# Revitalization of the Jamaican Dairy Sector. III

## Biogas as an Option for Enhancing International Competitiveness

**P.G. Jennings, R.C. Miller, D.L. Ffrench and B.G. Duffus***

**Jamaica Dairy Development Board**

***Beef and Dairy Producers Association of Jamaica**

## *Summary*

***The heavy reliance of the local dairy sector on imported inputs has exposed its vulnerability to the spiraling costs of the key inputs into the production of milk and has contributed to increasing competitive disadvantage in local milk production relative to world leading producers. As at 2008 the average variable cost of production in Jamaica, put local milk at a comparative disadvantage of 47 and 103 percent respectively, compared to the US and New Zealand. As a consequence operating margins enjoyed by local producers have rendered local production of milk increasingly unsustainable.***

***This paper examines the impact of the four key inputs into milk production (Concentrate Feeds, Fertilizer, Labour and Electricity) on the state of competitiveness of milk production in Jamaica. It reviews earlier recommended strategies for the first three and analyses the potential contribution of on-farm generation of electricity from Biogas, as an option for improving operating and financial efficiencies.***

***A sampling of eight dairy farms of varying sizes provided base data on electricity consumption and costs during 2009. The data indicated a significant linear relationship between daily electricity consumption and herd size, the individual cow within the herd, requiring 0.66 kWh per day and a contribution to variable cost of $2.60 per litre from electricity usage.***

***For dairy herds of 250 cows and above, the switch to on-farm generation of electricity from Biogas, consistently improved the unit cost of production as well as net present value and internal rates of return. At herd sizes of approximately 60 cows the financial outlays and depreciation charges associated with the investment in bio-digester and prime diesel electricity generator, makes this option non-viable and further reduces the cost-competitiveness of operations of this scale. There might be virtue, therefore in adopting a cluster approach to electricity generation from biogas at the Dairy Cooperatives at Rhymesfield and St. Elizabeth where individual farms are typically below 60 cows.***

***The analysis provides economic and financial justification for the promotion of electricity generation from Biogas for which dairy farms are particularly endowed given the huge disparity between generation capacity and requirement on dairy farms. Additionally, from an environmental perspective, the established negative impact of livestock on climate-change, adds justification to a national strategy of biogas generated electricity on dairy farms.***

## Introduction

The Jamaican dairy sector has experienced serial decline since peaking at 38.8 million litres milk entering the formal trade in 1992. From a proportional contribution of approximately 24 percent of total consumption in its peak year, local self-sufficiency in milk fell to 9.5 percent in 2008; production of fresh milk having fallen to 14.1 million litres ( Dairy Facts and Figures 2007-08, JDDB).

The factors which have contributed to the trend reversal in local milk production since 1992, have been delineated in several reports including Jennings (2005), Kirton and Witter (2006) and Jennings (2008). The issue of loss of competitiveness, particularly in the face of a surge in the importation of milk solids, heavily subsidized at origin, has been the major challenge to the revitalization of the sector. The annual cost of production survey conducted by the Jamaica Dairy Development Board since 2000, has highlighted and quantified the cost factors which limit the attainment of international competitiveness by the sector, as indicated by the relative changes in the variable cost of milk production and the relative proportion of costs attributable to various inputs (Table 1).

**Table 1**. Cost of production and distribution of costs in the production of milk 2004-2008

| | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Average variable cost (AVC) | 19.13 | 22.32 | 23.70 | 30.56 | 38.59 |
| Average farm-gate price | 22.00 | 24.00 | 26.00 | 28.33 | 41.84 |
| **Major cost components as % AVC** : | | | | | |
| Purchased Feed | 39.0 | 39.0 | 29.9 | 33.1 | 35.9 |
| Labour | 13.0 | 13.0 | 24.3 | 16.9 | 22.5 |
| Utilities | 7.0 | 7.0 | 6.5 | 10.1 | 9.6 |
| Pasture maintenance | 4.0 | 4.0 | 5.4 | 2.3 | 1.7 |
| Vet & Med | 3.0 | 3.0 | 3.4 | 4.3 | 2.4 |

Source: Ffrench *et al* 2009

The doubling in average variable cost between 2004 and 2008 reflects, largely, the heavy reliance on imported inputs which have spiraled since 2006. As a result gross margins have dwindled since 2004 from 15 percent to 8.4 in 2008, the average farmer actually sustaining operating losses in 2007. Although average farm gate price has increased at a lower rate than direct farm costs, the 90 percent increase in farm gate prices is indicative of the dwindling competitiveness of locally produced milk.

