KI Energy Supply Options

By Brian Kirke

Research Fellow, UniSA Sustainable Energy Centre

Report on visit to Kangaroo Island 8-9 September 2004

to discuss and investigate some energy supply issues

1. AIMS OF VISIT

1.1 To discuss energy supply options with KIDB, Council and others.
1.2 To meet with Greg Ward and discuss tidal current velocity monitoring
1.3 To look at possible sites for pumped hydro energy storage

2. BACKGROUND: UNRELIABLE ENERGY SUPPLY

I was aware of the energy supply problems on KI, and having a long-term interest in renewable energy and having recently returned to SA and joined the Sustainable Energy Centre at UniSA, I decided to see if I could help in any way. Before the visit I studied "Kangaroo Island Energy Review Part 1" to identify major issues. KI suffers from ageing and unreliable distribution infrastructure which is inadequate for current and projected future development. Present electricity supply is from the mainland via a long supply line, with only a backup diesel set on the island. Frequent blackouts occur and often last for hours.

In its August 2004 report "Kangaroo Island Network Support Back Up Generation Proposal," ETSA considered 4 options:
(i) duplication of the Yankalilla to Kingscote transmission system
(ii) single diesel generation site at Kingscote
(iii) two diesel generation sites at Kingscote and McGillivray, and
(iv) same as option (ii) but with single wind/diesel generation site at Kingscote.

ETSA recommend option (iii), replacing the existing 2.5 MW backup diesel generating station in Kingscote, which take about 3 hours to start in the event of an outage, with 6.5 MW of remotely controlled plant at Kingscote and McGillivray substations, which would presumably respond quickly to any outage, plus additional control and switchgear, at a cost of $10 million, to be borne by the whole state. This would improve reliability of supply, especially in the Kingscote area, but would not enhance the island's clean green image - unless it were to be run on locally produced biodiesel (see below).

2.1. Renewable energy and clean, green image. KIDB wishes to maintain a clean, green image for the island, and renewable energy supply would contribute to this aim. There is plenty of potential for renewable energy on the island: wind, wave, tidal stream and biomass energy appear to be the most promising.

2.1.1 Wind energy. Wind energy is plentiful along the exposed coast of SA, including KI, and SA is set to lead Australia in wind energy conversion. But wind energy availability does not necessarily correlate with demand. It has been estimated (ESIPC, 2004) that a wind farm will only be producing 8% of its rated generating capacity with 95% probability at any given time (i.e. the turbines are reliable but the wind is not). Thus there must be enough generating capacity from other sources to meet almost the full peak demand in case it occurs during a still period, and wind serves only as a fuel saver.

2.1.2 Backup for still periods. Other sources of energy for still periods could include
(i) diesel power as proposed by ETSA
(ii) a mix of "ambient" energy sources (e.g. tidal and wave energy) to reduce variability in supply
(iii) energy storage so energy generated by wind, tides and waves can be stored for when it is needed. This could include pumped storage, batteries or other devices
(iv) biomass.

2.1.3 Biomass energy. This can be stored and burnt to generate power as required, like diesel, but would be renewable, CO_2 neutral and could be produced on the island, thus satisfying the "clean green" requirement. Biomass could be either biodiesel produced from canola, which could replace mineral diesel in standard generating plant, or it could be wood, which would require a special power station. Although I had not planned to investigate biomass energy on this visit, this emerged as one of the most promising energy forms for KI and is discussed further below.

2.1.4 Tidal stream energy. Backstairs Passage appears to be a promising area for tidal stream energy conversion, a process in which turbines generate power from moving water in the same way that wind turbines generate power from wind. A preliminary "guestimate" puts the potential at about 50 MW, compared to 3.68 MW average demand on Kangaroo Island and about 1200 MW for the whole of SA. Thus it will be of more benefit to the state as a whole then to KI. Strong currents also flow into and out of the Bay of Shoals near Kingscote. Although the total resource at this site is probably small, it appears worth investigating.

