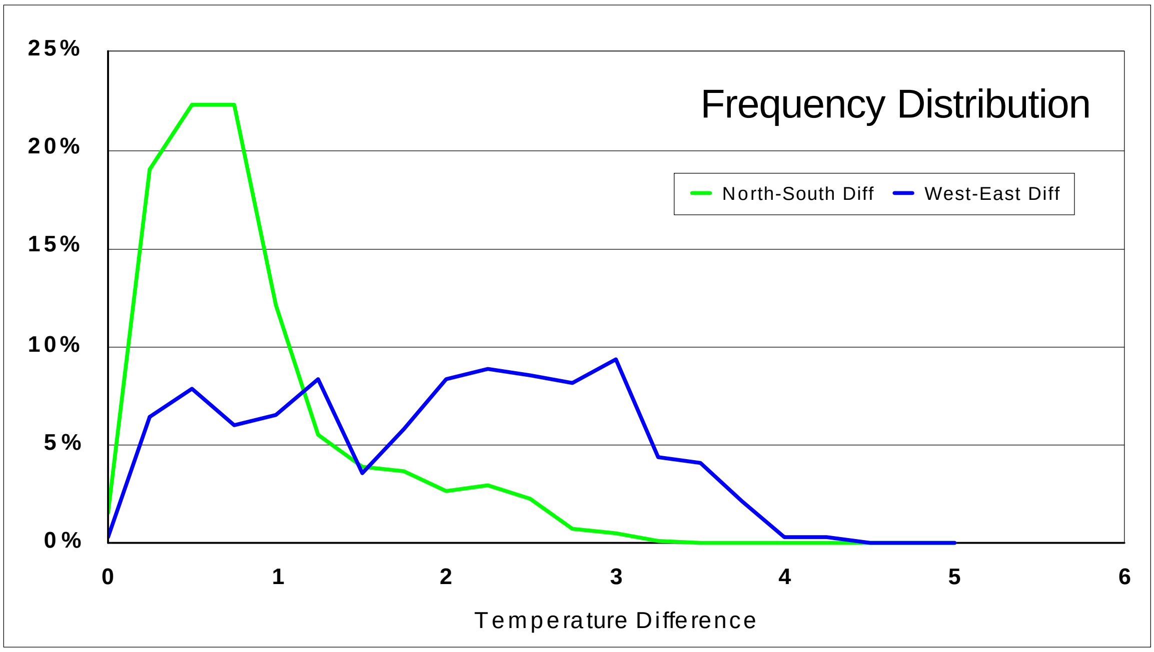
This charts compares North-South differences with West-East differences. (In each case, one temperature taken away from another e.g. North-South = Average of North temperature sensors minus Average of South Temperature sensors.)

This shows that North is usually slightly warmer than the South, but the temperatures are mostly quite close. However, differences between East and West are nearly always greater, with the West usually being warmer than the East..