## Assessment of the Competitive Status of Local Milk Production

Compared to average US retail prices, locally produced fresh milk at an average price of J$144.38 (US$1.98) per litre in 2008, had a competitive disadvantage of 98 percent (Ffrench et al, 2009). With trade margin differentials of +100 percentage units for Jamaican vs. US fresh milk, the competitive disadvantage of local milk has to be tackled at all levels of the value chain, particularly as the high fixed costs associated with grossly underutilized processing capacity and other chain deficiencies, are major contributors.

Improved on-farm efficiencies, nevertheless, remain a critical strategy in not only enhancing the international competitiveness of the local dairy sector, but also guaranteeing the sustainability of local dairy farming.

Some relevant coefficients of milk production in Jamaica, the US and New Zealand in 2008, are compared in Table 2. With respect to the proportion of direct costs represented by the primary inputs, comparative US statistics for 2008 are Feed – 60%; Hired Labour – 10.7% and Energy – 5.3% (Brown, 2008). The contrast with Jamaica in respect of the distribution of cost components (Table 1) might be indicative of the root causes of the local competitive disadvantage.

**Table 2**. Comparative efficiencies of milk production: Jamaica vs. US and New Zealand

| | **Jamaica**[1] | **U.S** | **N.Zealand** |
|---|---|---|---|
| Average variable Cost (US$/L) | 0.53 | 0.36[1] | 0.26[7] |
| Farm gate price | 0.57 | 0.41 | 0.37[1] |
| Indicative margin (%) | 7.5 | 13.9 | 0.42 |
| Stocking rate @ grazing (cows/ha) | 2.1 | 2.3 | 2.7 |
| Yield per cow (L/yr) | 2363 | 7105[3] | 3790[7] |
| Output per ha (L/yr) | 4867 | 16,340 | 10,250 |
| Feed price (US$/kg) | 0.29[2] | 0.20[4] | 0.30 |
| Milk: Feed Price ratio | 1.96 | 2.05 | 1.23 |
| Labour cost (US$/man hr) | 1.87[2] | 11.38[5] | 8.0[8] |
| Electricity cost (US$/kWh) | 0.32 | 0.12[6] | 0.18[9] |

1. Ffrench *et al* 2009
2. Miller *et al* 2009
3. McCall and Clark 1999
4. Gould, B. 2010
5. Anon. 2009
6. Michael Bluejay Inc 2009
7. N.Z. Agritech Inc. 2008
8. Kingston, C. 2005
9. www.meridian.co.nz

In terms of Average Variable Cost, Jamaican farmers are at a competitive disadvantage of 47 and 103 percent, relative to their US and New Zealand counterparts, respectively. This is reflective of the vulnerability of the local milk producer to the spiraling costs, since 2006, of key inputs such as proprietary concentrate feeds, fertilizers and electricity. The significantly reduced margins enjoyed by the Jamaican farmer, reinforces the absolute need to extract greater operational efficiencies, given that farm-gate prices are already 39 and 54 percent higher than those enjoyed by US and New Zealand farmers respectively. With respect to the European union, our major competitor, year-end 2009 FOB prices of whole milk powder, ranged between `US$3350 and $3750 per metric ton (AMS- USDA, Dec., 2009), equivalent to a median fluid equivalent (recombined) cost of J$41.06 per litre. This further reinforces the imperative of attaining greater efficiencies in local production as the first step to increased international competitiveness, particularly in light of the insistence of the EU in retaining export subsidies on powdered milk, an abrogation of earlier commitments to the WTO.

Miller *et al* 2009 highlighted the near-exponential increases in input costs to the dairy sector since 2000 (Table 3).

**Table 3**. Changes in unit costs of key inputs used in milk production in Jamaica 2000-2008

| **Input** | **2000** | **2005** | **2008** | **2008:2000** |
|---|---|---|---|---|
| Fertilizer (J$/kg N) | 29.81 | 65.83 | 119.33 | 3.00 |
| Concentrate feed (J$/kg) | 8.39 | 14.80 | 24.96 | 1.97 |
| Electricity (J$/kWh) | 7.50* | 14.78 | 27.86 | 2.71 |
| Hired Labour (J$/man hr) | 74.75 | 137.5 | 162.9 | 1.18 |
| **Weighted average cost of inputs** [1.] | **20.14** | **27.31** | **50.33** | **1.49** |
| Ave. Variable Cost (J$/litre) | 15.91 | 22.23 | 38.59 | 1.42 |
| **Farm- gate Price (J$/litre)** | **22.14** | **24.00** | **41.84** | **0.89** |

1. Weighted by proportion of AVC accounted for by input.

- Residential rate, year ended March 2002. www.jpsco.com

The four major inputs, cumulatively, accounted for between 65-70 percent of average variable costs between 2000 and 2008. Indexed on the basis of the proportion of variable cost represented by each input, the weighted average cost of these inputs increased by 149 percent during the nine-year period to 2008.

