THE EFFECT OF DUST ON THE PERFORMANCE OF SOLAR PHOTOVOLTAIC PANELS

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Dust effect on solar panels performance

As we know any shadow made on a solar collector can affect many parameters of the operating performance. In order to take electricity from a PV module we have the need of the main source which is the sun. The irradiation of the sun absorbed from each PV cell and conversed to electricity due to the photovoltaic phenomenon. If a shadowing effect take place on our PV module we have a performance decrease, due to the decreased irradiation absorption.

Purpose of the project :

The purpose of this project is to measure the performance fall in a photovoltaic installation Consider accretion of dust.

The measurements have been made with 3 types of materials :

- Red clay
- Sea sand
- Marble powder

- Red clay

- Sea sand

- Marble powder

To have the best coating, all materials must adapt to a specific size. This made with a sieve. (screen openings 0.075mm)

The next thing the had to be solved was the method of spreading, collecting and weighting the dust. We need the weighting in order to be able to calculate the thickness of the coating.

- Spreading decided to be with the sieve
- Collecting made with a rubber glass cleaner and then we set the powder in a preweighted piece of nylon.
- All weightings were made on a weighting scale with accuracy of 0.1 grams

The photovoltaic panel in which measurements were made is Solarworld sw 80 mono R5E with the following features:

Performance under standard test conditions (STC)					
P_m(watt)	V_{oc}(V)	V_{mpp}(V)	I_{sc}(A)	I_{mpp}(A)	NOCT (^oC)
80	21.9	17.4	5.00	4.6	46

Thermal characteristics		
TC I_{sc}	TC V_{oc}	TC P_m
0.036 % / K	-0.33 % / K	-0.48 % / K

Measurements:

Measurements follows are the first with clean PV module and the following are with the different types of dust, with two thicknesses of each material.

Type of dust	P_m(watt)	V_{oc}(V)	V_{mpp}(V)	I_{sc}(A)	I_{mpp}(A)	$T_{cell.avg}$ (°C)	Mass (grams)	Thickness (µm)	I_{avg}(w/m²)
-	62.38	20.2	14.97	4.84	4.17	46.2	-	-	1000.4
Red clay 1	56.00	19.29	14.18	4.50	3.95	54.0	1.4	1.54	997.6
Red clay 2	54.00	19.02	14.09	4.36	3.84	56.0	1.6	1.76	992.2
Sea sand 1	54.11	19.03	14.29	4.56	3.79	57.0	2.4	2.91	993.6
Sea sand 2	53.58	19.02	14.10	4.46	3.80	56.5	4.2	5.10	989.3
Marble powder 1	56.24	19.08	14.11	4.63	3.97	54.4	1.9	2.25	988.0
Marble powder 2	56.01	19.31	14.20	4.52	3.94	54.8	3.8	4.50	990.5

Thickness calculation:

$Thickness = m/\rho_m * A_{pv}$

Density of materials (gramm/cm^3)		
Red clay	Sea sand	Marble powder
1.72	1.56	1.60

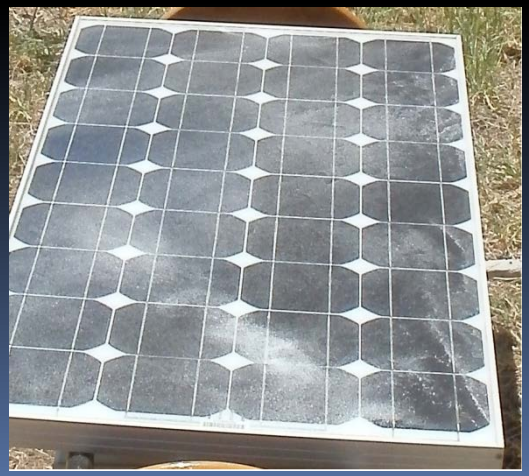
Red clay 1

Red clay 2

Sea sand 1

Sea sand 2

Marble powder 1



Marble powder 2

In order to be able to evaluate the results, we must convert them in to S.T.C.

