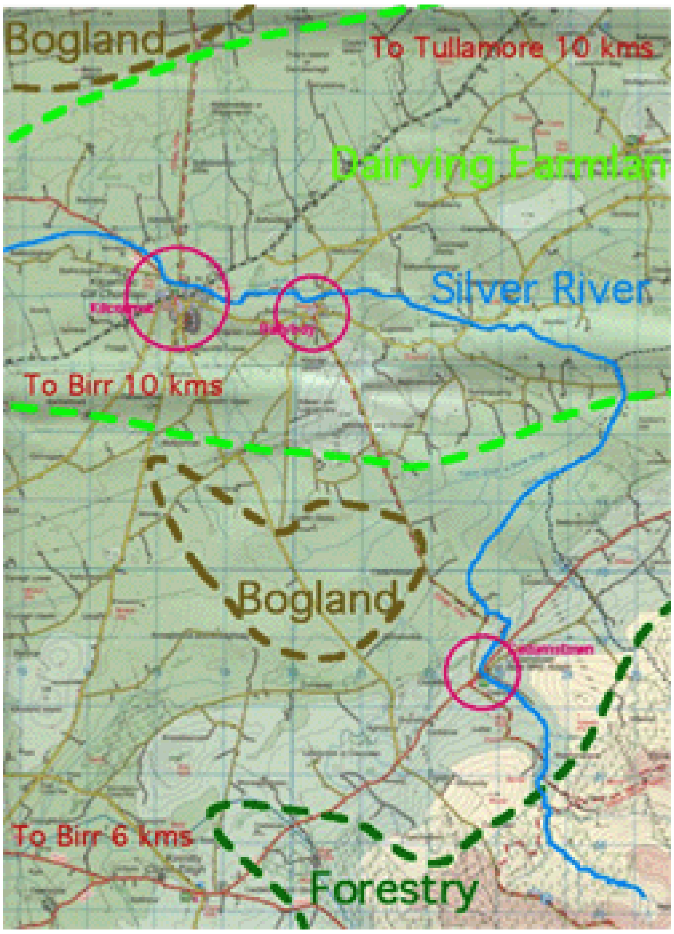
Chapter 3: Energy Options for Cadamstown and Ballyboy

This chapter explores whether it is legally and economically possible for Cadamstown, a not atypical rural community selected only because of a developer's plans for a hotel, hostel, health and fitness centre and business centre, 36 houses and other construction there, and its neighbour, Ballyboy, where another developer is planning to build over 60 houses and renovate the old mill and associated buildings, to meet most of their energy needs from their own financial and physical resources.

Figure 6.0 The energy resources of the Silver River catchment



The Case for Local Energy

One reason for wanting to supply almost all of both villages' energy needs from local sources is to minimise the drain on local financial resources that importing energy entails. Another reason is to provide a way in which those living in the area can invest in the development of their local resources – at present, there are very few ways in which they can do so and, if their savings are invested in the area at all, they are almost always used for property speculation. The most important reason, however, is that, in the past, as we have seen, the economic life and prosperity of the two communities was based on the energy supplied from the surrounding land and circumstances might be developing which could provide the opportunity for making this the case again. The looming shortages of oil and gas might mean that commercial activities will need to locate themselves once again in places where secure supplies of power are available at a predictable price. In other words, if Cadamstown and Ballyboy can offer the hotel developer and other commercial users of significant amounts of power a guaranteed supply of electricity and heat at a guaranteed price, they might be able to establish a competitive advantage over other locations and reverse their population decline.

The amount of money that can be profitably invested in developing the two communities' renewable energy resources depends crucially on the price of oil and other fossil fuels and on the rate of interest. Oil prices have moved up rapidly recently as Fig. 6.1 shows. Many people are beginning to think that, even if the very large sums the International Energy Agency states[i] will have to be invested to meet the annual growth in the world demand for oil and gas are found, the supply situation will be very tight and the cost of energy will therefore be even higher than it is today. This would make investment in renewable energy projects very attractive and we explore the relationship between energy prices, interest rates and the amount that it would be profitable to invest in Appendix 3.

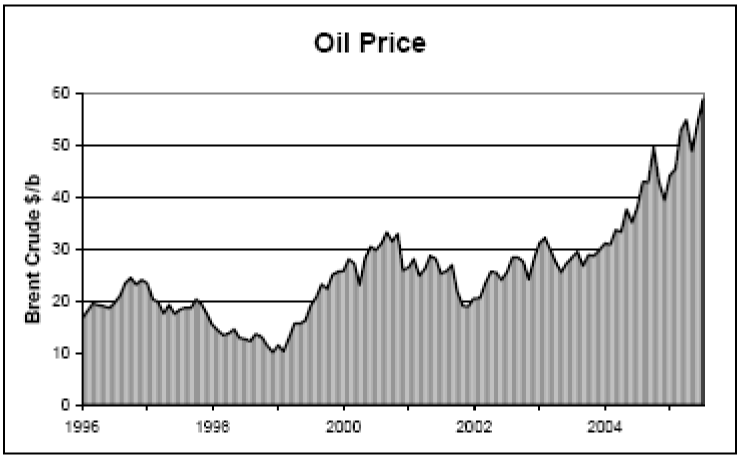


Fig. 6.1 Oil prices began to increase in 1999 and have done so consistently since apart from the period in which world economic growth paused after the dot.com investment bubble burst

Apart from sunlight, which is available everywhere, Cadamstown and Ballyboy have three possible sources of renewable energy. These are:

1. **Wind.** A turbine or turbines could be placed on the higher ground above Cadamstown. Sites in Ballyboy have good potential, too.

