Jean Marie River
Solar and Wind Monitoring Update

Prepared for

AURORA RESEARCH INSTITUTE
AURORA COLLEGE

By

Jean-Paul Pinard, P. Eng., PhD.
703 Wheeler St., Whitehorse, Yukon Y1A 2P6
Tel. (867) 393-2977; Email jpp@northwestel.net,

John F. Maissan, P. Eng., Leading Edge Projects Inc.
219 Falcon Drive, Whitehorse, Yukon Y1A 0A2
Tel. (867) 668-3535; Fax (867) 668-3533; Email john@leprojects.com
And
Annika Trimble (Ed.), Aurora Research Institute
191 Mackenzie Road, Inuvik, NT X0E 0T0
Phone: (867) 777-3298, Fax: (867) 777-4264; Email atrimble@auroracollege.nt.ca

March 31, 2014

Executive Summary

This study provides an update on the solar and wind monitoring activity in the community of Jean Marie River (JMR). A wind and solar monitoring station was set up on the roof of the JMR administration building and collected about 31 months of solar and wind data.

Solar radiation sensors established in Jean Marie River measured an average daily solar radiation of 2.83 kWh/m^2/day which is slightly less than 2.9 kWh/m^2/day estimated by NASA. This is still considered to be good for solar electricity production.

The wind speeds that were measured from the same station indicated an average of 2.0 m/s for the same 31-month period. This wind speed is consistent with the previously reported five-year (2007-2011) average wind speed in Jean Marie River projected to be 2 m/s at a height of 10 m above ground. This is considered to be very poor for wind energy potential in the community and the wind energy economics was thus not examined in this study.

A brief update on the cost of solar photovoltaic (PV) for JMR is also provided in this report. For a flush roof mounted solar PV project (net metering) on a home, the installed cost is estimated to be about $6,000 per kW. A ground mounted fixed tilt utility scale project of 18 kW the installed cost is estimated to be about $7,000 per kW.

The 25-year levelized cost of energy from grid connected photovoltaic systems is expected to range from $0.54 per kWh to $0.56 per kWh, which is only slightly more expensive than the present marginal cost of diesel generation estimated at $0.503 per kWh (fuel at $0.130 per litre) but lower than the 25-year levelized cost of $0.615 per kWh.

If Jean Marie River is considering alternative energy developments, the use of solar energy generation would be a far more attractive option than wind energy. PV systems can be scaled to a community's needs and the equipment is far easier to transport, install, and operate than wind systems. Should Jean Marie River wish to pursue a PV project, subsidies would probably be required for residential net metering systems to compete with the subsidized residential power rates but no subsidies should be required for utility projects, as it is already cost-effective compared to continued diesel generation.

Introduction

The community of Jean Marie River (JMR) has about 76 people and is located on the south shore of the Mackenzie River at the confluence of the Jean Marie River. Jean Marie River is located about 340 km southwest of Yellowknife (see Figure 1) and is accessible by air, by summertime barge and by an all season road connecting to the Mackenzie Highway.

On August 29, 2011 a solar and wind monitoring station was installed on the roof of the JMR administration building in the centre of the community. The last data set was collected in April 2014, so there is about 31 months of data that was available to analyse. The weather station consisted of a 2-metre tall tripod attached onto the peak of the roof which is at 7.7 m above the ground.

A pre-feasibility study of solar and wind energy for Jean Marie River was done in March 2012. The report stated that the average power use in the community is 39 kilowatts (kW) based on the annual generation requirement estimated at 340 MWh. The authors stated that the electrical load may have decreased in years leading up to the study. The marginal cost of producing electricity from diesel (fuel at $1.30 per litre, and variable maintenance only) was estimated to be $0.503 per kWh, and levelized over 25 years was estimated to be about $0.615 per kWh.

The Arctic Energy Alliance had produced a summary of the wind and solar potential for the community. In their online report (resource section at www.aea.nt.ca) it is stated that the average wind speed was considered low at 2.88 m/s (height was not noted); however the average solar insolation (radiation) was 2.9 $kWh/m^2/day$, which is considered to provide high solar energy potential for the community.

The purpose of this study is to provide an update on the solar and wind monitoring that was carried out in the community of JMR and also to provide an update of the economics of solar energy in Jean Marie River. Detailed economic analyses were not carried out for wind energy as the wind resource is too low to be practical for power generation.

The economic analyses look at the costs of building and operating two configurations of solar PV projects in the hamlet. Greenhouse gas emission reductions from these projects are estimated. An outline of next steps is given regarding the pursuit of solar energy integration in the hamlet.