The following equations are used for conversion to S.T.C. as proposed by E. Kaplani, "PV module performance at S.T.C. and field conditions", Innovation Week 2013, 1-10 July, Patras, Greece.

$$I'_{sc,STC} = I'_{sc}/\left[\left(1 + a_{Isc} \cdot (T_c - 25^0 C)\right) \cdot G/10^3\right]$$

$$V'_{oc,STC} = V'_{oc} - \beta_{Voc} \cdot (T_c - 25^o C) - n_s \cdot m \cdot k \cdot (T_c + 273)/q \cdot \ln(G/10^3)$$

$$P'_{m,STC} = P'_m/\left[\left(1 + \gamma_{P_m} \cdot \left(T_{pv} - 25^o C\right) + \delta \cdot \ln(G/10^3)\right) \cdot (G/10^3)\right]$$

$$FF'_{STC} = \frac{P'_{m,STC}}{I'_{sc,STC} \cdot V'_{oc,STC}}$$

where:

a_{Isc}	temperature coefficient for Isc in 1/K
β_{Voc}	temperature coefficient for Voc in V/K
γ_{P_m}	temperature coefficient for Pm in 1/K
δ	solar irradiance coefficient

Converted measurements

Type of dust	P_m(watt)	V_{oc}(V)	I_{sc}(A)	$T_{cell.avg}$ (°C)	Mass (grams)	Thickness (µm)	I_{avg}(w/m²)	FF (%)
Panel features	80.00	21.90	5.00	25	-	-	1000	-
-	69.42	21.73	4.80	25	-	-	1000	66.53
Red clay 1	65.21	21.39	4.46	25	1.4	1.54	1000	68.31
Red clay 2	63.94	21.26	4.35	25	1.6	1.76	1000	69.20
Sea sand 1	64.34	21.34	4.54	25	2.4	2.91	1000	66.45
Sea sand 2	63.81	21.30	4.46	25	4.2	5.10	1000	67.21
Marble powder 1	66.28	21.20	4.64	25	1.9	2.25	1000	67.40
Marble powder 2	65.99	21.46	4.51	25	3.8	4.50	1000	68.09

Comparative Table:

Clean PV vs red clay 1

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
69.42	21.73	4.80	66.53
65.21	21.39	4.46	68.31
6.1%	1.6%	7.0%	2.7%

Clean PV vs red clay 2

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
69.42	21.73	4.80	66.53
63.94	21.26	4.35	69.20
7.9%	2.2%	10.5%	4.0%

Clean PV vs sea sand 1

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
69.42	21.73	4.80	66.53
64.34	21.34	4.54	66.45
7.3%	1.8%	5.8%	0.1%

Clean PV vs sea sand 2

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
69.42	21.73	4.80	66.53
63.81	21.30	4.46	67.21
8.1%	2.0%	7.7%	1.0%

Clean PV vs Marble powder 1

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
69.42	21.73	4.80	66.53
66.28	21.20	4.64	67.40
4.5%	2.5%	3.5%	1.3%

Clean PV vs Marble powder 2

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
69.42	21.73	4.80	66.53
65.99	21.46	4.51	68.09
4.9%	1.2%	6.3%	2.3%

Red clay 1 vs 2

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
65.21	21.39	4.46	68.31
63.94	21.26	4.35	69.20
2.0%	0.6%	2.7%	1.3%

