SOLAR PV ARRAY & HEATING ELEMENT SELECTION GUIDE

PowerOptimal Elon^{TM} 100

The innovative PowerOptimal Elon^{TM} 100 incorporates proprietary solar PV (photovoltaic) power management technology to allow for direct solar PV DC to electric geyser power provision and switching and optimised solar power use in a single compact unit. The system can be connected to the grid (AC mains) as well, and intelligently switches between AC and solar power supply. The system requires no inverter and no battery, and can be connected to standard AC geyser heating elements and AC thermostats, which translates into the most cost-effective solar water heating option today.

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ELON KIT EASY SELECTION GUIDE

The below table provides an easy selection guide based on number of people in the household and/or hot water use (showers/day).

Elon kit	Showers per day*	50%+ of daily hot water use provided for how many people?	How many people off-grid for hot water?	Solar PV array size (kW_p)	Matching geyser element size (kW)	Geyser (water tank) size (litres)
Kit 1 – Solar Saver				1.0 – 1.3	3	100 - 150
Kit 2 – Solar Boost				1.5 – 1.7	2	100 – 150
Kit 3 – Solar Living				2.4 – 2.7	4	150 – 200
Kit 4 – Solar Pro				3 – 3.5	4	200+

* 6-minute showers at 40 ºC with 8 litre/min (low-flow) showerheads

SOLAR PV ARRAY AND HEATING ELEMENT FULL SELECTION GUIDE

It is important to match the solar PV array and heating elements for maximum power transfer efficiency.

1. Use Tables 1 to 4 to help you select the right size solar PV array for your needs.
2. Then use Table 5 to find the recommended AC heating element power rating for your selected solar PV array.
3. Use Table 6 to check element & thermostat compatibility with the Elon 100.

Contact PowerOptimal for advice on module-element matching if module properties (maximum power point current and voltage) are significantly different to the values provided in Table 5.

TABLE 1. ANNUAL AVERAGE LITRES OF WATER HEATED PER DAY

The below example table indicates the average number of litres of water per day that the system will heat from 15 to 60 °C over a year period for different solar array peak power ratings. (The amount of water heated will vary with weather conditions, by geographic location and by season. Water heated per day will be significantly lower in winter and significantly higher in summer. These numbers indicate heating capacity – i.e. if no hot water is used on a given day, there will be less water heated on that day. This is only an approximate guide.)

	Solar + Elon	Annual average litres of water heated per day for X kW_p installed solar capacity									
Location	**$kWh/kW_p/yr$**	**0.8 kW_p**	**1 kW_p**	**1.2 kW_p**	**1.4 kW_p**	**1.6 kW_p**	**1.8 kW_p**	**2 kW_p**	**2.5 kW_p**	**3 kW_p**	**3.5 kW_p**
Bloemfontein	**1894**	80	99	119	139	159	179	199	249	298	348
Cape Town	**1624**	68	85	102	119	136	154	171	213	256	299
Durban	**1447**	61	76	91	106	122	137	152	190	228	266
Jhb/Pretoria	**1724**	72	91	109	127	145	163	181	226	272	317
Mbombela	**1627**	68	85	103	120	137	154	171	214	256	299
Port Elizabeth	**1565**	66	82	99	115	132	148	164	205	247	288
Upington	**1912**	80	100	121	141	161	181	201	251	301	352
Saldanha	**1623**	68	85	102	119	136	153	170	213	256	298

Example:
For a solar PV array of **1.2 kW_p**, an installation in Johannesburg would yield about 1724 $kWh/kW_p/yr$, or 1724 x 1.2 kW_p = **2069 kWh/yr**. This would be sufficient to **heat on average 109 litres of water per day**. For a family of 2 each using 80 litres of hot water per day, this would provide about 109 ÷ (80 x 2) or **68% of the annual hot water requirement**.

