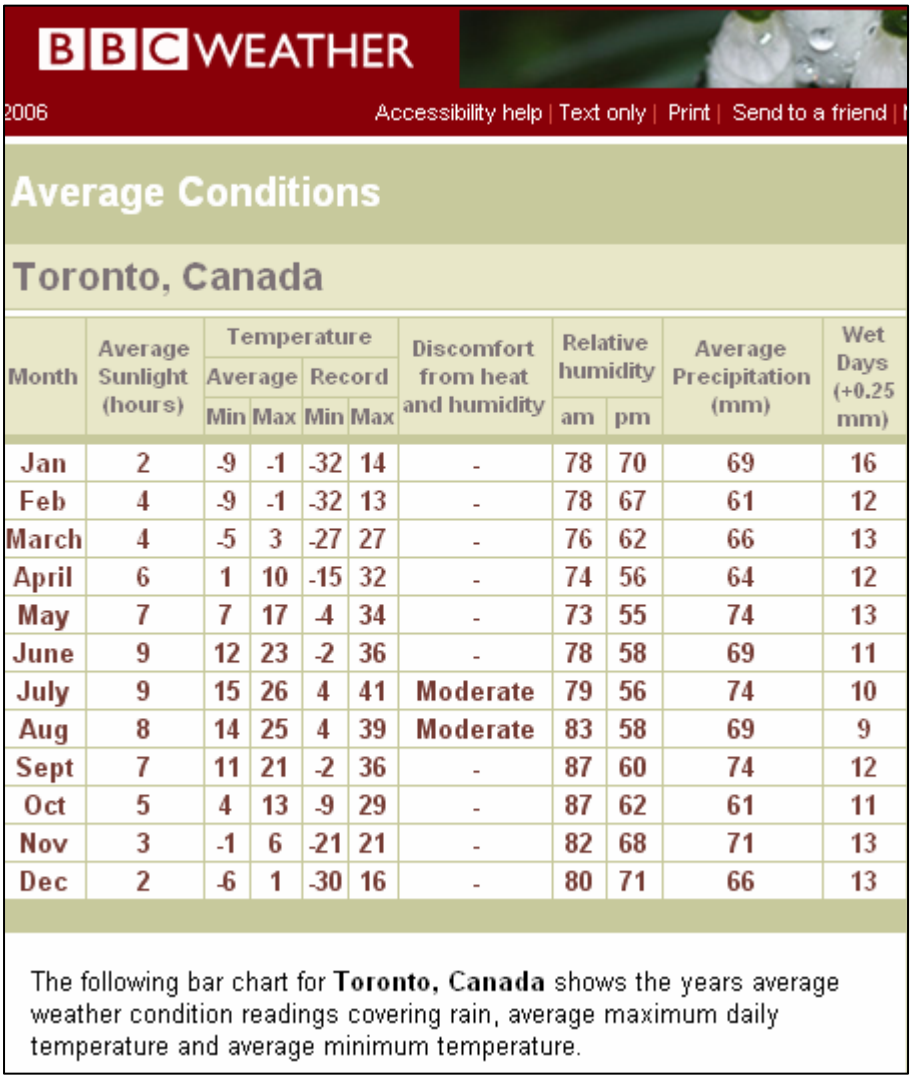
# Analysis of Solar Efficiency

The following analysis of the availability of Solar Energy was conducted in the year leading up to March 2006, by our Engineering Department, on Hybridyne's test site in Scarborough, Ontario.

The first step was to confirm the published figures for the amount of daylight available in the study area ( Toronto, Ontario ). The following charts are those supplied by BBC Weather

( www.bbc.co.uk/weather/world/city_guides )



BBC WEATHER

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## Average Conditions

### Toronto, Canada

| Month | Average Sunlight (hours) | Temperature | | | | Discomfort from heat and humidity | Relative humidity | | Average Precipitation (mm) | Wet Days (+0.25 mm) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average | | Record | | | | | | |
| | | Min | Max | Min | Max | | am | pm | | |
| Jan | 2 | -9 | -1 | -32 | 14 | - | 78 | 70 | 69 | 16 |
| Feb | 4 | -9 | -1 | -32 | 13 | - | 78 | 67 | 61 | 12 |
| March | 4 | -5 | 3 | -27 | 27 | - | 76 | 62 | 66 | 13 |
| April | 6 | 1 | 10 | -15 | 32 | - | 74 | 56 | 64 | 12 |
| May | 7 | 7 | 17 | -4 | 34 | - | 73 | 55 | 74 | 13 |
| June | 9 | 12 | 23 | -2 | 36 | - | 78 | 58 | 69 | 11 |
| July | 9 | 15 | 26 | 4 | 41 | Moderate | 79 | 56 | 74 | 10 |
| Aug | 8 | 14 | 25 | 4 | 39 | Moderate | 83 | 58 | 69 | 9 |
| Sept | 7 | 11 | 21 | -2 | 36 | - | 87 | 60 | 74 | 12 |
| Oct | 5 | 4 | 13 | -9 | 29 | - | 87 | 62 | 61 | 11 |
| Nov | 3 | -1 | 6 | -21 | 21 | - | 82 | 68 | 71 | 13 |
| Dec | 2 | -6 | 1 | -30 | 16 | - | 80 | 71 | 66 | 13 |

