Electricity Supply in Ontario:

The Potential Contribution of Agricultural Biogas Digesters

Ontario Clean Air Alliance

By Nicole Foss and William H. Kemp

Ontario is facing an energy crisis. The province is already often dependent on imports in order to meet demand and up to 80% of current generation capacity will reach the end of its design-life within the next fifteen years. Ontario would appear to be in an unenviable situation, yet at the same time, this could be considered a position of great opportunity. If appropriate action is taken now, Ontario could encourage the construction of a new form of power system, a system in which the private and agricultural sector plays a much larger role.

Summary

Industry, municipalities, communities, farm co-operatives, first nations and individuals are able and willing to install small-scale or modular generation adjacent to demand. It would be decentralized and efficient, as well as clean and economically viable. However, Ontario must find creative ways to facilitate the transition to a decentralized power system instead of allowing bureaucratic barriers to it to persist, or worse, forging new ones.

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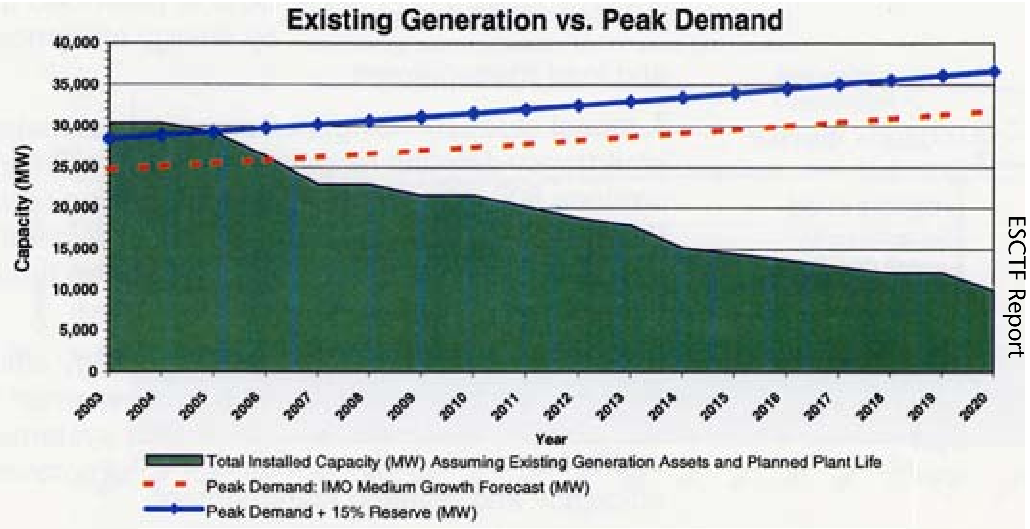
Bill 100 and the proposed net metering regulations act to reinforce the economically unsustainable power system model which has brought the province to the brink of energy crisis. The traditional centralized monopoly model - with its large power stations remote from centres of demand, almost exclusive emphasis on supply-side solutions, expensive power transportation requirements, cumbersome and bureaucratic control mechanisms, passive consumer base and ability to pass the costs of past mistakes on to the public purse – is no longer viable. In order to avoid deepening the financial crisis already faced by the public electricity supply industry in Ontario, new distributed generation must take the place of many traditional sources of electricity supply as they reach the end of their design life. Private capital can do a great deal to relive the strain on the current system, if the regulatory framework is amended in order to support it.

The agricultural sector is particularly well placed to make a very significant contribution through the production of biogas using digester technology developed by the Powerbase Biogas Consortium. In addition to the power system benefits of demand reduction, increase in supply, voltage support for the Ontario grid and reduced reliance on transmission infrastructure, this process has a number of other extremely beneficial consequences including non-governmental financial support for the agricultural sector, greenhouse gas reduction, water pollution control, reduction in demand for heating fuel, conversion of



ESCTF Report

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other intractable waste streams into energy, conversion of manure into a more suitable substitute for chemical fertilizers and odour control. Unfortunately, current and proposed regulations controlling small-scale generation through net metering constitute a barrier to the wider uptake of this technology. The legislative barrier should be removed as soon as possible, but in the meantime the development of generation co-operatives can effectively circumvent it.

Standard Offer Contracts, which have already been endorsed by the Ontario Liberal Party, can provide a stable financial framework for the development of renewable technologies in Ontario as they have for the European leaders in renewable energy generation. Standard Offer Contracts ensure that the benefits of distributed renewable generation are recognized and rewarded, and as such they can help to maximize the uptake of renewable options. Premium prices for renewable power would make almost no difference to the price paid by consumers, due to the extremely low renewable base at the present time. The price of power must increase in any case in order to cover repayment of Ontario's debt, putting the price currently necessary to make renewables viable in context. By the time a substantial proportion of renewables based on Standard Offer Contracts has come online, the price paid to other generators may well have risen to match the premium price in any case.

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Introduction – Centralized versus Decentralized Alternatives

Electricity has become an essential public good, indeed in many ways a life-support system, provided by government as a cheap and reliable public service. The traditional AC system - a vast single machine with independent users – has evolved as a natural responsibility of government for reasons of scale and because the stability of such a system requires central control in real time. It developed in its current form, with large generating plants remote from the end user, largely due to the distance of concentrated aggregations of inconvenient energy - waterfalls, coal seams, uranium ores and refinery residues - from centres of demand. Huge generating plants, with payback periods measured in decades, and the transmission infrastructure necessary to convey that energy across great distances, became the norm. The model includes built-in safety margins, or reserves, above the anticipated peak load for generation and network capacity in order to cover sudden outages and errors in load following.

The system is internally consistent and coherent, so long as cost is no object, but is financially unsustainable in the absence of tariffs adequate to cover past and present costs. In addition to cost overruns in building new generation and transmission - $38 billion in the case of Ontario - the nature of public service has led to political pressure to keep prices low overall and uniform - independent of the cost of supply for different locations and different classes of consumer. The resulting low tariffs and extensive cross-subsidies have muddied the waters between the provision of electricity and that of social welfare, fostering considerable inefficiencies in the process. In addition, the costs associated with environmental impacts have traditionally been left out of the equation entirely, allowing environmental degradation.

Forms of energy such as biogas, small hydro, wind, biomass, solar thermal electricity and photovoltaics do not place upon the system the same constraints of scale and location inherent in the centralized model. Newer small-scale or modular technologies developed to harness them, which do not have significant adverse effects on the local environment, do not have to be remote from centres of demand. Therefore, they do not require extensive infrastructure for power transportation. These technologies, along with many innovative means for improving energy efficiency, have the potential to attract the interest of private sector investors for many different applications, alleviating the scale of the investment otherwise to be required of the public sector. Taken to its logical conclusion, rapid technological innovation combined with the freedom to implement alternative choices and government support could result in a model which is decentralized, participatory and fluid, as opposed to bureaucratic, centralized and inflexible in the manner of a traditional electricity monopoly.

The inertia afforded by established institutions, infrastructure and attitudes will not be overcome easily. However, in electricity systems across the developed world, control is simultaneously devolving downwards to local decision-making and moving upward to the international level due to increasing instances of foreign ownership and more plentiful international, and interprovincial, transmission interconnections. Cosy fiefdoms are therefore being undermined from above and below, so that both the responsibility and the competence of national, or provincial, governments to keep lights on may be evaporating.

The Policy Framework:

Centralized Control of Large-Scale Generation:

Despite the short-comings of the traditional model, electrical systems deliver both physical and institutional power and the conventional wisdom as to how power systems should be run has therefore become deeply entrenched and resistant to change. However, given the unsustainable economics of the traditional model, it seems increasingly likely that the future will be a decentralized one. There is a transition in Ontario's future and it is the task of government to manage that transition as smoothly as possible.

What is unclear is the level of consumption that decentralized system could sustain, although there is evidence that it may be a significantly lower level than Ontarians have become accustomed to in recent years. A vigorous series of local programmes for demand-side management, efficiency and conservation could bring demand into line with what decentralized supply could hope to offer, but Ontario prefers to look to the past for failed solutions to the problems of the present and the future. Rather than embracing the transition and managing it actively, the Ontario government seems determined to attempt vainly to prevent it. The proposed solutions are framed in centralized terms, with mere lip-service paid to the value of decentralized options on both the supply and demand sides. The investments favoured by Ontario, including IPPs, generation plant refurbishment, and new transmission infrastructure can each be slotted easily into the system as currently constituted. They all assume, and depend upon, the traditional model remaining unchanged for decades.

