Part 3: Solar + simulation

17 March 2009 Richard Copeland

Part 3

The original design of the solar component was for 12 of 120w panels. I decided to arrange these in 3 sets of four, each set with its independent 30A charger. That's the obsession with multiple inputs again. The panels would be mounted on long aluminum angles and bolted onto the steep side of the barn roof on the shop structure, its slope with 5 degrees of the optimum winter angle. The panels could be wired either for 24VDC or 12VDC and we parallel wired each set of 4 for the 24V arrangement. The building had already been oriented due south Initially the RE system was to consist of the 12 panels and 5 turbines. Before confirming the design the system was simulated for 8.9Kwhrs per day by computer and was found wanting on the supply side. The simulation indicated that we would need to supplement with about 1100L of gasoline each year. With the geometry of the building indicating 4 turbines and not 5 the design was changed to 4 turbines and 15 solar panels. This change showed on the simulation to reduce the gas consumption by more than half. We decided to live with that and maybe approach the reduction of our in-house demand with a little more vigour, if necessary. The 15 panels were then grouped in 3 sets of 5, the controllers were still within their ampere range on the design change. The cables from the 3 sets of panels were laid out to be pulled through electrical conduit through the building and into a panel.

The batteries took some research. We finally settles on lead acid station batteries that had been withstood the test of time in the railway industry. I have described their spec's in a prior blog. The best arrangement for lead acid batteries is to place in series so that equal charge and discharge can happen and if there is a cell failure you would know because the system would shut down on output fairly quickly. Again, with my having at least something work even if partially, the arrangement made was series / parallel with 2 sets of 3 of 8V batteries arranged at 24VDC. I reckoned if one failed I would still have ½ of my storage and could limp along on that until repairs were made.

Tomorrow: OR the day after - more in Part 4

Richard

Add your comment

Part2 Design Scramble

17 March 2009 Richard Copeland

Part 2

I remembered little about Direct Current (DC) power, but being from the electrical industry it was fairly fast learning. I had installed a weather data station at our building site in that fall, a result of the builder reporting how gusty it was on our hill. I got some data but holes in my numbers and final battery freeze out in December. I knew from spending time in the area that the wind was blustery and that hydro was frequently out from trees blowing down on the power lines. The data did show frequent gusting. Even though I did not have great data I decided to go with part wind more from experience than good engineering. The data I did have suggested low wind average wind speed (you should have about 10mph annual average for most turbines) but the experience side suggested that when the weather was cloudy and precipitating the wind was there. I measured at only 36 feet of height and had to consider how high I wanted to go, the greater the height the greater the output. Since the installation would be on a hill top, there is an expanding air effect which happens when winds compress on a hill side and expand when they are less restricted at the top. The expansion increases wind speed, and I had good slope in all directions excepting the east. The gusts become important, because when the wind speed doubles - output increases much faster, For example one of my 400w turbines will produce 160w at 20mph winds and 800w at 40mph.The decision was made to go with wind and but not a big way. It would, hopefully, supplement poor solar conditions, and we were focusing the gusts.

We chose to go with multiple turbines instead of one. The small turbines we looked at were responsive to high winds (about 3 foot diameter on the sweep of the blades), were self regulating to the batteries, which made them easy to install and if one failed the others would continue to work. I'm almost obsessive with designing power continuation in the event of a failure. In high winds the blades are self regulating by twisting to dump off the winds. If the batteries are charged they automatically brake to prevent unplanned over charging.

Mounting the turbines became the next issue. We were banking on grandchildren shortly down the road and didn't want

to deal with guy wires for a number of towers crisscrossing .the property. We reasoned that the location was on a hill, we had experienced the wind (though our data wasn't terrific) and that a building that was yet to be built could provide better than the recommended distance required between turbines that towers, braced to the new shop was the way to go. When the shell for the shop was erected, it received extra bracing with steel brackets and channels. Standard TV antenna towers were acquired and their tops cut open and 1.5" rigid pipe welded into the top. The towers were assembled and pulled up against the sides of the building on the east, or lowered through the lower level roof on the west. In the case of the west a home built hinge was used to and the top section with the turbine on it levered onto the section below. The towers were secured to the building with large 9" brackets and cross braced with 1.5" square tubes. The total height was only 36 feet, not the 60-80 foot height that would be more desirable. A 60 foot height for example would deliver about 25% more energy than a 30 foot, but the air expansion from being on a hill top could double the output. We settled for the hill top probabilities of increase to compensate for the lower height and eliminated the guy wires from the property.
Tomorrow: Solar & Simulation
Richard

