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PV SYSTEMS FOR ISRAEL'S CITIES: HOW LARGE SHOULD THEY BE?
A Design Guide

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EXECUTIVE SUMMARY

Tables are presented showing the predicted hourly amounts of electricity to be expected from photovoltaic systems located on the roofs or walls of buildings in Israel's five principal cities: Haifa, Tel Aviv, Jerusalem, Beersheba and Eilat. For Jerusalem (the median city), a south-facing PV array, tilted at 30 degrees to the horizontal is expected to be capable of generating 1600 kWh of DC energy per year for each 1 kWp of modules. For the case of Tel Aviv, tables are also given for a variety of tilt angles from horizontal through vertical, and for orientations from east- facing, southward, through west-facing. Examples of the use of these tables, for a number of optimization problems, are given in the text. An appendix gives a number of ancillary pieces of information. These include: Meteorological summary sheets for the 5 cities; A comparison of the use of "Typical Meteorological Year" data files with data files from years having extremely low and extremely high solar radiation levels; A comparison of actual system performance with some after-the-fact computer simulations.

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1. INTRODUCTION

A photovoltaic system consists of an array of PV modules, which generate dc electric current when sunlight strikes them; and some kind of electronic power conditioning equipment. The function of the latter might be to charge batteries for nighttime use, or to convert the dc to ac current for insertion into the grid, or some combination of the two.

A fundamental problem that faces any designer of a PV system is: How large should the PV array be? The obvious requirement would be to size the system according to the energy needs of the household but two practical problems render this a difficult task. First, as the intensity of the sunlight varies, so too does the amount of power that is produced by the PV array. For example, a PV panel will generate considerably more power when exposed to direct sunshine than it will on an overcast cloudy day. Secondly, PV module manufacturers specify the power capability of their panels in "peak watts" [Wp] - which characterize the output of the panel under special test conditions - and it is no simple matter to correlate this artificial rating with one's actual power requirements.

The purpose of the present design guide is to enable a PV designer to be able to estimate how much actual electrical energy can be expected from each 1 kWp of installed PV modules in any of the 5 principal (from the geographic view point) cities: Haifa, Tel Aviv, Jerusalem, Beersheba and Eilat.

2. CONVERTING Wp TO kWh.

The Wp is an artificial unit of power, that was designed for standardization purposes. The need for such a kind of unit arises because the power output of a PV module depends upon the intensity of light (brighter light generates larger currents), upon the temperature of the module (higher temperatures produce lower voltages) and, to a certain extent, on the spectral content of the light. For this reason, PV modules are characterized under so-called "Standard Test Conditions" (STC). These are: a light intensity of 1000 W/m², a module temperature of 25 °C and certain well-defined spectral conditions designated "AM1.5" [**1**]. Roughly speaking, 1000 W/m² and AM1.5 are the intensity and spectral conditions one would expect in Israel, on a cloudless day at noon, in the Negev. However, under such conditions, the module temperature would normally be considerably higher than 25 °C; perhaps 50 °C in winter and 70 °C in summer. This means that in Israel a PV module would almost *never* operate at conditions that approximate STC!

But this does not matter, since it is possible to calculate the actual power that a module would produce under any situation if we know its electrical characteristics and the meteorological conditions.

What we do is to first calculate the amount of solar radiation that strikes the surface of the module at any given moment [**2**]. This is a geometrical calculation that requires knowledge of two meteorological parameters: the direct beam and the diffuse components of the incoming solar radiation. Next we calculate the module temperature [**2**]. This requires knowledge of the solar radiation, the ambient temperature and the wind speed. Once we know the amount of radiation falling on the module and the temperature of the latter, then the electrical characteristics of the module enable us to calculate the actual power it delivers at that moment.

In practice, meteorological data are usually available in the form of hourly averages. We thus, in effect, calculate the average power (in W), delivered each hour, or equivalently, the total energy for that hour (in Wh). These hourly totals may be summed on an annual basis. Alternatively, if electricity tariffs vary at different times of the day, different days of the week, different seasons of the year, then the hourly energy values can be converted to monetary units and appropriate sums can be carried out in order to enable the system designer to develop an idea as to how cost-effective the PV system will be. For carrying out the energy calculations, we have made use of the PVISRAEL code [**3**].

3. PV MODULE CHARACTERISTICS

Most of the PV modules that were commercially available during the 1990s were fabricated from solar cells of one of two types: monocrystalline or polycrystalline silicon (respectively c-Si and pX-Si). Modules of amorphous silicon (a-Si) cells had also been introduced but the first commercially-available batches of the latter turned out to have poor stability. During the first decade of the 2000s, it is expected that a-Si modules of higher stability will become available and also modules fabricated from other thin-film materials such as CdTe and $CuInSe_2$.

Fig.l shows a typical current vs. voltage characteristic for a PV module [**4**]. In the case of c- Si and pX-Si, the output current is directly proportional to the intensity of the incident radiation, and highly linear over the range 0 to well beyond 1000 W/m². The output current varies only slightly with temperature, typically *increasing* approximately 1 mA/°C. By contrast, the voltage is relatively independent of the light intensity but it is very sensitive to temperature, *decreasing* by typically 2.2 mV/°C *per cell.* Thus, a 50 Wp module, fabricated from 36 individual PV cells in series, would have a typical voltage temperature coefficient of about -80 mV/°C but a current temperature coefficient of only 1 mA/°C*,* or thereabouts.

We have performed several simulations using the electrical characteristics of modules fabricated from both c-Si and pX-Si cells. Even though the efficiency of the latter tends to be about 20% lower than that of the former (i.e. unit area of pX-Si modules tends to have a lower power rating than an equivalent area of c-Si modules), the simulations give extremely similar results for the two types of material, provided the simulations are normalized to equal amounts of Wp. This is the reason that the design tables presented in this report are normalized to 1 kWp of PV modules. In this manner we do not have to present tables for each different brand and type of module. The tables are also more convenient to use in this form because module manufacturers usually quote prices in $/Wp. Hence, if one is interested in building a 10 kWp PV system the amount of energy to be expected is simply 10 times the amount indicated in the appropriate 1 kWp table.

As to the expected performance of modules employing a-Si and other thin-film materials, we have not included tables in the present (first) edition of this guide because their electrical characteristics are still the subject of study. However, if they turn out to be stable and substantially different from c-Si and pX-Si modules, appropriate tables will be supplemented in a future edition. In any event, we expect c-Si and pX-Si to remain the dominant PV module types that will be commercially available in the near term.

4. METEOROLOGICAL DATA

As indicated above, four meteorological parameters are needed for these simulations: direct beam radiation, diffuse radiation, ambient temperature and wind speed. Since these parameters vary from moment to moment, some kind of representative average is needed. For such purposes, solar energy system designers have invented the concept of a Typical Meteorological Year (TMY). This is a data file comprised of 12 actual months of data. However, the months of the "Typical" year are not necessarily selected from the same calendar year. Instead, for each month, that year is selected whose data fall closest to the median of all years for which there are data. In this way, each month of data is typical in the sense of not being either anomalously high or low as regards the parameters of interest. In the past we have constructed TMY files, as part of the Negev Radiation Survey, for several sites in the Negev, including Beersheba and Eilat [**5**]. However, that survey does not include locations outside the Negev. For the present study, data were made available for Jerusalem, Tel Aviv and Haifa, for the five-year period 1994-1998. For this reason, it was decided to construct new TMY-style files for Beersheba and Eilat but using the same 5-year data set as was available for the non-Negev cities. For this reason, the present data files are here referred to as "Typical Photovoltaic Year" (TPVY) files. Summary tables of the TPVY files, in similar format to our more familiar TMY files are included as an appendix to the present guide (**Tables Ala, Alb, A2a, ... A5a, A5b**).

5. RESULTS OF THE STUDY

In preparing the tabulated results of our computer calculations, we have decided to deal exclusively with the DC output of such an array. The reason for this is that the PV array might be used for any of several different purposes (e.g. grid-connection via an inverter, battery charging, some industrial process requiring DC power, etc.), each of which would require DC power as its input. If the DC power is subsequently converted to AC, then the efficiency of the inverter must be taken into consideration. This would typically reduce the tabulated numbers by approximately 15%.

The results are tabulated, for each city, in the form of a matrix of numbers that gives the monthly total amount of DC electrical energy to be expected from 1 kWp of PV modules at each hour of the day. These matrices have been calculated for Tel-Aviv, Haifa, Jerusalem, Beersheba and Eilat.

As stated, each number in the body of these tables represents the total amount, in kWh, of DC electrical energy that would be generated by 1 kWp of PV modules during the hour in question. One might naively imagine that during all of the noon hours in June we could obtain close to 30 kWh from a 1 kWp array - because 1 kW of PV modules operating under full sun conditions for one hour should give close to 1 kWh, and 30 sunny days in June would add up to 30 kWh. However, the tables indicate otherwise: In Tel Aviv we would get only 22.3 kWh; in Haifa, 22.5 kWh; in Jerusalem, 21.9 kWh; in Beersheba, 22.3 kWh and in Eilat, 22.7 kWh. The reason for this deficit is a combination of the panels being at a relatively high temperature at noon, and the fact that their 30° tilt angle, optimized for all-year power production, is less than optimal for the month of June.

By comparing the individual entries in the matrix with the electricity tariffs of the Israel Electric Company (which vary with the hour of day, day of the week and season of the year) one can arrive at the monetary value of the electricity generated by the PV system.

5.1 Tel Aviv

Most of the country's population resides in the greater Tel Aviv area, where all kind of local obstructions are likely to dictate the possible orientation of any given PV system. Tables are, therefore, presented for a wide variety of PV array orientations (**Tables 1-16**).

Example 1: How much annual energy would be generated by a 1 kWp array incorporated on the southern wall of a building in Tel Aviv (assuming that no shadows would fall on the array at any time during the year)?

Answer: From **Table 14**, the annual total is seen to be 828 kWh.

Example 2: Is the southern wall of a building the best wall for using to generate electricity?

Answer: Only in winter. Perusal of **Tables 12-16** indicates that SE- and SW-facing walls would generate more power on an annual basis than a S-facing wall.

Perusal of these Tel Aviv tables reveals that the orientation which provides maximum energy throughout the year is south-facing at a tilt angle of 30°. This would generally be the optimal orientation except that specific circumstances might dictate otherwise. We have already indicated the possibility that shading by nearby buildings and other obstructions might force the designer to orientate a given PV array in a non-optimal manner. However, there are cases for which 30° is itself non-optimal. For example, a PV system needed for outdoor lighting all year, would best have a considerably steeper tilt than 30°, in order to neutralize the effect of longer winter nights coupled with less available solar radiation.

Example 3: What is the optimal tilt angle for a south-facing PV array on the roof of a school?

Answer: The school is not used during the months of July and August. Therefore, if PV- generated power could not be used during these months, **Table 4** indicates that the annual *useful* energy generated by a 30°-tilted array in Tel Aviv would be 1562.1 - 157.2 – 153.4 $\simeq$ 1250 kWh.

On the other hand, a 60°-tilted array would (from **Table 9**) generate 1318.6 - 102.6 – 112.5 $\simeq$1100 kWh of useful energy. Since this is less than the 30° tilt situation, we conclude that 60° is not to be preferred.

In order to find the truly optimal array orientation for any specific situation, it may be necessary to interpolate between the results given in our tables. For example**, Fig.2** shows the variation of annual energy with tilt angle for a 1 kWp south-facing array in Tel Aviv. Similar interpolation curves can be constructed for the individual months in **Tables 1, 4, 9** and **14**, allowing the interested reader to complete the optimization problem posed in Example 3.

Similarly, **Fig. 3a** and **3b** show the variation of annual energy with azimuth angle for a 1 PV array on a vertical wall in Tel Aviv.

5.2 Haifa, Jerusalem, Beersheba and Eilat

In order to minimize an already large number of tables, we present only the 30° S-facing tables for Haifa, Jerusalem, Beersheba and Eilat (**Tables 17-20**), i.e. those giving the hourly expected energy for a PV array having optimal orientation for all-year operation. For situations, in those cities, for which other orientations are desired, the Tel Aviv tables may be used in conjunction with the 30° S-facing table for the city in question.

Example 4: How much annual energy would be produced by a horizontal PV array in Haifa.

Answer: We turn first to the Tel Aviv **Tables 1** and **4**, and discover that a horizontal array in Tel Aviv (1422 kWh annual) produces 91% of a 30° S-facing array (1562 kWh annual).

Since (from our various simulations) these ratios turn out to be largely site-independent in Israel, we may turn to the 30° S table for Haifa (**Table 17**) and take 91 % of its annual total (1517 kWh), yielding the required result of 1380 kWh per year.

Example 5: In Jerusalem your annual electricity requirements amount to 6,000 kWh. What percentage of this could be met by a 3 kWp PV array on your roof?

Answer: From **Table 18**, each 1 kWp of 30°-tilted, south-facing PV modules, would generate 1600 kWh of DC electricity per year. This figure should be reduced by typically 15% to allow for dc->ac inverter losses, giving 1360 kWh AC. A 3 kWp PV system would, therefore, produce 4080 kWh per year = 68% of your needs.

6. OTHER CONSIDERATIONS

6.1 Accuracy of the Simulations

There are two aspects of the accuracy question. One is; how accurately can PVISRAEL simulate the performance of a PV system, *after* the fact. That is to say; if, on the one hand, we were to monitor the *actual* annual performance of a PV system, and then feed into PVISRAEL the concomitantly measured meteorological conditions and system parameters, how well would the predictions agree with performance?

The second question is a statistical one: How reliable are predictions that are based on a TPVY file of meteorological data? That is to say, if we design a system using a TPVY file (i.e. the tables printed here), how bad a surprise might we receive from poor system performance in an actual year?

To answer the first question, we present a month-by-month comparison of measured performance for an actual set of south-facing PV systems at Sede Boqer, tilted at 30 deg to the horizontal, during the 1-year period June 1999 through May 2000, with after-the-fact PVISRAEL simulations. Input to the PVISRAEL code consists of actual monitored meteorological data (global horizontal irradiance, normal direct beam irradiance, ambient temperature and wind speed) and actual measured PV module electrical parameters. The system performance data consist of the average over 10 independent "mini" power plants that were monitored on an hourly basis for that same entire year. Each plant consisted of 2 PV panels, of measured 39.3 Wp (average) specifications, connected in series to a 100 W inverter of nominal efficiency 95%. It should be emphasized that all 10 systems gave similar outputs to one another to within an average spread of ±1.5%. The results of this comparison are shown in **Fig. A1**.

From **Fig. A1**, one sees that the PVISRAEL monthly predictions tend to be low by approximately 10% compared to measured system performance. The annual prediction for each system is 137 kWh whereas the systems generated, on average, 149 kWh during the year. This, of course, is only a single test of PVISRAEL but it is a relatively comprehensive one in that it covers an entire year, and the experimental uncertainties are relatively small. We would therefore tentatively conclude that the predictions of the tables in this report are conservative by approximately 10% on an annual basis.