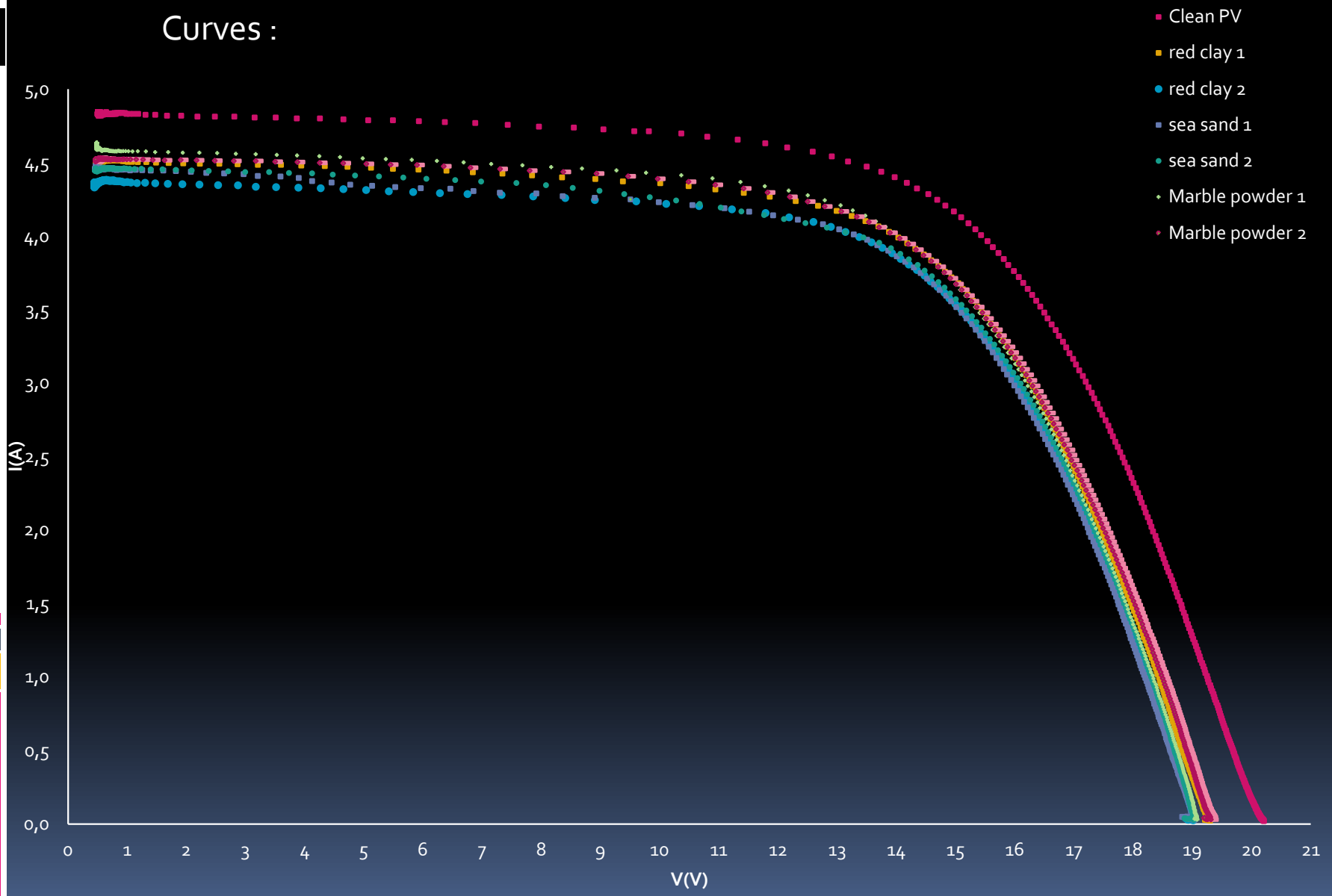
Sea sand 1 vs 2

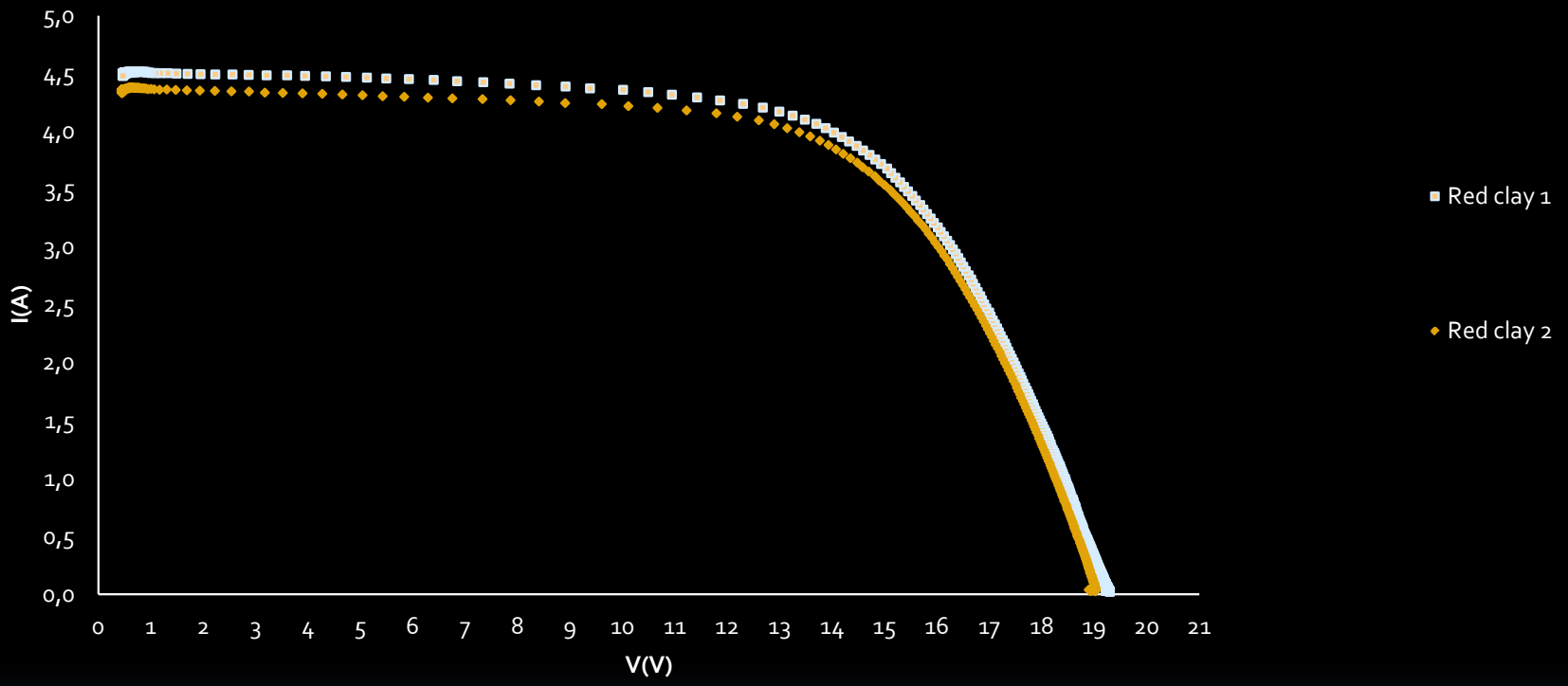
P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
64.34	21.34	4.54	66.45
63.81	21.30	4.46	67.21
0.8%	0.2%	1.8%	1.2%