Add your comment
Design Considerations Flashback
15 March 2009 Richard Copeland
Part 1
Living off-grid was not our initial intention. We were about 7 years away from retirement and had found the place where we figured we wanted to live out our lives. Living in a natural setting was important and we chose this area because we were familiar with it and had figured that a retirement boomer rush might drive up land costs in the near future. We purchased and decided to build the next year. I've mentioned before (I think Mar 2nd) that off-grid was not our intent, it was a long abandoned dream discarded because of the perception of cost. It was the cost that Hydro One had presented that influenced our rethinking on energy. In the summer of 2000 we decided to go off-grid. By the end of that year, once we looked at how we could reduce our future expenses by supplying our own water and sewage management, electricity, hot water and heating it became apparent that once the costs were sunk, and maintenance evaluated our living expenses were greatly reduced and our susceptibility to future increases in energy and water were nil. By changing the expense side of the home budget a new picture emerged and that new evaluation suggested we could retire earlier. Investing in our home and its systems versus investing dollars elsewhere for income to pay energy bills was the question. Invest in them or us? Wealth versus lifestyle. As it turned out, with the latest economic meltdown we made a good choice. We took the RE option, and decided to move in the following summer. That meant a fast furious energy system designing winter.
We spent a lot of time analyzing how we consumed in our suburban home. A large spreadsheet was developed that listed every electrical consuming device in the home, from light bulbs to air conditioners. Each device was recorded with its wattage and estimated time of usage. This consumption sheet was balanced to our hydro bills consumption over several months and recast until it made a tight match to our consumption. Then we looked at each device and decided how it could be eliminated or replaced with something more efficient. The analysis was a shocker. For example we were using 135KWhrs per month for lighting. That got cut to 14. Our refrigerator was using 600kwhrs per year; that got reduced below 300 with a product change. The freezer was a similar story. The desktop computer was traded off for a lap top. I developed a hate for hair dryers. Phantom loads from stereo and TV equipment were blocked with switchable power bars or wall switches in the new home. We seldom used the ait conditioner and did not include one in the home design. Instead a good air flow was designed with a vaulted ceiling. Our suburban consumption would have appeared below average to most at 21.3Kwhrs per day, but we got it down to 8.5 as a design target. This exercise is a good one to perform whether you are going with RE or not. It can save a lot of money. Our city savings would be would be over $450 per year at 10 cents per Kwhr. The analysis is an absolute step to be taken before going into a design. The consumption must be defined as clearly as possible. I have read reports of people who have switched to off-grid and found they soon destroyed their batteries, the load never understood nor reduced from on-grid living. It is this painful exercise that causes grief for the people in the RE construction business, too many potential clients chose not understand the effect of what they do and won't delve into how they can change to enable a much softer environmental impact.

Tomorrow: Design Scramble & Turbines
Richard

Add your comment

What's Coming

14 March 2009 Richard Copeland

I had intended to take Saturdays off, but just a quick note. Great day again as we continue to see sun and wind maintain a high charge in the batteries. The next 3 or maybe 4 blogs will be remembering (& trying to find old documentation to help with remembering) on why we did the RE system and how we did it. I'll try to keep the blog sizes small out of respect for the shortened attention spans we all seem to be developing through internet use. Have a good weekend.
Richard

Add your comment

Just Another Day

13 March 2009 Richard Copeland

Spent the day from early morning to dinner time on the road. Good readings on all guages when I got home. Audrey made good use of over supply in heat & electricity with laundry and the propane oven. Result - great baked beans and a chill out. Adam over while I was away and starting to check out the grrenhouse, including cleanup and figuring how to heat in the spring and thoughts of doing things differently this year including planting directly into the ground. Also some redesign thoughts on irrigation. Could be an interesting spring.
Its looking like spring again with the snow leaving, even though its still pretty cold.
Richard

Add your comment

Morning After the Wind

12 March 2009 Richard Copeland

BY this morning the winds had settled down to little gusts. The aftermath of the day and some of the night before included our barbeque cover off to the woods, the snow shovels blown out all over the property and a well charged set of batteries. For the community there was not a loss in hydro power, unusual for the speed of the winds and mostly likely due to the diligenence of Hydro One in finally doing a proper job of brushing out the problem trees. Credit due for the time they spent on that project last summer. Normally when these great winds blow my neighbours have no electricity and we, on the other hand, are producing it in abundance.
With the morning sun at full force we were soon up to full charge early, a situation that is good for batteries because the charge levels falls off, but a steady input (called the float charge) of energy keeps a mild bubbling of the elctrolyte and a reduction in sulphation on the plates of the batteries. (Noted March 10)
Audrey set off to do some laundry (for 2 people we have a lot of laundry) with high solar energy levels providing both electricity and hot water. With colder outside temperatures drying clothes in house helps with indoor humidity.
I'm reading an excellent book on climate change Keeping Our Cool by Andrew Weaver. Weaver is one the authors of the last IPCC report (Nobel Prize Winners) and does a great job of presenting climate change facts and analysis and, as a Canadian, does it with a Canadian perspective. Recommended.
Richard