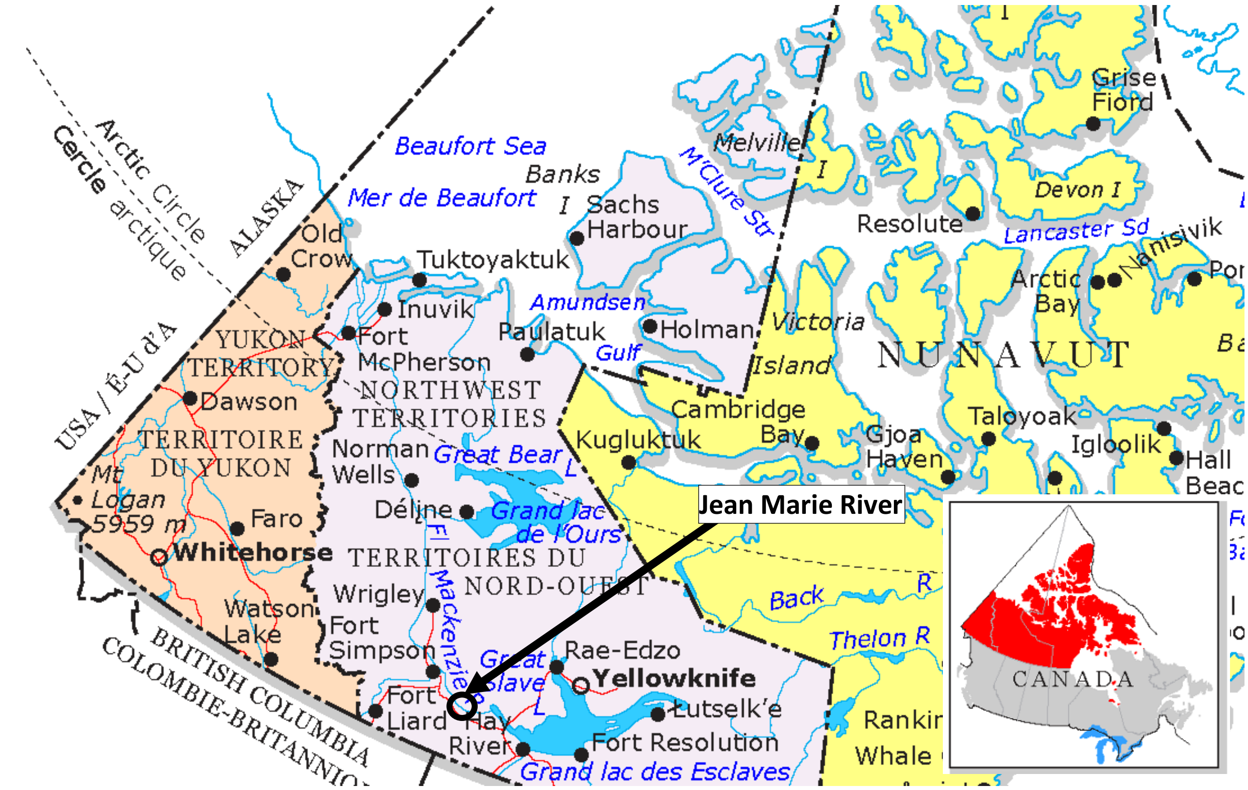

Figure 1: Jean Marie River is located in the southwest NWT, about 340 km southwest of Yellowknife.

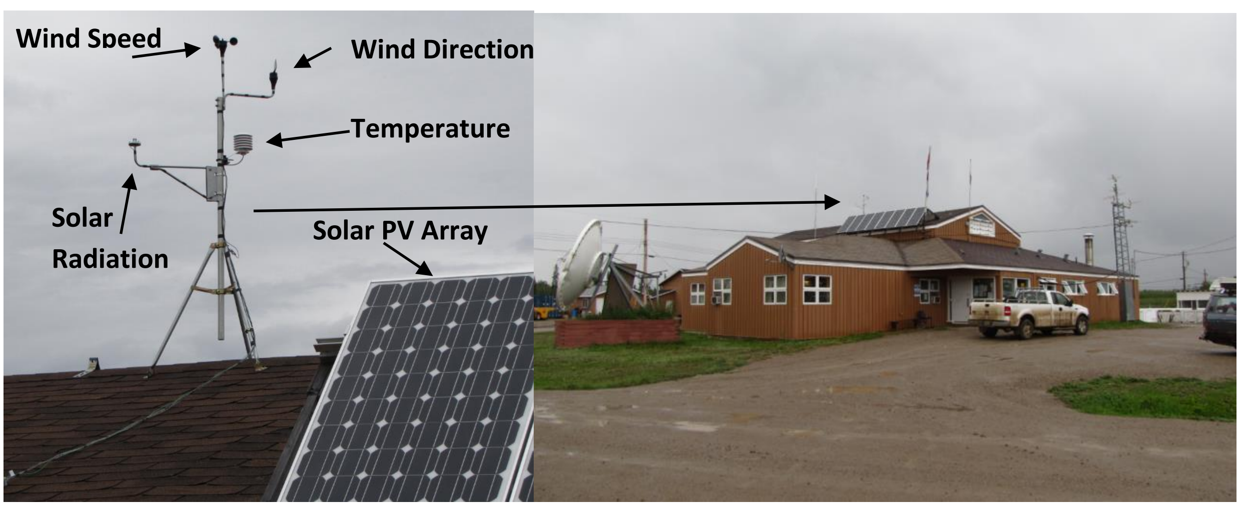

Figure 2: Photos of the monitoring station set on the roof of the main administration building in Jean Marie River. The boom of the solar radiation sensor is pointing south.

Wind Climate Assessment

The wind data used for the wind analysis was measured at the JMR administration building. The measurements made at the administration building were on a tripod set up on top of the building at a total height of 9.7 m AGL. Measurements were averaged to a 10-minute interval and included wind speed, direction, temperature and solar insolation.

Wind Speed

The weather station on the JMR administration building measured a mean wind speed of 2.02 m/s (at 9.7 m AGL) for the period of September, 2011 to April, 2014. This is consistent with the previous report in which the JMR wind speed was projected to a longer term mean wind speed of 2 m/s. A graph of monthly mean wind speed is shown in Figure 3 below.

As stated in the previous report this translates into a mean wind speed of about 3 m/s at 40 m AGL. This is considered inadequate for wind energy production (typically the minimum is 5 m/s). Therefore, the remainder of this study will focus on options for solar energy.