Tidal energy varies with daily and monthly cycles, but it is highly predictable, unlike wind. There is no noise or visual impact and no danger to fish because turbine blades move slowly, making this a very environmentally friendly energy form. The technology is just starting to take off in the UK and elsewhere (see for example www.marineturbines.com/home.htm). A company in Queensland has been developing an innovative tidal turbine since 1999, and another company in NSW has recently announced plans to develop another form of tidal turbine.

2.2 Energy storage. As mentioned above, the main problem with wind, solar, wave and tidal energy is variability of supply. A mix of these energy sources will reduce but not eliminate variability. If these energy sources are ever to make up a large proportion of our energy supply, they will need either storage or backup thermal generating capacity so energy can be available to meet demand whenever it occurs.

2.2.1 Pumped hydro storage is the only well-established form of large-scale energy storage, with hundreds of large installations already operating worldwide, including 2 in Australia. Some installations have been running for 90 years. For this form of energy storage, two water storages are necessary, connected by a pipe and one or more motor/generator and pump/turbine sets. 2 surface dams at different elevations may be used, or the sea may be used as one storage, and/or underground caverns such as disused mines may be used as the lower storage.

There have been investigations into pumped storage potential in SA in the past, and with plans for large scale wind energy development in SA, further investigation now seems justified. I have studied topographical maps of the Fleurieu Peninsula and KI to identify likely sites for pumped storage. This will be followed up by more detailed and accurate evaluation using GIS.

2.2.2 Large scale flow battery technology (Vanadium redox) of the type under trial on King Island in Bass Strait may also be worth investigating, although the King Island installation, costing $630,000, is about 10 times smaller than KI's current requirement (see Attachment 1).

2.2.3 Other forms of energy storage not yet available commercially include hydrogen, compressed air and flywheels.

3. POINTS ARISING FROM KI VISIT

On 8 September I presented some ideas about pumped storage to the monthly KI Council Meeting. I also met with David Furniss and David Honner of KIDB, and with Greg Ward, a Kingscote-based fisherman, who has agreed to help with deployment of tidal current monitoring instrumentation to assess the Backstairs Passage resource. The following points were made:

3.1 Power cuts tend to occur at times of peak demand on a few hot days in midsummer when visitor numbers and air-conditioner use are at a maximum. In fact ETSA data indicate peak demand of 5.7 MW in October 2003, slightly higher than in Dec-Jan-Feb 2003-4. Average demand is 3.68 MW.

3.2 Low energy building design. KIDB would like to reduce the peak demand by encouraging more energy-efficient building design so there is less need for air-conditioners, but lacks the expertise.

3.3 Faults can occur anywhere in the distribution network, from the submarine cable through to local SWER lines, so ETSA's proposal will not necessarily fix the problem for remote users, although it should go a long way towards solving the outage problems for users in and around Kingscote.

3.4 Middle River Dam was suggested as the most promising site for an initial investigation into pumped hydro storage because there is already a dam linked to the mains by a 3 phase powerline. The salt water pumped storage option, with the sea as the lower storage, was not favoured for fear of contaminating groundwater, although a geological investigation may show that this will not be a problem at some sites right on the coast where strata dip towards the sea.

3.5 Biomass energy should also be considered. I was told that Tasmanian bluegum plantations had been established in the west of the island, mainly for carbon credits, and that this biomass might be better used for power on the island rather than for export wood chips.

3.6 KINRB, National Parks and TKI should be kept informed of any proposals. I made initial informal contact with Helen Richards of KINRB, but did not have time to contact TKI or Deb Thomas or Tom Nelson, the contact names I was given at National Parks.

