Stewart Island

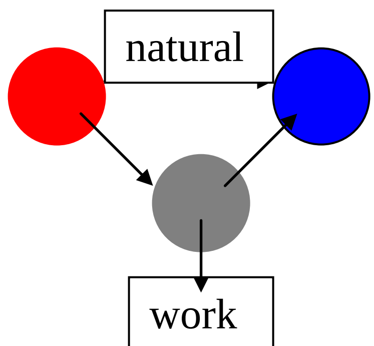
A G Williamson

As an introduction I guess my task is to remind you of some of the questions that need to be asked about sustainable energy and of the range of potential answers and in the expectation that the following contributors will provide more detail on some of these. This is based on the things that are happening round the world and my view of which of these are potentially applicable to Stewart Island

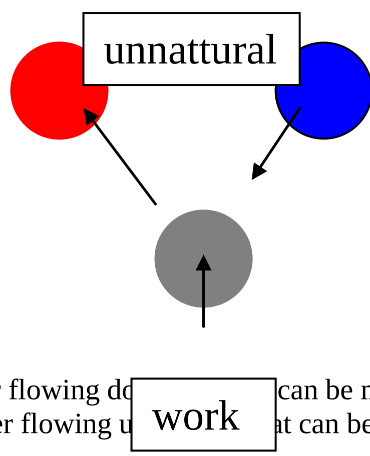
I know that the matter of energy supply for the Island has been the subject of a number of studies over recent years so I ask your forgiveness if at times I may seem to be teaching my grandmother how to suck eggs.

As an ex academic I do like to go back to fundamentals so bear with me as I start with a little bit of thermodynamics. Two important aspects of energy systems are

1) Any process that will take place of its own accord (a "natural" process) can be made to produce mechanical work if we can divert the process through a suitable mechanism



2) conversely an "unnatural" process (that would not occur of its own volition) can be made to take place if we can devise a suitable mechanism and supply an appropriate amount of energy



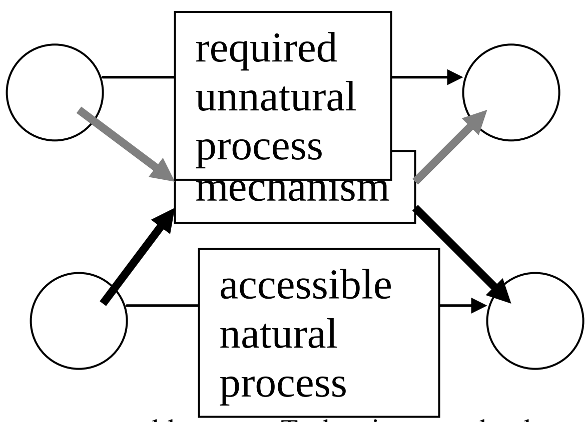
Examples ;
1) A natural process is water flowing d can be made to generate electricity
An unnatural process is water flowing u t can be made to occur with a pump that consumes energy

2)A natural process-heat going from hot to cold, can be made to produce work as in a steam engine.

An ununnatural process-heat going from a cold place to a hotter place can be made to happen with a heat pump that absorbs work as in a refrigerator or space heating heat pump.

A second aspect of thermodynamics is that if the work is obtained from a heat source not all the heat can be converted to work

An eminent thermodynamicist (Myron Trybus) once asserted that any process could be reversed if one could devise a suitable mechanism and provide enough energy. In effect one has to couple the unnatural process to the natural one via an appropriate mechanism



(When asked how to unscramble an egg Trybus is reputed to have said “simply follow the rules. In this case I would feed it to a chicken”)

A great deal of modern engineering consists of devising mechanisms to couple natural processes to drive unnatural ones that we find useful

In many of the things we do the accessible natural process is the combustion of a fossil fuel (coal or oil) and the mechanism involves the generation of electricity and its use to drive various devices such as pumps heaters refrigerators and vacuum cleaners. In many societies the use of electricity as an intermediate for transmitting energy from a source to a user is almost universal. (and we tend to forget that it is not the only way)

For a long while our major source of primary energy was the combustion of coal, oil and natural gas in large central electricity generating stations. In communities such as Stewart Island the primary conversion is Diesel generators running on imported fuel.
(6 Diesel generators providing for peak power of about 500 kW and an average of about 150 kW and costing about $500 000 pa for fuel to run). The potential problem with this is that fuel is bound to increase in price and supply become less reliable in future

The response to this is to become more self sufficient.
(and incidentally produce less greenhouse gas emissions). This is a trend that is happening world wide and numerous technologies have been and are being developed to harness so called renewable energy.

