

THE RELATIVE DEGRADATION OF VARIOUS KINDS OF PV MODULE AFTER 6-7 YEARS EXPOSURE TO DESERT CONDITIONS

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In February 1987 a variety of silicon photovoltaic modules were set out for testing at the Ben-Gurion National Solar Energy Center. A static test bed, facing southward at a tilt angle of 30 deg, contained, inter alia, an ARCO Solar M55 single-crystal module, a Solarex SX-146 polycrystalline module and an ARCO Solar G4000 amorphous module. In addition, a further 189 modules of type SX-146 were placed on a NS-axis tracker with V-trough mirrors giving them an average annual concentration of 1.57 suns [1]. All modules supplied power (the static modules to resistive loads and the tracking modules, via inverters, to the grid).

Some yellowing of the EVA laminate has lately become evident on the static M55 and SX-146 modules. [The G4000 module is also laminated with EVA but, owing to its construction, any yellowing that may be present would be difficult to observe visually.] In the case of the mirror-enhanced SX-146 modules the yellow-brown EVA coloration is visibly far more advanced.

The following tables display the results of outdoor I-V curve measurements performed during September 1993 on some sample modules. Further examples will be given in the full presentation of this work. All measurements have been converted to STC conditions (1000 Wm^{-2} , 25°C) using coefficients advertised by the manufacturers (M55 and SX-146) or measured by the authors (G4000). Tabulated percentages refer to changes compared to manufacturer's specifications.

1. ARCO Solar M55 (single-crystals)

Manufacturer's label on a specific module (Mod #6202):
($\partial V_{pp}/\partial T = -95 \text{ mV K}^{-1}$, $\partial I_{pp}/\partial T = +4.1 \text{ mA K}^{-1}$)

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
3.29	-	3.13	17.6	55	-	[13.7]

Sede Boqer field measurements on a specific module (Mod # 6202), exposed to 1 sun, on a fixed, south-tilted, test bed for 6-7 years.

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
2.73	21.3	2.42	17.1	41.4	71	10.3
-17%	-	-23%	-3%	-25%	-	-25%

2. SOLAREX SX-146 (polycrystalline)

Manufacturer's advertising brochure:
($\partial V_{oc}/\partial T = -88 \text{ mV K}^{-1}$, $\partial I_{sc}/\partial T = +2.7 \text{ mA K}^{-1}$)

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
2.9	22	2.67	18	48	75	[10.9]

Sede Boqer field measurements on a specific module (Mod # L-0943049), exposed to 1 sun, on a fixed, south-tilted, test bed for 6-7 years.

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
2.75	22.2	2.48	17.3	42.9	70.4	9.7
-5%	+1%	-7%	-4%	-11%	-6%	-11%

Sede Boqer field measurements on a specific, average "browned", module (Mod # E15), exposed on a mirror-enhanced NS-axis tracker for 6-7 years:

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
2.63	22.4	2.37	17.8	42.2	72	9.5
-10%	+2%	-11%	-1%	-12%	-4%	-12%

3. ARCO Solar G4000 (amorphous)

Manufacturer's advertisement:

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
2.35	22.0	1.9	16.0	30.0	[59]	[6.3]

Sede Boqer field measurements on a specific module (Mod # SN171933), exposed to 1 sun, on a fixed, south-tilted, test bed for 6-7 years.

($\partial V_{oc}/\partial T = -114 \text{ mV K}^{-1}$, $\partial I_{sc}/\partial T = 0 \text{ mA K}^{-1}$ - preliminary measurements)

Isc [amp]	Voc [volt]	Ipp [amp]	Vpp [volt]	Pmax [watt]	FF [%]	h [%]
1.93	22.4	1.43	15.1	21.6	50	4.6
-18%	+2%	-25%	-6%	-18%	-15%	-18%

One observes that both kinds of ARCO Solar modules have degraded in a substantial manner. On the other hand, the Solarex modules, including the mirror-enhanced ones, still show performance figures comparable to manufacturer's specifications. [Differences of up to about 10% are not regarded as significant for reasons discussed in an accompanying presentation.]

Reference

[1] J. Freilich & J.M. Gordon, *Solar Energy*, 46 (1991) 267.