Title: AN ENERGY SYSTEM

Abstract: Energy systems and associated methods are described for use in processing a raw material into a chilled processed product. Elements of the system and method include a biodigester; a combined heat and electric power generator; a refrigeration plant; and at least one heat exchanger. In an alternative embodiment the combined heat and power generator and refrigeration plant are replaced with an absorption refrigeration plant. Waste from processing is used to run the biodigester which in turn supplies fuel for the generator or absorption refrigeration plant. The refrigeration plant provides refrigerant, which via a thermal ice store and heat exchange step chills the processed product. Alternatively the refrigerant is used to make ice and this is used directly to chill the processed product. The systems and methods have the advantage of minimising processing energy use and also minimising processing waste.
AN ENERGY SYSTEM

TECHNICAL FIELD

The invention relates to energy systems and associated methods to minimise imported energy requirements. More specifically, the invention relates to systems and methods for minimising imported energy requirements in processing a product that requires chilling and which also has biodegradable waste products.

BACKGROUND ART

Minimising energy use is becoming of greater importance, especially in respect of where fossil fuels are used to generate energy. Also of greater importance is the minimisation of waste, particularly in production processes.

Using the dairy industry as an example, many network companies are experiencing a growing electrical load on rural networks due to the rapid expansion of dairying in New Zealand and overseas. Although the irrigation load can be the most significant demand increase in many instances, the refrigeration load that comes on the system at discernable times each day, can contribute to undesirable system peaks. Load levelling using ice-bank storage, offers a significant reduction in electrical demand. Ice banks also have other benefits to the dairy industry, such as reserve cooling capacity if the network supply fails.

The disposal of the manure from cows on a farm is also an increasing problem.

Similar chilling and disposal problems also exist for other processing operations such as meat or fish processing, and wine production. These processes all
require significant amounts of energy to chill processed products and can produce significant volumes of waste material.

It is an object of the present invention to provide a system which utilises a waste stream from a processing operation, optionally generates electricity and provides on site chilling of a processed product.

It is a further object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.
DISCLOSURE OF INVENTION

For the purposes of this description, the term 'processing' refers to any production process that processes an at least partly biodegradable raw material into a product for further sale and/or consumption.

The term 'raw material' preferably refers to largely biodegradable materials in an unprocessed form although it should be appreciated that semi-processed materials may also be incorporated within this definition.

The term 'processed product' refers to a material, preferably at least partly biodegradable that has been altered from its natural or normal form.

According to one aspect of the present invention there is provided an energy system for use in processing a raw material into a chilled processed product which includes:

- a biodigester;

- a combined heat and electrical power generating device;

- a refrigeration plant;

- at least one heat exchanger; and,

- wherein biodegradable waste from processing is digested in the biodigester to form biogas which is used to fuel the heat and electrical power generating device; and,

- hot water generated from the heat and electrical power generating device is used as an energy source for the biodigester; and,
power generated from the heat and electrical power generating device is used to run a refrigeration plant containing refrigerant; and,

cold refrigerant from the refrigeration plant is used to generate ice which is used directly to lower the processed product temperature; or

cold refrigerant from the refrigeration plant is used to generate chilled water which is used to lower the processed product temperature in the heat exchanger or exchangers; and,

characterised in that the system chills the processed product to a point at which the product is shelf stable.

Preferably, the combined heat and electrical power generating device is selected from the group including one or more of the following: a Stirling engine; an internal combustion engine; a micro gas turbine; a fuel cell; or other devices and combinations thereof. More preferably, the electrical power generating device is a Stirling engine.

Preferably, the refrigeration plant described above uses standard vapour compression refrigeration.

Preferably, hot water produced from the combined heat and electrical power generating device is also used as an energy source for the biodigester. Optionally, the hot water may also be used as a utility hot water source in raw material processing.

According to a further aspect of the present invention there is provided an energy system for use in processing a raw material into a chilled processed product which includes:

a biodigester;
an absorption refrigeration plant;

at least one heat exchanger; and,

wherein biodegradable waste from processing is digested in the
biodigester to form biogas which is used to fuel the absorption refrigeration plant;

and,

cold refrigerant from the refrigeration plant is used to generate ice which
is used directly to lower the processed product temperature; or

cold refrigerant from the refrigeration plant is used to generate chilled
water which is used to lower the processed product temperature in the heat
exchanger or exchangers; and,

characterised in that the system chills the processed product to a point at
which the product is shelf stable.

