BRITISH COLUMBIA | Ministry of Agriculture

Regulating
COMBINED HEAT AND POWER GENERATION AT GREENHOUSES
in the ALR

DISCUSSION PAPER AND STANDARDS

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Executive Summary

This discussion paper was prepared by the BC Ministry of Agriculture (AGRI) and outlines a set of criteria that can be used by local governments to regulate combined heat and power generation (cogeneration) at greenhouses in the Agricultural Land Reserve (ALR).

The demand for cogeneration at greenhouses is fueled by international climate change policies, increased focus on energy efficiency and the appetite of farmers to integrate new technologies into their businesses that will help them remain competitive in international markets.

This paper focuses on addressing the land use issues of cogeneration at greenhouses in British Columbia. The criteria that are presented reflect analysis by AGRI and Agricultural Land Commission (ALC) staff. The draft discussion paper, dated December 15, 2011 was used to solicit feedback from stakeholders. The feedback and further analysis by AGRI staff has been incorporated into this discussion paper dated April 2013. Part 4 of this document contains the definitions and bylaw criteria established as the Minister's Bylaw Standard under section 916 of the *Local Government Act*.

Parts 1, 2 and 3 provide the basis for developing standards in Part 4 that can be used by local governments to establish land use policy or regulations related to cogeneration at greenhouses. Although the emphasis of the criteria is on natural gas-fired cogeneration in the South Coastal region, local governments that are outside these areas may use the information as they see appropriate. The standards are intended to assist local governments in addressing the demand for cogeneration at greenhouses without compromising the long term productivity of agricultural land.

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Introduction

The draft discussion paper dated December 15, 2011 outlined a set of criteria for regulating the use of combined heat and power (CHP) generation, commonly referred to as cogeneration, at greenhouse operations in the ALR. The paper served as a basis for further discussion with local governments and the greenhouse sector to ensure the criteria effectively deal with the issue of cogeneration from a land use regulation perspective. The criteria were developed to reflect analysis undertaken by AGRI and ALC staff.

The criteria are intended to address the needs of the greenhouse sector while protecting the agricultural land base from non-farm use related activities. The criteria may be modified by local governments to meet local agricultural needs.

Parts 1, 2 and 3 of the initial draft Discussion Paper have been updated to incorporate the feedback from the consultation period and further analysis done by staff to reflect the criteria development process, background on the issue and the policy, guidelines and regulations in place at the time. Part 4 of this document provide the definitions and bylaw criteria established as the Minister's Bylaw Standard.

Part 1 – Criteria Development Process

The intent of this process is to develop criteria that can be used by local governments to establish land use policy or regulations to address on-farm energy production through natural gas-fired cogeneration systems. Following consultation with stakeholders, these criteria, if approved by the Minister, may become standards and be incorporated into the "Guide for Bylaw Development in Farming Areas".[1]

1.1 Purpose & Goals

The purpose of establishing the criteria is to meet the agriculture industry's demand for cogeneration in a manner that minimizes the impact on agricultural land and addresses local government concerns. These criteria will:

1. meet the needs of the greenhouse sector;
2. minimize the impact of cogeneration in the agricultural area; and
3. minimize the risk of cogeneration systems being installed for non-farm purposes.

1.2 Scope

While there may be other issues associated with energy production through cogeneration, the criteria considered in this paper only address the land use issues of regulating the scale of the cogeneration plant relative to the greenhouse facility and the heat demand of crops grown in the greenhouse. The criteria attempt to meet the needs of greenhouse operators who wish to invest in cogeneration systems, and at the same time, discourage the establishment of cogeneration facilities in the ALR that far exceed the heating needs of the greenhouse. The need for cogeneration is isolated to the South Coastal region where the larger greenhouse operations are located. Therefore, the criteria have been developed for greenhouse operations in the ALR in the South Coastal region.

These criteria have been developed for natural gas-fired cogeneration which minimizes the land use impacts due to the fuel source. If the cogeneration is fueled by other sources such as bio-mass, then other potential impacts should be considered in the criteria as well. Examples of the other impacts are the footprint of the fuel storage, increased traffic to deliver the fuel and dust from the fuel storage.

The BC Ministry of Agriculture recognizes that other agencies' regulations and requirements (BC Building Code, BC Environmental Management Act, etc.) must still be met and that the establishment of a cogeneration facility in the ALR must be consistent with the ALC Act and policy.

[1] Under the *Local Government Act* (Part 26, Division 8, Section 916), the minister responsible for the *Farm Practices Protection (Right to Farm) Act* can develop bylaw standards to guide the development of zoning and farm bylaws. Development of provincial standards is intended to promote consistency in the regulation of, and planning for, farming. However, provision has been made under Section 916 (3) to allow the standards to differ, if necessary, to respond to BC's diverse farming industry and land base.

1.3 Stakeholders

The following groups will be involved in the criteria development process:

- BC Ministry of Agriculture staff;
- Agricultural Land Commission staff;
- BC Greenhouse Growers' Association;
- United Flower Growers Co-operative Association;
- Local governments and their Agricultural Advisory Committees;
- Cogeneration technology providers;
- BC Ministry of Environment (MoE) staff; and
- BC Ministry of Energy and Mines staff.

1.4 Objectives of the Process

The objectives of the development process are to:

1. create a set of criteria for review by stakeholders;
2. consult with stakeholders; and
3. develop standards that local governments can adopt and apply as policy or regulation.

1.5 Methods to Develop the Criteria

Key Steps

Five key steps will be undertaken to develop the criteria:

1. Review relevant literature including AGRI and ALC policies;
2. Examine how other jurisdictions have addressed the issue of co-generation at greenhouses;
3. Consider case-studies and reports on co-generation at BC greenhouses;
4. Review and compare existing local government regulations and policies; and
5. Consult with AGRI staff, ALC staff, Ministry of Environment staff, local governments and the agriculture industry.

Process to Date

Current policies and regulations regarding on farm energy production in BC were examined and used in developing the criteria. Throughout the research process, careful attention was paid to the varying energy policies and energy markets that were driving adoption in co-generation at greenhouses in other jurisdictions. The pros and cons of co-generation have been considered from an environmental and economical point of view. Finally, the criteria were developed with respect to how co-generation should be regulated in the ALR. This information was then considered by a committee comprised of AGRI and ALC staff who worked together to draft the criteria currently listed in Part 4 of this document.

This discussion paper will be distributed to the MoE, ALC, local governments and the agriculture industry for their review and feedback. Once stakeholder input has been received and incorporated into the discussion document, the criteria will be sent to the Minister of Agriculture for final approval. Once approval has been received, the criteria may be incorporated into the "Guide for Bylaw Development in Farming Areas". Local governments would then be encouraged to amend their zoning bylaws to be consistent with the Minister's Bylaw Standard.