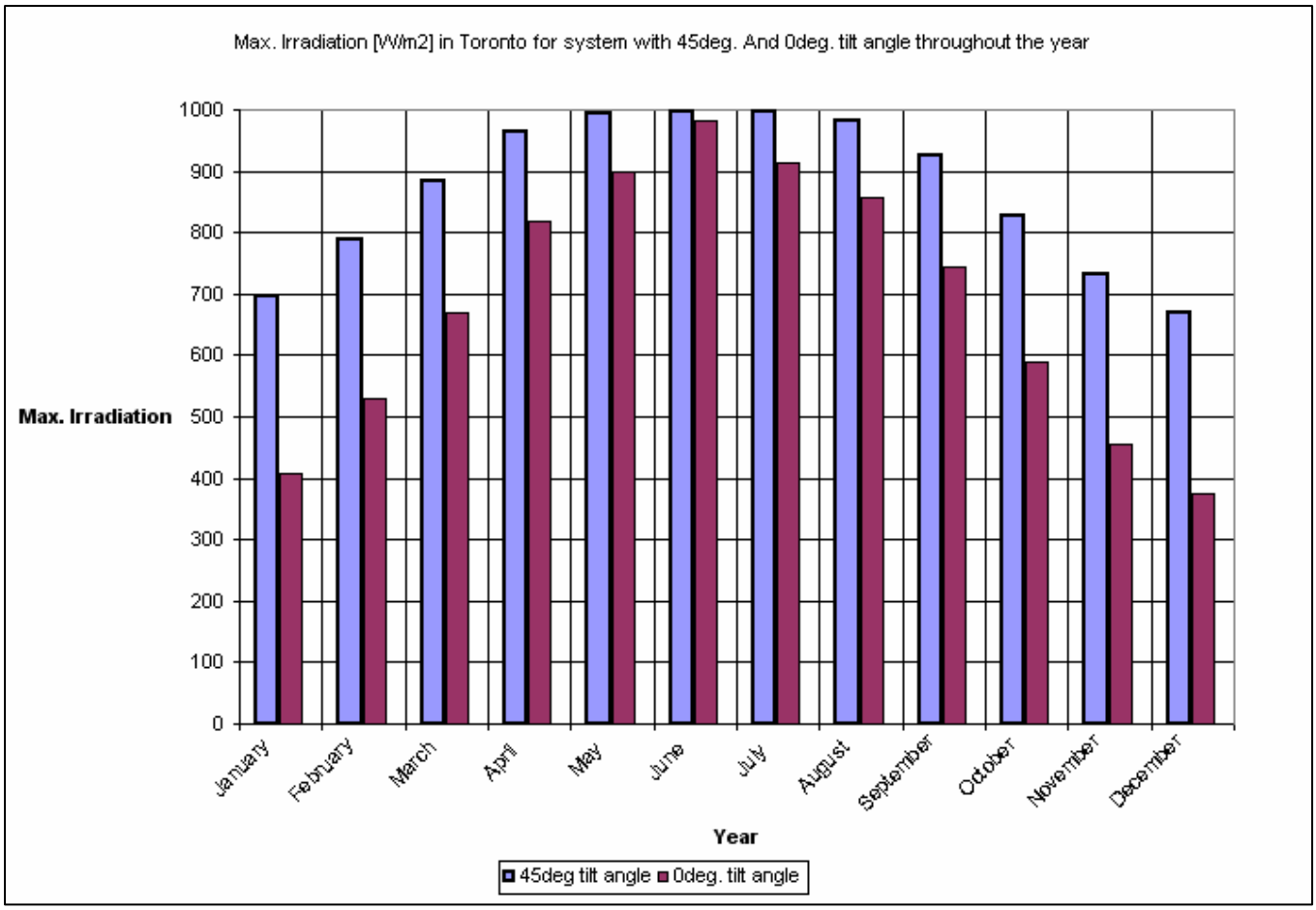
The following bar chart for **Toronto, Canada** shows the years average weather condition readings covering rain, average maximum daily temperature and average minimum temperature.

This table and graph show the amount of light energy ( irradiation ) which was measured as falling on the solar panels at the Beta site in Scarborough. Irradiation is the number of Watts of energy per square metre of receptor.