## Approaches to Increasing Efficiencies of Utilization of Key Inputs

**Concentrate feeds:**
The use of concentrate feeds, at 36 percent of variable cost in 2008, represents the major option for effecting increased production efficiency. It is instructive that the New Zealand dairy industry, with an adverse milk: feed price ratio (Table 2) has opted largely for a zero-concentrate pasture based system; exploiting the productive potential of well-managed pastures for maximizing output per hectare from high-cost farm lands. Grazing has also become increasingly popular in the US over the past 15 years and has been shown to yield advantages by way of reduced milk costs and increased milk income than the more traditional zero-grazing systems (Fontanelli *at al* 2001).

From a review of studies into concentrate supplementation of dairy cows grazing tropical pastures, Jennings and Holmes (1985), calculated a mean marginal response to concentrate feed of 0.82 litres per increment of concentrate feed. This suggests that the use of concentrate feeds remains economic at milk: feed price ratios above 1.25: 1. At 2008 prices the milk: feed price ratio of 1.96: 1 theoretically favours the continued use of concentrate feeds. However, the low level of fertilizer use indicated by pasture maintenance accounting for only 1.7 percent of variable cost in 2008, would suggest that the efficiency of utilization of concentrate feeds might be impaired by low intake of pastures given the likelihood of sub-optimal pasture quality, resulting in a substitution of herbage by concentrate feed.

To overcome this substitution effect requires a strategy of increased fertilizer use to facilitate an increase in the carrying capacity of the grazed pasture, as well as increased nutritive value, thus optimizing the additive effect of concentrate feeds. This strategy, '*The Pasture Extender Concept'* has been described by Jennings 1992 & 2005. Indicative per cow yields of 2363 litres per annum (Table 2) suggest that cows are currently producing at only 65 percent of the established potential of the Jamaica Hope in well-managed commercial herds (Holness *et al* 1994).

**Labour:**
Hired labour accounted for 22.5 percent of variable costs on Jamaican dairy farms in 2008. The productivity of labour on Jamaican dairy farms is impaired on three fronts viz;

1. Low level of competence relative to competitors who historically have invested significantly in life-long learning in addition to requiring a higher level of basic education at entry;
2. The low level of technology on farms relative to say New Zealand which has been at the forefront of milking parlour technology such that rotary milking systems currently account for approximately 34 percent of parlours facilitating upwards of 200 cows milked per person per hour (Jago *et al* 2007).
3. The resort to paying farm labour at or just above minimum wage is itself a major disincentive to improved productivity. Given that differences in milker attitude may account for as much as 20 percent of the differences in yields between herds, the motivational state of the dairy farm worker is a critical factor in farm productivity.

These disadvantages are reflected in the low level of labour productivity, compared to that which entails among the world-leading milk producing countries (Table 4 )

**Table 4**. International cost competitiveness (US$/L) of Locally Produced Milk 2005-2006

| Country | Farm Gate Price | Cost of Production | Average Wage Level ($/man hr) | Labour Productivity (kg milk/man hr) |
|---|---|---|---|---|
| New Zealand | 0.20 | 0.14 | 8.0 | 288 |
| Argentina | 0.16 | 0.07 | 3.0 | 86 |
| Poland | 0.25 | 0.07 | 3.0 | 35 |
| Australia | 0.23 | 0.16 | 13.0 | 289 |
| United Kingdom | 0.37 | 0.23 | 16.0 | 197 |
| **Jamaica** | **0.36** | **0.35** | **2.20** | **9.25** |

*Source: Jennings 2007*

A 2001 Memorandum of Understanding between the Ministry of Agriculture, The Jamaica Dairy Farmers Federation and HEART-NTA, envisaged the implementation of a modular on-the-job competency certification course within HEART-NTA. It is anticipated that this will be implemented as a matter of expediency. Jennings (2007) has recommended the adoption of strategies such as share-milking as a means not only of reducing barriers to entry but also, critically, as a means of improving HR competency in the management of dairy farms.

