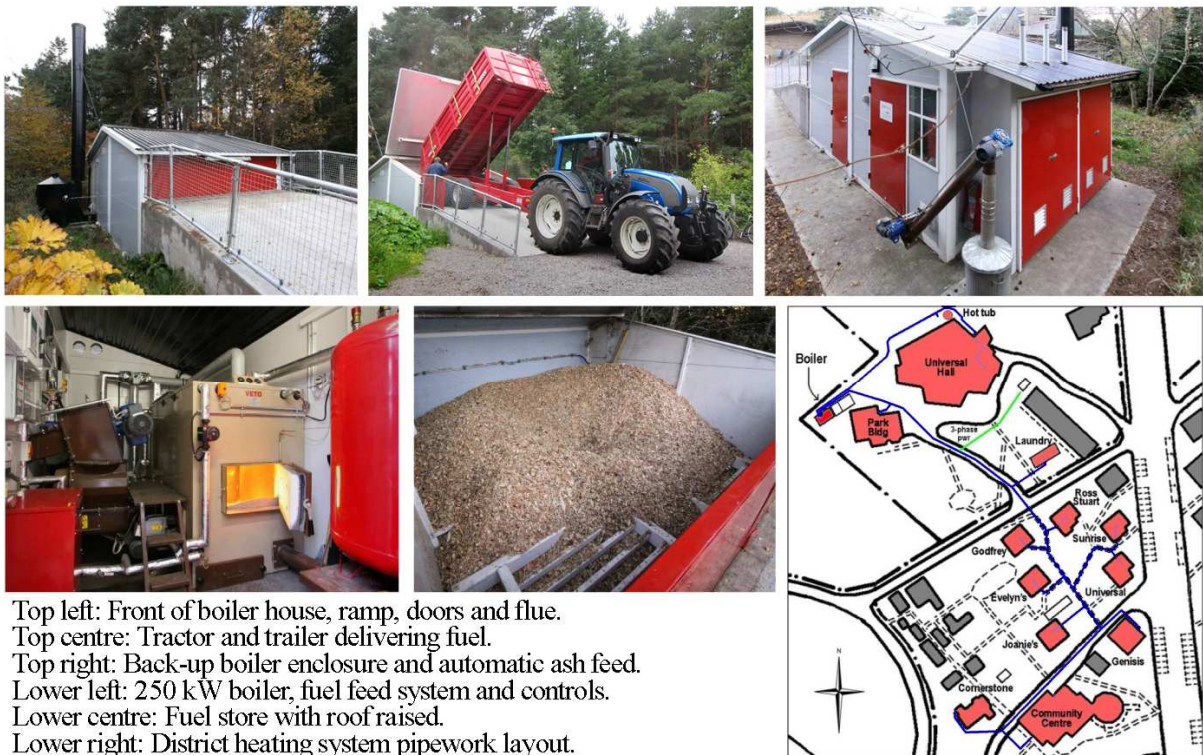


The Findhorn Foundation Biomass Boiler:

First Annual Report, November 2011.

Summary

In late 2010, the Findhorn Foundation¹ installed a biomass boiler with which to supply carbon zero heat to 13 of its community facilities: a performing arts centre, community centre, educational building, several residences and a hot tub. The boiler, boilerhouse, district heating pipework and requisite plumbing refurbishment within each of the facilities cost approximately £350,000 and took several months to install. The boiler is a 250 kW Veto, factory fitted within a purpose designed boiler house that also contains a fuel store. It arrived from Finland on the back of a lorry and was craned onto an already prepared concrete base. The system was commissioned in September 2010 and was fully operational by October. The boiler is maintained and operated by the Foundation's own Park Maintenance crew who collected weekly data throughout the first year of operation to enable us, now, to review costs, savings and procedures.



Top left: Front of boiler house, ramp and flue.
Top centre: Tractor and trailer delivering fuel.
Top right: Back-up boiler enclosure and automatic ash feed.
Lower left: 250 kW boiler, fuel feed system and controls.
Lower centre: Fuel store with roof raised.
Lower right: District heating system pipework layout.

