Energy Audit of Inagh Farmhouse Cheese Ltd,

Inagh, Co.Clare.

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1 Executive Summary

The results of the energy audit and carbon-footprint analysis show that Inagh Farmhouse Cheese has an annual energy requirement of 153,454 kWh of primary energy (see chap. 7.1). The annual energy bill is €**,*** and the carbon footprint is 45.8 tons of CO2 (see chapter 7.2). This footprint equates to *.* kg of CO2 per kg of cheese produced.

Energy Source	Quantity	Cost	Total Emissions	Emission cost
Road Diesel	***	****	9.5 tCO2e	€0 /tCO2e
Farm Diesel	***	****	1.9 tCO2e	€0 /tCO2e
Heating Oil	***	****	17.5 tCO2e	€0 /tCO2e
Electricity	***	****	16.9 tCO2e	€0 /tCO2e
Total		**€0**	**45.8 tCO2e**	

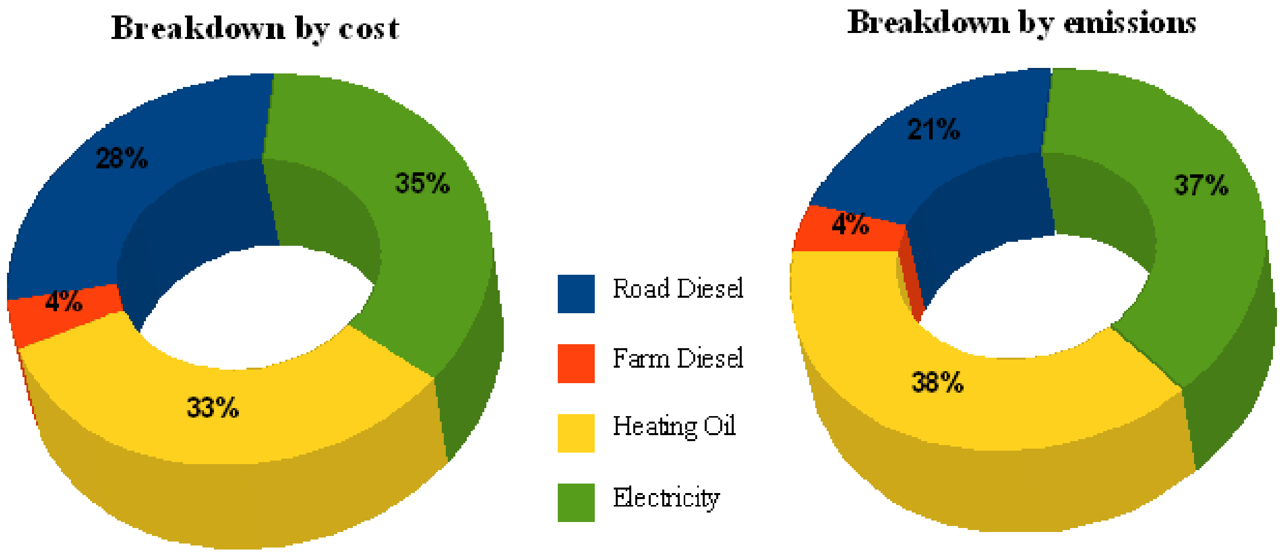

Figure 1: Summary of energy costs and emissions

The recommendations in chapter 6 are projected to give a 25% reduction in the annual energy requirement with for a capital cost of €8850 with projected annual operating cost savings of €2645. Full details of the calculation of savings in given in chapter 6.3 The overall reduction in the carbon footprint, as detailed by the recommendations in chapter 6.4 would be 74%.

2 Introduction

Inagh Farmhouse Cheese Ltd. has applied and received funding under the Innovation Vouchers Scheme[i] to address the following concern :

How can Inagh Farmhouse Cheese, an organic cheese/milk producer, reduce our carbon footprint and energy costs through the use of renewable-energy and energy-efficiency in a cost-effective manner ?

This report will deliver the following :

- an audit of current energy usages differentiating between different load types and seasonal/diurnal nature of demand
- a carbon footprint analysis of current energy profile
- A fully specified and costed proposal for energy-efficiency measures and potential renewable-energy solutions.
- a carbon footprint analysis of future potential energy profiles

Carbon footprinting has been successfully internationally used to assess and represent the environmental impact of an activity, e.g. a product, a city, a country or even a lifestyle. A carbon footprint is a "measure of the impact a given activity can have on the environment in terms of the amount of green house gases produced, measured in units of carbon dioxide"[i]

The unit of measurement for the carbon footprint is "kg CO2e", i.e. kilogrammes of carbon-dioxide equivalent. This is the internationally accepted metric for carbon-footprint measurement and allows carbon-footprint of dissimilar activities to be added to give a single combined figure e.g. electricity usage, fuel usage, materials usage.

The emissions covered in this report are considered "Scope 1 & 2" emissions according to the Greenhouse Gas Protocol[ii] and "Direct and Energy Indirect" emissions according to ISO 14064:1[iii]. This covers direct fuel usage and all electricity/gas usage.

