Energy Efficient Lighting for Year-Round Production

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Feed the Increasing World Population

Challenges

- Climate change – extreme weather, drought etc.
- Limited natural resource – water, energy, and fertilizers etc.
- Decreasing arable land area

Controlled Environment Agriculture

- Water efficiency – reduce water use by as much as 90%
- High yield per unit of land area

  1. Modern greenhouse

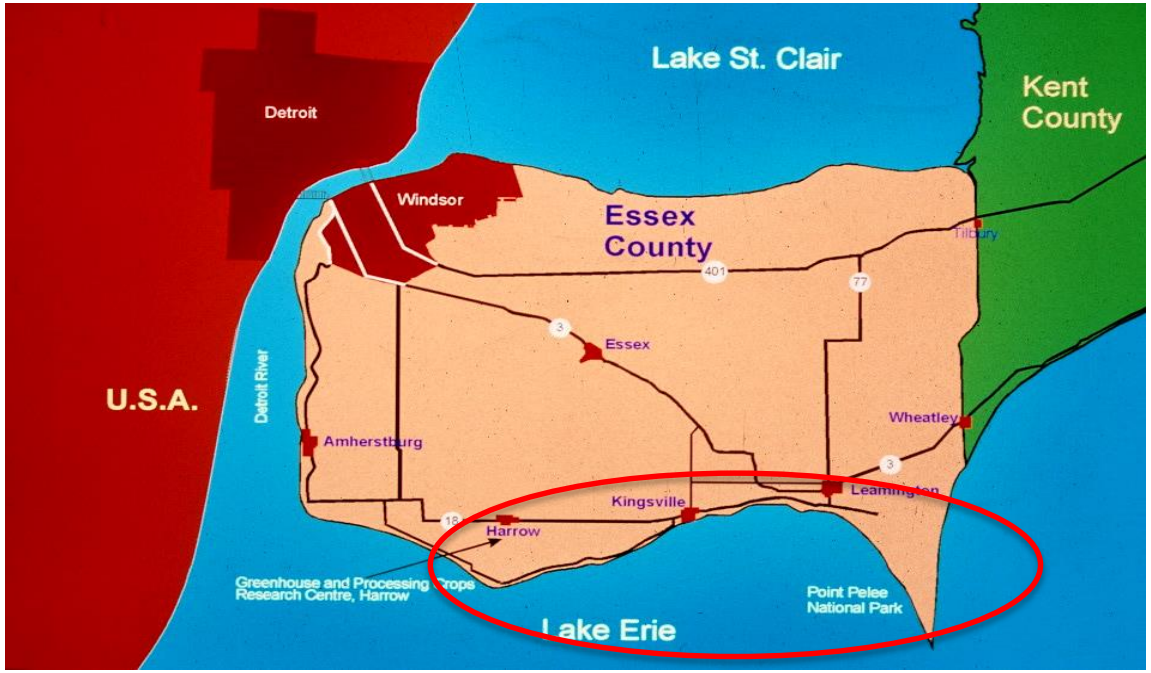
     (10-20 times)