2. **Biomass.** The hills around Cadamstown have been planted with softwoods, some areas of which are being harvested at present. The waste and the thinnings could be chipped, dried and burned in a Combined Heat and Power (CHP) plant to provide both hot water and electricity. The farms near both villages could

supplement this forest waste by turning part of their acreage to short rotation forestry, miscanthus or to hemp, to sell as fuel. The worked-out bogs could be used to grow willow. There is also the possibility of their growing seed oil rape to power an electric generator or motor vehicles but this is not explored in this report. Because more animals are kept in the Ballyboy area than around Cadamstown, it has the potential for a biogas digester. The gas would be used to produce electricity and heat

3. **Water.** As already noted, the Silver River powered several mills on the stretch which runs from Cadamstown to Ballyboy in the past. While it would not be worth putting low-head turbines in each of the old mill sites, it might be worthwhile to take part of the water in the river down through a pipe from the pond behind an existing weir above Cadamstown to a high-head turbine at the foot of the Cadamstown hill. If this pipe was installed, and the turbine could also double as a pump (as turbines do elsewhere), it would be possible to store wind energy when that was in surplus by pumping water up to the reservoir and then generating power with it at times of peak demand.

Fig 6.2 Abandoned millrace, Ballyboy Fig. 6.3 The Silver River at Cadamstown

The management of energy demand and its supply from these multiple power sources would be complex and this chapter therefore explores the feasibility of setting up an Energy Services Company (ESCo) to undertake the task. The ESCo could operate (but not necessarily own)

1. A woodchip-fired CHP plant close to the projected hotel complex in Cadamstown and supply heat for space heating and hot water for washing etc. through its own network of insulated pipes and electricity through its own direct lines.

2. Cooling for a cold store in the Cadamstown hotel, or for a possible refrigerated food depot if this was financially worthwhile

3. A biogas digester in Ballyboy. This would supply a CHP plant that would send heat and electricity through direct lines and pipes as in Cadamstown.

4. A wind turbine at Cadamstown, and another at Ballyboy.
5. A woodchip and wood pellet production plant at Cadamstown to supply throughout the area. The chipper would be a €500,000 diesel-powered mobile unit which would be taken into local forests. Initially at least it would have much more capacity than required by the project so it would be offered on hire for use in other areas.

At a later stage the ESCo might operate

6. A high-pressure water turbine and pumped storage facility on the Silver River in Cadamstown.

7. A flow battery electricity storage system, possibly as an alternative to no. 6.

8. A plant at Ballyboy bottling digester gas for domestic use.

It would obviously be desirable to link the ESCo's direct line electricity systems in the two villages. Negotiations would be held with the national grid operator to work out the terms under which the existing wires between the two villages could be used.

Although a direct line system has, by law, to be linked to the grid (since, as we will see, an EU directive requires that every purchaser of electricity has to be able to switch suppliers), the ESCo's aim would be to minimise the amount of electricity it takes from the grid, buying only when the price (which will vary from half-hour period to half-hour period under the new electricity trading arrangements) falls below its cost of production or if demand exceeds its capacity, and selling only if the price is above its cost of production and it cannot either store the electricity via the pumped storage arrangement, sell it at a slightly better price to its direct line customers, or use it more advantageously in some other way. Juggling wind and CHP supplies (and possibly inputs from a water turbine and a flow battery too) with the use of the grid will give the ESCo operators enormously valuable experience for communities elsewhere.

ESCos elsewhere

Private or communally-owned ESCos are common in many parts of the world - and not just in urban areas. Austria has 25 years' experience with rural ESCos based on biomass-fired district heating systems (BMDH). There are now 900 wood-fired district heating systems in the country but the first was built by a sawmill operator in the village of Feldbach in 1979 and many of the 200-odd systems in place at the end of 1994 were in quite small communities. "Villages with BMDH plants usually have between 500 and 3,000 inhabitants and are of a predominantly rural character," says an EU-financed report[ii] *Pathways from Small Scale Experiments to Sustainable Regional Development* which looks at factors which affected the adoption of renewable energy technologies in four EU countries. "Accordingly, the size of BMDH plants varies between a few hundred kW and up to 8MW, with corresponding grids between 100 metres and 21 km. Almost two-thirds of the plants have a power of less than 1500 kW" the report goes on.

Figure 6.4 A village district heating system in Austria.

While most of the early plants were erected by people in the timber industry with wood-waste to burn, farmers with a few hectares of trees who had been selling wood as one of their sources of income forced their co-ops to move into district heating when saw-lumber and pulpwood prices collapsed in the 1980s. This was particularly true in those parts of Austria with the poorest prospects of developing alternative activities for the rural population in tourism or industry. In these areas, the farmers lobbied their state-level political representatives especially hard and persuaded them to make 35% capital grants and an equal sum in low-interest loans available to the co-ops. A large part of the rest of the plants' cost was then raised from the connection fees paid by the owners of the homes to be heated.

Even with grants and the farmers behind them, the co-ops found it impossible to get a district heating plant built in some villages either because many of their inhabitants distrusted the new technology or objected to the traffic or the chimney it would mean. In general, the villages in which plants were built were those in which a lot of community activities were already taking place. Where a co-op built a plant in the face of local opposition, the financial out-turn was often poor because, with a high proportion of people refusing to be connected, it had to build longer pipelines to sell its heat *"We noticed that all the villages [with plants] we visited were characterised by numerous local associations of villagers sharing such hobbies as music, sports, preparation of local events, or the planting of trees and flowers in the village streets. Common celebrations and good communications within the village were another characteristic"* the report says.

Community cohesion was not enough by itself, however. Idealism was needed too, from both a plant's promoters and its customers. *"BMDH is neither a very good business for the operators nor a cheap way to heat for customers"* the report says. *"What are the motivations of local actors to realise a project?"* Interviews in eighty villages showed that many promoters were concerned about the environment, wanted to improve forest management and believed that their plants might make an important contribution to autonomous regional development. Their customers participated because they were also concerned about the environment, wished to support local farmers and the development of their region, and also appreciated the time and work that centrally-supplied heat saved them.

