Indigo Shire's Transition to Renewable Electricity and Self Sufficiency

Energy and Greenhouse Working Group
Indigo Shire Environmental Advisory Committee
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This document gives some preliminary workings towards **Key Issue Three** in the Energy and Greenhouse strategy groups deliberations: *Producing low carbon electricity and heating for the Shire*

These preliminary workings are constructed out of five elements:

- Projection of the Shire's human population out to 2051 for each of the 20 or so towns and rural areas that make up the Shire
- Converting human population to households for each of these areas
- Estimating the electricity requirements for households and commercial premises in the region
- Bringing together the electricity requirements and numbers of household/commercial premises to give an overall electricity requirement for the Shire
- Estimating the infrastructure requirement and cost for each of four renewable electricity generation types
- Developing a prototype 'combination plan' which brings these electricity infrastructures together for a 40-year transition plan to Indigo Shire's electricity self sufficiency (see figure below).

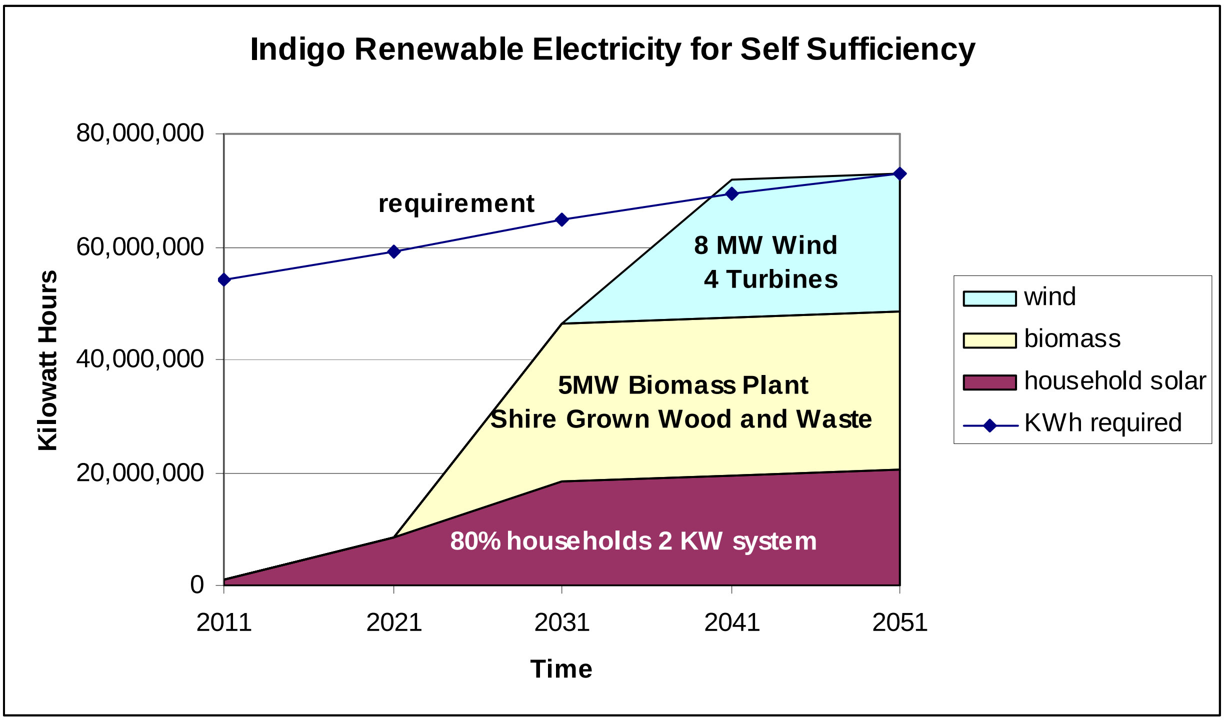

Figure 1. A prototype transition plan for Indigo renewable electricity built upon 80% of all shire households having a 2 kilowatt system by 2031, the building of a 5 megawatt biomass-electricity plant between 2021 and 2031 and then accessing 8 megawatts of wind turbines in a nearby area with suitable wind resources.

