# Nature Exchange Visit
# Sustainable Energy in Slovenia
# 10 to 17 October 2011

John M Whitfield

# 1. Executive Summary

This report has been produced following my trip to Slovenia in October 2011 as part of a group hosted by the Vitra Centre for Sustainable Development. The purpose of the trip was to share information on sustainable energy between Scotland and Slovenia.

We were shown many domestic and a number of commercial installations where improvements to the premises and energy systems have resulted in a significant reduction in fuels and therefore costs savings. The Slovenian Government seems to have developed a comprehensive and generally sensible approach to promoting more sustainable energy systems. Some reasonably generous subsidies have created a demand for major home insulation improvements and for the installation of more sustainable energy systems. The efforts that we were shown indicate that the money seems to have been generally well spent and the long-term prospects for a more sustainable balance are good. The subsidies have created a series of industries to deliver the goals of the programme and these facilities are a tremendous asset in a small country.

My view is that there are a number of issues where further work could enhance the path to a sustainable energy future for Slovenia:

- Greater emphasis on electrical efficiency, in particular in lighting, where I saw little current evidence of efforts to reduce demand;
- Further work on the true sustainability of the forests such that the biomass economy can be truly demonstrated to be sustainable in the long-term;
- Enhance efforts to ensure that sustainable energy security is available to all householders beyond those able to take advantage of generous subsidies.

The key lessons that I will be taking back to Scotland and using to enhance the energy saving and micro-generation courses that I offer are:

- External insulation of homes can improve the thermal performance of existing structures significantly, yet is generally resisted by planners. This needs to changed if older structures are to remain viable in the future;
- The many Scots with which I have talked about electrical energy efficiency (and who have no idea how much electricity they use) are not alone. Further efforts are needed to get people interested in real energy-saving efforts;
- Scotland in many ways has a more diverse range of sustainable options than Slovenia, given much greater wind, wave and tidal resources and should not waste this tremendous opportunity;
- Domestic-scale demand-reduction combined with domestic-scale micro-generation, where feasible, is by far the best way to achieve sustainability. Industrial-scale renewable energy has a place (not least to provide power to cities), but should only be part of the solution. Small is beautiful!

# 2. Introduction

## 2.1. Background

This report covers my visit to Slovenia from 10 to 17 October 2011 as part of a Nature Exchange programme to share information and experiences between different European Union (EU) countries.

Nature Exchange has been funded within the framework of the 'Leonardo da Vinci' programme of the European Commission Directorate-General for Education and Culture (DG EAC). Within Scotland the programme is promoted by the ARCH Network, based in Comrie, Perthshire. The purpose of the exchange is to focus on what can be brought back to Scotland, for integration (through training and dissemination) into Scotland's natural heritage, conservation, land management, nature protection and sustainable energy.

The visit was hosted by the Vitra Centre for Sustainable Development which is based in Cerknica, a town 40 km south of the capital, Ljubljana. Vitra is a non-governmental organisation which aims to promote sustainable development in Slovenia and has been involved in the exchange programme since 2000.

## 2.2. Visit Details

The group consisted of myself (a sustainable energy 'fanatic' (adviser) from northern Scotland), Professor Colin Norton of the Scottish Agricultural College in Edinburgh, Fiona Stewart of Scottish Natural Heritage in Glasgow and John Ross from The Highland Council. The group was very ably looked after by our guide, Bojan Žnidaršič, a sustainable energy adviser from Vitra in Cerknica. Bojan was an excellent host and is a celebrity in Slovenia due to his very active interest in all aspects of energy efficiency and sustainable development which he shares with others via a regular TV slot, the Vitra website and email responses to a wide variety of energy-related queries.

Bojan had prepared a packed programme of visits to a variety of sites in a region within an hour or so drive of Cerknica. The visits included factories making thermal insulation, timber kit houses, windows, and pallets. The group was also taken to 20 private houses which were part of the network of 'National Energy Path' (NEP) sites throughout Slovenia [1]. Each NEP house owner has undertaken a variety of improvements to thermal performance and space heating systems and has agreed to join the network to share their experiences with others and to spread best practice in sustainable energy systems to the wider population. Our group was welcomed at every house that we visited by the owner and given a tour and detailed explanation of each system and its various special features. The owners were extremely open and welcoming to our group and the hospitality that we received was remarkable and very much appreciated.

The table in Figure 1 below summarises the sites visited. The first column is a 'house reference number' which is only used for houses for which some data was available.

| Ref. | Type | Day | Date | Description | Town |
|---|---|---|---|---|---|
| | Factory | Tue | 11 Oct 11 | Fibran Insulation Factory | Sodražica |
| | Factory | | | Riko House Factory and Museum | Ribnica |
| | House | | | Tone's for Lunch | Novi Pot |
| 1 | House | | | Low Energy House | Bloke |
| 2 | House | | | Dormouse and Brandy | Laze |
| | Factory | Wed | 12 Oct 11 | Window Factory | Planina |
| | Facility | | | High school | Postojna |
| 3 | House | | | DIY Physicist | Postojna |
| | Facility | | | District Heating | Postojna |
| 4 | House | | | Part-renovated Town House | Postojna |
| 5 | House | Thu | 13 Oct 11 | Andrej's Brother | Preserje |
| 6 | House | | | Andrej's Dads | Preserje |
| 7 | House | | | Andrej's | Preserje |
| 8 | House | | | Pool House | Brezovica |
| 9 | House | Fri | 14 Oct 11 | 007 House | Bločice |
| 10 | House | | | Nursery | Bločice |
| | House | | | Solar Thermal on Ground | Bločice |
| 11 | House | | | Hollywood Villa | Cerknica |
| 12 | House | | | Professor Renovator's | Begunje |
| 13 | House | Sat | 15 Oct 11 | Empty Garage (Heat Pump) | Cerknica |
| 14 | House | | | Drums and Stove in Room | Rakek |
| 15 | House | | | Dried Fruit House | Selšček |
| 16 | House | | | Solar House | Begunje |
| 17 | House | | | Reed Bed House | Bezuljak |
| | Factory | Sun | 16 Oct 11 | Pallet Factory | Rovte |
| 18 | House | | | Passive House | Rovte |
| | Facility | | | Pub and Guitar Workshop | Hotedršica |
| 19 | House | | | Very Tidy House | Logatec |
| 20 | House | | | Renovated Pub House | Laze |

**Figure 1 – Itinerary**

# 3. Slovenia and Scotland

## 3.1. Geography

Slovenia is a small country in southern central Europe, bordered by Italy, Austria, Hungary and Croatia. Figure 2 shows a map of the country and highlights the location of Cerknica near where we were based during our visit. Formerly the northernmost part of Yugoslavia, Slovenia declared independence during a very brief war that marked the break-up of Yugoslavia in 1991. Slovenia joined the EU in 2004 and the Euro Zone in 2007. The population is around 2.05 million [2].