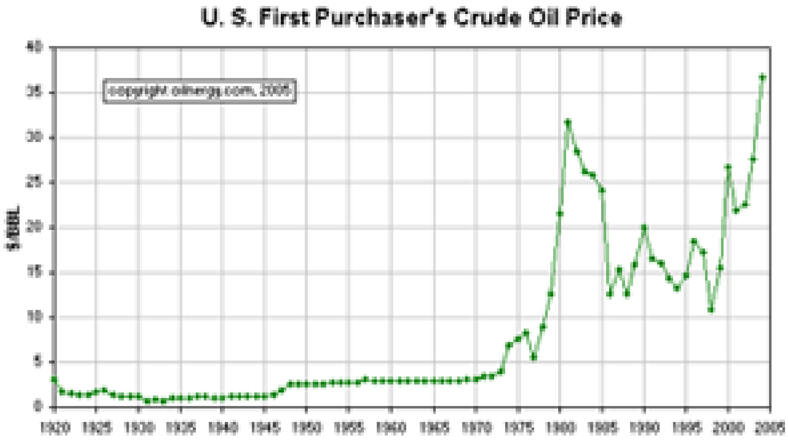


Figure 6.5 Crude oil prices have probably moved permanently into much higher territory. By June 2005 they had reach $60 a barrel. Similar prices were being paid for gas and coal.

It has to be remembered that the above comments on profitability were made at a time when fossil fuels for heating were very cheap. The Cadamstown and Ballyboy ESCo will be competing with oil-fired heating at $50 or more a barrel whereas the price of oil in the 1980s and early 1990s when the comment was made averaged around $15, as shown in Fig. 6.5 above. Another factor in the project's favour is that, rather than selling its electricity into the grid, it will be selling it direct to the consumer and will therefore be able to get close to the full retail price for it, should it choose to do so.

Financing and Ownership of Energy Assets

The ESCo's pricing policy will depend on how the generating equipment, direct line and heat pipes are financed. It is proposed that these assets should be owned by a Community Management Company in each village. If these CMCs were set up as normal companies, their shareholders would wish to set prices to maximise the return on their investments and would instruct the ESCo accordingly. On the other hand, if they were set up as mutuals – in other words, if each was owned by the people to whom the ESCo supplied energy in proportion to the amount of business they were doing with the company – their shareholders might well choose to set prices which just covered the operating costs and depreciation of the energy supply system, so that they took their profits in the form of cheap power rather than as a financial dividend. In this case, the availability of cheap power would add considerably to the value of their properties when they sold them, possibly giving them a greater capital gain than if they were to sell their shares in a non-mutual company.

Naturally, those buying into the CMC after the system is running can expect to pay more than the original subscribers for their share of the CMC's assets. This premium would cover the interest costs on the excess generating capacity likely to be installed when the system is set up. However, this is by no means the perfect solution although it is the one that will have to be used in Cadamstown and Ballyboy. What it fails to do is to capture for those who installed the energy system the full benefits of their actions. If the availability of a secure supply of moderately priced energy brings people and enterprises into an area and raises property values there, there is no way that those who created the higher values can capture a significant part of the monetary gain which arises when, for example, a site is sold, unless they own all the land and properties in the area. This makes the provision of renewable energy systems less attractive financially and will limit their development. As a result, energy prices will be higher and energy availability will be lower than would be the case if the energy producers, rather than passive landowners, reaped their due reward. And, in a world in which the supply of fossil fuels is going to be limited and the standard of living is closely related to the level of energy use, the fact that less renewable energy is available will make everyone materially less well off.

One remedy for this problem is for the local authority to develop an area's renewable energy resources by installing the equipment and local area pipe and wire networks on behalf of the whole community. It can then recoup, for the community, the gains in property values created by its action through a site value tax - if these were introduced - and through Section 49 payments, although, as the legislation now stands, the payments can only recompense the authority for the actual costs it has incurred. In the final section of this report, we recommend that local authorities should be prepared to play this role in future projects should the right circumstances arise.

Because the Austrian example shows the need for good community relations for an ESCo to do well, the authors of this report feel that the mutual road is the one that Ballyboy and Cadamstown should adopt, only raising finance from beyond the ESCo’s circle of customers if they were unable or unwilling to provide it. This report is written from that perspective.

Building type	Heating in buildings that are very energy efficient kW	Heating in typical buildings not up to Part L kW	Domestic Hot Water Instantaneous kW	Domestic Hot Water with 4000 litres storage kW	Electrical load	
					Peak kW	low kW
Hotel	42.8	107	270	20	52	26

Hostel	19	47.3	250	19	14	7
Business Centre	6.6	15.3	12	n.a.	8	2
Health Centre	62.5	125	375	28	35	15
Houses	154	307	n.a	n.a.	128	51

Figure 6.6 The Cadamstown project's energy needs. The space heating requirement will be half that of many modern Irish buildings which fall 10-30% below the standard set in Part L of the Building Regulations. The electrical load is not affected.

As the table shows, the Cadamstown hotel and hostel complex is likely to be ESCo's biggest single customer for the foreseeable future and smaller shareholders in the CMC might be concerned that it would use its votes to secure its power supplies at prices which effectively meant that smaller users were giving it a subsidy. This concern could be removed by writing a clause into the ESCo's Articles of Association requiring that the same price be offered to all customers.

Financing the power supply

The total cost to the CMCs of installing the power supply systems can be offset in part by the costs that the hotel complex and the householders would have to pay if they installed their own heating systems. Under the proposed arrangement, those purchasing properties in the new developments in both villages would pay an amount equivalent to the price of installing their own heating equipment to their local CMC in return for their shares. The sum raised this way would not be enough to cover the cost of providing the entire electrical supply system and the cost of the wind, water and flow battery elements of the latter would lead to extra money having to be paid by the purchasers of each property.