Add your comment

Windy Wednesday

11 March 2009 Richard Copeland

Didn't go in the bush today. My muscles reported in pleased with that decision.
Yes it is a windy day. Today we got a bit of sun, but the big story on energy input for today is wind. My four tiny (400w)

turbines twirled like crazy. I (friend Bill actually phones for the info most of the time) send in a weather report to Ian Black at CBC 5 days a week and I just sent him a supplement to one Bill just sent. I watched an 80kph gust picked up on my weather station. Each of my turbines has an ammeter in line and frequently they went off scale (max is 30Amps) during the day. That's 720w per unit at my 24VDC output. When the wind speed exceeds about 70kph the blades deform to break their speed and in that instant they produce quite a loud howl. Heard many of them today. Music to my ears.
This summer I had to replace the blades on the turbines, and while I was at it I readjusted the voltage regulation (VR). Each turbine has built in electronic smarts which monitor the battery voltage and will automatically shut down if they 'think' the batteries are charged. It is a good technology, particularly if your battery capacity is small and by shutting down on charge the wear in the bearings is greatly reduced. Since the battery voltage is always an average (ie: lessened on discharge and increased during charge) the turbines can be fooled as what the real voltage is at any point in time. They do reset themselves so not much is lost in terms of production and system safety is enhanced. It appears that I didn't reset all the VRs equally, I still have one that shuts down too early, but the other three are now performing at higher voltage charge levels than previously. I'll have to shinny up there when its warmer and tweak a little more.
Richard

Add your comment

Battery Maintenance

10 March 2009 Richard Copeland

Bushed. In the bush for pretty much the whole day cutting firewood. Not easy on this old body of mine, but well worth the exercise value and enjoying the company of my son Adam.
Arrived back home close to 4:30 and had to load some wood into the shop. Better done today if the rain forecast for tomorrow is accurate. I like to keep both me and my wood dry. The other item on the agenda was to check the battery water levels.
Every 4-6 weeks I check the water levels in each cell and add water as required to maintain a a manufacturers suggested level. Since the batteries are lead-acid they require some maintenance much like the batteries in an automobile. Lead acid batteries are not allowed to be placed in the home, so I keep them in my shop about 50 feet from the house. The electricity is supplied to the home via underground cables. Because they can produce hydrogen, they must be enclosed in a box which is sealed exept for a vent to allow hydrogen to escape outdoors, which it does quite readily as a very light element.
These batteries are larger than those in a car, there are 6 of them with 4 cells each totalling 8V per unit. Three are connected in series and then the two series sets are connected in parallel to supply the 24VDC to my inverters. Each battery weighs about 425 pounds. They are manufactured in Canada by Surrette in Nova Scotia and have an excellent warranty. When we were specifying our batteries these had a very good track record as railway batteries and a history of longevity. The warranty is free replacement for 3 years and a prorated warranty for 10 years. The water levels must be kept up to prescribed levels over the course of a year and they consume less than 8 litres of distilled water at a cost of less than $4.00.
I was recently introduced to a product called Battery Equilizer which is another product manfactured in Canada and can be used to revitalize and extend battery life when used as one would use distilled water. A nearby friend who is also off-grid used the product to restore 20 year old batteries and it worked very well. After checking out several testimonials I decided to give it a try as well, but have not yet got the quantity into the batteries that I need - about 16L, although the manufacturer suggested I should start seeing results at about 3.5 litres. I'm almost there but convinced already that I am getting improvement in the capacity. They are holding at the middle 24V range for longer periods of time, and I think that my not running the generator from 3/4 thru January to today is substantiaiting that. I had better get results, the stuff retails at $35 per 500ml.
The other peice of the battery maintenance procedure is the equalization charge, fancy term for over charging. I need to use the generator to do that and perform the operation about every 2-3 months. Doing so later in a day of full sun (batteries charged already) the idea is too overcharge or bubble the elctrolyte (liquid) to diminish the sulphation that

forms on the lead plates. This is a must. If you have sealed batteries then the procedure is not required. The newer systems have an equalization charge function built in and it can programmed to occur as specified by the user. In my case I would consume about 4-5 litres of gasoline to perform the equalization charge, maybe 5 time per year.

Comments (1)

Just another day

09 March 2009 Richard Copeland

Ugh snow! The same white covering that would that would raise my spirits in late fall, is a disappointment in late winter. The warm temperatures of February have done quite a job in ridding us of snow, so much so that any vehicle could ascend our sloping driveway, and those large patches of brown grass and those junipers rising above the deeper snow grant to me the anticipation of spring. All expectations were dashed overnight. But come on Richard, it's March and its Matawatchan. We get this in April too.

Still, with the afternoon warming it was a good day to get out in the bush and cut up firewood, which we (son Adam & friend Bill) did do. I properly layered myself in clothing this time and was able to get down to just overalls to let the heat and sweat out. Presently we are just piling the stuff up, and plan to lug it out when the conditions improve.

Audrey managed to bake bread and do a load of laundry, relying more on battery storage than the late day sun. We baby sat the grandkids yesterday and Milly the oldest of three stayed overnight. I had gone to the ORI Seedy Sunday in Pembroke for the morning and Adam & Fili went for the afternoon. The cook stove was not to be fired up (too warm outside) and so the propane oven had to be used for the bread. Even though it is a 'propane' oven it still is an electricity user. Where the burners have a spark ignition system, the oven uses a resistor to light the burner and keep it lit, as does a propane clothes dryer. So although the actual electrical consumption compared to an electric stove is drastically reduced, the oven is non the less a consumer. I did measure the wattage with a 'Kilowatt' meter at one point and I think the element measured measured about 130w. If you are designing a system - that's good to know.

Richard