The Ravina Project

Project Description and Status

Gordon Fraser B.A.
Director - The Ravina Project

www.theravinaproject.org

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Executive Summary

The Ravina Project is five years old. It started originally as a project to reduce the carbon footprint of a house in an old Toronto neighborhood. Today the Ravina Project is on the verge of becoming one of the first houses in Toronto to go off-grid. Off-grid living means that the house will generate all its electrical power using its own resources.

The Ravina Project has grown to become an experiment in off-grid living. Using the house as an ongoing experimental test bed, the Ravina Project will generate and publish a wide range of data, test new theories to increase efficiencies in the generation of solar power and produce technical papers across several disciplines over a period of 60 months. The project currently has the wiring infrastructure, the batteries, the electronics and the solar array installed. Today, depending on the time of year, the house can withstand several days to several weeks of power isolation from the grid by relying on the power generated by its 1500 watt solar array and its storage batteries. However, the energy density of the sun alone cannot provide enough household power on an ongoing basis. Wind power must be added to the generation capacity in order for enough energy to be harvested to satisfy household needs.

The Ravina Project so far has been a total success with all the installed technology working perfectly. The success did not happen by chance. The project directors Susan Laffier and Gordon Fraser have carefully planned and implemented various new technologies at each stage of the project. These technologies were researched and understood fully by the directors before being employed. As a result the Ravina Project has gone from success to success.

The Ravina Project is now poised to take on a whole new set of challenges. The biggest challenge is finding sponsor(s) to help with the additional expense of going off-grid. Twenty thousand dollars are required in order for the project to move forward.

History of the Ravina Project

The Ravina Project is centered upon the house at 75 Ravina Crescent. It was built in 1925 and was one of the last houses to be built in the neighborhood. When Susan Laffier purchased the house in the 1970s it had had very few upgrades over and above the original build. One upgrade involved the conversion of the coal furnace to an oil furnace. The wiring, plumbing, windows and insulation were all original equipment on the house.

Starting five years ago Susan Laffier implemented a five-year plan which had two goals. The first goal was to reduce the carbon footprint of the house and the second was to improve the safety of the household. As a result of the plan the house was wired with a 100 amp service including the installation of a modern distribution panel. Previously, the house had a 30 amp service with an obsolete mode of wiring. This upgrade greatly increased the safety of the household.

To reduce the household carbon footprint, Susan employed several upgrades to dramatically reduce the amount of energy the house used. She upgraded the insulation both in the attic and in the basement. The basement insulation sealed the joint between the top of the basement wall and the bottom of the first floor wall. This upgrade denied the passage of cold air from the basement into the walls of the first floor. The windows and back door of the house were original equipment. They were upgraded to modern double pane windows and door which were tightly sealed to the frame of the building. This upgrade dramatically increased the house's ability to hold air and heat.

The house had an oil furnace to provide heat to the hot water heating system and an electric hot water heater that provided domestic hot water. Both these devices were removed from the house and replaced with a boiler. The computer controlled boiler is no bigger than two breadboxes in size and uses natural gas to do its work. It has two jobs. Firstly, it provides hot water to the heating system just like a regular furnace. It is controlled by thermostat located on the first floor. Its second job is to provide domestic hot water. It does this by heating hot water on demand when a hot water tap is opened somewhere in the house. The boiler operates at over 95% efficiency. It is a substantial improvement over the technologies it replaced.

Changes were made to household appliances. All household appliances were examined for their power drain and efficiencies. Appliances were replaced with the most modern and efficient models where necessary. All light bulbs were upgraded to energy efficient models. Small power bars were attached to all appliances which operate in “always on” or “instant on” modes. The power bars are used to cut the power completely to these types of appliances. Each appliance was attached to a power meter for a period of time to measure the amount of power and the number of kilowatt hours used by the appliance. This procedure established a baseline usage for that particular appliance. Subsequent modifications to each appliance’s settings and usage could then be tested to see if the power usage increased or decreased. Using this method each appliance was tuned for proper operation and minimal power use.

Lifestyle changes were also made in the household. Clothes were dried outdoors whenever possible. We have many plants that are outdoors from late Spring to early Fall. They are brought into the house during the Winter. They provide enough humidity for the household so that a Wintertime humidifier is not required. During Wintertime we keep the house cooler and wear sweaters and during the Summertime we dress lightly, use fans to bring in cooler air and open windows to take advantage of cross breezes.

On really hot days there are three appliances we can use: we have a small window size 5000 BTU air conditioner in the master bedroom, we have a portable 10,000 BTU air conditioner that we use on the main floor and finally we have a dehumidifier. We have found that a combination of the dehumidifier plus the small air conditioner works well on most days. On other days we have to run both air conditioners during the daytime with the smaller one used at night. We find the temperature in the house can be rather high, but kept comfortable if the humidity is controlled. The bottom line from an energy usage point of view is that to achieve minimum energy usage, several appliances should be mixed and matched to maintain a comfort level in the house.