Slovenia contains a range of geographical regions within a land area of 20,273 $km^2$, from a short stretch of Adriatic coastline bordering Italy, rising to the Julian Alps in the northwest at an elevation of over 2,800 metres. The average elevation is over 500 metres. Around 60% (estimates vary from 58% to 63%) of the area is forested, the third highest proportion in the EU after Finland and Sweden [2]. Around 1/3 of the land area is protected from development.

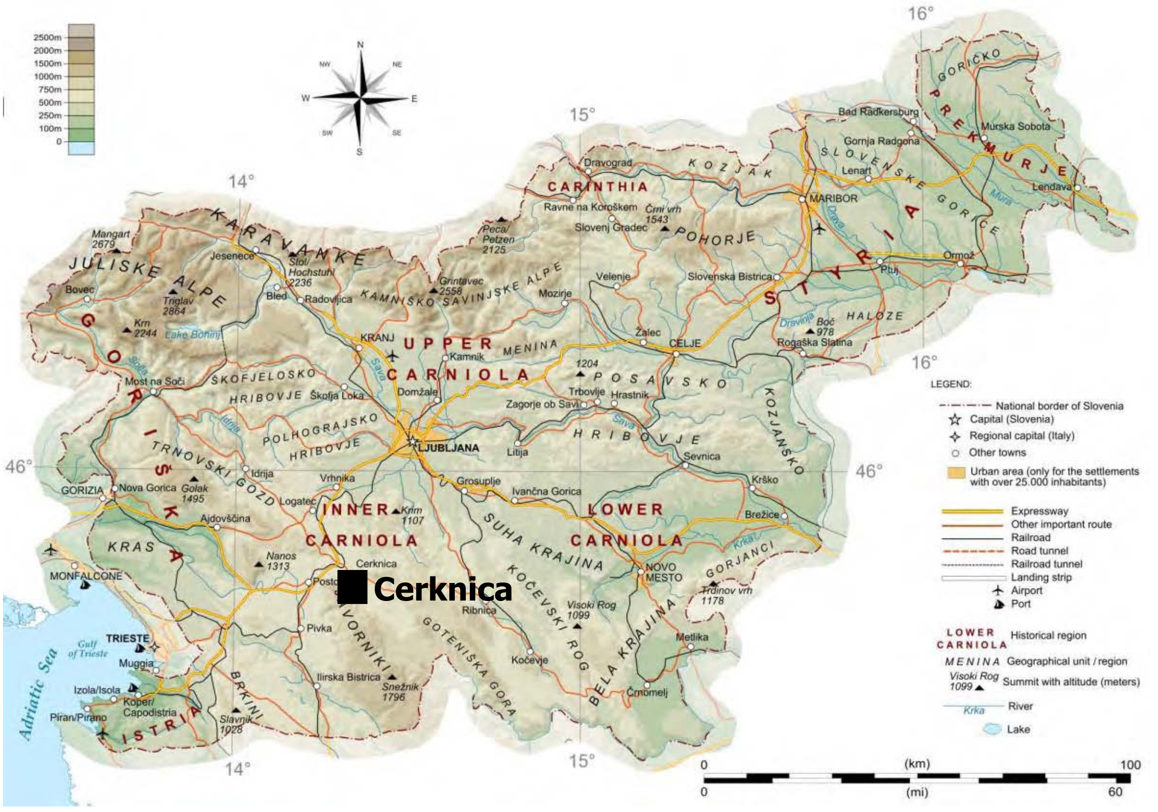


**Figure 2 – Map of Slovenia**

Scotland has around four times the land area (78,772 $km^2$) and 2.5 times the population (5.22 million) [2] compared with Slovenia but is in many ways a similar country. Indeed, if the 'central belt' of Scotland, comprising the main cities of Edinburgh and Glasgow and their surrounding satellites, was removed the residual Scotland of smaller cities and the Highlands would have a very similar profile to Slovenia.

## 3.2. Climate

The Slovenian climate is chiefly continental, with warm summers and cold winters. Rainfall varies significantly from under 800 mm per year in the eastern plain to over 3,000 mm per year in the Julian Alps. The annual average rainfall for Ljubljana is 1,400 mm, spread relatively evenly through the year. Nevertheless, Bojan remarked that the region had just experienced an extremely dry summer, with virtually no significant rain for the last four months - this had resulted in water shortages, in particular in the karst limestone region around Cerknica where there is limited surface water for much of the year. Figures 3 and 4 below compare average weather statistics for Ljubljana (data from the internet [3]) and Culgower in northern Scotland (data from my own automatic weather station [4]).