Part 2 – Background

2.1 State of the Greenhouse Sector in BC

The BC greenhouse sector uses modern greenhouses to produce high-valued vegetables and a wide range of ornamental plants, including both flowering potted plants and cut flowers. The sector accounts for almost 40% of farm cash receipts for agricultural crops in BC and is an important contributor to the provincial economy (BC Ministry of Agriculture, 2010). The majority of the production area is located in the Lower Mainland area, although production also occurs on Vancouver Island and in the Okanagan. The sector experienced considerable expansion through the 1990s (Figure 1), but growth stalled early in 2000 due to significant increases in the cost of natural gas and the value of the Canadian dollar. The production area has been stable at roughly 500 hectares for the past 7 years.

Total farm gate sales follow a similar trend to production area and have been relatively flat since 2004 for both vegetable (~$240 million) and ornamental (~$300 million) crops (Figure 2). Although sales are flat, net operating income and net worth are down (BC Ministry of Agriculture and Lands, 2009). Declines in revenue experienced in the mid-2000s for vegetable crops have been replaced by modest gains the past 2 or 3 years (Figure 3). Nonetheless, revenues in 2010 were below levels in 2003 by 15% for cucumbers and peppers and by 3% for tomatoes. The declines in revenue are directly related to changes in product prices.

The average price received for all greenhouse vegetable crops was higher in the 4-year period from 2003 to 2006 versus 2007 to 2010. The average price has declined 15% for peppers, 13% for tomatoes-on-vine and 3% for beefsteak tomatoes, and 4% for cucumbers. Data on changes in price and production per area are not available for greenhouse ornamental crops. However, it is clear from Table 1 that the average price of ornamental crops is also declining. The average change in selling price of eleven selected floriculture crops at the local flower auction declined 6.5% in 2008 and 5.7% in 2009 (Table 1).

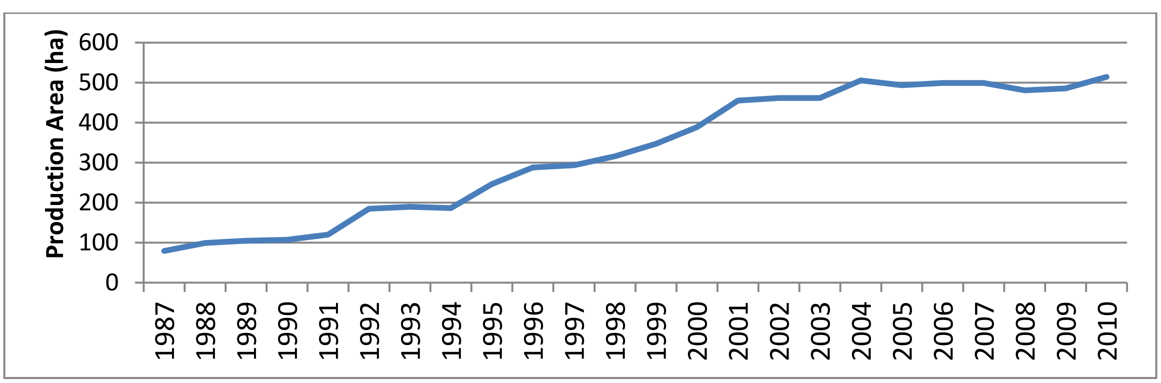

Figure 1 Greenhouse area of production from 1987 to 2010 (Source: Statistics Canada)

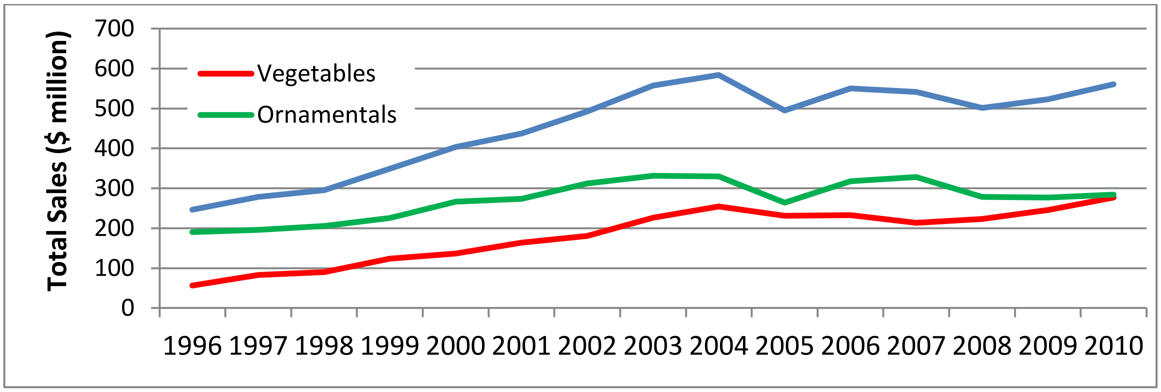

Figure 2 Total sales of greenhouse vegetables and ornamentals from 1996 to 2010 (Source: Statistics Canada)

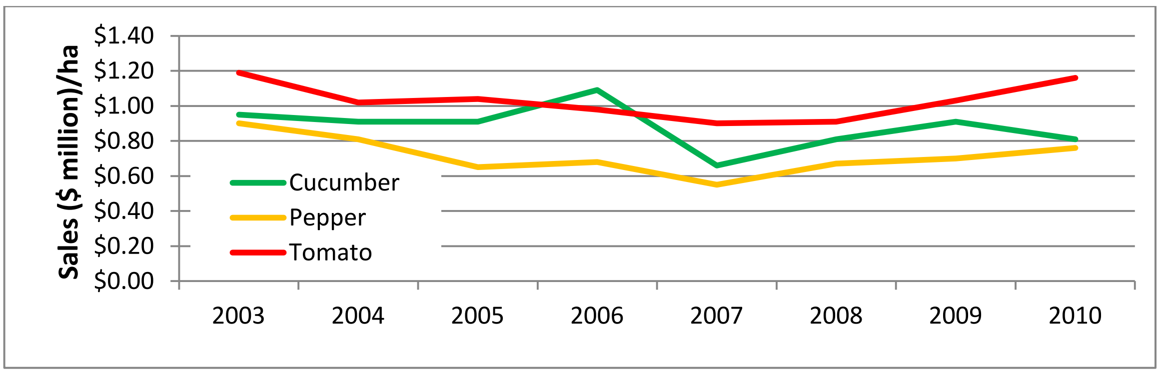

Figure 3 Greenhouse vegetable sales per area of production (Source: BC Vegetable Marketing Commission)

Table 1 The % change in price and units sold for 2008 and 2009 versus the average for the previous 4 years for 11 representative floriculture crops (Source: UFG Product Statistics)