Note that the figures given for the carbon footprint do not represent the entire carbon-ffotprint of the finished product, i.e. The cheese. What it represents is the share of the footprint which is the responsibility of Inagh Farmhouse Cheese Ltd. For full product footprinting, in accordance with PAS 2050[iv], it would be required to know the emissions figures associated with the feed-supplier for example, or of all building work carried out on the farm.

Note that this report is subject to revision. The most recent revision is available from colm@carbontracking.com. Only the most recent revision should be used as a data source.

3 About Carbon Tracking Ltd.

Carbon Tracking Ltd. is an energy- and carbon-management consultancy offering the following services:

- Auditing of existing energy-management processes to maximise efficiency gains
- Advice on implementation of energy-management standards such as I.S. 393 and relevant parts of ISO 14001
- Definition of improvement paths for Building Energy Ratings, both commercial and domestic
- Advice on potential renewable-energy solutions in the client's energy profile including full financial profiling.
- Carbon-footprint analysis and reduction strategies for businesses,organisations,events and private individuals
- Guidance through the existing and emerging standards in carbon-management i.e. PAS 2050, ISO 14064-1, WRI/GHG-Protocol
- Evaluation of potential carbon-offset providers covering benefits and pitfalls of the path to "carbon neutral" or "carbon-positive" status .
- Training/workshops on energy and/or carbon management ranging from 1 hour motivational talks to full-day practical workshops

4 Inagh Farmhouse Cheese Ltd Operations

All data presented in this report is based on figures supplied by Inagh Farmhouse Cheese Ltd, unless where otherwise specifically stated.

The operations in Inagh Farmhouse Cheese Ltd. are presented in the following flowchart. Where possible the type of energy demand has been highlighted for a particular process.

In the process flowchart, a box outlined in blue indicates a cooling demand, a box outlined in red indicates a heating demand. A yellow background indicates that the demand is met from electrical energy and a brown background indicates demand is met from water heated currently by an oil boiler and/or existing solar-panels.

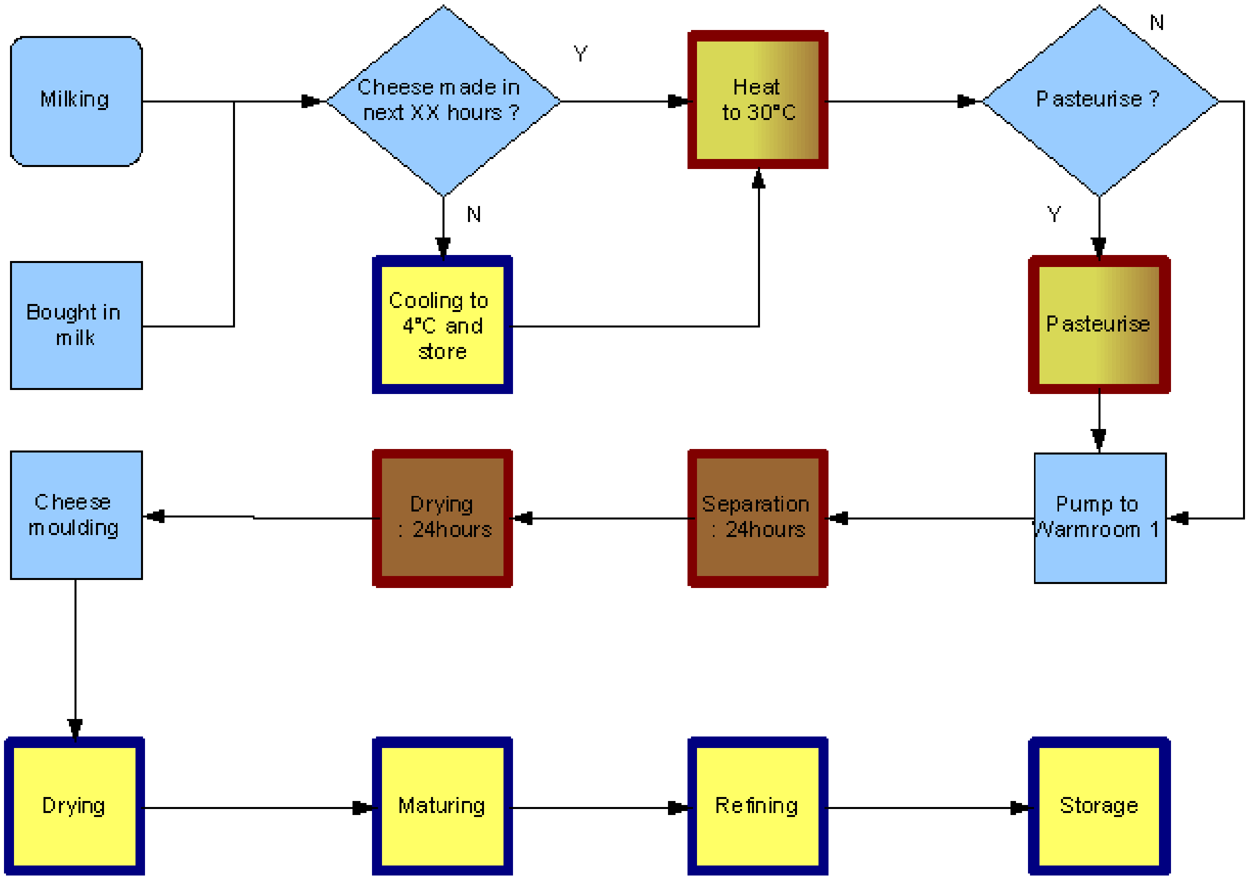

Figure 2: Inagh Farmhouse Cheese process description

As milk production has a seasonal nature the activity varies widely through out the year. Cheese is made from milk produced by the farm's own goats and also from milk bought-in form other farms. The following chart displays the variations in milk processing through the year.