The sums involved could simply be added to the price of the properties as an extra item. The purchaser would borrow a little bit more to cover it on his mortgage, a very cheap form of finance. However, because the houses are to be built to a high standard in any case, particularly in relation to their energy use, the another addition to the purchase price might produce some sales resistance, If this is anticipated, the CMC will borrow itself and have the ESCo issue two-part bills, one to cover the actual cost of the energy used, the other to cover the period's repayment of the loan to install the electrical plant. A two-part bill would be issued because loan repayments are not liable to VAT. Once the loan had been repaid, only depreciation and the actual cost of producing the energy would be payable because the CMC would have no borrowings and no shareholders wanting a return on their capital. As energy prices rose elsewhere in the country because of shortages of oil and gas, these fixed, low prices should make both the hotel complex and the houses extremely attractive to investors and new purchasers.

Even though they will be shareholders in their local CMC, the initial purchasers of the houses are likely to want to know how easy it would be for them to put in their own heating systems if the supply from the district heating plant became too expensive, broke down frequently, or ceased because the CMC got into financial problems. It will be necessary to assure them that switching to an independent heat supply would be easy as they would only need a furnace to produce hot water and that the place where the district heating pipes entered their house had been selected to suit such an installation. They will also need to be assured that they will be able to opt for an outside supply of electricity and, as mentioned elsewhere, their right to one has to be provided by law.

Cadamstown's potential for energy production from biomass

The land to the south of Cadamstown rises steeply into a low mountain range. Some land on the lower slopes is used for cattle grazing, but mostly for sheep. The higher land is mostly mountain grazing and forestry. The land to the north, east and west is fairly level ground, but is mostly heavy and not very productive. Both cattle and sheep are raised. There is an area of bog to the north. The farms are fairly small and the numbers of cattle housed are few.

The forest is mostly owned by Coillte. This is beginning to be harvested but there is a significant amount of forest that is privately owned, and some of this is ready for thinning. The forest residues from roughly 3 acres of harvested forest would be required each year to fuel a biomass boiler sufficient to provide 550kw for the base heating requirements for the energy efficient houses, hotel, hostel, business centre and leisure centre, planned for Cadamstown. This should be easily achievable in the area around Cadamstown.

If a willow system is used to purify the waste water from the development the willow will require harvesting every three years. To utilise this amount of material on its own for biomass fuel would not make sense. However because there would already be a chipper and the biomass boiler available, the willow produced by such a sewage treatment system could be utilised for energy. The food waste created by the development and by the other existing residences in Cadamstown could be collected and transported to the neighbouring community of Ballyboy, where and anaerobic digester facility is proposed.

Ballyboy's potential for energy production from biomass

The land in and within a four mile radius of Ballyboy is gently undulating and is good farm land. Farming is mixed, cattle and arable. The cattle farming is mostly beef rearing utilising bought-in stock, but there are also some suckler herds. The cattle are kept in for about 5 months in slatted houses during winter and out in fields during summer. Stocking rates would be fairly intensive at 1 LSU (livestock unit) per acre. The average farm size for beef cattle is 75 acres. The farm size range in the area would be from 30 to 400 acres. Most arable farms would be amongst the larger farms.

To provide the heat required for the 60 houses (together equivalent to 57kw average demand) by using the spare heat (after process requirements) produced from an electrically-efficient CHP burning biogas would require a 800 cubic metre digester. The feedstock for the digester would require 28 tonnes/day of slurry. This would come from 1200 livestock units of cattle kept inside for 5 months a year. In addition, 4.75 tonnes/day of food and the sewage sludge produced by 2,400 people would be requiired although other feedstocks such as food processing waste could be substituted.. Many more than 1,200 cows are kept within a 4 mile radius of Ballyboy. Although Ballyboy and Cadamstown combined would have a population less than required for the sewage sludge, Tullamore is sufficiently close to provide the food or food processing waste.

The CHP plants - 1. Cadamstown

A choice has to be made at Cadamstown between two possible approaches to CHP. One is to burn the woodchips in a gasifier, the gas from which would be used in an internal combustion engine which would turn a generator. The waste heat from both would be used to supply hot water both for space heating and for washing purposes. The other approach is to burn the chips in a conventional boiler which would produce the hot water directly. Some of the heat from the boiler would, however, be used by a Stirling engine which would turn a generator to generate electricity. Stirling engines are based on the Stirling cycle in which an external heat source expands a fluid or gas which moves a piston which turns the shaft of a generator. Unlike internal combustion engines, the gases used inside a Stirling engine never leave the engine and no explosions take place. Because of this, Stirling engines are very quiet.

Figure 6.7. This Austrian-built Stirling engine powers a generator capable of producing 75kW of electricity. The heat output from both generator and boiler is 500kW.

Although the project has not made a final decision which option to take, we tend to prefer the Stirling engine approach on the grounds of its reliability, high efficiency, low noise and minimal vibration. In addition, the use of a Stirling engine enables the amount of electricity being produced to vary within a wide range. For example, if the wind was blowing and there was plenty of electricity from the wind generator, it would be possible to shut the Stirling engine down, thus conserving heat in the boiler and limiting the quantity of wood chips being burned to that required for heating purposes. (Wood chips are the sole variable cost element in the whole system). If little heat was needed, but electricity demand was strong, the boiler could be run almost entirely for the Stirling engine. With a gasifier, neither option is available because the amount of electricity generated is closely linked to the heat output. We have therefore assumed the use of a boiler/Stirling engine combination in the following discussion.