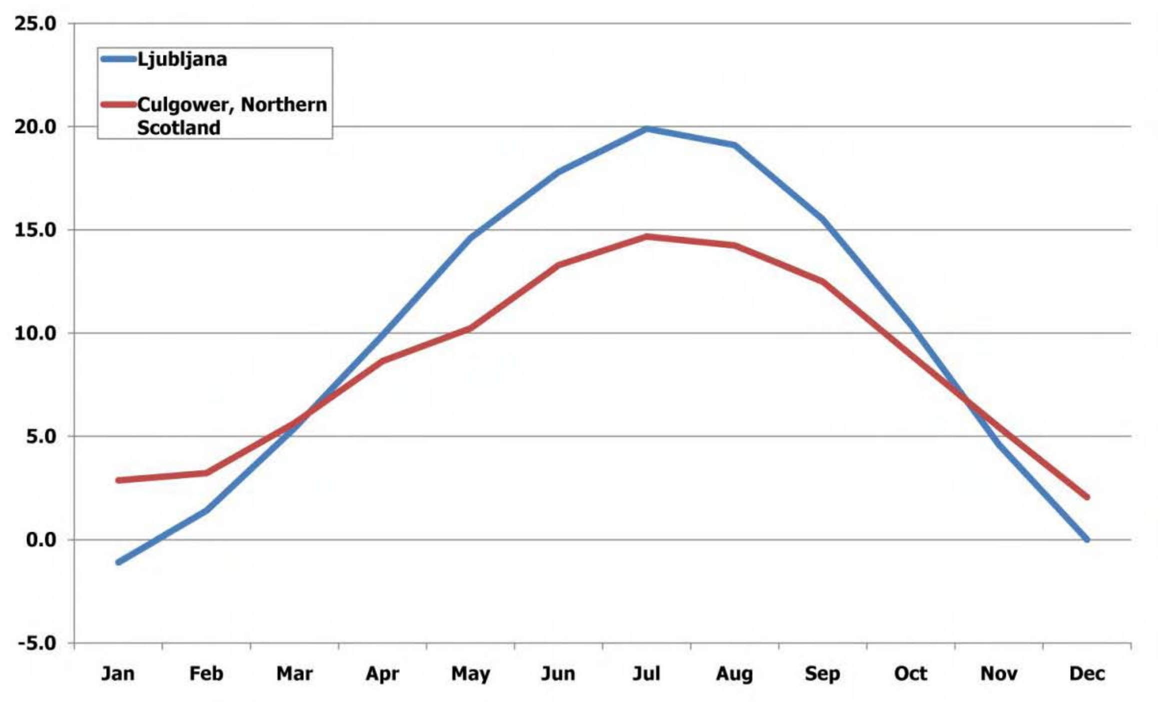


**Figure 3 – Monthly Average Temperature (°C)**

Summer temperatures in Slovenia are around 5°C warmer on average and mid-winter temperatures around 5°C cooler on average compared with northern Scotland. This is not entirely unsurprising, given the continental locations and the difference in latitudes (Ljubljana is around 46°N and Culgower 58°N), although the maritime influence on coastal Scotland moderates what could otherwise be a more extreme temperature range. Given the image of Scotland as being perpetually rain-drenched it is perhaps surprising to note that the rainfall on the east coast of northern Scotland is significantly lower than the average in Ljubljana.

The climate is one of a number of factors that influence the style and quality of housing. Houses in Slovenia tend to have strong roofs with larger overhangs than those in most of Scotland due to heavy snow loads in the winter. Many Slovenian houses have basements which provide significant additional floor area, although it sometimes complicates the issue of ground water ingress control.

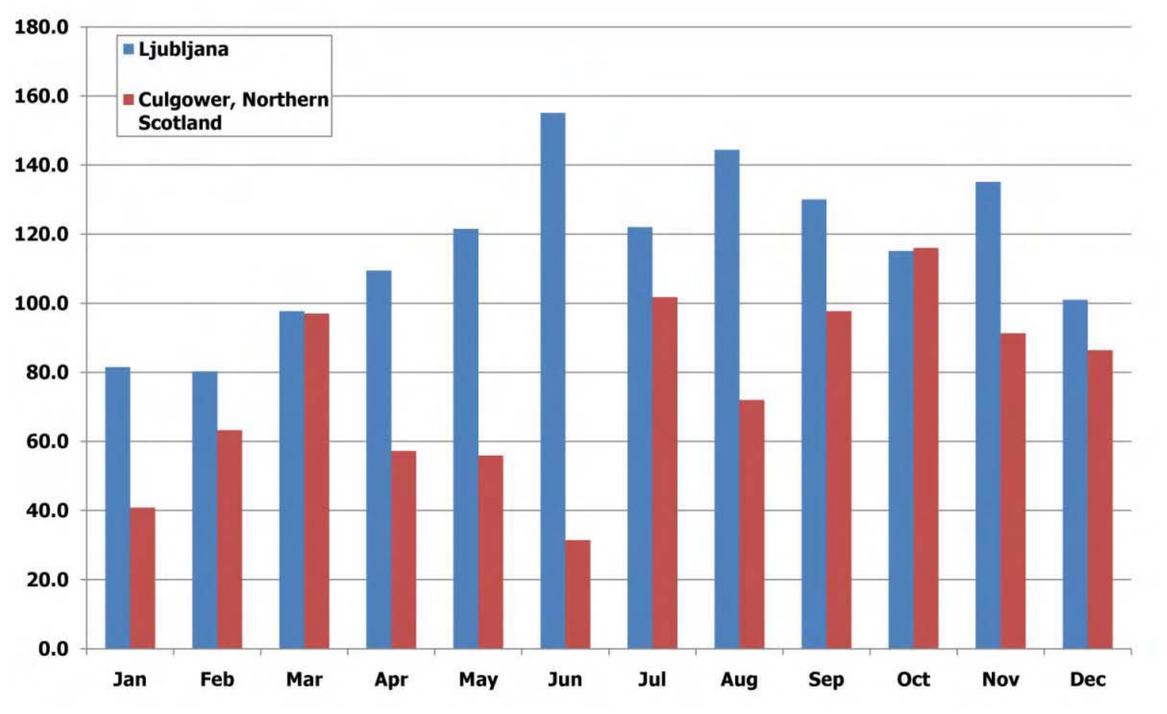


**Figure 4 – Monthly Average Rainfall (mm)**

## 3.3. Energy

Slovenia generated 16.4 TWh (ie 16.4 billion kWh or 'units' of electricity) in 2009 [5]. The sources were split fairly evenly as shown in the pie chart in Figure 5.