The net result of all these changes was a dramatic decrease in the household energy input. Before the upgrades a Wintertime heating bill of over $900 per month was not uncommon. This amount did not reflect any electrical usage. The cost of the actual monthly energy input to the house was substantially more. Since the upgrades were completed databases containing house usage data for both electricity and gas over the last several years have been maintained. Based upon 853 days of electrical usage the house uses on average 14 kilowatt-hours a day. At various times of the year daily usage varies from a low of about 5.5 kilowatt-hours to a high of about 20 kilowatt-hours. For a substantial part of the year the house is running on about 350 W.

The monthly usage of natural gas resides in a database which extends for 1037 days. The house uses on average about 8 m^3 of gas a day. During the Summertime the house uses less than a cubic meter of gas a day and on the coldest days in the Winter it uses about 20.

The household total energy cost per day averages out to be $6.34 over the last 853 days.

Given the age of the house, the upgrades and lifestyle changes have proven to be extremely successful. The goals set out several years earlier have been achieved in a spectacular manner.

The cost of the upgrades was about $20,000.

New goals for 2006 and further upgrades

Early in 2006 the Ravina Project adopted a set of goals for the year 2006:

- To further reduce the household carbon footprint,
- To provide for household energy during a blackout of 24 hours by building a household uninterruptible power supply containing 14 kWh of usable energy,
- To build a 1500 watt solar array to generate clean household power on a daily basis, run the house and charge the battery during an extended blackout,
- To export excess clean energy to the grid for others to use, and
- To collect extensive data on household energy usage and generation of clean power.

A Request For Proposal was issued in the late Spring of 2006 for a solar collector, backup battery, associated electronics and labor for the installation. One of the key requirements in the RFP was that the equipment had to be off-the-shelf and “vanilla” flavored. In other words, the equipment and technologies employed were to be nothing special and in common use throughout the green power industry. Three companies responded to the RFP. The contract was awarded in late August 2006 to Solsmart Energy Solutions Inc. of Toronto.

The RFP specified the installation of:

- 1500 watt tiltable solar array,
- 17 kilowatt-hours of battery,
- solar charge controller,
- 4000 W inverter/charger,
- grid tie interface,
- the associated support structures and wiring required to make it all operate together.

The house wiring had to be modified in order for various circuits to be powered by the emergency power that comes ultimately from the batteries through the inverter/charger. C.F.I. Electric LTD of Toronto provided the expertise and equipment required to make the modifications to the house wiring at a cost of $1,200.

The solar array is designed to be tiltable from flat position which is parallel to the ground to a raised position which of 70° with respect to the ground. The mechanism for raising and lowering the array automatically based upon the time of day was provided by Satellites Unlimited of Oshawa at a cost of $550.

The work was completed in November 2006 at a total cost of about $29,000.

Since the technology has been in operation for 3 months, the goals for 2006 can now be evaluated.

The household carbon footprint was reduced by the generation and usage of clean power from the solar array. Since the installation in November of 2006 a total of 256.10 kWh of clean energy has been produced. Of that total amount 37.51 kWh of clean energy was exported to the grid for others to use. The net amount of clean power used in the house was about 218.59 kWh. The household carbon footprint was reduced by the equivalent carbon reduction of 218.59 kWh of grid power. The installation of electrical heaters in critical places in the house used some green power. The heaters were placed in areas identified as being heat sinks for the warmth generated by the boiler. This modification to the house's internal thermodynamics translated into less usage of natural gas by the boiler. The gas reading at the end of January differed from the estimated gas usage provided by the natural gas supplier by 110 m^3. The extra usage of a few kilowatt-hours a day of clean power translated into a real saving of 110 m^3 of natural gas.

Our goals, ***to further reduce the household carbon footprint, to build a 1500 watt solar array to generate clean household power on a daily basis,*** and ***to export excess clean energy to the grid for others to use*** have been achieved.

On February 23, 2007 at 15:19 the connection to the grid was severed. The house drew its power from the late afternoon sun and the battery. Over a 24 hour period we lived in the house as we normally do. We operated various appliances, lights and other electric and electronic equipment during the time of the simulated blackout. There was no change in the performance of any of this equipment. During the next day, the 24th, the array generated 7.8 kWh. The generated power was used in the house and to charge the battery that was somewhat depleted since it had been providing power to the household for about 18 hours.

On February 24th at 15:22 the grid power to the house resumed. The off-grid power test was successful.

Our goal to ***provide for household energy during a blackout of 24 hours by building a household uninterruptible power supply containing 14 kWh of usable energy*** and ***using the 1500 watt solar array to run the house and charge the battery during an extended blackout*** has been achieved.