Estimated heat demand for development in Cadamstown

It is assumed that

1. a hot water storage system will be installed of 4000 litres capacity to meet the peak demand for hot water from all the establishments on the development
2. the swimming pool will be used as a balancing factor in heat demand as well.
3. the hot water demand is assumed to be 20% higher in summer than winter, but the space heating demand is assumed to be 60% of winter levels in the summer (this is higher than usual because the houses are thermally efficient and domestic hot water demand is about 80% of the heat demand/house)
4. the domestic houses will have independent control over their space heating and hot water supply, and will be energy efficient at 5-7kWth and 1.4kWe
5. all public spaces will have independent control over space heat but utilise the central heat store for hot water provision

- 36 energy efficient houses = 214kWth and 50kWe
- 1 small hotel (60 beds) = 127kWth and 26-52kWe
- 1 hostel (60 beds) = 67kWth and 7-14kWe
- Business centre = 16kWth
- Leisure centre including 360cu m swimming pool = 153kWth and 15-35kWe
- Winter heat demand space heating only = 510kW
- Summer heat demand for space heating = 300kW
- Hot water demand in store is 67kW in winter and 80kW in summer

Heat demand in houses and the hotel will fluctuate considerably throughout a 24-hour period and during the year. Biomass boilers operate most efficiently when used consistently and are therefore usually sized to the base load. This would be considerably lower than the average heat requirement. However because there is a swimming pool included in the development, its water can be used as a heat dump when building heating requirements are low, and therefore be used to even out the demand cycle. For this reason the biomass boiler for the development at Cadamstown has been sized at 500kW.

A Stirling engine operates at either 20% electrical output with 60% heat output or up to 80% heat output and no electricity output. It is assumed that in the winter nearly all the energy required for hot water will be provided by the wind and by a solar thermal array on the hotel roof but in the summer, the energy will come mostly from the heat from biomass. In the summer the Stirling engine will operate producing electricity most the time and in the winter mostly heat. Therefore the equivalent of a 500kW biomass boiler is required

The CHP Plants – 2. Ballyboy

The 60 houses planned by the developers in Ballyboy will have a combined energy demand of approximately 1800 kWh per day. To provide this using the spare heat (after process requirements) from an electrically efficient CHP would require a 800 cubic metre digester. The feedstock for the digester would require 28tonnes/day of slurry produced by 1200 livestock units of cattle kept inside for 5 months per year and 4.75 tonnes per day of food and sewage sludge produced by 2,400 people although other feedstocks such as food processing waste could be substituted. Many more cows than this are kept within a 4 mile radius of Ballyboy and Tullamore is sufficiently close to provide the food or food processing waste required.

Figure 6.8 Biogas digester at Tullamore

Fig. 6.9 A slurry delivery to a Co. Kilkenny biogas digester of a comparable size to that planned for Ballyboy

The gas from the digester could either be used to run a gas-engine powered generator and the waste heat used for hot water and space heating purposes, or, as at Cadamstown, it could be used directly to heat water and to provide heat for a Stirling engined generator. This latter arrangement would give maximum flexibility, particularly as it would be possible to store some of the gas. However, if a gas-engine was used, as the heat demand in housing varies throughout the day and during the year, a balancing use for any surplus heat is desirable such as ground heating for a polytunnel. There should be no excessive peak demand for space heating even in winter and hot water demand should remain constant. The peaks of heat demand in winter would be met by a fossil fuel boiler although the digester would be used to meet the majority of the heat demand, rather than just the base load.

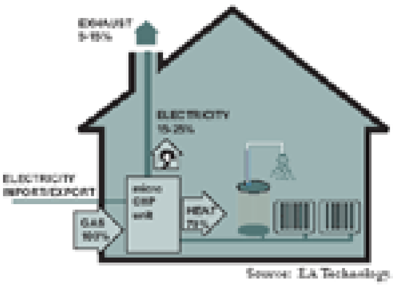


Figure 6.10 Only 5-15% of the energy in gas is lost with Micro CHP

Although a centralised CHP plant is almost certain to be used, if the direct line system encounters electricity regulatory problems the project intends to explore the possibility of having installing a gas-grid in Ballyboy rather than a hot water and electricity one. Each house would then have a mini-CHP plant. Gas would be piped to the unit and burned in an internal combustion engine that turns a generator to produce electricity while the heat exhausted by the engine is used to provide space and water heating in the house. Modified car engines can be used and Honda is currently developing a 1 kW CHP system for the Japanese residential market. A pilot is being tested in the UK too. This system will have a 20% electrical efficiency and a system efficiency of over 80%. In Europe, reciprocating engine systems of around 5kWe are widely used for small apartment buildings and other multi-family dwellings. Units made for individual houses can be housed underneath the sink, hanging from a wall, or outside.

Several European utilities are currently demonstrating such units. In order to keep the cost low, they have developed a very simple system with minimal heat exchangers and thus low electrical efficiency. However, in higher value applications, electric efficiencies of more than 40 % and system efficiencies of more than 95 % have been achieved. In the US, it is said that bigger homes, higher energy costs, volatile fuel costs, recent electricity blackouts, and increasing concern over the environment have opened the door for micro-CHP. RKS, a leading US market research firm, found that more than 38% of high-income households, (i.e., incomes > $50,000) were interested in generating their own electricity.

Stirling engines are also being tried for domestic CHP as they offer lower levels of vibration. They are, however, more expensive at present. Commercial Stirling micro-CHP packages cost around €2,000/kW (thermal + electric) compared to €1,000/kW or less for Internal Combustion Engine CHP packages. In Britain, Powergen, a major generator and distributor of electricity, has been running trials with its WhisperGen Stirling-engined CHP plant in 400 houses, which sell any surplus electricity they generate to Powergen through the grid. It announced in 2005 that it plans to instal 80,000 systems over the next few years and thinks that half the houses in the UK have the potential to usde them. If they did, a spokesman told the BBC, they would have the same generating capacity as Britain's nuclearrstations. Theoretically, Stirling engines should have very high availability and reliability. Service intervals of between 3,500 and 5,000 hours (equivalent to over one year's economic operation) are claimed for current models. We are, however, not convinced of the longevity of the units (some are given only a six-year life) and tend to the view that a centralised plant would be the better solution if it is legally possible to take it. We review the legal position on direct line systems below.