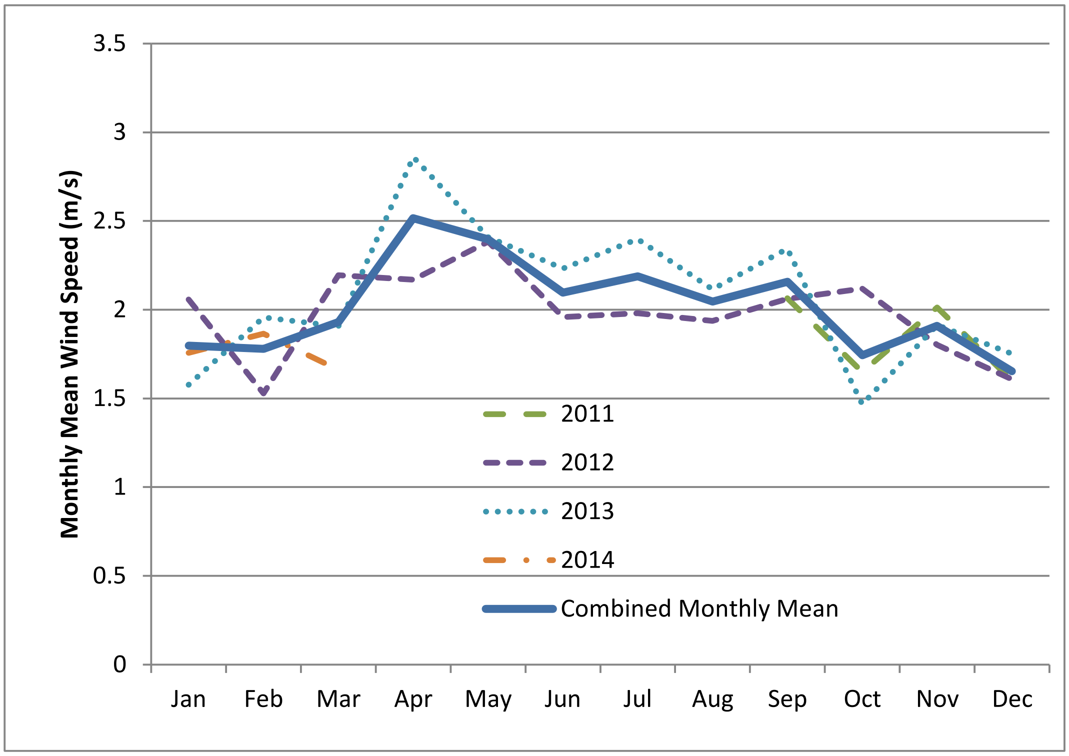

Figure 3: Monthly mean wind speed in Jean Marie River at 9.7 m above ground on the roof of the main administration building

Solar Climate Assessment

The solar data used here was from the solar radiation sensor on the rooftop of the JMR main administration building as shown in Figure 2. The measurements from the solar sensor are compared to the solar radiation estimates made from NASA's Surface Meteorology and Solar Energy (SSE) website (eosweb.larc.nasa.gov/sse/) which are described in Pinard and Maissan (2012). The database at SSE is a combination of meteorological observations and numerical modeling that provides an estimate of such things as solar radiation for locations that are lacking in measurements, as was the case at Jean Marie River.

Solar Insolation at Jean Marie River

From the SSE website solar radiation data was extracted for the Jean Marie River area and compared with actual measurements that were made in Jean Marie River. This is shown in Figure 4 below. Values shown are the monthly average daily solar radiation onto a horizontal plane at the Earth's surface. Typically solar radiation is measured with the sensor pointing straight up on a flat horizontal (leveled) plane. The measurement is made in watts per square metres (m^2), but converted to the form of energy (kWh) per unit area (m^2) per day. As will be described later, solar photovoltaic panels are typically not set up on a horizontal plane but rather at an angle facing south towards the sun.

In Figure 4 we can see that the average solar radiation measured in Jean Marie River is similar to the estimates by SSE for the same community. The most visible difference is in June when the measurements show a flatter average monthly solar radiation over the three-month period of May to July. The measured average annual solar radiation was 2.83 kWh/m^2/day compared to the NASA estimates of 2.90 kWh/m^2/day.

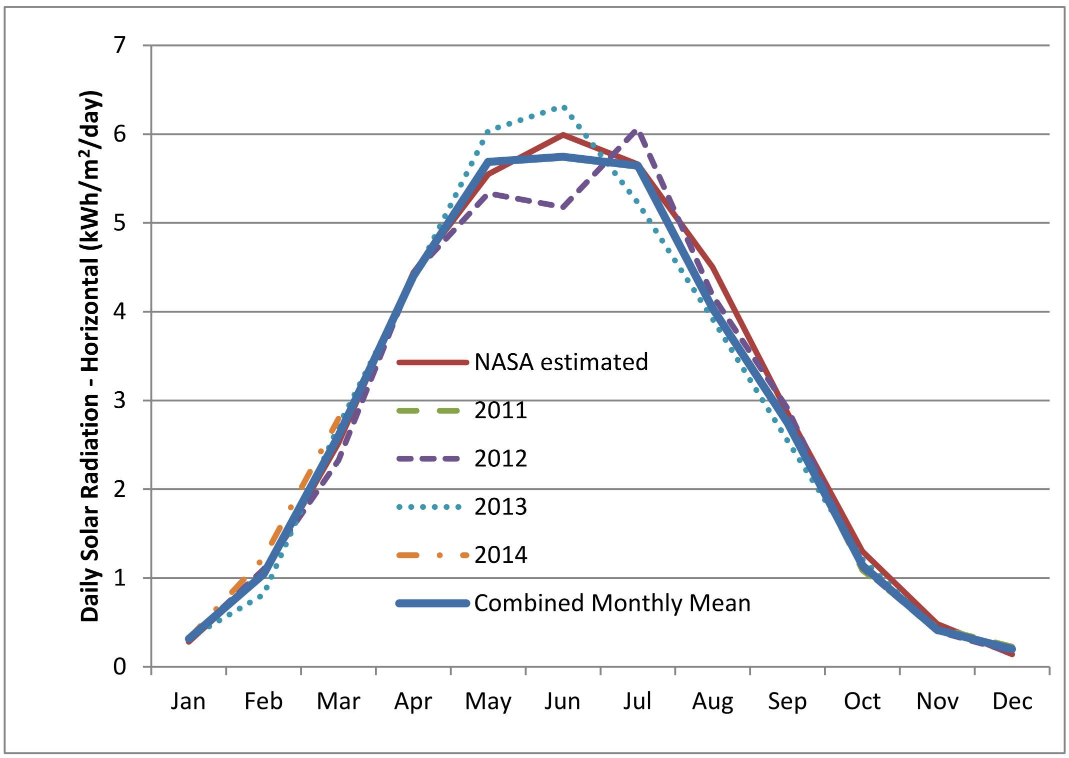

Figure 4: Monthly average insolation, or solar radiation, on a horizontal surface measured at Jean Marie River and compared to NASA estimates for the area.

Site Selection for Solar Systems

Within the community of Jean Marie River, the insolation values are likely similar anywhere that there is an open area toward the south without obstructions such as trees and buildings to shade the solar installation. Ideally the solar PV installation would be next to the power grid. If a home PV installation is considered, it would be best placed on a south-facing roof or on the ground if there is clear exposure to the sun. For a utility scale fixed array installation, the best location is close to a powerline in a large field (or hillside) exposed to the south.