Starting in the first week of December 2006 extensive data on the usage of energy by the household and the generation of clean power was recorded on a daily basis. Included in this recording is an estimation of the amount of clean power exported to the grid using a conservative calculation. The data is contained in a series of spreadsheets. Added to the household data on a daily basis have been the mean temperature for the day, the mean wind speed and mean wind chill temperature. As well, all of the energy inputs from the house had been converted to kilowatt-hours using common industry accepted conversion factors between the energy of natural gas and the energy in a kilowatt hour. Each 24 hours a total amount of energy usage is calculated for the house in kilowatt hours.

Our goal to ***collect extensive data on household energy usage and generation of clean power*** has been started and is ongoing.

New Goals for 2007 - 2012

Based upon the successes of the Ravina Project so far, it is now possible to plan the project goals for the next 60 months. Critical to these new goals is the fact that the house is now fully capable of acting as a test bed for green power generation and furthermore because the solar array is tiltable and programmable according to the time of day, various hypotheses can be tested using the data generated by the solar array. Practical solar power research is possible now and can continue into the foreseeable future.

The Ravina Project's new goals are as follows:

- To increase public demand for the products and services provided by the green power industry.
- To sever the connection between the house and the electrical grid for a period of 60 months. That is, we will attempt to generate all of our electrical power from clean sources for a period of five years.
- To collect, analyze and propagate household energy usage and power generation statistics while off-grid.
- To be a platform for solar power research,
- To be a platform for urban wind energy research,
- To demonstrate by off-grid living that modern off-the-shelf technology is reliable, easily maintained and easily installed.

In the next section we want to discuss each one of these goals in detail.

New goals - a detailed discussion

An introduction and some initial comments

The Ravina Project has had a great amount of success over the past five years. The success did not come about by chance. The project has been successful so far because each step of the way was carefully planned, the alternatives were carefully examined and finally the execution of the various parts of the project, and there have been quite a few, have all been executed with extreme care and professionalism by the contractors mentioned above.

The Ravina Project intends to carry on in the same mode and expects to go from the substantial successes of the past to more successes in the future. We will do this primarily by following industry standard procedures in the awarding of contracts, in the publishing of RFPs and using off the shelf, standard technologies at all times.

We intend on using the house at 75 Ravina as a test bed and a data gathering instrument. We intend on publishing the data gathered from the various generation devices and from the thermodynamic characteristics of the house in technical journals and in other media/industry periodicals.

All the money so far invested in the project has been our own money. We have received no money nor materials from any industry source. We are going to generate data, do our own valid statistical analysis on that data and publish the results without any spin whatsoever. We believe that the data should speak for itself and that the public should be informed with the results of our data analysis, thereby, it is hoped, forming in the public mind realistic expectations regarding the benefits of clean power production on a household by household basis.

It is quite possible that the industrial approach to solar generation is not a valid approach. What we mean by this is the following. Traditional approaches have involved large industrial plants devoted to the production of electrical power. Utilities have large coal, gas or nuclear power plants. These power plants hook into the grid and provide power for the users on the grid. There are many reasons why this industrial approach to traditional forms of electrical generation are successful. We're not interested in listing them all here except to point out that the equipment and power supplies used to generate electricity are fairly compact in size. The power output density per square meter of space used is high.

For example, a 20 acre area is used to construct a 250 MW gas powered plant. Twenty acres contain 80,937 square meters. That results in a power density of 3,089 watts per square meter of area used by the plant.

Let's examine the power density of wind power. Wind power is essentially vertical in nature. A small horizontal area is used but the structure towers into the sky at sometimes substantial heights. An eighth of an acre of land could conceivably have 1 MW of wind power generation located upon it. The area of 505 square meters is used to generate 1 MW of power. This results in a power density of 1980 watts per square meter. Wind power doesn't have the power output density per square meter of the traditional industrial power plants but certainly wind power is closer to them than solar power generation. See below.

Contrast this with the use of solar panels to generate power. Solar panels take a lot of area to generate a very modest amount of power. Our solar array is approximately 12 square meters in area and on a good day we can theoretically generate almost 1500 watts from that area or about 125 watts per square meter. In practice we generate about 75% of that value on average for the whole year or about 93.75 watts per square meter.

By this analysis solar power seems to be the odd man out when it comes to power output density per square meter of generator space. This observation leads us to conclude that traditional industrial modes of power generation are not compatible with solar power generation. That is, solar power generation must operate using its own power generation paradigm and not one inherited from traditional industrial methods.

What is this new paradigm? There are several answers to this but we think the one that is the most important is the concept of distributed power generation rather than concentrated power generation. Traditional power plants are certainly concentrated but we see that the nature of solar power generation is antithetical to those traditions. It seems to us that solar power generators can most effectively be used by being distributed among the users of electrical power on the grid. 500 watts here and 1000 watts there of solar panels on the roofs of thousands of houses quickly add up to a huge moderating influence on the surging power demands during those hot sunny Summer days. The power is used at the point of generation so there are no transmission losses incurred. Furthermore, there are not maintenance issues with the generators. Modern solar collectors are built to last for at least 25 years and probably can last for many more years. What will terminate their use will most probably be huge increases in efficiencies such that their rooftop space will be needed for the installation of newer panels.