Another possibility would be to use clean, compress and bottle the gas so that it could be sold for domestic use in the area or used to power vehicles. The technology for bottling biogas has been developed by Methanogen in England.

2. Wind Potential

Figure 6.11 The ENLIVEN area wind resource

The wind potential in the Cadamstown/Ballyboy area is excellent. Figure 6.11 is a wind resource map of the project area. Location 1 (marked by an "x") is that of the Cadamstown development project, and Location 2 is that of the Ballyboy development. According to the Irish Wind Atlas, both locations have annual average winds at different heights as summarised in the table below.

ENLIVEN area wind speeds

	Annual average wind speed (m/s)		
Location	**50m height**	**75m height**	**100m height**
Cadamstown site	**6.75 – 7**	**7.5 – 7.75**	**8 – 8.25**
Ballyboy site	**7 – 7.25**	**7.5 – 7.75**	**8 – 8.25**

The table suggests that a wind turbine on a 75m tower at either location would have a load factor (average output) of about 35% (of its rated power). For example, a Vestas V52 wind turbine on a 75m tower at either location will have an average output of about 300kW, resulting in the production of 2.5 million kilowatt-hours of electricity annually.

Figure 6.12 – View from the Cadamstown wind turbine site

The preferred option for harvesting the abundant local wind power in the area is the use of a single large commercial wind turbine at each site, operating as an “autoproducer” in conjunction with a “mini-grid”. The only other approach for harvesting wind power at the two sites would be to use small grid-connected domestic turbines. Once again, however, there are no small turbines operating on this basis in Ireland, and the legal possibility of doing this is being investigated by Sustainable Energy Ireland. Also, there are few small grid-connected machines on the market. Small battery-charging turbines would not be recommended for either project, as the extra capital cost per unit generated makes its electricity more expensive than that from a larger turbine.

Economic analysis of an 850kW wind turbine operating as an autoproducer

A detailed spreadsheet model has been developed for the analysis of the wind turbine being installed as an autoproducer at Dundalk Institute of Technology.[iii] This model has been adapted to take a preliminary look at the Cadamstown and Ballyboy sites. It assumed that half of the electricity produced would be exported to the grid, where it would be bought at low cost by a green electricity company such as Airtricity.

The total cost of the turbine installation will be about €1.2 million. Annual operating costs (insurance, maintenance contract, rates, operating costs, etc.) are about €30,000. The project receives an annual income from sale of electricity to the grid of €62,500 (€0.05/kWh), and an annual income from customers of €125,000 (€0.10/kWh). The total net annual income is therefore €157,500, and the project pays for itself in 7.6 years. If the customer demand is higher the project becomes more economic and vice versa.

It is also possible that a flow battery storage unit (see below) could be installed as part of the project. The purpose of this storage would be to store valuable wind-generated electricity at times when it otherwise would have been exported to the grid. Preliminary investigations suggest that such storage would at least not disimprove the payback time of the wind project.

3. Water Power

Whether the water turbine is worth installing depends on the pattern of energy use. Because of the cost of the wood chips, the CHP plant is going to be the most expensive part of the system to run and, ideally, it should only be used to the extent that heat is required. Any electricity beyond the amount generated along with the heat should, if possible, come from the wind or a water turbine. For example, little electricity and heating is likely to be required on a summer's night. This might make it desirable to shut down the CHP plant entirely as it would operate at low efficiency because of the low electricity demand and use power from the wind turbine instead. If the wind was not blowing and a water turbine was available, that could be run to avoid bringing power from the grid, even though that would be cheap at night. Similarly, it might be desirable to use the water turbine system for pumped storage - as a way of storing wind-electricity which Cadamstown does not need rather than feeding it into the grid at a low price. This electricity could be recovered later and used to replace that from the CHP plant on occasions when the heat is not needed as well, or sold into the grid at a high price when demand in the local area around Cadamstown was high and the supply to the area needed strengthening. In short, adding the water turbine to the system would give the ESCo more production options and, even though the cost of installing the water turbine is high in relation to its output, it might still be worth carrying out because of the savings it enabled in the operation of the CHP plant, or the sales to the grid it permitted. Only after the CHP plant and wind turbine are installed and their outputs known in relation to demand and the price of power from the grid will it be possible to calculate if the turbine would be a worthwhile investment.

4. Flow batteries

Several flow / redox battery types are under development at present and some are on the verge of commercialisation. Their key feature is that the energy is stored in charged electrolytes outside the cell. This enables the "power" function - determined by the size and number of cells - to be separated from the "energy" function, which is determined by the volume of electrolyte available. Flow batteries can therefore be built with a much greater storage capacity than most other battery types. The inert electrodes mean that flow batteries have a very long life. A calculation will have to be done to see if the possession of a flow battery would enable the system to make significant savings by avoiding buying electricity from the grid at expensive times, or by selling power to the grid when the price was exceptionally high. As with the water turbine, will be impossible to make this calculation until

1. the new 'gross mandatory pool' electricity market arrangements come into effect and have settled down so that the peak power prices and their frequency are known, and,

2. the demand and supply patterns in Cadamstown and their peaks and troughs have become known.

Flow battery technologies and prices should both improve in this period. It will be interesting to see whether, with a grid connection, either form of electricity storage (pumped storage or flow battery) will be economic in Cadamstown's circumstances and, if so, which is the least-cost option.

Other storage technologies

Electricity could also be stored in the batteries of a fleet of electric vehicles. The project therefore needs to investigate whether the ESCo should operate a fleet of electric cars and a minibus on a car-pool basis as is done at BedZed. These vehicles would be hired by the hour to hotel guests and to the occupants of the houses. Their availability would do two things. One is that it would make living in Cadamstown and working in, say, Birr or Tullamore, much more sustainable when liquid fuel prices are very much higher than they are today. The hotel would be able to use the minibus to pick up guests from say, the railway station or the nearest Expressway bus stop, something which could be important for its survival if people have to do without cars as fuel prices rise. The second advantage is that a fleet of electric vehicles would provide a demand for electricity at night while they were being charged. By enabling more electricity to be sold at a slightly better price than to the grid, this extra demand might enable the ESCo to offer lower prices at other times.