Crop		**% Change in Price**	
		2008	**2009**
Cut Flower	Gerbera	-7.8%	+9.3%
	Alstroemeria	-12.0%	-7.9%
	Rose, Std (55 cm)	-9.4%	-5.8%
	Tulips	+0.8%	-13.2%
	Gladiolus (field)	-1.2%	+6.0%
	Cymbidium (on stem)	-14.2%	-27.0%
Potted	Poinsettia (15 cm)	-9.5%	-16.8%
	African violets (10 cm)	0.0%	+8.4%
	Tropical (10 cm)	-8.7%	-3.8%
	Geranium (10 cm)	+1.8%	+15.9%
	Primula (10 cm)	-0.4%	+5.5%
	Average Change	-6.5%	-5.7%

Export sales are very important for the greenhouse sectors. For instance, it is estimated that about 60% of BC-produced greenhouse vegetables are exported. The majority of exports go to the U.S. market. Greenhouse growers in BC are facing increasing competition in the domestic and export markets. For the greenhouse vegetable sector, this has materialized due to recent expansion of protected cultivation in Mexico. The area of protected cultivation in Mexico has increased nearly 40% in the past three years to approximately 15,000 hectares in 2010 (USDA Foreign Agricultural Service, 2010). In addition, some Mexican operations are now producing year-round which is reducing the price premium that BC growers previously received in April to June. There is also increasing competition in the ornamental sector from US product and cut flowers grown in South America.

Canadian greenhouse growers are becoming less competitive as a result of the appreciation of the Canadian dollar and increases in the cost of inputs, such as fertilizers, pesticides, labour, and fuel. The Canadian dollar has appreciated 32% relative to the US dollar since March 2009, and in the past year the price of fertilizer has increased 8% for nitrogen (urea), 32% for phosphate, and 9% for potassium (Shiell, 2011). The industry also contends that the BC Carbon Tax is eroding the competitiveness of the industry.

Energy is a significant cost to produce greenhouse crops and accounts for approximately 25% of the total production costs for greenhouse vegetable crops in BC (Willis Energy Services, 2005). For this reason, the greenhouse sector has been quick to adopt energy saving technologies such as thermal screens, heat storage, and more efficient boilers. Many growers have also switched to biomass as a fuel source. However, growers continue to see their margins decline and are looking for new options to reduce their costs of production and improve their industry competitiveness.

2.2 Cogeneration at BC Greenhouses

Cogeneration is one option being considered by BC greenhouse growers to reduce energy costs and to increase the availability of CO_2 to enhance crop production. In 2005, Willis Energy Services studied the economics of cogeneration for the BC greenhouse industry. The authors of the report stated that cogeneration is well-suited for the industry because: greenhouses require heat at a relatively low temperature, many greenhouses are located close to load centers, and greenhouses can use the CO_2 produced (Willis Energy Services, 2005). BC greenhouse growers have seen their competitors successfully implement cogeneration at facilities around the world and now wonder if they can take advantage of similar technology adoption here in BC. For example, a successful cogeneration installation in the Netherlands saw Royal Pride Holland achieve 20% reduced production costs on a 45 ha greenhouse tomato operation (Neville, 2009).

Cogeneration is most attractive to the larger greenhouse operations in the Lower Mainland because they have the resources and scale of production to justify the investment in this technology. Greenhouse vegetable operations are more apt to consider cogeneration than floriculture operations due to the higher heat demand and benefits of CO_2 fertilization for vegetable crops. Research has shown that increasing the CO_2 level by 400 ppm can increase pepper fruit set by 55% and production by 30% (BC Ministry of Agriculture, Fisheries and Food, 1996).

British Columbia's energy policy and pricing has hindered the uptake of cogeneration in BC compared to other jurisdictions around the world. However, the recent announcement of BC Hydro's Standing Offer Program (SOP) has once again triggered BC greenhouse growers to explore the opportunity of implementing cogeneration facilities at their operations. If greenhouse growers can negotiate favorable, long term electricity and natural gas contracts with utility companies in BC, on-farm cogeneration could make greenhouse operations more competitive in their industry.

Other benefits of cogeneration include producing electricity in communities where it is needed, thereby avoiding or deferring investments in transmission and distribution network infrastructure (Kerr, 2008; PEW Center, 2011), and displacing higher-cost generation plants (Kerr, 2008). Cogeneration also reduces losses of electricity that inevitably occur during transmission from a large central power station, which are estimated to be around 9-10% of net generation (Kerr, 2008; Willis Energy Services, 2005).

The barriers to adopting cogeneration at greenhouse in BC are mostly economic and require careful negotiation between BC Hydro, Fortis BC and the BC Greenhouse Growers Association. The key issues identified by the industry are:

- The acceptance of natural gas fueled electricity for BC Hydro's SOP;
- Natural gas supply constraints and commodity price risks;
- Capital and Interconnections Costs;
- Agricultural vs. Industrial Zoning for CHP units; and
- Securing permits and paying fees prior to SOP application.

2.2.1 BC Hydro Standing Offer Program

BC Hydro implemented a SOP to encourage the development of small and clean or renewable energy projects throughout British Columbia. The program was developed to streamline the process for small developers selling electricity to BC Hydro, simplify the contract and decrease transaction costs for developers while remaining cost-effective for rate payers. The SOP embodies the principles and policies set out in the BC Energy Plan and the Clean Energy Act (BC Hydro, 2011a).

Current SOP pricing applies to projects between 0.05 MW and 15 MW. A base price is set according to the regions defined by BC Hydro. Regional pricing varies from $94.86/MWh in the Peace River region to $103.69/MWh in the Lower Mainland (2010). BC Hydro published SOP Rules for 2011 that fully explain eligibility, payment price and application process (BC Hydro, 2011b).

There are two eligibility rules of specific interest to the greenhouse industry. First, electricity must be generated either from clean or renewable resources or from a high-efficiency cogeneration facility. Second, the project site must be zoned appropriately if local government land-use requirements apply.

2.3 Economic Factors

The key driver for profitability of gas-fired cogeneration systems is the 'spark spread' (Figure 4), which is the margin between natural gas purchase price and electricity sale price (Daniels et al., 2007). The tipping point of profitability occurs when the selling price of electricity exceeds the price paid for natural gas by a margin that covers the costs of running the cogeneration system.

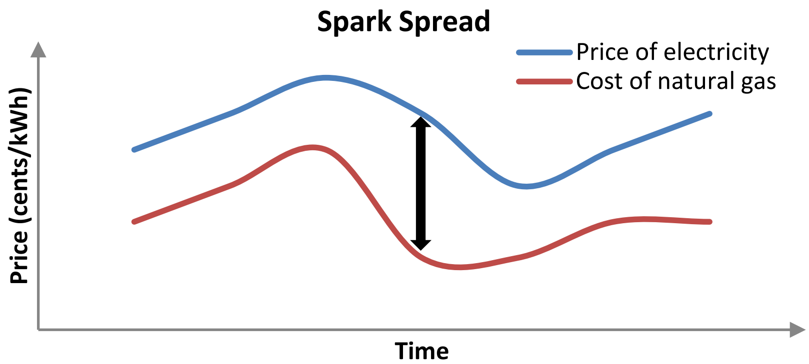

Figure 4. Spark spread between electricity and natural gas prices

The best example of how greenhouses maximize profits from cogeneration takes place in the Netherlands. Dutch greenhouse operators will only run their cogeneration engines when electricity prices are high and the 'spark spread' is the greatest. They store heat during that time and then operate back up boilers to meet heat demands when electricity prices are low. The Dutch have a liberalized energy market and the government has created substantial feed-in subsidies to support the cogeneration industry and achieve political targets for greenhouse gas reduction and improved energy efficiency.