The options are

Solar: Thermal high temp – power generation
Thermal low temperature - water heating direct indirect
Photovoltaic
Biomass anaerobic digestion – methane
gasification – Fischer Tropsch liquids
Hydro
Wind
Wave
Ocean thermal gradient
Osmotic
Geothermal
Tidal Barrage
Current
Of these all but Geothermal and Tidal are traceable back to solar energy

Of these the ones that might be applicable to Stewart Island are

Solar: Thermal low temperature - water heating direct indirect
Photovoltaic
Biomass
Hydro
Wind
Wave
Tidal Barrage
Current

Of which the ones that are "fully developed reliable technologies" are

Solar: Thermal low temperature - water heating direct indirect
Photovoltaic
biomass
Hydro
Wind

although
Wave and
tidal current
are on the way

When we go from sources that generate from stored fuel to natural sources we run into another characteristic

Most natural energy sources are intermittent and variable in ways that do not match up with the times we wish to use energy. The answer to this problem is storage. In large distributed systems covering a range of time and weather zones (USA Europe) this is partly overcome by the averaging effect of the size and geographical distribution of sources and uses. In smaller systems The “problem” can be overcome with storage. We are already familiar with this in the case of hydro power in which the intermittent rainfall is dealt with using storage dams. On the smaller scale we already use storage to offset intermittency in the use of solar energy to provide hot water by installing a collector and storage cylinder that that are sized to cope with the variability of input and output. The information required and the plant required in these two instances are quite different. In the first case we need an extended system and a distribution grid. The second case can be implemented on a house-by-house basis but we need local information on when the sun shines and how much and when and how much water we want so that we can match the collection, storage and delivery systems.

A particular problem for solar systems and renewable electricity distribution systems is that God didn’t give us simple buckets in which we can store large quantities of photons or electrons. If we want to store solar energy we have to convert it into some other form for storage.   Heat is not bad for shortish periods (heat leaks).High temperature thermal storage is beginning to be used with large solar thermal power stations using molten salts essentially, for overnight use. For longer term storage there are several options being used. In Germany and USA there are a couple of large scale compressed air storage systems in which excess electricity is used to compress air into large underground caverns in salt domes. The compressed air is used as required as the air feed to a gas turbine burning natural gas. In effect one is using a gas turbine with free electrical compressor to yield a very much higher (near 100%) efficiency of conversion of the gas thermal energy to electricity. Another option is so called pumped storage in which water is pumped to an elevated storage lake using excess power and is recovered via a hydro generator as required chemicals are better and you will hear about one form (Hydrogen) from Alistair Gardner. In every case there is a price to pay namely that the energy recovered from storage will be rather less than the amount initially collected.

The likely options for Stewart Island are pumped storage in conjunction with wind and PV, electrochemical chemical storage in batteries or chemical storage in conjunction with electrical generation and fuel cells.

Renewable energy systems are usually more capital intensive than fossil based systems

Stewart Island has developed a local energy system based on diesel fuel burning electricity generation for a small scale grid and and coal and wood burning for space and water heating and in some cases for cooking.

A typical Diesel generator produces about 3.5-4.0kWh of electrical energy per litre of fuel and the remaing 6 -6.5kWh of energy is rejected as heat from the exhaust and the cooling system

With the rising cost of diesel and the concern about carbon emissions attention has recently been directed to reducing the use of non-fossil energy sources. This means either replacing diesel and coal with non–fossil fuels by

1) Driving the diesel generators with non-fosssil sourced oil such by product oil from fish processing or bio fuel oil grown locally

2) making use of the waste heat from the generator to replace other fuel use in a combined heat and power system (CHP)

3) replacing the diesel generators with electricity generation from another source such as hydro wind or solar

4) replacing electricity with another non-fossil energy such as wood
Or some mixture of all three.