In one preferred embodiment, the energy system is used on a dairy farm where
the raw material is milk which is chilled and the biodegradable waste is cow
manure.

In an alternative embodiment, the energy system is used in a fish processing
operation where the raw material is raw fish or fish pieces which are processed
into fish product such as fillets and then chilled and the biodegradable waste is
skins, heads, fins, entrails, bones etc.

In a further embodiment, the energy system is used in a winery where the raw
material is grapes prior to fermentation and the material to be chilled is juice
(either before fermentation, during fermentation or after fermentation) and the
biodegradable waste is grape skins, stalks, pips, yeast waste, must etc.
It should be appreciated by those skilled in the art that the above embodiments should not be seen as limiting as other processes may also be used without departing from the scope of the invention.

Preferably, the biodigester uses standard anaerobic digestion to breakdown the biodegradable waste stream and in the process, produce biogas. Preferably, the biodigester uses microbes selected from: mesophillic microbes; thermophillic microbes; and combinations thereof. Optionally, the biogas is separated to concentrate the methane content.

Preferably, the biodigester temperature is maintained, via heat exchange using hot water, at a temperature of between 15°C and 70°C depending on the microbes used. Most preferably, the biodigester incorporates use of polybutylene or similar in-ground flexible bags or an enclosed lagoon or pond.

Optionally, additional biodegradable waste streams can be added to the biodigester to generate additional biogas as required to run the energy system.

Preferably, the refrigeration plants described above use air or water cooling to remove heat from the refrigeration plant. This should not be seen as limiting as a variety of other heat removal methods may be used in accordance with the present invention. However, for environmental and cost effectiveness, water or air provide favourable methods. Most preferably water is used. Optionally, heated water from the refrigeration plant is used as an additional energy source for the biodigester and/or the hot water utility source.

Most preferably, refrigerant from the refrigeration plant is used to produce ice. The ice formed is then used to chill water by passing water over the ice.

Optionally, the ice formed may also be used in packaging a process material.
In preferred embodiments, ice is produced between and during product chilling operations. By way of example, the ice is replenished in a dairy farming operation during the 10 to 12 hours between milk collection runs. It should be appreciated by those skilled in the art that the amount of ice required will depend on a number of factors including but not limited to:

- The amount of processed product to be chilled;
- The temperature to which the product must be chilled;
- The size of the product chilling heat exchanger;
- The time within which the processed product must be chilled; and,
- The amount of water used as a pre-coolant if this is used.

Preferably, the ice is formed as an 'ice bank', equivalent to a thermal ice storage tank that refrigeration pipes or plates pass through (conveying refrigerant), and the water in the ice storage tank at least partially freezes on the pipe or plate surfaces.

Optionally, ice is removed from the pipe or plate surface by reversing the refrigeration cycle. This may be done for example to produce loose ice for packaging.

Preferably, only one heat exchanger is used to lower the processed product temperature. Preferably, this heat exchanger is a plate heat exchanger.

In one option, a recycle loop circulates processed product in a loop around the heat exchanger should more than one pass of cooling be required.

In an alternative embodiment, an additional heat exchange step is used before the chilled water-fed heat exchanger or exchangers. This additional heat
exchanger is used to reduce the processed material temperature to ambient
temperature levels. For example, the additional heat exchanger uses cold
ground water from a cold ground water supply source to bring temperature down
to cold ground water source temperatures. For a dairy farm operation this may
assist considerably in reducing the duty required from the chilled water fed heat
exchanger or exchangers as the initial milk temperature on collection is body
temperature or approximately 37°C.

In a further option, chilled water from the ice bank may be used to further chill /
maintain the low temperature of a storage container or tank for the processed
product.

In a further option, refrigerant from the refrigeration plant may be used to further
chill / maintain the temperature of a storage container or tank for the processed
product.

In a further option, the hot water temperature is also maintained or elevated
using other energy inputs selected from: mains power; a solar collector or
collectors; a fuel cell or cells; and combinations thereof. Preferably, both a hot
water solar collector and a mains electricity supply are available for use when
required.

Optionally, mains electricity may also be used to supplement or completely run
the refrigeration plant.