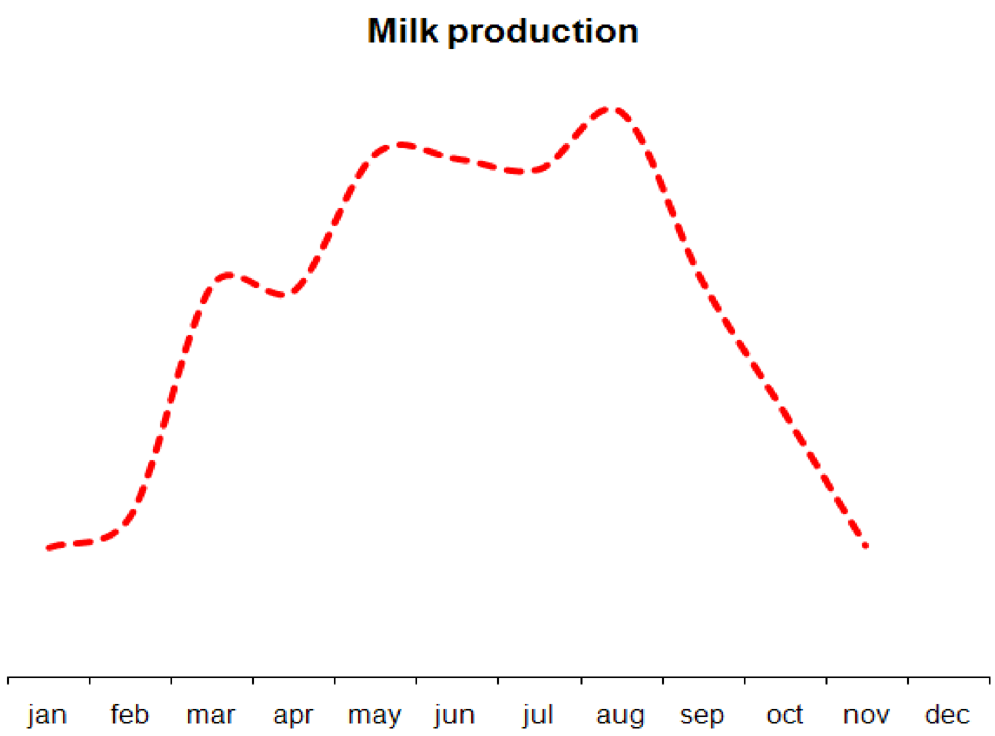

Figure 3: Inagh Farmhouse Cheese Milk processing, 2008

5 Energy Audit

5.1 Heating Loads

The heating loads can be further divided into milk-related loads (heating/pasteurising) and space-heating loads. All heating is sourced from a 500 ltr hot-water tank.

- Milk related

  When milk is produced it is pumped into one of the two milk tanks. There is one 1200 ltr tank and another 2000 ltr. Once in these tanks, the milk can either be cooled to 4°C, when milk needs to be held pending cheese-making, or heated to **°C when the cheese-making process begins. The heating is done using heated water from the 500 ltr heating tank and pumped through the outer skin of the tanks.

  Some milk, particularly milk bought-in from other farms, is pasteurised before processing to cheese. The pasteuriser is a flat-plate heat-exchanger which used an electrical heating element to heat the milk to 70°C for 90 seconds.

- Space-heating

  The separation and drying stages of cheese production occur in one of the two "warm" rooms in the farm buildings. During times of low production, October to March, only one of these rooms is used. As milk/cheese production increases from March onwards, the second warm-room is brought in to use. When in use each warm room must be kept at a stable ** °C. This is controlled by separate thermostats in each room. The rooms are heated via under-floor heating which is heated by an oil-burner. Each warm-room measures 15m^2 approx

5.2 Cooling Demands

Cooling loads can be divided into milk-related and cheese-finishing related loads.

- Milk-related

  When milk is produced at a time where cheese making will not occur immediately (e.g. evening milking) the cheese is chilled and stored at 4°C. A specific cooler performs this task using chilled water which is pumped through the outer skin of the tanks (1200ltr or 2000ltr).

- Cheese-finishing

  There are 4 walk-in cold-rooms in the building. Cold Room 1 is used for draining the cheese and is maintained at *°C. Cold Room 2 is used for maturing the hard cheese and is maintained at 9°C. Cold Room 3 is used for drying the soft cheese and is maintained at *°C. The dispatch cold room is used for cheese ready for dispatch and is maintained at *°C. There are also two "armoires" which are used for high-quality finishing of soft-cheeses for specific requirements.