TABLE 2. ANNUAL AVERAGE NUMBER OF SHOWERS PER DAY

The below table indicates the average number of showers per day for which the system will supply hot water over a year period for different solar array peak power ratings. (The amount of water heated will vary with weather conditions, by geographic location and by season. Water heated per day will be significantly lower in winter and significantly higher in summer. These numbers indicate heating capacity – i.e. if no hot water is used on a given day, there will be less water heated on that day. This is only an approximate guide.)

	Solar + Elon	Number of showers per day (based on annual average) for X kW_p installed solar capacity									
Location	**$kWh/kW_p/yr$**	**0.8 kW_p**	**1 kW_p**	**1.2 kW_p**	**1.4 kW_p**	**1.6 kW_p**	**1.8 kW_p**	**2 kW_p**	**2.5 kW_p**	**3 kW_p**	**3.5 kW_p**
Bloemfontein	1894	2.4	3.0	3.6	4.2	4.8	5.4	6.0	7.5	9.0	10.4
Cape Town	1624	2.0	2.6	3.1	3.6	4.1	4.6	5.1	6.4	7.7	9.0
Durban	1447	1.8	2.3	2.7	3.2	3.6	4.1	4.6	5.7	6.8	8.0
Jhb/Pretoria	1724	2.2	2.7	3.3	3.8	4.3	4.9	5.4	6.8	8.2	9.5
Mbombela	1627	2.1	2.6	3.1	3.6	4.1	4.6	5.1	6.4	7.7	9.0
Port Elizabeth	1565	2.0	2.5	3.0	3.5	3.9	4.4	4.9	6.2	7.4	8.6
Upington	1912	2.4	3.0	3.6	4.2	4.8	5.4	6.0	7.5	9.0	10.5
Saldanha	1623	2.0	2.6	3.1	3.6	4.1	4.6	5.1	6.4	7.7	9.0

The table is based on **6-minute** showers at **40 °C** and **8 litres/min** low flow showerheads. Old showerheads can use up to 15 litres/min and would substantially reduce the number of showers.

Example:
For a solar PV array of **2.5 kW_p**, an installation in Johannesburg would yield about 1724 $kWh/kW_p/yr$, or 1724 x 2.5 kW_p = **4 310 kWh/yr**. This would be sufficient for about **6 to 7 showers per day**.

TABLE 3. PERCENTAGE OF ANNUAL HOT WATER REQUIREMENT

The below example table indicates what % of the annual hot water requirement will on average be supplied by the system for **2 people each using 80 litres of hot (60 °C) water per day**. (The amount of water heated will vary with weather conditions, by geographic location and by season. Water heated per day will be significantly lower in winter and significantly higher in summer. These numbers indicate heating capacity – i.e. if no hot water is used on a given day, there will be less water heated on that day. This is only an approximate guide.)

	Solar + Elon	Annual average % of hot water requirement supplied for 2 people each using 80 litres of hot water per day for X kW_p installed solar capacity									
Location	**$kWh/kW_p/yr$**	**0.8 kW_p**	**1 kW_p**	**1.2 kW_p**	**1.4 kW_p**	**1.6 kW_p**	**1.8 kW_p**	**2 kW_p**	**2.5 kW_p**	**3 kW_p**	**3.5 kW_p**
Bloemfontein	1894	50%	62%	75%	87%	99%	112%	124%	155%	187%	218%
Cape Town	1624	43%	53%	64%	75%	85%	96%	107%	133%	160%	187%
Durban	1447	38%	47%	57%	66%	76%	85%	95%	119%	142%	166%
Jhb/Pretoria	1724	45%	57%	68%	79%	91%	102%	113%	142%	170%	198%
Nelspruit	1627	43%	53%	64%	75%	85%	96%	107%	134%	160%	187%
Port Elizabeth	1565	41%	51%	62%	72%	82%	92%	103%	128%	154%	180%
Upington	1912	50%	63%	75%	88%	100%	113%	126%	157%	188%	220%
Saldanha	1623	43%	53%	64%	75%	85%	96%	107%	133%	160%	186%

Examples:
An array of **1.2 kW_p** will provide approximately **64%** of the annual hot water requirement for a family of two people in Cape Town.