According to a further aspect of the present invention there is provided a method
of operating an energy system for use in processing a raw material into a chilled
processed product wherein the energy system includes:

  a biodigester;
a combined heat and power generating device;

a refrigeration plant;

at least one heat exchanger; and,

wherein biodegradable waste from processing is digested in the

biodigester to form biogas which is used to fuel the heat and electrical power
generating device; and,

hot water generated from the heat and electrical power generating device
is used as an energy source for the biodigester; and,

power generated from the heat and electrical power generating device is
used to run a refrigeration plant containing refrigerant; and,

cold refrigerant from the refrigeration plant is used to generate ice which
is used directly to lower the processed product temperature; or

cold refrigerant from the refrigeration plant is used to produce chilled
water which is used to lower the processed product temperature in the heat
exchanger or exchangers; and

characterised in that the method results in a processed product chilled to
a point at which the product is shelf stable.

According to a yet further aspect of the present invention there is provided a
method of operating an energy system for use in processing a raw material into a
chilled processed product wherein the energy system includes:

a biodigester;

an absorption refrigeration plant;
at least one heat exchanger; and,

wherein biodegradable waste from processing is digested in the biodigester to form biogas which is used to fuel the absorption refrigeration plant; and,

cold refrigerant from the refrigeration plant is used to generate ice which is used directly to lower the processed product temperature; or

cold refrigerant from the refrigeration plant is used to generate chilled water which is used to lower the processed product temperature in the heat exchanger or exchangers; and

classified in that the method results in a processed product chilled to a point at which the product is shelf stable.

It should be appreciated by those skilled in the art that, from the above description there is provided an energy system and method that provides a practical way to encourage load levelling to benefit network and processing companies alike. The system and method uses sustainable fuel sources wherever possible therefore making the system appealing from an environmental point of view. The system and method as a whole is an integrated sustainable energy system with network peak load shaving ability. The system and method may also enable a user to operate independently from the national grid and is suitable for use in remote areas or locations without an electricity supply network.
BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the ensuing description which is given by way of example only and with reference to the accompanying drawings in which:

5 Figure 1 shows a process flow diagram of a dairy farm embodiment of the present invention;

Figure 2 shows an alternative dairy farm process flow diagram embodiment of the present invention;

Figure 3 shows a process flow diagram of a fish processing embodiment of the present invention;

Figure 4 shows a process flow diagram of an alternative fish processing embodiment; and,

Figure 5 shows a process flow diagram of a wine processing embodiment of the present invention.

BEST MODES FOR CARRYING OUT THE INVENTION

The energy system of the present invention is now described with reference to preferred embodiments known to the inventor as shown in the process flow diagrams of Figures 1 to 5.
Example 1 - Dairy Farming

Figure 1, shows a process flow diagram for one preferred energy system of the present invention. The system is used on a dairy farm to assist in energy management surrounding collection of milk. Dairy cows are cycled in 100 and out 101 of a milking shed 1. Milk 102 collected from cows 100 in the milking shed 1 is transported to a milk storage silo 7 via a heat exchanger 6 using known transport methods such as via gravity or by use of a pump (not shown). The milk 102 from the milking shed 1 is chilled through the heat exchanger 6 and the chilled milk 103 is then held in the silo 7 until transfer from the dairy farm 10.

Important characteristics of the process is to chill the milk 102 from 37°C when collected to below 7°C 103 within a time period of approximately 2 hours or less in order to prevent bacterial infestation of the milk 102,103,104. To achieve this temperature decrease the collected milk 102 must be chilled, requiring an energy input.

A number of temperatures, energy requirements and other details are provided below using a standard twice daily milking regime and based on a herd of approximately 200 cows 100,101. The requirements for other sizes of herd can be obtained by simple proportion. Under normal circumstances a farm with 200 cows 100,101 producing 2000L milk 102 per milking requires chilling of: 2000 x 30 x 4200/(2 x 3600000) = 35kW. This assumes that the specific heat of milk 4.2 kJoules/Litre-Kelvin. In an area with many dairy farms, or even with relatively few but larger dairy farms, this twice daily load increase in power can place a significant peak demand on the mains power distribution network.