Population Projections

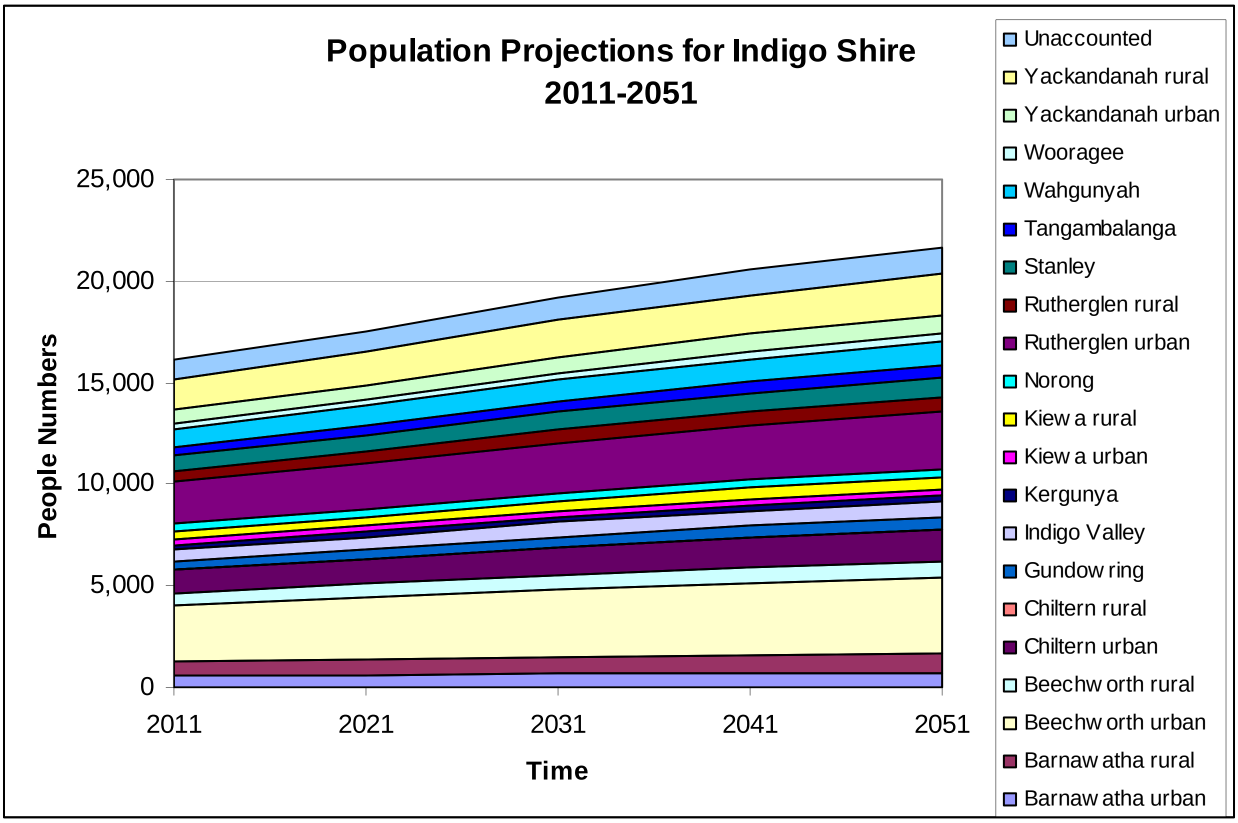

Figure 2. Projected human population numbers for localities in Indigo Shire for period 2011-2051.