Regarding year-to-year statistical variations in climatic parameters, we have run PVISRAEL for a number of extreme years for which we have meteorological data. Specifically, we used data from the "radiation-poor" year 1992, which followed the burning oil wells during the 1991 Gulf War and the eruption of Mt. Pinetubo in the Philippines that same year. We also used the highest "radiation rich" year that we have on record, 1999. **Table A6** shows a month-by-month comparison between the monthly PVISRAEL predictions based on a Sede Boqer TMY file and the predictions based on the data from these extreme years.

From **Table A6**, one sees that if the TMY data file had been used for predicting system performance for the years 1992 or 1999, some individual month predictions would have been wrong by up to 27%. However, the predicted annual total would only have been in error by approximately 5%.

6.2 Reliability of PV Module Specifications

Careful tests carried out at the National Solar Energy Center, Sede Boqer, on a large variety of PV modules, fabricated by major manufacturers in various parts of the world, indicate a tendency for manufacturers to over-specify the power rating of their modules. This over- rating probably arises from differences between the tests that manufacturers perform in solar simulators (using artificial light sources) and tests performed with real sunshine. In some cases, *differences of up to 20% have* *been found* [**6**]. In the case of our PVISRAEL simulations it is assumed that 1 kWp really is 1 kWp. Most manufacturers sell modules by the kWp and will make up any *proven* deficit by providing additional modules. However, it is up to the customer to prove that his/her PV modules are under-powered and, in the case of a roof-mounted system, it is necessary for the roof to have enough space to accommodate any additional modules that may be needed in order to bring the system up to its specified power.

6.3 System Reliability

The annual predictions presented in the tables assume that the PV system will operate, with no breakdowns, throughout the year. In practice, the PV module components tend to be very reliable these days. More than 20 years of manufacturing experience have led to increasingly improved products and it is probably no idle dream to expect 20 years of continuous high performance from modern PV modules.

Unfortunately, progress in improving the reliability of the auxiliary electronics, e.g. inverters, has been slower. In a recent one-year study of several modern inverters, conducted at the Ben-Gurion National Solar Energy Center, most of them operated in a completely fault-free manner for the entire year. People who are enthusiastic about the future of PV systems will see this as an example of the "half-full cup", but a customer who purchases a system that fails will probably see mainly the "empty half"! The point to emphasize, however, is that system economics depend critically upon system performance. Thus a prospective user of PV would be well advised to insure that the contract he/she negotiates with a PV supplier guarantees the speedy replacement of parts which break down.

6.4 Economic considerations

In the 30, or so, years since PV modules first appeared on the domestic market, their cost has fallen considerably. Furthermore, costs will almost certainly continue to fall. However, at the present time, electric power generated in this manner is considerably more expensive than purchasing electricity from the Israel Electric Corporation. As a concrete example, detailed studies performed for a potential large PV plant at Kibbutz Samar in the Negev indicate that the initial investment would be equivalent to an electricity cost of 30¢/kWh over an assumed 20 year system lifetime [**7**].

However, a straight cost comparison between PV and grid power can be misleading. First, there are many situations in which grid power is unavailable and there are other situations in which, although available, grid power is more expensive. A simple example of the latter is the case of parking meters in many European cities. Here, it turns out to be less costly to power each parking meter with a small PV panel than to provide each meter with a connection to the grid.

Secondly, experience in many European countries has demonstrated that the public is willing to pay more money for environmentally clean electricity. Switzerland is a good example. There, the voluntary excess money added by the public to their monthly electricity bills is used to construct additional PV power plants.

How much does it cost to generate PV power today?

In Europe and the USA one can purchase a 100 Wp PV panel for approximately $300. One can purchase a 100 W "mini" inverter for approximately $150. So, for $450 one has a mini power plant that may literally be plugged into the wall. The panel would be placed in a window or on the roof and the electricity would enter the grid via the regular grid connection of the house.

How would such electricity be accounted for?

There are two basic possibilities, both of which are used in various parts of the world. The first is to allow the electricity meter of the house to run backward when a net flow of electricity is occurring *into* the grid. The other method is to use two meters in order to monitor separately, electricity *sold* to the grid and electricity purchased from the grid.

How much electrical energy would such a system produce?

The answer can be calculated from the tables in the following pages!

7. CONCLUSIONS

If we look at the annual totals in **Tables 1-5** we find that the DC output of a 1 kWp PV array increases from a minimum in Haifa (1520 kWh per year), through Tel-Aviv (1560 kWh per year), Jerusalem (1600 kWh per year), Beersheba (1640 kWh per year), to a maximum in Eilat (1700 kWh per year). We notice that Jerusalem is both the median and the average, and that the annual outputs of PV arrays in the other cities would deviate from the output of a similar array in Jerusalem by ±6% at most. This major result reflects the relatively small geographic size of the State of Israel and is a boon to PV system designers in that a given-size PV system will produce more-or-less the same amount of annual energy anywhere in the country, i.e. about 6% less than the average in Haifa and about 6% more than the average in Eilat.

The tables have been printed with one more significant figure than is strictly meaningful. This is to remove the danger of cumulative rounding errors in calculations of the kind given in the above examples. After such calculations are complete it is sufficient to round the end results to 3 significant figures. These results enable a designer to estimate the optimal orientation for any specific requirement, to take into account local constraints that may prevent an optimally oriented system, and to calculate the energy penalty (and hence the economic penalty) of non-optimal system orientation.

It will not have escaped the notice of the observant reader that the Tel-Aviv tables are not perfectly east-west symmetric (as illustrated graphically by **Figs. 3a** and **3b**). This is probably related to the close proximity of Tel-Aviv (actually Bet Dagan) to the sea, and the associated east-west asymmetry of clouds. Different, but comparable differences are to be expected for Jerusalem, where the arid Judean Desert begins immediately to the east of the city. However, quantitatively, these east-west asymmetries are only a few percent of the mean, and well within the overall typical ±10% uncertainty we associate with these monthly predictions.

8. REFERENCES

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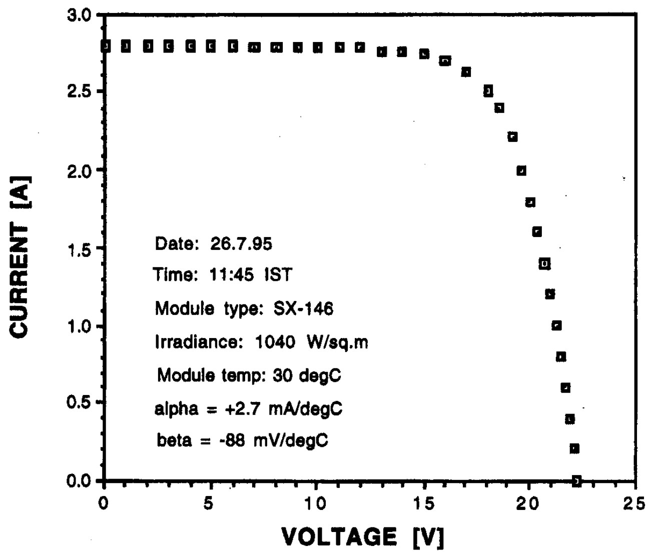

Figure 1: Current-voltage curve for a typical PV module, measured at Sede Boqer, Israel [**4**]. Also indicated are measurement conditions, and current and voltage temperature coefficients. Such information, needed for calculating module performance under a variety of operating conditions, is always available from reputable module manufacturers.

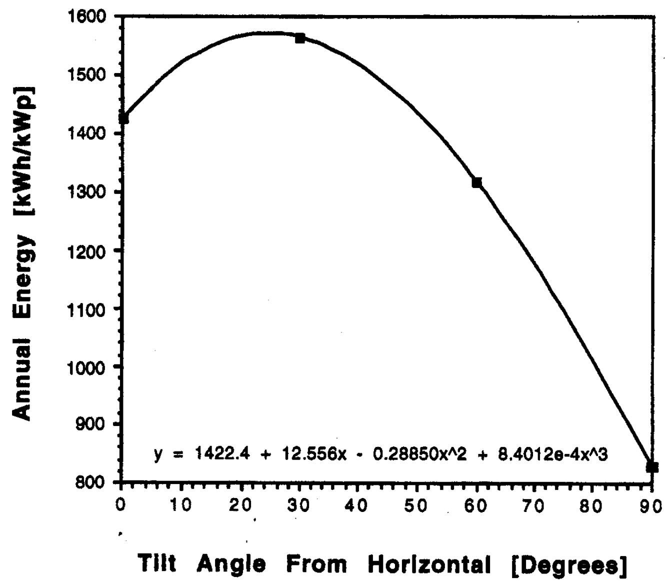

Figure 2: Interpolation curve for south-facing PV arrays at various tilt angles in Tel-Aviv

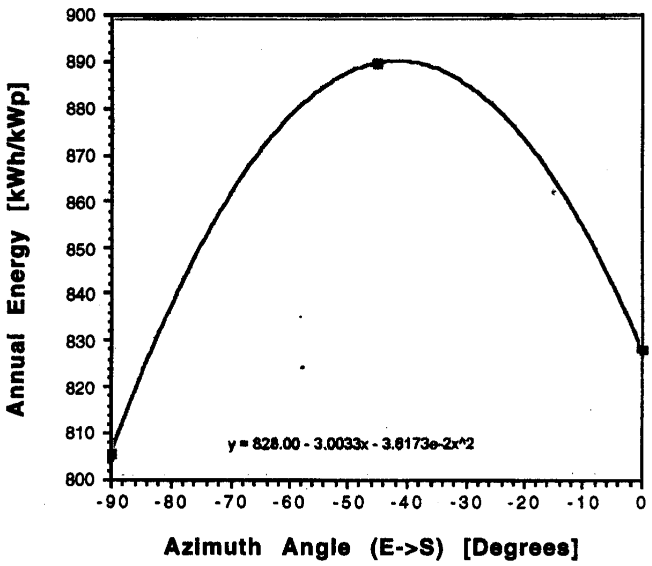

Figure 3a: Interpolation curve for vertical PV arrays at various azimuth angles in Tel-Aviv (from -90° = E, to 0° = S)

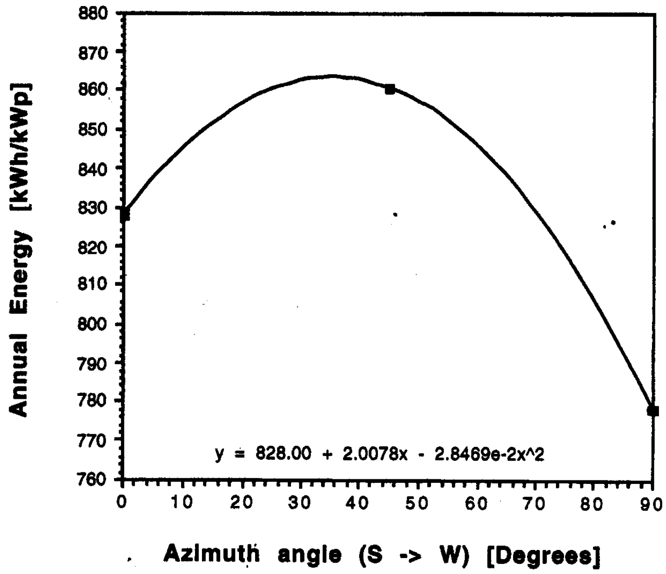

Figure 3b: Interpolation curve for vertical PV arrays at various azimuth angles in Tel-Aviv (from 0° = S, to 90° = W)

					Tel Aviv, tilt = 0° (Horizontal)								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	1	1.6	1	0.3	0	0	0	0	**4.1**
06-07	0	0.1	0.9	2.9	4.3	4.7	4.1	2.9	2.4	1	0.1	0	**23.4**
07-08	1.2	2	3.6	6.4	9	8.7	8.5	7.4	5.9	4.4	2.6	1.5	**61.2**
08-09	3.6	5.4	7.7	11.3	14	13.4	13.3	11	10.3	8.3	5.3	3.8	**107.4**
09-10	6.7	8.5	10.9	15.5	18.9	18.4	18.2	16.2	14.2	12	8.3	7.1	**154.9**
10-11	8.6	10.8	13.6	18.6	22.2	22	22	20.2	17.6	14.6	11.1	9.2	**190.5**
11-12	9.6	12.1	15.6	20.5	23.7	23.7	23.3	22.3	19.4	16.3	11.5	10	**208**
12-13	10.4	12.6	15.2	20.8	23.3	23.5	23.1	21.9	19.3	15.9	10.8	9.8	**206.6**
13-14	8.6	10.4	14	19	20.9	21.7	21.2	19.9	17.2	13.4	9.3	8.1	**183.7**
14-15	6.1	7.7	10.7	14.9	17.5	18.3	17.9	16.4	13	9.3	5.8	4.9	**142.5**
15-16	2.9	4.1	6.2	9.6	12.4	13.2	13.1	11	8.1	4.6	2.2	1.6	**89**
16-17	0.7	1.3	2.5	4.7	6.5	7.5	7.3	5.4	3	0.9	0.3	0.1	**40.2**
17-18	0	0	0.3	1.2	1.9	2.6	2.5	1.3	0.4	0	0	0	**10.2**
18-19	0	0	0	0	0.1	0.3	0.3	0	0	0	0	0	**0.7**
Total	**58.4**	**75**	**101.2**	**145.6**	**175.7**	**179.6**	**175.8**	**156.2**	**130.8**	**100.7**	**67.3**	**56.1**	**1422**

Table 1: Monthly hourly DC output [kWh] of 1 kWp of PV modules mounted horizontally, in Tel Aviv

					Tel Aviv, Tilt = 30°, Azimuth = -90°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.3	1.7	3.1	1.9	0.8	0	0	0	0	**7.8**
06-07	0	0.3	2	5.6	8.2	9.5	8.2	7.2	5.3	2.6	0.3	0	**49.2**
07-08	2.6	4.8	7.8	10.5	14.3	13.5	13.8	13.6	11.9	10.5	6.2	3.9	**113.4**
08-09	7.3	9.6	12.1	15.4	18.8	17.5	17.8	15.2	15.6	14.6	10.3	7.9	**162.1**
09-10	9.8	11.7	13.7	18.4	22.3	21.4	21.5	19.6	17.8	16	12.4	11	**195.6**
10-11	10	12.3	14.7	19.7	23.5	23.1	23.2	21.7	19.2	16.4	13	11.1	**207.9**
11-12	9.3	11.6	14.8	19.5	22.4	22.3	21.9	21	18.5	15.5	11	9.7	**197.5**
12-13	8.2	10	12.3	17.3	19.2	19.3	19	17.7	15.3	12.3	8.1	7.3	**166**
13-14	5	6.3	9	13	14.1	14.6	14.3	12.6	10.3	7.3	4.8	4	**115.3**
14-15	2.7	3.2	5	7.7	8.4	8.8	8.7	6.8	4.7	2.4	1.5	1.5	**61.4**
15-16	1.6	1.6	2.3	3.9	3.5	3.7	4	2.2	1.5	0.6	0.6	0.6	**26.1**
16-17	0.6	0.8	1.5	2.4	1.7	1.7	1.9	1.2	1	0.3	0.2	0.1	**13.4**
17-18	0	0	0.3	0.9	1.1	1.1	1.2	0.8	0.3	0	0	0	**5.7**
18-19	0	0	0	0	0.1	0.3	0.3	0	0	0	0	0	**0.7**
Total	**57.1**	**72.2**	**95.5**	**134.6**	**159.3**	**159.9**	**157.7**	**140.4**	**121.4**	**98.5**	**68.4**	**57.1**	**1322**