5.3 Electrical Demands (Non-heating/cooling)

The major electrical demands are as follows :

- Milking equipment

  The herd, comprising 160 milking goats, is milked twice each day, at 7:30 a.m. and again at 6 p.m.in the evening. Before each milking session all milking equipment is washed automatically. Washing/milking is a purely electrical load.

- Dishwasher

  An industrial dishwasher is used every day when cheese is made. The dishwasher is connected to the cold water circuit.

- Office equipment.

  The building includes a small office with 2 computers, fax-machine as well as a kitchen/meeting-room area containing a domestic fridge, an electric grill and an electric kettle.

- Lighting

5.4 Heating Sources

All water heating requirements are met either by the oil-fueled boiler or the solar-water heater.

5.4.1 Oil-fueled boiler

The boiler is a Firebird Heat PAC 98, with a Riello G5X burner. Its fuel usage during the course of the year is as follows :

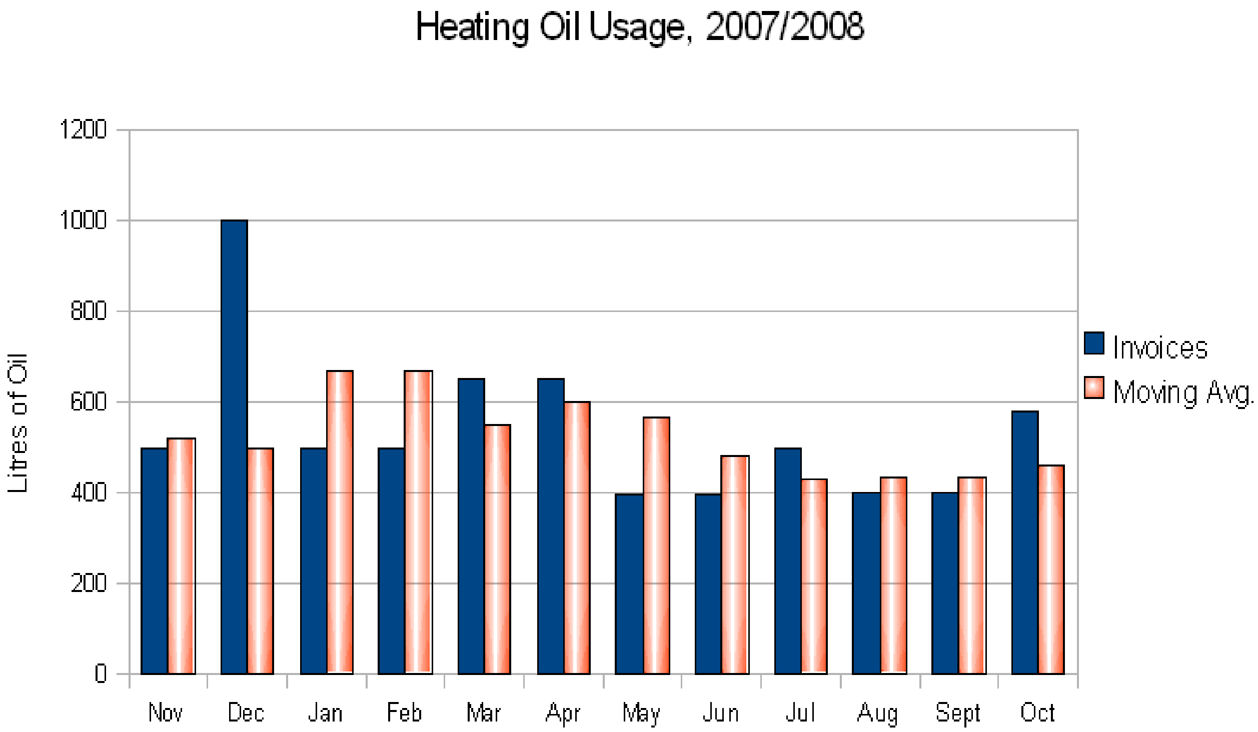

Figure 4: Heating Oil Usage, 2007/2008

Since fuel is ordered in quantities of over 500 ltrs per order it is difficult to see detailed monthly usage changes from the invoices figures. The addition of the 3-month moving average shows underlying trends during the course of the year.

5.4.2 Solar-Water Heater

There is an evacuated-tube style solar water heater on the roof of the building comprising 50 tubes. The simplicity of the controller used for the heater does not allow any estimate of how much useful energy is produced.

5.5 Road Vehicles

Inagh Farmhouse Cheese operates a number of road-vehicles. Vehicle fuel is bought in bulk for the tank at the farm and also as needs arise from fuel-stations.