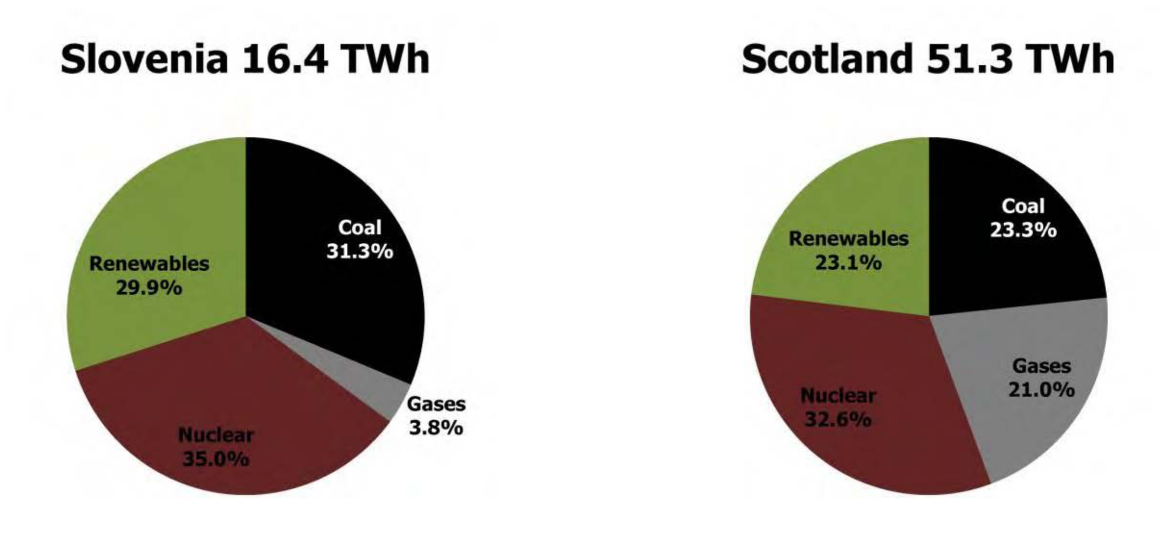


**Figure 5 – Annual Electricity Generation Share by Source (2009)**

The brown coal (lignite) was used mainly in 2 large plants and the nuclear output was from the single 700 MW (electric) Krško plant, shared jointly with Croatia (but located in Slovenia - a legacy of Yugoslavian days). The renewable sources are mainly (4.0 of 4.9 TWh) from hydroelectric plants on the Drava, Sava and Soča Rivers [2].

Scotland also still produces a significant share of the annual 51.3 TWh (2009) of electricity from fossil fuels (mainly coal and gas) and currently relies heavily on 2 nuclear power plants at Hunterston and Torness. The renewables share comes from large onshore wind farms, many small hydro schemes and 2 pump storage schemes. Growth in this sector is significant and there are ambitious plans for offshore wind, wave and tidal generation schemes in northern Scotland in particular [6].

Slovenia imports the vast majority of petroleum and gases, due to the lack of indigenous sources (as in much of continental Europe). The resulting total energy mix (ie electricity, transport, heating etc) is estimated at 55.9 TWh. In 2005, when setting targets for 2020, the EU estimated that 16% of this total figure was derived from renewable sources. This compares favourably with the EU as a whole (6%) and the UK (less than 2%). The EU target for 2020 is to produce 20% of the total energy requirement from renewable sources. Slovenia has to reach 25% and the UK 15% (since it was so far behind the rest in 2005). Slovenia should achieve the target; Scotland should also exceed the target, but it will take a lot of work for the UK as a whole to meet the target.

# 4. Building Performance

## 4.1. Housing Types

The houses that we visited were mainly of the single detached family dwelling, common throughout continental Europe. Whilst the 20 houses that we visited varied significantly in age, form of construction and subsequent renovation standards, they seemed to form the higher end of the range of housing on a country-wide scale. We saw apartments and social housing from the road, but few of the visits revealed much about the condition of the lower end of the housing range.

## 4.2. Thermal Performance


Traditional house construction in Slovenia incorporates thick stone walls with timber joists and roof structures as in much of Europe. Houses constructed in the second half of the Twentieth Century consist of a concrete frame and floor slabs with infill walls of clay bricks or concrete blocks, almost always plastered internally and rendered externally. Little attention was paid, until the latter part of the last century, to thermal performance and insulation was rarely incorporated into the original structure, except by a few far-sighted individuals (some of whom we met on our visit). The image shows a display model in the Fibran insulation factory for the foundation / wall interface of a Passive House.

Improving the thermal performance of both new houses and the existing housing stock has rightly been identified as a key part of reducing the space heating requirements and ensuring a more sustainable future. To achieve this, the Slovenian Government, funded by increased fossil fuel and electricity taxes, is subsidising the retro-fitting of insulation to the exterior of existing houses. The owners of the houses that we visited where insulation had been retro-fitted had generally added around 10 cm thick styrofoam blocks to the outside of the house which had subsequently be rendered and repainted. Work was needed at openings such as windows, doors and vents to make good the finish, but in general it was difficult to see that the work had been carried out once it had been completed. The cost of retro-fitting varied widely depending on the building's site and complexity of shape, but where the cost had been compared to savings in energy use (before and after insulation), the payback period was only a few years (less than five in most cases). One owner noted that it would have cost €3,500 to just repaint the house, but only €9,500 to insulate and paint and that the additional cost would be covered by savings on energy costs very quickly.

Bojan was particularly keen to point out thermal bridging in structures, where the insulation envelope is breached by a structural element (such as a roof joist) or at the surrounds of windows.

Renovation of old structures, such as the 200 year old pub in the photo, did not result in an obviously 'old-looking' house after the work was completed. Indeed, there seemed to be a general acceptance in Slovenia that this work was necessary, and the planning difficulties that are being encountered in Scotland with this sort of work, in particular in conservation areas and 'historic' houses, did not seem to be present in Slovenia. Given Scotland's huge stock of old structures of varying quality and historic interest, there is a clear case for adopting less restrictive planning restrictions on improving the energy performance of these structures, otherwise they will soon become unsellable and will be abandoned as has happened with many listed buildings already (a strange result of rules intended to preserve such structures).

Windows are a key element of improving the thermal performance of an existing structure. In general the standards and build quality of windows in Slovenia seem to be better than Scotland. The visit to the window factory at Planina reinforced the view of a commitment to high quality design and fabrication. Whereas double glazed units with a U-value of 1.8 ($W/m^2°C$) is common in Scotland, basic units in Slovenia achieve 1.3 and triple glazed units for passive houses have a U-value as low as 0.79. The units on display in the showroom retailed at between €300 and €500 (including taxes and fitting) for an 80 x 120 cm unit, depending on the specification. This is about half the cost of similar windows in Scotland. With a Slovenian government grant of €100 per square metre of window, up to a maximum of €3,000 per house, the economics of retro-fitting existing houses with improved windows is significantly better than in Scotland.

## 4.3. Ventilation


A considerable part of the heat losses from a house comes from that lost during the ventilation process. Existing houses, particularly in Scotland, are often draughty due to ill-fitting windows and the need to provide enough air to make the fireplaces work properly. In Scotland's generally more humid climate, it is essential that ventilation is maintained to prevent mould forming and timber rotting leading to an unhealthy environment and possible structural damage. Slovenia seems to have less of a humidity problem and can therefore seal the renovated houses more effectively.