Here's an example of a concentrated approach to solar power generation. Let build a solar power plant, on paper at least.

Suppose that 1 acre of industrial land is purchased. It is 4046 square meters in area. The area is populated with solar panels. The panels can't be close packed together because they cannot shade each other in the late Fall, Winter and early Spring. Each panel takes 3 square meters of space so 1,348 panels can be fit into the 4046 square meters of area. Let's assume that each solar panel generates 200 watts.

1,348, 200 W panels can theoretically generate 269.6 kW at full power at noon on March 21st at the equator with no internal resistance and no losses when the DC power is converted to AC power. Since we are not on the equator and the sun gets up only to about 70 degrees of elevation in the sky, the power output at noon sun time on June 21st would theoretically be about 90% of the rated power. However, heat takes its toll and the yearly average real power output is about 75% of the rating on the panels. Cold winter days allow for sustained power output of about 85 percent. Hot summer days reduce that power output into the high 60's. We have seen these de-rating values on our own 1,500 watt array.

The bottom line for this discussion is that the rated power of the panels and actual power generated by the panels is not a product of their power rating and the number of sun hours in the year at a location. All the other factors contribute to being able to generate about 75% of that product.

The wholesale cost for the power plant PV panels is presently between $5,500 and $7,500 a kW for a total of $1,482,800.00 to $1,887,200.00. There are about 2000 hours of sun in Toronto of which about 80% is usable for full power generation if azimuth tracking is used. 1,600 hours of usable sun multiplied by a de-rated 202.2 kW of panels gives a yearly total power generation of 323,520 kWh. Let's add another 40,000 kWh as a 'fudge factor' accounting for cloud cover that does produce some power for a yearly total of 363,520 kWh. The power is sold to Ontario Power Authority at $.42 a kWh for a yearly gross income of $152,678.40. When all the expenses including the cost of land/borrowing, electronic equipment for grid tie, cost of a power corridor, labour, support structures, taxes, overhead, operating costs and etc., etc are factored in, the initial investment of about $1.8M plus does not have a better return than an investment in blue chip securities with no risk involved.

At this latitude, the concentrated, industrial model for solar power generation is, in our opinion, a myth and if implemented would be a boondoggle without government incentives. Buy bonds instead, there will be more return.

However if solar panels were broken out in twos or fours on existing roofs then there is no price for land and no tax to be paid. Only the cost of the solar panels, some electronics and the installation are a factor. Many industries are using the roofs of their buildings to generate solar power especially in California where they have more cash incentives to build solar generation and of course better sun. This business model seems to have more legs than the other one above structured on Ontario. For society at large in Canada, it seems that urban rooftops are the places to put solar power generators.

In sum, it is our view that, for solar power generation, the distributed power generation model is the correct model to use. It is therefore incumbent, given the paradigmatic nature of solar power production, that governments and other interested parties, sponsor and encourage the rollout of solar panels and the associated electronics to urban rooftops.

The project goals

To increase public demand for the products and services provided by the green power industry.

Of all the project goals we might list first, this might seem to be an odd one considering we are a couple of retired people with part time jobs. Why should we care about the green power industry? We've received no help in any way from that industry, hold no securities of any kind in that industry and have never worked for or been associated with the green power industry.

It's a good question.

The answer to the question is both philosophical and economic in nature. As it stands right now the industry is very small and the people that are actively installing green power devices need winter jobs to sustain themselves. The ‘man on the street’ may know of a house that has solar panels on it. We stress the word, ‘may’. When we were contemplating putting solar panels on our house we asked many people in our area of Toronto about the existence of solar panels on homes. Few people knew of any homes with solar panels on them and those that did directed us to the two houses in a geographic area of several square kilometers which had solar panels attached to them. It was very slim pickings to say the least. We knew we were going to be early adopters but we weren’t quite prepared for how early the adoption would be. We were going to be very, very early adopters of this new technology.

The Ravina Project intends to take this adoption of new technology one step further. We intend to install wind power and use that increase in power generation to pull the plug from the grid and live independently from it. We intend on becoming a beacon for others who are considering installing some green power generation on their houses. We want to demonstrate for them that the current technology used to generate green power is reliable, because of course we're depending on it day by day, easily maintained and easily installed.

We want to demonstrate over 60 months that this off the shelf technology is not new nor radical. It is mainstream stuff that the average homeowner can have installed and use. They don't have to live like us, off-grid; they can take part of the technology we will have in place and adopt it to their own situation. Our demonstration will show them that it's not risky business at all to harvest energy from the sun/wind and decrease the carbon footprint of their household.