An array of **2 kW_p** will provide approximately 124% x (4 / 2) = **62%** of the annual hot water requirement for a family of four people in Bloemfontein.

TABLE 4. PEAK POWER OUTPUT FOR VARIOUS SOLAR MODULES AND ARRAY SIZES

The peak power production (W_p) of the modules at STC (Standard Test Conditions: irradiance 1000 W/m², module temperature 25 ºC, AM 1.5) and at NOCT (Nominal Operating Cell Temperature, 800 W/m²) are provided by the solar PV module manufacturer. The below table indicates the peak power at STC for a range of solar module power ratings and array sizes.

No. of cells per module	Module STC power rating (W_p)	Total peak power at STC in kW_p for an array of X modules						
		3 modules	4 modules	5 modules	6 modules	8 (2 x 4) modules	10 (2 x 5) modules	12 (2 x 6) modules
60	250	0.75	1.00	1.25	1.50	2.00	2.50	3.00
60	255	0.77	1.02	1.28	1.53	2.04	2.55	3.06
60	260	0.78	1.04	1.30	1.56	2.08	2.60	3.12
60	265	0.80	1.06	1.33	1.59	2.12	2.65	3.18
60	270	0.81	1.08	1.35	1.62	2.16	2.70	3.24
60	275	0.825	1.10	1.375	1.65	2.20	2.75	3.30
60	280	0.84	1.12	1.40	1.68	2.24	2.80	3.36
60	285	0.855	1.14	1.425	1.71	2.28	2.85	3.42
60	290	0.87	1.16	1.45	1.74	2.32	2.90	3.48
72	295	0.885	1.18	1.475	1.77 NOT ALLOWED (exceeds maximum rated Elon 100 voltage)	2.36	2.95	3.54 NOT ALLOWED (exceeds maximum rated Elon 100 voltage)
72	300	0.90	1.20	1.50	1.[illegible]0	2.40	3.00	3.[illegible]0
72	305	0.915	1.22	1.525	1.[illegible]3	2.44	3.05	3.[illegible]6
72	310	0.93	1.24	1.55	1.[illegible]6	2.48	3.10	3.[illegible]2
72	315	0.945	1.26	1.575	1.[illegible]9	2.52	3.15	3.[illegible]8
72	320	0.96	1.28	1.60	1.[illegible]2	2.56	3.20	3.[illegible]4
72	325	0.975	1.30	1.625	1.[illegible]5	2.60	3.25	3.[illegible]0
72	330	0.99	1.32	1.65	1.[illegible]8	2.64	3.30	3.[illegible]6
72	335	1.005	1.34	1.675	2.[illegible]1	2.68	3.35	4.[illegible]2
72	340	1.02	1.36	1.70	2.04	2.72	3.40	4.08

Examples:
An array of **4 x 300 W_p modules** in series will have a total peak power (at STC) of **1.2 kW_p**.

An array of **2 parallel strings of 5 modules of 280 Wp each** (10 modules of 280 Wp in total) will have a total peak power (at STC) of **2.8 kWp**.

TABLE 5. SOLAR PV MODULE AND AC HEATING ELEMENT MATCHING GUIDE

Contact PowerOptimal for advice on module-element matching if module properties are significantly different to the values provided in the table below.

