UK Controlled Environment Users Group – Light Workshop 15/06/2017

Energy efficiency monitoring and light

Summary Guide and Case Study

Retrofitting plant growth facilities with LED lighting is expensive and disruptive for researchers. Achieving energy savings is often a major driver for seeking LED solutions and so quantifying them to justify the investment is vital.

To do so, it is necessary to appropriately monitor the performance of the new lighting system and compare it to the system that it replaces.

Electrical metering considerations:

- Metrics – Which variables are going to be useful? Instantaneous power (kW) at the time of logging and cumulative electricity used (kWh) should be considered the minimum. Additionally, metrics such as individual phase current logging could be useful for fault finding and maintenance.
- Metering level – The signature of the lights' electrical usage within the collected data must be clear. If the meter captures the usage of too much equipment, it becomes difficult to discern the lights from 'background noise' of other rooms, equipment etc. At the other end of the spectrum, though metering only the section of distribution board that powers the lights themselves will return good data on the light performance, any 'knock-on' effects will not be captured. Metering an individual chamber or cabinet usually offers a good compromise.
- Time Resolution – The frequency of logging should be set to capture the right level of detail of lighting performance. Half-hourly logging may be sufficient for constant lighting behaviour, but higher frequency would be needed if artificial lighting requirements fluctuate with ambient conditions. Consideration should also be given to how often this data is going to be analysed. Logging every minute generates a lot more data to have to then deal with.
- Temporary or Permanent? – If the facility does not already have sufficient metering, think carefully about whether the data that is required for this project could also be useful in the long-term. Proving a saving and clarifying knock-on effects from a controlled environment does not require permanent metering, especially if savings impact on the billing meter record. However, the installation of a permanent metering system could be a valuable tool for facilities management to identify faults and target maintenance.

Context considerations:

- What are the environmental settings for the controlled environment? Keep a log (especially if settings are often changed). Chambers and cabinets can usually be set-up to log temperature, humidity, heater activation signals etc.
- Are the heating and cooling demands of the controlled environment satisfied by local or networked provision? If local, make sure that heater and chiller electrical usage can be isolated from light usage in the data set. If networked, it will be difficult to tease out the power usage attributed to an individual unit. A proxy metric such as refrigerant flow measurement or refrigerant supply valve position could help prove an effect even if it is difficult to quantify.
- If plants dim or switch on/off in response to ambient light (i.e. in glasshouses), a log of the variable that dictates luminaire behaviour will be necessary, to normalise electrical usage data for this external factor.

- Similarly, the performance of heaters and chillers change with ambient conditions. An assessment of the relationship using degree days may be necessary, though this can be time consuming with little tangible benefit to your original aims of monitoring.

Case Study

Plant Growth Facility (PGF), Department of Plant Sciences, University of Cambridge

2015

Following small-scale trials of LED plant growth lights, two Conviron chambers were retrofitted with Valoya NS1 luminaires in 2015. Insufficient sub-metering at the PGF meant temporary Tinytag Energy Loggers were installed on the chambers before the work.

Each logger captured the usage of a whole chamber every five minutes. This metering level and time resolution clearly showed the lighting load, as well as baseload - consisting of fans, pumps and other ancillaries. A before-and-after picture was quickly established. After consulting the context records of the chambers' environmental conditions (set light intensity, temperature, humidity, etc.), like-for-like savings were:

- >5kW reduction in lighting load (at 200µmol m^2 s^{-1})
- ~0.5kW reduction to baseload (due to LED canopies not requiring the waste heat exhaust fans of the fluorescent light canopies).
- The light load was reduced by ~65%. The load of the room as a whole was reduced by 40%.

2016

Sub-meters for each plant growth chamber were installed, as well as on socket circuits, the cold room, general lighting etc. Energy usage data from each is collected every half-hour and logged in CSV format by a hub, from which it can be downloaded and analysed.

2017

Four more Conviron chambers were retrofitted in spring 2017. The new metering system tracked the changes in energy usage:

- Chambers are saving ~100kWh/day (at 200µmol m^2 s^{-1}, 16 hour days)
- When context records of chamber environmental conditions were factored in, comparison of the retrofitted chambers confirmed consistent behaviour and similar energy usage.
- Half-hourly day-profiles of the chambers now highlight when faults have occurred, such as failed ventilation fans or over-chilling that requires excessive heating.
- Logging the 'CMVLV' (Chill Modulation Valve) output from the Conviron management software provided a proxy for each chamber's chilling demand of the central process chillers. A reduction in 'daytime' chilling requirement of room by 8% was recorded (at 200µmol m^2 s^{-1}, 20'C, 60%RH).
- Process chiller energy usage did not show a corresponding reduction. Degree day analysis confirmed that chiller consumption is dominated by ambient conditions, which masks minor alterations in demand from the rooms that they serve. There is a chill demand reduction by installing LEDs, but the energy cost savings are not yet quantifiable.

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