Investments such as efficiency improvements, agricultural energy co-operatives, community power, small-scale distributed generation and widespread co-generation, act to weaken prevailing model as they are inherently decentralized. They are therefore being held in check to a large extent by targets which seem designed to limit their penetration to the point where they cannot make a genuine difference. The Ontario government has recently issued a tender for 300MW of renewable generation, intended to form part of the 5% of total supply (1,350 MW) target for renewable generation to be met by 2007, with a further 5% projected by 2010. These are modest targets indeed in comparison with the existing renewable energy potential and are more likely to act as a ceiling on renewable investment than as a floor.

The targets, as constituted, are an attempt to force renewable energy to compete primarily in a manner it is less than ideally suited for. A few relatively large and centralized renewable energy projects, which can slot into the present system, are favoured by the bidding system of the renewables RFP, whereas the true potential of renewable energy lies in widespread use of very small-scale applications. Farmers, co-operatives, communities, first-nations groups and some individuals are ideally placed to install renewable energy systems, but may need financial support from government in order to do so. Individually, they would not likely be able to navigate the costly and bureaucratic bidding system upon which the RFP is based, although the formation of sufficiently large generation co-operatives would allow them to compete with larger players. The establishment of such co-operatives should be aggressively pursued in order to capture economies of scale and bargaining power on behalf of the small generators whose aggregate contributions to the grid are likely to be of great importance to the electricity supply system of the future.

Public Ownership:

In some ways electricity represents the ultimate strategic 'commodity' due to its having become integral to the life-support system of modern societies whilst not being able to be stockpiled. Governments often feel that the essentials cannot be trusted to decentralized control, yet many already are, for the most part, with few problems. Imagine, for instance, a government attempting to treat food in the centralized manner in which they commonly approach electricity.

The government of Ontario, having been spooked by its predecessor's brush with liberalization, means to retain ownership and control of the means of production and distribution wherever possible. Globally there are many instances where governments have attempted this in a wide variety of economics sectors, indeed sometimes across whole economies simultaneously, but it is common knowledge that the results have not been encouraging. Such experiments have typically been characterized by bloated bureaucracy, an inability to control costs, a lack of transparency and accountability, and, too frequently, opportunities for corruption.

Public ownership of the means of production is widely discredited as ideological position. In the electricity sector, it goes hand in hand with centralization and large-scale generation, and is incompatible with a decentralized vision of small-scale generation serving local areas. It makes sense for small-scale generation to be owned by those who install and maintain it, be they farmers' co-operatives, community power groups or individuals. It also makes sense for government to offer financial support for that which they will not subsequently own because of the contribution that generation can make to the overall viability of the rest of the system. Distributed generation can reduce overall demand and, more importantly, the peak demand that defines the need for peaking plant. It can reduce pressure on the transmission system and increase local supply, if the owners are allowed to sell power to the grid for consumption by third parties. Some generating technologies can also support system voltage. It is much cheaper for government to achieve these benefits by offering limited financial support as a supplement to local private capital than it is to build even one new nuclear power plant.

Low Power Prices for Industry:

The Ontario government has argued it cannot allow power prices to rise significantly due to the impact that would have on industry, and the knock-on effect that industrial distress would have on the rest of the economy. Their policy has therefore been to hold prices increases in check for all consumers. However, the Canadian economy has been awash in cheap energy for a very long time, and there has therefore been no incentive to conserve it. Either the government of Ontario can perpetuate this situation - propping up a few profligate industries by effectively subsidizing consumption for all at the expense of the whole economy – or it can raise electricity prices to an appropriate level and give those same industries an incentive to practice conservation.

Table 1: Energy Intensity (Btu/Unit GDP in 1995 dollars*)

Canada	15,496
Germany	7,378
Japan	7,222
France	7,560
United States	8,918
United Kingdom	8,650
Taiwan	8,972
India	5,639
China	7,213

**GDP based on OECD figures for Purchasing Power Parity (PPP)*


Powersmiths Inc.

The Canadian economy uses almost twice as much energy to produce a unit of GDP than international industrial powerhouses like Germany. Industry in Ontario should be encouraged, through the electricity pricing regime to attain similar levels of efficiency.

The energy intensity of the Canadian economy is much greater than that of our major competitors, which is to say that the Canadian economy uses far more energy to produce a unit of GDP than other comparable economies do. In fact, the Canadian economy uses almost twice as much energy to produce a unit of GDP than international industrial powerhouses like Germany (Table 1), where electricity prices have traditionally been higher. In fact, prices for most other industrial inputs are also considerably higher in Europe, yet the Germans manage to remain competitive by using those inputs as efficiently as possible. Industry in Ontario should be encouraged, through the electricity pricing regime, to do the same.

Nuclear Patriotism:

The Ontario government seems recently to have embarked on a strategy of demonizing coal-fired generation in order to pave the way for a nuclear future supplemented by natural gas as a transitional fuel. The disadvantages of coal have been continually emphasized and the government has promised to phase it out – initially by 2007 and now delayed until at least 2009. This strategy does not take into account the fact that not all coal generation in Ontario is created equal. Some units are indeed highly polluting, but others are very modern, and in any case, technology exists which can reduce emissions from coal-fired generation to the point where the emissions are comparable to those from natural gas plants. Existing coal plants are also relatively near to centres of demand, reducing the need for transmission infrastructure.

Coal is relatively plentiful in comparison with other fossil fuels and its deposits are located much closer to where the energy is needed. In contrast, natural gas production in North America has already peaked while demand continues to increase. The storage system is stretched to the limit and may not be able to cover another colder than average winter. The LNG infrastructure necessary to permit imports does not yet exist and cannot be built in time to forestall price spikes and supply problems. Natural gas cannot fuel a transition to a nuclear future.


Lorraine E. Kemp

Improvements in residential and commercial energy efficiency helped the State of California save billions of dollars in electricity and natural gas costs.

energy

Money Isn't All You're Saving

The CANDU reactor is Canadian technology. Building them can provide Canadian jobs. When they have been built, they can provide Canadian electricity from Canadian uranium while burning no increasingly-scare fossil fuels and producing no greenhouse gases. Exporting the technology can bring money into the Canadian economy. Unfortunately, committing the Ontario economy to a nuclear future amounts to making a bad situation worse as expensively as possible.

CANDU reactor technology does not have a particularly good record for reliability. The reactors Ontario already has have developed problems much more quickly than had been anticipated and have required extremely expensive premature refits. There is no solution to the problem of waste, which must be sophisticatedly, and expensively, contained for tens of thousands of years in order for it not to cause terrible environmental damage. There is likewise no realistic plan for decommissioning the reactors Ontario already possesses, let alone any more.

Ontario Power Generation

Committing the Ontario economy to a nuclear future amounts to making a bad situation worse as expensively as possible. Adding billions of dollars more debt without even having established a workable plan for the repayment of existing nuclear-funded debt already incurred would amount to highly irresponsible financial stewardship.

Building reactors is extremely capital intensive, resulting in a pay-back period measured in many decades at least. Public aversion ensures that reactors cannot be built close to centres of demand, adding the cost of expensive transmission system upgrades to the capital required for the project. All of this would have to be financed over the long-term, but the Ontario power system is already so burdened with debt that its continued financial viability is in doubt. Adding billions of dollars more debt without even having established a workable plan for the repayment of debt already incurred would amount to highly irresponsible financial stewardship.

Clearly, Ontario must look elsewhere for its solution – to efficiency and conservation above all, but also to as many sources of renewable supply as possible. The cost of facilitating a reduction in demand through efficiency is minuscule in comparison with the cost of providing additional supply, particularly if that supply is large-scale and distant from centres of demand. Encouraging efficiency, conservation and renewable supply would also tap into reserves of private capital, further relieving the burden on the public purse.

The Regulatory Framework

Bill 100:

Bill 100 is intended to bring balance back to an electricity sector in turmoil and facing a significant supply-demand imbalance in the near future. Energy Minister Duncan asserts that balance is to be found at the centre, not the extremes, yet Bill 100 itself represents an extreme position – an extreme of bureaucratic centralization. It does nothing fundamental to challenge the monolithic nature of the electricity system.