  2. Indoor vertical farming

     (100-350 times)
- Intensive energy input

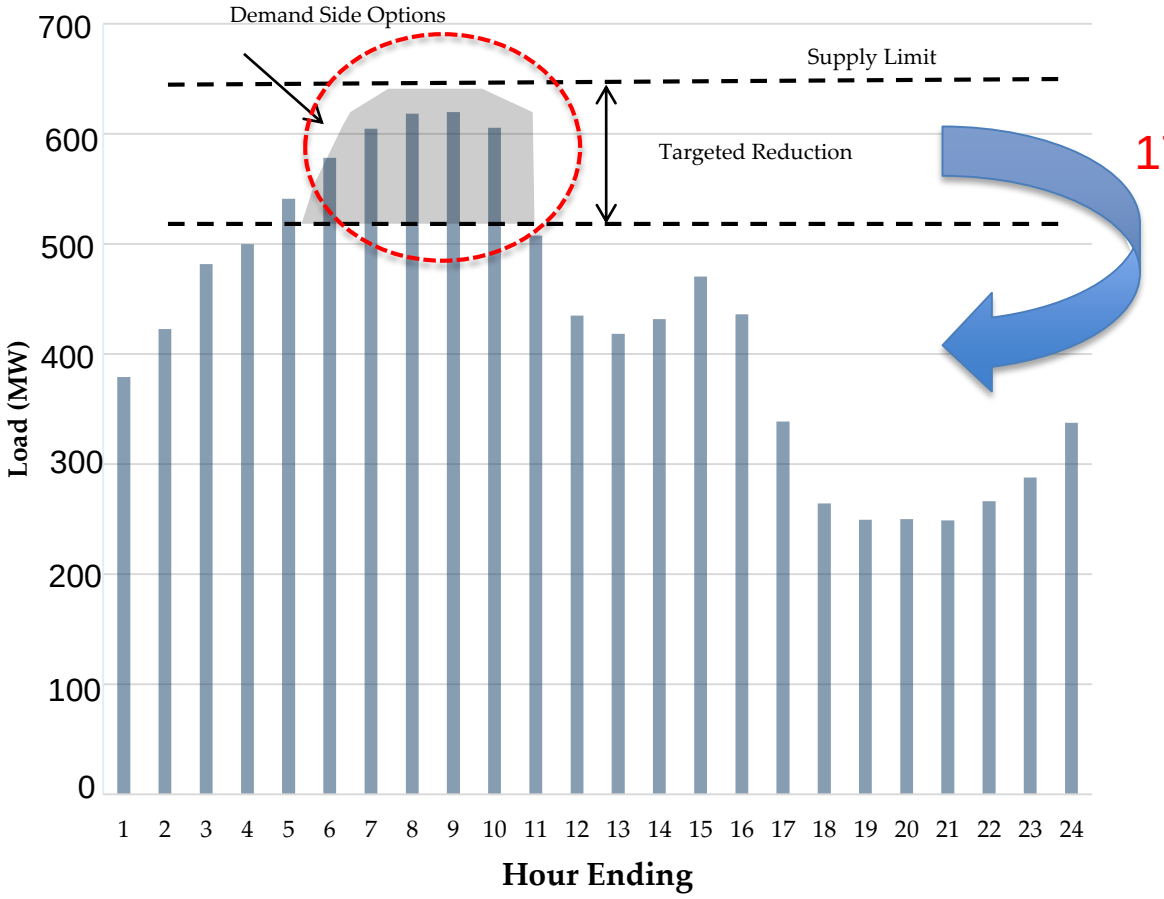
Plant factory, Japan

Leamington-Kingsville Area is the Largest Concentration of Vegetable Greenhouses in Canada and USA



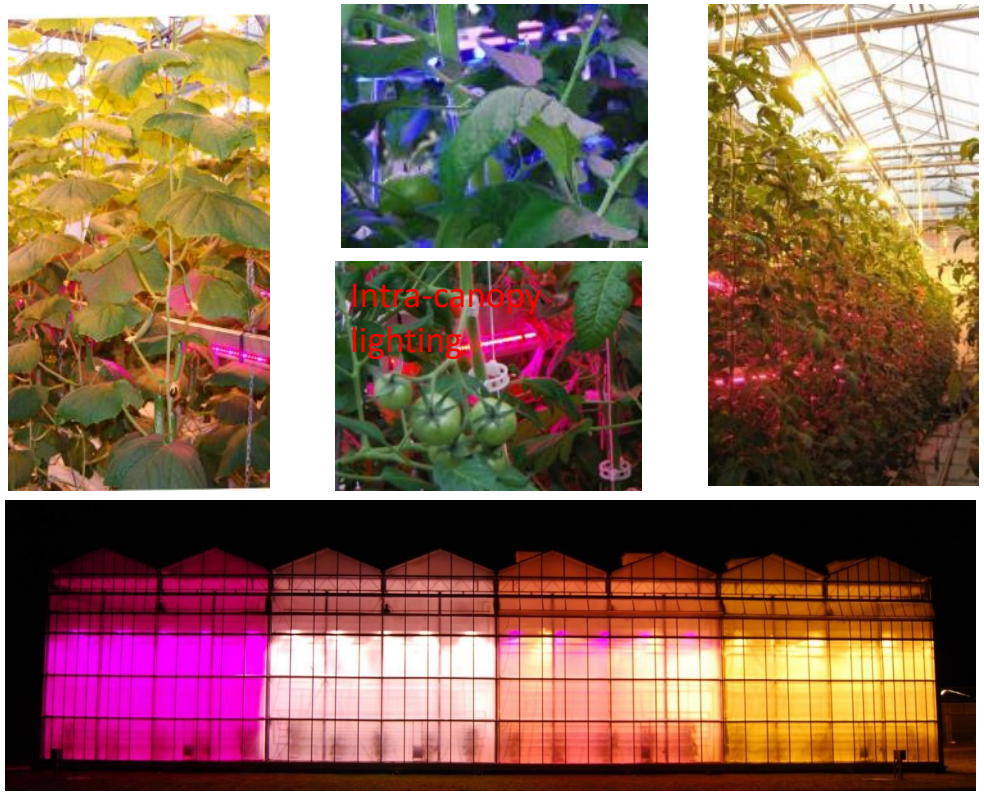
Substantial increase in production with supplemental lighting