Out of recognition of the limitations posed by the state of technology, the Jamaica Dairy Development Board is committed to the launch of a capital leasing programme during fiscal 2010, as a strategy for promoting equipment upgrading within the sector (Jennings *et al*, 2009).

**Pasture Maintenance and Fertilizer:**

Fertilizer prices moved by a factor of 3 between 2000 and 2008, triggering a slide from 5.4 to 1.7 percent in the relative contribution of pasture maintenance to average variable cost between 2006 and 2008. With respect to fertilizer nitrogen, Jennings (2005) reported that application rates for nitrogenous fertilizers had fallen from an already low 80-90 kg N per hectare during the early 1990s, to 51 kg N per hectare in 2004. The declining stocking rates and output per hectare reported since 2004 by Ffrench *et al* (2009), strongly suggest even further drastic declines in fertilizer use on dairy farms.

Increased fertilizer nitrogen application represents, arguably, the most cost-effective strategy for raising productivity levels on dairy farms. Table 5, extracted from Jennings (2005), presents a model for significantly increasing yields per hectare, to levels well beyond the capacity of temperate countries, including New Zealand.

**Table 5.** Carrying Capacities and Estimated Milk yields at Varying Levels of Fertilizer N

| Fertilizer N Level (kg/ha) | Est. Herbage Yield (kg DM/ha/yr) | Carrying Capacity (Cows/ha) | Yield per hectare (Litres/yr) | |
|---|---|---|---|---|
| | | | **Zero supplement** | **Plus Concentrate @ 0.4 DMI** |
| 0 | 10,000 | 2.0 | 4,925 | 7,100 |
| 56 | 11,800 | 2.3 | 5,850 | 8,450 |
| 112 | 13,450 | 2.7 | 6,780 | 9,780 |
| 170 | 15,140 | 3.0 | 7,400 | 10,100 |
| 225 | 16,800 | 3.5 | 8,620 | 12,450 |
| 336 | 20,200 | 3.9 | 9,850 | 14,200 |
| 450 | 23,550 | 4.7 | 11,700 | 16,900 |

It is worth noting that through the application of a strategy of optimizing carrying capacity through high fertilizer N rates, Serge Island Farms Limited, achieved levels of productivity of 15,629 and 13,542 litres per hectare per year, from supplemented Friesian and Jamaica Hope cows, respectively, at corresponding stocking rates of 4.4 and 4.6 cows per hectare (Jennings and Clayton 1995).

## Reducing Utility Costs – Biogas the Sustainable Alternative to Grid Electricity

As a proportion of variable cost, utilities have increased sharply since 2006, reflecting the spiraling in the cost of electricity consequent on the growing instability in world oil prices. The increases in the other major utility, water, has lagged behind electricity, buffered by the high levels of public subsidy on both potable and irrigation water. With less than 15 percent of dairy farms applying irrigation, potable water is by far the more significant form of this utility.

Compared to rates in 2001, electricity costs increased by 271 percent in 2008; residential rates as at January 2010 approaching the $30.00/kWh threshold for the average Jamaican household. Given that more than 95 percent of electricity generated by the Jamaica Public Service Company, is derived from oil, and given the likelihood of continuing medium/long term volatility in the petroleum market, a strategy of on-farm generation of electricity from renewable resources provides an option for sustainably reducing the recurrent cost of electricity on Jamaican dairy farms and narrowing the 166 and 78 percent competitive disadvantage which currently exists with respect to electricity costs, relative to the United States and New Zealand, respectively (Table 2).

Table 6 below, summarizes electricity consumption and costs during 2009, as typified by a sample of eight dairy farms of varying herd sizes. The data, in the main, represent the averages of three monthly billings per farm spread across the calendar year. In every case except the St. Thomas sample which enjoys the lower Rate 40, farms are billed at Rate 20. Consumption includes that utilized at the farmstead.