Supplies outside the development areas.

In both villages, the ESCo would seek to connect existing properties to its heat and electricity grids. Those being connected would have to pay a capital sum equivalent to that being paid by the purchasers of the new properties so that they, too, owned shares in the CMC. The two-part bill arrangement would enable them to buy in painlessly, particularly as, even with the loan repayment element, the energy they were buying from the ESCo would cost no more than they would have paid to their previous suppliers.

Existing residents signing up to use the ESCo in the planning stage would present few problems but the major aim of the project is to make Cadamstown and Ballyboy attractive locations for manufacturing, horticultural and other businesses requiring sufficient quantities of heat and electricity to warrant them moving or establishing themselves in either village. Every effort will be made to identify such businesses while the project is at the planning stage too because it will enable their energy requirements to be met at least cost simply by increasing the size of the CHP units and, possibly, the wind turbines,

Until oil and gas prices rise significantly above present levels, however, many firms will prefer to stay where they are and the CMCs will therefore have to decide whether they should build extra capacity into the systems to cater for those who relocate in later years. They may also wish to offer heat and electricity to the builders of houses being constructed later on too. If they decide to put in the extra capacity, to accommodate companies that relocate they should probably secure sites near the CHP plants so that they have space to sell or lease for business use. Naturally, those buying into the CMC after the system is running can expect to pay more than the original subscribers or their share of the CMC’s assets. This premium would cover the interest costs on the excess generating capacity.

Apart from linking new and existing properties to its supply networks the ESCo will wish to use its mobile wood chipping equipment to supply customers outside its heat supply area as well as for meeting its own needs. It will therefore seek to win contracts to build and operate wood-chip-fired CHP plants within a 30km radius of the two villages. The wood chips produced in the forests will be brought into either Cadamstown or Ballyboy to be dried with surplus heat from the CHP plants before being sold, thus making good use of the heat. The ESCo will also use the chips to make wood pellets to supply to houses beyond the range of its piped heat supplies. Small-scale pelleting machines are available from Swedish Power Chippers AB capable of producing 300kg of pellets per hour. The machines are designed for 24 hour operation so the smallest machine has an annual production capability of 2000 tonnes. A typical cost for a fully installed and commissioned system 'pellet factory' is said to be between €115,000 and €140,000 depending on the specification.

Fig. 6.13 A 300kg per hour pelleting machine

At present, there is only one plant in Ireland producing pellets. This is the Balcas CHP and pelleting plant in Co. Fermanagh which uses sawmill and timber processing waste and is building up to an output of 50,000 tonnes per year. At the moment, however, until its market builds up, it does not have adequate outlets for its pellets and has agreed to sell two 25,000 tonnes batches to conventional power stations to be burned with other fuels. This is obviously a waste of a premium fuel. Balcas currently supplies pellets in the Republic at €150 per tonne plus VAT delivered. Each tonne of pellets has the calorific value of 500 litres of kerosene which would cost roughly €300 plus VAT delivered at the prices ruling in rural Ireland in August 2005.

Wood pellets are almost exactly equivalent to oil as a source of heat since they can be delivered from a tanker to a hopper by being blown through a pipe. They can then be transferred automatically into a furnace via an auger which can be thermostatically controlled. Moreover, oil-fired boilers can be converted to pellets, as Fig. 6.14 shows.


Fig. 6.14 Retrofitted oil-fired boiler


Fig. 6.16. A domestic pellet stove. The pellets are placed in a hopper under the lid. No chimney is needed.

The ESCo would attempt to build a market for pellets in its own area by advising on and supplying suitable stoves. The advantage of getting into pellet production on this small scale is that it allows the ESCo to enter the market at a relatively low capital cost. The electrical power required by the pelleter is low and it would be possible to run it, and the wood chipping equipment, when the ESCo had a surplus from the wind turbine and the CHP plant combined. Moreover, the heat required to dry the wood chips and cure the pellets could be provided by the CHP plant.

Supplying Electricity Through Direct Line Systems

No legal or technical problems are expected to arise over the ESCo's supply of heat and hot water to the hotel complex and old and new houses in Cadamstown as systems such as the one run by Dublin Corporation in Temple Bar, Dublin have been operating successfully for some years. The project would, however, be a pioneer as far as the direct line supply of electricity is concerned. No direct line systems are in operation in Ireland yet and the legal possibility of having them is being investigated by Sustainable Energy Ireland.

However, the Commission for Energy Regulation (CER) has to permit their establishment under the 2003 European Directive 2003/54/EC on the common rules for the internal market in electricity. Article 22 reads

> ***Direct lines***
> *1. Member States shall take the measures necessary to enable:*
> *(a) all electricity producers and electricity supply undertakings established within their territory to supply their own premises, subsidiaries and eligible customers through a direct line;*
> *(b) any eligible customer within their territory to be supplied through a direct line by a producer and supply undertakings.*
> *2. Member States shall lay down the criteria for the grant of authorisations for the construction of direct lines in their territory. These criteria must be objective and non discriminatory.*
> *3. The possibility of supplying electricity through a direct line as referred to in paragraph 1 shall not affect the possibility of contracting electricity in accordance with Article 20.*
> *4. Member States may make authorisation to construct a direct line subject either to the refusal of system access on the basis, as appropriate, of Article 20 or to the opening of a dispute settlement procedure under Article 23.*
> *5. Member States may refuse to authorise a direct line if the granting of such an authorisation would obstruct the provisions of Article 3. Duly substantiated reasons must be given for such refusal.*