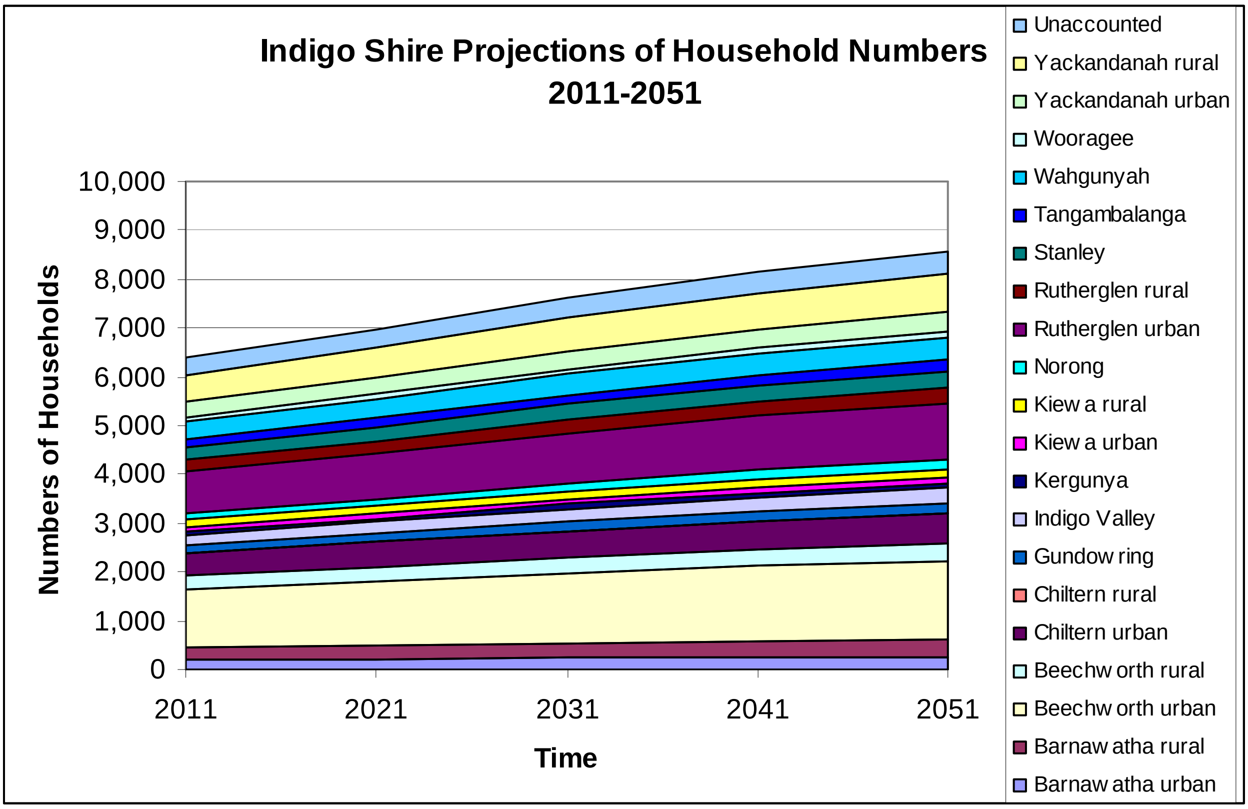

Figure 3. Figure 4. Projected household numbers for localities in Indigo Shire for period 2011-2051.

Household Energy Use[1]

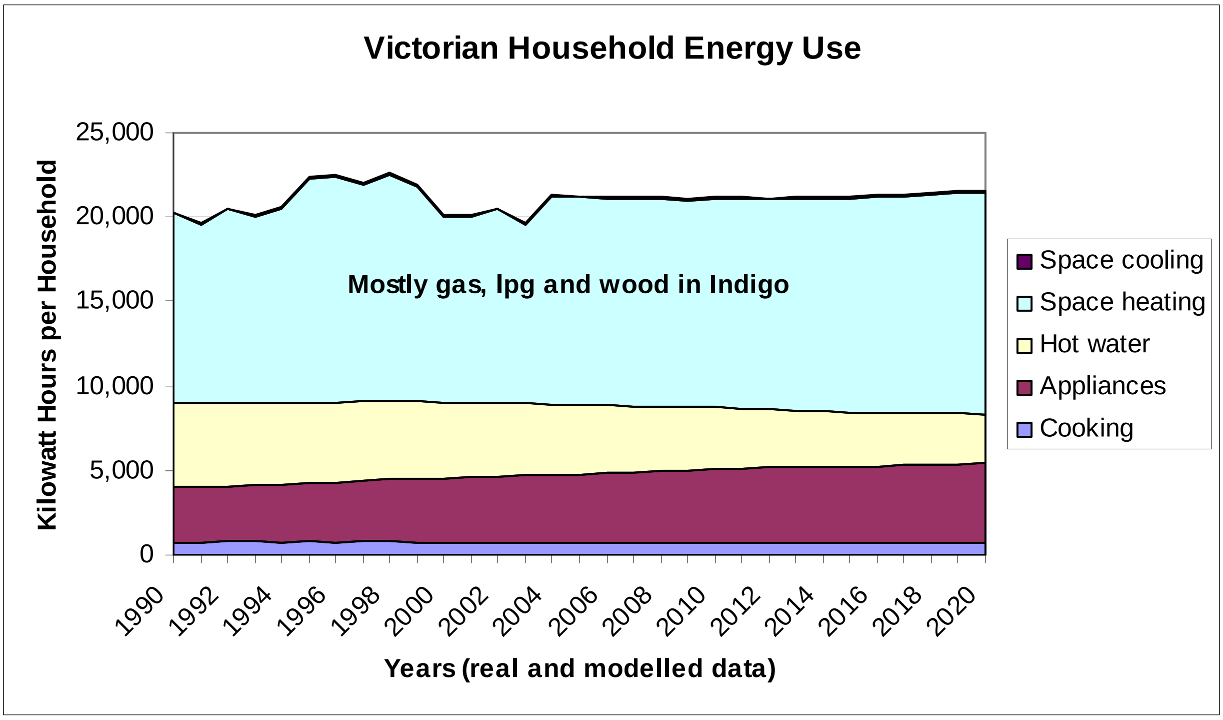

Figure 5. Modelled energy use for Victorian households for the period 1990-2020. Note that less than half of this is electricity (shown by the bottom three layers) and the larger part is winter heat supplied mostly by natural gas, LPG and wood.

From this study, a likely household electricity use of 8,500 kilowatt hours per year was taken.

There is an additional 12,000 kilowatt hours of heat required for winter space heating and this is supplied in Indigo mainly through LPG and wood, although split systems and thus more electricity are coming increasingly into usage.

The 8,500 kilowatt figure used then is a conservative one, but will remain robust in expected electricity savings through energy efficiency programs, new household appliances and carbon taxes etc.