**Table 6**. Electricity Consumption on Dairy Farms of Varying Sizes in 2009

| Farm No. | Location | Total Cows | Annual Output (Litres) | Energy Consumption (kWh) | | Monthly Current Charge (J$) | Average Cost/kWh (J$) |
|---|---|---|---|---|---|---|---|
| | | | | Monthly | Daily | | |
| 1 | Clarendon | 45 | 41,793 | 624 | 20.8 | 15,003 | 24.05 |
| 2 | Clarendon | 70 | 52,001 | 543 | 18.1 | 14,060 | 25.88 |
| 3 | St. Elizabeth | 95 | 195,029 | 1438 | 47.9 | 33,694 | 23.44 |
| 4 | St. Elizabeth | 35 | 94,648 | 1269 | 42.3 | 32,109 | 25.31 |
| 5 | St. Thomas | 440 | 1,100,050 | 8149 | 271.7 | 201,960 | 24.78 |
| 6 | Manchester | 220 | 514,318 | 3906 | 130.2 | 114,145 | 29.22 |
| 7 | Manchester | 195 | 300,037 | 3378 | 112.6 | 92,898 | 27.50 |
| 8 | St. Ann | 330 | 639,897 | 5152 | 171.7 | 141,618 | 27.48 |
| **Average** | | **179** | **367,222** | **3057** | **101.9** | **79,062** | **25.96** |

Simple linear regression analysis of the data in Table 6 gives the best- fit line as:

$$Y = 0.6626\,X - 9.90$$

$$R^2 = 0.918;\ s.e._{XY} = 27.42:$$

where X = number of cows; Y = Energy consumption (kWh/day); $R^2$ = Coefficient of Determination and $s.e._{XY}$ = standard error of an individual estimate.

The simple linear regression explains 91.8 percent of the total sample variance ($R^2$). For a 100-cow herd it estimates daily electricity consumption at 56.36 kWh.

The indicated output was 10.01 litres per kWh. At an average cost of J$25.96 per kWh (Table 6), an electricity cost per litre of milk of $2.60 is indicated for 2009. Annualized electricity consumption per cow is estimated at 205 kWh.

Options for readily reducing dependence on the grid for electricity supply include photovoltaics, wind and biogas. With respect to photovoltaics, current cost of modules runs at approximately US$3.00 per watt and total installed capacity (inverters, controllers, batteries etc) at close to US$5.00 per watt hour of electricity; wind only marginally lower (Source: Clean Energy Limited – pers. Comm.). The major disadvantage of photovoltaics and wind is the inconsistency of supply on a daily basis which is exacerbated by the absence of a net-metering arrangement with the utility company as well as the prohibitive cost of battery storage which precludes investment in safe buffering capacity.

Biogas is the preferred option on two main premises:

i. The dairy cow is estimated to void, as faeces, between 25 -30 percent of its daily dry matter intake, based upon the digestibility of the ingested food. At a biogas potential equivalent to 0.300 $m^3$ of methane per kg faeces total solids, and an energy value of 6kWh/$m^3$ (Julia Brown, SRC, unpublished data), a Jamaica Hope cow producing 10 litres per day and consuming 13 kg dry matter per day, can potentially generate 7.0 kWh of electricity; outstripping its daily requirement by a factor of 12.5. This offers the real prospect of significant on-farm earnings from sale of energy to the national grid. Further, it is established that Biogas may replace as much as 90 percent of diesel fuel requirement in a diesel-driven electricity generator; diesel oil being critical only for ignition.

ii. The need to mitigate the harmful effect of green house gases from livestock production: The livestock sector, globally, is significantly implicated in the critical problem of climate change and has been estimated to account for 18 percent of anthropogenic greenhouse gas emissions, measured in $CO_2$ equivalents (Steinfeld *et al* 2006). Biogas generation from the local livestock sector is therefore critical in enhancing Jamaica's commitment to mitigation efforts under the Kyoto Protocol, as well as offering possibilities for earnings from Carbon Credits.

## Financial Feasibility of On-farm Electricity Generation from Biogas

Table 7; adapted from Brown (2008- unpublished), relates biogas generator capacity, its related costs and electricity generating capacity; to breeding herd size. The costs relate only to bio-digester construction, inclusive of concrete channels for conveyance of effluent from collecting yard to digester. An inflation-adjustment factor of 1.15 has been applied to the 2008 data provided in the SRC data of Brown *op cit.*

**Table 7**: Relationship of Herd Size to Bio-Digester Size, Cost and Electricity Generation Capacity

| **Breeding Cows** | **Biogas Output** ($m^3$/day) | **Electricity Generation** (kWh/day) | **Electricity Consumption** (kWh/day) | **Required Bio-digester** ($m^3$) | **Estimated Cost** (J$M) |
|---|---|---|---|---|---|
| 50 | 33 | 198 | 23.2 | 100 | 3.3 |
| 100 | 66 | 396 | 56.4 | 150 | 4.4 |
| 150 | 100 | 590 | 89.5 | 200 | 5.4 |
| 200 | 130 | 790 | 122.6 | 250 | 6.3 |
| 250 | 150 | 990 | 155.8 | 300 | 7.1 |
| 350 | 230 | 1380 | 222.0 | 350 | 7.8 |
| 450 | 300 | 1780 | 288.3 | 400 | 8.5 |

An evaluation of the feasibility of business models for intensive dairy production (Miller et al 2008) indicated that *de novo* investments in farm sizes below 250 cows are unlikely to be financially viable even at comparatively high levels of intensification. The salient statistics of the five milk production models evaluated are given in Table 8.