The Minister vows not to return to the old Ontario Hydro model, but it is difficult to see how the model inherent in Bill 100 is materially different from its predecessor. If anything, Bill 100 proposes an even more strongly centralized system with all parameters for decision-making coming from the top down, filtered through an additional layer of centralized bureaucracy. It is quite unclear how the structures and mechanisms proposed in Bill 100 can deliver Ontario from the consequences of previous decisions when they amount to little more than tinkering with the traditional monopoly.

All roads lead back to the minister under the government's proposed legislation. The stated intent of the government is to take the politics out of OPG and electricity pricing, but the Minister is to appoint the CEOs, the Board members and advisory committees. He will prescribe through regulation the classes of consumers, licensing conditions, situational pricing, targets for conservation and renewable energy, the means for implementing integrated resource planning and the remainder of the details missing from Bill 100 itself. The minister may be shielded behind layers of bureaucracy, but he is still holding the reins of the power system and this is semantically incompatible with the stated objective of depoliticising it.

The Bill sets no specific targets for new supply, but the Minister has called for proposals offering 2500 MW of new generation or demand-side management (DSM) initiatives, plus 300MW of renewable generation. The inclusion of DSM on an equivalent basis to new supply is a step forward, although the government's thinking remains centralized even here as they are looking for large-scale DSM rather than small-scale distributed demand reductions. This top-down approach is unlikely to be the most effective means of achieving the provincial government's stated goals, let alone exceeding them.

According to Bill 100, a regulated price is to be set by the OEB for electricity supplied by heritage generation. This price is to be blended with a contract price, for newly constructed output contracted for by the Ontario Power Authority (OPA) and existing non-utility generator assets currently under contract to the OEFC, and a competitive market price for other generation. There may however, be limited liquidity in the market segment as there are relatively few obvious players. Fixing a relatively low price to be paid to such a large percentage of generation is intended to stabilize consumer prices at an affordable level, but it is difficult to justify why the price associated with heritage generation should be low. After all, it is this portion of the system that is associated with $38 billion in debt. If the price is kept artificially low, there will be very limited potential for debt recovery and price signals for consumers will be unduly muted.

Regulating the price paid to so many generators leaves few to participate in the 'market' in order to set a reference price indicative of the 'true cost' of power at a given point in time. The potential for all stakeholders to be alienated by the cumbersome and impenetrable tariff-setting process is therefore increased, as is the likelihood that investors will perceive it as constituting political interference.

The provincial government is trying to play safe with electricity, placing its confidence in the organizing principles of the traditional centralized power monopoly. However, change is coming, for technological, environmental and, most importantly, economic reasons. The status quo, which Bill 100 seeks to reinforce, is simply not an option that can be sustained. It constitutes an attempt to hold back the tide, and as such is destined to fail. The government of Ontario would be better advised to embrace change, despite the inevitable short-term upheaval, than to attempt to prevent it. The passive consumers of today are likely to find the transition uncomfortable, but that transition can only be delayed, not prevented. The longer it is delayed, the more painful and prolonged it will be. The solution will be found in grass-roots investment in both efficiency and supply, and it will happen much more quickly if it is legislatively facilitated and financially supported by government.

Net-Metering Regulations:

Ontario must be far more ambitious, and also far more creative, in tapping its tremendous potential for renewable generation, and decentralized thinking is an essential part of that task. Unfortunately, both the current and the proposed regulations covering net metering do not reflect this reality. The regulations shortly to come into force explicitly specify that net-metering customers must be generating for their own use and are therefore not selling electricity for consumption by others. Given that these regulations cover all generation up to a limit of 500 kW, most distributed generation is to be treated as offset consumption rather than generation proper. This places a serious and unwarranted limitation on the generation capacity the government should be trying most assiduously to encourage. It encourages inefficiency, by discouraging investment at the most economical scale, and limits the amount of capital that can be usefully and profitably committed.

Section 57 of the Ontario Energy Board Act, 1998 requires all generators connected to the grid, including through a distributor, to be licensed by the Ontario Energy Board. Section 4.0.3.1 of Ontario Regulation 161/99, exempts


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The proposed net metering regulations may also hinder the development of small-scale projects, by having to be concerned with artificial requirements which serve no useful purpose other than to create unnecessary obstacles to the development of community power.

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net-metering customers from the licensing requirement, provided they only receive credit against consumption and are not paid outright for electricity by the distributor. An annual accounting cycle is proposed, with the intention of accommodating seasonal variations between a net-metering customer's consumption and generation. During this period, unused credits can be carried over from one bill to the next, but any credits not used at the end of the year will be reduced to zero.

The regulations therefore discourage those considering investing in renewable supply from installing generation at the most appropriate scale, which, depending on the technology, may be large enough to exceed individual consumption by a considerable margin. For instance, farm-based biogas digesters sized to manage a farm's manure production can comfortably supply all the electricity needs for the farm and produce a surplus, even where the power demands for the farm itself are very high. Farmers who installed facilities at the right scale for manure processing would, under the current regulations, be required to provide the surplus electricity they would be producing to the grid for free. This acts as a direct disincentive to install the technology in the first place, and, by limiting an important source of revenue, acts as a barrier to securing the necessary financing should the farmer wish to proceed in any case for other reasons.

The proposed net metering regulations may also hinder the development of small-scale community power projects as these would generally produce under 500kW but would not be intended for personal consumption only. The success of community power would then be dependent on the legal treatment of generation co-operatives, which may be permitted to aggregate the production from many small generation units in order to clear the regulatory hurdles necessary to sell power in the regulated market. Even if this can be achieved and the net-metering regulations circumvented, having to be concerned with artificial limits which serve no useful purpose creates an unnecessary obstacle to the development of community power.

By throwing hurdles in the way of all but the smallest renewable generation in the under-500kW range, the regulations emphasize the government's bias toward large-scale centralized generation able to be slotted into the existing electricity framework under existing network connection agreements. There is no recognition of the important contribution towards meeting peak demand which could be made by distributed renewable generation. As this figure defines the economics of the power system by determining the number of peaking plants and the quantity of power imports required, any reduction is extremely valuable. Those providing this service through their own investments should be financially rewarded for their contribution. The proposed net metering regulations should be rethought as soon as possible.

The Overwhelming Advantages of Biogas Digesters

Biogas technology represents one of the most feasible and most advantageous forms of renewable energy generation. The energy related aspects alone would be sufficient to recommend a policy of active support for the technology, but in combination with the significant additional benefits the case for support becomes overwhelming. The Powerbase Biogas Consortium has pooled the resources of a team of recognized experts in the field in order to offer the technology at the lowest cost to the widest possible range of agricultural operations.

Given that a digester and its associated engine-generator is a capital-intensive investment, it is important to introduce a long-term payment mechanism, such as Standard Offer Contracts, for the energy produced. Since, as constituted, they prohibit any form of recompense, the proposed net metering regulations could actively prevent this technology from achieving the market penetration it merits.


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Energy-Related Benefits:

Energy-related benefits include the following:

- Electricity Demand Reduction
- Increase in Electricity Supply
- Voltage Support for the Ontario Grid
- Reduced Pressure on Transmission Infrastructure
- Heating Fuel Demand Reduction
- Conversion of Additional Waste Streams into Energy

Electricity demand reduction:

Biogas digesters are generally more than capable of supplying the electrical load of the farm on which they are situated. Were all of the several thousand farms suitable for the production of biogas to cover their own power needs, and those of their neighbours if the net-metering regulations are suitably amended, it would represent a significant and reliable reduction in demand for electricity. This would reduce the need for peaking plant and reliance on expensive power imports.

Increase in Electricity Supply:

Digesters typically produce sufficient electrical power for the farmer to be able to supply surplus power to the grid. However, the regulatory framework currently prohibits generators of this scale (<500kW) from generating other than for their own use and being paid for their output. Anything they contribute to the local distribution system beyond what is required for their own use, netted out annually, they are forced to offer free of charge. Generators larger than 500kW, which are able to produce electrical power for sale to others under the proposed regulations, must go through an onerous and expensive connection process. Such a requirement, should it be applied to biogas generation on individual farms, or farm collectives, would act as a significant deterrent. Generation co-operatives may be able to circumvent this problem until the net-metering regulations can be amended in order to remove artificial obstacles to bringing additional small generation on stream.

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Voltage Support for the Ontario Grid:

The voltage supplied by large generators decreases with the distance travelled through the grid, but can be supported along its route by contributions of reactive power from distributed generation. Biogas systems can offer this important voltage support for the grid if they employ synchronous generators. Provision of reactive power is an ancilliary service which large generators would be paid for, hence it would be reasonable for small generators to have this contribution to system stability recognized financially, if it is sufficiently reliable from the point of view of grid operators.