Community Power Requirements and Costs

The community of Jean Marie River has its electricity requirements supplied by a Northwest Territories Power Corporation (NTPC) diesel power plant, consisting of three generators. The total capacity is 265 kW, and one generator was replaced in 2013. Previously the smallest generator was 70 kW, and it is assumed that it is still in place. The most recent NTPC GRA (general rate application) no longer provides individual community fuel efficiencies because of the creation of new rate zones, but the prior GRA (2006/7 – 2007/8) indicates that the fuel efficiency of the diesel plant was 2.749 kWh per litre.

Information available from the prior GRA indicated that power generation in the community was about 340 MWh per year. We have no updated information from the most recent GRA. This represents an average diesel plant load of about 39 kW and a peak load of about 78 kW at the GRA load factor. The authors estimated that the minimum plant load is in the order of 15 kW. Relevant excerpts from the prior NTPC GRA documents are attached as Appendix 1. With the diesel plant fuel efficiency provided above, and the expected annual electrical energy produced from diesel, this represents about 123,681 litres of diesel fuel consumed for electricity production in the community each year.

In modelling the integration of solar energy with the diesel plant, the authors assume that the minimum allowable load of the smallest diesel generator is 30% (typical) of the generator's capacity. For the 70 kW generator, this sets the minimum load at 21 kW. If a community's load drops below this level it simply means that the generator is producing at a lower efficiency, and power quality may become more difficult to control. When adding a renewable energy source to the overall system, on occasions when the community load will be so low (e.g. down to 15 kW in the summer) and the renewable energy production will be high (e.g. 18 kW), then the diesel generator will produce at less than 30% capacity (negative 3 kW in this example if, in the very unlikely event, the minimum load occurs in the daytime). The plant operator will likely wish to cut back on the renewable energy source to keep the diesel generator operating at above the 30% load to keep the efficiency up. To cut back on the renewable energy system one must use power controllers that either dump the excess electricity from the solar system to outdoor heaters or store the excess electricity for later use. The storage can take the form of heat, say, in hot water tanks, or in batteries, which adds another level of complexity to the system. The storage of renewable energy has a future in diesel communities like Jean Marie River; however, it is beyond the scope of this study, which is simply to assess the economics of solar energy production. The sizing of the renewable energy systems in this study are meant to be optimized so that little storage or power stabilizing technology is required, thus keeping the renewable energy system integration relatively simple.

This study examines solar PV opportunities in two grid connected applications. The grid connected options are a 5 kW net metering arrangement by a residential consumer and an 18 kW utility owned project. A solar system larger than 18 kW would likely result in the 70 kW diesel generator being driven below a 30% load, which is NTPC's stipulated minimum. Larger PV systems would thus require some form of energy storage (such as batteries) which is beyond the scope of this study. It is noteworthy that the estimated minimum community load is already well below a 30% loading on the 70kW generator.

Considering this, additional advantages of solar energy over wind energy become evident for Jean Marie River. PV arrays can be sized in small increments (of about 250W) and projects can easily be expanded, and, unlike wind turbines, solar energy is never available at night when electrical loads are at their lowest. It is available only in the daytime when electrical loads are at their highest. As well, the transport and installation of PV equipment is simple compared to wind turbines. The operation of PV systems is also relatively simple, but the integration of significant PV capacity (e.g. 50 kW) with the diesel plant may be as challenging as significant wind capacity.

For the purposes of this study it has been assumed that the NTPC diesel power plant would save diesel fuel at a rate of 1 litre per 2.749 kWh displaced. This diesel plant would produce variable (or incremental) electrical energy at a levelized cost of $0.615 per kWh levelized over 25 years with diesel fuel starting at $1.30 per litre (this is an estimate as the most recent GRA only indicates diesel fuel cost increase of 20 to 25% in the thermal community zone compared to the prior GRA) and increasing with general inflation (2% in model). These costs include only fuel and $0.03 per kWh for variable operation and maintenance (O&M) costs. Today's cost would be $0.503 per kWh for fuel and variable O&M. The economic model assumes that the cost of capital is 6.808%, the cost of capital approved for NTPC in NWT Public Utilities Board Order 1-2013.

Solar PV Project

Project Owners

Two different solar PV applications were considered in this study, and in each case the ownership was different. The first application was a net metering installation of a 5 kW PV array (i.e. grid connected), assumed to be owned by a private residential power consumer. The residential consumer was assumed to be acting individually as opposed to being part of a larger project involving many homes. The second application was a larger grid connected project of 18 kW owned and operated by the utility owning the diesel plant, or an independent power producer.

PV Equipment

For the 5 kW net metering grid connected applications, the complete system was assumed to be roof mounted and installed by a professional supplier-installer. The 5 kW net metering system would include PV modules, micro-inverters or string inverters, a fixed array mounting system, and all cabling. Typical PV module sizes are 230 to 250 Watts.

The 18 kW utility scale project was estimated from residential scale systems and other recent utility installation cost experience. The pricing for PV modules at a wholesale level remains competitive and supplier-installers are getting more experienced, even in the north.

Energy Production

The residential 5 kW array was assumed to be flush mounted on a roof with a 4:12 pitch (18.4°) facing due south. For the utility scale ground mounted system only a 50° fixed tilt array configuration was considered. The tilt angle that was chosen for this configuration is the optimum angle; it maximizes the annual solar energy production in the Jean Marie River area.

The above PV array configurations were analysed for their theoretical performances through the use of the RETScreen Clean Energy Project Analysis Software. RETScreen (Microsoft Excel - based) is a decision support tool developed and supported by the CanmetENERGY research centre of Natural Resources Canada (NRCan). The software is free-of-charge and is used worldwide to evaluate the energy production and savings, costs, emission reductions, financial viability and risk for various types of Renewable-energy and Energy-efficient Technologies (RETs). More information on the software can be found at www.retscreen.net.

Using the solar radiation measurements (and the NASA estimates) for Jean Marie River and RETScreen's modelling capability, the monthly and annual energy production of each configuration were evaluated. RETScreen's solar modelling tool takes into account such factors as ground (snow) reflectance, inverter efficiency, solar cell types and sizes to calculate monthly energy production from these difference array configurations. The RETScreen energy production calculations are based on an array of generic PV modules with total power capacity of 1 kW (7 m^2 area), with an efficiency of 14.0%, a temperature coefficient of 0.40%, and a nominal operating cell temperature of 45°C. Losses of 10% from inverter inefficiency (90% efficiency assumed) and 15% from miscellaneous sources (including module ageing and snow shading in the winter) were assumed in the model.