**Table 8**. Financial Performance of Dairy Farm Models

| Coefficient | Traditional 1200-cow | Specialized 1200-cow | Specialized 440-cow | Traditional 250-cow | Specialized 60-cow |
|---|---|---|---|---|---|
| **Mgt system** | Full-grazing + concentrate | Partial zero Grazing – TMR | Partial zero Grazing – TMR | Full-grazing + concentrate | Partial zero Grazing – Purchased TMR |
| **Stocking Rate** (cows/ha) | 5.0 | 6.25 | 6.25 | 5.0 | 6.0 |
| **Yield/cow/day** (L) | 11.0 | 12.0 | 12.0 | 11.0 | 12.0 |
| **Yield/ha/yr** (L) | 8,650 | 23,270 | 23,400 | 11,380 | 22,340 |
| **Unit Cost** (J$/L) | 20.55 | 20.96 | 26.43 | 24.90 | 30.89 |
| **Cap. Invest** (J$M – 2008) | 144.1 | 149.1 | 84.6 | 48.8 | 16.6 |
| **Op. Ex** (J$M) | 79.9 | 93.7 | 43.2 | 21.2 | 6.9 |
| **Net Income** (J$M) | 40.2 | 46.1 | 5.7 | 5.6 | -0.72 |
| **NPV (8%; 14yr)** (J$M) | **+212.9** | **+414.5** | **+62.9** | **+14.7** | **+1.09** |
| **IRR (%)** | **20** | **30** | **16** | **11** | **9** |

A sensitivity analysis indicated that only farms above 250 cows are sufficiently financially robust to retain viability in the face of a ten-percent increase in operational costs or reduction in farm-gate price of a similar magnitude.

In order to evaluate the financial feasibility of the Biogas option, the original analysis was updated for inflation and changes in exchange rate. It was then amended to include the additional investment in biogas generating capacity and continuous power generation using a prime diesel-electric generator set, the consequential savings on the purchase of electricity, the potential revenue from sale of surplus electricity to the grid and the incremental benefit to Net Present Value (NPV) and Internal Rate of Return (IRR). A 15 percent adjustment to all operating expenses was made to account for inflation and the average 2009 farm-gate price of $45.33 substituted. All capital costs were adjusted for exchange rate variation since 2007 (J$70.62: US$1 to 89.76:1). The assumptions are:

1. Biogas will substitute 90 percent of diesel fuel consumption for stand-by electricity supply;
2. Surplus electricity will be sold to the grid at $15.11 per kWh, the average ‘Fuel and IPP charge’ billed by JPSCo for the nine-month period ending February 2010;
3. Projected average cost of electricity in 2010 - $30.00/kWh;

4. Biogas digester size and electricity generation capacity on-farm is equivalent to three times daily power requirement,
5. Diesel fuel consumption of diesel-electric generator set – 0.35L/kWh
6. Biogas replaces 90 percent of requirement for diesel fuel at current cost of $92.00 per litre.

Table 9 summarizes estimated incremental capital costs, savings on electricity and diesel fuel and potential revenue from surplus electricity for each of the five farm models described in Table 8.