To do this we need to re-examine

1) the various energy using activities (kind and amount)
2) the various energy forms that one can use to achieve these ends (kind and amount).

Of particular note is the fact that we have become so accustomed to using electricity to drive all our devices that we think of it as indispensable. However it is almost always possible to find alternative ways of achieving a given end. In rural china it is possible to obtain a refrigerator that is driven by heat from the wood fired cooking stove. In outback Russia in the 1960s radios were powered from a thermoelectric module heated by a kerosene lamp. I would not go so far as to suggest that we go back that far but I would say that one should ever be alert to unconventional options. The aim might be to maintain a comfortable lifestyle while eliminating the need to import fossil fuels. Recently I have been working with a designer who uses a thermo-electric generator incorporated in a log fire to drive a fan circulating heat from the log fire. As a gimmick he has included an USB socket that allows one to charge one's cellphone from the woodfire (PICTURE?)

Some systems for electricity supply like wind are best installed in relatively large units. My own experience with small scale wind generation indicates that it is not particularly effective. Others like Photo-voltaics (PV) are constructed in small modules and can be installed in large central units or in domestic sized units. PV is of increasing in interest because prices of panels have reduced dramatically over the last few years and the flexibility of overall systems has improved so that one has a choice among single domestic size with battery storage, multiple users on a small micro grid with several inputs and battery storage or large central grid supply

In looking at the renewables one needs to take into account the fact that capital outlay for renewable electricity supply is almost always higher than for fossil fuel driven supply. The compensation is that the running costs are virtually negligible.

Example:
1.5 kVA diesel genset costs about $2 000 and will last about 6000 hours burning about $4000 of fuel and producing about 9000kWh at an average cost of 66 cent/kWh
1.5 KVA PV plus inverter plus 15 KWh battery costs about $4 500 (panels) + 2 500 (Inverter/charger) + 4500 (storage batteries 2 sets) = $11 500 (+$4500 at 10 yrs for replacement batteries) and will last about 20 years + producing about 30 000kWh in its lifetime at average cost 50c/kWh

In both cases the costs will be reduced for larger scale installations but I think the two main points will hold namely that the PV will have higher initial capital and lower lifetime costs.

One way of keeping the capital and running cost low is to use high efficiency appliances

Example:
standard refrigerator $1000 uses 500 kWh yr so needs 500W of PV plus 4.5 kWh battery = $ 4 000
A low energy refrigerator costs an extra $500 and uses 150kWh/yr so needs 150W of PV and 1.5 kWh of battery = $2500

The moral of this story is that if one is to use renewable energy such as PV it pays to spend some capital on high efficiency appliances and on reducing one's electricity use by other means.
One of these is to use electricity only for "high grade" energy applications such as refrigeration and lighting.

So how do we use electricity and do we need to?

1)lighting alternatives none really convenient so stay with electricity
2) refrigeration alternatives gas/kerosene driven doesn't contribute to elimination of imported fuel so stay with electricity
3) cleaning-the wood fired vacuum cleaner is not a great idea so stay with electricity or retreat to old fashioned carpet sweeper
4) cooking could use wood but not particularly convenient. If electric use microwave where possible
5) water heating use solar (Stewart island ?) or heat pump to reduce electricity use
6)space heating use wood or heat pump

How much energy is used for various activities
Lets look at a typical all electric household
water heating 3000-4000kWh/yr 35-40%
space heating 4000 kWh/yr 40%
lighting 600kWh/yr 7%
cooking 600-800kWh/yr 7-8%
other 600-800kWh/yr 6-8%
TOTAL 9000 10 000 kWh/yr

Step 2 is to look at how far we can reduce this so a to reduce the capital cost of renewables equipment.

As an example let us assume that the overall capital cost of renewable power supply is $10/watt.
change water heating from resistance to heat pump
capital outlay $5000
reduction in energy 2000-2500kWh/yr
reduction in installed power 2000-2500W == $20000- 25000

Summary of points to note in renewable energy

1) How much and for what
2) Match sources with uses (choices are often site specific)
3) there are two characteristics to match (power and energy)
4) there is usually no single solution
5) Minimise energy use for given output
6) Renewables are variable (so need to consider storage)
7) most renewables come from sunlight one way or another

Re read past studies (Venture Southland and MUCER)