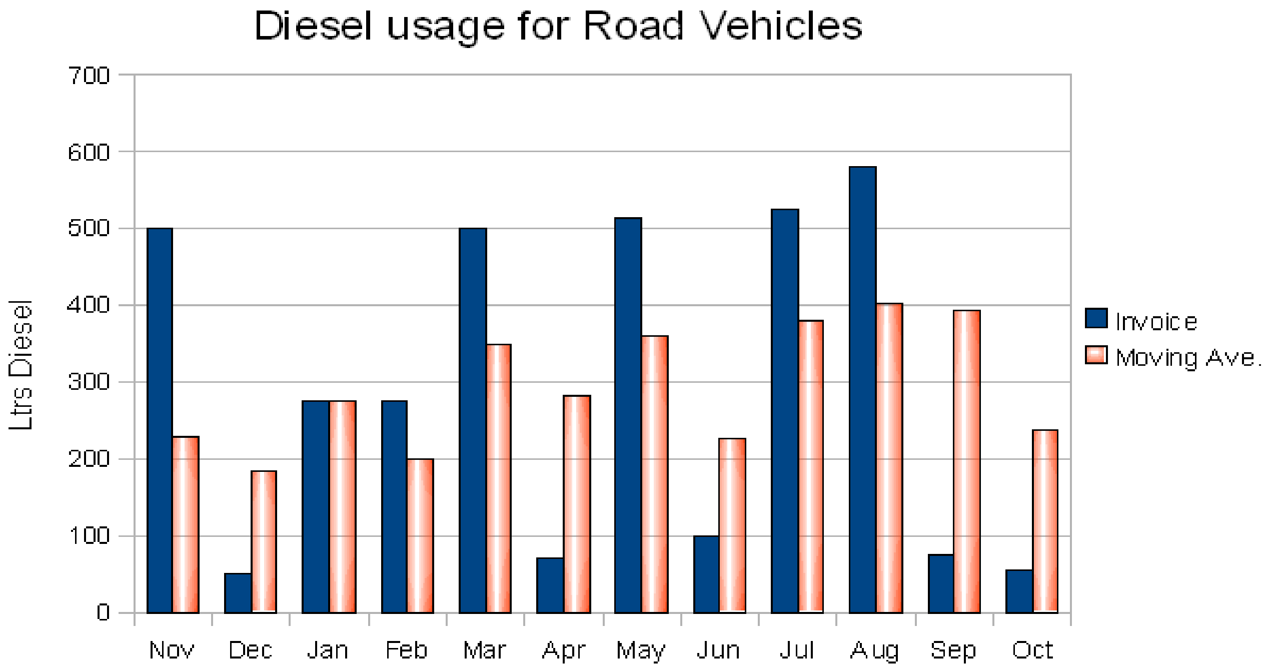

Figure 5: Road Vehicle Diesel Usage

A 3-month moving average has been added to show underlying trends during the course of the year.

5.6 Farm vehicles

Inagh Farmhouse Cheese operates a number of road-vehicles. Vehicle fuel is bought in bulk for a tank at the farm. Fuel was purchased on two occasions giving a total of 700 ltrs for the year.

5.7 Electricity usage

Monthly data is available for electricity usage.

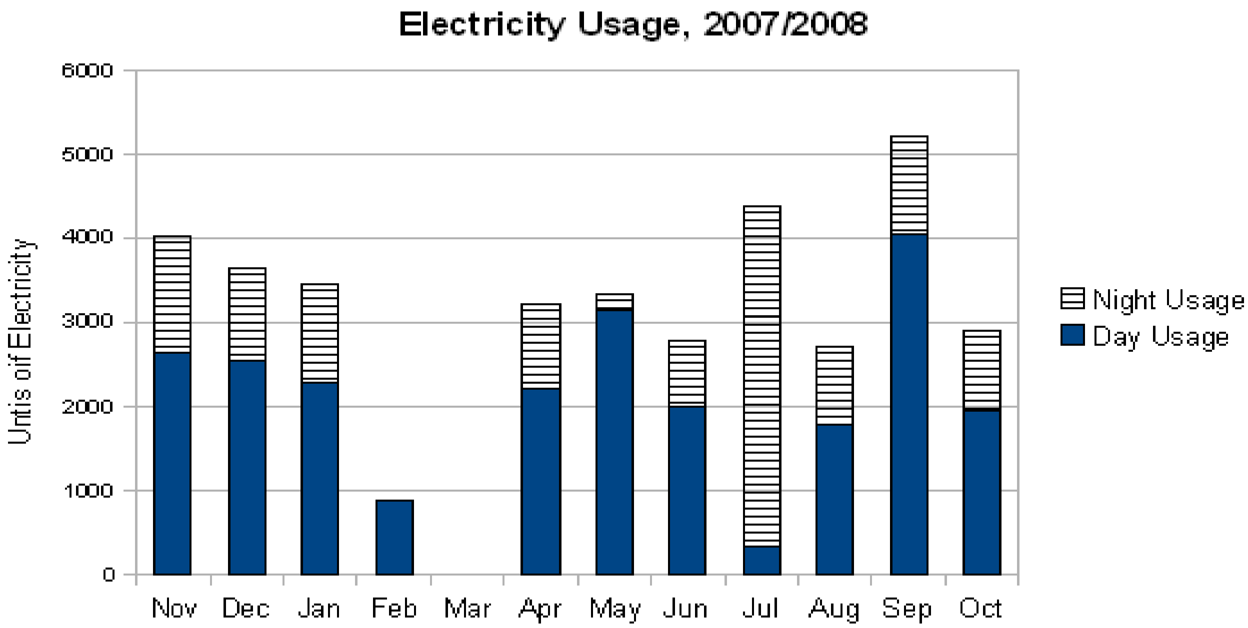

Figure 6: Electricity Usage, 2007/2008

The dip in the electricity usage in February and March, as well as the imbalance of nightrate in July probably reflects a readjustment of billing rather than a genuine sharp decline in usage.

