

## Greenhouses: Using the CO<sub>2</sub> produced by natural gas appliances to save money

For horticultural and vegetable producers in Quebec, greenhouse heating represents up to 30% of their operating costs. To remain competitive, they have to reduce these costs by implementing new solutions, such as more efficient equipment, thermal screens and methods for controlling nighttime temperatures. These measures are interesting strategies for reducing their energy bill. From a perspective of increasing profitability, greenhouse producers need to balance saving energy with improving productivity. Using artificial lighting and enriching greenhouse air with CO<sub>2</sub> accelerates plant growth by prolonging the photosynthesis periods.

### Two ways to enrich greenhouse air with CO<sub>2</sub>

There are two methods for CO<sub>2</sub> enrichment in greenhouses:

- Injection of CO<sub>2</sub> purchased and delivered in liquid form;
- Local production of CO<sub>2</sub> from natural gas combustion.

### Two methods, four technologies

#### Liquid-CO<sub>2</sub> storage tank

The process of injecting liquid CO<sub>2</sub> into greenhouses requires a storage tank for the CO<sub>2</sub> equipped with an integrated depressurization system to vaporize the liquid.

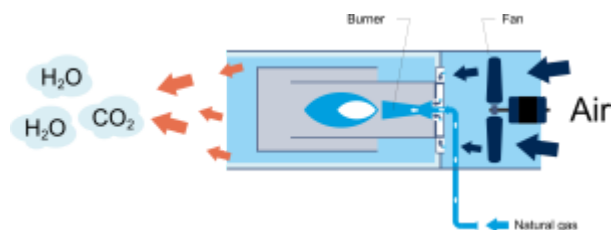
It is important to note that small variations in pressure can impact the distribution of the CO<sub>2</sub> in the greenhouse.

#### Natural gas CO<sub>2</sub> generator

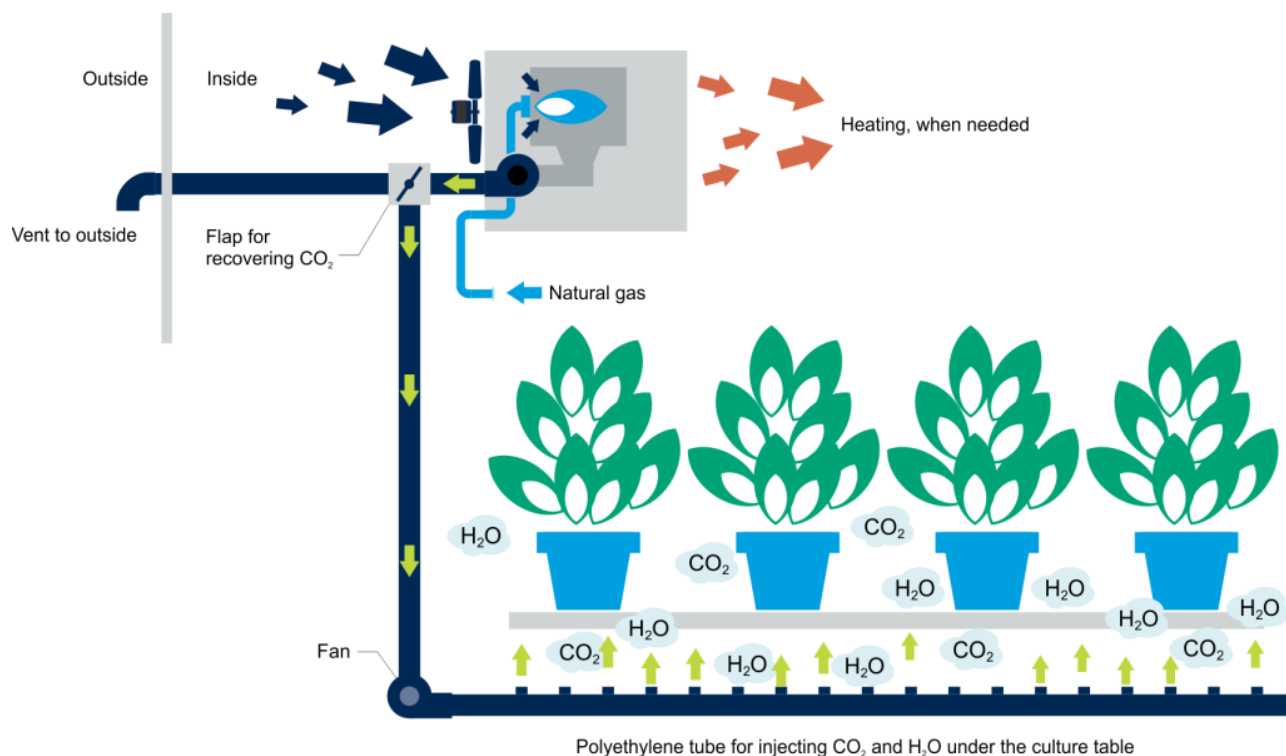
A CO<sub>2</sub> generator is a natural gas burner that exhausts its combustion products (CO<sub>2</sub> + H<sub>2</sub>O vapour) directly into the greenhouse. Each cubic metre of natural gas burned produces 1.9 kg of CO<sub>2</sub>.

CSA code B149.1<sup>1</sup> allows the use of this type of equipment provided the installed capacity does not exceed 20 BTU/hr\*ft<sup>3</sup> of greenhouse volume.

Although the heat is recovered in the greenhouse, using this equipment for heating is not recommended. In fact, the greatest need for heating is during the night when adding CO<sub>2</sub> is not required. What's more, injecting CO<sub>2</sub> during the nighttime can harm the plants.