The economics of cogeneration are different in British Columbia due to different costs and sources of fuel and electricity. BC currently relies on the cleanest and lowest cost electricity generation technology available worldwide. The volatility of gas prices in North America also means that there is a level of risk on the payback of investment in cogeneration. Recent volatility of natural gas prices and below market value of electricity has slowed the installation of cogeneration systems in Ontario (Nyboer et al., 2011). Greenhouse growers in BC also need to consider the carbon tax implications of consuming increased volumes of natural gas to fuel CHP engines.

In general, greenhouse vegetable operations in BC have not adopted high intensity supplemental lighting that would increase their electricity demand. In BC, supplemental lighting is more commonly used by floriculture greenhouses at levels of 4,000-10,000 lux (Willis Energy Services, 2005). Most of the electricity produced by on-farm cogeneration in BC would need to be sold to the grid because production would exceed greenhouse needs. The Willis Report concluded that cogeneration is viable for greenhouses in the Lower Mainland assuming that "the value of the electricity generated has a premium value because of its location at BC Hydro's load center, and gas distribution costs for the cogeneration facilities would be lower than Terasen's [FortisBC's] standard rates" (Willis Energy Services, 2005).

2.4 Technical Analysis of Cogeneration

Cogeneration is achieved through the use of CHP engines. CHPs simultaneously produce thermal and electric energy from a single fuel source, in this case natural gas. Heat from the engine cooling system and the exhaust gas is extracted by a heat exchanger and then used as a low temperature heat source in greenhouses (Daniels et al., 2007; Nyboer et al., 2011). CHP engines also release CO_2 that can be captured and used as a fertilizer in greenhouse operations.

2.4.1 Configuration

Figures 5 and 6 show how CHP engines can be connected to existing greenhouse infrastructure to supply heat, electricity and CO_2 to the facility. In practice, CHP engines will not completely replace natural gas boilers. A combination of the two systems will be necessary to maximize efficiencies and meet seasonal heat demands of the greenhouse.

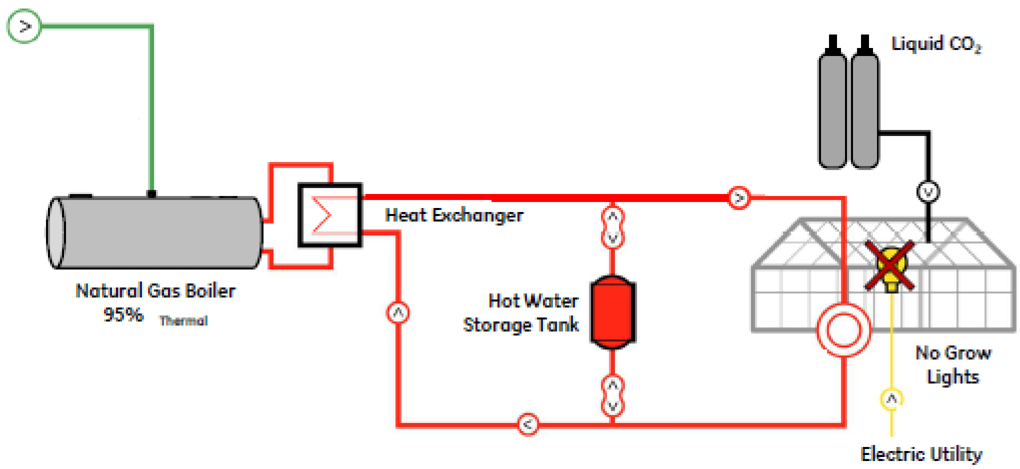

Figure 5. Existing greenhouse infrastructure with natural gas boiler and liquid CO_2 (Modak, 2011)

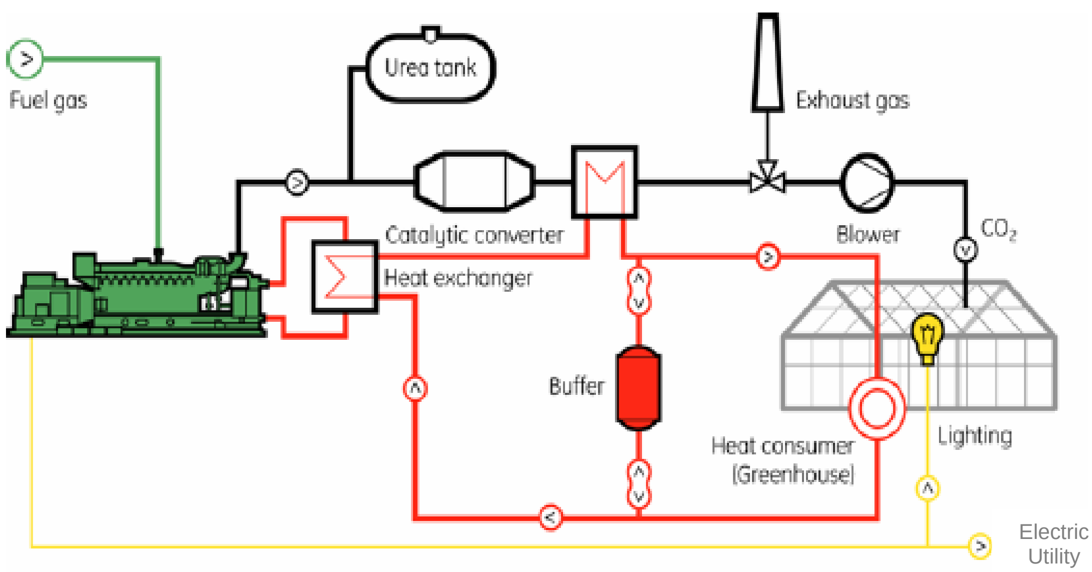

Figure 6. Heat, electricity and CO_2 supply to greenhouse by cogeneration (Kramp and Hesener, 2011)

2.4.2 CHP Sizing

To maximize the benefits of cogeneration, the thermal capacity of the system should "be sized to meet the base thermal load required by the host facility" and electricity production should be maximized (Nyboer et al. 2011). It is not desirable to install a system with a higher power rating than required for the application because doing so would reduce the hours of operation and, therefore, the duration of CO_2 fertilizing per day (Hovius, 2010b). Figure 7 shows how an existing boiler and a CHP generator can be used in combination to meet the heat demand of a greenhouse tomato operation in the Lower Mainland. In this example, annual CHP operating hours are maximized and an existing boiler is used to meet seasonal heat demands.