From 19 February 2005, an eligible customer has been anyone whose electrical demand is 0.1 kilowatt hour. Article 20 requires the CER to ensure that the operators of a direct line have to provide third party access to it at a published, non-discriminatory price, unless there are capacity constraints. In other words, anyone obtaining electricity through a direct line must be given the option of buying it from someone else. This is confirmed by clause 8 of Article 3 which says

> *Member States shall ensure that the eligible customer is in fact able to switch to a new supplier.*

Effectively, the customer has to have access to the grid, either indirectly through the ESCo's connection, or, as in Woking, (see case history in next chapter) through a separate set of wires. If the connection was through the ESCo, and its former customer had opened an account with an outside electricity supplier, the ESCo would have to buy in electricity on its former customer's behalf at times when it was supplying electricity to the grid itself at a much lower price. No doubt this situation could be handled but it would entail a lot of trouble for a small sum of money. Installing a second pair of wires so that the former customer can make his or her own direct connection to the grid would seem to be a better solution as the cost of these wires would be minimal if they were laid at the same time as those for the ESCo's supply. It would not be necessary for ESB Networks to put in its meter and to connect that to the customer's fuseboard unless and until he or she had decided to cease buying from the ESCo.

The real problem might be elsewhere in Article 3 which says, in clause 8, that

> *Member States may decide not to apply the provisions of Articles 6, 7, 20 and 22 insofar as their application would obstruct the performance, in law or in fact, of the obligations imposed on electricity undertakings in the general economic interest and insofar as the development of trade would not be affected to such an extent as would be contrary to the interests of the Community. The interests of the Community include, amongst others, competition with regard to eligible customers in accordance with this Directive and Article 86 of the Treaty.*

In other words, the CER has the power to prevent a direct line system if it decides that it is not in the national economic interest. In the past, the CER has been criticised for behaving as if the ESB's and Eirgrid's interests were the national interest and there is a serious risk that it will not support the direct line systems this project proposes in the belief that to do so would establish a precedent which would undermine the national grid structure. In other words, the CER has the power to prevent a direct line system if it decides that it is not in the national economic interest.

However, the CER has a limited brief and thus a limited view of what is, and is not, in the national interest. The government on the other hand has the responsibility of looking at the bigger picture and it would be a serious matter if it did not direct the CER to permit the development of direct line systems since, without them, small-scale renewable energy plants are unlikely to be set up in large numbers. This would deny thousands of rural people the opportunity to develop the resources of their areas. It might even be unconstitutional to prevent these developments, and the incomes they would bring, since Article 45, Clause 2(v) of the Irish Constitution states "*That there may be established on the land in economic security as many families as in the circumstances shall be practicable.* " Financial viability is not enough. As Appendix 9 makes clear, a great many jobs could be created if small-scale, community-based energy projects became practically possible throughout the country. Moreover, preventing the local supply of locally produced electricity is likely to damage Ireland's international competitiveness since local systems will only be established in places where they can supply power more cheaply than can the national-grid-based system.

The CER's powers to block the Cadamstown/Ballyboy development go far beyond preventing the use of a direct line system – it could, if it wished, prevent any electricity generation at all unless one was prepared to break the law and then attempt to get the law changed by exposing the CER's policies to ridicule in the courts. The CER has the power to block any generation under the Electricity Regulation Act, 1999, which sets out the different types of license that it may or may not decide to grant. These are:

1. Authorisation to Construct
Anyone wishing to construct a new generating station or reconstruct an existing generating station must obtain from the CER an 'Authorisation to Construct' under Section 16 of the Act.

2. Licence to Generate Electricity
Under Section 14 (1) (a) the Act the CER has powers to grant, or refuse to grant, a

Licence to Generate Electricity.

3. Licence to Supply Electricity
There are two classes of ‘Licence to Supply Electricity’ relevant to this project which the CER has powers to grant, or refuse to grant:

1. A licence to supply eligible customers, under Section 14 (1) (b) of the Act
2. A licence to supply all final customers with electricity produced from “green” sources, under Section 14 (1) (c) of the Act.

Getting a Grid Connection

Besides being necessary to meet the requirements of the EU Directive, a grid connection is advantageous because it enables larger wind turbines to be installed - most turbines on the market are rated in excess of 500kW. It also provides the ESCo’s customers with a greater security of supply and creates commercial opportunities for the ESCo itself, allowing it to sell into the grid when prices are high and buy from it when prices are so low that it is not worth running its own equipment. However, opposition to the direct line system may be enough to cause ESB Networks to refuse or delay a connection. And, even if this is not the case, it is at present difficult to secure a grid connection agreement for any renewable energy project. For example, the Camphill Community in Ballytobin, Co. Kilkenny, is having to burn off surplus gas from its biogas digester as it cannot use its gas-fired generator to turn the energy in the gas into electricity to sell into the grid.

If these problems can be ironed out, the fact that Rhode, Portarlington and Ferbane ESB power stations are near the two villages suggests that it should be possible to use the grid as a back-up to the communal generating facilities even though the three stations are now closed. The nearest transmission grid 38kV substation is at Lumcloon, and is associated with the Ferbane station. It is 17km from Cadamstown and 12km from Ballyboy. The distribution grid serving both areas has rather old 10kV lines and a study would have to be done by ESB Networks to determine what level of back-up supplies and of wind generation it could accommodate. It is likely to be less than 1 megawatt at either location, but this will increase when the grid is upgraded to 20kV as is happening countrywide

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[i] *World Energy Outlook*, 2004.
[ii] *‘Express Path’* Summary Report, CEC Contract No. EV5V-CT92-0086, March 1995. The technologies are biomass use in Austria, Denmark and Greece, windpower in Denmark, and solar heating in Greece and Austria.
[iii] L. Staudt, *Wind Turbines as Autoproducers*, European Wind Energy Conference, Nov. 2004