The aim of this energy system is to minimise the amount of electrical energy sourced from the network which is required to chill the milk 102,103,104.
As shown in Figure 1, biodegradable waste 105 from the milking shed 1 primarily being cow manure is collected and digested in a biodigester 2. The digestion process is anaerobic and produces biogas 106 as well as a second residual waste stream 107. Residual waste 107 can be distributed back onto the land as a fertiliser supplement to encourage grass growth. Biodigesters are commonly used for treatment of effluent such as human sewerage. The biodigester 2 is heated using hot water 121,122 from a hot water storage cylinder 8.

The biogas 106 is collected and used to run a combined heat and power generator 3. It is the inventor's experience that a Stirling engine may be one option for use as the combined heat and power generator 3 although other options which may also be used include an internal combustion engine, a micro gas turbine, or a fuel cell or cells. By way of example, in one embodiment envisaged by the inventor, a Stirling engine is used as the combined heat and power generator 3 with an output of 1.1kW AC (electrical) and 8.5 kW (thermal).

Heat produced from the generator 3 is used to heat water 108,109 which circulates in a loop between the generator 3 and a hot water tank 8. It is envisaged that when the system as a whole reaches steady state, the water 109 temperature into the generator 3 will be approximately 50°C and the outlet water 108 temperature from the generator 3 will be approximately 75°C. It should be appreciated that these temperatures are given by way of example only and will vary depending on the size of the generator 3 used and amount of hot water 108,109 required for the system as a whole.

Electricity 110 produced from the generator 3 is then used to operate a refrigeration plant 4 running using a standard vapour compression refrigeration cycle with air or water as the coolant. Optionally, where water is used as the coolant, the warmed water is circulated to the hot water tank 8.
In one embodiment envisaged by the applicant, the refrigeration plant 4 has an output of 3.7kW (thermal) and requires an input of 2.2 kW (electrical). The cold refrigerant produced 111 is used to form ice in an ice bank 5 through which heat is exchanged to chill water 115,117 running between at least one heat exchanger 6 which is used to chill the milk 102,103. Warm water from the heat exchanger or exchangers 116, 118 is returned to the ice bank 5. In the embodiment envisaged by the inventor, the amount of ice required in the ice bank 5 is estimated as follows:

(assume the latent heat of fusion of ice is 320 kJ/kg)

(assume the specific heat of milk is 4.2 kJ/LK)

then the cooling requirement is: $2000 \times 30 \times 4.2\text{KJ} = 2000 \times 30 \times 4.2/320 = 787\text{kg (ice).}$

An alternative is to use an additional heat exchanger (not shown) to lower the collected milk 102 temperature (and therefore energy load) from collection at 37°C to ground water temperature levels using ordinary cold tap water (not shown) exchanging heat with the collected milk 102 before entry into at least one further heat exchanger 6.

For this two-stage cooling process the ice requirement per milking is about 60% of the full load, or about 472 kg.

The ice bank is built up over a time period of approximately 10 to 12 hours or between milkings ('the ice making period').

The refrigeration plant 4 runs continuously at a capacity of 6 kW (cooling) or about 2 kW (electrical). This load can be met by a Stirling engine 3 running on
biogas 106. LPG or other gas supply 119 can be used as a back-up source in event of the digester 2 failing or making insufficient biogas 3.

The milk 102 is chilled in the heat exchanger 6 and ice in the ice bank 5 is melted to produce water 115 at 2°C (or cooler if a lowered freezing point fluid is used) and via the heat exchanger 6, the milk 102 is chilled to 7°C or less, and in doing so, the water 116 temperature rises by approximately 20°C. The "warm water" 116 is recycled to the ice bank 5 where it is chilled to 2°C 115 by melting more ice in the ice bank 5. The cycle begins again after milk 102 chilling is completed by the refrigeration plant 4 producing more ice in the ice bank 5 (the ice making period) for use in the next milk chilling operation.

Optionally, chilled water 117, 118 is also used to maintain and/or further chill the milk 103 after heat exchange 6 by heat transfer in a storage silo 7. Refrigerant 113, 114 from the refrigeration plant 4 may also be used to maintain and/or chill milk 103 in the storage silo 7 after heat exchange 6.