The result of the RETScreen solar array configuration performance evaluation for Jean Marie River are summarised in Figure 5. Here the NASA estimated and the measured solar radiation are applied to the RETScreen model for a PV array at 50° angle from horizontal facing south and are compared to each other. The authors have also included PV monthly production for a solar PV array mounted flush on a south facing roof with a 4:12 pitch (18.4° slope, we use 20° in the model).

Modelling of the net annual energy production per kW of array capacity (after losses) at Jean Marie River is outlined in Table 1, which also compares the modelled results to actual production data from the Fort Simpson array explained in the follow text. As Table 1 shows, a 1 kW system on a fixed array facing south and tilted to 50 degrees from horizontal may produce about 1,077 kWh per kW installed per year based on measurements made at Jean Marie River. For a rooftop PV array the annual energy production may be reduced by about 10% to 971 kWh per kW. The total energy production for a 5 kW home based system flat on a roof will translate into 4,855 kWh per year. A utility scale 18 kW fixed array system in Jean Marie River will produce 19,386 kWh per year without producing significant excess electricity.

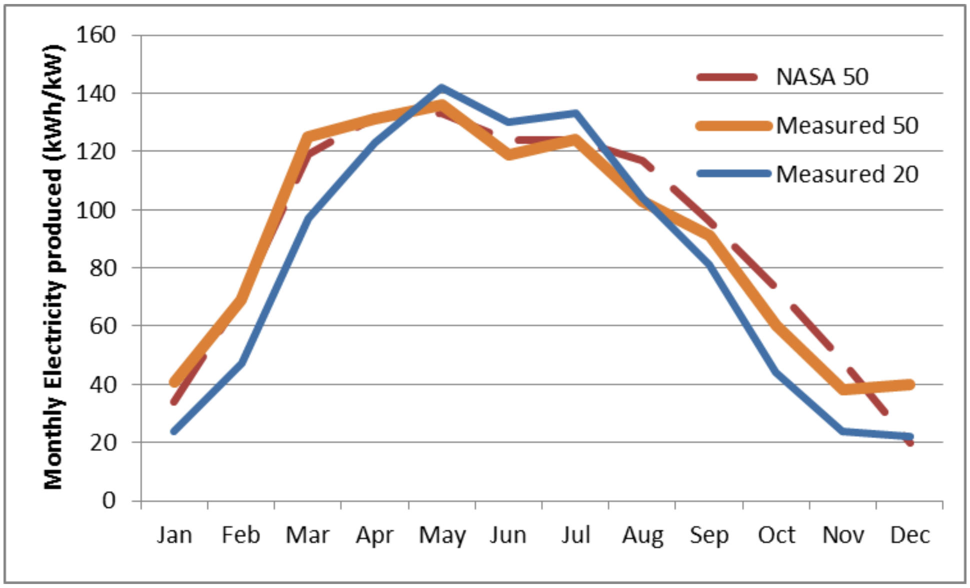

Figure 5: Monthly electricity production modelled by RETScreen using the solar radiation estimated by NASA and from the measurements made in JMR. The optimum angles used for the comparison are at 50 degrees from horizontal ("NASA 50" and "Measured 50"), facing due south. The measured data applied to the 20-degree angle scenario ("Measured 20") is for the case where a solar system would be installed on the roof of a house that would have a typical 4:12 roof pitch.

Table 1: Modelled net energy production using RETScreen for Jean Marie River based on solar radiation estimated by NASA and on locally measured solar radiation. All are compared to actual production in nearby Fort Simpson (see below).

	Tilt Angle (° from horizontal)	Annual production (kWh per kW installed)
NASA estimates	50	1090
Measurements	50	1077
Measurements	20	971
Ft Simpson PV	~40	1099

In Figure 6 the modelled results from RETScreen using the solar radiation measurements in Jean Marie River with the 50° angle solar array are compared to the actual production of the 104 kW PV arrays in Fort Simpson. The PV system in Fort Simpson consists of two arrays that are connected to the town's local diesel grid; it is shown in Figure 7. The larger 60.6 kW array was installed in January, 2012 and the second 43.4 kW array in February, 2013. The authors confirmed from the installer that at least one of the PV arrays (the newer one) is set at 35° from horizontal. The other is unconfirmed but looks to be a bit steeper from the photograph in Figure 7.

There is a third dotted line in Figure 6 that shows the RETScreen energy modelling of a PV system with a 100% efficient inverter and no other losses. The striking comparison of this model outcome and the actual energy production from the Fort Simpson system is that they match during the months of May to September, but the model overestimates in the other months. While the authors aren't assuming that a PV system will be 100% efficient (also that performance will diminish over time) this exercise shows that perhaps losses in the winter months will be due such factors as snow cover, shadowing (e.g. one array shadowing the other), and lower solar incident angle on panels, and lower electrical efficient on the inverter. Losses due to snow cover have been estimate at about 12% based on work done by Wohlgemuth (2007).