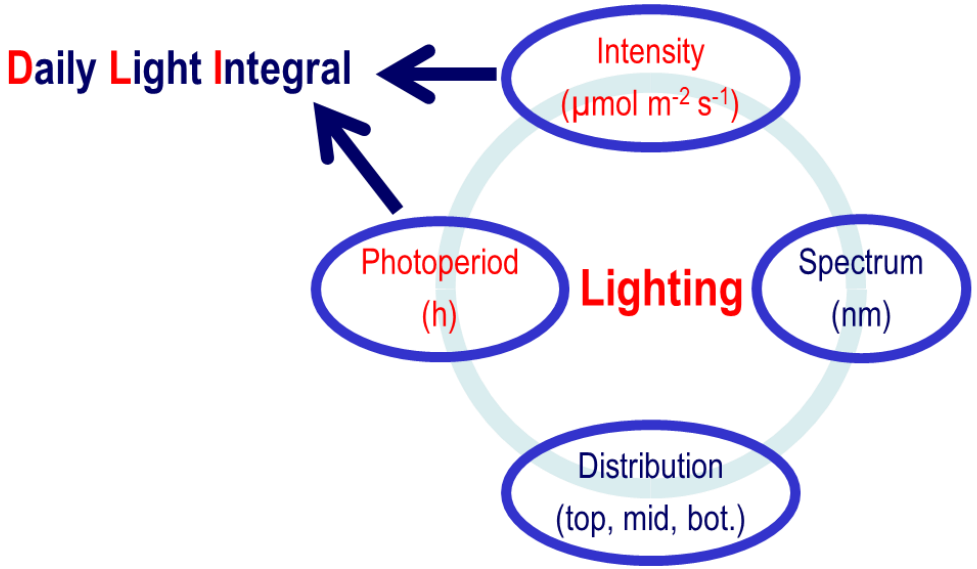
Demand-Side Solutions – Reduce Peak Power Demand



IESO, Oct. 2019

Why Do We Want to Move Towards 24-h Lighting?





Using low light intensity and long photoperiod to achieve target **DLI:**

1. Low capital costs (less light fixture) – facilitate the adoption of energy efficient LEDs.
2. Low daytime peak electricity demand
3. Low electricity rate during the night
4. High overall energy efficiency – Less heating requirement during the night

Challenge

- If photoperiod is > 17 hours
  - Leaf chlorosis
  - Reduced or no further yield increase

