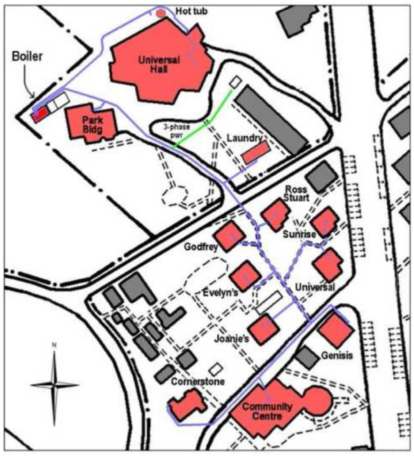
The Findhorn Foundation Biomass Boiler:

First Annual Report, November 2011.

In 2010, the Findhorn Foundation[1] installed a biomass boiler with which to supply carbon neutral heat to 13 of its community facilities: a performing arts centre (the Universal Hall), a community centre, an office and educational building, several guest bungalows and a hot tub. The boiler, boilerhouse, district heating pipework and requisite plumbing 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 and was fully operational by October 2010. 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: Ramp and hydraulically lifting roof, flue and 'cyclone grit arrestor'.
Top right: Back-up boiler enclosure and automatic ash feed.
Lower left: 250 kW boiler, fuel feed and controls.
Lower middle: Fuel store with roof raised.
Lower right: District heating pipework layout..

Running Costs

A feasibility study[2] commissioned before the project went ahead (and upon which that decision was based) predicted that the FF would save between £10,000 and £12,000 per year in fuel costs. This review attempts to work out the *actual* savings by comparing the fuel costs due to

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[1] The Findhorn Foundation is a Charitable Trust in Moray, Nth Scotland. See www.findhorn.org.

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

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 Bldg, 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.[3] 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 = **£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 a 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 = **£11,358.55**.

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

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). By averaging these cost rises, we can assume further savings (or rather, cost rise avoidance) of approx. £2,436.14. (Note that the cost of the biomass fuel is fixed by a three year contract. See below.) Therefore, the total hypothetical cost savings, assuming today's prices, are £11,358.55 + £2,436.14 = **£13,794.69**. There are further cost savings due to a changed operation and maintenance regime (O & M)

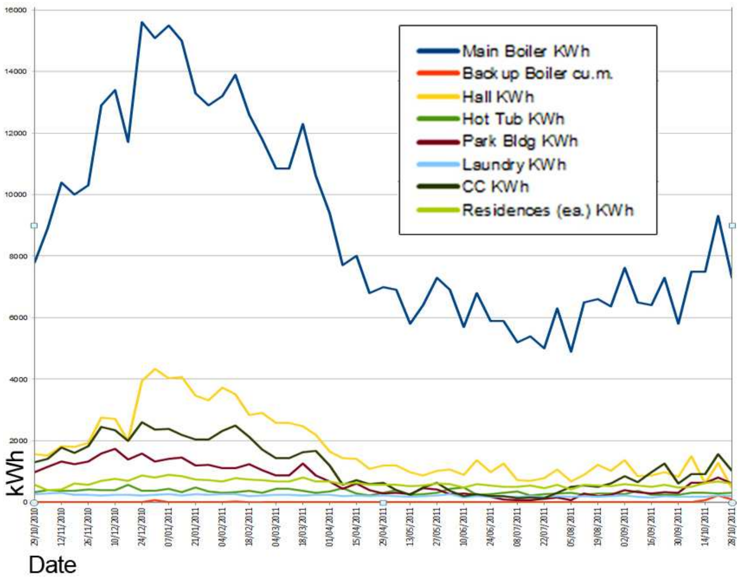
[3] All heating fuel costs are charged 5% VAT, incl. biomass fuel.

that could also be factored in, albeit inaccurately. The FF decommissioned eight gas and oil boilers in making the change over to biomass heating. Most of these 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. Park Maintenance are operating and maintaining the biomass boiler with enthusiasm, commitment and skill, and whilst there are some minor costs incurred, they are minimal 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**.

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, representing 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 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. The relative consumption of each of the buildings is shown in the 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 boilers 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.[4] 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 tender process, to be able to secure a nearby source of woodchips. They 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.[5] 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 causes 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 cubic metre rather than tonnage. 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/m^3 for three years and guarantees that the moisture content be no more than 30% of the weight. A trailer load, if filled to the top, contains 12.25 m^3 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 m^3 of fuel costing **£9326.76 + VAT**.

Importantly, we could not be happier with our choice of fuel supplier. Andrew, the tractor driver is responsive and constructive. The fuel has been of a consistent quality and administration of the contract, invoicing and payment etc., has been running smoothly.