6 Analysis / Recommendations

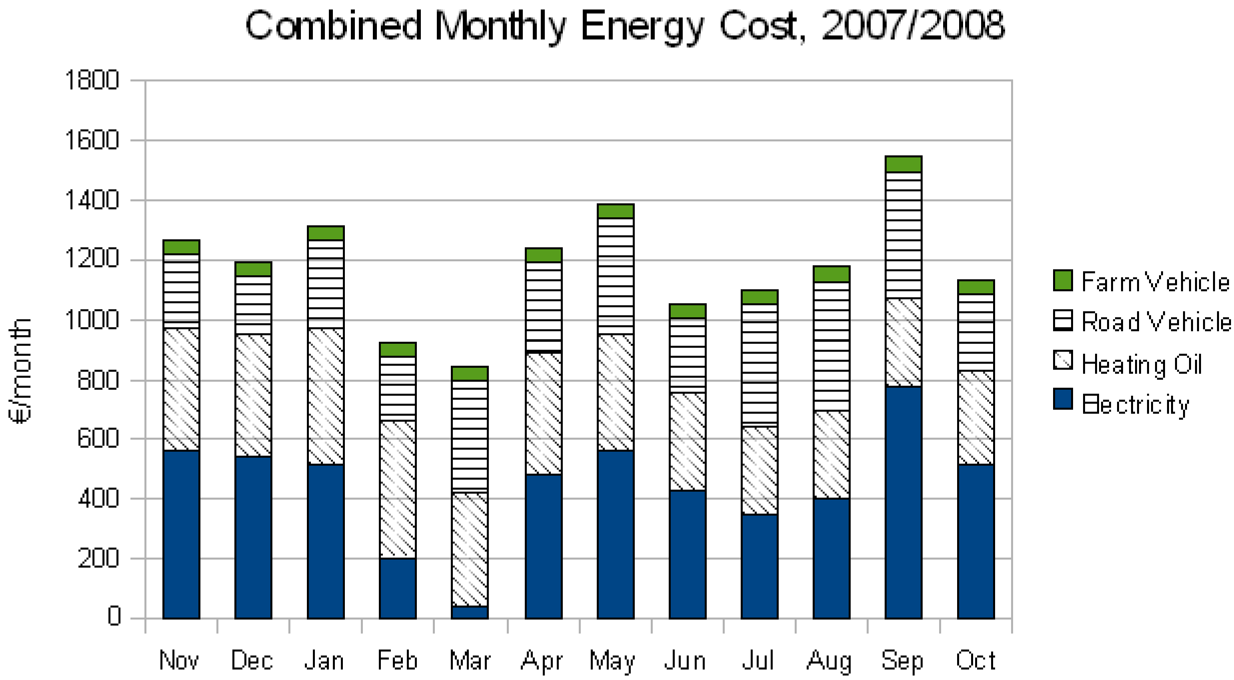

Figure 7: Combined Monthly Energy Costs 2007/2008

In a business of a seasonal nature, it would be expected that energy costs should follow variations in production to some extent. If we compare the energy costs in Figure 7 with the milk processing levels in Figure 3 we see that this is not the case. Even in the quietest production periods of December / January, when production is less than ¼ of summer time production, energy costs actually exceed the average monthly value of €1,181. As mentioned previously the data for March can probably be discounted owing tto a change of electricity supplier and inaccurate data.

This significant lack of variation in energy demand is indicative of inefficiencies in the chees-making process which can be pinpointed/eliminated using the recommendations that follow.

6.1 Demand Monitoring/Reduction

- Installation of an electricity usage meter at the entrance/exit to the cheese-house. An example of a suitable low-cost meter is that available from Current Cost Ltd. UK at http://www.currentcost.com. The meter provides for 3-phase monitoring/recording with readings stored every 6 seconds. Data may be downloaded to a PC and open-source software is available which allows time-based analysis of electricity demand.
  - Cost : €60.
  - Expected benefit : Monitoring of electricity usage can provide a 10% saving in electricity costs by increasing staff awareness of the different loads in the cheese-house. It also allows for the identification of "phantom" loads, loads due to unused but powered-on machinery.

- Installation of pvc-strip curtains in all cold-rooms. Currently none of the cold-rooms have pvc-strip curtains which causes a loss of cold air each time a door is opened. The multiple effects of this unnecessary loss are increased workload on the compressors, leading to reduced efficiencies, higher electrical costs, more frequent variations in the temperatures of the cold-rooms with potential impact on the stored goods, decrease in temperature of the work-area in the cheese house with consequent rise in heating demand.