So how does this help the green power industry? It helps the industry simply by demystifying the technology and demonstrating to future customers that it is mainstream, reliable and easily installed. As more and more households give more and more business to the green power industry, more viable businesses will be formed to satisfy that demand. More money will be invested in the industry and more technology will be invented to satisfy the demands of the customer base. Research and development will increase, further hastening the arrival of the next generation of clean energy technology.

The key to this future avalanche of consumer demand is, we believe, projects like the Ravina Project which will demonstrate that the technology is not scary, is not complex, is reliable and is dependable. As far as we know there are no houses in Toronto that are living off the electrical grid. The Ravina Project intends to break this ice and become a beacon for people who are seriously considering green sources of electrical power for their own household.

The Ravina Project firmly believes that the increase in consumer demand for green power generating products has to start somewhere and furthermore we believe that by our actions we can substantially contribute to that beginning.

The Ravina Project believes we need to transition to a healthy, creative and busy green power industry in this country. We want to do everything we can to help that transition along.

To sever the connection between the house and the electrical grid for a period of 60 months. That is, we will attempt to generate all of our electrical power from clean sources for a period of five years.

Can it be done?

Is there enough power in the sun and the wind to allow a household to go off-grid here in Toronto? That's the big question. We are not aware of any household living off-grid in Toronto. Could there be a reason for this fact, if it is true? Maybe it can't be done. We don't know. It's like walking around a darkened room with a blindfold on. We are totally blind because there is exists no relevant data for us to get our bearings and think about the problem.

The idea of living off-grid in one of the oldest and most established Toronto neighborhoods is therefore quite probably unique. It will require the installation of a wind turbine, optimized for small to moderate wind speeds, which has a power output of at least 1.5 kW. A solar array of 1500 watts will not produce enough power to run a house, even a house somewhat optimized for electrical power efficiency like ours.

One associates off-grid living with rural living, where there is plenty of room for multiple solar arrays and several wind turbines or one big turbine. In an old Toronto neighborhood where properties are small, solar arrays can be constructed on top of houses but wind turbines would seem to be out of the question. Except for recent technological innovations, older wind turbines have been noisy and expensive to maintain. In cramped spaces of old Toronto a noisy turbine is not welcome. The new generation of wind turbines are very low maintenance and their blades rotate at a relatively slow speed even in the most powerful wind. Since rotational speed is proportional to the noise generated by the turbine, the low rotational speed at all wind velocities means the noise generated is not greater than the ambient noise of the wind in the trees. This new generation of turbines can be thought of as being very much like appliances, that is, they can be installed and used without fuss for many years

According to a city bylaw, towers cannot exceed 10 m in this neighborhood. The trees here are anywhere from 12 to 17 meters tall. A wind turbine on top of the 10 m tower would be dwarfed by the trees around it and therefore get no wind or very turbulent wind. In this neighborhood a tower of at least 25 m is required. One of the directors of the Ravina Project, Gordon Fraser, is a licensed amateur radio operator. Amateur radio operators can build towers on their property to any height required to support their antennae. The Ravina Project therefore can build a 25 m tower on its property.

The house that is the focus of this science experiment has a unique location and is situated on a unique piece of property. The property is pie shaped and consists of two lots side by side. One lot has a house built upon it and the other lot contains a large garden. Directly behind the house is a public access laneway and behind the laneway is a large high school athletic field. This unique set of circumstances compares favorably with a rural location or at least a location in the suburbs of Toronto with their larger lot sizes, smaller trees and more open spaces. Because of these factors, the high tower and the open spaces around the tower, it is highly probably that the wind generator will provide realistic data on the actual power density at 25m.

The question still remains. Will the energy harvested from the sun and wind be enough to allow the household to keep its off-grid status over a 60 month period? The Ravina Project is prepared to find the answers to this and many other related questions.

To collect, analyze and propagate household energy usage and power generation statistics while off-grid.

When the power to the street is finally severed and the Ravina Project starts the off-grid living part of the project, the house will become a science experiment yet will remain a working house lived in by two people and three cats. The house, over the period of 60 months, will be a fully functional house with people using appliances, doing their work, cutting the lawn, upgrading and doing all the things that people do every day in every season in a typical urban house. There'll be no dummy loads faking the use of a blender or microwave oven like in a science experiment. No, all the data generated in the house will be generated by real people, going about their real lives, doing real things. In a sense then the data generated by this household will be as real as it gets.

The household will have energy inputs. On a daily basis all the various inputs will be monitored and data recorded from them. As well, since the house will be operating from the solar array and the wind turbine, the battery will be supplying power to the house when there's not enough wind or sun to provide power. Daily readings of the amount of power in the battery will become part of the ongoing data collection.

Along with the power inputs and outputs to the house, the weather conditions, air temperature, wind conditions and wind chill will be collected on a daily basis. It is hoped that all this data compiled daily over 60 months will provide the basis for good statistical analysis and research by ourselves and others.