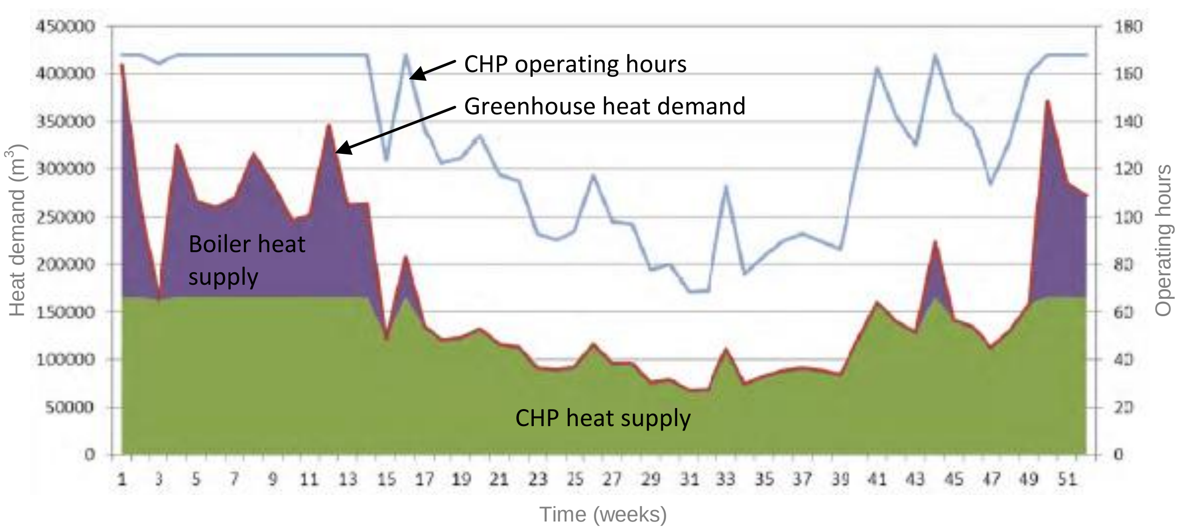

Figure 7. Annual heat demand and CHP operating hours for tomatoes in the Lower Mainland (Kramp and Hesener, 2011)

Unfortunately, CO_2 demand at greenhouses does not correspond with heat demand. CO_2 demand is the greatest during summer months, when crops are growing rapidly and setting fruit. At this time, CHPs would be idled back because heat demand is lower, as seen in Figure 7. The result, as shown in Figure 8, is that liquid CO_2 would be necessary to meet CO_2 demand during the summer. When CHP operating hours are maximized, CO_2 demand of greenhouse crops is actually the lowest, meaning that excess CO_2 will be generated.

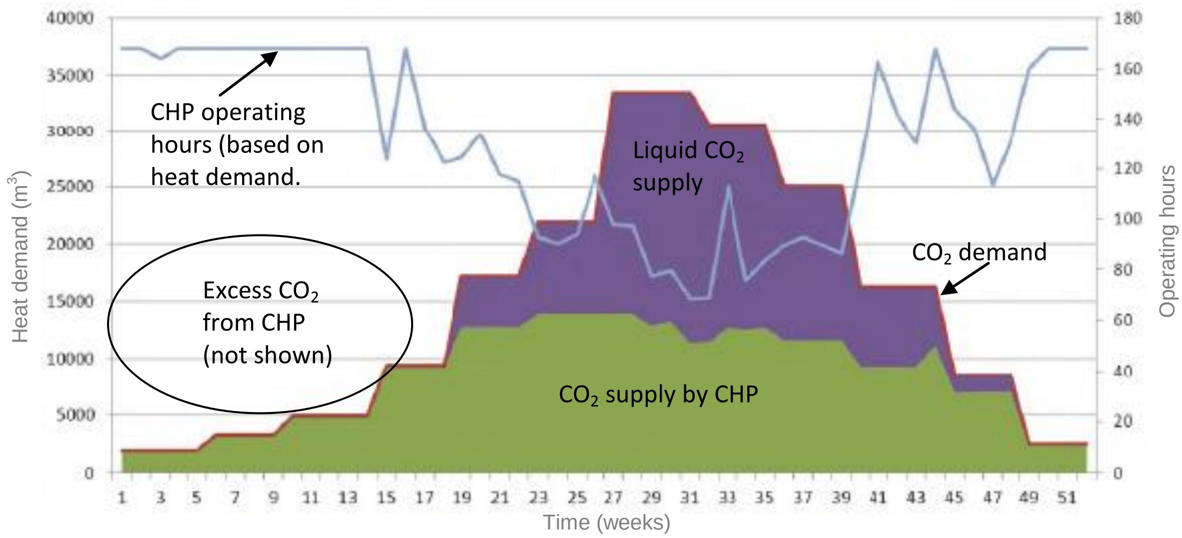

Figure 8. Annual CO_2 supply and demand considering CHP operated to meet heat demand (Kramp and Hesener, 2011)

In addition, the cogeneration system should be appropriately sized to minimize the capital costs. Cogeneration plants are a large capital investment and the cost of the plant is directly related to its size. The estimated capital cost for a cogeneration system in BC is $1.4 million/MW electric installed (Kramp and Hesener, 2011). The industry will size and operate cogeneration systems efficiently due to the tight economics of the situation. Another major upfront cost is the interconnection fee to tie into BC Hydro's grid. It is often assumed to be less than 5% of the total capital cost, although the authors of the Willis Report acknowledged that the cost could exceed 25% of capital costs depending on the site (Willis Energy Services, 2005).

In 2008, the 'rule of thumb' for heat demand in the Netherlands was 0.5 MW electric per hectare when CO_2 fertilization is used but not grow lights (GE Energy, 2008). The greenhouse industry in B.C. has suggested that up to 1.5 MW electric per hectare would be required at peak load when grow lights are used. The cogeneration system should be sized based on the value of electricity and the operational demands for heat and CO_2. A UBC master's thesis reported that the typical heat demand for floriculture crops was 6,250 GJ/ha and for vegetable crops was 24,000 GJ/ha (Chau, 2008).

2.4.3 Environmental Considerations

Cogeneration is considered to provide substantial gains in energy efficiency versus producing heat and energy separately (Nyboer et al., 2011; PEW Center, 2011). The reason for this is that thermal power stations commonly release the heat produced into the environment (Coyne, 1999). It has been estimated that two-thirds of the primary energy combusted in a power station is lost as waste heat (Henvey, 2006; Kerr, 2008). In contrast, cogeneration systems are very efficient and are commonly reported to convert 75% to 80% of the fuel into useful energy (Kerr, 2008). Modern systems being used by greenhouse operations around the world have even higher overall efficiencies of 90% or more (Kerr, 2008; Willis Energy Services, 2005).