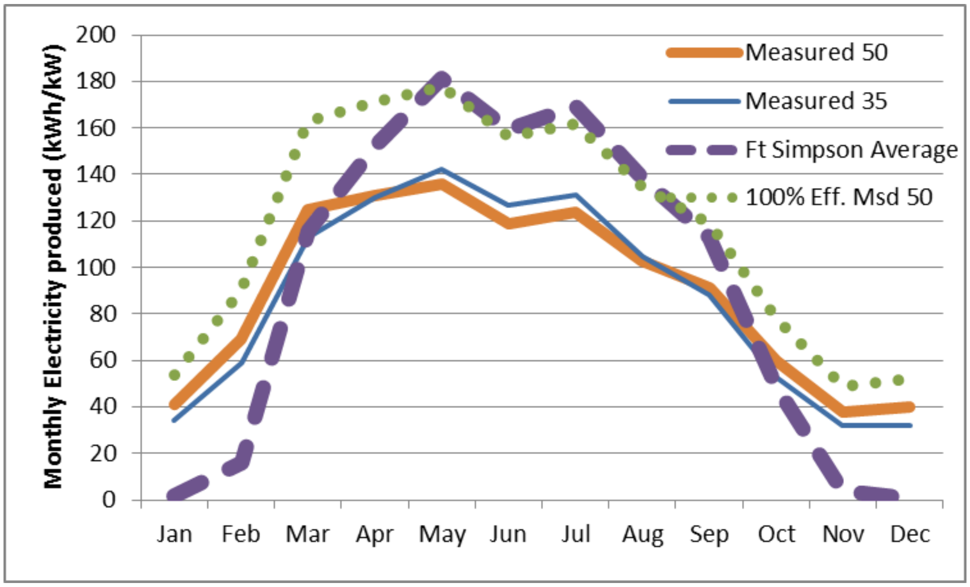

Figure 6: Solar energy production using a 50° (and 35°) tilt scenario ("Measured 50" and "Measured 30") modelled by RETScreen from solar radiation measurements at Jean Marie River is compared to actual production from a 104 kW PV array in nearby Fort Simpson ("Ft Simpson Average"). The RETScreen model assumes 90% inverter efficiency and 15% other losses. The green dotted line shows the RETScreen solar production if the PV system with a 50° tilt were assumed to be 100% efficient with no losses ("100% Eff. Msd 50").

Figure 7: Solar PV array installed in Fort Simpson, which is 130 km northwest of Jean Marie River. Photo from the SkyFireEnergy website.

Capital and Operating Costs

Capital costs for the net metering home applications were based on recent experience for professionally installed systems by supplier-installers in the north. Expected installed costs are about $6,000 per kW of capacity.

Capital costs for a small utility scale PV system of 18 kW were based on recent experience in the north for roof or simple ground mounted systems. These are higher than typical costs for larger utility scale installations (50kW or higher), which can be derived from a various existing cost breakdowns available. These indicated that in southern Canada commercial projects of this size would probably cost as little as $3,000 per kW at the present time. With increased shipping costs and higher installation costs in the north, $7,000 per kW would be considered to be a reasonable estimate for these smaller simple utility scale projects (no tracking systems – where solar panels follow the path of the sun throughout the day). With tracking systems the costs would be $2,000 to $3,000 more per kW.

Table 2: Capital and operating costs of PV systems

System description	Capital cost ($ per kW)	O&M cost ($ per kW per year)
Net metering home (5 kW grid connected)		
Flush mounted fixed array (4:12 pitch)	$6,000	$25
Utility (approximately 18 kW)		
Ground mounted fixed array (50°)	$7,000	$25

In all cases operating and maintenance costs were estimated at $25 per kW of capacity per year. A summary of the operating and capital costs appears in Table 2 above.

Cost of PV Energy and Economic Analysis

The levelized cost of energy (LCOE) for PV was examined on the basis of a 25 year project life (some solar products now carry a 25-year warranty) using an economic model that assumed that the cost of capital was 6.808% and that the inflation rate was 2% per year. As well, a modified simple payback was calculated. This consisted of offsetting the O&M cost on the basis of kWh at the applicable marginal rate and then using the savings on the remainder to pay off the capital. The resulting costs and payback are shown in Table 3.

Table 3: Summary of PV energy cost and payback ranges.

System description	LCOE $/kWh	LCOE diesel $/kWh	Yellowknife rate	Thermal zone run-out rate	Former Community rate	Simple payback after maintenance years
Net metering home						
Fixed array	$0.537	$0.615	$0.276	$0.601	$1.487	4.2 to 24.7
Utility						
Fixed array	$0.560	$0.615		$0.601		11.0

For net metering homes, four PV energy value cases were considered: (1) the subsidized Yellowknife rate of $0.2759 per kWh including GST, (2) the run-out thermal zone rate of $0.6014 per kWh including GST, (3) the former community rate of $1.487 per kWh including GST, and (4) the 25-year LCOE of diesel at $0.615 per kWh which does not include GST. Note that the diesel LCOE of $0.615 per kWh is calculated with fuel starting at $1.30 per litre and increasing with inflation at 2% per year.

For the PV array on a grid connected home, the 25-year LCOE is $0.537 per kWh, very near today's diesel cost of $0.503 per kWh (with diesel fuel at an estimated $1.30 per litre in Jean Marie River). The modified simple payback at the former unsubsidized community rate is 4.2 years, at the thermal zone run-out rate 10.7 years, and at the subsidized Yellowknife rate (applicable to the first 600 kWh per month) is 24.7 years, and at the LCOE diesel cost is 10.5 years.

For an 18 kW Utility scale project, the LCOE of PV energy was $0.560 per kWh for the fixed array configuration (with tilt at 50°). The modified simple payback was about 11 years.

NTPC could consider the installation of a smaller diesel generator in Jean Marie River more suited to the small electrical load there. This would likely make the diesel plant more efficient and would also allow a higher penetration level of solar PV. Alternatively a battery bank operated on a cycle-charge basis for times when the electrical load is low may be worth considering.

Greenhouse Gas Reductions

Greenhouse gas (GHG) reductions are directly proportional to the diesel energy displaced. The GHG reductions resulting from solar systems connected to the grid are shown in Table 4. Net metering and utility scale projects both displace fuel at utility power plant fuel efficiencies, which in the case of Jean Marie River was 2.749 kWh per litre. Roof mounted PV systems would save 1,060 kg of CO_2 equivalent per kW of installed capacity per year and utility ground mounted systems would save 1,175 kg of CO_2 equivalent per kW of installed capacity per year. Larger projects in which some of the PV energy is surplus to system needs would result in lower GHG reductions.

Table 4: Annual energy productions, fuel savings and GHG reductions from roof mounted and utility ground mounted grid-connected solar projects of 5 or 18 kW in Jean Marie River. The roof mounted configurations flush mounted at 4:12 pitch (18.4°) and the utility project is ground mounted with a fixed tilt of 50°.