Table 2: Monthly hourly DC output [kWh] of 1 kWp of PV modules, East-facing at a 30° tilt angle, in Tel Aviv

					Tel Aviv,	Tilt = 30°,	Azimuth = -45°						
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	1.2	1.9	1.3	0.5	0	0	0	0	**5.1**
06-07	0	0.3	1.7	4.4	6.1	6.7	5.9	5.2	4.3	2.3	0.3	0	**37.2**
07-08	2.8	4.8	7.3	9.4	12	11.1	11.3	11.5	10.8	10.2	6.5	4.3	**102**
08-09	8.5	10.4	12.2	14.7	17.1	15.6	15.9	14.1	15.3	15.3	11.6	9.3	**160**
09-10	11.9	13.3	14.5	18.5	21.4	20.2	20.3	19.2	18.5	17.7	14.8	13.8	**204.1**
10-11	12.6	14.7	16.3	20.6	23.6	22.7	23	22.4	21	19.1	16.6	15	**227.6**
11-12	12.5	14.7	17.4	21.2	23.4	22.9	22.7	22.9	21.4	19.6	15.5	14.2	**228.4**
12-13	12.4	14.1	15.7	19.9	21.2	20.7	20.6	20.5	19.5	17.5	13.2	12.7	**208**
13-14	9.4	10.4	13	16.4	16.8	16.7	16.6	16.3	15.3	13.1	10.2	9.5	**163.7**
14-15	5.8	6.6	8.4	10.8	11.2	11.1	11.2	10.5	9.2	7.2	5.3	4.9	**102.2**
15-16	2.2	2.6	3.7	5.4	5.2	5.2	5.5	4.3	3.6	2.1	1.3	1.1	**42.2**
16-17	0.6	0.8	1.5	2.4	1.7	1.8	2	1.2	1	0.3	0.2	0.1	**13.6**
17-18	0	0	0.3	0.9	1.1	1.1	1.2	0.8	0.3	0	0	0	**5.7**
18-19	0	0	0	0	0.1	0.3	0.3	0	0	0	0	0	**0.7**
Total	**78.7**	**92.7**	**112**	**144.8**	**162.1**	**158**	**157.8**	**149.4**	**140.2**	**124.4**	**95.5**	**84.9**	**1501**

Table 3: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-East-facing at a 30° tilt angle, in Tel Aviv

					Tel Aviv,	Tilt = 30°,	Azimuth = 0°						
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.9	1.4	1	0.3	0	0	0	0	**3.8**
06-07	0	0.2	0.9	2.6	3.4	3.3	3	2.3	2.3	1.1	0.2	0	**19.3**
07-08	1.8	2.8	4.2	6	7.3	6.7	6.6	6.4	6.3	5.9	4	2.6	**60.6**
08-09	6.3	7.8	9.2	11.3	12.5	11.2	11.4	10.4	11.4	11.4	8.8	7.1	**118.8**
09-10	10.5	11.6	12.6	15.9	17.8	16.5	16.6	16	15.8	15.4	13	12.3	**174**
10-11	12.4	14.2	15.5	19.2	21.5	20.4	20.7	20.5	19.6	18.3	16.2	14.8	**213.3**
11-12	13.3	15.5	17.8	21.3	23.1	22.3	22.2	22.8	21.8	20.5	16.5	15.3	**232.4**
12-13	14.6	16.2	17.5	21.6	22.8	22	22.1	22.4	21.9	20.2	15.7	15.4	**232.4**
13-14	12.7	13.6	16.4	19.8	20.1	20.1	19.9	20.2	19.6	17.7	14.4	13.7	**208.2**
14-15	9.7	10.8	12.7	15.3	16.3	16.2	16.2	16.3	15	13.1	10.1	9.5	**161.2**
15-16	5	6.3	7.5	9.5	10.7	10.6	10.9	10.4	9.4	7.3	4.5	3.9	**96**
16-17	1	2.1	2.9	4.3	4.8	4.9	5.1	4.4	3.3	1.6	0.4	0.3	**35.1**
17-18	0	0	0.3	1	1.2	1.3	1.4	1	0.4	0	0	0	**6.6**
18-19	0	0	0	0	0.1	0.3	0.3	0	0	0	0	0	**0.7**
Total	**87.4**	**101**	**117.6**	**148.1**	**162.5**	**157.1**	**157.2**	**153.4**	**146.7**	**132.6**	**103.7**	**94.8**	**1562**

Table 4: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-facing at a 30° tilt angle, in Tel Aviv

					Tel Aviv, tilt = 30°, Azimuth = 45°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.9	1.4	1	0.3	0	0	0	0	**3.8**
06-07	0	0.1	0.8	2.4	3.2	3	2.8	2.1	2.1	0.9	0.1	0	**17.5**
07-08	1	1.4	2.1	4	4.7	4.3	4.1	3.3	3.3	2.9	2.1	1.3	**34.5**
08-09	2.7	3.7	4.9	7.3	7.9	7.3	7.2	6.4	6.2	5.3	3.9	3	**65.8**
09-10	6.3	7.3	8.8	11.7	13	12.3	12.1	11.3	10.8	9.9	7.6	7	**118.1**
10-11	9.3	10.9	12.6	16.2	18.1	17.3	17.4	16.7	15.8	14.2	11.9	10.5	**170.9**
11-12	11.4	13.5	16	19.7	21.6	21	20.8	20.9	19.6	17.8	13.9	12.8	**209**
12-13	13.6	15.4	17	21.5	23.1	22.6	22.5	22.5	21.4	19.3	14.6	14.2	**227.7**
13-14	12.9	14.1	17.3	21.3	22.3	22.6	22.2	22.3	21.1	18.6	14.7	13.9	**223.3**
14-15	11	12.5	14.8	18.2	20.4	20.6	20.3	20.4	18.2	15.7	11.8	10.9	**194.8**
15-16	6.7	8.7	10.4	13.1	16.3	16.5	16.6	16.1	13.9	11	6.5	5.5	**141.3**
16-17	1.6	4	5	7.5	10.4	10.8	10.7	9.9	6.9	3.7	0.7	0.5	**71.7**
17-18	0	0.1	0.5	1.9	3.6	4.6	4.5	2.8	0.8	0	0	0	**18.8**
18-19	0	0	0	0	0.1	0.5	0.4	0	0	0	0	0	**1**
Total	**76.5**	**91.7**	**110.2**	**145**	**165.6**	**164.8**	**162.6**	**155**	**140.1**	**119.3**	**87.8**	**79.6**	**1498**

Table 5: Monthly hourly DC output of 1 kWp of PV modules, South-West-facing at a 30° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 30°, Azimuth = 90°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.9	1.4	1	0.3	0	0	0	0	**3.8**
06-07	0	0.1	0.8	2.4	3.2	3	2.8	2.1	2.1	0.9	0.1	0	**17.5**
07-08	1	1.4	2.1	3.9	4.6	4.2	4	3.3	3.3	2.9	2.1	1.3	**34.1**
08-09	1.8	2.5	3.4	5.8	6.4	6.2	6	5	4.2	3.4	2.7	2.2	**49.6**
09-10	3	3.8	5.7	8.8	10.5	10.4	9.9	8.4	7	5.5	3.2	2.9	**79.1**
10-11	5.3	6.6	9.1	13.2	15.4	15.4	15.1	13.3	11.3	8.9	6.2	4.9	**124.7**
11-12	7.7	9.6	12.7	17.1	19.6	19.6	19.2	18	15.6	12.7	8.7	7.6	**168.1**
12-13	10	12.1	14.5	19.7	22	22.1	21.8	20.7	18.4	15.1	10.4	9.5	**196.3**
13-14	10	11.8	15.4	20.3	22.2	23	22.4	21.5	19.1	15.6	11.3	10	**202.6**
14-15	9	10.9	13.8	18.2	21.3	22.2	21.6	20.8	17.5	13.9	9.5	8.4	**187.1**
15-16	5.7	8	10.3	13.9	18.3	19.1	18.9	17.6	14.3	10.3	5.6	4.4	**146.4**
16-17	1.5	4.1	5.4	8.7	13.1	14.2	13.7	12.2	7.9	3.9	0.7	0.4	**85.8**
17-18	0	0.1	0.6	2.5	5.5	7.4	7.2	4.1	1.1	0	0	0	**28.5**
18-19	0	0	0	0	0.1	1	0.8	0	0	0	0	0	**1.9**
Total	**55**	**71**	**93.8**	**134.7**	**163.1**	**169.2**	**164.4**	**147.3**	**121.8**	**93.1**	**60.5**	**51.6**	**1326**

Table 6: Monthly hourly DC output of 1 kWp of PV modules, West-facing at a 30° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 60°, Azimuth = -90°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.4	2.2	4.5	2.7	1.2	0.1	0	0	0	**11.1**
06-07	0	0.5	3	7.2	10.3	11.9	10.3	9.8	7.5	4.1	0.5	0	**65.1**
07-08	3.8	6.5	9.9	12	15.9	14.8	15.3	16	14.6	13.9	8.7	5.8	**137.2**
08-09	9	11.1	13.3	15.8	19.1	17.6	17.9	15.6	16.8	16.6	12.4	9.8	**175**
09-10	10.2	11.8	13.2	17.4	20.8	19.7	19.9	18.4	17.2	15.9	12.9	11.7	**189.1**
10-11	8.7	10.6	12.5	16.6	19.4	18.9	19	17.9	16.2	14	11.4	9.9	**175.1**
11-12	6.7	8.1	10.4	13.9	15.4	15.1	14.9	14.1	12.6	10.6	7.5	6.7	**136**
12-13	4.7	5.3	6.7	9.5	9.8	9.4	9.4	8.3	7.1	5.6	3.9	3.6	**83.3**
13-14	2.9	3.1	4.1	5.5	5	4.5	4.7	3.6	3.1	2.3	2	2	**42.8**
14-15	2.4	2.4	3.4	4.4	3.4	3	3.2	2.4	2.2	1.3	1.2	1.4	**30.7**
15-16	1.5	1.5	2.2	3.4	2.6	2.4	2.7	1.7	1.6	0.7	0.6	0.6	**21.5**
16-17	0.5	0.7	1.4	2.2	1.7	1.8	2	1.3	1	0.3	0.2	0.1	**13.2**
17-18	0	0	0.3	0.8	1	1.1	1.1	0.8	0.3	0	0	0	**5.4**
18-19	0	0	0	0	0.1	0.3	0.2	0	0	0	0	0	**0.6**
Total	**50.4**	**61.7**	**80.4**	**109.2**	**126.6**	**125**	**123.5**	**111**	**100.2**	**85.3**	**61.3**	**51.6**	**1086**

Table 7: Monthly hourly DC output of 1 kWp of PV modules, East-facing at a 60° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 60°, Azimuth = -45°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.3	1.3	2.1	1.4	0.6	0	0	0	0	**5.7**
06-07	0	0.4	2.4	5.3	6.7	7.1	6.3	6.4	5.7	3.5	0.4	0	**44.2**
07-08	4.1	6.5	9	10.1	12.1	10.7	11.1	12.5	12.8	13.4	9.2	6.6	**118.1**
08-09	10.9	12.3	13.5	14.7	16.2	14.2	14.7	13.9	16.3	17.8	14.5	12.2	**171.2**
09-10	13.6	14.4	14.6	17.4	19.1	17.3	17.7	17.8	18.3	18.8	17	16.4	**202.4**
10-11	13.3	14.9	15.4	18.2	19.6	18.1	18.6	19.3	19.5	18.9	17.6	16.5	**209.9**
11-12	12.3	13.9	15.3	17.4	17.6	16.2	16.4	17.8	18.3	18.1	15.3	14.5	**193.1**
12-13	11.4	12.1	12.5	14.4	13.5	12	12.5	13.5	14.5	14.5	11.9	12	**154.8**
13-14	7.7	7.7	8.8	9.6	8.1	7	7.5	7.9	8.9	8.9	8	7.9	**98**
14-15	4	3.9	4.5	5.1	3.8	3.2	3.6	3.1	3.5	3.2	3.1	3.3	**44.3**
15-16	1.5	1.5	2.2	3.4	2.6	2.4	2.7	1.7	1.6	0.7	0.6	0.6	**21.5**
16-17	0.5	0.7	1.4	2.2	1.7	1.8	2	1.3	1	0.3	0.2	0.1	**13.2**
17-18	0	0	0.3	0.8	1	1.1	1.1	0.8	0.3	0	0	0	**5.4**
18-19	0	0	0	0	0.1	0.3	0.2	0	0	0	0	0	**0.6**
Total	**79.4**	**88.4**	**99.8**	**119**	**123.5**	**113.5**	**115.8**	**116.5**	**120.8**	**118.1**	**97.9**	**90.1**	**1283**

Table 8: Monthly hourly DC output of 1 kWp of PV modules, South-East-facing at a 60° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 60°, Azimuth = 0°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.8	1.3	0.8	0.3	0	0	0	0	**3.4**
06-07	0	0.2	0.8	2.1	2.8	2.8	2.5	1.9	1.9	1.1	0.2	0	**16.3**
07-08	2.2	3.1	3.8	4.6	4.8	4.2	4.1	4.2	5.2	6.1	4.8	3.5	**50.6**
08-09	7.4	8	8.2	8.8	8.1	6.8	7	7.5	9.5	11.3	9.9	8.6	**101.1**
09-10	11.4	11.6	11.3	12.6	12.2	10.4	10.7	11.8	13.5	14.8	14	13.8	**148.1**
10-11	13	14	13.9	15.7	15.3	13.5	14	15.5	17.1	17.5	16.9	16.1	**182.5**
11-12	13.6	15.1	16.1	17.6	16.9	15.1	15.5	17.6	19.1	19.6	17.1	16.4	**199.7**
12-13	15.1	15.9	15.9	17.7	16.6	14.7	15.3	17.3	19.1	19.4	16.3	16.6	**199.9**
13-14	13.4	13.4	14.9	15.9	14.2	12.8	13.3	15.2	17	17.2	15.2	15.1	**177.6**
14-15	10.5	10.9	11.4	11.9	10.6	9.3	9.9	11.5	12.7	12.9	11.1	11	**133.7**
15-16	5.8	6.7	6.8	7.1	6.1	5.1	5.8	6.5	7.6	7.5	5.5	5	**75.5**
16-17	1.3	2.5	2.7	3.1	2.4	2.1	2.4	2.4	2.6	1.8	0.5	0.4	**24.2**
17-18	0	0	0.3	0.8	1	1.1	1.1	0.8	0.3	0	0	0	**5.4**
18-19	0	0	0	0	0.1	0.3	0.2	0	0	0	0	0	**0.6**
Total	**93.7**	**101.4**	**106.1**	**118.1**	**111.9**	**99.5**	**102.6**	**112.5**	**125.6**	**129.2**	**111.5**	**106.5**	**1319**