[1] http://www.energyrating.gov.au/library/details2008-energy-use-aust-res-sector.html

Shire Electricity Requirements

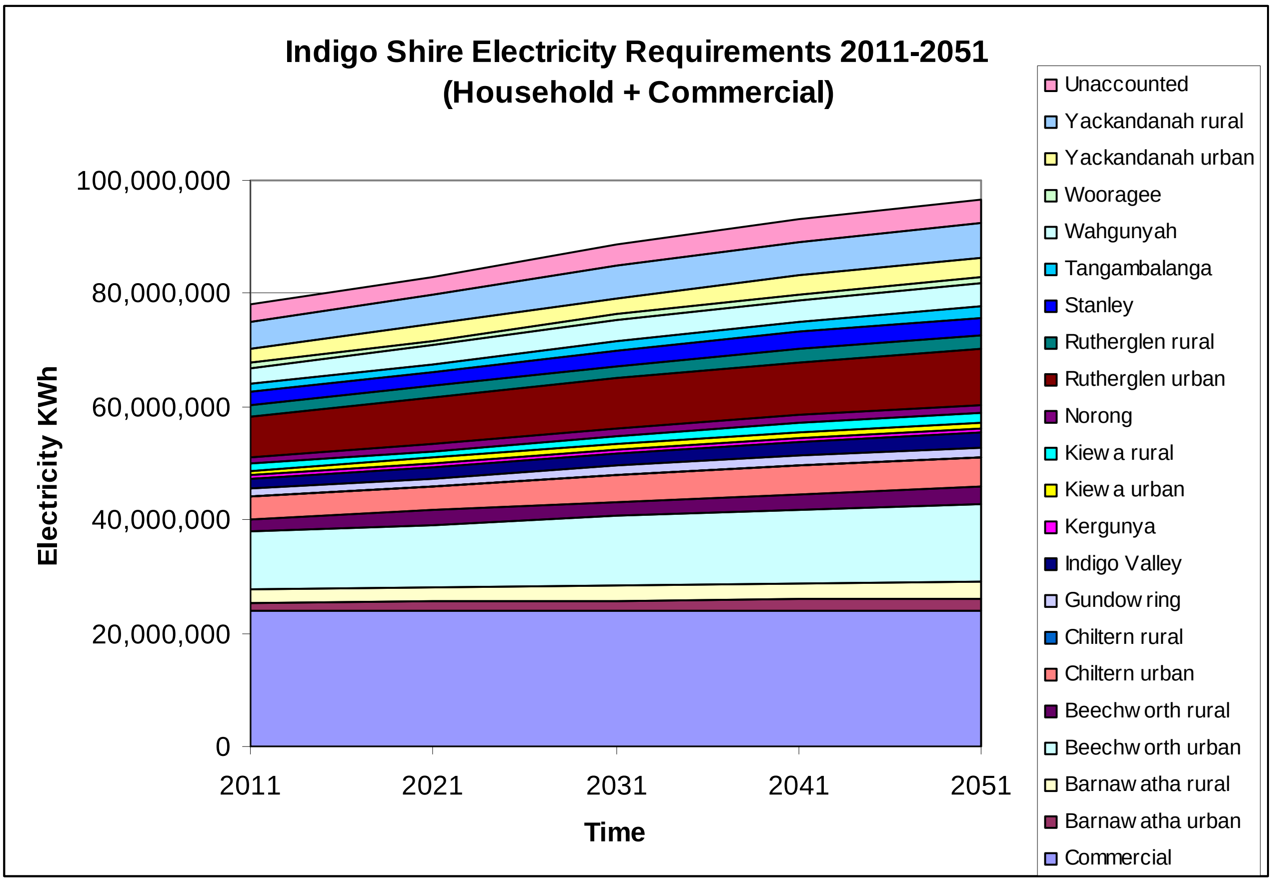

Figure 6. Projected electricity requirement for Indigo Shire 2011 to 2051.

This figure results from bringing together the projection of household numbers with the expected long term electricity usage.

Commercial and business is very roughly done by multiplying the number of businesses in the Shire that employ people by an electricity usage FIVE times that of domestic households. A few chats to business owners say this is in the right ballpark.

The proper way to do it of course is to classify businesses into size and type and survey each type for its electricity usage. For example Indigo Council uses (roughly) 570,000 KWh per year which is 13 times the 'average' figure used here but is still one fortieth or 2% of overall commercial usage.

The Shire total gives a reasonable approximation "per customer" to the little data that SP AUSNET the distribution utility, chooses to publish in its annual commercial report.

Thus overall we are looking at a current Shire requirement of 80 million kilowatt hours per year (80,000 megawatt hours or 80 gigawatt hours) which rises to near 100 million kilowatt hours by 2051 assuming of course that settlement patterns are more or less maintained, and that ten Uncle Tobys-like manufacturing plants are not located here.