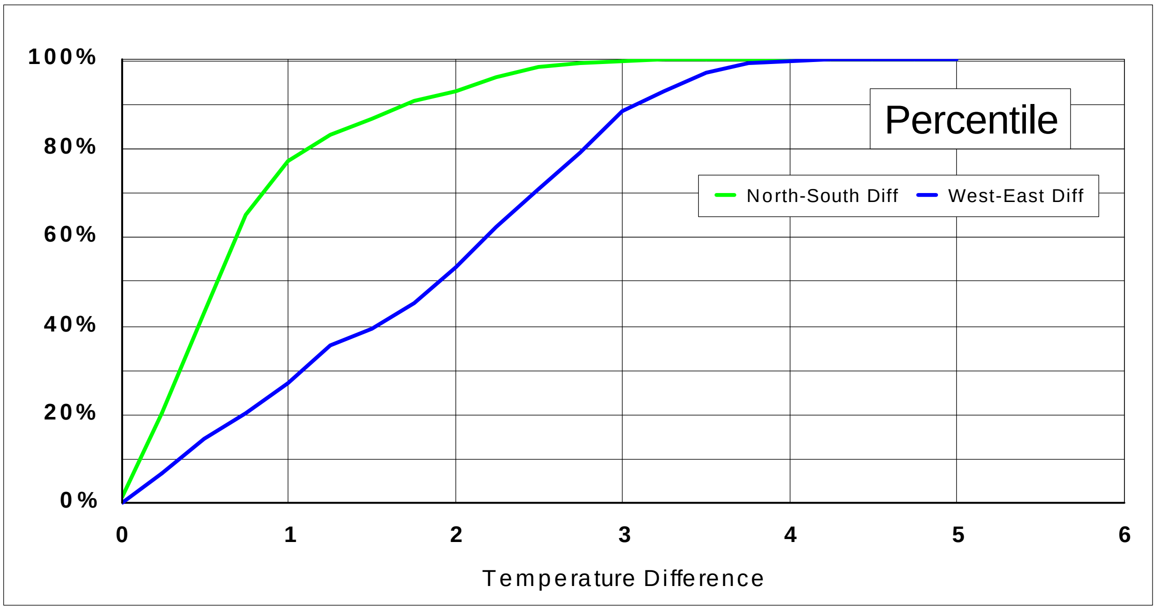


In this chart, the maximum temperature difference within the room at any one time (Max Diff) - the difference between the highest in the room and the lowest in the room - is compared to the North to South Difference and the West to East difference. In this chart, the direction of N-S and W-E differences is ignored (absolute difference).

It can be see that usually, Max Diff is close in value to the West to East difference, with North to South difference being smaller.
In other words, temperature differences within the room are mostly differences within zones rather than differences between zones.



This chart shows the frequency distribution of temperature differences (how often they occur). Mostly, temperature difference side to side of the building (North-South) is from 0 to 1ºC, with a most common value around 0.7ºC.
Temperature differences end to end (West-East) are spread right across the band between 0 and 3ºC, with no particularly characteristic value.



This shows the same data in a different form -
Almost 80% of side to side differences are 1ºC or less, whilst 80% of end to end differences are 2.8ºC or less.
Only 10% of side to side differences are greater than 1.6ºC - just over half the corresponding value for end to end differences.

Reason for this case study

This case study was occasioned by an issue raised about temperature differences, after installation of new Dicam controls. Previous (non-Dicam) controls regulated side to side (as now), but based on single sensors in the middle of each zone, without temperature displays.

Concern was expressed about the zone to zone differences - the user having spent a few hours observing temperature changes for the north and south zone, and felt these were large and the system may not be operating as it should - such as, the windward side of the building being much warmer than the leeward.

There is no particular substantiation of the impression that the windward side was cooler than the leeward side. Perhaps the gauging of wind direction was wrong, or surrounding buildings have a considerable effect.

It is worth mentioning that the data gained from a few days of logging gives a great deal more detailed, quantifiable and analysable information than a few hours of observation.

This is not to say observation is not useful - it may be important and helpful in assessing factors that cannot be easily measured, such as pig reactions and lying behaviour. However, it is expensive (in labour costs), and may easily provide distorted information. It may be selective in terms of the data chosen, the fact of being present in the building may affect the result, and is unlikely to be carried out at all and any time of the day and night.

Whilst much longer term logging is needed to give a complete picture, there is no reason to suppose that this period of data is wholly exceptional.

Discussion

Temperature control of the room as a whole is reasonable - it operates reasonably close to set temperature.
However, temperature differences ***within*** zones are greater than those ***between*** zones.

The control system can adjust curtains to try to correct temperatures (compared to set) and thereby temperature differences between zones (though with limitations, see below). However, it can do nothing about temperature differences between sensors within a zone. These will be determined by wind speed, direction and so on.

In ACNV systems, air generally flows through the building, picking up heat along the way and thereby creating a temperature gradient. The longer the air path, the greater the likely temperature gradient.

When air is flowing from one zone to another, the air is warmed before it reaches that second zone. In that case, the second zone (where is leaving the building, rather than entering) may have limited control over its own temperature. For example, it might open as much as it could, but have no effect on the amount of air entering the zone - which would be determined by the zone it is flowing from. Nevertheless, there may be some additional ventilation by eddy currents around the building and peripheral winds.