- Cost : Currently being costed in Ireland with http://www.samson.ie. Price from the UK indicate a cost of €45 per curtain.
- Expected benefit : Difficult to quantify in the short term. Electricity consumption of the cold-rooms should drop by 10% and the efficiencies of the cold-rooms will improve. More detailed monitoring of the electricity consumption of the cold-rooms is needed in order to estimate the potential savings.

- Improve the insulation of both warm-rooms. Warm-room 1, which is used year round, has two external walls and two internal walls. The internal walls are 4" concrete block and the external walls are doubled 4" block with 2 inches of polystyrene insulation. This gives a U of 0.44 for the external walls and 0.54 for the ceiling, both of which are far below current building regulations. (0.22 for roofs / 0.27 for walls). The ceiling is insulated with 4" of fiberglass insulation bewteen joists at 60cm centers. The rooms must be kept at 20.5°C during the cheese-making process.
    - Cost : €5/m2 for attic insulation (entire cheese-house for €400). Cavity Wall Insulation injected into external walls around warm-rooms @ €15/m2 over 40m2 of external wall.
    - Expected benefit : If we assume a split of 50% space heating and 50% hot-water-heating then improved insulation in the warm rooms will at lower the heat requirement by at least 10% from the current €4453 annum.

- Improved temperature management with programmable thermostats. The thermal inertia the warm rooms should be measured to understand the rate at which they heat-up and cool down. Currently the thermostats endeavour to keep the warm rooms at 20.5°C permanently. It pay be acceptable to drop this temperature to 16°C at the weekend and automatically increase to 20.5°C previous to the first cheesemaking session on Mondays. If the inertia of the room permits, the temperature could be allowed to drop at night time and increase in early morning. The temperature in warm room 2 is also currently set to 20.5°C although no cheese-making is carried out in this room for the 6 months of low-milk production.
    - Cost : €70 for a wireless thermostat, one required for each warm-room
    - Expected benefit : With correct management to fit the cheese-making schedule, a further 15% cut in space-heating needs is achievable.

- Investigation of the cooling parameters of cold-rooms. Currently all coldrooms are set to a fixed temperature depending on the usage of the respective cold-rooms. If production will allow, the possibility of dynamically managing the temperature of the cold-rooms could be investigated. Cold-rooms operate more efficiently at night as outside temperatures drop. An acceptable variation of temperatures may exist for each specific cold-room, i.e. Instead of sticking at a permanent 4°C it may be acceptable to vary between 3°C and 5°C. In this case the cold-room would run at 3°C at night, at higher efficiencies and at 5°C during the day, lessening the cooling demand as efficiencies drop.
    - Cost : Not yet defined. Further observations of the programming possibilities of the cold-room thermostats is needed.
    - Expected benefits : Strong possibility of reduced electricity demand for cooling requirements.

6.2 Capital investment options

- Plumb the dishwasher to use hot water from the hot-water circuit. Currently the dishwasher heats water using electricity, which is expensive when compared to heatig water from solar or even and oil burner.
  - Cost : unknown labour cost
  - Expected benefit : Further monitoring is required to ascertain the level of electricity usage required by the dishwasher.

- Upgrading/Expansion of solar water-heating. The controller of the exisiting installation should be replaced with a modern version which will allow monitoring of the useful energy dervied from solar. Once this is done (after the summer of 2009) the decisions can then be taken concerning an eventual expansion. Peak milk/cheese season coincides with peak solar energy so the possibility of a cost-effective solution is enhanced.
  - Cost : €150 for installation of upgraded controller.
  - Expected benefit : Quantify the useful energy derived from the solar water heater and allow an informed decision on whether to expand the system.

- Replacement of oil-burner by air-water heat-pump. An air-water heat-pump can produce between 3-5 kWh of heat energy from 1 kWh of electricity. If we base our calculations on an average of 4 then each kWh of heat will cost €0.17/4 i.e. 4.25c. Currently heat energy from the oil-burner is costing 11.9c/kWh (see chapter 7.4).
  - Cost : Estimated cost of €7000 after grant-aid. Awaiting more accurate figures from suppliers.
  - Expected benefits : If we assume a 25% reduction in space-heating energy requirements (50% of total thermal load) due to improved monitoring, the overall heating requirement will drop to 66832kWh/annum. We will also assume that 30% of the electricity requirements will be consumed at night-rate, i.e. €0.11. This will require 16705 kWh of electricity for a total cost of €2538/annum when compared to an annual heating oil cost of €4453 currently (or €3896 including assumed 25% efficiency improvements). This gives an annual saving of €1357/annum.

- Linking of waste heat from cool-room heat-pumps to air intake for oil-burner/air-water heat-pump. Currently, the three cool-rooms at the north of the the cheese-house reject the waste hot air from the cooling heat-pumps to the atmosphere. Rather than waste this energy, the hot air could be ducted to be used as input to the existing oil-burner or to the potential replacement, an air-water heat-pump. This would improve the efficiencies of both systems but moreso the air-water heat-pump.
  - Cost : Not yet quantified.
  - Expected benefits : A virtuous energy-cycle is created where previously wasted heat from the cooling loads is recycled for use in the heating loads.