4. FINDINGS

4.1 Pumped storage. On 9 Sept I inspected Middle River Dam, which may be worth further investigation as a potential site for pumped storage, either to provide greater security of supply to the area west of Parndana or to enhance the value of any future wind power development by providing some capacity to store energy from windy periods for use during still periods. However it should be understood that no net power would be generated by such a scheme: more energy is used pumping water to the upper storage than is recovered by the turbines when the same water drops to the lower storage. A small amount of energy could be generated directly without pumping, from the water which now flows over the existing dam: estimates of annual flow ranged from 3 to 10 times the capacity of the dam, or about 1500-4800 ML. Falling through a head of 50m, this water could generate about 160 to 530 MWh per annum. In pumped storage mode, assuming half of the capacity of the existing dam flows at 10 m^3/s at 50m head, about 4 MW could be generated for about 6 hours. This would cover the existing average demand in the event of an outage of 6 hours duration, but it would not be enough for a full day without wind. The proposed diesel upgrade in Kingscote and McGillivray would serve the same purpose at less cost.

A new dam would be required, probably downstream from the existing dam, with a pipeline connecting the 2 dams and a pump-turbine set at the lower dam. There may be environmental issues with dam construction below the existing dam as it would require clearance of some vegetation, but no national parks, wilderness protection areas or conservation parks would be affected. A lower dam would increase both the catchment area and storage capacity, which could be a side benefit, although I was told that there is no problem with shortage of mains water because everyone has a rainwater tank. A smaller scheme involving new dam above the existing dam would be possible. In this case there would be no need to extend the existing powerline and minimal need to clear scrub.

There appear to be other possible sites on the island for pumped storage, but at this stage Middle River Dam appears to be the best. If the sustainable Energy Centre at UniSA is successful in getting support for an investigation into pumped storage for SA as a whole, this site could be one to investigate further.

4.2. Biomass energy appears to be promising for further investigation for KI for a number of reasons.

4.2.1 Biomass can be stored and used as required to generate energy on demand, unlike wind, wave, solar and tidal energy.

4.2.2 Natural mallee type vegetation can be harvested by coppicing so the roots are not disturbed, on a rotational basis so there is minimal disruption to wildlife, in a manner analogous to Aboriginal Land management by patchwork burning. Annual yields may vary from 0.4 tonnes/Ha in dry mallee country (Allender, 1988) to about 20 T/Ha for Eucalypts irrigated with treated effluent in the Riverland (ibid) to over 60 T/Ha for eucalypts under ideal conditions (Tillman, 1978:209). Heating value of air dried wood is about 15 GJ/Tonne, which translates to about 20,000 kWh per Ha per annum assuming the 20 T/Ha figure, or about 1700 Ha of trees to supply the current electricity needs of KI, but this will depend on productivity.

4.2.3 Wood-burning generation plant is available. A 1 MW plant running on mallee is being trialled at Narrogin, WA (see Attachment 2). It will produce activated carbon and eucalyptus oil as well as power. Something similar may be appropriate for KI. Green Pacific Energy (GPE) has a 5 MW plant operating in SE Queensland: see Attachment 2 and www.greenpacific.com.au.

4.2.4 If native species suitable for wildlife habitat are planted on previously cleared land, more habitat is created.

4.2.5 If the rate of growth is at least as great as the rate of use, little net greenhouse gas is generated.

4.2.6 High value structural timber could be grown for construction, and thinnings could be used for power generation. Portable sawmills can move around the country so that landowners can harvest timber from their own woodlots for construction.

4.2.7 Small decentralised power stations could reduce dependence on the grid and reduce the impact of outages. A micro gasifier turbine is being developed by the CSIRO to generate 25-200 kW from fuelwood (see Attachment 3). This could be suitable for decentralised power generation, for example at an isolated ecotourism resort. Waste heat could be used for winter space heating and water heating.

4.2.8 Biodiesel could be produced locally on KI from canola, and used as both transport fuel and for electricity generation in diesel generators. This would save on fuel imports and add value to the island's canola crop, since freight costs both ways would be saved: canola from KI to Port Adelaide and diesel to KI. Much of KI is suitable for canola and should yield 2 to 2½ tonnes/Ha of seed, yielding about 1 T/Ha of canola oil. Converted to biodiesel with a heating value of around 38 MJ/l, about **3,000** kWh of electrical power could be generated from 1 Ha of canola annually. About **10,000** Ha would be needed to meet the total current electricity needs of KI. Local company SA Farmers Fuel (www.farmersfuel.com.au) is planning to build 2 large biodiesel plants in SA in 2004-5 and would probably welcome an approach from KIDB.