In summary, the boiler has been running well, albeit with minor teething problems, and the fuel cost and carbon emission savings are, more or less, in line with expectation based on initial feasibility studies: up to £15,000 in fuel savings and an 80 tonne reduction in carbon emissions in the first year. The fuel supply regime has been excellent in terms of both service and the fuel quality.

¹ The Findhorn Foundation is a Charitable Trust in Moray, Nth Scotland. The Findhorn Foundation community of about 500 people live in and around an ecovillage and holistic education centre. See www.findhorn.org.

Running Costs

An independent feasibility study² commissioned before the project went ahead (and upon which that decision was based) predicted that a biomass boiler would save the FF between £10,000 and £12,000 in fuel costs and 100 tonne of carbon emissions each year – predictions later duplicated in a design report conducted by the installers.³ This review attempts to work out the *actual* savings by comparing costs due to heating with gas and oil in 2010 with those of 2011. (The first full year of biomass operation is taken to be Nov 1st, 2010 to Oct 31st 2011). In fact, such a comparison of costs from one year to the next is not straightforward, requiring several assumptions. As it happens, it's reasonable to assume that the weather in 2010 was similar to that in 2011; there were two similarly severe cold snaps in Dec-Jan 2010 and Dec-Jan 2011 and the weather was mostly similar otherwise (i.e. there were two lousy summers). A more detailed analysis of the weather in degree-days is beyond the scope of this report but would have been necessary if conditions had varied greatly from one year to the next.

The buildings being heated with biomass (i.e. for space *and* water heating) are: the Universal Hall, Community Centre (CC), Park Building (an office and education building), community laundry (hot water only), seven residential buildings (named Ross Stewart, Godfrey, Evelyn, Sunrise, Universal, Genesis, Joannies and Cornerstone) and a hot tub. Previously:

- the Hall, Ross Stewart, Godfrey, Evelyn, Sunrise, Universal and CC were heated with oil;
- the Park Building, laundry and Cornerstone were heated with bulk (tank) LPG;
- Genesis and Joannies were heated with bottled LPG; and,
- the hot tub was electrically heated.

In 2010 the cost to the FF of heating these facilities (excluding the hot tub which is operated as an independent business and billed separately) was **£21,548.16** incl. VAT.⁴ In 2011, the cost of biomass heating for these facilities was **£13,040.61** incl. VAT. (Note: this includes a credit or reduction of £733.91 for hot tub charges paid to the FF.) Therefore the actual savings to the FF due to the biomass boiler installation when comparing simple costs in 2010 with those in 2011 was $£21,548.16 - £13,040.61 = \mathbf{£8,507.55}$. However, in the months before the biomass came online the oil tanks at the Hall, CC and Ross Stewart (which also fed Godfrey, Evelyn, Sunrise and Universal via an aged mini-district heating system) were run down to near empty since they were to be decommissioned. It's reasonable to assume that otherwise, each of them would have received (at least) one more delivery during 2010. This extra cost would have been £2,851 (assuming similar sized deliveries and charges). Hence we can assume that, hypothetically, the savings would have been $£8,507.55 + £2,851 = \mathbf{£11,358.55}$.

This figure is exactly as the feasibility study predicted (i.e. between £10,000 and £12,000).

² Conducted by Steve Luker Associates, Glasgow. See www.stevelukerassociates.co.uk.

³ HWEnergy, the installers, are located near Fort William. See www.hwenergy.co.uk.

⁴ All heating fuel costs are charged 5% VAT, incl. biomass fuel.