Reduced Pressure on Transmission Infrastructure:

Power produced adjacent to demand places no burden on the transmission infrastructure and very little burden even on a local distribution network. Given the cost of constructing and maintaining transmission infrastructure, any reduction in the need for it should be considered very valuable.

Heating Fuel Demand Reduction:

Farms using biogas technology are typically able to supply not only their requirement for electrical power, but also their energy requirements for heating and cooling where those are provided other than through the use of electricity. This contribution should be considered extremely valuable, particularly where it can reduce demand for natural gas. As North American natural gas production appears to have peaked while demand is still increasing rapidly, natural gas is likely to become increasingly valuable, as well as being potentially subject to supply constraints.

Conversion of Additional Waste Streams into Energy:

Biogas digesters are capable of processing additional waste streams, such as surplus chicken fat, into energy. This reduces reliance on traditional means for processing difficult wastes and allows energy rich wastes to become an asset rather than a liability. The additional feedstock would boost electricity production from the digester dramatically. For example, adding as little as 10% supplementary chicken waste may double methane production. If the regulatory framework were amended to permit “off farm” waste handling, it would result in an enhanced income stream for the farmer, from both increased electricity generation and waste tipping fees.

Supplementary Agricultural Benefits:

The potential pollutants from decomposing livestock manures are BOD, pathogens, nutrients, methane and ammonia emissions. The major pollution problems associated with these wastes are surface and ground water contamination and surface air pollution caused by odours, dust and ammonia. There is also concern about the contribution of methane emissions to global climate change.

Supplementary benefits include the following:

- Greenhouse Gas reduction/Carbon Trading Credits
- Non-Governmental Financial Support for the Agricultural Sector
- Chemical Fertilizer Substitution
- Pathogen Reduction
- Water Pollution Control
- Odour Control
- Ease of Manure Handling

Greenhouse Gas Reduction:

Methane is approximately 21 times more potent as a greenhouse gas than is carbon dioxide and the historical record indicates that it is more abundant in the atmosphere now than at any time in the last 400,000 years. Since 1750, global average atmospheric concentrations of methane have increased by 150% from approximately 700 to 1,745 ppb by volume in 1998. It is estimated that 60% of global methane emissions are related to human activities. Statistics for the US indicate that manure management associated with domestic livestock is responsible for approximately 10% of total methane emissions.

As farms have become larger, and the use of liquid and slurry-based manure management systems therefore more common, the problem of uncontrolled methane emissions from open lagoons has become more acute. However, manure with low solids content can alternatively be managed effectively using biogas digestion to encourage methane production under controlled circumstances. Methane production is captured and burned to produce usable energy, carbon dioxide and stable bi-products. Preventing methane emissions from agricultural operations in this manner could very significantly reduce Canada's contribution to global warming.

At an average of 100kW per facility, if 3000-5000 farms were able to install biogas technology, 300-500MW of distributed power could be added to the grid. This would offset the carbon dioxide emissions from 10,000MW of fossil fuel based generation capacity, while simultaneously eliminating very substantial emissions of methane.

Under proposed carbon trading schemes, biogas generators will be able to offset their consumption of fossil fuel-based energy (electrical load, domestic hot water and space heating) with carbon-neutral biogas produced electricity and heat. In the European Union, spot market prices for carbon offset credits are trading in the range of US$ 30 per tonne. Once a similar program is implemented in Canada, additional income will be available to farms utilizing biogas technology.

Non-Governmental Financial Support for the Agricultural Sector and the Rural Economy:

The agricultural sector has recently been battered by several significant financial shocks, such as the closure of the US border to cattle due to the discovery of BSE, which collectively pose an unprecedented threat to the financial viability of the sector. There are consequently many farmers seeking financial assistance from government. Encouraging the installation and use of biogas digesters would provide a significant new income stream for agriculture, which may reduce, or over time even eliminate, the need for government financial aid.

Conventional manure handling represents a sunk cost to the farmer, whereas biogas digester technology can convert this sunk cost into a revenue stream. It is quite possible that profits from the sale of electricity could exceed those from farming itself, which could go a long way toward increasing the viability of agriculture in Ontario on a permanent basis. It would also result in significant support for the rural economy generally, as the profits from energy sales on the farm would filter into the local economy and support other local businesses.

Chemical Fertilizer Substitution:

Farmers commonly apply large amounts of chemical fertilizer to their crops, at considerable cost. Raw manure represents an alternative source of plant nutrients, but the nutrients in raw manure are chemically bound into organic compounds such as protein, and are released into the soil only slowly as those compounds are broken down. Free nutrients may not therefore be available to the crop in sufficient quantity at the right time, leaving the farmer still needing to supplement with chemical fertilizers. Raw manure has a tendency to suppress plant growth as the viscous material can stick to leaves and reduce plant respiration. As it is acidic, containing volatile fatty acids (VFAs), it may burn the leaves of the crop plants. It may also, if it has been stored in open lagoons prior to spreading, have lost a substantial fraction of its nitrogen content to the atmosphere as ammonia.

The digestion process solves many of the problems associated with the use of raw manure and allows manure residues to act as an effective substitute for chemical fertilizers. Digestion conserves the nitrogen content as the manure is held in an airtight containment vessel. The nutrients are released from their organic state and are much more readily available to plants during the growing season, initially as ammonia but quickly converted to soluble nitrate. The filtrate, being less viscous, does not stick to leaves and does not suppress plant respiration. It is low in VFAs, since this fraction has been converted into methane, and is therefore unlikely to burn crops. Given that chemical fertilizers are generally manufactured from natural gas, finding an affordable substitute may be extremely important in the near future.

Pathogen Reduction:

Undigested manure may harbour a considerable pathogen load, including Escherichia coli 0157:H7, Salmonella, Cryptosporidium and Giardia, which may contribute to water source contamination and cause illness in either farm animals or humans. The elevated temperatures manure is exposed to for prolonged periods during the digestion process can reliably reduce the pathogen load. A simple biogas digester operating in the mesophilic temperature range with a hydraulic retention time of 15-20 days can reliably reduce pathogen load by 99.9% or more, resulting in a product which can safely be applied to crops.

Weed seeds in digested manure appear to exhibit lower rates of germination and viability compared to seeds found in untreated manure. Conceivably, this effect could reduce reliance on chemical herbicides.

Water Pollution Control:

Traditional methods for manure storage and handling can result in contamination of groundwater with nutrients or pathogens, which can render the water of affected aquifers unfit for human consumption. Nitrates in groundwater may lead to significant health problems in humans and animals, including methemoglobinemia (otherwise known as blue-baby syndrome), which causes oxygen starvation in developing tissues.

Surface runoff water can also be contaminated with pathogens, nutrients or excess organic matter. Ammonia from decaying manure is toxic to life in surface waters. To put the problem in perspective, runoff from swine-raising operations and manure-fertilized fields can contain 200 mg/l of ammonia, while fish kills can occur at concentrations of 0.08 mg/l. Eutrophication - the introduction of excess nutrients into aquatic systems - leads to blooms of algal growth, which can seriously disrupt the ecology of the watercourse. Blooms of the highly toxic algae Pfiesteria have been implicated in fish kills and the deaths of other aquatic life. There may also be adverse health effects on humans and animals drinking the water. Excess biological oxygen demand (BOD) - organic substances which consume oxygen in the water as they are broken down – deprives aquatic life of sufficient oxygen for survival.

Manure processed through biogas digestion is very much less likely to result in contamination of either surface or groundwater. The carbon fraction is removed as methane for energy production so that there is little residual BOD to find its way into watercourses. As explained above, the nutrient fraction is converted into a form which is much more accessible to plants. The nutrients from treated manure applied at the right time for plant uptake, especially if it is injected directly into the soil, will be unlikely to find its way in watercourses.

Odour Control:

The open-air decay of untreated manure results in the release to the atmosphere of many intermediate metabolites - notably hydrogen sulfide, ammonia and amines, volatile fatty acids (VFAs), mercaptans, carbonyls, phenols and indoles - associated with objectionable smells. Hydrogen sulphide can cause loss of appetite at concentrations as low as 0.005ppm, and other compounds also have very low odour thresholds. The odour can attract pests including insects and rodents. The combination can result in considerable local opposition to farming operations near centres of habitation.