Cogeneration is sometimes considered to reduce emissions of CO_2 (Nyboer et al., 2011) and other atmospheric pollutants (Coyne, 1999) when displacing energy produced by a thermal power station. It has been suggested that its efficiency at greenhouses is even greater because the CO_2 can be used for crop production (Willis Energy Services, 2005). For these reasons, some countries have provided incentives to increase the adoption of cogeneration systems as an approach to reduce greenhouse gas emissions and improve energy efficiency (van Berkum, 2009). In Europe, 15% of reductions in greenhouse gas emissions from 1990 to 2005 were achieved through increased use of cogeneration (Kerr, 2008).

Keep in mind that energy efficiency and greenhouse gas emissions are different categories of performance measurement. If cogeneration is considered to be highly efficient, compared to producing heat and electricity separately, it does not necessarily translate to reduced greenhouse gas emissions. A comparison must be made between current or baseline energy generating technology and cogeneration. In British Columbia, cogeneration at greenhouses is compared against hydro-electricity and existing thermal boilers. In most European countries and in the US, cogeneration at greenhouses is compared against coal-fired electricity and thermal boilers.

Given that the electricity supply in BC is dominated by a carbon neutral method like hydro, it is difficult to claim that cogeneration will decrease greenhouse gas emissions. Consider that CHP engines burn roughly twice as much fuel, compared to standard boilers, in order to produce the same amount of heat. Figure 9 demonstrates this situation and shows that doubling the fuel input also doubles the CO_2 output. In this example, switching from natural-gas fired boilers to CHP engines on farms in the Lower Mainland would actually increase greenhouse gas emissions. However, with increasing demand for electricity and a diminishing ability to build new dams in BC, the use of CHP systems may be preferable to the alternatives, such as importing coal-fired power from the U.S. In addition, the application of CHP systems will displace the need to truck bulk, liquid CO_2 to some greenhouse operations.

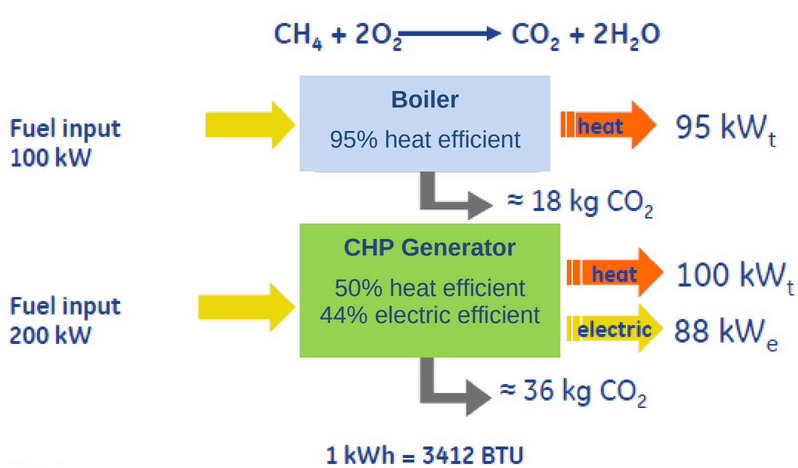

Figure 9. Fuel input and CO_2 output of CHP is twice that of boiler to produce similar heat (Kramp and Hesener, 2011)

2.6 Cogeneration in Other Jurisdictions

Regulatory policies have helped to drive adoption of cogeneration in many parts of the world. For example, the Public Utilities Regulatory Policies Act (1978) and federal tax credits for cogeneration investments were responsible for a three-fold increase in cogeneration capacity in the US (PEW Center, 2011). The Energy Improvement and Extension Act of 2008 and the American Recovery and Reinvestment Act of 2009 further encourage adoption of cogeneration in the US (PEW Center, 2011). Some states also offer investment tax credits to help offset the capital costs of cogeneration investments (PEW Center, 2011). The situation is the same in many European countries. Government initiatives have played a major role in Europe achieving the highest proportion of cogeneration in the world (Brown and Robb, 2005).

Cogeneration is most attractive in regions with high electricity prices and good access to the electricity grid (Nyboer et al., 2011), and is less attractive in countries with a hydropower-based economy (Kerr, 2008). Cogeneration is most attractive to industries with high simultaneous demand for heat and electricity (Nyboer et al., 2011). The latter reason explains why 80% of electricity produced through cogeneration globally is represented by industrial sites in the chemicals, metal, oil refining, pulp and paper, and food processing sectors (PEW Center, 2011). Another advantage is the reliability of electricity supply; operations with a cogeneration system should not be impacted by failures in the transmission system (Henvey, 2006).

2.6.1 Canada

There are more than 200 cogeneration systems in Canada with a total operating capacity of 9.1 GW_e, which represents 7% of national electricity generation capacity (Nyboer et al., 2011). By comparison, cogeneration accounts for 12% of total electricity generating capacity in the US (PEW Center, 2011). Nearly 50% of the national capacity is located in Ontario, while BC ranks 3rd at 16% (Nyboer et al., 2011). The paper manufacturing sector accounts for 32% of the capacity, followed by the utilities sector at 23% (Nyboer et al., 2011). The first cogeneration systems were implemented by agricultural operations in the 1990s but today only account for 0.03% of national production capacity (Nyboer et al., 2011). Cogeneration systems have not been widely used by greenhouse operations in Canada.

Two years ago a 12 MW cogeneration plant (DDACE Power Systems, 2009) was installed at a 22 hectare greenhouse tomato operation in Ontario, Great Northern Hydroponics (UPI.com, 2009). The facility is reported to supply sufficient electricity to the grid to power up to 15,000 homes (UPI.com, 2009).

2.6.2 Europe

Europe is a leader in the adoption of cogeneration. Cogeneration in Europe has been fostered by favorable government policies, the high cost of electricity, and interest to reduce greenhouse gas emissions and improve energy efficiency. Cogeneration accounts for about 11% of the heat and electricity needs in Europe (Nyboer et al., 2011), which is on par with the US. However, cogeneration accounts for 40% of electricity generation in Denmark, Finland, and the Netherlands (Brown and Robb, 2005).

In the Netherlands, cogeneration was first adopted by greenhouse growers in the 1980s as a means to provide electricity for grow lights (van Berkum, 2009). Cogeneration was chosen because on-site production of electricity is often cheaper than purchasing electricity in the Netherlands (Daniels et al., 2007). Greenhouse operations in the Netherlands have been early adopters of the technology and it has played a role in maintaining the competitiveness of the Dutch greenhouse vegetable industry (Kramp and Hesener, 2011). In 2009, greenhouses in the Netherlands produced about 2,700 MW of electricity, which was equal to roughly 10% of the total electricity produced in the country (Hovius, 2010a). Cogeneration is considered to be economically viable in the Netherlands for large-scale greenhouse operations that produce energy-intensive crops (Daniels et al., 2007).