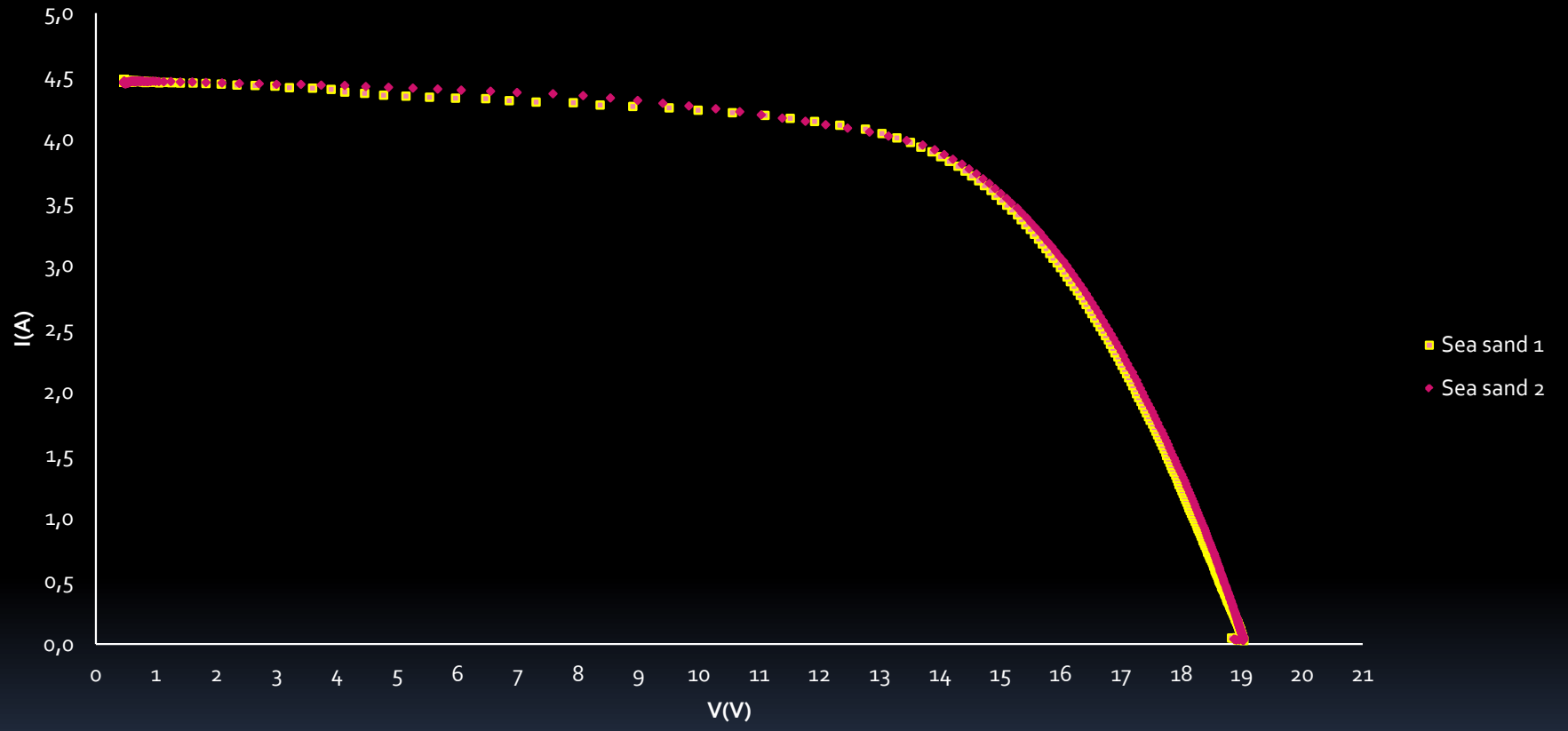
Marble powder 1 vs 2

P_m	V_{oc}(V)	I_{sc}(A)	FF (%)
66.28	21.20	4.64	67.40
65.99	21.46	4.51	68.09
0.4%	-1.2%	2.6%	1.0%