It is also hoped that the data compiled will allow people to make good decisions about whether green living or at least partial generation of their electrical power is good for them or even possible for them. It is hoped that this demonstration data allows people to make good economic decisions about their lives and about their household carbon footprint. For instance, one can approach a solar project or even a wind project for one's house if one can go to a place that has been running wind and solar power together for several years and determine that such a project is possible given the technology of the day. Compare that with the situation in which a homeowner would like to generate green power locally but has absolutely no data or maybe even just theoretical data to guide them on making that decision.

Having access to real data generated by a real demonstration project takes away alot of the worry for the householder when planning for green power generation.

To provide a platform for solar power research

The Ravina Project designed its solar array to be a platform for solar power research. Various hypotheses can be verified using the solar array as a scientific instrument. The array is sensitive to solar power between 25 watts and 1500 watts. This gives the solar array a dynamic range of about 17 decibels. That capability, along with the other capability of being able to totally eliminate any losses due to the elevation of the sun, plus its ability to mimic any industry standard angle on a seasonal, weekly, daily or hourly basis, makes it an ideal instrument to test various hypotheses regarding the most effective way to collect solar energy using a fixed azimuth tiltable array.

The first area of research compares, during the Summer months, the power generated by various attitudes/angles the solar array might have to the sun with the power generated using industry standard recommended seasonal angles.

Here in Toronto, the elevation of the sun above the horizon at noontime varies from a low of about 23° around the 21st of December to a high of almost 70° around the 21st of June. If a solar array were to be placed at one angle and not adjusted for a whole year, the sun would hit the array straight on for a small amount of time during the year. The rest of the year the sun would hit the array at some type of oblique angle. These oblique angles would reduce the collecting area of the array and therefore reduce the power the array can possibly generate.

Theoretical analysis of the sun angles and solar collection devices suggest strongly that a power output increase of 10% is possible over the three Summer months of May, June and July. This increase, suggested by calculations, requires the use of new and different array angles to the sun. Since during May, June and July the sun moves very little in the sky and the sun each day is very high in the sky at noontime, the power generated by the array at a maximum during this time. In fact this is the most intense time of the year for generating solar power. A 10% increase in the power generated during this time is a significant amount of power increase.

The array operated by the Ravina Project is designed to be remotely adjustable on its elevation and at the same time fully programmable according to the time of day. It may assume any series of angles between zero and 70°. The programmability of the solar array allows its elevation to match that of the sun on an hour by hour basis during the course of a day. This allows the array to eliminate any loss of power due to a poor sun elevation angle. This is a very different approach. Other “tracker” kinds of sun following technologies follow the sun on its azimuth.

This approach allows the array to be programmed with both the industry standards and new angles based on theoretical calculations. The array then becomes an instrument that can duplicate on a daily basis various regimens for the angle of solar collectors. The instrumentation inherent in the solar charge controller produces recordable data points. It is possible therefore, to test new theories about the most efficient array angle with respect to the sun during the Summer months.

The Ravina Project plans to publish a paper in the Winter of 2007/2008, analyzing the success of the two regimens. Every Summer, data will be generated using the same methodology for a minimum of five years and every Winter, the cumulative data will be published.

The Ravina Project intends to carry out several other experiments based upon theoretical calculations during the six transition months of: February, March, April and August, September, October. Theoretical calculations strongly suggest other efficiencies can be realized over and above the efficiencies generated by industry norms.

The sun during these transition months is very dynamic in that from day to day and week to week the sun moves dramatically higher or lower in the sky. In fact during this period, the sun moves more in a two-week period than it does during the three Summer months of May, June and July or the three Winter months of November, December and January.

Since the array used by the Ravina Project is fully real-time programmable, the dynamic altitude of the sun in the sky can be tracked by the array on an hourly basis. During these transition months, the sun can peek over the horizon at a few degrees of elevation early in the morning yet at midday be as high as 60° in the sky. Industry-standard angles for the array are locked in at 43° which corresponds to the latitude of us here in Toronto. However with such dynamic movement on a daily basis on the part of the sun, the ability to move the array so that the sun's altitude is always perpendicular to the face of the array could possibly generate more power than the standard settings.

The Ravina Project intends to explore this area of dynamic orientation to the sun using its fully adjustable and programmable solar array.

Initial computations show that another 10% increase of solar panel productivity using this aiming methodology can be achieved. Data will be collected in 2007 during the months of August, September, and October. As with the Summer project industry standard angles and the power generated from them will be compared to the power generated using a dynamic array.

Statistical analysis will be provided professionally by Professor Fraser Bleasdale Ph.D. of Trent University, a friend of the Ravina Project. Fraser will also assist in the creation of the academic papers that are generated over the length of the project to ensure their format is acceptable for publication.

As the Ravina Project matures, a WEB site will be constructed where raw data will be posted as well as project news and updates.