Project Configuration	Diesel Electricity Displaced (kWh)	Diesel Fuel Saved (litres)	GHG Reductions (kg CO_2 equivalent)
Roof mounted 5 kW	4,855	1,766	5,298
Utility ground mounted 18 kW	19,386	7,052	21,156

PV Project Conclusions

1. PV systems can be utilized in a variety of applications and scaled in size to meet requirements.
2. Home size roof mounted net metering (grid connected) PV systems of about 5 kW are likely to cost in the order of $6,000 per kW of installed capacity.
3. Small utility scale projects (15 to 20 kW) ground mounted at a fixed tilt would likely cost in the order of $7,000 per kW of installed capacity.
4. The 25-year LCOE from grid connected PV systems at $0.54 to $0.56 per kWh is only slightly more expensive than the marginal cost of diesel generation at $0.503 per kWh (fuel at $1.30 per litre), but less expensive that the 25-year LCOE of diesel at $0.615 per kWh.
5. The 25-year LCOE of PV energy would be lower if NTPC's new debt rate is used to reduce the cost of capital to 5.691% from 6.808% used in the above analyses.

Next Steps

1. If Jean Marie River is considering alternative energy developments, the use of PV energy generation would be a far more attractive option than wind energy. PV systems can be scaled to a community's needs and the equipment is far easier to transport, install, and operate than wind systems.
2. Should Jean Marie River wish to pursue a PV project, a subsidy would be required to make the project cost-effective compared to continued diesel generation.
3. Given the small size of the Jean Marie River electrical load, installing a few residential scale net metering projects may be more practical than having the utility do an 18 kW project. Alternatively the utility could consider installing smaller diesel generators more suited to the electrical load and/or a battery system, which would make a larger utility project possible and probably reduce unit costs.
4. To increase the total capacity addition beyond the maximum size stated in this study (18 kW), further feasibility work with energy and economic modelling would be recommended.

Reference

Pinard, JP, and John F. Maissan, 2012. **Jean Marie River Wind and Solar Energy Pre-Feasibility Analysis**. For the Aurora Research Institute.

Wohlgemuth, D., 2007. **Solar Photovoltaics in the NWT, Jean Marie River Band Office, System Overview**. Summary paper for the Arctic Energy Alliance.

Appendix 1

NORTHWEST TERRITORIES
POWER
CORPORATION

Department of Finance, 4 Capital Drive, Hay River, NT X0E 1G2; *Phone (867) 874-5200 Fax (867) 874-5251*

November 24, 2006

John Hill, Chair
Northwest Territories Public Utilities Board
203-62 Woodland Drive
Box 4211
Hay River, NT

Dear Mr. Hill,

Enclosed are seven copies of Northwest Territories Power Corporation's ("NTPC's") 2006/07 and 2007/08 Phase I General Rate Application and supporting materials ("Phase I Application"). The Phase I Application sets out the forecast costs to supply customers for the two test years, the revenues that are forecast to arise at existing rates, and a consequent shortfall requiring changes to rates.

The Phase I Application addresses company-wide costs, revenues and investments required to determine the NTPC overall revenue requirement. Also included in the Phase I Application is the NTPC's response to various directives of the Northwest Territories Public Utilities Board ("PUB" or "Board") related to revenue requirement matters.

Community-specific revenue requirements and resulting final rate proposals will be addressed as part of NTPC's Phase II Application. In addition, the Phase II Application is expected to address three remaining Board directives from the 2001/03 GRA[1].

[1] Board Directive 10 from Decision 3-2003 regarding time of use rates, Directive 2 from Decision 7-2003 regarding legacy assets in cost-of-service and Directive 3 from Decision 7-2003 regarding cost-of-service for Rae/Edzo (now Behchoko) and Dettah are all properly cost-of-service or rate design topics and are more properly suited to a Phase II filing.

NORTHWEST TERRITORIES POWER CORPORATION Schedule 3.3.2

2007/08 FORECAST PRODUCTION FUEL COST

Line No.	Plant No.		Generation (kWh)	Plant Efficiency (kWh/L)	Fuel Required (Litres)	Fuel Price ($/L)	Fuel Cost ($000's)
1	101	Yellowknife	1,379,000	3.500	394,000	0.755	297
2	104	Wha Ti	1,730,422	3.711	466,256	0.897	418
3	105	Gameti	975,320	3.398	287,008	0.927	266
4	108	Behchoko	21,125	3.250	6,500	0.778	5
5	110	Lutsel K'e	1,637,723	3.778	433,468	0.896	388
6	201	Fort Smith	465,700	3.277	142,102	0.793	113
7	203	Fort Resolution	60,000	3.459	17,345	0.860	15
8	205	Fort Simpson	8,238,565	3.755	2,193,767	0.862	1,890
9	206	Fort Liard	2,719,334	3.725	730,105	0.877	641
10	207	Wrigley	667,892	3.525	189,491	0.885	168
11	208	Nahanni Butte	372,594	2.511	148,360	0.877	130
12	209	Jean Marie River	339,598	2.749	123,547	0.858	106
13	301	Inuvik Power - D	1,675,500	3.635	460,935	0.797	367
14	304	Norman Wells - D	63,000	3.414	18,451	0.841	16
15	305	Tuktoyaktuk	4,584,515	3.697	1,240,016	1.001	1,241
16	306	Fort McPherson	3,422,267	3.609	948,301	0.926	878
17	307	Aklavik	2,776,285	3.475	798,914	0.914	730
18	308	Deline	2,658,924	3.546	749,826	1.015	761
19	309	Fort Good Hope	2,874,492	3.576	803,823	1.001	804
20	310	Tulita	2,200,488	3.634	605,551	0.905	548
21	311	Paulatuk	1,350,941	3.492	386,914	1.090	422
22	312	Sachs Harbour	907,022	3.189	284,401	1.075	306
23	313	Tsiigehtchic	864,359	3.537	244,353	0.985	241
24	314	Colville Lake	338,554	2.957	114,488	1.133	130
25	315	Ulukhaktok	1,986,962	3.616	549,489	1.111	610
26	**Subtotal - Diesel**		**44,310,582**	**3.603**	**12,337,411**	**0.931**	**11,491**

NATURAL GAS

Line No.	Plant No.		Generation (kWh)	Plant Efficiency (kWh/L)	Fuel Required (m^3)	Fuel Price (m^3)	Fuel Cost ($000's)
27	301	Inuvik	29,773,906	3.399	8,758,336	0.430	3,769
28	**Subtotal - Natural Gas**		**29,773,906**		**8,758,336**		**3,769**