Many of the new build or major refurbishment examples that we saw in Slovenia had installed whole-house ventilation systems. In addition to controlling the flow of air in and out of the house to reduce heat loss, they often incorporate mechanical heat exchange systems which pass the departing warm air over (without mixing with) the incoming cooler air. This ensures that as much of the heat is kept within the house as possible and is an essential element of the passive house design. The systems all required energy to run them and it was not clear what happens when there is a power cut. Furthermore the most extreme examples of the ventilation control in very well sealed houses made me feel that the house was too well sealed and any even minor pressure changes within the house (such as the closing of an internal door) could be noticed.

## 4.4. Kit Houses

We visited the Riko Hiše factory during our tour and were very impressed by the quality of construction and attention to detail. Weather-proof conditions ensured that year-round working was possible in a comfortable environment. A high-quality pre-fabricated house can be erected on site in a matter of hours and the ball-park cost of €600 per square metre is competitive with more traditional methods of construction.

# 5. Space Heating

## 5.1. General

I gathered a great deal of data during our visit on the details of thermal performance improvements and space heating systems. Much of the data was provided by the owners of the houses, supplemented by data provided on the NEP database. The accuracy of the data cannot be guaranteed, in particular since some related to 'expected' improvements in fuel usage following recent upgrade work. Furthermore, comparison of very different houses and inhabitants with very different lifestyles cannot result in very detailed findings. Nevertheless, it is possible to identify broad trends from the data gathered. The chart in Figure 6 below summarises the relationship between the approximated floor area of the heated part of the house (x-axis, in square metres) against the estimated annual energy input (y-axis, in kWh). The energy input figures have been derived from fuel usage estimates and assume a similar heat value for all firewood. Since the majority of houses with solar thermal systems used some of the output for pre-heating accumulator tanks, an estimate for this component has been made as well (see later section on solar thermal).

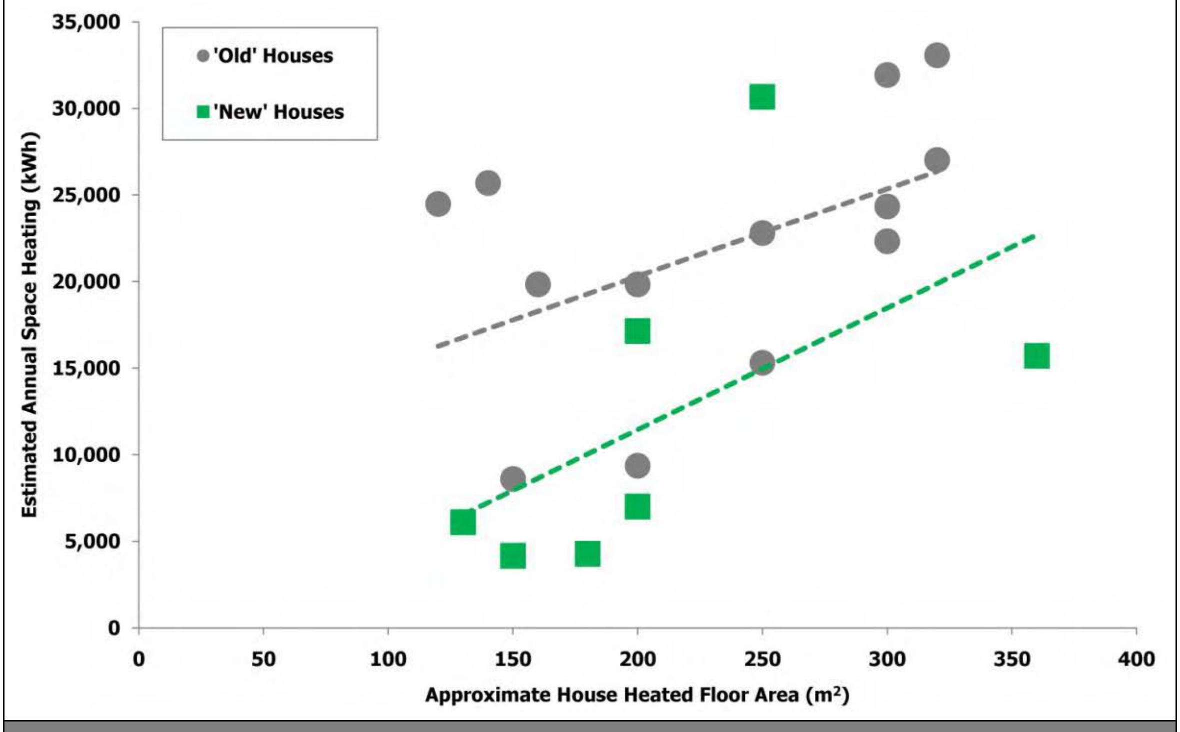


**Figure 6 – Comparison of Estimated Space Heating and Floor Area**

The clearest trend on the chart is the obvious improved thermal performance of the 'new' (ie recently-built) compared with the 'old' (ie renovated) houses. Of particular note is the cluster of very efficient low energy or Passive houses in the 'new' group. Also of note is the wide variation from the average trend within each of the groups. This reflects partly the inaccuracies inherent in this basic approach (ie lacking detailed data and measurements), but also highlights the wide range of approaches taken, some more successful than others, in reducing energy use.

The outliers in each category are partly due to widely different approaches to lifestyle, in particular the temperatures that thermostats are set at (some houses were very warm inside and a 22°C or over thermostat setting was not uncommon) plus some owners appeared far more frugal than others. Whether the house was kept at a constant temperature, 24 hours a day, clearly also had a big impact.

Given the lower winter temperatures, the values for kWh/$m^2$ of heated area compare favourably with houses in Scotland. Most of the existing houses that I have gathered data on would not fit on the above chart since the energy use in Scotland is between 2 and 3 times the equivalent level for existing houses in Slovenia.

## 5.2. Biomass

Slovenia is a heavily wooded country and firewood has always played a big role in domestic space heating. The examples of traditional houses that we saw all used a wonderful oven that was linked to the kitchen but provided heat also for the main living room. This was often the only form of heat in these houses, but provided an effective way of both cooking food and keeping more of the house warm. The thermal mass in the stove structure ensures that the heat continues to be useful a long time after the fire has gone out (when it was traditionally used for bread making). Some of the new or renovated houses that we visited had incorporated this technique and it seemed an elegant solution to providing a good background level of heat to a well-insulated house.