Electricity wholesalers/retailers will soon have to release this data as part of national greenhouse targets, but this estimate seems pretty robust (or as good as we can do it at the moment).

Wind Turbines

how can they deliver Indigo's electricity requirement?

Figure 7. Hepburn community wind project at Leonards Hill near Daylesford….local manufacturing jobs for the turbine stands and raising the first turbine in April 2011[2].

Indigo Shire generally has poor wind resources itself, but there are good wind resources fairly nearby (See Figure 8on next page ….the browns and the yellows).

Indigo wind capacity could be brought/developed as part of a bigger wind project in nearby areas.

Table 1. Wind turbine infrastructure in megawatts installed and total cost to meet 100% of Shire's electricity requirements for the period 2011-2051. Electricity yields and project cost are based on Hepburn Community Wind Farm. To give numbers of turbines "like Hepburn's" divide megawatts by 2.

	2011	2021	2031	2041	2051
Installed "nameplate" capacity required MW	18	19	21	23	24
Number of 'Hepburn-like' turbines (each 2 MW)	9	9	10	11	12
Total cost $ millions	56	61	66	71	75

[2] http://hepburnwind.com.au/author/itadmin/

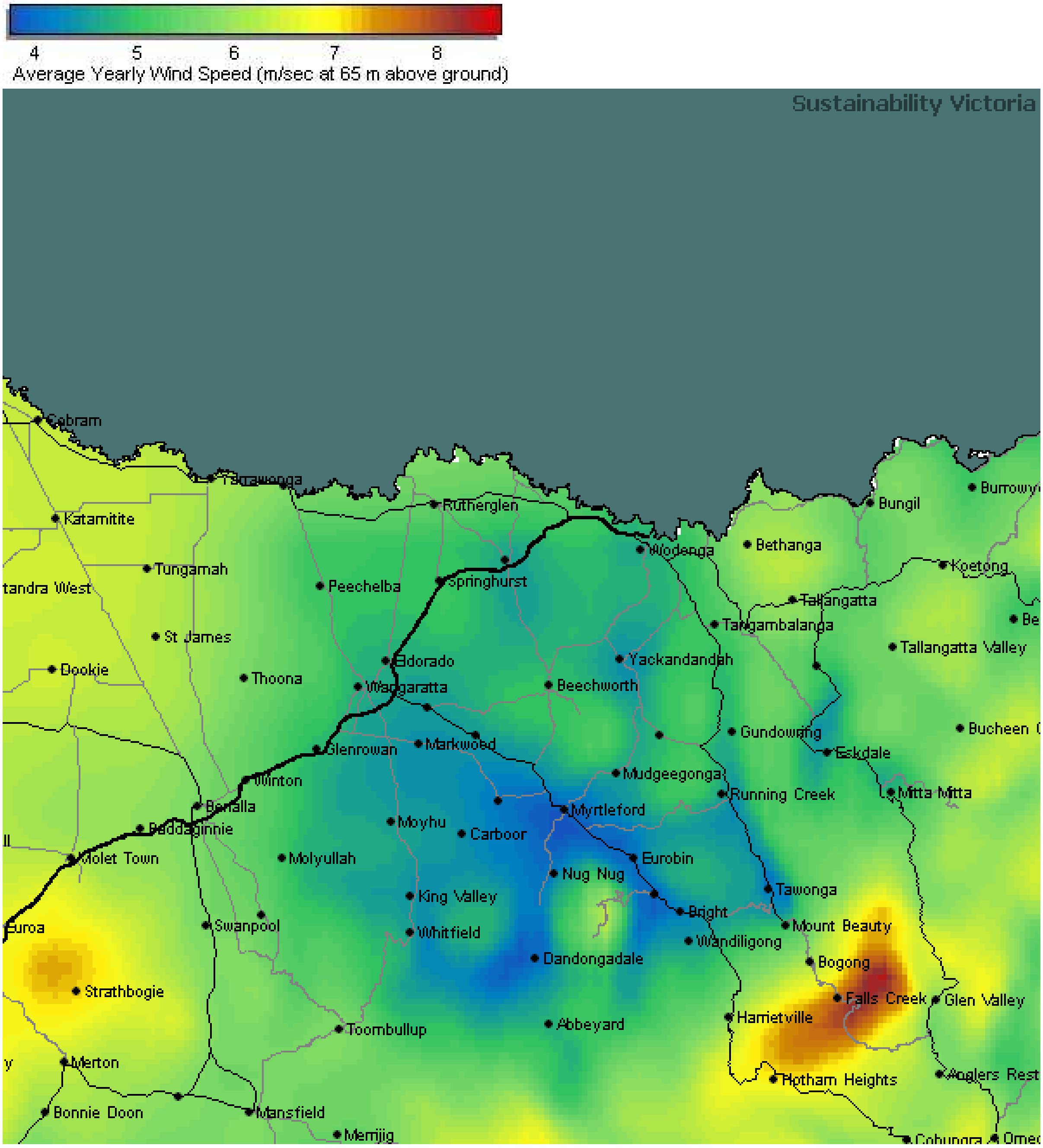

Figure 8. DSE wind maps of the broader north east region where yellow and brown areas are sufficient for economic wind development.