After the liberalization of the electricity market in 2001, the Dutch government began providing incentives for cogeneration to revitalize the industry and meet national greenhouse gas and energy efficiency targets. Incentives were introduced in the form of long term agreements, feed-in subsidy schemes, energy tax exemptions, rebates, financing schemes and internal emissions trading systems. New development in agriculture was a response to changing electricity prices and profits from joint gas purchases and electricity trading services.

Part 3 – Current Policies and Regulations

This section summarizes the roles, policies, and regulations of the government agencies that are likely to be involved with permitting on-farm cogeneration projects. These agencies include the ALC, MoE, local governments, and AGRI.

3.1 Agricultural Land Commission

Legislation guiding the activities of the ALC includes the *Agricultural Land Commission Act* (ALC Act) and the *Agricultural Land Reserve Use, Subdivision and Procedure Regulation* (ALRUSP Regulation). Neither of these statues includes information about on-farm energy production systems specifically. Section 25 of the ALC Act allows applications for permission for non-farm use within the ALR.

Since the land use regulation under the *Agricultural Land Commission Act* does not currently permit this activity in the ALR, the Commission will consider this use as a non-farm use application. The ALC will endeavour to streamline these applications where the proposed use demonstrates support for and is clearly a benefit to the agricultural operation. While the proposed Ministry criteria are an important component to this initiative, they are not the ALC's criteria. However the Commission will use the standards as a guideline when considering non-farm use applications related to CHP facilities at greenhouses located in the ALR.

3.2 Ministry of Environment

Under the *Environmental Management Act (EMA)*, the *Waste Discharge Regulation* states that establishments engaged in the production of electricity by the combustion of fuel, and have a rated production of less than 5 megawatts under peak load do not require an authorization to discharge waste into the environment. The MoE intends to amend EMA to include facilities that have a rated production from 0.1 megawatts to 5.0 megawatts at peak load and develop a Code of Practice to regulate the discharge of waste into the Environment from these facilities. Facilities that have a rated production of greater than five megawatts would continue to be authorized and regulated by air and effluent permits (and ***not*** the code of practice).

3.3 Local Governments

Regional districts, municipalities, and other types of local governments have jurisdiction over various permits and processes that may be necessary for on-farm cogeneration projects. These include:

- Bylaw development, adoption, and enforcement;
- Building regulations including building codes and building permits.

In some cases, a zoning amendment may be required for an on-farm cogeneration project. However, the Ministry of Agriculture proposes that local governments not require a zoning amendment if the following conditions are met:

1. a Minister's Bylaw Standard for on-farm cogeneration is established;
2. the project meets the criteria within the standard;
3. the project is in the ALR or on land zoned for agriculture.

It is important for on-farm cogeneration project proponents to contact their local government early in their planning process to find out what steps they need to take.

3.4 Ministry of Agriculture

Section 916 of the *Local Government Act* states that the Minister of Agriculture may establish, publish, and distribute standards to guide local governments in the preparation of bylaws for their farming areas. The Ministry's Guide to Bylaw Development in Farming Areas contains the standards that have been adopted as Minister's Bylaw Standards.

AGRI staff have engaged with on-farm cogeneration project proponents, technology providers and affected local governments. These stakeholders have indicated that a Minister's Bylaw Standard for on-farm cogeneration would facilitate the development of these projects. Therefore, the objective of this discussion paper is to propose a standard for adoption by the Minister of Agriculture as an official Minister's Bylaw Standard. This should assist local governments in developing bylaws affecting on-farm cogeneration projects.

3.5 Policies and Regulations in California and Ontario

The existence of the ALR is something that makes BC different from other jurisdictions. In BC, various government agencies work collaboratively to ensure that farming remains the priority use in the ALR. Decisions regarding the development of policy incentives in BC are likely to be driven by this context in addition to economic and environmental benefit considerations.

The criteria presented in this discussion paper are intended to address land use issues and outline what is an acceptable farm use of cogeneration in the ALR. Research on regulations affecting cogeneration in other jurisdictions was therefore focused on aspects of sizing and operating the systems, rather than on energy policy.

3.5.1 California Waste Heat and Carbon Emissions Reduction Act

In 2007, the State of California enacted the Waste Heat and Carbon Emissions Reduction Act by passing Assembly Bill No. 1613. The bill stated the intent of the Legislature to: "(A) dramatically advance the efficiency of the state's use of natural gas by capturing unused waste heat, (B) to reduce wasteful consumption of energy through improved residential, commercial, institutional, industrial, and manufacturer utilization of waste heat wherever it is cost effective, technologically feasible, and environmentally beneficial, particularly when this reduces emissions of carbon dioxide and other carbon – based greenhouse gases, and (C) to support and facilitate both customer- and utility-owned combined heat and power systems."

The Act was added under Chapter 8: Energy Efficiency Systems to Part 2 of Division 1 of the Public Utilities Code. A "combined heat and power system" is defined in the Act is a system that produces both electricity and thermal energy for heating or cooling from a single fuel input that is (1) interconnected to, and operates in parallel with, the electric transmission and distribution grid, (2) is sized to meet the eligible customer-generator's onsite thermal demand, and (3) meets efficiency and greenhouse gas emissions standards set by the state. An "eligible customer-generator" is defined as a customer of an electrical corporation that (1) uses a combined heat and power system with a generating capacity of not more than 20 megawatts and (2) uses a time-of-use meter capable of registering the flow of electricity in two directions.

Subdivision (a) of Section 2843 of the Act states that The Energy Commission shall, by January 1, 2010 adopt guidelines that combined heat and power systems (subject to the chapter) shall meet, and shall accomplish the following:

(1) Reduce waste energy.
(2) Be sized to meet the eligible customer-generator's thermal load.
(3) Operate continuously in a manner that meets the expected thermal load and optimizes the efficient use of waste heat.
(4) Are cost effective, technologically feasible, and environmentally beneficial.

Subdivision (e) of Section 2843 of the Act states that an eligible customer-generator's combined heat and power system shall meet the oxides of nitrogen (NO_x) emissions rate standard of 0.07 lbs/MWh and a minimum efficiency of 60 percent. The minimum efficiency is calculated as useful energy output divided by fuel input and determined based on 100 percent load.

3.5.2 Ontario Power Authority – CHPSOP

On November 23, 2010 the Minister of Energy directed the Ontario Power Authority (OPA) to procure 1000MW of CHP projects, less the approximate 500MW procured to date. The directive specified that new CHP projects shall consist of: individually negotiated contracts with projects over 20MW and a SOP for projects under 20MW.

With 500MW to be procured, the Clean Energy Standard Offer Program (CESOP) Initiative was developed to procure 200MW of small projects (≤20MW). Under the CESOP Initiative, 150MW projects were delegated to a Combined Heat and Power Standard Offer Program (CHPSOP) and 50MW were delegated to an Energy Recovery Standard Offer Program (ERSOP).