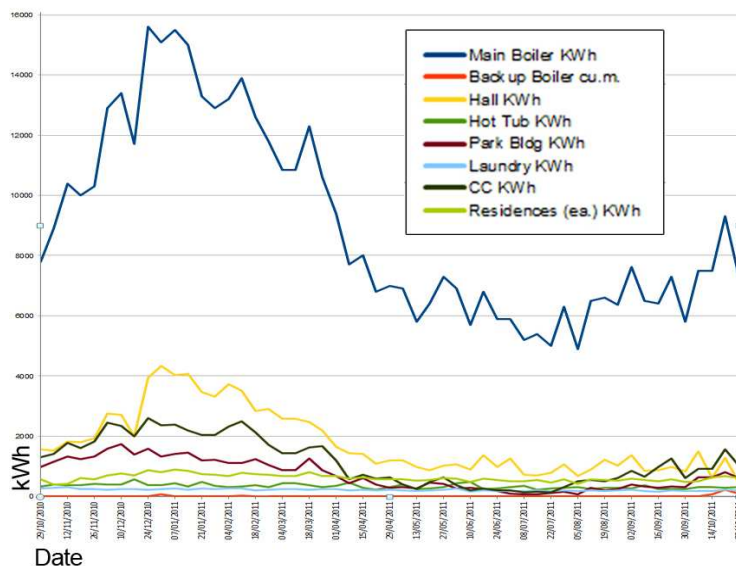
However, a further qualification is required. Fuel costs have risen in the last year. The cost of bottled gas has risen by approx. 17% and the cost of oil by approx. 34% (whilst interestingly, the cost of bulk LPG has remained roughly the same).⁵ These cost rises imply further savings (or rather, 'cost rise avoidance') of approx. £2,436.14. Therefore, the total hypothetical cost saving, assuming today's prices, are $£11,358.55 + £2,436.14 = \mathbf{£13,794.69}$.

There are further cost savings due to a changed operation and maintenance regime (O & M) that could also be factored in, albeit inaccurately. The FF decommissioned eight gas and oil boilers in making the change over to biomass heating. All of them were way past their 'use by dates' and needed constant maintenance, which usually required the services of a *Gas Safe* registered engineer which incurred considerable extra cost. Now, Park Maintenance are operating and maintaining the biomass boiler with enthusiasm, commitment and skill, and whilst there are some minor costs incurred, they are miniscule compared with previous O & M costs. So if we were to push the analysis, we could add perhaps another £1000 - £2000 in cost savings due to reduced O & M costs.

Hence, at longest stretch, it could be argued that the cost savings amount to about **£15,000 p.a.**

Heat Consumption

The FF now has a rich data source from which to make inferences about the distribution and usage of the biomass heat between and within each of the facilities being serviced. The graph below showing the relative consumption rates for each of the installations is revealing.



Facility	kWh	Proportion
Main Boiler	469,100	
Universal Hall	92,820	20%
Community Centre	60,269	13%
Park Building	36,835	8%
Residences (each)	32,088	7%
Hot Tub	17,629	4%
Laundry	11,236	2.5%

The blue line which represents the total amount of heat being produced by the boiler, comprises the sum total of the amounts consumed by the individual facilities plus an allowance of 5% for inefficiencies and losses. It is clear that consumption is acutely weather affected. Winter

⁵ Note that the cost of the biomass fuel is fixed by a three year contract. See below.

consumption is more than double that in summer. This reflects the poor level of insulation (by modern standards) in these 30 – 40 year-old buildings.⁶ The relative consumption of each of the buildings is shown in the above table: not surprisingly, the largest user is the Universal Hall at 20% of the total; next largest user is the Community Centre; then the Park Building; and, perhaps most surprisingly, *each* of the residential buildings use approx. 7% of the total and, together, about 50% of the boiler's output. Yet, the graph shows that the residences do not undergo the same seasonal variation, presumably due to their using a higher proportion of the incoming heat for water heating. This may mean that, in order to reduce undue consumption, we need to review the timing regime in these buildings and ensure that the space heating is turned right down *and water heating turned off* when the guest bungalows are not occupied.⁷ There are, no doubt, many more inferences that can be drawn from this data that will enable the Foundation to reduce its biomass fuel bills in the future.