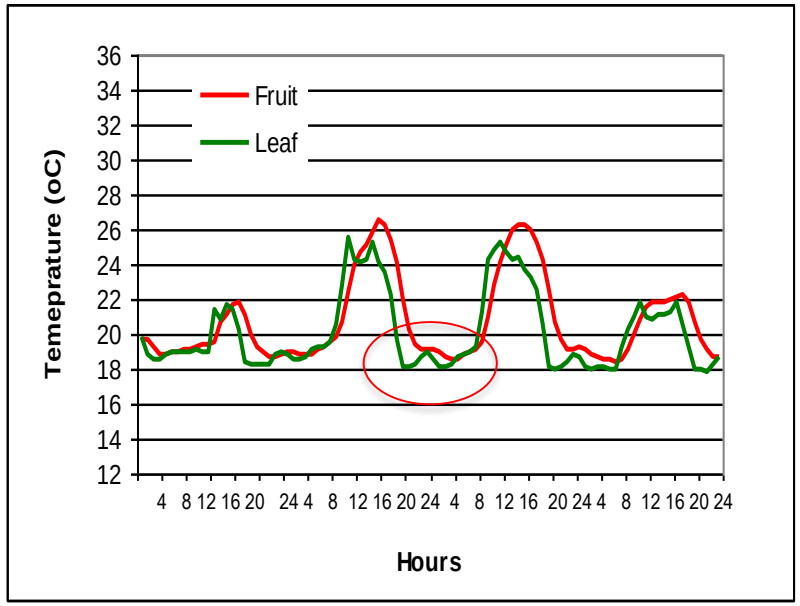
Circadian rhythm

Integrated temperature and light signal pathway

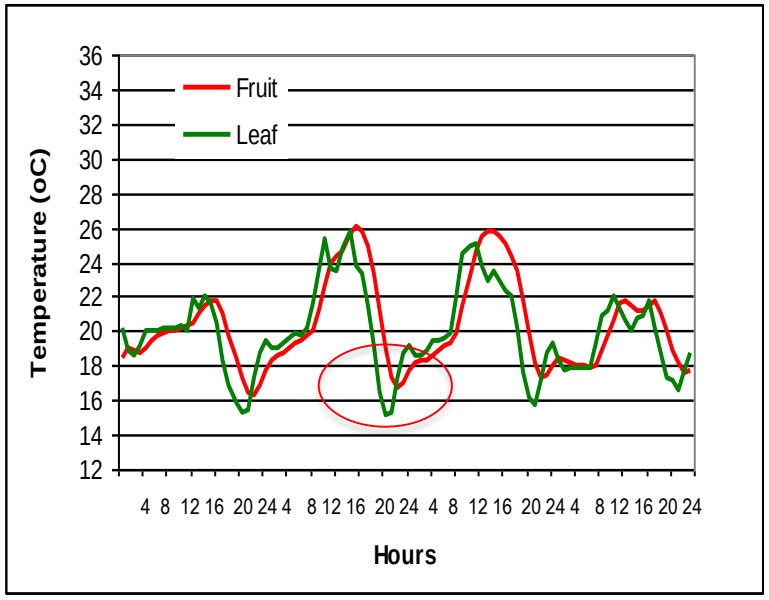
Leaf chlorosis under continuous light (24 hours) – Red, Blue and White together (Tomato)

Dynamic Temperature Integration (TI) with a Pre-night Temperature Drop

Normal TI



TI with drop



Pre-night temperature drop improved responses to long photoperiods (up to 21 h)

- Dynamic TI with a pre-night temperature drop reduced leaf chlorosis on tomatoes and sweet peppers but not on cucumbers.
- Pre-night temperature drop improved fruit yield on tomatoes, cucumbers, and in late production on sweet peppers (10-30%) at long photoperiods.
- Dynamic TI with a pre-night temperature drop reduced energy use during cold months.

Daytime Red and Nighttime Blue LED Lighting – Tomatoes

Control (16h)

24 lighting

Red/Blue
Day

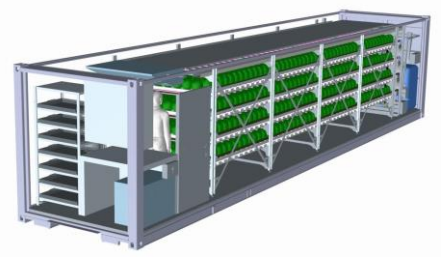
Red
Day

Blue
Night

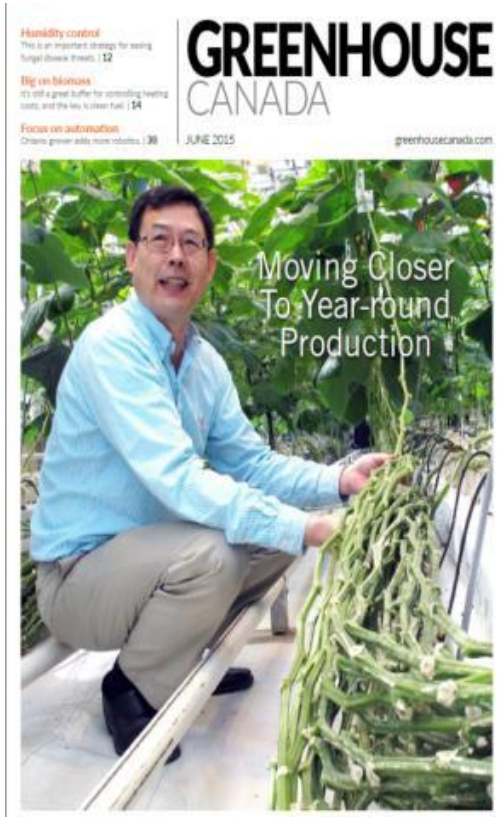
LED – 24 h Lighting in Tomatoes and Cucumbers

- 24h LED lighting can be used in mini-cucumber production to reduce light fixture and daytime peak hour power demand (by 1/3), and electricity costs without compromising fruit production in comparison to 16 h conventional lighting.
- Daytime Red nighttime Blue LED 24h lighting can reduce light fixture and daytime peak hour power demand by 12% and electricity costs in tomato production.
- Further study is being conducted to reduce it by 1/3 in tomato and pepper production.

Model study also indicates 24h LED lighting can reduce electricity use (growing light and air conditioning) by 30% in comparison to 16h lighting for a 40 ft. container vertical farm at Harrow and also reduces capital costs.



Sustainable Year-round Cucumber Production System



Microsoft Research AI, AAFC and OMAFRA win the first international autonomous greenhouse challenge at the Wageningen University & Research in the Netherlands – Highest net profits, yield and environmental sustainability/resource use efficiency (2018)

Acknowledgments

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