The system energy requirements may be supplemented by further energy inputs such as by mains electricity 120 directed to maintain and/or heat further hot water in the hot water tank 8. The mains power supply 120 may also be used to run or supplement the energy requirements to generate and/or maintain ice in the ice bank 5 via the refrigeration plant 4. Other energy sources are also envisaged such as a solar hot water collector 9 to heat and/or maintain the temperature of hot water 123, 124 in the hot water tank 8. Other external energy supply options may also be used such as fuel cells, wind generators and the like.

A further option is to use hot water 125 as a utility from the hot water storage cylinder 8 in the milking shed 1 such as for cleaning and other duties requiring hot water.
Example 2 - Absorption Refrigeration Cycle Plant

As shown in Figure 2, the combined heat and power generator 3 and refrigeration plant 4 of Figure 1 may be replaced by an absorption refrigeration cycle plant 20.

The plant runs on biogas 106 generated from the biodigester 2 which may also be supplemented by LPG 119 or by mains power 120.

The remainder of the operation operates in a similar manner to that described in Example 1 above.

Example 3 – Fish Processing

As shown in Figures 3 and 4, the system may also be applied to fish processing. The raw material is whole unprocessed fish 100 which are processed in a factory 1. Non-biodegradable waste leaves the factory 101. As shown in Figure 3, the processed product is fish fillets 102 which are then chilled via heat exchanger 6 and held in a storage chiller 7 before eventual transport 10 off site. In an alternative process as shown in Figure 4, the fish fillets 102 are chilled by direct application of ice 126 generated by the ice forming plant 5A.

Waste stream 105 includes all biodegradable fish waste from the processing operation such as skins, heads, entrails, bones etc.

The remainder of the operation operates in a similar manner to that described in Examples 1 and 2 above.
Example 4 – Wine Production

As shown in Figure 5, the system may also be applied to wine production. The harvested grapes 100 enter the winery 1 and are pressed and filtered to obtain a pressed juice 102. The pressed juice 102 is then fermented in heat exchanger 6 and the resulting fermented juice 103 is then transported to a storage vessel 7. Non-biodegradable waste leaves the winery 101. Waste from the winery 1 such as stalks and skins and must (not shown) left after fermentation in the heat exchanger 6 form the basis of the waste stream 105 used as raw material for the digester 2.

The remainder of the operation operates in a similar manner to that described in Examples 1 and 2 above.

It should be appreciated from the above descriptions that the system can be applied to a variety of processes to minimise energy use through the utilisation of a biodegradable waste. Furthermore, the process is also environmentally friendly as waste from processing is minimised and transformed into a biofertiliser.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.
WHAT I CLAIM IS:

1. An energy system for use in processing a raw material into a chilled processed product which includes:
   
a biodigester;
   
a combined heat and electrical power generating device;
   
a refrigeration plant;
   
at least one heat exchanger; and,
   
wherein biodegradable waste from processing is digested in the biodigester to form biogas which is used to fuel the heat and electrical power generating device; and,
   
hot water generated from the heat and electrical power generating device is used as an energy source for the biodigester; and,
   
power generated from the heat and electrical power generated device is used to run a refrigeration plant producing refrigerant; and,
   
cold refrigerant from the refrigeration plant is used to generate ice which is used directly to lower the processed product temperature; or
   
cold refrigerant from the refrigeration plant is used to generate chilled water which is used to lower the processed product temperature in the heat exchanger or exchangers; and
   
characterised in that the system chills the processed product to a point at which the product is shelf stable.
2. The energy system as claimed in claim 1 wherein the combined heat and
generator is a Stirling engine.

3. The energy system as claimed in claim 1 or claim 2 wherein the
refrigeration plant uses vapour compression refrigeration.

4. The energy system as claimed in any of the above claims wherein hot
water produced by the generator is used to heat the biodigester.

5. The energy system as claimed in any of the above claims wherein hot
water produced from the combined heat and power generator is used as a utility
hot water source in raw material processing.

6. An energy system for use in processing a raw material into a chilled
processed product which includes:

   a biodigester;

   an absorption refrigeration plant;

   at least one heat exchanger; and,

   wherein biodegradable waste from processing is digested in the
   biodigester to form biogas which is used to fuel the absorption refrigeration plant;
   and,

   cold refrigerant from the refrigeration plant is used to generate ice which
   is used directly to lower the processed product temperature; or

   cold refrigerant from the refrigeration plant is used to produce chilled
   water which is used to lower the processed product temperature; and,
characterised in that the system chills the processed product to a point at which the product is shelf stable.