Biogas digesters contain the intermediate products of anaerobic decomposition within the enclosed fermentation medium, where they are further metabolized into odourless methane and carbon dioxide. Odour problems can be virtually eliminated, as the carbon fraction is removed and burned and sulphur compounds are precipitated and removed. The resulting organic matter is stabilized and has very little smell. As a result, it attracts very few pests. In the US, farmers commonly install digester systems purely for odour control.

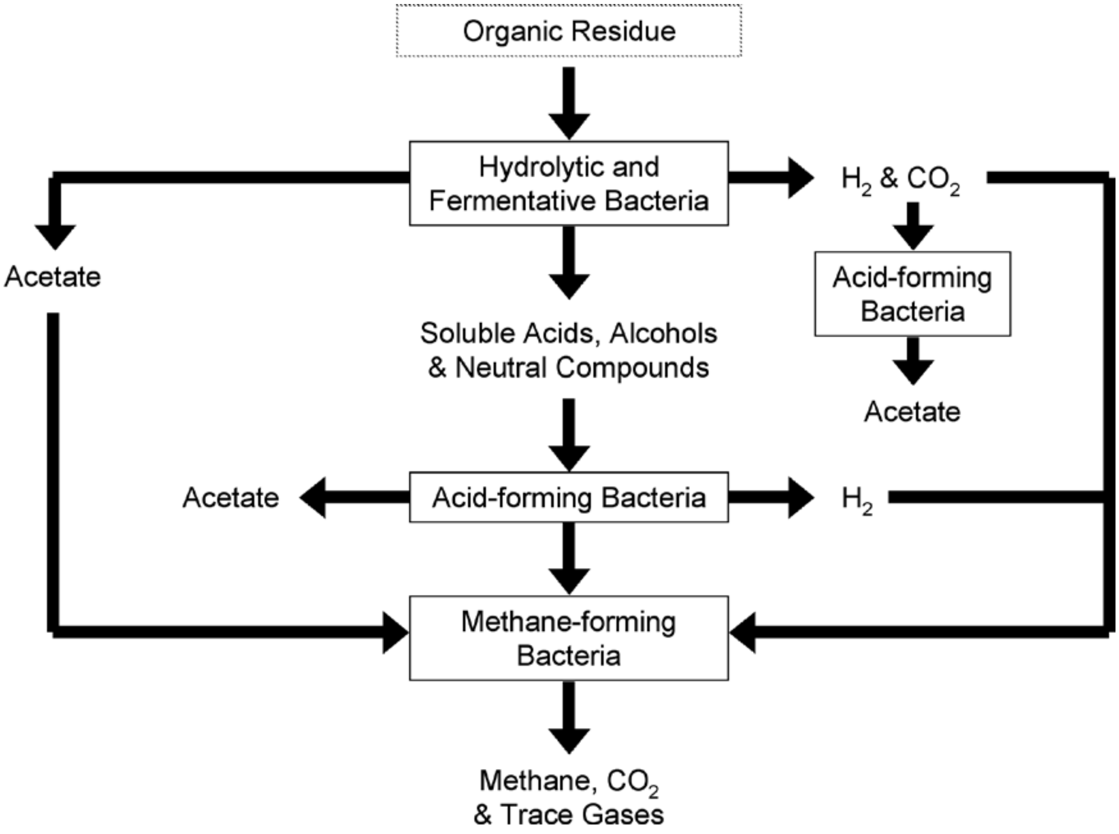
Ease of Manure Handling:

In addition to producing a stable, humus-rich compost with a greatly reduced pathogen load as a residue, digestion reduces the volume of biosolids to be dealt with by 50-80%. It is therefore a much simpler product to handle than raw manure.

Biogas Technology

The Anaerobic Digestion Process

Anaerobic digestion is a biological process where the synergistic activity of different bacteria in the absence of oxygen converts organic waste into biogas – a mixture of methane, carbon dioxide and numerous trace elements – and a stabilized residue. The first step is hydrolysis, which breaks down a wide range of organic materials into sugars and amino acids, followed by fermentation, or acidogenesis, which produces volatile fatty acids (VFAs), carbon dioxide and hydrogen. Acetogenesis converts VFAs into carbon dioxide, hydrogen and acetate, and finally, methanogenesis uses these compounds to produce biogas. The symbiotic relationship between the acetogenic and methanogenic bacteria is extremely close, as acetogenesis only continues to be possible if methanogenesis is able continually to take up the hydrogen it produces. If methanogenesis in prevented, acetogenesis will also cease once the hydrogen concentration has built up to an inhibiting level.



The biological process is delicately balanced, and can take up to a year before the methanogens develop to their full potential. Many factors can disrupt the process, which may require the digester to be clean out and restarted. All known methanogens are obligate anaerobes, in other words, they are killed by the presence of oxygen in very small concentrations. Biomethanogenesis is also inhibited by the presence of alternate electron acceptors such as, nitrate, sulphate, and volatile organic acids. The bacteria are sensitive to temperature, pH and the ratio of carbon to nitrogen.

Biogas production can happen anywhere between 4-68°C, with gas production increasing with temperature, up to a limit. Conventional anaerobic digesters are commonly designed to operate in either the mesophilic temperature range (30-40°C), or thermophilic temperature range (50-60°C). A higher digester temperature allows for a greater loading of organic materials to be processed, a shorter hydraulic retention time, increased output for given digester capacity and greater pathogen removal. Digesters operated at lower temperatures are more stable and require less process energy. In a Canadian climate, digesters would need to be heated in order to produce a useful amount of biogas.

Under conditions of over-loading or the presence of inhibitors, hydrogen and VFAs are produced more quickly than methanogenesis can remove them, leading to an accumulation of acids. The natural buffering of the system can be depleted, leading to a drop in pH from the normal neutral position. A VFA concentration of 2000 mg/l or higher indicates imbalance, although digesters may be able to tolerate 10,000 mg/l depending on the alkalinity level. If uncorrected via pH control and reduced feeding of the digester, pH will drop to a level at which fermentation will stop. A normally healthy volatile-acid to alkalinity ratio is 0.1. An increase to 0.5 indicates the onset of failure, and a ratio of 1.0 or greater is associated with total failure. Lime and sodium bicarbonate are the alkaline chemicals most commonly used to control pH. The amount of alkalinity needed to neutralize excess VFAs is calculated by multiplying 0.833 x VFA concentration (mg/l as acetic acid).

The ideal carbon/nitrogen ratio for an optimum rate of digestion is 30:1. If the nitrogen level is too high then digestion can be affected by ammonia toxicity, which can be remedied by dilution or with the addition of carbon-rich material such as straw.

Depending on the digestion process, biogas is typically 55-80% methane with an energy content of 550-800 BTU/cubic foot. The remainder is predominately carbon dioxide with trace amounts (1-15,000 ppm) of corrosive hydrogen sulphide and water. The methane content of the biogas produced is a good indicator of stability, since a reduced rate of methanogenic activity is a key factor leading to imbalance. Methane percentage is therefore a key performance parameter, and has been used as on-line control parameter. Another useful parameter is the ratio of propionic and other higher numbered acids to acetic acid. The formation of acids with a higher number of carbon atoms in their chemical structure is associated with digester failure because they are produced as way to use up excess hydrogen under conditions of methanogenic inhibition.

Biogas Digesters

A typical 1400-pound dairy cow produces 112 lbs of manure per day, while a typical 180-pound hog produces 11 pounds per day. Conventional manure handling represents a sunk cost to the farmer, whereas a biogas digester can cover that need and generate revenue. If the energy produced is used to maximum effect and the surplus can be sold, the payback period can be as little as 3-7 years. The economics are affected primarily by the price of power locally and by the price of fertilizer, the use of which is avoided where digested manure is available as an alternative. In Ontario, the failure to allow farmers to sell surplus electricity for consumption by others may render the economics unfavourable.

A digester is a large, poured concrete or steel container with an air-tight expandable cover. Manure is collected in a mixing pit by gravity flow or by pumping and fed into the digester at regular intervals, while gas is drawn out from under the cover and piped to an engine where it is burned to produce energy. The waste heat from the engine is used to heat the digester in order to maintain the proper temperature for the necessary biological reactions to take place.