No. of cells	Module STC power rating (W_p)	Module NOCT mpp* voltage (V)	Module NOCT mpp* current (A)	Best element size match (rated power in kW @ 230V AC) for an array of X modules						
				3 modules	4 modules	5 modules	6 modules	8 (2x4) modules	10 (2x5) modules	12 (2x6) modules
60	**250 - 290**	28 – 29	6.5 – 7.3	**4 kW**	**3 kW**	**2 kW**	**2 kW**	**4 kW**	**4 kW**	**4 kW**
72	**295 - 340**	33 - 35	6.5 – 7.3	**3 kW**	**2 kW**	**2 kW**	**NA**	**4 kW**	**4 kW**	**NA**

* mpp = maximum power point
STC = Standard Test Conditions (irradiance 1000 W/m², spectrum AM 1.5, cell temperature 25 °C)
NOCT = Nominal Operating Cell Temperature (800 W/m², spectrum AM 1.5, cell temperature ~ 43 – 45 °C)
NA = Not Allowed (exceeds maximum rated Elon 100 voltage)
NR = Not Recommended (poor array-heating element matching efficiency)

Example:
For **4 x 300 W_p (1.2 kW_p) solar modules**, the best heating element match is a **2 kW AC element** (as rated at 230V).

TABLE 6. ALTERNATIVE MATCHING (ABOUT 5 – 10% EFFICIENCY LOSS COMPARED TO THE ABOVE TABLE)

No. of cells	Module STC power rating (W_p)	Module NOCT mpp* voltage (V)	Module NOCT mpp* current (A)	Best element size match (rated power in kW @ 230V AC) for an array of X modules						
				3 modules	4 modules	5 modules	6 modules	8 (2x4) modules	10 (2x5) modules	12 (2x6) modules
60	**250 - 290**	28 – 29	6.5 – 7.3	**3 kW**	**2* or 4 kW**	**3 kW**	**NR**	**NR**	**NR**	**3 kW**
72	**295 - 340**	33 - 35	6.5 – 7.3	**4 kW**	**3 kW**	**3* kW**	**NA**	**NR**	**3 kW**	**NA**

* Marginal (10%+ loss)

Example:
For **4 x 300 Wp (1.2 kWp) solar modules**, the best heating element match is a 2 kW AC element (as rated at 230V), but a 3 kW element can also be used. It will have about 5 - 10% efficiency loss compared to a 2 kW element.

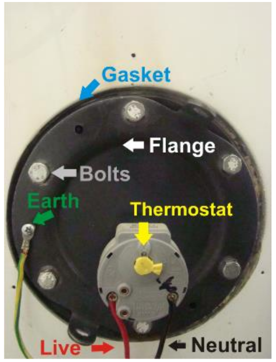
Contact PowerOptimal for advice on array-element matching if module properties (V_{mpp} and I_{mpp} at NOCT) are significantly different to the values provided in the table.

DO NOT DEVIATE FROM THE RECOMMENDED MODULE-ELEMENT MATCHING CONFIGURATIONS WITHOUT CONSULTING POWEROPTIMAL.

TABLE 7. GEYSER ELEMENT & THERMOSTAT COMPATIBILITY GUIDE

Element type	Compatible thermostat type	Comments
Screw-in element: 	VKF-11 thermostat: 	Element & thermostat have separate electrical connections, so each can be connected (wired) separately to the Elon. Thus, **this element-thermostat combination is directly compatible with the Elon.** (No need to use the bridging wire or element adapter supplied with the Elon unit.) The thermostat pocket in the element is the right size for the VKF-11 thermostat.

<table>
<tr><th>Element type</th><th>Compatible thermostat type</th><th>Comments</th></tr>
<tr>
<td>Spiral element (flange type) with smaller diameter thermostat pocket:


</td>
<td>TSE thermostat:

Thermowatt (RTS) thermostat:
</td>
<td>The spiral element generally has a smaller thermostat pocket than the screw-in element. The TSE and Thermowatt (RTS) thermostats fit into this smaller pocket. The VKF-11 thermostat requires a larger pocket and does not fit into standard spiral element pockets.

The TSE and Thermowatt thermostats normally clip directly into the element, but this won't be the case when the Elon is connected.

Use the bridging wire and element adapter supplied with the Elon (see the Installation Guide) to connect the Elon to these thermostats and elements.</td>
</tr>
</table>

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