In this building, the longer potential air paths and distances are within a zone (the building is 35m long, but only 18m wide).

Whilst it appears that winds are generally from a southerly than northerly direction, the larger typical differences end to end suggest that winds tend to be somewhat peripheral (i.e. at an angle, rather than square on). There may also be localised effects from impact of winds on nearby buildings.

Sensor position will, of course, have some effect on the temperatures and differences measured. It is likely that temperatures (at animal level) at some points in the building, on some occasions, will fall outside those measured.

Curtain motors are usually mechanically capable of operating a long length of curtain - such as all the curtains on one side of a building. Being mechanically less convenient to operate both sides with one motor, it is common - in ACNV curtain sided buildings - to have a motor on one side.

Since the decision has been made to install two motors, one on each side, it probably appears reasonable or sensible to divide the control - whether zoned or separate - into these two zones. One motor per side - either as two control zones or both sides together - tends to be the used, irrespective of length, width or building orientation.

To put it another way, ventilation regulation and control is based on mechanical convenience - the raising and lowering of the curtain load - rather than on effectiveness or otherwise of regulation. The logic appears to be - "how few motors can I use" rather than "how do I best regulate this building".

This is in sharp contrast to fan ventilation, where fans are generally distributed around the building to try to achieve even ventilation and temperatures - often to an absurd degree, and often at considerable cost. In extract systems, distribution is mostly determined by air inlets - not air outlet through the fans - so precise extract fan positioning is not generally needed.

To what extent temperature variations within this and other ACNV buildings may be stress factors and/or may have an effect on pig comfort, performance, feed conversion, incidence of vices or other economic effects is not known. So it's hard to judge whether these temperature differences really matter in an economic or welfare sense.

However, if there seems to be reason enough to try to reduce temperature differences in fan buildings the same should, logically, apply to any buildings, including ACNV ones. Whilst

ACNV can never control and regulate with the precision of fan ventilation, there seems little sense in abandoning standards altogether.

If there seems to be reason enough to zone the ACNV building to reduce temperature differences, it would appear to make sense to tackle the whole problem.

There seems little reason to think that side to side differences justify zoning, whilst end to end differences don't - especially as the "air path length" logic suggests that end to end differences are liable to be greater.

Since the building in this study is zoned side to side (north-south) it is difficult to speculate as to whether the end to end differences are greater or smaller than they would be if the whole building was controlled as one.

However, it is reasonable to suppose that total temperature differences could be reduced if the building was divided into four zones (one in each quarter) instead of, as now, only two zones - side to side.

Summary

The study shows that there are side to side differences, but that the end to end differences - beyond the control of the regulation system - are greater.

Average side to side difference is 0.75ºC, whilst average end to end difference is 1.9ºC.

Whilst this building is unusually wide, the measured side to side differences are not especially great. The end to end differences are relatively typical of long buildings controlled as a single zone along their length.

It is likely that better results in terms of temperature consistency and reduced differences would be obtained by dividing the building into 4 instead of 2 zones. This could be achieved at modest cost by adding a further two motors, with minor changes to the control equipment.

As a result of this study, the farm concerned is considering updating the installation to improve zone control.

Author's Note

This study was made possible by the installation of Dicam controls on an existing installation, where existing controllers - in place for many years - had failed.
It is extremely unlikely that the temperature differences and other issues identified in this study have resulted from the installation of the new controls. Rather, the new controls have made it possible to identify pre-existing situations which had always been present.

Data for this study was obtained using standard Dicam network data logging and the Barn Report service. This gathers data remotely using already installed equipment - no additional data logging or other equipment was required, no site visit was required, and cost was minimal.

Whether or not the farm decides to make modifications to their system after this study, there is at least a more rational basis for assessing the situation and, subsequent to any change, an objective method for review of the benefits or otherwise.

For more information on how Dicam data logging can be applied to your farm, contact Nick Bird on (UK) 0118 986 7252