Table 9: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-facing at a 60° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 60°, Azimuth = 45°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.8	1.3	0.8	0.3	0	0	0	0	**3.4**
06-07	0	0.1	0.7	2.1	2.8	2.8	2.5	1.9	1.8	0.8	0.1	0	**15.6**
07-08	0.9	1.3	2	3.6	4.3	3.9	3.7	3.1	3	2.6	1.9	1.2	**31.5**
08-09	1.8	2.4	3.2	5.1	5.1	4.7	4.6	4.2	3.9	3.3	2.6	2.1	**43**
09-10	4.4	4.5	5.1	6.3	5.8	5.2	5	5.1	5.6	5.9	4.9	5	**62.8**
10-11	7.7	8.1	8.7	10	9.2	8.1	8.2	8.7	9.8	10.1	9.4	8.9	**106.9**
11-12	10.4	11.6	12.7	14.4	13.8	12.4	12.6	13.8	14.7	14.8	12.6	12	**155.8**
12-13	13.5	14.5	15	17.6	17.2	15.9	16.3	17.4	18.3	17.8	14.5	14.5	**192.5**
13-14	13.8	14.3	16.5	18.8	18.4	17.8	17.9	19.2	19.7	18.8	15.9	15.5	**206.6**
14-15	12.6	13.7	15.1	17.2	18.2	17.7	17.8	19.1	18.5	17.3	13.9	13.3	**194.4**
15-16	8.5	10.6	11.6	13.3	15.6	15.2	15.5	16.3	15.4	13.5	8.8	7.7	**152**
16-17	2.3	5.9	6.3	8.4	11	10.9	11	11.2	8.8	5.4	1.1	0.8	**83.1**
17-18	0	0.1	0.6	2.4	4.3	5.2	5.3	3.6	1.1	0	0	0	**22.6**
18-19	0	0	0	0	0.1	0.6	0.5	0	0	0	0	0	**1.2**
Total	**76**	**87**	**97.5**	**119.4**	**126.7**	**121.6**	**121.8**	**123.9**	**120.6**	**110.4**	**85.7**	**80.9**	**1272**

Table 10: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-West-facing at a 60° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 60°, Azimuth = 90°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.8	1.3	0.8	0.3	0	0	0	0	**3.4**
06-07	0	0.1	0.7	2.1	2.8	2.8	2.5	1.9	1.8	0.8	0.1	0	**15.6**
07-08	0.9	1.3	2	3.6	4.3	3.9	3.7	3.1	3	2.6	1.9	1.2	**31.5**
08-09	1.7	2.3	3.2	5.1	5.1	4.7	4.6	4.2	3.9	3.3	2.5	2	**42.6**
09-10	2.6	2.9	4.1	5.6	5.4	5	4.7	4.4	4.4	4	2.7	2.7	**48.5**
10-11	3.2	3.3	4.6	6.3	6	5.8	5.5	4.6	4.5	4.1	3.1	2.7	**53.7**
11-12	4.5	5.2	6.9	9.7	10.2	9.8	9.6	8.6	7.6	6.2	4.2	3.9	**86.4**
12-13	7.1	8.4	10.2	13.9	15	14.8	14.7	13.8	12.3	10.2	7	6.5	**133.9**
13-14	8.8	10.1	13.1	17	18.2	18.7	18.3	17.7	16	13.3	9.8	8.9	**169.9**
14-15	9.4	11	13.5	17.2	19.9	20.5	20.1	19.8	17.1	14.2	10.1	9.2	**182**
15-16	7.1	9.5	11.4	14.6	19.2	19.8	19.5	19	16	12.5	7.2	5.9	**161.7**
16-17	2.2	5.9	6.9	10.3	15.6	16.4	15.9	15	10.3	5.7	1	0.7	**105.9**
17-18	0	0.1	0.8	3.5	7.6	10	9.7	5.9	1.5	0	0	0	**39.1**
18-19	0	0	0	0	0.2	1.6	1.3	0	0	0	0	0	**3.1**
Total	**47.5**	**60.1**	**77.2**	**109**	**130.2**	**135.1**	**131.1**	**118.4**	**98.7**	**76.9**	**49.7**	**43.7**	**1078**

Table 11: Monthly hourly DC output of 1 kWp of PV modules, West-facing at a 60° tilt angle, in Tel Aviv

					Tel Aviv, Tilt = 90°, Azimuth = -90°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.4	2.2	4.6	2.7	1.2	0.1	0	0	0	**11.2**
06-07	0	0.5	3.1	7.1	9.8	11.2	9.7	9.7	7.6	4.3	0.5	0	**63.5**
07-08	3.8	6.4	9.4	10.8	13.9	12.7	13.3	14.3	13.6	13.6	8.8	6.1	**126.7**
08-09	8.2	9.8	11.2	12.9	15.1	13.6	13.9	12.5	14.1	14.5	11.1	9	**145.9**
09-10	7.8	8.8	9.6	12.3	14	13	13.1	12.5	12.3	11.8	9.8	9.1	**134.1**
10-11	5.4	6.2	7.3	9.5	10.1	9.5	9.5	9.2	8.9	8.1	6.7	5.9	**96.3**
11-12	3.7	4	5	6.6	6.2	5.7	5.6	5.2	5.1	4.6	3.4	3.3	**58.4**
12-13	3.5	3.7	4.4	5.9	5.4	4.8	4.9	4.4	4.1	3.6	2.8	2.7	**50.2**
13-14	2.8	3.1	4	5.2	4.8	4.3	4.5	3.8	3.5	2.8	2.3	2.1	**43.2**
14-15	2.2	2.4	3.3	4.3	3.9	3.7	3.8	3.1	2.7	1.8	1.4	1.4	**34**
15-16	1.3	1.5	2.1	3.2	2.9	2.9	3.1	2.2	1.9	1	0.7	0.6	**23.4**
16-17	0.4	0.6	1.2	2	1.9	2	2.1	1.5	1	0.3	0.1	0.1	**13.2**
17-18	0	0	0.2	0.7	0.9	1.1	1.1	0.7	0.2	0	0	0	**4.9**
18-19	0	0	0	0	0.1	0.2	0.2	0	0	0	0	0	**0.5**
Total	**39.2**	**46.9**	**60.9**	**80.8**	**91.1**	**89.3**	**87.6**	**80.3**	**75**	**66.2**	**47.6**	**40.4**	**805.3**

Table 12: Monthly hourly DC output of 1 kWp of PV modules, mounted vertically, East-facing, in Tel Aviv

Tel Aviv, Tilt = 90°, Azimuth = -45°													
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
05-06	0	0	0	0.3	1.2	1.9	1.2	0.6	0	0	0	0	**5.2**
06-07	0	0.4	2.4	4.8	5.7	5.6	5.1	5.8	5.6	3.7	0.5	0	**39.6**
07-08	4.2	6.4	8.4	8.5	9.3	7.7	8.2	10.1	11.5	13	9.4	6.9	**103.6**
08-09	10.4	11.2	11.5	11.4	11.3	9.3	9.8	10.3	13.4	16	13.7	11.8	**140.1**
09-10	12	12.1	11.4	12.4	11.9	10	10.4	11.8	13.8	15.4	14.9	14.7	**150.8**
10-11	10.9	11.5	10.8	11.5	10.3	8.7	9.1	10.7	12.9	14.1	14.2	13.8	**138.5**
11-12	9.1	9.5	9.4	9.4	7.6	6.2	6.5	7.8	10	11.7	11	10.9	**109.1**
12-13	7.5	7	6.5	6.7	5.4	4.8	4.9	4.8	6.1	7.5	7.3	7.9	**76.4**
13-14	4.3	3.9	4.2	5.2	4.8	4.3	4.5	3.8	3.6	3.5	3.9	4.3	**50.3**
14-15	2.3	2.4	3.3	4.3	3.9	3.7	3.8	3.1	2.7	1.8	1.5	1.6	**34.4**
15-16	1.3	1.5	2.1	3.2	2.9	2.9	3.1	2.2	1.9	1	0.7	0.6	**23.4**
16-17	0.4	0.6	1.2	2	1.9	2	2.1	1.5	1	0.3	0.1	0.1	**13.2**
17-18	0	0	0.2	0.7	0.9	1.1	1.1	0.7	0.2	0	0	0	**4.9**
18-19	0	0	0	0	0.1	0.2	0.2	0	0	0	0	0	**0.5**
Total	**62.6**	**66.5**	**71.4**	**80.3**	**77**	**68.3**	**70**	**73.2**	**82.8**	**88**	**77.2**	**72.6**	**889.9**

Table 13: Monthly hourly DC output of 1 kWp of PV modules, mounted vertically, South-East-facing, in Tel Aviv

Tel Aviv, Tilt = 90°, Azimuth = 0°													
Hour	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
05-06	0	0	0	0.1	0.7	1	0.7	0.2	0	0	0	0	**2.7**
06-07	0	0.1	0.6	1.7	2.4	2.4	2.2	1.6	1.5	1	0.2	0	**13.7**
07-08	2.1	2.5	2.6	3.2	3.8	3.5	3.4	2.9	3.3	4.7	4.3	3.4	**39.7**
08-09	6.3	6	5.3	5.2	4.8	4.4	4.4	4.2	5.6	8.1	8.2	7.5	**70**
09-10	9.3	8.5	7.3	6.9	5.8	5.1	4.9	5.6	7.9	10.4	11.1	11.6	**94.4**
10-11	10.4	10.3	9	8.6	6.6	5.5	5.6	6.9	9.9	12.3	13.3	13.3	**111.7**
11-12	10.9	11.1	10.4	9.6	7.2	5.7	5.9	7.7	11	13.7	13.4	13.4	**120**
12-13	12	11.6	10.3	9.4	6.9	5.3	5.8	7.5	10.8	13.4	12.7	13.5	**119.2**
13-14	10.8	9.8	9.5	8.2	5.8	4.6	5	6.3	9.4	11.7	11.9	12.5	**105.5**
14-15	8.6	8	7.2	6.1	4.3	3.7	3.9	4.5	6.7	8.7	8.8	9.3	**79.8**
15-16	4.9	5	4.3	3.9	2.9	2.9	3.1	2.6	3.9	5.1	4.5	4.5	**47.6**
16-17	1.2	2	1.8	2.1	1.9	2	2.1	1.5	1.4	1.3	0.5	0.4	**18.2**
17-18	0	0	0.2	0.7	0.9	1.1	1.1	0.7	0.3	0	0	0	**5**
18-19	0	0	0	0	0.1	0.2	0.2	0	0	0	0	0	**0.5**
Total	**76.5**	**74.9**	**68.5**	**65.7**	**54.1**	**47.4**	**48.3**	**52.2**	**71.7**	**90.4**	**88.9**	**89.4**	**828**

Table 14: Monthly hourly DC output of 1 kWp of PV modules, mounted vertically, South-facing, in Tel Aviv

					Tel Aviv, Tilt = 90°, Azimuth = 45°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.1	0.7	1	0.7	0.2	0	0	0	0	**2.7**
06-07	0	0.1	0.6	1.7	2.4	2.4	2.2	1.6	1.5	0.7	0.1	0	**13.3**
07-08	0.7	1.1	1.7	3.1	3.8	3.5	3.4	2.9	2.7	2.3	1.6	1	**27.8**
08-09	1.6	2.2	2.9	4.5	4.8	4.4	4.4	3.9	3.7	3.1	2.3	1.8	**39.6**
09-10	2.6	2.8	3.8	5.2	5.4	5.1	4.8	4.5	4.3	3.9	2.7	2.8	**47.9**
10-11	4.4	4.1	4.5	5.8	5.6	5.3	5.1	4.6	4.6	4.8	4.9	5	**58.7**
11-12	6.9	6.8	6.6	6.9	5.8	5.1	5.1	5.1	6.5	7.9	7.7	8	**78.4**
12-13	10	9.9	9.2	9.2	7.3	5.9	6.3	7.6	9.8	11.4	10.4	10.9	**107.9**
13-14	11.3	10.9	11.5	11.5	9.4	8	8.5	10.3	12.7	13.8	12.8	12.9	**133.6**
14-15	11.1	11.5	11.8	11.9	10.8	9.5	10	12.1	13.6	14.2	12.2	12	**140.7**
15-16	8.1	9.7	9.9	10.2	10.5	9.4	10	11.8	12.6	12.2	8.4	7.5	**120.3**
16-17	2.4	5.9	5.9	7.1	8.2	7.6	7.9	9.1	7.9	5.4	1.1	0.8	**69.3**
17-18	0	0.1	0.6	2.3	3.7	4.1	4.3	3.3	1.1	0	0	0	**19.5**
18-19	0	0	0	0	0.1	0.6	0.5	0	0	0	0	0	**1.2**
Total	**59.1**	**65**	**69**	**79.5**	**78.4**	**71.8**	**73.2**	**76.9**	**81.1**	**79.6**	**64.3**	**62.8**	**860.7**

Table 15: Monthly hourly DC output of 1 kWp of PV modules mounted vertically, South-West-facing, in Tel Aviv

					Tel Aviv, Tilt = 90°, Azimuth = 90°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.1	0.7	1	0.7	0.2	0	0	0	0	**2.7**
06-07	0	0.1	0.6	1.7	2.4	2.4	2.2	1.6	1.5	0.7	0.1	0	**13.3**
07-08	0.7	1.1	1.7	3.1	3.8	3.5	3.4	2.9	2.7	2.3	1.6	1	**27.8**
08-09	1.6	2.2	2.9	4.5	4.8	4.4	4.4	3.9	3.7	3.1	2.3	1.8	**39.6**
09-10	2.5	2.8	3.8	5.2	5.4	5.1	4.8	4.5	4.3	3.9	2.7	2.6	**47.6**
10-11	3	3.2	4.3	5.8	5.6	5.3	5.1	4.6	4.5	4.1	3.2	2.7	**51.4**
11-12	3.4	3.6	4.6	6.1	5.7	5.1	5.1	4.6	4.5	4	3	3	**52.7**
12-13	3.8	4	4.8	6.4	5.9	5.3	5.4	4.9	4.7	4.1	3.1	3.1	**55.5**
13-14	5.4	5.9	7.4	9.3	9.2	8.9	9	8.7	8.3	7.1	5.6	5.2	**90**
14-15	7.2	8.2	9.7	11.9	13	13	13	13.1	11.9	10.2	7.6	7.1	**125.9**
15-16	6.4	8.4	9.7	11.8	15	15.2	15.2	15.2	13.4	11	6.6	5.5	**133.4**
16-17	2.2	5.9	6.6	9.3	13.8	14.3	14	13.7	9.8	5.7	1.1	0.7	**97.1**
17-18	0	0.1	0.8	3.4	7.4	9.7	9.4	5.9	1.6	0	0	0	**38.3**
18-19	0	0	0	0	0.2	1.6	1.3	0	0	0	0	0	**3.1**
Total	**36.1**	**45.5**	**56.8**	**78.7**	**92.7**	**95**	**93**	**83.7**	**70.8**	**56.3**	**36.8**	**32.7**	**778.1**