PURCHASED POWER

Line No.	Plant No.		Generation (kWh)	Price ($/kWh)	Cost ($000's)
29	304	Norman Wells	9,305,234	0.279	2,593
30	**Subtotal - Purch. Power**		**9,305,234**	**0.279**	**2,593**

Schedule A.14

Northwest Territories Power Corporation
2006/07 - 2007/08 General Rate Application
Summary of Generation, Sales, and Revenue
209 Jean Marie River

Line no.	Description	2002/03 Negotiated Settlement	2004/05 Actual	2005/06 Actual	2006/07 Forecast @ Existing Rates	2007/08 Forecast @ Existing Rates
	SALES AND REVENUE					
	Residential					
1	Sales (MWh)	101	119	110	121	123
2	Customers	25	22	23	22	22
3	Av. MWh Sales/Cust.	4.07	5.40	4.77	5.53	5.47
4	Revenue (000s)	91	102	98	107	109
5	Cents /kWh	89.88	85.58	89.17	88.49	88.53
	General Service					
6	Sales (MWh)	105	108	95	109	111
7	Customers	18	15	15	15	16
8	Av. MWh Sales/Cust.	5.77	7.20	6.31	7.15	7.11
9	Revenue (000s)	138	140	124	141	144
10	Cents /kWh	131.54	129.92	130.58	129.76	129.76
	Wholesale					
11	Sales (MWh)					
12	Customers					
13	Revenue (000s)					
14	Cents /kWh					
	Industrial					
15	Sales (MWh)					
16	Customers					
17	Av. MWh Sales/Cust.					
18	Revenue (000s)					
19	Cents /kWh					
	Streetlights					
20	Sales (MWh)	11	12	11	10	11
21	Revenue (000s)	20	22	19	18	18
22	Cents /kWh	175.89	174.15	174.14	186.59	174.14
	Total Community					
23	**Sales (MWh)**	**218**	**239**	**216**	**239**	**244**
24	Customers	**43**	**37**	**38**	**37**	**38**
25	Revenue (000s)	**249**	**264**	**241**	**266**	**271**
26	Cents /kWh	114.47	110.19	111.73	111.30	110.94
	GENERATION (MWh)					
27	**Total Station Service**	37	31	31	31	31
28	**Total Losses**	19	57	58	63	65
29	***Losses - % of Gen.***	*7.0%*	*17.3%*	*19.0%*	*19.0%*	*19.0%*
30	**Total Generation**	**274**	**327**	**304**	**333**	**340**
	Source (MWh)					
31	Hydro Generation					
32	Gas Generation					
33	Gas Efficiency					
34	*Cubic Meters (000s)*					
35	Diesel Generation	274	327	304	333	340
36	Diesel Efficiency	2.520	2.591	2.907	2.749	2.749
37	*Liters (000s)*	*109*	*126*	*105*	*121*	*124*
38	Purchased Power					
39	Total Generation	274	327	304	333	340
	% of Total Generation					
40	Hydro					
41	Gas					
42	Diesel	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*
43	Purchased					
	Peak (kW)					
44	Total Peak	80	64	70	76	78
45	Load Factor	39.1%	58.4%	49.6%	49.8%	49.8%

Zone: Thermal

Residential Government

Monthly Service Charge: $18.00

Energy Charge

Wha Ti	84.57	¢/kWh
Gameti	129.80	¢/kWh
Lutsel K'e	78.53	¢/kWh
Fort Simpson	73.44	¢/kWh
Fort Liard	78.06	¢/kWh
Wrigley	137.92	¢/kWh
Nahanni Butte	166.40	¢/kWh
Jean Marie River	148.70	¢/kWh
Inuvik	60.35	¢/kWh
Tuktoyaktuk	70.80	¢/kWh
Fort McPherson	81.59	¢/kWh
Aklavik	64.84	¢/kWh
Deline	83.20	¢/kWh
Fort Good Hope	72.41	¢/kWh
Tulita	89.51	¢/kWh
Paulatuk	122.92	¢/kWh
Sachs Harbour	152.12	¢/kWh
Tsiigehtchic	112.71	¢/kWh
Colville Lake	230.26	¢/kWh
Ulukhaktok	70.75	¢/kWh

Minimum Monthly Bill: $18.00

Residential Non-Government

Monthly Service Charge: $18.00

Energy Charge: 47.39 ¢/kWh

Minimum Monthly Bill: $18.00

RATE SCHEDULE

NORTHWEST TERRITORIES POWER CORPORATION

Effective Date: December 1, 2010
Supersedes: November 1, 2008

Zone: Thermal

General Service Government

Demand Charge: $8.00/kW

Energy Charge

Wha Ti	78.50	¢/kWh
Gameti	149.18	¢/kWh
Lutsel K'e	73.03	¢/kWh
Fort Simpson	64.34	¢/kWh
Fort Liard	70.37	¢/kWh
Wrigley	147.49	¢/kWh
Nahanni Butte	214.65	¢/kWh
Jean Marie River	200.65	¢/kWh
Inuvik	53.68	¢/kWh
Tuktoyaktuk	62.87	¢/kWh
Fort McPherson	74.64	¢/kWh
Aklavik	61.95	¢/kWh
Deline	78.50	¢/kWh
Fort Good Hope	63.42	¢/kWh
Tulita	86.46	¢/kWh
Paulatuk	116.15	¢/kWh
Sachs Harbour	142.58	¢/kWh
Tsiigehtchic	99.84	¢/kWh
Colville Lake	200.26	¢/kWh
Ulukhaktok	64.04	¢/kWh

Minimum Monthly Bill: $40.00

Stand-by Charge: $24.00 /kW

* General Service – Billing Demand shall be the greater of the current month's maximum Demand or the maximum Demand experienced during the 12 month period ending with the current billing month.

* Stand-by eligibility is negotiated with NTPC on a per customer basis and subject to all applicable energy rates and riders.

Zone: Thermal

General Service Non-Government

Demand Charge:	$8.00 /kW
Energy Charge:	40.20 ¢/kWh
Minimum Monthly Bill:	$40.00
Stand-by Charge:	$24.00 /kW

* General Service – Billing Demand shall be the greater of the current month's maximum Demand or the maximum Demand experienced during the 12 month period ending with the current billing month.

* Stand-by eligibility is negotiated with NTPC on a per customer basis and subject to all applicable energy rates and riders.