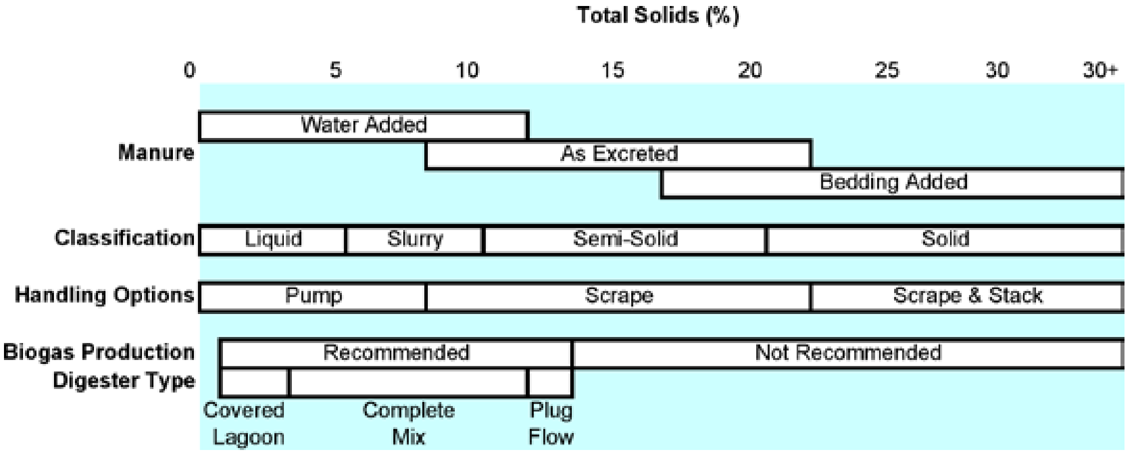
As of the late 1990s, 35 operating digesters produced 4MW of electricity per year in the US, and prevented the emission to the atmosphere of 124,000 metric tonnes of methane. As of 2002, there were 70 farms in the US with digesters and many more were planned or under construction. Some were swine operations, but most were dairy farms. Three facilities were centralized, serving several farms in one area. The theoretical yield is 0.35 cubic meters of methane per kg of chemical oxygen demand (COD), but the exact recoverable yield depends on environmental conditions. Farmers may expect to generate 2.3-5.5 kWh per cow per day.

In order to benefit from digester technology, the manure management strategy for a given farm must be compatible with the digester technology. The farm requires a large, confined herd with stable year-round manure production in order to feed the digester regularly. Irregular feeding can disrupt the delicate balance of the biological processes, thereby making the system work inefficiently or causing it to fail outright. Care must be taken with feed additives like antibiotics, or cleaning chemicals as these may damage the process. It is not known how much of these substances can be tolerated.

Manure needs to be collected at one point and managed as a liquid, slurry or semi-solid. In other words, it needs to be free of large quantities of bedding, as bedding forms clumps which clog pipes and interfere with digestion. The amount of collectible manure and its total solids content must be known in advance in order to design the digester, and size the engine and generator components.

Raw manure is excreted with a total solids contents of 8-25% depending on type of animal. For swine the figure would typically be 9.2-10%, for beef cattle 11.6-13.0%, for dairy cattle 11.6-12.5%, and for caged laying hens 25%. Manure can be diluted by process waters, misters, spilled drinking water or washing water, or it can be thickened by air drying or the addition of bedding materials. When designing a digester, all water in the manure-handling system and all processes affecting the total solids content of the resulting manure must be accounted for in order to choose the appropriate digester technology. Flushed manure with less than 3% solids cannot be processed to produce energy in the heated digesters necessary in the Canadian climate.

In order to achieve economies of scale, manure from several farms can be collected centrally and blended to the proper consistency. Manure would have to be transported fresh, with very little process water, from farms within about 5 miles. Transportation may be costly, but the benefits associated with digestion may make it worthwhile.



Complete Mix

A complete mix digester is a heated circular tank of concrete or steel with an airtight expandable cover. Heating the tank to the same temperature year-round provides a stable and predictable gas flow. Mixing optimizes digestion by enhancing the interaction between the substrate and bacterial cells and removing inhibitory metabolic products from cells. It keeps the substrate homogeneous so that solids are kept in suspension and the formation of a surface crust is prevented. The combination of mixing and heating improves efficiency.

Complete mix digesters are suitable for slurry-based manure management systems, which result in manure with a total solids concentration of 3-10%. The hydraulic retention time (HRT) is typically10-20 days.

Plug Flow

A plug flow digester is a long, rectangular trough (dimensions typically 1:5), often built below ground level, with an airtight expandable cover. As with the complete mix design, heating the tank to the same temperature year-round provides a stable and predictable gas flow. Plug flow digesters are used where the manure to be handled has a higher solids content, typically 11-13%, than for the complete mix design. Plug flow digesters are suitable for use on dairy farms as long as they do not use flush systems, but not for swine operations as the total solids content of swine manure is insufficient for this method of handling. If the solids content is too low then solids do not remain in suspension, but sink to the bottom where they are not properly digested.

Manure, typically collected daily by scraping, is added to a mixing pit where the solids content is adjusted by dilution if necessary. Manure containing a great deal of bedding will need to be screened in order to remove solids prior to digestion, although some bedding is tolerable. The recoverable fibre has the consistency of moist peat moss and has value as a soil improver or potting soil. The manure is then added to one end of the trough, while a similar volume of processed material is removed from the other end. Manure slowly makes its way from one end of the digester to the other, the HRT being 20-30 days. Mixing of the slurry occurs through convection due to the heat from the heating pipes suspended inside the digester. There are few moving parts, hence there is minimal maintenance required.

Effluent Storage

Treated effluent will need to be stored, as it cannot be applied to crops all year round. The storage lagoon needs to be sized to meet farm requirements during the non-growing season. The effluent is biologically stabilized so that it will not produce more than a minimal odour and will not represent a health hazard. Care must nevertheless be taken to ensure that the contents of the lagoon cannot drain into ground or surface water sources.

Engines/Generators

Active management is required for stable digester and engine operation, hence there is a need for basic 'screwdriver-friendliness'. The owner needs to be familiar with key components and also needs technical support for unusual problems. The system generally requires a time commitment for daily maintenance/monitoring of 15-30 min, and also additional blocks of time for repair and preventive maintenance. Tasks range from 10 min to 10 hours, with most needing between 30 min and 2 hours. The required skills include engine repair and maintenance, troubleshooting and repair of electrical control problems, plumbing and welding. Parts and technical services should be easily accessible. It is preferable not to leave the management of biogas technology to seasonal farm labour or third parties, because they may lack the motivation or incentive to do what is required. Delegation of the responsibility also reduces the owner's familiarity with the system.

Current biogas systems are known to be overly complex, requiring operating and maintenance procedures that may be outside of the owner's capacity to supply. Further development work is required to reduce the general labour requirement and complexity to match other typical farm machinery, such as a tractor or combine - all equipment with which the average farm operator is familiar. The Powerbase Biogas Consortium is working to produce a simplified, low-cost biogas digestion system which will be applicable across a wide range of agricultural operations.

Internal Combustion Engines

Practical experience with small-scale internal combustion engines with a rated capacity of less than 200kW indicates an electrical conversion rate of less than 25%. Larger engines can have greater conversion efficiency. Natural gas or propane (spark ignition) engines can easily be converted to run on biogas with small modifications to carburetion and ignition systems. Farmers are often very familiar with engines of this type and are thus well positioned to be able to maintain them.

Compression ignition engines (diesel) are known to operate on a mixture of approximately 10% petrodiesel and 90% biogas, presenting a very durable and economically superior alternative to the spark ignition engine. Compression ignition engines have been shown to provide greater fuel conversion efficiencies in comparison with spark ignition engines, although the overall efficiency between the competing technologies is similar when waste heat capture is factored in through a combined heat and power system.

Miniature Gas Turbines

Small Capstone gas turbine engines are an offshoot of large aero industry units. Long-term studies of aircraft engine life indicate the units to be extremely reliable and cost effective enough to be used in large, industrial combined heat and power systems. The desire to provide miniature gas turbine units of 10 to 100 kW capacities in this market segment would appear to be obvious.

Current experience with miniature gas turbine technology has not developed to the point where lifecycle economics are compatible with internal combustion engines, although investment in gas turbine technology may change this situation over time.

Heat Recovery

Waste heat represents approximately 75% of the energy contained in the fuel used to run the engine. This heat is commonly recovered from the engine's exhaust and cooling systems and used to heat the digester and to provide for other farm heating needs. Properly sized heat exchangers can recover up to 7000 BTUs of heat per hour for each kW of generator load, increasing the overall efficiency to of the process to 80%.