Fuel Supply

We were very fortunate, following a wide geographic search and protracted tender process, to be able to secure a nearby source of biomass fuel. The woodchips come by tractor and trailer from a sawmill just 10 miles away. The mill produces fence posts and construction lumber from trees grown on the property, a large, densely wooded estate.⁸ The edges or 'backs' cut from the logs are air dried for twelve months before being chipped. Thus, our fuel is manufactured from waste wood and the process of manufacture and delivery releases minimal carbon emissions.

In considering options for a fuel supply contract we settled on a measure of volume rather than weight i.e. payment by the cubic metre rather than the tonne. This seemed, at the time, to be the more easily verifiable at the point of delivery and would offer an incentive to the supplier to keep the moisture content low; the lower the moisture content, the more bulky is the fuel. The contract fixes the price at £16.50/m³ for three years and guarantees that the moisture content be no more than 30% of the weight. A full trailer load contains 12.25 m³ so we pay £16.50 x 12.25 = **£202.13 + VAT** per delivery. In the first year of operation we took 47 deliveries, a total of 565.25 m³ of fuel, costing **£9326.76 + VAT**.

Importantly, we could not be happier with our choice of fuel supplier. The fuel has been of a consistently high quality and administration of the contract (i.e. accounting, invoicing, payment etc.) has been smooth. Andrew, the tractor driver, is responsive, constructive and always a pleasure to work with.

⁶ We have begun to address this issue by recently installing ceiling insulation in the CC, funded by a grant from from the Scottish Government's *Community and Renewable Energy Grant Scheme* (CARES) delivered by *Community Energy Scotland*.

⁷ The FF has high guest numbers in summer and much reduced numbers of guests in winter. This means that some of the guest accommodation is unoccupied in winter.

⁸ *Altyre Estate* has a woodchip supply business which it is keen to develop. See <http://www.altyre-estate.co.uk>.

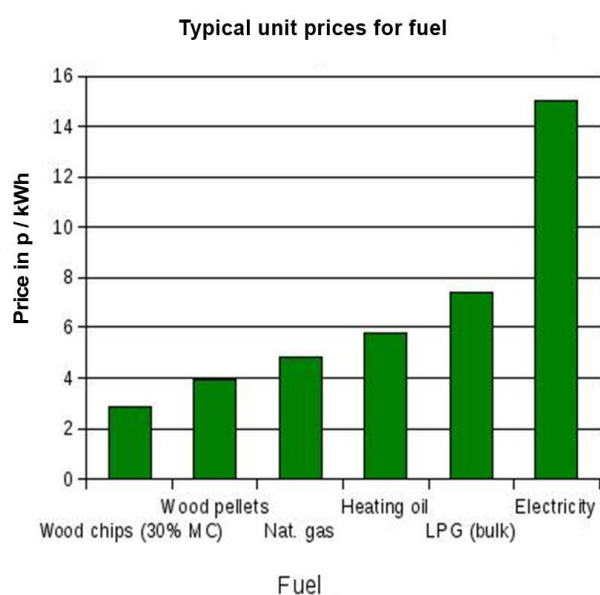
Boiler Costs

Apart from the woodchips, there were two additional fuel costs: LPG gas used by the back-up boiler and electricity used in the boilerhouse. The total fuel costs for the year were:

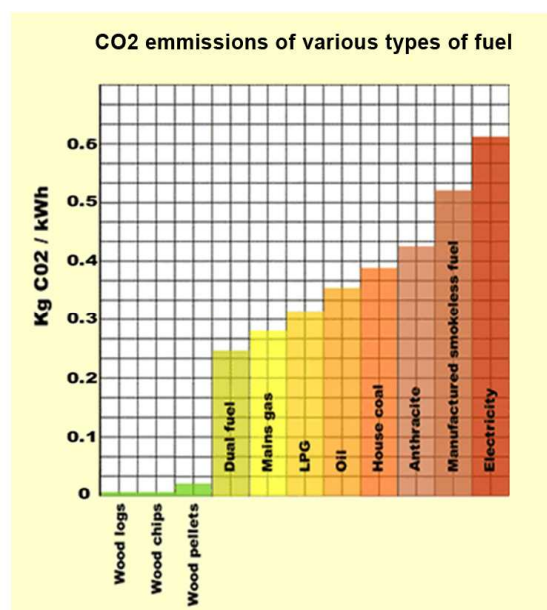
Wood chips	£9,326.76
Gas	£1,003.66
Electricity	£3,444.11
TOTAL	£13,774.52

