EVALUATING AND OPTIMIZING THE PERFORMANCE OF ENERGY-SAVING DEHUMIDIFICATION IN ONTARIO YEAR-ROUND GREENHOUSES PRODUCTION

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BACKGROUND

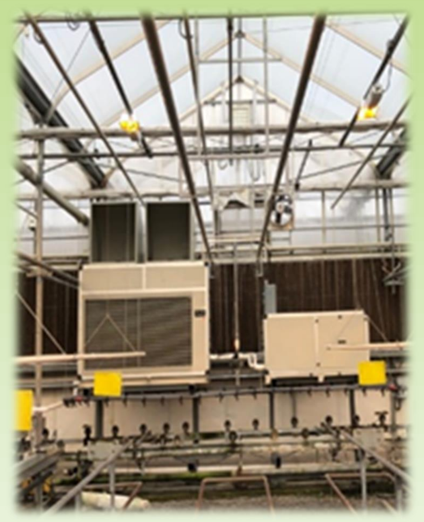
1. The project addresses heat (and therefore energy) recovery to reduce fossil fuel consumption and resulting greenhouse gas emissions.
2. Ventilation for humidity control causes energy loss, especially in spring, fall and winter seasons.
3. The performance of four dehumidification technologies continue to be tested and evaluated at three commercial greenhouses.
4. The four technologies are: commercial mechanical refrigeration dehumidification (MRD), chemical liquid desiccant dehumidification (LDD), air-to-air heat recovery ventilation (HRV), and a prototype called energy recovery ventilation (ERV), which is a combination of the liquid desiccant approach (wet mode) and an air-to-air heat exchanger (dry mode).
5. MRD power is 100% electricity, LDD power is 87% natural gas (NG) vs 13% electricity, which impacts operating costs.

OBJECTIVES

1. To evaluate energy savings and the reduction of fossil fuel use by adding a dehumidification system;
2. To assess the impacts on plant health, air quality, and yield due to energy recovery dehumidification;
3. To assess the reduction of condensation occurrences on the greenhouse cover surfaces;
4. To explore optimized control strategies for the dehumidification systems.

PRELIMINARY RESULTS

- The following tables show the nighttime results at a floriculture greenhouse when **the unit is on** *versus* when **the unit is off**
- When the units are off, the greenhouse depends on traditional ventilation to manage humidity levels
- The greenhouse RH target is 80%
- The actual removed moisture by the units was measured with a rain gauge, but the RH set point was rarely reached
- The extra moisture removal is the calculated amount of moisture that needs to be removed from the greenhouse if the indoor RH to maintain 80%



MRD

Table 1. MRD performance compared with traditional ventilation method

Month	RH actual achieved (%)	MRD on - U^T value[1] (W/m^2/°C)	MRD off - U^T value[1] (W/m^2/°C)	Energy savings[2a] (%)	Actual removed moisture by MRD (L/day)	MRD power usage (kWh/day)	Extra moisture removal (L/day)	Total estimated power (kWh/day)	Estimated total heat loss with ventilation to achieve 80%RH[2b] (kWh/day)	Estimated total heat loss with ventilation to achieve 80%RH & 20% transpiration[2c] (kWh/day)	Energy savings[2b] (%)	Energy savings with 20% transpiration[2c] (%)
Jan	85.2	5.5	--[3]	--	760	236	235	312	1244	1721	129	121
Feb	83.0	5.1	9.3	**45.3**	686	209	208	276	1160	1606	129	121
Mar	82.4	6.2	13.3	**52.8**	506	184	112	221	778	1096	126	118
Apr	80.6	5.2	7.9	**33.0**	540	163	122	203	753	1033	133	124
May	81.4	7.8	31.0	**74.9**	286	96	125	137	423	544	134	126

LDD

Table 2. LDD performance compared with traditional ventilation method

Month	RH actual achieved (%)	LDD on - U^T value[1] (W/m^2/°C)	LDD off - U^T value[1] (W/m^2/°C)	Energy savings[2a] (%)	Actual removed moisture by LDD (L/day)	LDD power usage (kWh/day)	Extra moisture removal (L/day)	Total estimated power (kWh/day)	Total estimated hot water usage by LDD (kWh/day)	Estimated total heat loss with ventilation to achieve 80%RH[2b] (kWh/day)	Estimated total heat loss with ventilation to achieve 80%RH & 20% transpiration[2c] (kWh/day)	Energy savings[2b] (%)	Energy savings with 20% transpiration[2c] (%)
Jan	84.1	4.6	--	--	220	53	189	96	692	511	726	0	30
Feb	85.4	4.7	--	--	180	47	257	106	727	558	787	4	32
Mar	85.0	6.0	7.7	**21.7**	121	37	246	93	631	426	578	-12	18
Apr	81.9	4.9	5.8	**15.5**	114	32	241	87	605	406	534	-11	16
May	81.1	7.7	21.5	**64.2**	70	22	124	51	353	198	258	-37	-5