Table 16: Monthly hourly DC output of 1 kWp of PV modules, mounted vertically, West-facing, in Tel Aviv

					Haifa, Tilt = 30°, Azimuth = 0°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	1.1	1.4	1	0.3	0	0	0	0	**4**
06-07	0	0.1	1.1	2.4	3.6	3	2.9	2.5	2.2	1	0.1	0	**18.9**
07-08	2	2.3	4.6	6.4	7.6	6.8	7	6.6	6.2	5.5	3.8	1.7	**60.5**
08-09	6.6	6.4	9.2	11.4	13.3	11.9	12.8	12.4	11.9	10.2	8.9	7	**122**
09-10	10.5	10.1	14.2	16.6	17.8	17.2	17.9	17.7	17	14.6	12.4	11.8	**177.8**
10-11	12.6	12.9	16.7	19.7	21.5	20.6	21.8	21.6	20.1	17.2	15.7	14.7	**215.1**
11-12	13.4	15.9	18.2	20.5	22.3	22.5	23	23.4	22.2	19.6	16.3	14.5	**231.8**
12-13	12.5	14.5	18.3	19.8	21.6	22	22.2	22.8	21.5	18.9	15	13.3	**222.4**
13-14	10.3	13.3	16.9	17.6	19.1	19.9	20.5	20.3	18.1	15.5	12.7	11.5	**195.7**
14-15	7.5	10.6	12.5	13.3	15	15.7	16.1	16	13.6	11.6	8.8	7.9	**148.6**
15-16	3.3	6.5	6.8	8.3	9.9	10	10.4	10	8.3	5.9	3.1	2.2	**84.7**
16-17	0.4	1.7	2.7	3.5	4.3	4.3	4.6	4.1	2.7	1.1	0.2	0.1	**29.7**
17-18	0	0	0.2	0.8	1	0.9	1.3	0.8	0.3	0	0	0	**5.3**
18-19	0	0	0	0	0.1	0.2	0.2	0	0	0	0	0	**0.5**
Total	**79**	**94.3**	**121.4**	**140.5**	**158.1**	**156.3**	**161.8**	**158.7**	**144.3**	**121.1**	**97**	**84.8**	**1517**

Table 17: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-facing at a 30° tilt angle, in Haifa

					Jerusalem, Tilt = 30°, Azimuth = 0°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.1	0.9	1.3	1	0.4	0	0	0	0	**3.7**
06-07	0	0.1	1.1	2.3	3.1	2.6	2.7	2.6	2.4	1.1	0.2	0	**18.2**
07-08	2.1	2.7	4.6	6.9	7.5	6.8	6.8	6.9	6.8	6.5	4.7	2.8	**65.1**
08-09	6.3	8	9.9	11.9	13.5	12.7	12.6	13	13.1	12.4	10.4	7.3	**131.1**
09-10	11	12.4	14.3	17.7	18.3	17.4	18.4	18.4	18.4	17.5	14.7	13.6	**192.1**
10-11	14.4	15.5	17.5	21.3	21.2	20.6	21.5	22.2	21.4	20.6	17.2	16.5	**229.9**
11-12	14.4	16.5	19.1	21.8	22.4	21.9	23.4	23.7	22.8	20.8	18.3	16.8	**241.9**
12-13	13.3	15.3	18.4	21.9	22.2	22	22.8	23.5	22.3	19.1	16.6	14.3	**231.7**
13-14	11.8	13.6	15	19.3	19.4	19.7	20.9	21.4	19.7	15.4	14.2	12.2	**202.6**
14-15	8.4	11.3	12.5	15.4	15.5	15.7	17	17	15.3	11	9.1	8.5	**156.7**
15-16	3.3	7	8.4	9.7	10.4	10.2	11.2	11	9.3	4.7	3.4	1.5	**90.1**
16-17	0.6	1.7	3.3	4	4.8	4.4	4.9	4.3	2.5	1	0.2	0.2	**31.9**
17-18	0	0.1	0.4	0.8	1.3	0.8	1	0.9	0.2	0	0	0	**5.5**
18-19	0	0	0	0	0.1	0.2	0.2	0	0	0	0	0	**0.5**
Total	**85.5**	**104.1**	**124.4**	**153.3**	**160.6**	**156.3**	**164.4**	**165.3**	**154.1**	**130.1**	**109**	**93.7**	**1601**

Table 18: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-facing at a 30° tilt angle, in Jerusalem

					Beersheba, Tilt = 30°, Azimuth = 0°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	1	1.3	0.9	0.3	0	0	0	0	**3.7**
06-07	0	0.2	1.2	2.9	3.8	3.6	3.2	2.7	2.4	1.2	0.2	0	**21.4**
07-08	2.6	2.9	5.1	7.1	7.8	7.4	7.2	6.9	6.7	6.5	4.4	3.2	**67.8**
08-09	7.6	7.7	11	12.9	13.2	12.8	12.7	13.1	12.6	12.8	9.9	8	**134.3**
09-10	13	12.5	15.3	17.5	18.6	17.7	17.8	18.4	17.6	17.7	14.3	13	**193.4**
10-11	15.8	15.9	17.9	20.4	22	21.1	21.2	22.2	20.8	20.6	17.4	16.7	**232**
11-12	16	17	20.1	22.1	23.2	22.3	22.7	23.6	22	21.6	19	17.6	**247.2**
12-13	16.2	17.3	18.9	21	22.4	21.6	22.6	23	21.3	19.3	18	17.4	**239**
13-14	13.5	14.7	16.4	18.5	20.3	19.2	20.6	20.6	18.8	17.5	14.9	13.6	**208.6**
14-15	10.1	10.5	12.9	14.6	16.1	15.4	16.5	16.3	15.1	13	10.1	9.1	**159.7**
15-16	4.9	6.5	7.7	9.2	10.4	10.1	11	10.6	9.2	6.9	4.3	3.7	**94.5**
16-17	1	2.2	3.2	4.1	4.7	4.5	5	4.4	3.2	1.4	0.4	0.4	**34.5**
17-18	0	0.1	0.4	1	1.4	1.3	1.4	0.7	0.3	0	0	0	**6.6**
18-19	0	0	0	0	0.1	0.2	0.3	0	0	0	0	0	**0.6**
Total	**100.7**	**107.5**	**130.1**	**151.5**	**165.1**	**158.6**	**163.3**	**162.7**	**150.1**	**138.5**	**113.1**	**102.7**	**1644**

Table 19: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-facing at a 30° tilt angle, in Beersheba

					Eilat, Tilt = 30°, Azimuth = 0°								
Hour	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Total**
05-06	0	0	0	0.2	0.9	1.5	0.9	0.3	0	0	0	0	**3.8**
06-07	0	0.2	1.1	2.5	3.3	3.3	2.4	2.3	2.2	1.2	0.3	0	**18.8**
07-08	2.8	3.5	5.8	6.8	7.5	7.5	6.6	6.7	6.8	6.6	4.8	4	**69.4**
08-09	8.5	8.9	12	12.5	13	13.2	12.5	13.1	13	12.7	10.2	9.8	**139.4**
09-10	12.9	14.3	17.3	17.3	17.8	18.2	17.6	18.6	18.3	18	15	15.3	**200.6**
10-11	17.4	17.6	21	21.3	21.2	21.4	20.8	22.1	21.6	21.2	18.1	18.6	**242.3**
11-12	18	19.1	22.9	22.8	22.1	22.7	22.2	23.6	22.7	22.4	19.2	19.5	**257.2**
12-13	18.2	18.6	22.9	22.3	22.1	22.1	21.9	23.1	22	21.3	17.5	19.3	**251.3**
13-14	16.8	16.6	19.9	19.6	19.8	19.8	19.7	20.7	19.3	18.3	14.7	17.1	**222.3**
14-15	12	12.6	15	14.8	15.4	15.6	15.6	16.5	14.7	13.4	10.5	11.3	**167.4**
15-16	6.8	7.8	9.5	8.8	9.1	9.9	9.8	10.4	8.7	6.7	4.2	5.5	**97.2**
16-17	0.8	2	3.4	3.3	3.3	4.2	4	3.9	2.6	0.9	0.2	0.2	**28.8**
17-18	0	0	0.2	0.5	0.8	1	0.9	0.6	0.2	0	0	0	**4.2**
18-19	0	0	0	0	0	0.1	0.1	0	0	0	0	0	**0.2**
Total	**114.2**	**121.2**	**151**	**152.6**	**156.3**	**160.6**	**155.1**	**161.8**	**152.1**	**142.8**	**114.6**	**120.7**	**1703**

Table 20: Monthly hourly DC output [kWh] of 1 kWp of PV modules, South-facing at a 30° tilt angle, in Eilat

SITE: TEL AVIV
YEAR: TPVY
LATITUDE 32.0 N
LONGITUDE 34.8 E

SOLAR RADIATION ON VARIOUS TRACKING AND STATIONARY PLANE SURFACES
(ASSUMES: ISOTROPIC SKY MODEL, GROUND ALBEDO = 0.30)
[KWH/SQ.M/DAY]

MONTH	FULL TRACKING [2 - AXES]			POLAR MOUNT [1 - AXIS]			N-S AXIS [1 - AXIS]			E-W AXIS [1 - AXIS]			TILT=LATITUDE NON-TRACKING			HORIZONTAL NON-TRACKING		
	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL
1/TPVY	3.18	0.83	4.20	2.97	0.96	4.04	2.23	0.96	3.29	2.68	0.86	3.72	2.43	1.04	3.52	1.46	1.12	2.59
2/TPVY	4.21	1.01	5.45	4.11	1.10	5.36	3.35	1.12	4.60	3.38	1.07	4.62	3.23	1.20	4.51	2.25	1.30	3.55
3/TPVY	4.14	1.32	5.68	4.13	1.34	5.66	3.65	1.40	5.20	3.19	1.46	4.77	3.17	1.49	4.75	2.57	1.61	4.18
4/TPVY	5.39	2.08	7.71	5.32	1.98	7.61	5.15	2.12	7.47	4.10	2.35	6.52	3.97	2.25	6.37	3.82	2.44	6.25
5/TPVY	7.08	1.73	9.04	6.71	1.59	8.68	6.98	1.74	8.94	5.39	1.95	7.38	4.78	1.85	6.80	5.24	2.01	7.24
6/TPVY	7.82	1.57	9.62	7.20	1.42	9.03	7.73	1.57	9.53	6.02	1.76	7.82	4.97	1.68	6.82	5.82	1.82	7.64
7/TPVY	7.42	1.54	9.19	6.91	1.41	8.71	7.33	1.55	9.10	5.70	1.75	7.48	4.85	1.66	6.69	5.53	1.80	7.33
8/TPVY	7.07	1.23	8.53	6.87	1.16	8.36	6.87	1.25	8.32	5.28	1.41	6.73	4.94	1.34	6.43	5.03	1.45	6.49
9/TPVY	6.46	1.26	7.97	6.44	1.24	7.96	5.93	1.31	7.43	4.86	1.43	6.40	4.84	1.41	6.38	4.23	1.53	5.75
10/TPVY	5.74	0.95	6.95	5.66	1.01	6.87	4.79	1.04	5.99	4.44	1.02	5.66	4.33	1.12	5.55	3.20	1.21	4.41
11/TPVY	4.51	0.71	5.45	4.27	0.81	5.22	3.27	0.81	4.21	3.77	0.75	4.71	3.47	0.89	4.43	2.19	0.96	3.15
12/TPVY	3.90	0.63	4.73	3.59	0.74	4.43	2.61	0.74	3.44	3.35	0.65	4.18	2.97	0.80	3.82	1.71	0.87	2.57

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

2038	452	2573	1954	449	2494	1824	475	2360	1588	501	2131	1459	509	2011	1311	551	1862

MONTH	AVG. INPUT DATA			COMPONENTS ON A S-FACING SURFACE			TOTAL RADIATION ON VERTICAL SURFACES				TOTAL RADIATION ON 60 DEG INCLINED PLANES				TOTAL RADIATION ON 30 DEG INCLINED PLANES			
	BEAM	GLOB	KT	BEAM	DIFF	REFL	S	W	N	E	S	W	N	E	S	W	N	E
1/TPVY	3.18	2.59	0.46	2.23	0.56	0.39	3.18	1.67	0.95	1.67	3.70	2.10	1.03	2.10	3.48	2.43	1.30	2.43
2/TPVY	4.21	3.55	0.51	2.50	0.65	0.53	3.68	2.24	1.18	2.23	4.53	2.85	1.24	2.84	4.48	3.32	2.00	3.33
3/TPVY	4.14	4.18	0.49	1.87	0.80	0.63	3.30	2.52	1.43	2.53	4.42	3.29	1.52	3.25	4.74	3.89	2.88	3.88
4/TPVY	5.39	6.25	0.62	1.41	1.22	0.94	3.57	3.70	2.18	3.47	5.41	4.92	3.00	4.61	6.40	5.90	5.01	5.68
5/TPVY	7.08	7.24	0.65	0.85	1.00	1.09	2.94	4.24	2.31	3.74	5.26	5.67	4.12	5.10	6.87	6.87	6.23	6.44
6/TPVY	7.82	7.64	0.66	0.50	0.91	1.15	2.56	4.46	2.54	3.82	4.98	6.03	4.83	5.24	6.92	7.31	6.88	6.71
7/TPVY	7.42	7.33	0.65	0.64	0.90	1.10	2.64	4.23	2.35	3.73	4.99	5.71	4.41	5.11	6.77	6.95	6.47	6.49
8/TPVY	7.07	6.49	0.62	1.36	0.73	0.97	3.06	3.86	1.80	3.40	5.21	5.17	3.00	4.57	6.48	6.18	5.21	5.75
9/TPVY	6.46	5.75	0.63	2.37	0.76	0.86	4.00	3.53	1.63	3.18	5.74	4.64	1.77	4.20	6.38	5.48	4.01	5.16
10/TPVY	5.74	4.41	0.59	3.05	0.60	0.66	4.32	2.85	1.27	2.68	5.48	3.65	1.24	3.44	5.51	4.20	2.47	4.05
11/TPVY	4.51	3.15	0.53	3.04	0.48	0.47	4.00	2.00	0.95	1.96	4.69	2.55	0.96	2.52	4.38	2.96	1.38	2.92
12/TPVY	3.90	2.57	0.49	2.86	0.43	0.39	3.68	1.66	0.82	1.65	4.18	2.10	0.84	2.09	3.77	2.42	1.01	2.41