After a period when heating oil was cheap (luring many folk in both Scotland and Slovenia into installing oil-fired boilers), the price in Slovenia is currently hovering around €1 per litre. This is higher than in northern Scotland, where it is around the equivalent of €0.70 per litre. In Scotland, price of heating oil has almost quadrupled in the last eight years. In both countries, the search for alternatives is often resulting in a variety of biomass, predominantly wood-based, systems being chosen. In Slovenia this is particularly popular at present due for subsidies for installing biomass systems (around €2,000 per household, up to a maximum of 25% of the investment) and the ready availability of firewood. Many of the people that we met owned a plot of forest land, normally of 10 hectares. This had been the case in nominally communist Yugoslavia, where ownership of property, within limits, was allowed. The current price of firewood is €50-60 per cubic metre and this price seems fairly consistent throughout the region. The average use of the houses with firewood systems that we visited was around 11 $m^3$ per year, this would cost around €600 compared with an oil bill previously 2 to four times higher at current oil prices. If the firewood is cut from your own forest, then the actual cost is zero plus your own labour, so it is not hard to see why so many people are installing wood boilers at present.

It was interesting to see that the unit of firewood was standardised throughout the region (and, I believe, the entire continent) as a 'cubic metre'. The initial cut of logs was into 1 metre long sections. These logs were then split (normally using a tractor-mounted or stand-alone hydraulic splitter and then stacked - very neatly - to dry for at least a year, preferably two. Prior to bringing closer to the boiler room for use, the logs were cut, normally into 33 cm or 50 cm lengths and then stacked, again very neatly. I am a particular admirer (and practitioner) of log-stacking and I was delighted to see the care and obvious pride with which the firewood was treated. Scotland and the UK do not benefit from this standardised unit of measure for firewood. Logs are generally sold in whatever length they were cut in (normally less than 30 cm long) and either as a 'load' (a very variable measure, depending on the size of the pickup or trailer), the contents of a '1 tonne' bag, by weight (which brings the problem of selling recently cut, wet wood which is little use for burning and loses half of its weight if it is allowed to season properly) or a cubic metre (which often means a 1 $m^3$ bag loosely filled with logs). The cost of these widely varying units is more variable since it is difficult to compare them, benefitting the seller but not the buyer.

The type of wood used for firewood varies, but it was generally noted that beech seemed to be the wood of preference, with other hardwoods such as birch and oak next, followed by softwoods (spruce, fir and pine). Some people were very particular about the mix of wood used, others were happy to use 'waste' wood and sell the good stuff for cash. The canny ones noted that they bought firewood now while the price was relatively low and were saving their own wood for the future when the price was likely to rise.

Although logs were the main form of biomass fuel, wood chips and pellets were also chosen by some householders. Wood chips require a large storage area, have a tendency to jam auto-feed systems due to their variability in size and are susceptible to damp (it was said that this fuel was only suitable for systems over 50 kW, meaning commercial systems). Pellets are an industrial product and could be subject to price increases in the future if demand exceeds supply. However, they are reasonably standardised, require less space, are less prone to jam auto-feed systems and are less susceptible to moisture problems.


**Figure 7 – A Gallery of Biomass Boilers**

## 5.3. Oil


Despite the huge increases in the cost of oil over recent years a notable number of people that we visited, almost half, continue to use heating oil for their main source of space heating, with others keeping oil as a backup. What has made it affordable is the significant reduction is quantities used to heat the newly insulated houses (or the newly built ones where the insulation levels are high and oil was still chosen as the system). In general the amount used before and after insulation was at least halved. With the convenience of oil (smaller boiler and storage tank size, automatic availability and no need to load or regularly clear out waste), the system still appeals to older people and busy people in particular.

## 5.4. Heat Pumps

Electrically powered heat exchangers or 'heat pumps' are an ingenious way of multiplying the heating effect from electricity up to fourfold. The input energy comes from external air or a liquid which has been passed through a heat collection system of buried pipes from which energy is extracted following compression and transferred into the house. The result is a fairly low temperature output, but this is normally sufficient to heat a well insulated house.

The examples that we saw were between 2 and 16 kW (thermal), ie requiring between 0.5 and 4 kW electrical input to run the compressor. We saw both air-source and ground-source heat pumps during our visit. Of particular note was the clever use of pre-heating the input air for the heat pump by drawing the air though a tube sunk into the ground (where temperatures will remain higher than the air during the deep winter). Some of the heat pumps that we saw were just used to heat hot water, but the majority were used for space heating in very well insulated houses.

## 5.5. Storage of Heat

An oil-fired heating system normally provides heat to radiators on demand (ie when a thermostat indicates that more heat is needed). Modern, efficient (92%) wood burning boilers achieve this high efficiency by burning larger quantities of fuel in a number of connected chambers at very high temperatures (over 800°C) for an extended period. To smooth out the varying demand, heat is stored in 'buffer' or 'accumulator' tanks. These are large (the average domestic system that we saw used around 2,000 litres) and well insulated. This enables a log burner to be loaded once per day and provide sufficient heat to the storage tank to run the heating system, normally for 24 hours. A lot of the Slovenian systems that we saw connected the solar thermal array output to the base of the space heating storage tank, thus pre-heating the water.

## 5.6. Large-scale Heating

We were taken to two larger-scale heating systems in the town of Postonja. The High School 500 kW wood chip boiler, combined with some insulation work, had replaced the old oil boiler and reduced the annual heating bill from €100,000 in 2008 to €42,000 in 2010. The district heating system, based upon a 1 MW plus 0.5 MW wood chip boiler system (with 2 MW oil backup) was predicted to use 5-6,000 $m^3$ of wood chips per year.

The contractor was particularly pleased the he was paying his wood chip supplier on energy output (kWh) and not input quantities ($m^3$), so he was not worried about the quality of the wood chips. The system had received a subsidy to cover 50% of installation costs and the contractor hoped to pay his investment back in 8 to 10 years.

## 5.7. Control Systems

Many of the systems that we saw had quite complex control systems, a number of which were home-made or modified. I was very impressed with some of the ingenious solutions that some of the owners had developed and with the degree of self-sufficiency displayed. These control systems are dependent on a reliable power supply and some of the more complex systems would fail completely if the power was cut for whatever reason. I suspect that Building Control officials would be wary of endorsing similar home-made systems in Scotland.