Generators

Induction (asynchronous) generators operate in parallel with the utility and cannot stand alone, as they derive frequency and voltage from the utility supply. Although they are technologically simple and inexpensive, they are unable to function as backup if the utility supply is unavailable and cannot be considered a viable technology.

A synchronous generator produces its own frequency and voltage and can operate either in isolation or in parallel with utility supply. If it operates in parallel, more sophisticated control facilities are required in order to ensure that the generator output is consistent with the frequency and voltage requirements of the utility supply. They are therefore more expensive, but are capable of acting as a backup in the absence of the utility supply.

Stand Alone or Parallel Power Production

Farm electricity generation can be done either in isolation, as a stand-alone system, or in parallel with utility supply. Most farmers choose to operate in parallel with utility supply, if they can secure a reasonable deal for the sale of surplus production. If they cannot, as is the case in Ontario due to the net-metering regulations which prevent them for generating power for use by others, then they may be more likely to chose to operate in isolation. This option is, however, much more challenging – challenging enough that farmers may still chose to connect to the utility even though the result would be offering surplus production without compensation. The regulations clearly place farmers in an unfair position.

An isolated system must be able to function continuously, without interruption, to meet fluctuating levels of electricity demand while maintaining a steady 60 Hz current. Frequency drift from varying loads, or from large motors starting suddenly, can result in wear on motors, speed up/slow down of timers, or operating problems with computers or programmable logic controllers. An isolated system is free from the utility, but needs a sophisticated control system and a gas reservoir in order to meet changing loads. The engine/generator is usually oversized in order to accommodate peak electrical demand, which means that it operates less efficiently at average or partial load. The system must be operated and maintained at all times, and backup generation must be provided for. That means purchasing and maintaining a backup generation system, or paying the utility for emergency backup if power supply is critical to farm operations. Utilities have been known to charge dearly for such services. Electricity demand must also be managed in order to reduce unnecessary demand fluctuations.

In contrast, a parallel system is directly connected to the utility and matches frequency and voltage so that farm-produced power blends with utility supply. It is necessary to install a utility interconnection panel with safety relays, and to disconnect from the utility if there is problem with either farm or utility supply. Parallel operation allows farm generation to run at constant output, regardless of farm demand, which allows more efficient use of biogas and less wear on the engine. It is then possible to size engine/generator for biogas availability rather than for farm requirements.

Protection and Control Systems

Protection and control systems exist to regulate the connection between farm generating equipment and the utility supply for the protection of both. In addition, the control system must regulate waste heat by accurately measuring and directing thermal energy to the digester, farmhouse and other buildings. Systems intended to function reliably for biogas generation must be designed to work in a damp environment where corrosive gases such as ammonia may be present. They must include facilities for monitoring and displaying engine-generator operating conditions as well as for remote operation and data retrieval.

Protection:

The protection system exists to protect the utility from faults in the engine-generator and its ancillary equipment, for instance short circuit electrical faults, by disconnecting the farm from the utility supply under fault conditions. The farm would also be disconnected for the protection of utility staff if the utility supply were to fail. This would avoid the potential for the farm supply to energize the connection inadvertently while utility staff were engaged in repairs.

The system also acts to protect the farm engine-generator from faults arising from the utility supply or from potential damage resulting from any internal faults. The engine-generator would be disconnected from the utility if electrical supply parameters such as frequency varied more than a predetermined amount from the set-point. The protection system would also shut down the engine-generator if electrical, thermal or mechanical faults were detected. This would include, for instance, low engine oil or high generator stator temperature.

Control:

The control system exists to set and maintain desired operating conditions for the engine-generator, for instance, regulation of the engine-generator speed and voltage. Start-up and shutdown sequences would be fully automated.

End-Use Applications

A thousand cubic feet of biogas is roughly equivalent in energetic terms to 600 cubic feet of natural gas, 6.4 gallons of butane, 5.2 gallons of gasoline or 4.6 gallons of diesel oil. Biogas can be used in all applications designed for natural gas, although some equipment modifications may need to be made due to the lower energy content. It is suitable for electricity generation, boiler fuel, space heating, refrigeration equipment, cooking, or lighting. Dairies use vacuum pumps, milk chillers (15-30% of total electricity load), feed mixers and fans, and swine farms have heat lamps and ventilation equipment, all of which consume large quantities of electricity in an uneven demand profile. For instance, heating, air-conditioning and ventilation are seasonal, lighting is required only at night, and milking is done two or three times a day for four hours. Biogas production is constant and storage is expensive, so it is easier to generate continuously and sell surplus production than to try to match on-farm demand, unless the farm is very large. An available market for the electricity surplus is therefore very important.

Where a market for surplus electricity is not available, some farms can make increased use of direct combustion options. These can make more efficient use of the energy contained in the biogas than the generation of electricity, but are often not so convenient. A boiler, for instance, has an efficiency of 75-85%, although it would first have to be adapted for biogas by adjusting the air/fuel mix, enlarging the burner jets and painting all metal surfaces in order to prevent corrosion. Hog farms in the Canadian climate may be able to use all biogas produced for heat.

Gas-fired chillers, either for air-conditioning or refrigeration, may also be a suitable end-use. It is typical for a dairy to need 0.014 tons of cooling (one ton of cooling = 12000 BTU/h) per hour of milking per cow per day, which represents approximately 15% of the biogas production from the same cow. Double effect chillers can make hot and cold water simultaneously for large applications.

Biogas can also be used for transportation in light and heavy-duty vehicles designed to burn compressed natural gas (CNG), if the gas is scrubbed of carbon dioxide, hydrogen sulphide and water in order to leave usable methane. A million vehicles worldwide currently run on CNG alone or as a bifuel. They make less noise, require less maintenance and produce less exhaust emissions than conventional vehicles because methane burns so cleanly.

Success or Failure

In the US, many agricultural biogas digesters were built in quick succession after oil shocks of 1970s. There was a great deal of government grant money available, but too little screening of project proposals, so that a history of failed projects developed. In the 1980s, funding was cut drastically, essentially killing the North American anaerobic digestion industry. By 1994, only 25 digester systems were still operating in US, although there are several thousand farms in a position to benefit from biogas production. There are now relatively few commercial providers of the technology and they have been able to keep prices high enough to limit the uptake of biogas digestion technology to very large farms only. The Powerbase Biogas Consortium seeks to lower the cost of a complete system dramatically by moving away from a commercial model based on over-engineered custom installations. A farmer will no longer need to have hundreds of cows in order to be able to justify the capital expenditure of biogas digestion, and the penetration of the technology should therefore increase substantially.

Successful projects from the early biogas building boom tended to share several primary characteristics. Most importantly, successful systems were designed and built to be compatible with farm operation. The owner realized the benefits of the technology and wanted it to work. Owners needed at least some mechanical knowledge and ability, and also ready access to knowledgeable technical support. Success was associated with a stable and profitable framework for the sale of energy, and also the exploitation of additional profitable opportunities such as the sale of manure by-products. In fact, some diary farmers earn more revenue from the sale of electricity and manure by-products than on sale of milk.

Failed projects also shared many characteristics. Digesters were often built with little thought to their compatibility with the manure handling methods used by the farm, or with inappropriately sized components. Poor system design often made the system too expensive to maintain and repair, and farmers were given inadequate training and subsequent technical support. Owners may not have had the skills or the time to keep a marginal system operating. Financial returns on such systems were poor or non-existent.

As a result of previous errors leading too frequently to failure, traditional lending agencies may be reluctant to provide financing for projects, even where the prospects for success are excellent. It may therefore require the collaboration of government agencies, with a combination of direct technical assistance, grants and low interest loans to supplement the farmer’s available capital. As financial viability can hinge on a contract to sell excess electricity, Ontario is in a far less advantageous position than it should be with regard to exploiting biogas technology. This position can be easily remedied by the introduction of an appropriate regulatory and financial framework.

The Financial Framework:

The Current Situation – Political Quotas With No Revenue Guarantee:

Ontario employs a cumbersome and legalistic bidding system for renewable energy projects, which favours large projects and concentrates ownership in relatively few hands as the price of entry is prohibitive for smaller players. The quantity of renewable energy on the system is politically determined - pre-set at a very low level through an RFP - while the price to be paid for it is determined by the bidding process. Only a few sites with exceptional resources of renewable energy will be exploited as they are best able to deliver profitability where there are no revenue guarantees. It is a process guaranteed effectively to ghetto-ize renewable energy – to render it a virtually insignificant component of a monolithic centralized system. Moreover, it forces renewable energy to compete in the same large-scale, remote-from-demand form that has led the province into so much financial difficulty.