Heat Cost

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:

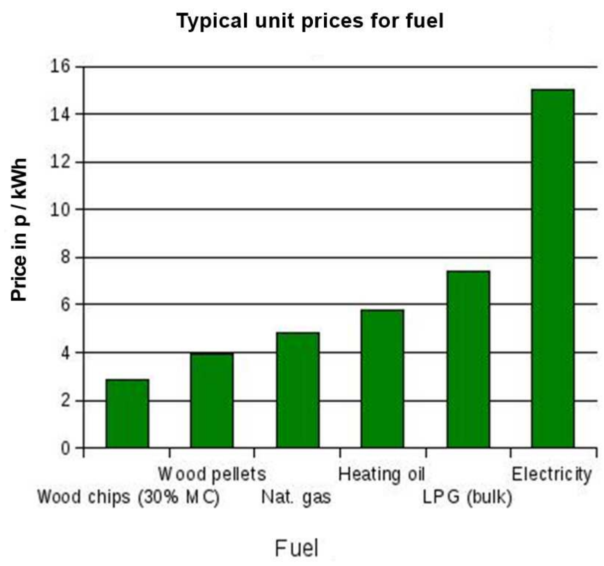
Wood chips	£9,326.76
Gas	£1,003.66
Electricity	£3,444.11
TOTAL	£13,774.52

During the course of the year the boiler (i.e. biomass boiler plus gas backup) produced 469,100 kWh of heat. Hence the unit cost of the heat is £13,774.52/469,100 = **2.93 p/kWh**.

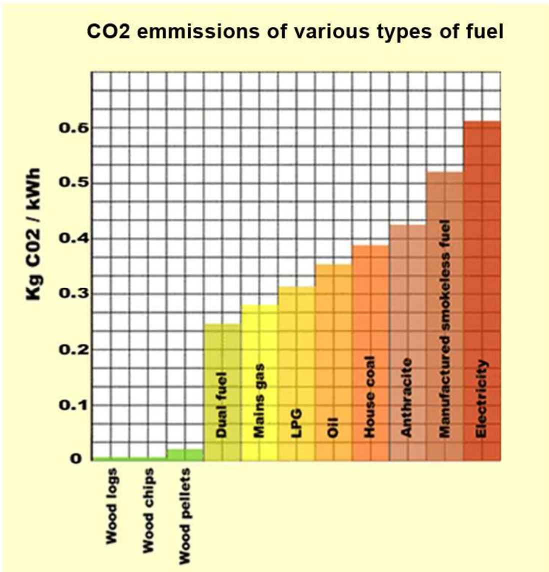
[4] The FF has high guest numbers in summer and much reduced numbers of guests in winter. This means that some of the guest accommodation is mostly unoccupied in winter.

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

This figure, at less than 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 expected. However, the backup boiler 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 due to monthly servicing. 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 feasibility study.[6]



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 as follows: Oil: 350 kg/MWh, LPG: 323 kg/MWh and woodchips: 7 kg/MWh.[7] Using the date from the table on page 3 above, we can calculate the CO2 that would have been emitted had the biomass boiler not been installed:

[6] HWEnergy are located near Fort William. See www.hwenergy.co.uk.

[7] See http://www.biomassenergycentre.org.uk

Due to the use of oil in the Hall, CC and Residences: (92.82 + 60.27 + 32.1) x 350 = 64.817 t.
Due to the use of LPG in the Park Building and Laundry: (36.84 + 11.24) x 323 = 15.530 t.
80.347 t.

Note: the Hot Tub would not have incurred carbon emissions previously due to it being run on carbon neutral electricity from our own wind park.

Emissions due to the burning of woodchips over the year were: 469.1 x 7 = 3.283 t.
Emissions due to the burning of gas by the backup boiler were: 1458 l. @ 1.7 kg/l = 2.478 t.
5.761 t.

Therefore, the carbons savings due to the biomass installation are: 80.347 – 5.761 = **74.586 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 Bldg, 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 Foundation[8] (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 = **80.832 t.**

Conclusion

We can assume that the carbon emissions saved in 2011 lie somewhere **between 75 and 80 t**.

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, this is equivalent to taking 45 averaged sized vehicles off the road each year.

The RHI

The government has recently announced, after some years of consultation, that a *Renewable Heat Incentive* will become available in 2011 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 the FF

[8] See http://www.nef.org.uk

biomass boiler. Indeed the Foundation received a grant of £150,000 from Community Energy Scotland, without which the project would not have progressed beyond the feasibility study.

Installations that have already received grant funding will be eligible if and only if the grant is paid back, but only that component due to the boiler and boiler house – 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 £50,000. 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 x 328,500 + 1.9 x 121,500 = **£17,748 p.a.**

Over 20 years this will amount to about **£350,000!**