# 6. Solar

## 6.1. General

We were blessed with generally lovely autumn sunshine during our visit and it is clear to me that solar is a viable and important element of any sustainable energy system. I have been unable to gather any reliable solar data from Slovenia, but have used data from the UK Open University [7] for the French town of Carpentras (at a similar latitude to Ljubljana) to compare with real solar energy data that I have gathered in northern Scotland [4]. The result is shown in Figure 8 below and demonstrates that both sites follow a clear seasonal variation, but that the energy available in Slovenia is at least twice that of northern Scotland in the summer and more than three times that in mid winter.

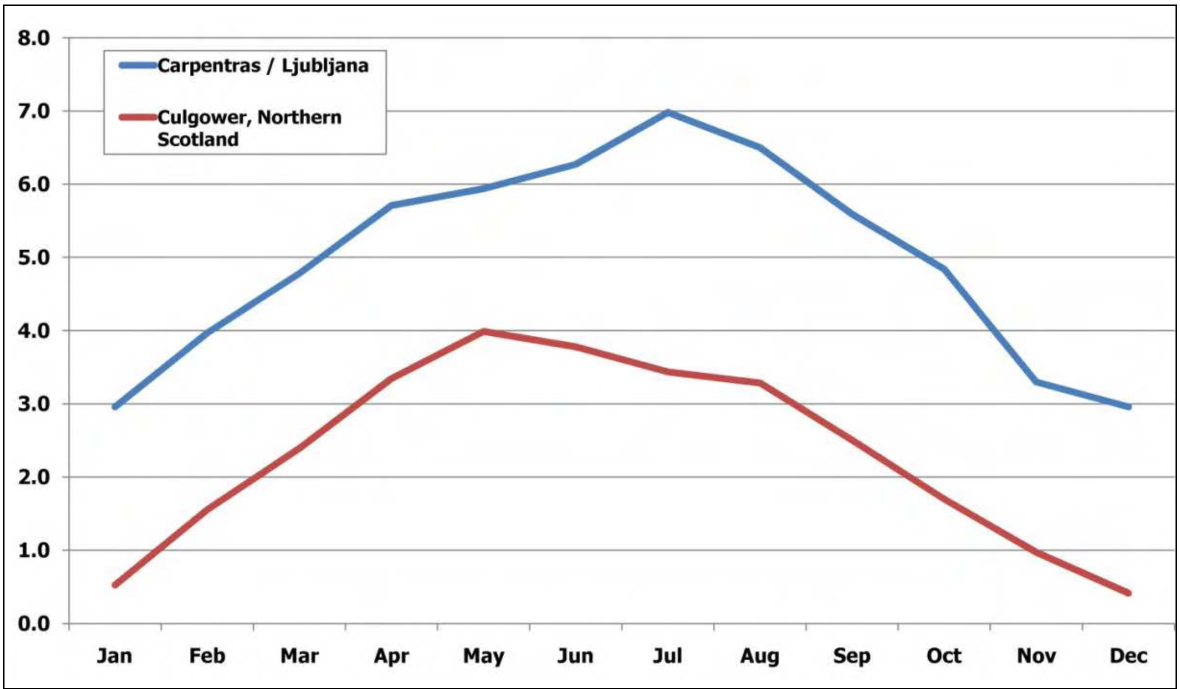


**Figure 8 – Mean Solar Radiation on 45° Tilted Surface (kWh/m$^2$/day)**

## 6.2. Passive Solar Gain

It usually makes sense to design and orientate a building to take advantage of 'free' energy from the sun. In the past, when energy costs were lower, this did not happen very often, as shown by the window distribution and seemingly random (or governed by other priorities) layout of houses. With much higher energy costs now, the design of new houses more often (but not always) takes this into account. Even in northern Scotland, the amount of energy that can be gained by having larger south-facing windows, smaller or no north-facing windows and perhaps some thermal mass which can absorb the sun's rays, can contribute at least 10% of the annual space heating needs. The 'sun house' that we visited in Slovenia incorporated a lovely glazed front area which the owner said contributed greatly to comfort levels in the house as a whole in winter. In summer, the large opening windows allowed the excess heat to be dissipated.

Intriguingly, one house that we visited had ignored this concept. The owner had observed the sun's movement in the vacant plot for a number of years and had even built a model of the house to rotate under a model 'sun'. The result was a house that was deliberately orientated not to benefit from passive solar gain in the summer. When the sun is high and the air temperature outside warm, the design ensures that the house remains in shade and is thus kept cooler. When the sun is lower in the winter, solar gain is still possible. This cunning design was typical of Slovenian ingenuity that we saw throughout our visit.

## 6.3. Solar Thermal

Over half of the houses that we visited in Slovenia had solar thermal panels, a number of which that had been installed for over 20 years. A number were of the self-build variety, particularly popular in Austria, although the stated current subsidy for solar thermal of €200 per $m^2$ of panel sounded particularly generous. All the systems appeared to be working well. Most were connected to both the hot water and space heating systems, with priority to the hot water.

Using the data from Figure 8, panel sizes and estimated space heating consumption, it is estimated that the solar thermal systems contribute between 9% and 35% of the annual space heating energy – a significant share. Given the reasonable solar energy levels, even in mid-winter, a fair amount of pre-heating of the water in the large accumulator tanks will be possible from the solar panels on sunny winter days. This is not generally the case in Scotland, where the technique has been tried in a few locations, but found to be of too little benefit to warrant the effort. Pure solar thermal for hot water systems are worthwhile in northern Scotland, they just need to be properly designed.

It was interesting to see the variation in numbers of panels relative to the size of the hot water or accumulator tanks to which they were connected. A 'rule of thumb' of 1 $m^2$ of solar panel for every 70 litres of storage was given. However, care is needed and it was interesting to note that the house with the largest solar thermal array had experienced problems in August of too much hot water, even with the large 2,000 litre accumulator tank, just from the solar panels. This system will help considerably towards space heating needs in the winter, but more work may be needed to deal with an excess of heat in mid-summer.