Solar Photovoltaic Electricity
worked on 2 kilowatt systems on 80% of households


Fairly well established in Shire by now due to Federal Government schemes

A two kilowatt system is a bare minimum giving say 3,000 kilowatt hours per year and a $10,000 infrastructure cost (or $5,000 per kilowatt or $5 per watt)

This is an expensive system in a whole of system sense but has five real advantages:
- Well accepted and does not require new laws or new technology
- Under the current ‘export credits’ system a two kilowatt system can make a household nearly cost neutral
- Technology developments and bulk buying schemes will quickly reduce costs
- A distributed system and thus much more robust in the face of centralised failures (provided cut-out switches are developed
- Amenable to a Shire-led scheme where capital cost could be folded into rates and paid of over 5-10 years

Table 2. Solar photovoltaic infrastructure in megawatts installed and total cost to meet 100% of Shire’s electricity requirements for the period 2011-2051. Electricity yields and project cost are based on Beechworth solar productivity and would be better for Chiltern and Rutherglen.

	2011	2021	2031	2041	2051
Installed “nameplate” capacity required in MW	38	41	45	48	50
Total cost $ millions	188	205	224	240	252

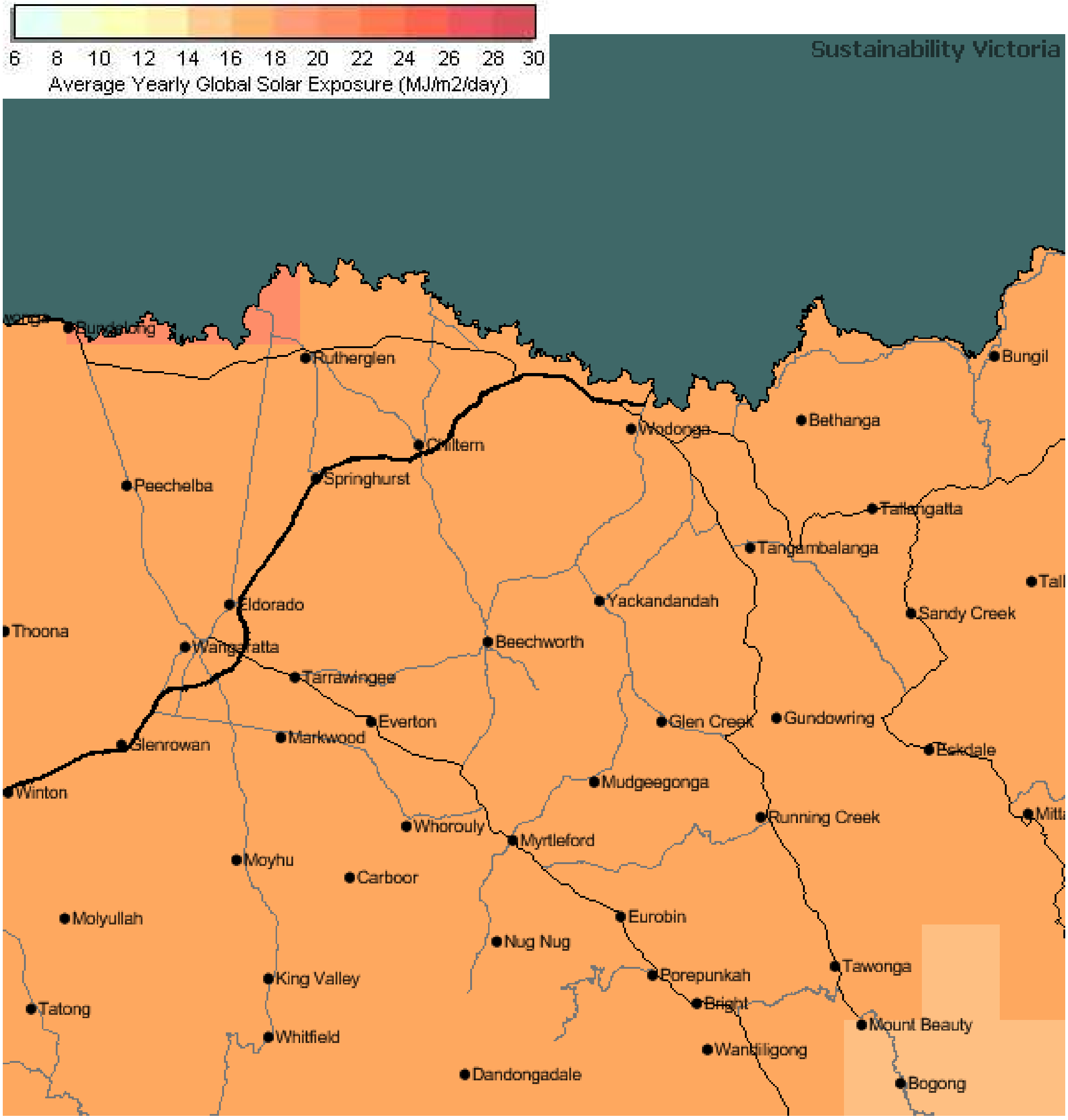

Figure 9. DSE solar incidence map of the northeast region suggesting an average solar energy input of 16 MJ or 4.5 KWh per square metre per day. The table below shos roughly how solar panels of different conversion efficiencies translate this to electricity supply.

Table 3. Rough workings of conversions (from map) of solar insolation to kilowatts of electricity produced per day.

SOLAR MJ/m/day	SOLAR KWh/m/da	Efficiency Conversior	Electricity KWh/m/da	Panels Square m	TOTAL Electricity KWh/day
16	4.44	0.1	0.44	20	9
16	4.44	0.11	0.49	20	10
16	4.44	0.12	0.53	20	11
16	4.44	0.13	0.58	20	12
16	4.44	0.14	0.62	20	12
16	4.44	0.15	0.67	20	13
16	4.44	0.16	0.71	20	14
16	4.44	0.17	0.76	20	15
16	4.44	0.18	0.80	20	16

Biomass Electricity[3]

Using purpose grown wood, straw/hay and municipal waste

Figure 10. Typical 10 MW (electric) plants installed in the UK (left) and Northern Ireland (right).

Worked on basic figures that plant is operational 65% of the year and that it converts 35% of the heat energy in wood to electrical energy (eg 100 units of wood energy convert to 35 units of electrical energy in the transmission wire). The capital cost is $3 million per megawatt of nameplate capacity[4]. Could supply heat to industry if located close to an industrial plant like Uncle Tobys.