During the course of the year the boiler (i.e. biomass boiler plus gas back-up) produced 469,100 kWh of heat. Hence the unit cost of the heat is $\text{£}13,774.52/469,100 = \mathbf{2.93 \text{ p/kWh}}$.

This figure, at about 3p/kWh, is exactly in line with industry expectations of the cost of biomass heat (see left hand graph below). And yet, the cost of the biomass fuel alone comprises just two thirds of this total. The cost of the gas fuel for the backup boiler and electricity to run the boilerhouse comprise the other third. These proportions are considerably higher than we expected. However, at least the gas cost component is likely to reduce in future. We had an incident late in the year when the main boiler was shut down for several days in order to affect a repair (to the electronics) which required consumption of gas costing £750 (of the year total of £1003.66). We hope and expect that this and other, more minor, repairs were teething problems and that, in future, the backup boiler will only be called on to cover the few hours of down time each month due to maintenance. The high cost of electricity consumed by the boiler house is a genuine surprise, since there was little prior awareness of it. In retrospect, perhaps it should not be so surprising that the three-phase power load due to the hydraulically lifting roof, mechanical fuel feed system, automatic ash feed system, pumps, valves, fans and electronics, is as considerable.



Source <http://www.biomassenergycentre.org.uk/>



Source: <http://www.forestfuels.co.uk/>

Carbon Savings

The right hand graph above gives an indication of the amount of CO₂ that is emitted for each fuel type. Now that we have data for the quantities of heat used in each of the buildings we can calculate the reduction in carbon emissions due to the biomass installation. The carbon emissions caused by the fuels in question are: Oil, 350 kg/MWh; LPG, 323 kg/MWh; and woodchips, 7 kg/MWh.⁹ Using the data from the table on page 3 above, we can calculate the CO₂ that would have been emitted had the biomass boiler not been installed:

Due to the use of oil in the Hall, CC and Residences: $(92.82 + 60.27 + 32.1) \times 350 = 64.817 \text{ t}$.
 Due to the use of LPG in the Park Building and Laundry:¹⁰ $(36.84 + 11.24) \times 323 = \underline{15.530 \text{ t}}$
80.347 t.

Emissions due to the burning of woodchips over the year were: $469.1 \times 7 = 3.283 \text{ t}$.
 Emissions due to the burning of gas by the backup boiler were: $1458 \text{ l. @ } 1.7 \text{ kg/l} = \underline{2.478 \text{ t}}$
5.761 t.

Therefore, the carbons savings due to the biomass installation are: $80.347 - 5.761 = \mathbf{74.586 \text{ t}}$.

Alternative method

An alternative means of calculating carbon emissions would be to convert directly from the quantities of fuel used in 2010:

Bulk LPG used in the Park Building, Laundry and Cornerstone: 8,106 litres
 Bottled LPG used in Genesis and Joannies: 60 bottles @ 91.8 l/bottle = 5,508 litres
 Total LPG 13,614 litres

Total oil used in the Hall, CC and Ross Stewart: 21,665 litres

Using conversion factors provided by the National Energy Foundation¹¹ (3.0595 kgCO₂/l of oil and 1.4918 kgCO₂/l of LPG) we get a total volume of carbon emissions in 2010: 86.593 t.

Therefore, the carbons savings due to the biomass installation are: $86.593 - 5.761 = \mathbf{80.832 \text{ t}}$.

Thus, we can assume that the carbon emissions saved in 2011 lie somewhere **between 75 and 80 tonne**. This is slightly disappointing since the original feasibility study and also, the design study conducted by the biomass installers, indicated carbon savings in excess of 100 t. Still and all, this is roughly equivalent to taking 50 averaged sized vehicles off the road for a year, so is a worthy contribution to the UK government's ambitious carbon emission reduction targets.