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

2038	1862		689	275	279	1244	1125	591	1036	1782	1483	853	1372	2015	1764	1367	1682

NUMBER OF MISSING DAYS

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	0	0	0	0	0	0	0	0	0

CLIMATOLOGICAL DATA FOR TEL AVIV TPVY

Latitude = 32.0 N   Longitude = 34.8 E   Elevation = 50m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
TEMPERATURE [DegC]													
mean	12.7	13.9	14.8	20.0	20.8	21.7	26.0	26.1	25.6	21.9	19.3	14.8	19.8
max obs hourly avg	24.3	27.2	28.7	41.1	33.5	34.7	33.2	32.6	33.4	35.9	30.7	26.9	41.1
min obs hourly avg	3.3	5.7	5.9	8.2	9.5	10.8	17.8	18.7	16.4	12.1	9.0	4.9	3.3
DEGREE DAYS													
HDD [18.3 DegC base]	175	124	115	19	6	0	0	0	0	0	8	108	555
CDD [18.3 DegC base]	0	0	5	70	83	103	239	242	220	110	38	0	1112
HUMIDITY													
mean 5am DBT [DegC]	8.8	9.5	10.5	14.3	15.5	16.2	27.7	21.5	20.6	16.4	14.5	11.3	15.6
mean 5am WBT [DegC]	8.1	8.6	9.1	12.2	14.7	14.3	22.3	19.9	18.8	14.7	12.8	10.3	13.8
mean 5am RH [%]	92	90	86	81	92	83	63	86	84	85	84	89	85
mean 2pm DBT [DegC]	17.5	18.5	19.0	25.8	25.1	26.5	28.1	29.8	30.1	27.0	24.6	19.6	24.3
mean 2pm WBT [DegC]	13.0	13.6	13.5	17.3	19.1	18.7	23.0	22.8	22.7	19.7	17.9	14.7	18.0
mean 2pm RH [%]	62	59	56	46	57	49	65	55	53	52	54	60	56
WIND													
mean speed [m/s]	2.4	2.7	3.6	2.4	2.2	2.4	2.9	2.8	2.3	2.1	2.6	3.0	2.6
max hourly speed [m/s]	9.0	9.0	12.0	13.0	6.0	8.0	7.0	7.0	7.0	6.0	9.0	11.0	13.0
prevailing direction	E	SE	SE	NW	NW	W	W	W	NW	E	E	SE	
prevailing occurence [%]	23	21	22	18	27	20	27	28	18	27	23	23	
SOLAR ENERGY [kWh/sq.m]													
horizontal global total	80	99	130	188	224	229	227	201	173	137	94	80	1862
max obs daily total	3.83	4.85	6.03	7.38	7.82	8.61	8.09	7.03	6.67	5.62	4.04	3.20	8.61
max obs hourly avg	0.62	0.72	0.85	0.99	1.00	1.04	0.99	0.93	0.90	0.80	0.66	0.53	1.04
direct beam total	98	118	128	162	220	235	230	219	194	178	135	121	2038
max obs daily total	7.50	8.60	8.64	10.06	9.52	10.07	10.16	8.47	8.48	8.79	7.26	6.88	10.16
max obs hourly avg	0.93	0.96	0.95	0.99	0.94	0.97	0.93	0.90	0.93	0.95	0.90	0.91	0.99
SUMMARY OF INCLUDED DATA													
% of temperature data	100	100	100	100	100	100	100	100	100	100	100	100	
% of humidity ratio data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind speed data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind direction data	100	100	100	100	100	100	100	100	100	100	100	100	
# of days of beam data	31	28	31	30	31	30	31	31	30	31	30	31	
# of days of global data	31	28	31	30	31	30	31	31	30	31	30	31	

SITE: JERUSALEM
YEAR: TPVY
LATITUDE 31.8 N
LONGITUDE 35.2 E

SOLAR RADIATION ON VARIOUS TRACKING AND STATIONARY PLANE SURFACES
(ASSUMES: ISOTROPIC SKY MODEL, GROUND ALBEDO = 0.30)
[KWH/SQ.M/DAY]

MONTH	FULL TRACKING [2 - AXES]			POLAR MOUNT [1 - AXIS]			N-S AXIS [1 - AXIS]			E-W AXIS [1 - AXIS]			TILT=LATITUDE NON-TRACKING			HORIZONTAL NON-TRACKING		
	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL
1/TPVY	2.99	0.76	3.94	2.80	0.87	3.77	2.06	0.87	3.02	2.60	0.79	3.56	2.36	0.95	3.37	1.45	1.03	2.48
2/TPVY	4.13	1.04	5.40	4.02	1.14	5.31	3.24	1.16	4.53	3.36	1.11	4.66	3.21	1.25	4.54	2.23	1.35	3.58
3/TPVY	3.84	1.67	5.73	3.83	1.69	5.72	3.39	1.77	5.31	2.96	1.84	4.92	2.94	1.86	4.91	2.40	2.02	4.42
4/TPVY	5.74	1.97	7.95	5.66	1.88	7.85	5.50	2.01	7.70	4.39	2.22	6.67	4.26	2.12	6.53	4.10	2.30	6.40
5/TPVY	7.60	1.51	9.35	7.20	1.39	8.98	7.50	1.52	9.24	5.66	1.70	7.40	4.95	1.62	6.73	5.48	1.75	7.23
6/TPVY	9.19	0.95	10.39	8.46	0.87	9.74	9.09	0.96	10.28	6.91	1.07	8.01	5.63	1.02	6.83	6.67	1.10	7.78
7/TPVY	8.60	1.19	10.03	8.02	1.09	9.51	8.50	1.20	9.93	6.45	1.34	7.82	5.43	1.27	6.88	6.24	1.38	7.62
8/TPVY	8.22	0.96	9.43	7.98	0.91	9.24	8.01	0.98	9.20	6.14	1.11	7.30	5.72	1.06	6.94	5.88	1.15	7.02
9/TPVY	7.17	1.00	8.44	7.16	0.99	8.43	6.60	1.04	7.83	5.43	1.14	6.68	5.40	1.13	6.66	4.73	1.22	5.94
10/TPVY	5.30	1.00	6.56	5.22	1.06	6.47	4.35	1.09	5.58	4.29	1.08	5.56	4.18	1.18	5.46	3.08	1.27	4.35
11/TPVY	4.62	0.77	5.63	4.37	0.88	5.38	3.33	0.89	4.33	3.89	0.81	4.91	3.57	0.96	4.61	2.24	1.04	3.28
12/TPVY	3.71	0.58	4.49	3.41	0.69	4.20	2.44	0.68	3.22	3.26	0.60	4.04	2.90	0.75	3.70	1.70	0.81	2.51

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

2166	408	2658	2074	409	2575	1950	431	2442	1685	451	2177	1539	461	2043	1408	499	1907

MONTH	AVG. INPUT DATA			COMPONENTS ON A S-FACING SURFACE			TOTAL RADIATION ON VERTICAL SURFACES				TOTAL RADIATION ON 60 DEG INCLINED PLANES				TOTAL RADIATION ON 30 DEG INCLINED PLANES			
	BEAM	GLOB	KT	BEAM	DIFF	REFL	S	W	N	E	S	W	N	E	S	W	N	E
1/TPVY	2.99	2.48	0.44	2.15	0.52	0.37	3.04	1.35	0.89	1.67	3.54	1.75	0.96	2.14	3.34	2.17	1.23	2.44
2/TPVY	4.13	3.58	0.51	2.50	0.67	0.54	3.71	2.11	1.21	2.32	4.56	2.71	1.28	2.95	4.51	3.25	2.02	3.42
3/TPVY	3.84	4.42	0.51	1.71	1.01	0.66	3.38	2.54	1.67	2.81	4.52	3.31	1.86	3.63	4.90	4.00	3.20	4.23
4/TPVY	5.74	6.40	0.63	1.48	1.15	0.96	3.59	3.48	2.12	3.78	5.52	4.67	2.99	4.99	6.56	5.78	5.09	6.02
5/TPVY	7.60	7.23	0.65	0.83	0.87	1.08	2.79	3.98	2.24	4.17	5.13	5.32	4.12	5.57	6.80	6.57	6.25	6.74
6/TPVY	9.19	7.78	0.68	0.53	0.55	1.17	2.24	4.21	2.35	4.34	4.79	5.69	4.83	5.84	6.92	7.07	7.01	7.16
7/TPVY	8.60	7.62	0.67	0.68	0.69	1.14	2.51	4.31	2.29	4.15	5.01	5.79	4.54	5.57	6.96	7.08	6.74	6.89
8/TPVY	8.22	7.02	0.67	1.49	0.57	1.05	3.12	3.86	1.75	3.93	5.54	5.21	3.14	5.25	6.99	6.41	5.62	6.44
9/TPVY	7.17	5.94	0.65	2.63	0.61	0.89	4.13	3.33	1.50	3.51	6.00	4.44	1.59	4.61	6.66	5.42	4.04	5.53
10/TPVY	5.30	4.35	0.58	2.96	0.64	0.65	4.25	2.25	1.29	2.89	5.39	3.00	1.28	3.74	5.42	3.77	2.47	4.30
11/TPVY	4.62	3.28	0.55	3.16	0.52	0.49	4.17	1.88	1.01	2.22	4.88	2.44	1.03	2.82	4.56	2.93	1.45	3.20
12/TPVY	3.71	2.51	0.48	2.77	0.40	0.38	3.55	1.36	0.78	1.68	4.04	1.79	0.79	2.15	3.66	2.20	0.96	2.45

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

2166	1907		694	249	286	1229	1055	582	1140	1792	1404	866	1500	2048	1726	1405	1791

NUMBER OF MISSING DAYS

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	0	0	0	0	0	0	0	0	0

CLIMATOLOGICAL DATA FOR JERUSALEM TPVY

Latitude = 31.8 N   Longitude = 35.2 E   Elevation = 760m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
TEMPERATURE [DegC]													
mean	10.4	9.3	11.4	18.8	20.5	21.7	23.1	23.4	22.8	22.6	15.4	8.3	17.3
max obs hourly avg	18.7	19.3	21.8	34.2	36.4	32.5	31.4	34.0	34.5	31.8	23.2	18.4	36.4
min obs hourly avg	4.4	4.1	4.6	6.2	10.5	13.5	16.6	17.7	16.1	15.4	9.8	0.9	0.9
DEGREE DAYS													
HDD [18.3 DegC base]	246	253	215	67	37	4	0	0	0	2	89	309	1221
CDD [18.3 DegC base]	0	0	0	82	107	105	148	157	136	136	1	0	871
HUMIDITY													
mean 5am DBT [DegC]	8.8	7.5	9.3	16.2	17.8	17.7	20.0	19.9	19.4	20.7	13.2	6.9	14.8
mean 5am WBT [DegC]	6.9	6.3	7.1	11.6	12.1	13.5	13.6	17.3	15.8	15.8	10.8	5.6	11.4
mean 5am RH [%]	78	85	77	62	58	66	50	80	72	64	76	83	71
mean 2pm DBT [DegC]	12.3	11.6	14.2	22.6	24.5	26.6	26.8	28.4	27.8	25.9	18.4	10.2	20.8
mean 2pm WBT [DegC]	9.3	8.9	10.3	16.8	16.6	17.9	18.6	19.4	18.7	17.4	12.8	7.9	14.6
mean 2pm RH [%]	71	74	66	60	51	45	47	45	44	46	55	76	57
WIND													
mean speed [m/s]	3.6	3.7	2.9	3.2	2.8	3.3	4.3	3.6	2.8	2.4	2.3	3.1	3.2
max hourly speed [m/s]	11.0	9.0	11.0	9.0	9.0	10.0	9.0	8.0	8.0	7.0	7.0	10.0	11.0
prevailing direction	E	W	NW	NW	NW	NW	W	NW	NW	NW	E	E	
prevailing occurence [%]	35	42	42	35	62	73	51	67	57	36	35	36	
SOLAR ENERGY [kWh/sq.m]													
horizontal global total	77	100	137	192	224	233	236	218	178	135	99	78	1907
max obs daily total	3.94	5.32	6.17	7.16	8.12	8.21	8.14	7.79	6.55	5.50	4.18	3.57	8.21
max obs hourly avg	0.67	0.85	0.92	1.04	1.00	0.99	1.02	0.98	0.91	0.80	0.68	0.61	1.04
direct beam total	93	116	119	172	236	276	267	255	215	164	139	115	2166
max obs daily total	7.24	9.06	8.65	9.72	10.84	10.97	10.43	10.51	9.15	7.45	7.94	7.59	10.97
max obs hourly avg	1.01	1.04	1.01	0.99	0.99	0.99	0.95	0.96	0.96	0.91	0.96	1.02	1.04
SUMMARY OF INCLUDED DATA													
% of temperature data	100	100	100	100	100	100	100	100	100	100	100	100	
% of humidity ratio data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind speed data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind direction data	100	100	100	100	100	100	100	100	100	100	100	100	
# of days of beam data	31	28	31	30	31	30	31	31	30	31	30	31	
# of days of global data	31	28	31	30	31	30	31	31	30	31	30	31	

SITE: HAIFA
YEAR: TPVY
LATITUDE 32.8 N
LONGITUDE 35.0 E

SOLAR RADIATION ON VARIOUS TRACKING AND STATIONARY PLANE SURFACES
(ASSUMES: ISOTROPIC SKY MODEL, GROUND ALBEDO = 0.30)
[KWH/SQ.M/DAY]