To demonstrate by off-grid living that modern off-the-shelf technology is reliable, easily maintained and easily installed.

So far the Ravina Project has installed 80% of the technology and infrastructure required to live off-grid. The equipment is working perfectly and data on a daily basis is being collected.

The work to be done to get the house totally off-grid is as follows:

- More battery must be purchased. The battery size currently at about 15 kilowatt-hours must be doubled to about 30 kilowatt-hours of usable power.
- The house wiring must be further modified so that all circuits run from the sub-panel that in turn is connected to the power output of the inverter/charger.
- A freestanding tower of 25 m has to be purchased and erected in the backyard of the house.
- A Southwest Windpower Skystream 3.7 wind turbine of 1.8 kW is to be purchased and installed at the top of the tower. It has to be wired into the battery to allow it to charge the battery using wind energy.

Huge strides have been made in the technology of small wind generators under 5 kW. The new generators are low in maintenance and work at full power in moderate winds.

The Skystream 3.7 is an example of the new generation of wind generators. It is manufactured by Southwest Windpower in Flagstaff, Arizona USA. The device spent a year in NREL testing and passed with flying colors. The AC version of the Skystream has been on the market since November 2006; the battery charging DC version is on its way and is currently available.

The skystream 3.7 has the following characteristics:

- Its rated capacity is 1.8 kW
- it weighs 70 kg
- the three bladed rotor diameter is 3.72 m
- the maximum speed of the rotor blades is 325 rotations per minute which makes it very quiet even at its top speed. The relatively slow rotational rate at its top speed ensures that birds are not harmed by the rotation of the blades because they can see the blades.
- the air speed required to start generating power is 3.5 m per second or 8 miles an hour
- full power is achieved with the wind speed of 9 m per second or 20 miles an hour
- the rotor blades are designed to survive a wind speed of 63 m per second or 140 mph.

In order to use a wind generator effectively it must be on a tower that's at least 15 feet or 5 m higher than any building or trees within 100 m radius of the site. The Ravina Project has taken measurements and calculated the heights of the various trees and buildings around the project site. It is estimated that a tower of 25 meters in height is required to place the wind generator in non-turbulent air.

The wind project does require money to be reality. The Ravina Project has spent about $50,000 completing the projects that it has undertaken over the last several years. All this money has come from the Director's personal savings. More money is not available from that source. The Ravina Project will require financial help in order to carry through on this particular part of the project.

A total of $20,000 will be required for the off-grid part of the project to become a reality.

To be a platform for urban wind energy research

If solar data is hard to find, wind data for this area of the country is even harder to find. Various agencies provide theoretical data but there seems to be no source available for wind data at less than or equal to 25 meters in altitude. The actual power density of a small wind generator like the Skystream 3.7 here in Toronto at 25 meters in altitude is totally unknown.

Why 25 meters? Toronto is blessed with lots of mature trees of various kinds. In urban neighbourhoods the trees are so tall that good wind cannot be found at altitudes of less than 20 meters and for most, it lies at about 25 meters. The wind charts like the one at http://www.windatlas.ca/en/index.php do not cover altitudes of 25 meters. Their lowest is

30 meters. When they are used to calculate the amount of power one should expect from a wind turbine of a certain size they only generate yearly numbers. These numbers are typically misleading because the average monthly wind speed varies by as much as 90% from season to season. From November to April the wind speed is high but the rest of the year it is lower. Yet when planning to use wind power, the November to April time is critical because the solar power is not up to speed. The backbone supplier of energy to the household is wind power during these months. So the question is; how much power can be generated in Toronto at 25 meters with a modern wind generator on a per monthly basis? Furthermore, when solar generation is added to the mix what is the total household electrical energy budget on a monthly basis?

We have no idea what these number are. We are ‘in the dark’ on this. The Ravina Project wishes to open this area of research up and provide some very important and valuable data.

Theoretically, we know that wind power will complement solar power given the time of year. There's very little or no data published as to exactly what this complementarity is. Gathering data from wind and combining it with the data gathered from solar will provide a real basis for thinking concretely about the future of wind/solar power in Toronto and may even provide insight into its future in other large urban centers.

Conclusion

Here’s a list (in no particular order) of questions The Ravina Project wants to answer.

- How much power can a homeowner realistically expect to generate with a 1 kW solar array on a yearly basis?
- Will the off-the-shelf components used by The Ravina Project stay reliable for the length of the project?
- How much maintenance will be required to keep the components in proper working order?
- What is the cost of a realistic maintenance program for any household that installs solar power generation components?
- Are the industry standard solar array angles to the sun in the summertime the correct angles to use?
- Active sun azimuth tracking is the preferred method of collecting solar power however azimuth tracking is not compatible with urban rooftops. Will active tracking of the sun’s altitude provide better results than passive collectors and be more roof friendly than the azimuth trackers?
- If active sun altitude tracking is better, by how much is it better?
- Will the support structure that provides active sun altitude tracking be hardy enough to survive Canadian winters and other weather related events?
- Will the support structure be roof friendly over the test period of 60 months?
- If 20 MW of solar were installed in the GTA, what would be the base level of power output for various kinds of cloud conditions? These cloud conditions are broken out as follows: overcast, moderate diffuse, bright diffuse, and clear. We are seeing, to date, a distinct power output signature for each of these sky states based upon our daily time of day power generation logs. This information is critical to utilities who plan for power availability over large areas if large scale rollout of solar power becomes a reality.