6.3 Cost/benefit analysis of different measures

Action	Cost	Annual Savings	Payback
Improved electricity monitoring	€60.00	10% of electricity = €469	2 months
Improved thermostat control of heating	€140.00	15% of space heat requirements = €334 (assume space heating is 50% of total thermal demand)	5 months
PVC strip curtains	€650.00	10% of fridges electricity following improved monitoring, assuming fridges account for 70% of electricity demand = €295	26 months
Improved insulation, ceiling and walls	€1,000.00	10% of space heat requirements, assuming improved thermostat control = €190	64 months
Replace oil-burner by air-water heat-pump	€7,000.00	As per section 6.2 savings of €1357	62 months

6.4 Carbon-footprint reduction strategies

- Increased energy efficiency. If all monitoring/demand-reduction recommendations are implemented then it is foreseen that energy requirements for electricity and heating will drop by over 25%. These categories are responsible for 75% of emissions so overall emissions would drop by 18.75% or 8.6 tons of CO2e.
- Replacement of oil-burner by air-water heat pump. As detailed in chapter 6.2, the replacement of the oil-burner, in addition to 25% reduction in primary energy requirements due to increased efficiencies would replace 6472 liters of heating-oil with 14320 kWh of electricity. When the 25% reduction is factored in this represents a drop in emissions, for heating , from 13.14 tons CO2e to 6.7 tons CO2e per annum or an overall drop of 14.7%
- Change of electricity supplier from Energia to Airtricity. A kWh from Airtricity generates 0.142 kg CO2e. By comparison a kWh from Energia generates 0.465 kg CO2e. If Inagh Farmhouse Cheese Ltd switched to Airtricity this would result in an emissions reduction of non-heating related electricity from 16.4 tons CO2e currently to 3.36 tons CO2e or an overall drop of 19.73%. If coupled to the replacment of the oil-burner by an air-water heat-pump running on renewable electricity, this would give a further overall reduction in emissions of 10.22%.
- Change to renewable transport fuels. The company vehicles could, when the time arises, be replaced by vehicles running on either some mix of bio-ethanol or bio-diesel. As an example, if a diesel chill-van was run purely on bio-diesel its emissions would be reduced by at least 50% when compared to fossil-fuel diesel. When translated to the road-diesel consumption of Inagh Farmhouse Cheese Ltd this would represent a reduction of 4.75 tons CO2e or an overall reduction in emissions of 10.45%. This emissions reduction would entail a increased cost which would not necessarily be recovered through increased efficiencies.
- In general, when we compare the two charts in Figure 1 we see that road-diesel bears the highest cost per ton CO2e emitted. Normally, from an emissions reduction point of view, this would be the first area to look at for reductions since each ton of CO2e reduced brings higher savings.

7 Energy Calculation

7.1 Primary Energy Requirements

Each energy source is transformed into its kWh equivalent using the following factors[v]

Fuel type	Unit	Equivalent in kWh
Diesel Oil	1	10.9
Heating Oil	1	11.8
Electricity	1	1

7.2 Emissions Factors

Each energy source is transformed into its tons CO2 equivalent (tCO2e) using the following factors

Diesel 1 ltr = 2.7kg CO2e

Heating Oil 1 ltr = 2.7kg CO2e

Electricity 1 kWh = 0.465 kg CO2e[vi] since switching to Energia, previously 0.624kg CO2e with ESB Customer Supply

7.3 Heat loss calculations

Here are the calculations for the heat losses from warm-room 1.

Losses through ceiling and external walls with current U of 0.54 (ceiling) and 0.44(walls)using degree data for Shannon from http://www.degreedays.net.

Annual loss 1685 kWh

Adding 4" of fiberglass to the walls and 6" to the attic would reduce this annual loss to 686 kWh.

Assuming a 60% efficiency for the boiler and 10% losses within the cheesehouse, each kWh of heat in warm room 1 requires 2 kWh provided by the heating oil. Therefore for 1000 kWh excessive heat loss, 2000 kWh equivalent of heating oil are required. At a ratio of 11.8kWh/ltr heating-oil, this equates to a loss of 285ltrs/year due to inadequate insulation of external walls and attic.

7.4 Cost of heat-energy kWh from oil

Each liter of heating oil can generate 11.8 kWh of heat energy at 100%efficiency[vii]. If we assume a 60% efficiency of the oil-burner and 10% losses elsewhere then one liter of heating oil delivers 5.8 kWh of useful heat. Each liter costs 69c on average so each kWh of useful heat costs 11.9c.

i http://www.innovationcouchers.ie : A scheme run by Enterprise Ireland
ii http://www.ghgprotocol.org/standards/corporate-standard
iii http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=38381
iv http://www.carbontrust.co.uk/carbon/briefing/developing_the_standard.htm
v http://www.sei.ie/energymap/Identify/Step_6_Develop_and_overview_total_energy_consumption/
vi http://www.cer.ie/en/renewables-current-consultations.aspx?article=9b9d4683-57b9-4bab-a31f-a3e8e9716a7d : Emissions factors for 2007 for all Electricity Suppliers.
vii http://www.sei.ie/energymap/Identify/Step_6_Develop_and_overview_total_energy_consumption/