The CHP Directive specified that in undertaking procurement, the OPA shall consider the following factors:

- Projects shall be located in parts of the Province that the OPA identifies as appropriate;
- The cost effectiveness of the project;
- Whether the project can be accommodated by local distribution systems and whether there are local benefits associated with the project;
- Whether the project meets the technical requirements for CHP and is designed as an integral and financially viable source of supply to a heat load;
- The extent to which a project is sized to match the heat load requirements;
- A project's ability to accommodate electricity system load following and other operability requirements;

- Contract terms shall reflect a reasonable cost for Ontario electricity consumers and a reasonable balance of risk and reward between proponents and Ontario electricity consumers.

The CHPSOP is a financial contract between the OPA and the supplier. Contract terms are based on a Net Revenue Support Level (NRSL) in $/MW-month and include physical obligations relating to Useful Heat Output (UHO), Capacity Test Checks and Availability. Contract terms are 20 years and the supplier must provide a metering plan (for both electrical and thermal metering) to the OPA for approval. The supplier is free to physically operate the CHP facility at its own discretion, but must pay a completion and performance security fee.

Contract payments are calculated monthly as the difference between a negotiated fixed capacity payment and imputed net revenue. The fixed capacity payment requires suppliers to meet a minimum usable heat output (UHO) of ≥ 15% from the 3rd contract year on and an average of ≥ 15 % in the first 10 years of operation. If UHO requirements are not met, the NRSL component of the fixed capacity payment will be decreased by 1.33% for each 1.0% shortfall, based on a 5-year rolling average UHO shortfall. If there is a drop in UHO demand from the host facility, the supplier may terminate the contract and the facility must be shut down for the remainder of the term.

For each contract year, UHO is calculated as:

$$\frac{kWh_{thermal}}{kWh_{electrical} + kWh_{thermal}}$$

Where,
$kWh_{thermal}$ = annual net useful thermal energy produced as measured by thermal metering
$kWh_{electrical}$ = annual net electrical energy produced as measured by revenue meter

Part 4 – Cogeneration – Criteria

4.1 Definitions

The following definitions are provided to clarify the meaning of certain words that are used in the criteria. The definitions are drawn or adapted from the *Farm Practices Protection (Right to Farm) Act*, 'Guide for Bylaw Development in Farming Areas', *BC Assessment Act*, and various local government bylaws.

Cogeneration Facility includes the CHP engine and all additional components needed to achieve the production and transfer of heat and electricity from the engine to the greenhouse or interconnection site.

CHP a combined heat and power engine that produces both electricity and thermal energy for heating or cooling from a single fuel input.

CHP Efficiency useful energy output divided by fuel input, based on 100% load.

Farm Class a designation given to a *lot* or part of a *lot* that is classified as "farm" under the BC Assessment Act.

Farm Operation as defined under the "*Farm Practices Protection (Right to Farm) Act*" see Appendix B for complete definition.

Farm Unit an area of land used for a *farm operation* consisting of one or more contiguous or non-contiguous *lots*, that may be owned, rented or leased, which form and are managed as a single farm.

Greenhouse means a structure covered with translucent material and used for the purpose of growing plants, and which is of sufficient size for persons to work within the structure.

4.2 Criteria

Local governments are encouraged to incorporate these criteria into their bylaws. These criteria were developed for natural gas-fired cogeneration. Additional criteria may be required to address fuel storage and delivery for biomass-fired cogeneration or other fuel sources.

1. **Farm Class**
    - The farm *lot* where the *cogeneration facility* is to be located must be classified as 'farm' under the *BC Assessment Act.*
    - Local governments may wish to ask for a copy of the farm's BC Assessment notice, as part of a building permit application.

2. **Fuel Type**
    - The CHP engine must be fueled by natural gas.

3. **CHP Capacity**
   - The CHP must be sized to be commensurate with the heat demand of the farm operation.

4. **Maximum CHP Capacity**
   - The CHP capacity must not exceed 1.0 MW_e/ha of land in greenhouse crop production on the farm operation. A CHP engine with a capacity up to 1.5 MW_e/ha is permitted if high intensity lighting (greater than 10,000 lux) is used in the greenhouse.

5. **CHP Efficiency**
   - The CHP must operate with an efficiency of at least 80%.

6. **Heat Storage**
   - The farm unit must have capacity to store excess heat generated by the CHP for beneficial use by the greenhouse.

7. **Emissions**
   - The CHP must meet emission standards outlined in the *BC Environmental Management Act.*

8. **Nuisance**
   - The CHP should be located and managed to minimize noise impacts on neighbours.

4.3 Discussion – pros and cons of the criteria

Criteria	Pros	Cons
Farm Class	• Limits *cogeneration* to bona fide farm operations. • Reduces risk that the cogeneration facility is used for non-farm purposes. • Easy requirement for farm to meet.	• This criterion alone is not adequate.
Fuel Type	• Municipalities and Regional Districts will determine whether or not other fuels are permitted for use with CHP systems. • Allows natural gas fueled systems to proceed while additional criteria are developed for the other fuel types to address delivery, storage and combustion concerns.	• Greenhouse operators would require permission from the local government if they want to use a fuel other than natural gas.
CHP Capacity	• Ensures size of the cogeneration unit meets the thermal needs of the farm operation. • Prevents wasting heat to benefit from the generation and sale of electricity beyond what is needed at the farm. • Prevents over-sizing the cogeneration unit to a point where energy generation	• This criterion is subjective.

	becomes the primary activity taking place on the farm.	
Maximum CHP Capacity	• 1.0 MW_e/ha will meet the thermal and electricity demands of most greenhouses. • 1.5 MW_e/ha will meet future thermal and electricity demands for greenhouses that use high intensity grow lights. • Avoids construction of excessively large power plants in the ALR. • Easy criterion to enforce.	• 1.5 MW_e/ha is oversized today for most greenhouse applications. • Floriculture operations have highly variable thermal loads that may be much less. • BC Hydro's Standing Offer Program will be relied on to ensure that the CHP efficiency is at least 80%.
CHP Efficiency	• Ensures optimization of running hours to benefit the greenhouse operation. • Allows for flexibility to optimize the generation of heat, electricity or CO_2 based on crop needs and seasonal weather. • Based on industry reports of current installations running at > 80% efficiency.	• Difficult criterion to monitor and enforce.
Heat Storage	• Allows for flexibility in run times and acts as buffer for heat usage. • Minimizes wasted heat when CHP is operating for electricity or CO_2 optimization.	• Difficult to provide specific heat storage requirements.
Emissions	• Ensures compliance with existing regulations.	•
Nuisance	• Minimizes nuisance concerns of CHP operation.	• Difficult to provide specific criteria.

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