7. The energy system as claimed in any of the above claims wherein the system is used on a dairy farm where the raw material is milk.

8. The energy system as claimed in claim 7 wherein the biodegradable waste is cow manure.

9. The energy system as claimed in any of claims 1 to 6 wherein the system is used in a fish processing operation where the raw material is raw fish or fish pieces which are processed into a processed product.

10. The energy system as claimed in claim 9 wherein the biodegradable waste is selected from: skins, heads, fins, entrails, bones, and combinations thereof.

11. The energy system as claimed in any of claims 1 to 6 wherein the system is used in a winery where the raw material is grapes.

12. The energy system as claimed in claim 11 wherein the biodegradable waste is selected from: grape skins, stalks, pips, yeast waste, and combinations thereof.

13. The energy system as claimed in any of the above claims wherein the biodigester uses anaerobic digestion to breakdown the biodegradable waste stream and in the process, produce biogas.

14. The energy system as claimed in any of the above claims wherein the biogas is separated to concentrate the methane content.
15. The energy system as claimed in any of the above claims wherein the biodigester temperature is maintained indirectly via heat exchange using hot water at a temperature of between 15 and 70°C.

16. The energy system as claimed in any of the above claims wherein additional biodegradable waste streams are added to the biodigester.

17. The energy system as claimed in any of the above claims wherein the refrigeration plant uses air to remove heat from the refrigeration plant.

18. The energy system as claimed in any of the above claims wherein the refrigeration plant uses water to remove heat from the refrigeration plant.

19. The energy system as claimed in any of the above claims wherein refrigerant from the refrigeration plant is used to produce ice in an ice bank.

20. The energy system as claimed in claim 19 wherein water is passed through the ice bank and into at least one heat exchanger for chilling processed product.

21. The energy system as claimed in claim 19 wherein water is frozen to ice and used directly to chill processed product.

22. The energy system as claimed in any of the above claims wherein processed product is recycled around the heat exchanger or exchangers.

23. The energy system as claimed in any of the above claims wherein an additional heat exchange step is included to reduce the processed material temperature.
24. The energy system as claimed in claim 23 wherein the additional heat exchange step uses water from a ground water supply as the coolant to reduce the product temperature to ground water supply temperature levels.

25. The energy system as claimed in any of the above claims wherein the chilled water is used to chill the temperature of the processed product in a storage container.

26. The energy system as claimed in any of the above claims wherein refrigerant from the refrigeration plant is used to chill the temperature of processed product in a storage container.

27. The energy system as claimed in any of the above claims wherein the hot water temperature is maintained or elevated using a solar collector and mains power.

28. The energy system as claimed in any of the above claims wherein mains power is used to run the refrigeration plant.

29. The energy system as claimed in any of the above claims wherein supplementary gas is used to augment or replace the biogas.

30. A method of operating an energy system for use in processing a raw material into a chilled processed product wherein the energy system includes:

   a biodigester;

   a combined heat and power generating device;

   a refrigeration plant;

   at least one heat exchanger; and,
wherein biodegradable waste from processing is digested in the
biodigester to form biogas which is used to fuel the heat and electrical power
generating device; and,

hot water generated from the heat and electrical power generating device
is used as an energy source for the biodigester; and,

power generated from the heat and electrical power generating device is
used to run a refrigeration plant containing refrigerant; and,

cold refrigerant from the refrigeration plant is used to generate ice which
is used directly to lower the processed product temperature; or

cold refrigerant from the refrigeration plant is used to generate chilled
water which is used to lower the processed product temperature in the heat
exchanger or exchangers; and,

classified in that the method results in a processed product chilled to
a point at which the product is shelf stable.

31. The method as claimed in claim 30 wherein the combined heat and power
generator is a Stirling engine.

32. The method as claimed in claim 30 or claim 31 wherein the refrigeration
plant uses vapour compression refrigeration.

33. The method as claimed in any of claims 30 to 32 wherein hot water
produced by the generator is used indirectly to heat the biodigester.