**Table 9**: Benefit: Cost Analysis of Biogas/Electricity Option

| | **Traditional 1200-cow** | **Specialized 1200-cow** | **Specialized 440-cow** | **Traditional 250-cow** | **Specialized 60-cow** |
|---|---|---|---|---|---|
| Electricity Consumption (kWh/day) | 785.2 | 785.2 | 281.6 | 155.8 | 29.9 |
| Required Bio-digester ($m^3$) | 750 | 750 | 320 | 240 | 45 |
| Est. Bio-digester Cost (J$M) | 13.26 | 13.26 | 7.13 | 6.05 | 1.5 |
| Differential Gen Set cost (J$M) | 1.277 | 1.277 | 0.656 | 0.350 | 0.139 |
| Differential depreciation – Biogas (J$M/yr) | 59.0 | 514 | 272 | 216 | -123.5 |
| Annual Savings on Electricity (J$M/yr) | 8.6 | 8.6 | 3.08 | 1.71 | 0.33 |
| Annual Revenue from Electricity Sales (J$M) | 8.70 | 8.70 | 3.11 | 1.72 | 0.33 |
| Saving on Op. expenses – Incl. depreciation (%) | 5.1 | 2.7 | 1.9 | 1.4 | -1.9 |
| Unit Cost of production – Grid dependent (J$/L) | 25.76 | 30.51 | 30.26 | 33.76 | 37.38 |
| | 28.03[1] | - | - | 35.93[1] | - |
| Unit Cost of production – Biogas user (J$/L) | 24.46 | 29.67 | 29.66 | 33.30 | 38.08 |
| | 26.73[1] | - | - | 35.46[1] | - |
| **Incremental NPV (Biogas) (J$M)** | **63.3** | **95.2** | **28.9** | **10.4** | **-0.270** |
| **IRR % (Biogas)** | **34 (31)[1]** | **33** | **30** | **21 (18)[1]** | **11** |
| **Change in IRR (% units)** | **+2** | **+3** | **+2** | **+1** | **0** |

1. Adjusted for 2009 cost of dairy ration @ $29,400/ton

Except for the 60-cow model, the Biogas option resulted in consistent advantages in unit production cost, Net present value and internal rate of return. The original 60-cow model excluded investment in emergency electricity generation. This assumption was retained in the current analysis. The inescapable investment in prime generating capacity in the Biogas option, would have added substantially to depreciation costs thus inflating unit cost of producing milk.

The substantially improved financial performance relative to the original 2007 analysis, might be attributed to the movement in farm gate price of milk between 2007 and 2009; from $28.33 to $46.33 per litre (63%) juxtaposed against the assumption of a concomitant 15 percent increase in operating expenses. This assumption might also explain the reversal in relative performance of the 1200 cow models (Refer to Table 8), given that the cost of concentrate feed grew well in excess of the 15 percent assumed. This would have favoured the traditional model in which proprietary concentrate feed is the supplement to grazing versus the Total Mixed Ration used in the Specialized model; based upon on-farm mixing of ingredients. When adjusted for the actual price of dairy concentrate, cost per litre increases by 8.8 and 6.4 percent respectively on the grid dependent traditional options, with associated declines of 3 percentage points in IRR thus restoring the financial and operating advantages of the specialized dairy models.

## References


**Anon. 2009** *Dairy Industry Demonstrates how Cheap, Pliable Labor and Technological Innovation are at Odds.* http://anepigone.blogspot.com/2009/07/dairy-industry-demonstrates-how-cheap.html

**Brown, J. 2008** *Biogas /Anaerobic Technology*. PPT Presentation to JDDB/Dairy Herd Services/SRC Awareness Building Workshop. Grove Place, Manchester, November 04, 2008.

**Brown, S. 2008** *The Impact of the CWT Programme on the US Dairy Industry*. 2008 CWT Town Hall Meeting. http://www.nmpf.org/files/file/2008CWT Town Hall Meeting presentation.pdf

**Fontanelli, R.S., Sollenberger, L.E. and Staples, C.R. 2001** *Dairy Cow Performance on Pasture-Based Feeding Systems and in Confinement*. 19th International Grassland Congress, Sao Paulo, Brazil, Feb. 11-21, 2001. www.internationalgrasslands.org/publications/pdfs/id2231.pdf

**Ffrench, D.L., Miller, R.C. and Jennings, P.G. 2009** *Cost of Producing Milk in Jamaica in 2008.* Presentation to JDDB Farmers Workshop, Bodles Agricultural Station, October 21, 2009 www.jddb.gov.jm

**Gould, B. 2010** *Costs of Major Inputs. National Average Dairy Feed Costs*. From: *Understanding Dairy Markets*. http://futureaae.wisc.edu/data/monthly_values/by_area/3002?area=US

**Holness, J.A., Fielding, W. and Wellington, K.E. 1994** *Characteristics of Jamaica Hope Lactation Curves in the ALCAN Herd, 1990-1991*. **JAGRIST 5** (2): 18-26.