MONTH	FULL TRACKING [2 - AXES]			POLAR MOUNT [1 - AXIS]			N-S AXIS [1 - AXIS]			E-W AXIS [1 - AXIS]			TILT=LATITUDE NON-TRACKING			HORIZONTAL NON-TRACKING		
	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL
1/TPVY	2.77	0.76	3.71	2.60	0.88	3.57	1.90	0.89	2.88	2.38	0.79	3.33	2.16	0.95	3.17	1.29	1.03	2.32
2/TPVY	3.83	0.93	4.98	3.74	1.02	4.90	3.00	1.04	4.16	3.13	0.99	4.29	3.00	1.11	4.20	2.07	1.21	3.28
3/TPVY	3.88	1.59	5.69	3.87	1.61	5.68	3.41	1.69	5.25	3.03	1.75	4.90	3.01	1.78	4.90	2.44	1.93	4.38
4/TPVY	5.12	2.00	7.34	5.05	1.91	7.25	4.87	2.05	7.11	3.85	2.25	6.16	3.74	2.15	6.03	3.56	2.33	5.89
5/TPVY	7.02	1.76	9.01	6.62	1.62	8.62	6.91	1.77	8.90	5.27	1.98	7.29	4.59	1.87	6.63	5.09	2.03	7.13
6/TPVY	8.42	1.21	9.86	7.75	1.09	9.25	8.32	1.21	9.75	6.43	1.36	7.82	5.27	1.29	6.74	6.20	1.40	7.60
7/TPVY	7.70	1.58	9.51	7.17	1.44	9.01	7.59	1.59	9.40	5.83	1.76	7.63	4.92	1.67	6.77	5.63	1.81	7.44
8/TPVY	7.42	1.17	8.83	7.22	1.09	8.66	7.19	1.19	8.59	5.60	1.34	7.00	5.26	1.27	6.69	5.33	1.38	6.71
9/TPVY	6.29	1.26	7.80	6.27	1.24	7.78	5.74	1.31	7.24	4.74	1.42	6.27	4.71	1.40	6.25	4.08	1.52	5.60
10/TPVY	5.10	0.89	6.22	5.03	0.95	6.16	4.21	0.98	5.33	4.01	0.96	5.14	3.92	1.04	5.06	2.87	1.14	4.01
11/TPVY	4.10	0.69	5.01	3.89	0.79	4.80	2.92	0.80	3.83	3.48	0.72	4.40	3.22	0.86	4.15	2.00	0.94	2.94
12/TPVY	3.33	0.61	4.13	3.06	0.72	3.88	2.16	0.72	2.97	2.93	0.63	3.74	2.62	0.78	3.45	1.49	0.85	2.34

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

1979	440	2500	1896	437	2423	1774	464	2297	1543	486	2070	1413	493	1949	1282	535	1817

MONTH	AVG. INPUT DATA			COMPONENTS ON A S-FACING SURFACE			TOTAL RADIATION ON VERTICAL SURFACES				TOTAL RADIATION ON 60 DEG INCLINED PLANES				TOTAL RADIATION ON 30 DEG INCLINED PLANES			
	BEAM	GLOB	KT	BEAM	DIFF	REFL	S	W	N	E	S	W	N	E	S	W	N	E
1/TPVY	2.77	2.32	0.42	1.99	0.52	0.35	2.86	1.34	0.86	1.59	3.32	1.72	0.95	2.01	3.12	2.07	1.17	2.28
2/TPVY	3.83	3.28	0.48	2.33	0.61	0.49	3.43	2.11	1.10	1.93	4.21	2.70	1.15	2.49	4.15	3.14	1.83	2.98
3/TPVY	3.88	4.38	0.51	1.76	0.97	0.66	3.39	2.57	1.62	2.67	4.53	3.37	1.79	3.45	4.89	4.04	3.13	4.11
4/TPVY	5.12	5.89	0.58	1.39	1.17	0.88	3.44	3.35	2.07	3.50	5.17	4.43	2.79	4.62	6.07	5.40	4.69	5.54
5/TPVY	7.02	7.13	0.64	0.82	1.02	1.07	2.91	4.00	2.35	4.01	5.15	5.34	4.13	5.38	6.73	6.56	6.17	6.58
6/TPVY	8.42	7.60	0.66	0.59	0.70	1.14	2.43	4.25	2.36	4.00	4.91	5.76	4.66	5.44	6.88	7.09	6.80	6.84
7/TPVY	7.70	7.44	0.66	0.70	0.91	1.12	2.72	4.08	2.41	4.19	5.10	5.49	4.46	5.62	6.89	6.79	6.56	6.88
8/TPVY	7.42	6.71	0.64	1.52	0.69	1.01	3.22	3.74	1.79	3.67	5.47	5.04	2.97	4.94	6.76	6.19	5.33	6.12
9/TPVY	6.29	5.60	0.62	2.37	0.76	0.84	3.97	3.28	1.61	3.27	5.65	4.33	1.72	4.31	6.25	5.20	3.88	5.18
10/TPVY	5.10	4.01	0.54	2.77	0.57	0.60	3.94	2.45	1.17	2.46	4.99	3.19	1.15	3.17	5.01	3.75	2.25	3.73
11/TPVY	4.10	2.94	0.51	2.84	0.47	0.44	3.75	1.75	0.91	1.86	4.38	2.27	0.92	2.39	4.09	2.69	1.29	2.77
12/TPVY	3.33	2.34	0.46	2.52	0.42	0.35	3.29	1.36	0.78	1.51	3.74	1.76	0.81	1.94	3.39	2.11	0.94	2.24

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

1979	1817		656	268	273	1196	1044	580	1056	1722	1383	839	1394	1956	1676	1343	1684

NUMBER OF MISSING DAYS

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	0	0	0	0	0	0	0	0	0

CLIMATOLOGICAL DATA FOR HAIFA TPVY

Latitude = 32.8 N   Longitude = 35.0 E   Elevation = 275m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
TEMPERATURE [DegC]													
mean	12.0	12.6	13.5	19.8	21.0	23.0	24.4	26.7	24.0	21.1	19.1	15.4	19.4
max obs hourly avg	18.7	19.6	22.5	37.8	32.4	31.1	30.0	34.4	30.0	32.0	26.4	22.0	37.8
min obs hourly avg	6.4	5.3	8.0	9.5	12.6	17.9	20.9	21.6	19.4	12.7	14.2	10.7	5.3
DEGREE DAYS													
HDD [18.3 DegC base]	196	160	149	36	11	0	0	0	0	9	5	91	655
CDD [18.3 DegC base]	0	0	0	81	94	140	189	259	171	95	28	1	1058
HUMIDITY													
mean 5am DBT [DegC]	10.6	11.4	11.9	17.4	18.4	20.7	22.3	24.2	22.0	19.3	17.3	14.2	17.5
mean 5am WBT [DegC]	8.9	8.7	10.8	13.8	15.7	18.9	21.1	23.2	20.1	16.2	13.2	11.4	15.1
mean 5am RH [%]	81	72	88	71	78	85	90	91	86	75	65	73	79
mean 2pm DBT [DegC]	13.8	14.9	15.8	22.5	23.8	25.4	26.8	29.2	26.4	23.9	21.9	17.7	21.8
mean 2pm WBT [DegC]	10.8	10.7	13.1	17.3	18.7	20.5	22.5	24.1	21.6	17.5	16.2	13.6	17.2
mean 2pm RH [%]	71	61	75	63	64	65	70	66	66	55	57	65	65
WIND													
mean speed [m/s]	2.1	2.1	2.1	2.3	2.4	2.7	4.0	2.4	2.2	2.1	2.1	2.1	2.4
max hourly speed [m/s]	5.0	6.0	7.0	8.0	6.0	7.0	9.0	6.0	6.0	5.0	7.0	6.0	9.0
prevailing direction	SE	W	W	W	W	W	W	W	W	W	E	SW	
prevailing occurence [%]	20	28	39	33	42	48	58	53	41	31	25	30	
SOLAR ENERGY [kWh/sq.m]													
horizontal global total	72	92	136	177	221	228	231	208	168	124	88	73	1817
max obs daily total	3.72	4.86	6.15	7.25	8.21	8.18	8.22	7.26	6.84	5.38	3.86	3.15	8.22
max obs hourly avg	0.61	0.73	0.88	0.99	1.01	1.00	1.00	0.94	0.92	0.79	0.64	0.54	1.01
direct beam total	86	107	120	154	217	253	239	230	189	158	123	103	1979
max obs daily total	6.79	8.37	7.84	9.43	10.06	10.71	10.39	9.10	9.16	8.43	6.97	6.35	10.71
max obs hourly avg	0.92	0.95	0.92	0.94	0.95	0.96	0.93	0.90	0.92	0.92	0.91	0.94	0.96
SUMMARY OF INCLUDED DATA													
% of temperature data	100	100	100	100	100	100	100	100	100	100	100	100	
% of humidity ratio data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind speed data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind direction data	100	100	100	100	100	100	100	100	100	100	100	100	
# of days of beam data	31	28	31	30	31	30	31	31	30	31	30	31	
# of days of global data	31	28	31	30	31	30	31	31	30	31	30	31	

SITE: ELAT
YEAR: TPVY
LATITUDE 29.5 N
LONGITUDE 34.9 E

SOLAR RADIATION ON VARIOUS TRACKING AND STATIONARY PLANE SURFACES
(ASSUMES: ISOTROPIC SKY MODEL, GROUND ALBEDO = 0.30)
[KWH/SQ.M/DAY]

MONTH	FULL TRACKING [2 - AXES]			POLAR MOUNT [1 - AXIS]			N-S AXIS [1 - AXIS]			E-W AXIS [1 - AXIS]			TILT=LATITUDE NON-TRACKING			HORIZONTAL NON-TRACKING		
	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL
1/TPVY	4.80	0.63	5.66	4.48	0.73	5.33	3.46	0.73	4.30	4.04	0.66	4.90	3.65	0.79	4.50	2.34	0.84	3.18
2/TPVY	5.26	0.99	6.50	5.12	1.08	6.37	4.27	1.09	5.51	4.23	1.06	5.48	4.05	1.18	5.31	2.96	1.27	4.22
3/TPVY	5.98	1.21	7.44	5.97	1.23	7.43	5.40	1.27	6.85	4.59	1.34	6.06	4.57	1.37	6.05	3.87	1.47	5.34
4/TPVY	6.79	1.21	8.22	6.69	1.16	8.14	6.56	1.23	7.98	5.14	1.38	6.57	4.97	1.33	6.43	4.87	1.42	6.29
5/TPVY	6.60	1.68	8.50	6.25	1.56	8.15	6.54	1.69	8.43	5.15	1.89	7.07	4.62	1.81	6.56	5.05	1.94	6.99
6/TPVY	8.31	1.39	9.93	7.65	1.27	9.32	8.24	1.39	9.86	6.48	1.56	8.07	5.45	1.50	7.11	6.34	1.61	7.95
7/TPVY	8.43	0.86	9.51	7.86	0.79	9.02	8.36	0.87	9.43	6.51	0.98	7.51	5.61	0.95	6.70	6.37	1.01	7.38
8/TPVY	8.09	0.88	9.20	7.87	0.83	9.02	7.92	0.88	9.01	6.11	1.01	7.15	5.74	0.97	6.85	5.90	1.03	6.93
9/TPVY	6.96	0.95	8.16	6.95	0.94	8.15	6.49	0.99	7.66	5.29	1.08	6.47	5.26	1.08	6.46	4.72	1.15	5.88
10/TPVY	5.72	1.04	7.02	5.63	1.10	6.93	4.79	1.12	6.08	4.61	1.14	5.93	4.49	1.23	5.81	3.45	1.31	4.76
11/TPVY	5.10	0.63	5.97	4.83	0.71	5.68	3.81	0.72	4.65	4.26	0.67	5.12	3.91	0.78	4.76	2.60	0.84	3.44
12/TPVY	5.24	0.55	6.03	4.82	0.65	5.58	3.63	0.64	4.38	4.48	0.58	5.27	3.96	0.71	4.73	2.43	0.76	3.19
TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]																		
	2353	366	2804	2256	366	2712	2116	384	2562	1854	405	2301	1713	416	2169	1550	445	1995

MONTH	AVG. INPUT DATA			COMPONENTS ON A S-FACING SURFACE			TOTAL RADIATION ON VERTICAL SURFACES				TOTAL RADIATION ON 60 DEG INCLINED PLANES				TOTAL RADIATION ON 30 DEG INCLINED PLANES			
	BEAM	GLOB	KT	BEAM	DIFF	REFL	S	W	N	E	S	W	N	E	S	W	N	E
1/TPVY	4.80	3.18	0.52	3.27	0.42	0.48	4.17	1.97	0.90	2.01	4.87	2.51	0.87	2.55	4.51	2.96	1.30	2.98
2/TPVY	5.26	4.22	0.58	2.99	0.63	0.63	4.26	2.49	1.27	2.64	5.34	3.23	1.27	3.39	5.32	3.86	2.34	3.99
3/TPVY	5.98	5.34	0.60	2.44	0.73	0.80	3.97	3.05	1.54	3.17	5.55	4.05	1.58	4.14	6.05	4.90	3.62	4.97
4/TPVY	6.79	6.29	0.61	1.53	0.71	0.94	3.19	3.37	1.69	3.57	5.28	4.61	2.67	4.75	6.42	5.71	4.92	5.83
5/TPVY	6.60	6.99	0.63	0.63	0.97	1.05	2.65	3.69	2.20	3.77	4.91	5.09	4.12	5.11	6.55	6.38	6.10	6.40
6/TPVY	8.31	7.95	0.69	0.35	0.80	1.19	2.35	3.96	2.49	4.41	4.91	5.51	5.10	5.99	7.09	7.07	7.22	7.41
7/TPVY	8.43	7.38	0.65	0.52	0.51	1.11	2.13	3.66	2.01	4.07	4.66	5.11	4.39	5.52	6.68	6.55	6.54	6.84
8/TPVY	8.09	6.93	0.65	1.33	0.52	1.04	2.89	3.61	1.66	3.91	5.33	4.95	3.18	5.24	6.83	6.22	5.60	6.43
9/TPVY	6.96	5.88	0.63	2.34	0.58	0.88	3.80	3.20	1.46	3.42	5.70	4.31	1.69	4.52	6.46	5.32	4.11	5.47
10/TPVY	5.72	4.76	0.61	3.03	0.66	0.71	4.40	2.74	1.37	2.77	5.69	3.64	1.34	3.66	5.82	4.39	2.79	4.40
11/TPVY	5.10	3.44	0.54	3.34	0.42	0.52	4.27	2.02	0.93	2.17	5.08	2.65	0.89	2.79	4.77	3.15	1.48	3.24
12/TPVY	5.24	3.19	0.56	3.73	0.38	0.48	4.59	1.95	0.86	2.04	5.25	2.51	0.81	2.59	4.74	2.94	1.10	2.99
TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]																		
	2353	1995		775	223	299	1297	1087	559	1155	1903	1466	850	1530	2168	1810	1436	1855