34. The method as claimed in any of claims 30 to 33 wherein hot water
produced from the combined heat and power generator is used as a utility hot
water source.
35. A method of operating an energy system for use in processing a raw material into a chilled processed product wherein the energy system includes:

   a biodigester;

   an absorption refrigeration plant;

   at least one heat exchanger; and,

   wherein biodegradable waste from processing is digested in the biodigester to form biogas which is used to fuel the absorption refrigeration plant; and,

   cold refrigerant from the refrigeration plant is used to generate ice which is used directly to lower the processed product temperature; or

   cold refrigerant from the refrigeration plant is used to generate chilled water which is used to lower the processed product temperature in the heat exchanger or exchangers; and,

   characterised in that the method results in a processed product chilled to a point at which the product is shelf stable.

36. The method as claimed in any of claims 30 to 35 wherein the system is used on a dairy farm where the raw material is milk.

37. The method as claimed in claim 36 wherein the biodegradable waste is cow manure.

38. The method as claimed in any of claims 30 to 35 wherein the system is used in a fish processing operation where the raw material is raw fish or fish pieces which are processed into a processed product.
39. The method as claimed in claim 38 wherein the biodegradable waste is selected from: skins, heads, fins, entrails, bones, and combinations thereof.

40. The method as claimed in any of claims 30 to 35 wherein the system is used in a winery where the raw material is grapes.

41. The method as claimed in claim 40 wherein the biodegradable waste is selected from: grape skins, stalks, pips, yeast waste, and combinations thereof.

42. The method as claimed in any of claims 30 to 41 wherein the biodigester uses anaerobic digestion to break down the biodegradable waste stream and in the process, produce biogas.

43. The method as claimed in any of claims 30 to 42 wherein the biogas is separated to concentrate the methane content.

44. The method as claimed in any of claims 30 to 43 wherein the biodigester temperature is maintained indirectly via heat exchange using hot water at a temperature of between 15°C and 70°C.

45. The method as claimed in any of claims 30 to 44 wherein additional biodegradable waste streams are added to the biodigester.

46. The method as claimed in any of claims 30 to 45 wherein the refrigeration plant uses air to remove heat from the refrigeration plant.

47. The method as claimed in any of claims 30 to 46 wherein the refrigeration plant uses water to remove heat from the refrigeration plant and this is stored in a hot water storage cylinder.

48. The method as claimed in any of claims 30 to 47 wherein refrigerant from the refrigeration plant is used to produce ice in an ice bank.
49. The method as claimed in claim 48 wherein water is passed through the ice bank and into at least one heat exchanger to for chilling processed product.

50. The method as claimed in claims 30 to 48 wherein ice is used directly for chilling processed product.

51. The method as claimed in any of claims 30 to 49 wherein processed product is recycled around the heat exchanger or exchangers.

52. The method as claimed in any of claims 30 to 49 wherein an additional heat exchange step is included to reduce the processed material temperature.

53. The method as claimed in claim 52 wherein the additional heat exchange step uses water from a ground water supply as the coolant to reduce the product temperature to ground water supply temperature levels.

54. The method as claimed in any of claims 30 to 53 wherein the chilled water is used to chill the temperature of the processed product in a storage container.

55. The method as claimed in any of claims 30 to 54 wherein refrigerant from the refrigeration plant is used to chill the temperature of processed product in a storage container.

56. The method as claimed in any of claims 30 to 55 wherein the hot water temperature is also maintained or elevated using a solar collector and mains power for use when required.

57. The method as claimed in any of claims 30 to 56 wherein mains power may be used to run the refrigeration plant.
58. An energy system substantially as hereinbefore described with reference to the examples and figures.

59. A method substantially as hereinbefore described with reference to the examples and figures.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. 7: B09B 3/00, C02F 3/28
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
IPC as above
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)
Derwent WPI: IPC as above and (+digest+ or ferment+) and refrigerat+ and biogas

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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[X] Further documents are listed in the continuation of Box C  [X] See patent family annex

* Special categories of cited documents:
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Date of the actual completion of the international search 3 March 2005

Date of mailing of the international search report 16 MAR 2005

Name and mailing address of the ISA/AU
AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustralia.gov.au
Facsimile No. (02) 6285 3929

Authorized officer
DAVID K. BELL
Telephone No: (02) 6283 2309

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### DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>&quot;Not so Dirty Dairying&quot;, E.NZ magazine, <em>The Institute of Professional Engineers New Zealand</em>, July/August 2004, pages 22 to 26</td>
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