For small-scale producers, there may be no revenue at all, if they generate less than 500 kW and are covered by the net metering regulations. They are not permitted to generate power for the use of others and cannot be paid at all for surplus produced above their own consumption, netted out over an annual cycle. There is therefore no financial recognition at all of the valuable contribution they would be making towards meeting peak demand. This model is characteristic of the past, not the future. Generations co-operatives may be able to circumvent the regulations and allow smaller players to aggregate their production in order to respond to an RFP, but co-operatives should not be forced by artificial limits to operate at a specific scale which may or may not be appropriate for their circumstances. Much more flexibility is required if Ontario is to realize the benefits of small-scale power production.

With the impact of renewables deliberately limited by political fiat, attention is focussed instead on the development of new large-scale supply projects. Despite dire financial circumstances due to an accumulated electricity system debt of $38 billion, the Ontario government is contemplating financing a new round of public power plant construction, with the emphasis on expensive nuclear power. Private capital for large-scale projects is being kept on the sidelines by Ontario's recent history of political interference, by the lack of economic visibility and by the government's refusal to offer any form of revenue guarantee for an investment with a very long payback period. The current government's attitude toward private ownership or control of any power system assets betrays a deep-seated lack of trust, which is certainly mutual following the disastrous policy flip-flop of the previous government. It is not an atmosphere conducive to a successful partnership.

Energy Minister Duncan has explained that he does not want taxpayers assuming risks he feels should be borne by power producers, but it is typical for the builders of Independent Power Producers (IPPs) in many jurisdictions to ask more favourable terms than pertain in the public part of the system. There is a common perception in many places, Ontario among them, that this is unfair. However, it would be unfair to expect private entities to risk their own capital on terms comparable to the public sector with its traditionally deep pockets, tolerance for decades-long payback periods and cost overruns, access to capital at advantageous rates, relative disregard for efficiency, ability to pass the cost of its mistakes on to captive consumers or taxpayers, and revenues from a captive tax-base.

The Alternative – Standard Offer Contracts (SOCs):

Standard Offer Contracts (SOCs) are simple and transparent long-term contracts whereby producers of renewable energy allowed access to the grid and are paid a premium price for their power – a premium determined by the technology they use and its potential production rate in the area in which it is deployed – over a period of up to twenty years. Prices are paid in tranches which progressively reduce as the capital cost is repaid, allowing for an appropriate rate of return based on productivity. Prices are fixed politically, while quantity is determined by the market. A new report entitled “Powering Ontario Communities” was recently released by the Ontario Sustainable Energy Association and is available on the web at:

(**http://www.ontario-sea.org/pdf/PoweringOntarioCommunities.pdf**).

In areas well endowed with renewable resources, it is necessary to offer less of a premium for the project to deliver a return on investment over the life of the contract, whereas in less fortunate areas a higher premium may be warranted. What this mechanism achieves is the widespread distribution of renewable technology across the territory in question, and hence widespread access to locally produced electricity. If the future is indeed to be a decentralized one, then renewable generation cannot be concentrated only in those areas of the country with the best resources. To capitalize only on pockets of relative abundance is to view renewable energy in the same terms as traditional large generation remote from demand, and it is precisely this centralized model which is no longer economically sustainable.

SOCs have had a tremendous impact on the rate of installation of small-scale renewable technologies in other jurisdictions. For instance, in Germany, SOCs have led to individuals investing $1.7 billion and installing 20,000 solar-electric systems in one year. Since 1991, the country has also installed 14,000MW of wind generation, a renewable energy boom by any standards. Already more than 300,000 Germans own shares in wind turbines, as does 5% of the Danish population. Indeed, nearly 90% of the wind power capacity installed worldwide in 2002 was installed in Europe through the mechanism of renewable tariffs. With so many people employed in the renewable energy industry, owning shares in it, or otherwise benefiting from it, SOCs have a broad base of political support.

SOCs are inherently egalitarian, allowing the smallest-scale producers of a net power surplus to be compensated for their contributions to the grid and thereby preventing the concentration of the renewable energy industry in the hands of only a few large players. Under a renewable regime based on SOCs, Ontario farmers could install, for instance, thousands of MW of biogas or wind power capacity. They may be able to earn perhaps $150,000 per year from the sale of electricity, injecting huge sums into the rural economy rather than sending it abroad to pay for expensive power imports during peak periods. They may, in fact, be able to earn more from the sale of electricity than from farming itself, an important factor as farming has become less and less profitable in recent years and farmers have become burdened with ever greater levels of debt. SOCs have the potential to revitalize the rural economy at far less cost to the government than building new large-scale supply itself. In addition, they stimulate a home-grown renewable energy manufacturing base, thereby providing stable employment.

As the interest on the old Ontario Hydro debt is running at approximately $125 million per month, the current price of power must rise significantly for the government even to be able to cover the interest from what it charges consumers, let alone be able to pay down the principle. Given that the price of power must rise, what currently looks like a premium price paid to private power producers may prove to be an extremely good deal for the public purse over the lifetime of a long-term contract.

Conclusions

Ontario must take decisive action now in order to forestall a looming energy crisis, and looking to the past for solutions to the problems of the future is not a constructive approach. The era of the monolithic power system controlled from the centre is drawing to a close, with public power authorities choking on their own debt. As technically coherent as it is, it cannot be sustained economically in its current form and must give way to a more decentralized alternative. The task of government is to manage that uncomfortable transition, not to attempt to prevent the inevitable. Committing relatively modest sums to fund the transition, by encouraging investment in efficiency, conservation and distributed generation, will be far more productive than throwing huge amounts of money at the system as presently constituted. The latter option can only increase the already crushing debt burden of the Ontario electricity supply industry, while doing nothing at all to tackle its fundamental unsustainability.

Ontario should be raising the price of power very substantially in order to devise a workable repayment schedule for the existing power system debt, which is mounting continually, even in the absence of additional large scale supply and transmission investments. Raising the price of power will go some way towards both instituting a culture of conservation and making distributed supply price competitive. By itself this will, however, take time to achieve the desired effect. Providing direct incentives - through capital grants, tax breaks or long-term supply contracts for distributed generation - to a wide variety of private entities, for both demand and supply side investments, could speed the transition considerably, and at very little cost to the public purse in comparison with the government's chosen nuclear 'solution'. Such incentives would also act to reduce the political impact of necessary price increases.

Private entities ranging from industry and agribusiness at one end of the scale to small farmers' cooperatives, community power initiatives and individuals at the other end should all be able to sell surplus renewable power to the grid over the long term at a premium price. Standard Offer Contracts have succeeded in bringing huge amounts of renewable power on to the system in other jurisdictions, and have done so at relatively low cost to the governments involved, in comparison with more traditional investments in supply and transmission.

Agriculture is particularly well placed to produce and sell surplus power to the grid through investment in biogas digester technology. Doing so benefits the grid by both reducing demand and increasing supply, and converts a sunk cost for manure handling into a revenue generating opportunity for the farmer. Biogas can be used to generate heat and power and can also substitute effectively for natural gas across a wide range of applications, which may prove to be a very considerable benefit as natural gas supply gets tighter in the coming years. Very substantial greenhouse gas reductions can be guaranteed as methane emissions are minimized and fossil-fuel based generation is offset by farm-based energy recycling.

The Powerbase Biogas Consortium is well equipped to offer a complete biogas digester technology package at a price which will allow the biogas advantage to be taken up by a much wider range of agricultural operations than would previously have been possible. It will no longer be necessary for participating farms to operate on a gigantic scale for biogas technology to be justifiable on cost grounds, particularly where additional waste streams can be incorporated into the process. The Consortium is also encouraging farmers to aggregate their generation capacity on a co-operative basis in order to empower the rural economy while leveraging the advantages to the power system.

Facilitating the introduction of this technology, and other forms of small-scale distributed generation, will require major shift in the present government's bias towards centralized monopoly control. The net-metering regulations, which reflect this bias particularly acutely, represent a considerable obstacle to the very factors most likely to solve Ontario's looming supply-demand imbalance. Removing this obstacle, and offering funding through Standard Offer Contracts, would be evidence that the government of Ontario understands the problems it is facing and is prepared to take meaningful action to address them.

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