The solar panels at this test site were divided into two groups for experimental analysis. Half were laid flat ( horizontal ) and half were tilted slightly toward the vertical to 'point' at the average altitude of the sun. The two right columns of this table show the Maximum Irradiation in each month at either of the two degrees of 'tilt.

| Month | Max. Irradiation for 45deg tilt | Max. Irradiation for 0deg tilt |
|---|---|---|
| | [W/m2] | [W/m2] |
| January | 695 | 407 |
| February | 788 | 530 |
| March | 883 | 669 |
| April | 965 | 819 |
| May | 994 | 899 |
| June | 996 | 982 |
| July | 998 | 914 |
| August | 982 | 857 |
| September | 927 | 743 |
| October | 826 | 588 |
| November | 731 | 454 |
| December | 669 | 374 |

The same results are displayed graphically below.



Given the above illumination conditions, the following results were observed at this site over a period of almost two years. The following is a typical year based on the observations.

| | Monthly Total KwH | |
|---|---|---|
| January | 509.84 | |
| February | 581.15 | |
| March | 824.36 | |
| April | 1326.88 | |
| May | 959.23 | |
| June | 2134.79 | |
| July | 1614.01 | |
| August | 1886.29 | |
| September | 1208.31 | |
| October | 750.91 | |
| November | 504.16 | |
| December | 562.88 | |
| **Annual Total** | **12,862.82** | **KiloWattHours** |
| | **12.86** | **MegaWattHours** |

**Note** – this is the total output from two strings of PV panels, one at zero inclination, and the other at 45 degrees inclination. The string at 45 degrees were NOT pointed directly at the sun because they were attached to the face of the building which is aligned roughly south-west.

Thus , neither string was aligned at the optimum inclination or angle ( South ) for maximum yield.

As a comparison, it is interesting to examine the following output from **the Retscreen model**.

( The RETScreen International Clean Energy Decision Support Centre seeks to build the capacity of planners, decision-makers and industry to implement renewable energy and energy efficiency projects
http://www.retscreen.net/ )

Please note that Retscreen is designed to estimate the yield of a " NORMAL " photovoltaic array, which DOES NOT HAVE the advantage of Hybridyne's Conversion/Inversion Technology.

As you can see, with equivalent solar panels at the same location and optimum alignment, a traditional installation would only yield 9.124 mWh per year, as opposed to the measurements from Hybridyne's site, which yielded 12.86 mWh during the period from April 2006 through March 2007 .

**RETScreen® Energy Model - Photovoltaic Project** — Training & Support

| Site Conditions | | Estimate | Notes/Range |
|---|---|---|---|
| Project name | | HPS Beta Site | See Online Manual |
| Project location | | Scarborough, On | |
| Nearest location for weather data | - | Toronto, ON | Complete SR&SL sheet |
| Latitude of project location | °N | 43.7 | -90.0 to 90.0 |
| Annual solar radiation (tilted surface) | MWh/m² | 1.45 | |
| Annual average temperature | °C | 7.2 | -20.0 to 30.0 |

| System Characteristics | | Estimate | Notes/Range |
|---|---|---|---|
| Application type | - | On-grid | |
| Grid type | - | Central-grid | |
| PV energy absorption rate | % | 100.0% | |
| **PV Array** | | | |
| PV module type | - | mono-Si | |
| PV module manufacturer / model # | | ABC Inc. | See Product Database |
| Nominal PV module efficiency | % | 11.7% | 4.0% to 15.0% |
| NOCT | °C | 45 | 40 to 55 |
| PV temperature coefficient | % / °C | 0.40% | 0.10% to 0.50% |
| Miscellaneous PV array losses | % | 5.0% | 0.0% to 20.0% |
| Nominal PV array power | kWp | **7.50** | |
| PV array area | m² | 64.1 | |
| **Power Conditioning** | | | |
| Average inverter efficiency | % | 90% | 80% to 95% |
| Suggested inverter (DC to AC) capacity | kW (AC) | 6.8 | |
| Inverter capacity | kW (AC) | 6.0 | |
| Miscellaneous power conditioning losses | % | 0% | 0% to 10% |

| Annual Energy Production (12.00 months analysed) | | Estimate | Notes/Range |
|---|---|---|---|
| Specific yield | kWh/m² | 142.3 | |
| Overall PV system efficiency | % | 9.8% | |
| PV system capacity factor | % | 13.9% | |
| Renewable energy collected | MWh | 10.138 | |
| Renewable energy delivered | MWh | **9.124** | |
| | kWh | 9,124 | |
| Excess RE available | MWh | **0.000** | |

Complete Cost Analysis sheet

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## Conclusion :

Under perfect conditions as expected by the Retscreen Analysis, the 48 Solar Panels would be expected to deliver a total of 9,124 kiloWatthours of electricity per year.

The Hybridyne Conversion Inversion Technology ( CIT ) has allowed the Solar Panels at the Beta Site to deliver 12,863 kiloWatthours ( about one-third more power annually) in the same sunlight conditions even with imperfect alignment.

On other words Hybridyne can achieve the same ( or better ) annual energy yield (annual performance) as could be expected with a sophisticated electro-mechanical solar tracking system, without the anticipated high cost of purchase, installation, ownership and maintenance associated with such systems.