NUMBER OF MISSING DAYS

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	0	0	0	0	0	0	0	0	0

CLIMATOLOGICAL DATA FOR EILAT TPVY

Latitude = 29.5N   Longitude = 34.9E   Elevation = 275m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
TEMPERATURE [DegC]													
mean	16.9	18.9	18.6	22.9	27.7	32.2	32.0	32.7	30.9	27.9	23.2	15.9	25.0
max obs hourly avg	23.3	27.1	26.2	34.6	38.2	44.3	40.6	42.3	41.7	39.3	30.6	25.3	44.3
min obs hourly avg	7.4	11.5	11.2	11.7	17.4	22.4	24.6	25.9	22.3	18.3	17.4	9.6	7.4
DEGREE DAYS													
HDD [18.3 DegC base]	48	13	15	4	0	0	0	0	0	0	0	76	155
CDD [18.3 DegC base]	4	30	24	143	290	418	424	447	378	299	146	2	2605
HUMIDITY													
mean 5am DBT [DegC]	14.2	15.9	15.1	18.9	23.0	26.6	27.5	27.5	26.3	24.4	20.6	13.3	21.1
mean 5am WBT [DegC]	10.0	11.3	10.1	13.0	16.5	19.2	19.7	20.3	19.8	17.9	14.9	9.2	15.2
mean 5am RH [%]	59	58	53	51	53	50	49	52	55	55	55	59	54
mean 2pm DBT [DegC]	19.9	22.0	21.9	26.3	30.9	36.1	35.2	35.6	34.7	31.4	26.3	19.4	28.3
mean 2pm WBT [DegC]	13.1	13.7	13.3	16.4	19.5	21.8	22.2	22.8	22.0	21.0	18.1	12.6	18.0
mean 2pm RH [%]	46	39	37	36	35	28	32	33	33	39	45	45	37
WIND													
mean speed [m/s]	3.0	4.0	3.2	4.2	4.5	4.6	3.0	4.2	4.8	4.1	3.8	3.4	3.9
max hourly speed [m/s]	8.0	12.0	9.0	9.0	10.0	9.0	7.0	9.0	9.0	8.0	9.0	9.0	12.0
prevailing direction	N	N	N	N	N	N	N	N	N	N	N	N	
prevailing occurence [%]	51	40	42	43	39	45	39	51	46	63	55	55	
SOLAR ENERGY [kWh/sq.m]													
horizontal global total	99	118	166	189	217	238	229	215	176	148	103	99	1995
max obs daily total	3.93	5.24	6.46	7.25	7.96	8.53	7.80	7.23	6.48	5.45	4.38	3.72	8.53
max obs hourly avg	0.68	0.78	0.92	0.97	1.01	1.06	0.99	0.95	0.89	0.80	0.68	0.63	1.06
direct beam total	149	147	185	204	205	249	261	251	209	177	153	162	2353
max obs daily total	7.38	8.79	8.98	9.40	9.33	9.95	9.56	9.07	8.22	7.48	7.62	7.61	9.95
max obs hourly avg	0.96	1.00	0.98	0.97	0.98	0.98	0.94	0.94	0.90	0.86	0.91	0.96	1.00
SUMMARY OF INCLUDED DATA													
% of temperature data	100	100	100	100	100	100	100	100	100	100	100	100	
% of humidity ratio data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind speed data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind direction data	100	100	100	100	100	100	100	100	100	100	100	100	
# of days of beam data	31	28	31	30	31	30	31	31	30	31	30	31	
# of days of global data	31	28	31	30	31	30	31	31	30	31	30	31	

SITE: BEERSHEBA
YEAR: TPVY
LATITUDE 31.2 N
LONGITUDE 34.8 E

SOLAR RADIATION ON VARIOUS TRACKING AND STATIONARY PLANE SURFACES
(ASSUMES: ISOTROPIC SKY MODEL, GROUND ALBEDO = 0.30)
[KWH/SQ.M/DAY]

MONTH	FULL TRACKING [2 - AXES]			POLAR MOUNT [1 - AXIS]			N-S AXIS [1 - AXIS]			E-W AXIS [1 - AXIS]			TILT=LATITUDE NON-TRACKING			HORIZONTAL NON-TRACKING		
	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL	BEAM	DIFF	TOTAL
1/TPVY	3.67	0.93	4.82	3.43	1.07	4.62	2.58	1.08	3.77	3.11	0.97	4.27	2.80	1.16	4.03	1.72	1.26	2.97
2/TPVY	4.46	1.09	5.78	4.34	1.18	5.69	3.56	1.21	4.90	3.59	1.16	4.94	3.44	1.30	4.82	2.44	1.40	3.84
3/TPVY	4.41	1.62	6.27	4.40	1.64	6.26	3.92	1.71	5.79	3.37	1.79	5.29	3.35	1.82	5.27	2.75	1.96	4.71
4/TPVY	5.41	2.26	7.91	5.33	2.16	7.81	5.18	2.31	7.70	4.12	2.56	6.74	4.00	2.45	6.59	3.86	2.64	6.50
5/TPVY	6.96	2.02	9.22	6.58	1.87	8.84	6.88	2.03	9.13	5.33	2.27	7.63	4.71	2.16	7.03	5.19	2.33	7.51
6/TPVY	8.19	1.58	10.01	7.54	1.43	9.39	8.11	1.58	9.92	6.28	1.76	8.07	5.20	1.68	7.05	6.09	1.81	7.91
7/TPVY	7.70	1.73	9.66	7.18	1.58	9.16	7.62	1.73	9.58	5.87	1.93	7.84	5.00	1.84	7.01	5.70	1.99	7.69
8/TPVY	7.41	1.47	9.12	7.20	1.39	8.94	7.22	1.49	8.92	5.55	1.68	7.28	5.20	1.60	6.95	5.32	1.72	7.04
9/TPVY	6.52	1.46	8.25	6.51	1.44	8.23	6.03	1.52	7.74	4.85	1.64	6.61	4.82	1.63	6.58	4.25	1.75	6.00
10/TPVY	5.91	1.02	7.20	5.83	1.08	7.12	4.95	1.11	6.22	4.61	1.11	5.90	4.48	1.20	5.78	3.35	1.29	4.64
11/TPVY	4.90	0.79	5.93	4.65	0.89	5.68	3.58	0.90	4.61	4.11	0.83	5.14	3.78	0.98	4.83	2.43	1.06	3.48
12/TPVY	4.24	0.66	5.13	3.90	0.78	4.80	2.86	0.78	3.74	3.65	0.69	4.54	3.23	0.85	4.15	1.90	0.92	2.82

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

2125	506	2719	2037	503	2634	1903	531	2498	1658	560	2261	1522	568	2134	1371	612	1983

MONTH	AVG. INPUT DATA			COMPONENTS ON A S-FACING SURFACE			TOTAL RADIATION ON VERTICAL SURFACES				TOTAL RADIATION ON 60 DEG INCLINED PLANES				TOTAL RADIATION ON 30 DEG INCLINED PLANES			
	BEAM	GLOB	KT	BEAM	DIFF	REFL	S	W	N	E	S	W	N	E	S	W	N	E
1/TPVY	3.67	2.97	0.51	2.57	0.63	0.45	3.64	1.82	1.07	1.97	4.25	2.30	1.16	2.50	4.00	2.73	1.49	2.86
2/TPVY	4.46	3.84	0.54	2.61	0.70	0.58	3.89	2.31	1.27	2.41	4.82	2.97	1.34	3.10	4.80	3.54	2.20	3.63
3/TPVY	4.41	4.71	0.54	1.93	0.98	0.71	3.62	2.75	1.69	2.96	4.87	3.58	1.84	3.82	5.27	4.30	3.34	4.49
4/TPVY	5.41	6.50	0.64	1.37	1.32	0.98	3.67	3.64	2.32	3.81	5.57	4.86	3.23	5.05	6.61	5.95	5.27	6.09
5/TPVY	6.96	7.51	0.67	0.74	1.16	1.13	3.03	4.23	2.52	4.07	5.39	5.69	4.46	5.51	7.08	6.98	6.56	6.84
6/TPVY	8.19	7.91	0.69	0.45	0.91	1.19	2.55	4.40	2.60	4.21	5.06	5.92	5.05	5.75	7.11	7.32	7.15	7.16
7/TPVY	7.70	7.69	0.68	0.59	0.99	1.15	2.74	4.47	2.52	4.01	5.19	5.98	4.73	5.45	7.07	7.26	6.84	6.85
8/TPVY	7.41	7.04	0.67	1.37	0.86	1.06	3.28	4.14	2.02	3.73	5.60	5.50	3.39	5.06	6.99	6.65	5.72	6.31
9/TPVY	6.52	6.00	0.65	2.30	0.88	0.90	4.08	3.67	1.78	3.43	5.88	4.79	2.00	4.51	6.58	5.67	4.28	5.46
10/TPVY	5.91	4.64	0.61	3.13	0.65	0.70	4.47	2.81	1.34	2.91	5.70	3.63	1.32	3.76	5.76	4.29	2.64	4.38
11/TPVY	4.90	3.48	0.58	3.29	0.53	0.52	4.34	2.15	1.05	2.15	5.11	2.78	1.05	2.77	4.80	3.26	1.57	3.25
12/TPVY	4.24	2.82	0.53	3.10	0.46	0.42	3.98	1.70	0.88	1.85	4.53	2.19	0.90	2.36	4.11	2.59	1.11	2.70

TOTAL RADIATION FOR THE YEAR TPVY [KWH/SQ.M/YEAR]

2125	1983		712	306	297	1315	1160	642	1142	1885	1529	929	1511	2136	1844	1469	1828

NUMBER OF MISSING DAYS

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	0	0	0	0	0	0	0	0	0

CLIMATOLOGICAL DATA FOR BEERSHEBA TPVY

Latitude = 31.2 N   Longitude = 34.8 E   Elevation = 280m

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
TEMPERATURE [DegC]													
mean	12.2	12.8	14.0	21.2	22.4	25.0	25.6	26.4	25.1	21.1	19.2	14.5	20.0
max obs hourly avg	24.6	22.8	28.3	39.9	38.9	40.7	36.7	36.7	38.9	34.8	30.6	30.0	40.7
min obs hourly avg	4.0	6.2	5.7	7.5	11.1	14.2	17.8	17.7	15.6	10.8	9.3	5.2	4.0
DEGREE DAYS													
HDD [18.3 DegC base]	190	155	137	19	2	0	0	0	0	8	9	126	647
CDD [18.3 DegC base]	0	0	3	106	131	201	228	252	205	95	36	8	1266
HUMIDITY													
mean 5am DBT [DegC]	8.6	9.5	9.9	15.6	16.5	19.2	20.3	21.2	19.7	16.2	14.6	10.2	15.1
mean 5am WBT [DegC]	7.5	7.6	8.4	11.8	14.2	17.5	18.5	19.9	18.0	14.0	13.0	8.3	13.2
mean 5am RH [%]	86	79	84	68	81	86	85	89	84	80	85	79	82
mean 2pm DBT [DegC]	17.2	17.8	18.8	28.5	30.1	31.7	32.2	33.3	32.2	27.1	25.6	20.1	26.2
mean 2pm WBT [DegC]	11.7	12.8	13.1	17.3	21.0	22.2	21.5	22.8	22.6	18.8	17.5	13.0	17.9
mean 2pm RH [%]	54	58	55	34	47	45	39	41	44	47	45	45	46
WIND													
mean speed [m/s]	2.5	2.4	3.1	2.8	2.7	2.6	2.7	2.6	2.5	2.6	2.1	2.3	2.6
max hourly speed [m/s]	7.0	8.0	8.0	7.0	8.0	7.0	7.0	7.0	8.0	6.0	6.0	6.0	8.0
prevailing direction	E	E	E	NW	NW	NW	NW	NW	NW	E	E	E	
prevailing occurence [%]	39	19	29	24	40	39	36	46	43	29	35	42	
SOLAR ENERGY [kWh/sq.m]													
horizontal global total	92	107	146	195	233	237	238	218	180	144	104	87	1983
max obs daily total	4.08	5.40	6.52	7.62	8.22	8.32	8.31	7.45	7.04	5.69	4.24	3.39	8.32
max obs hourly avg	0.66	0.81	0.93	1.04	1.07	1.06	1.03	0.98	0.94	0.82	0.67	0.58	1.07
direct beam total	114	125	137	162	216	246	239	230	196	183	147	132	2125
max obs daily total	7.87	9.04	9.40	8.75	9.27	10.05	9.54	9.53	9.15	8.61	7.39	7.17	10.05
max obs hourly avg	0.95	1.00	0.97	0.96	0.90	0.92	0.92	0.91	0.92	0.94	0.89	0.92	1.00
SUMMARY OF INCLUDED DATA													
% of temperature data	100	100	100	100	100	100	100	100	100	100	100	100	
% of humidity ratio data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind speed data	100	100	100	100	100	100	100	100	100	100	100	100	
% of wind direction data	100	100	100	100	100	100	100	100	100	100	100	100	
# of days of beam data	31	28	31	30	31	30	31	31	30	31	30	31	
# of days of global data	31	28	31	30	31	30	31	31	30	31	30	31	

MONTH	Prediction for year 1992 [kWh/kWp/m²]	Prediction for year 1999 [kWh/kWp/m²]	Prediction for TMY [kWh/kWp/m²]	Error if TMY data used for 1992 [%]	Error if TMY data used for 1999 [%]
Jan	97.8	123.2	104.3	6.6	-15.3
Feb	91.9	117.4	116.6	26.9	-0.7
Mar	137.4	167.2	146.6	6.7	-12.3
Apr	155.3	166.3	161.5	4.0	-2.9
May	159.5	173.4	167.5	5.0	-3.4
Jun	159.1	168.5	159.6	0.3	-5.3
Jul	168.8	171.6	166.4	-1.4	-3.0
Aug	167.3	171.4	170.7	2.0	-0.4
Sep	157.5	166.5	158.4	0.6	-4.9
Oct	146.6	149.2	139.4	-4.9	-6.6
Nov	111.4	130.5	122.9	10.3	-5.8
Dec	96.3	128.2	115.6	20.0	-9.8
Annual	1649	1834	1730	4.9	-5.7

Table A6: Monthy PVISRAEL predictions for south-facing 30°-tilted array at Sede Boqer, for: 1992 (lowest radiation year on record); 1999 (highest radiation year on record); TMY. Also shown are percentage errors that would have been incurred if TMY data had been used to predict system performance for these extreme years.

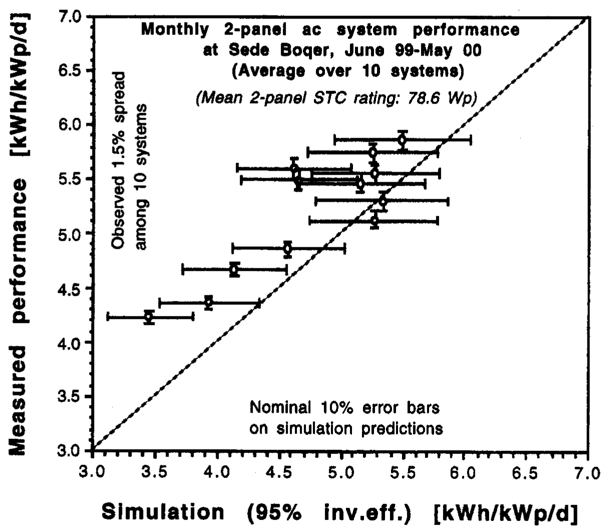

Figure A1: Comparison of PVISRAEL monthly predictions with average measured performance of 10 PV systems at Sede Boqer, June 1999 - May 2000. Predictions use data measured concomitantly during the test period.