**Jago, J., Ohnstad, I. and Reinemann, D.J. 2007** *Labour Practices and Technology Adoption on New Zealand Dairy Farms*. Paper presented at 6th International ASABE Dairy Housing Conference, 16-18 June 2007. http://www.uwex.edu/uwmril/pdf/Robotic Milking/07ASABE Jago New Zealand dairy.pdf

**Jamaica Dairy Development Board 2008** *Dairy Facts and Figures 2007-2008*. www.jddb.gov.jm

**Jamaica Public Service Company Limited**. Annual Reports 2004 to 2008. www.jpsco.com

**Jennings, P.G. 1992** *A New Approach to Pasture Management for Profitable Milk Production*. In: *A Guide to the Strategic Feeding of Dairy Cattle.* A **JAGRIST** Supplement. P.G. Jennings and L.E. McLaren (Eds.) November 1992.

**Jennings, P.G. 2005** *Managing Dairy Cattle for International Competitiveness in Unfavourable Economic Environments: A Strategy for Developing Sustainable Competitive Advantage in Milk Production in Jamaica*. In: Jennings, P.G. *Livestock Production in Unfavourable Economic Environments: Strategies for Attaining Sustained Competitive Advantage*, BOOKSURGE LLC (Pub.) 2006. ISBN 1-4196-4052-6. www.amazon.com

**Jennings, P.G. 2007** *A 20/20 Perspective on the Jamaican Cattle Industry*. www.jddb.gov.jm

**Jennings, P.G. 2008** *Recovering from the Trauma of Liberalization: The Jamaican Dairy Industry as Case Study*. Presented at International Congress on Tropical Agriculture, UWI, St. Augustine, Trinidad and Tobago, Nov. 30 – Dec. 05, 2008. Available at www.jddb.gov.jm

**Jennings, P.G. and Clayton, D.M. 1995** *Comparative Performance of Jamaica Hope and Friesian Cattle under Intensive Grazing Management. The Serge Island Experience*. **JAGRIST 7**: 23-25.

**Jennings, P.G. and Holmes, W.** (1985) *Supplementary Feeding to Dairy Cows Grazing Tropical Pasture: A Review*. **Tropical Agriculture (Trinidad) 62** (4): 266-272

**Jennings, P.G., Miller. R.C., Ffrench, D.L and Duffus, B.G. 2009** *Revitalization of the Jamaican Dairy Sector: Strategies for Financing New Investments in Dairying*. Presented at Conference on 'Food Security and Agricultural Development in the Americas', UWI, Mona campus, Kingston, Jamaica, July 28 – 30, 2009. Available at www.jddb.gov.jm

**Kingston, C. 2005** *An Analysis of the Economic Advantages to New Zealand Dairy Farmers of Extensive Electronic Monitoring of Dairy Cows*. http://www.rezare.co.nz/ifms/Situation Analysis/NZTE 5470114 1 DairyCowElectricMonitoring.pdf

**Kirton, C. and Witter, M. 2006** *Liberalization of the Jamaican Economy and the Impact of Import Surges on Dairy, Poultry and Onion Production.* Draft report of study conducted under the aegis of FAO project: The Extent and Impact of Import Surges in Developing Countries. June 2006.

**McCall, D.G and Clarke, D.A. 1999** *Optimized Dairy Grazing Systems in the Northeast United States and New Zealand. II. System Analysis*. **J. Dairy Sci. 82**: 1808-1816

**Michael Bluejay Inc. 2009** *How Much Electricity Costs and how They Charge You.* http://michaelbluejay.com/electricity/cost.html

**Miller, R.C., Ffrench, D.L., Duffus, B.G. and Jennings, P.G. 2008** *Revitalization of the Jamaican Dairy Sector: Evaluation of the Feasibility of Business Models for Intensive Dairy Production*. Paper presented at 19th Annual conference, Jamaican Society for Agricultural Sciences, Bodles Agricultural Station, Feb 20, 2008. Available at www.jddb.gov.jm

**Miller, R.C., Ffrench, D.L. and Jennings, P.G. 2009** *Tracking Milk Production Efficiencies on Jamaican Dairy Farms II.* Presentation to JDDB Farmers Workshop, Bodles Agricultural Station, October 21, 2009. Available at www.jddb.gov.jm

**N.Z. Agritech Inc. 2008** *Excellence: Pasture-Based Dairying the New Zealand Way*. www.agritech.org.nz/dairy.shtml

**Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, V. and de Haan, C. 2006** *Livestock's Long Shadow: Environmental Issues and Options.* FAO, Rome 2006.

**USDA – Agricultural Marketing Service 2009**. *International Market News and Prices*. www.ams.usda.gov