## 6.4. Solar thermal – Tubes vs Panels

Two of the houses that we visited had installed the vacuum tube arrays rather than the flat plate collectors which are the most common now. The 'early adopters' of the vacuum tubes had been attracted by the higher efficiency (in colder weather) which was said to more than make up for the higher purchase costs. Both said that they would not install vacuum tubes again – either due to the limited additional efficiency (claimed to be only 3%) compared with modern flat plates or their fragility (despite assurances, a hail storm had shattered 20% of the tubes and replacements were now not possible to source). The ingenious sun-tracking array (pictured) was very impressive, but the technique probably did not provide sufficient gain for most installations to warrant the additional cost and effort.

## 6.5. Solar PV

We saw a number of solar photovoltaic (PV) arrays during our visit, some quite large on commercial units, but only one house that we visited had solar PV panels installed. Sadly, the owner was still waiting after 2 months for his sizeable (11 kW peak) array of 54 panels to be allowed to be connected to the grid. In Scotland an installation by a pre-approved contractor can 'go live' immediately after commissioning is complete. The owner was therefore missing the opportunity to generate a significant amount of electricity.

It would seem that the subsidies for solar PV are lower in Slovenia compared to house insulation, double glazing and solar thermal, hence the slow take-up of this technology. This is a shame, since the resource in Slovenia is significantly better than in cloudier and more northern Germany or Scotland; yet subsidies in these countries are higher and the take-up is much greater. The coming reduction in solar PV feed-in-tariffs in the UK is likely to stop the recent stampede into solar PV in its tracks.

# 7. Electrical Efficiency

## 7.1. General

A surprisingly small number of householders were able to say how much electricity their house used (4 of the 20 houses visited), including the owners of the new low energy house and the passive house - in these, the heat pump was a large part of their electricity usage and the owners took more interest in recording the data. This is surprising, given how knowledgeable everyone was about their space heating systems and annual usage. A number of others guessed an annual usage based on how much they paid. In general, the limited data implied that each household used around 3,000 to 5,000 kWh of electricity per year. This range is similar to the average for Scottish households (excluding those with electrical heating). The cost of electricity, at around 14 euro cents per kWh is similar to that for a standard tariff in Scotland (Scottish Hydroelectric currently charge the equivalent of €0.135 per kWh, including tax (plus a daily standing charge)).

## 7.2. Lighting

I was also surprised to see so many incandescent lamps and halogen downlights, even in the new houses. Energy saving in Slovenia seems mainly to have focussed on the (admittedly biggest) problem of poor thermal performance, rather than targeting improved electrical efficiency. Early replacements of traditional lighting such as the first compact fluorescent lamps (CFL) were pretty poor – they used 20% of the energy of traditional lamps, but were slow to start, the light emitted was dim and they failed quickly. The CFLs seem to have given a bad name to all energy efficient lighting. In both Slovenia and Scotland efforts need to be made to promote Light Emitting Diode (LED) lamps which use only 10% the energy of traditional lamps and are more effective.

## 7.3. Coal-powered Passive Houses

Given the current electrical energy supply mix (see earlier) it is somewhat ironic that the 'low energy' houses are currently being powered by electricity produced from burning fossil fuels in distant power stations with large generation and transmission losses. Whilst this situation will hopefully improve as the electrical grid input becomes 'greener' it demonstrates an interesting aspect of different policies being 'out of sync' with each other.

# 8. Sustainability

Is all of this effort sustainable? Clearly the move to indigenous biomass from imported fossil fuels and electricity produced from nuclear or 'dirty' brown coal will be a major improvement, but do the figures add up?

I have tried to find definitive forest yield data, but have not found clear answers. The range for the sustainable crop from a managed forest in temperate zones is anything from 2 (Centre for Alternative Technology (CAT), mid-Wales) to 10 (Open University [7]) tonnes of wood from a hectare of managed forest per year. If one takes the lower end of the range, this would imply that a hectare of Slovenian forest could provide on average a sustainable yield of 2 tonnes (or, say, 6 $m^3$ of stacked wood) per year.

A very crude estimate of the available forest land is 20,273 $km^2$ (total land area) x 2/3 (unprotected) x 60 % (forested) = 8,100 $km^2$. These 810,000 hectares could sustainably provide almost 5 million $m^3$ of firewood per year. Divide this by, say half a million households would result in around 10 $m^3$ per household, which is not dissimilar to the average 11$m^3$ of the households that we visited. By this very crude estimate, it could be said the Slovenian biomass could provide for the entire country's space heating requirements, although there would be little left for construction and other timber uses. A more thorough assessment both by individuals and at a higher level would be worth doing to ensure that this valuable resource is used sensibly and sustainably into the future. In the case of Scotland, the forest resource is much smaller and the land ownership is much less well distributed. The current rush into biomass as an alternative to fossil fuels is likely to result in problems of availability and quality, putting an upward pressure on the price.

**Figure 9 – A Biomass Gallery**

# 9. Notes

## 9.1. Units and Numbers

**Units**

This report uses only metric units in order to ensure consistency and to keep comparisons as simple as possible. The units used are:

| | **Primary unit** | **Secondary unit** |
|---|---|---|
| Length | metre (m) | 1 kilometre (km) = 1000 m |
| Volume | litre (l) | 1 cubic metre ($m^3$) = 1000 l |
| Mass | kilogramme (kg) | 1 tonne (t) = 1000 kg |
| Power | watt (W) | 1 kilowatt (kW) = 1000 W |
| Energy | kilowatt-hour (kWh) | 1 kWh = 1 'unit' of energy |
| Temperature | Degree Celsius (°C) | |

**Standard terms**

| | |
|---|---|
| Kilo | 1,000 x |
| Mega | 1,000,000 x |
| Giga | 1,000,000,000 x |
| Tera | 1,000,000,000,000 x |

**Energy content of common fuels**

| **Fuel** | **Typical energy content** | | |
|---|---|---|---|
| Heating oil (kerosene) | 9.7 kWh/litre | | |
| Air-dry (*) wood | 4.2 kWh/kg | (* 10% moisture content) | [7] |

## 9.2. References

1. Vitra Centre for Sustainable Development NEP: nep.vitra.si
2. Country statistics and map: www.wikipedia.com
3. Weather data for Ljubljana: www.climate-charts.com
4. Culgower Microgen: www.culgowermicrogen.com
5. European Union Energy Portal: www.energy.eu
6. Scottish government: www.scotland.gov.uk
7. Open University: www.open.ac.uk