- What are the total power generation expectations expressed in MW-hours for each of the sky states described above? This will help utility power planners integrate next day cloud forecasts with power generation expectations from 20 MW of installed solar generation infrastructure.
- What is the power density of wind at 25 meters in Toronto if a state of the art wind turbine is used at that height on a day by day and month by month basis?
- Is the wind power density enough so that wind power should be considered by the urban householder as a clean source of power?
- Furthermore, is the wind power density enough for local municipal governments to lift zoning laws regarding tower heights in neighbourhoods?
- The complementarity of wind and solar power are well established in the mythology of clean power generation. What exactly is this complementarity in real data terms on a month by month basis in a dense urban area?
- Can an old but upgraded house in Toronto using a reasonably sized solar power collector and a reasonably sized wind turbine at 25 meters generate enough power to go off-grid for 60 months?
- Can a modern wind turbine survive a series of Canadian winters?
- How much does the wind turbine and its associated technologies cost to install?
- How much does the wind turbine and its associated technologies cost to maintain over 60 months of use?
- How reliable is the wind turbine and its associated technologies in terms of the number of days a year it is unusable?

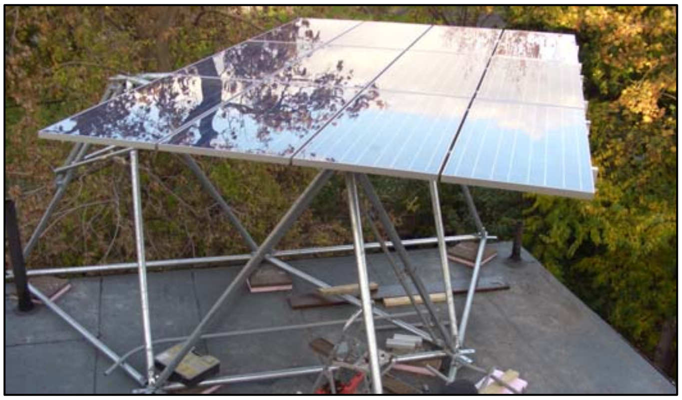
We have observed that good, real data supporting the use of green power does not exist … or put another way … we have had huge problems finding it. The data may exist in academic papers and other documents that are not available to the general public in a user friendly format. We thought about other people, homeowners and owners of commercial properties who are grappling with the idea of going green is some way. They may look ahead to spending tens to hundreds of thousands of dollars for their green upgrade. Faced with such expenditures, prudent people will want to investigate the issues and find as much relevant data as possible. By publishing the answers to the questions listed above, we hope to improve dramatically the availability of relevant data.

We fervently hope that access to our data will be a factor in giving people the confidence to press forward with their own green power projects.

Ravina Project Pictures

Solar Array

Array tilted at about 65 degrees. Picture shows tilting mechanism. The support structure, designed by Ben Rodgers of Solsmart Energy Solutions Inc., consists of three interlocked tetrahedra. Each strut is 7 feet 6 inches (2.286 m) long consisting of 2.38 inch (6.03 cm) OD schedule 40 steel pipe.



Array in its horizontal position. Picture taken at the end of the installation.

This picture is included to show the actual size of the array with respect to a person. The array is 12 square meters (129.1 square feet) in area. It is shown as the finishing touches were being made to the installation.

Power Room

The two large plastic containers house the batteries. The black hose takes the hydrogen from the containers to an unused chimney. The electronics on the wall form the power control center for the house. Picture was taken during the inspection process when all covers were removed from critical components.

View From the Street

The array as seen from Ravina Crescent. The solar panels are fabricated from a crystalline substrate giving them a mottled blue/indigo appearance in the sunlight. They are manufactured by Centennial Solar Inc. of Montreal.

"Live simply so that others may simply live."
- Mahatma Gandhi

Project Directors

Susan Laffier B.SW., M.SW.
Gordon Fraser B.A., MCSE, CCDP

The Ravina Project,
Toronto, Ontario,
Canada M4J3L9

gord@theravinaproject.org

Friends of the Ravina Project

Ben Rodgers B.A., M.A.,
NABCEP Certified Solar PV Installer™
Designer of the solar array support structure

Prof. Fraser Bleasdale Ph.D.
Department of Psychology
Otonabee College
Trent University