⁹ See <http://www.biomassenergycentre.org.uk>

¹⁰ Note that the hot tub would not have caused carbon emissions previously due to it being run on carbon zero electricity from our own wind park.

¹¹ See <http://www.nef.org.uk>

The RHI

The government has recently announced, after years of consultation, that a *Renewable Heat Incentive* will become available in 2012 to commercial and community interests heating with renewable fuels in lieu of fossil fuels. This scheme is intended to replace grant funding which, until now, has been offered as capital funding for expensive installations such as ours. Indeed, the Foundation received a grant of £150,000 from the Scottish Government's *Community and Renewable Energy Grant Scheme (CARES)* delivered by *Community Energy Scotland*,¹² without which, the project would not have proceeded.¹³

Installations that have already received grant funding but were commissioned after July, 2009 will still be eligible for the RHI if the grant is paid back, but only that component of the grant attributable to the boiler – not that due to a district heating system or downstream plumbing installations such as we now have in each of the buildings being fed by the biomass boiler. We believe that the sum we will need to pay back will be approximately £25,000. In return we should be eligible for a tariff paid quarterly, calculated on this basis:

Levels of support					
Tariff name	Eligible technology	Eligible sizes	Tariff rate (pence/kWh)	Tariff duration (Years)	Support calculation
Small biomass	Solid biomass; Municipal Solid Waste (incl. CHP)	Less than 200 kWth	Tier 1: 7.6	20	Metering Tier 1 applies annually up to the Tier Break, Tier 2 above the Tier Break. The Tier Break is: installed capacity x 1,314 peak load hours, i.e.: kWth x 1,314
			Tier 2: 1.9		
Medium biomass		200 kWth and above; less than 1,000 kWth	Tier 1: 4.7		
		Tier 2: 1.9			
Large biomass		1,000 kWth and above	2.6		Metering

Our 250 kW installation will generate, let's assume, 450,000 kWh of heat in a typical year. Its "Tier Break" is determined by multiplying 250 kW x 1,314 = 328,500 kWh. It will therefore receive the Tier 1 tariff for 328,500 kWh, and Tier 2 tariff for the remaining 121,500 kWh. So the total tariff could be $4.7 \times 328,500 + 1.9 \times 121,500 = \text{£}17,748 \text{ p.a.}$ Over 20 years this could amount to as much as £350,000.

¹² Not only did we receive significant financial support from CES, but our contact there, Steven Watson, could not have been more supportive with information, hand-holding and encouragement.

¹³ Critically, we also received an interest free loan of £100,000 from the Energy Saving Trust (EST) who were also extremely helpful and supportive.

Conclusion

It is very satisfying to have reached this point in the progression of this project. The timeline has taken about five years from inception, through planning, feasibility, community consultation, expert consultation, fund raising, design, tendering, installation, commissioning, operation and maintenance. It has taken a lot of hard work by many, many, people both within and without the Foundation. But, as I hope this report makes clear, it has definitely been worth it!

In general, we are very happy with the installation. It's working well and requires little looking after. The installers have generally been quick to respond to questions and the abovementioned teething problems. We are now planning a similar installation at our other campus in Forres, for which the same installers are currently conducting a design study.

The Findhorn Foundation is very keen to share its experience with other community groups who are considering biomass heating. We see it as one way we can show gratitude for the support we have received along the way and make an ongoing contribution to fighting climate change and environmental degradation.

Every year, our ecovillage hosts thousands of guests from around the world, many of whom come specifically to learn about sustainability. In summer, thousands more day visitors take tours of The Park where they can view, not only the biomass boiler, but also our wind park (of four wind turbines), biological sewerage treatment, ecological architecture, organic food production and sustainable forestry.

Please contact our Visitor Centre for further information: enquiries@findhorn.org.

Our web site is: www.findhorn.org

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