4.2.9 A conference on "Bioenergy Australia 2004" will be held in Adelaide in November-December (Attachment 4). Contact emma@conferenceaction.com.au.

4.3 Energy-efficient buildings. The principles of low energy passive solar design are well established, but in my experience most project home builders show little awareness of low energy design. Designs by architects who specialise in energy-efficient design often cost twice as much per square metre as ordinary project homes (typically $1500-2000 compared to $550-1000).

However it would be possible to make some modifications to a standard project home which would significantly improve performance (i.e reduce heating and cooling energy consumption while maintaining comfort) without adding much to the cost. For example

- (i) the cost of extra insulation is minimal compared to the overall cost of a house
- (ii) proper layout of rooms, orientation of windows and eaves to maximise winter sun and minimise summer sun should cost nothing.

Modifications such as

- (i) raking ceilings to let hot air out by convection on hot nights
- (ii) clerestorey windows to let winter sun into southern rooms, and
- (iii) use of Hebel panels rather than clay bricks to reduce embodied energy and improve thermal performance

all increase costs to some extent and their cost-effectiveness should be questioned.
The book "Warm House Cool House" by Nick Hollo (Choice Books, 1995) includes some low energy standard designs for project homes. See Attachment 5. The same principles would apply to motels and resorts. It may be useful to discuss these issues with builders supplying the KI market.

Energy-efficient heating and cooling. Reverse cycle air-conditioners have become very popular, and these contribute to the high peaks in summer electricity demand. Evaporative cooling is typically several times more energy-efficient in the dry heat of southern Australia, and should be encouraged instead of reverse cycle. Winter heating can be provided by bottled gas or wood. Remote resorts on KI might consider wood-fired generators for electricity, and use of waste heat for winter heating.

RECOMMENDATIONS

This was only a brief visit to KI and I have not investigated the issues as extensively as some others. My conclusions and recommendations are therefore only tentative. Having said that, I would suggest the following:

1. Go ahead with ETSA's proposal and get reliable diesel sets on the island. This will provide reliable backup to cover interruptions in supply from the mainland in the short term, and variability in wind or other ambient energy in the longer term.
2. Investigate the possibility of producing biodiesel locally and using it in place of mineral diesel, so the proposed ETSA installation is converted to green energy.
3. Investigate wood energy for power generation with use of waste heat for water and space heating, especially for users near the end of the grid such as remote resorts
4. Approach builders who supply the KI market and discuss possibilities to improve energy efficiency of housing and other buildings.
5. Invite wind farm and other developers to install wind and/or tidal stream and/or wave power integrated with pumped storage (this now appears to me to be more relevant to mainland SA, and I will be pursuing this option, but not specifically for KI).

REFERENCES

Allender, E.B. (1988). "Fuelwood production potential on degraded and under-utilised sites." Land Energy Pty Ltd, SA.

Australian Greenhouse Office (2003). Renewable Energy Commercialisation in Australia.

ESIPC (2004). "Annual planning report." Electricity Supply Industry Planning Council, SA, June.

ETSA Utilities (2004). "Kangaroo Island Network Support Back Up Generation Proposal." August.

Hollo, N. (1995). "Warm House Cool House." Choice books.

Sun, Wind, Water – Energy Solutions (consultants) (2003). "Kangaroo Island Energy Review Stage 1: Electricity infrastructure, demand, reliability." SENRAC/KIDB, June.

Tillman, D.A. (1978). "Wood as an energy source." Academic Press, New York.

www.farmersfuel.com.au

www.greenpacific.com.au.

www.marineturbines.com/home.htm