HRV

Table 3. HRV performance compared with traditional ventilation method

Month	RH actual achieved (%)	HRV on - U^T value[1] (W/m^2/°C)	HRV off - U^T value[1] (W/m^2/°C)	Energy savings[2a] (%)
Jan	82.0	6.9	5.5	**-24.2**
Feb	80.9	6.4	7.2	**10.2**
Mar	81.1	8.5	11.5	**25.8**
Apr	78.4	7.4	5.4	**-37.4**
May	81.4	8.1	22.1	**63.3**

Notes:

1. U^T value (W/m^2/°C) is the total energy required to increase the greenhouse temperature by 1°C/m^2; it includes heating, lighting, CO_2 burners, and the electricity consumed by the dehumidification units;

2a. Energy savings is compared the dehumidification system with the ventilation method; it is calculated as divided the U^T value when the units are on compared to the U^T value when units are off;

2b. Energy savings is compared the estimated total energy used by the units with the estimated total heat loss with ventilation to achieve 80%RH;

2c. Energy savings is compared the estimated total energy used by the units with the estimated total heat loss with ventilation inducing 20% more transpiration at night.

3. '--' in the table means the units were on for the whole night in January and February, so no on-off comparison could be made.

ERV

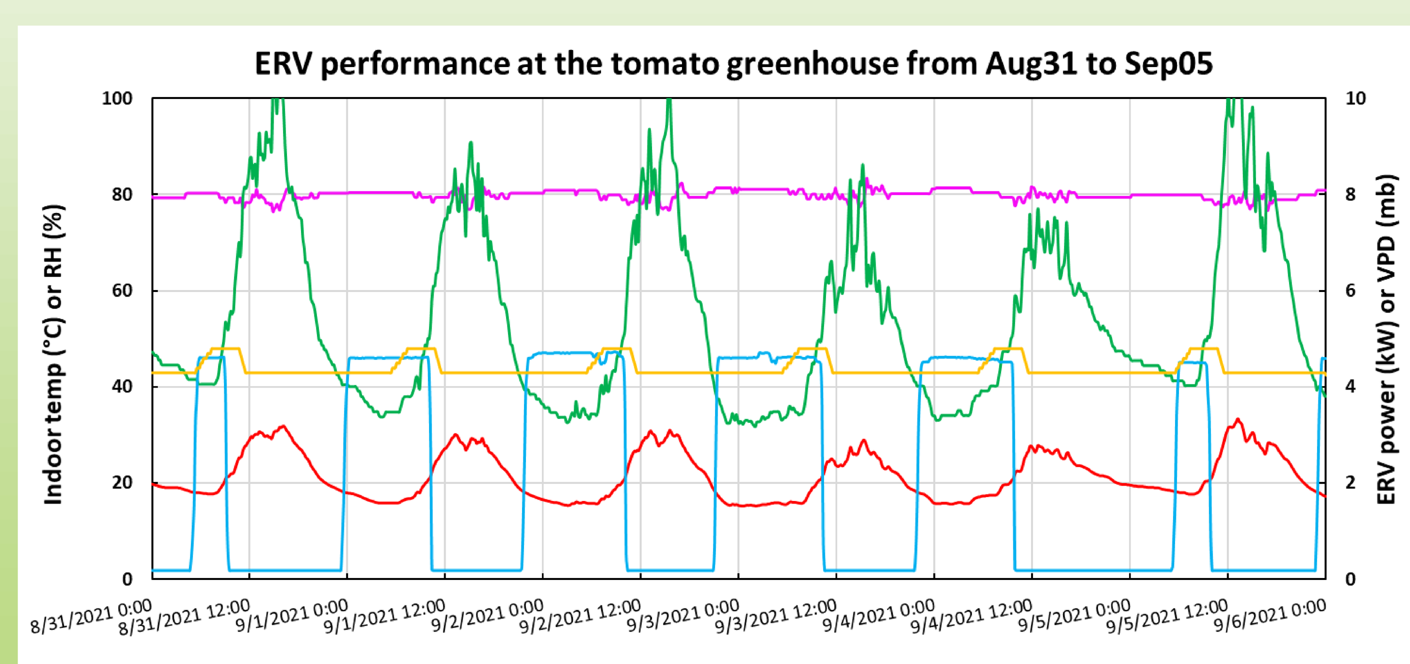


Figure 1. ERV performance at the tomato greenhouse

4. The ERV treatment zone had limited canopy, resulting in very high VPD.

5. The ERV was only running in dry mode during the period shown.

PRELIMINARY CONCLUSIONS

1. More energy savings at nighttime than during the daytime when the units are running.
2. The systems can control the indoor relative humidity to a certain degree, however, their capacity is not big enough to keep the indoor RH at the target level.
3. The vapour pressure deficit (VPD) at the tomato greenhouse is well controlled with the ERV unit.
4. The detailed costing information and a basis for determining return on investment (cost-benefit analysis) will be provided.
5. More performance trials will be conducted.

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REFERENCES

1. Parbst, Kurt. Personal communication.
2. Assaf, G., and N. Zieslin. Night water consumption by rose plants. 1996. Journal of Horticultural Science. 71 (5) 673-678.