While biomass energy is carbon neutral in that it uses purpose grown wood (thus recycling the same carbon molecules) it nevertheless requires that plantations be grown nearby to supply the plant.

Table 4. Biomass electricity infrastructure in megawatts installed and total cost to meet 100% of Shire's electricity requirements for the period 2011-2051.

	2011	2021	2031	2041	2051
Installed "nameplate" capacity required in MW	10	11	12	12	13
Total cost $ millions	29	32	35	37	39

<u>Yearly Indigo Wood requirement for a 10 MW-electric power plant</u>

- 54,280,000 KWh of electricity is 195,406,207 MJ of electricity (1 KWh =3.6MJ)
- This requires 558,303,450 MJ of wood feedstock requirements (or three times the energy value of the electricity produced)
- This is 558,303 GJ of wood feedstock (1,000 MJ in one GJ)
- Which requires 31,017 tonnes of bone dry wood (18 gigajoules of energy in one tonne of bone dry wood)
- 3,102 hectares of land in permanent Indigo plantation needed to sustain the biomass electricity powerplant (one hectare grows 20 cubic metres or 10 dry tonnes per year)
- For home heating, 21,000 bone dry tonnes of plantation wood per year (2.5 tonnes per household per year) from 2,100 hectares
- The Shire could be electricity and home heating self sufficient with its own plantation estate of 5,200 hectares or 2.5% of the Shire's total area (204,380 ha)or 4.6% of its agricultural area (113,000 ha). New industries and additional employment driven by localised energy.

[3] http://www.sustainability.vic.gov.au/resources/documents/Biomass_Technology_Review.pdf
[4] http://www.iea.org/techno/essentials3.pdf

Solar Concentrating[5]

Sun is concentrated to make steam to drive steam turbines


Probably not an option for the Shire and would be better located at somewhere like Mildura

This technology has the advantage of being able to store heat in molten salt or hot oil and thus can operate at night or over-ride short cloudy periods during the day. Numbers here assume a 16 hour 'salt storage' configuration.

However west of Rutherglen would be good for six months of the year.

Nationwide plans call for the integration of 'solar concentration' and 'biomass electricity' power plants. So particularly for a Rutherglen site, an integrated development of the right mix of each technology would give sun-driven summer production and biomass-driven winter production.

Can achieve temperatures at the concentrating 'focal point' in excess of 1,000 degrees centigrade and so can be used for high temperature industry requirements such as metallurgy, glass and ceramics

Table 5. Solar concentrating electricity infrastructure[6] in megawatts installed and total cost to meet 100% of Shire's electricity requirements for the period 2011-2051.