## Recovery of the exhaust gases from a decentralized condensing natural gas unit



This concept of exhaust gas recovery is possible because of an exemption in *Natural gas and propane installation code* CSA B149.1. Article 8.9.1 requires that all appliances be connected to a chimney or vent pipe, with certain exceptions, such as in paragraph d):

(d) for an **appliance** installed for the production of carbon dioxide in a greenhouse where the rate of combustion does not exceed 3 Btuh/ft<sup>3</sup> (30 W/m<sup>3</sup>) of greenhouse volume and the concentration of carbon dioxide in the atmosphere does not exceed 5000 ppm (0.5%); and

This process recovers the CO<sub>2</sub> contained in the combustion products of a decentralized natural gas heating appliance (e.g. a unit heater) and injects it into the greenhouse as needed. When CO<sub>2</sub> is required, a deviation valve routes the exhaust gas into the greenhouse. To maintain the same humidity level in the greenhouse during CO<sub>2</sub> injection, use of a unit whose efficiency enables condensing is recommended given the dehumidification of the exhaust gases. Note that Gaz M tro offers financial assistance for the installation of condensing unit heaters.

## Recovery of the exhaust gases from a centralized natural gas unit

High-capacity boilers exhaust combustion products that are too hot to be injected directly into a greenhouse. So a condensing recuperator is required to lower the temperature of the combustion products while condensing the water vapour resulting from the combustion. However, this can create an energy surplus. If so, it can be stored in a well-insulated buffer water tank to be used when heating the greenhouse.

Water is produced at a rate of 1.5 kg/m<sup>3</sup> of natural gas burned and can be recovered for use in irrigation. It must be neutralized or diluted to obtain the required PH level. The rate of CO<sub>2</sub> injection in the greenhouse depends on the type of plants grown. Since the CO<sub>2</sub> will tend to acidify the water from the combustion products, the recuperator must be designed for a slightly acidic PH.

To distribute the thermal energy in the greenhouses, networks of hot-water pipes are the most effective for achieving a uniform temperature. The hot-water pipes also serve as rails for the carts between the rows of plants and facilitate transpiration while creating air movement around the plants. A second, moveable hot-water network, installed above the plants, can be used to heat the plant tops and control vertical growth. Finally, a third high-temperature network can be installed under the greenhouse roof, if necessary, to provide heat to melt snow and prevent accumulation.

## Which solution to choose?

Technology	Advantages	Disadvantages
<b>Liquid-CO<sub>2</sub> injection</b>	<ul style="list-style-type: none"> <li>Does not generate humidity</li> <li>Easy to use</li> <li>Low maintenance</li> <li>Easy to direct at plant leaves</li> <li>Adapts well to production schedule</li> </ul>	<ul style="list-style-type: none"> <li>Provisioning cost</li> <li>Compressor location</li> <li>Deliveries</li> <li>Loss of space used by tank</li> </ul>
<b>CO<sub>2</sub> generator</b>	<ul style="list-style-type: none"> <li>Ease of installation</li> <li>No storage tank or need to manage deliveries</li> <li>Heat recovery possible</li> <li>Doesn't require much space</li> <li>Adapts well to production schedule</li> </ul>	<ul style="list-style-type: none"> <li>Need to manage greenhouse oxygen levels to avoid oxygen deprivation from breathing the air</li> <li>Periodic maintenance to ensure complete combustion of the natural gas</li> <li>CO<sub>2</sub> not evenly distributed in the greenhouse</li> <li>Need to manage humidity contained in gases</li> <li>Excess heat in the greenhouses</li> <li>CO<sub>2</sub> requirements different than those for heating</li> </ul>
<b>CO<sub>2</sub> recovery from gases (Decentralized – Unit heater)</b>	<ul style="list-style-type: none"> <li>Simple, low-cost installation, because it uses existing combustion equipment and standard plumbing products</li> <li>No storage tank or need to manage deliveries</li> <li>Recovers the heat from the appliance</li> <li>No loss of space inside or outside the enclosure</li> <li>Condensing unit: high efficiency</li> </ul>	<ul style="list-style-type: none"> <li>Periodic maintenance to ensure complete combustion of the natural gas</li> <li>CO<sub>2</sub> sensor required to ensure concentration does not exceed 5,000 ppm</li> </ul>
<b>CO<sub>2</sub> recovery from gases (Centralized – Boiler)</b>	<ul style="list-style-type: none"> <li>A tank makes it possible to recover heat when necessary</li> <li>Since acidic condensate must be neutralized before being discarded, might as well use it for irrigation</li> <li>Very effective process with no greenhouse gas impact</li> </ul>	<ul style="list-style-type: none"> <li>Space required for equipment</li> <li>Expensive system</li> <li>Uses extensive piping</li> </ul>

A pilot project to inject CO<sub>2</sub> from the gases of condensing unit heaters and modify the temperature conditions in a Gaz Métro customer's horticultural greenhouse served to demonstrate the cost-effectiveness and potential savings of this strategy. For this project, the customer received \$35,000 in financial assistance under Gaz Métro's Innovation program.

In the final analysis, with natural gas heating appliances, each cubic metre consumed produces 1.9 kg of CO<sub>2</sub>, which customers can use to boost plant growth and significantly reduce production costs while recovering greenhouse gases for a good purpose and keeping savings from going up the chimney.

Sami Maksoud, Eng., M. Eng., MBA, CMVP®  
Advisor, Energy Efficiency, DATECH, Gaz Métro

Charles Côté, Eng.  
Advisor, Technologies, Codes and Standards, DATECH, Gaz Métro

1 Natural gas and propane installation code

Informa-TECH is a publication of DATECH Group of Gaz Métro offered free of charge. For further information on these topics, contact DATECH Group at [DATECH@gazmetro.com](mailto:DATECH@gazmetro.com).

Copyright ©2017. Gaz Métro. All rights reserved | [Legal notice](#)