	2011	2021	2031	2041	2051
Installed "nameplate" capacity required in MW	10	11	12	13	14
Total cost $ millions	41	45	49	53	55

[5] http://www.energy.unimelb.edu.au/uploads/ZCA2020_Stationary_Energy_Report_v1.pdf
[6] Figures worked on a 60% load factor (60% of yearly hours) with 16 hours of salt storage to allow night time and low sun operation.

A Shire Transition Plan

A very rough example

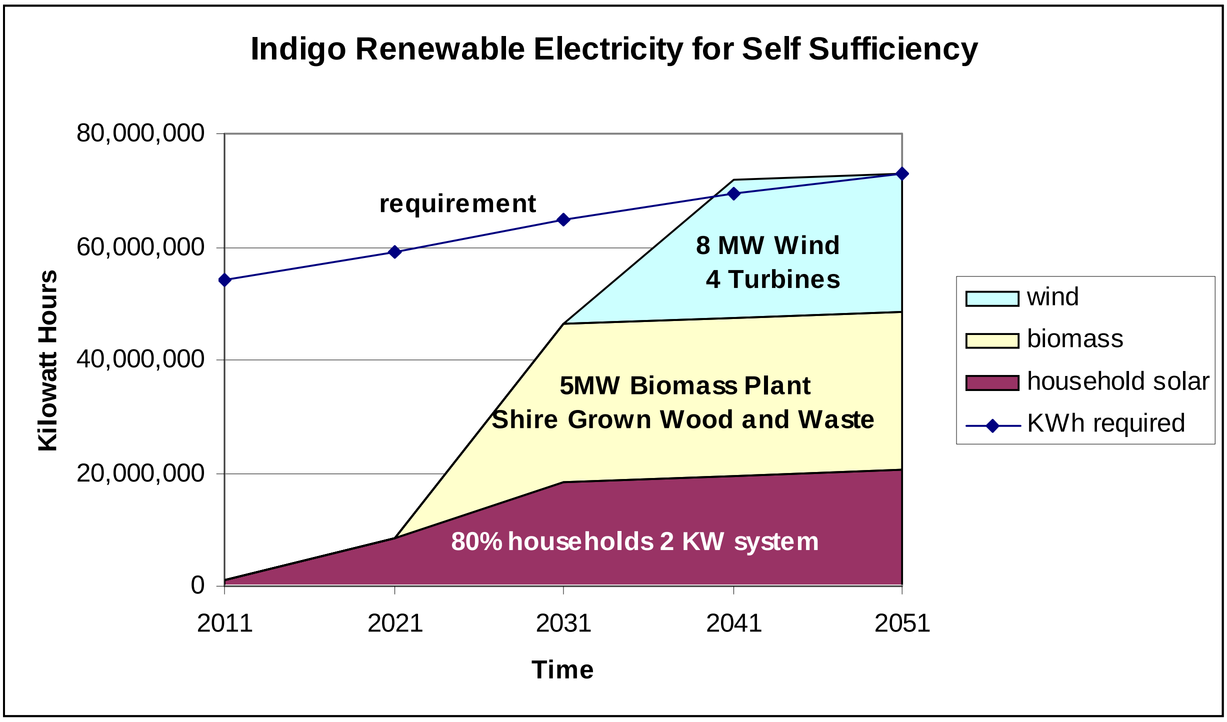

Figure 11. A schematic diagram of how Indigo Shire might achieve self sufficiency in low carbon electricity by 2051.

Australia's low-carbon electricity transition will be implemented by integrating a mix of renewable technologies not just one 'silver bullet' technology that somehow magically costs nothing.

The plan here rests on three elements:

- 80% of Indigo household installing a two kilowatt system over the next 20 years by 2031
- A 5 MW biomass driven power plant underpinned by 1,500 hectares of locally grown wood plantation. This plant can also use most of the local waste/rubbish stream.
- 8 MW (four turbines) of windpower located nearby in the north east region where wind resources are physically and economically sufficient.

The individual household plan would require that 350 households per year (7 per week) install a two kilowatt grid connected system at a current capital cost of $3.5 million per year or $70 million for the 20-year project. Cost will decrease and panel efficiency increase over the project lifetime. Probably best rolled in with a scheme to upgrade home insulation and advanced hot water systems.

Many local governments around the world capitalise these costs into the rates system and allow a 5-10 year payback time. If part of a Shire strategic plan, the whole project would be attractive to long term money such as superannuation and private equity funds.

The economic development returns for the Shire would be the infusion of new business models, a skill base for the 'new economy' and an 'attractiveness quotient' as a 'Shire going somewhere'

The biomass electricity power plants are basic 'turnkey' developments that should be located close to wood resources and preferably close to industry or institutional clusters so that waste heat can be used for heating and cooling. Water is necessary for cooling and steam and adjacency to sewage treatment plants or industrial water (Uncle Tobys) could be considered.