Curves :


Clean PV
red clay 1
red clay 2
sea sand 1
sea sand 2
Marble powder 1
Marble powder 2
I(A)
5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
V(V)


5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
I(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
V(V)
Red clay 1
Red clay 2


5,0
4,5
4,0
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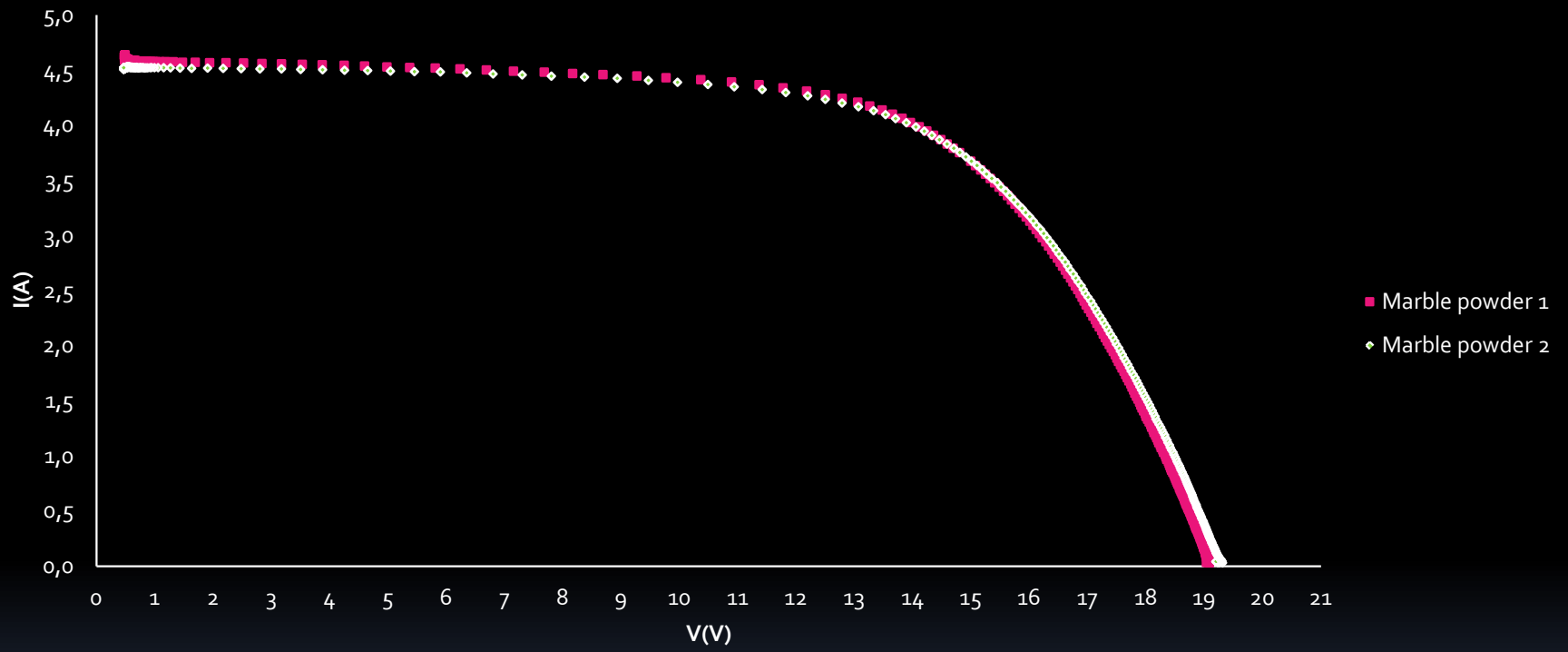
2,0
1,5
1,0
0,5
0,0
I(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
V(V)
Sea sand 1
Sea sand 2


5,0
4,5
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
I(A)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
V(V)
Marble powder 1
Marble powder 2

Conclusions:

- The results show that dust considerably reduces the power production by 4.5% to 8.1 %.
- The electrical parameters of solar panel are sensitive to the dust density so it is very essential to provide auto cleaning mechanism to remove the dust particles from the surface of the panel in order to ensure high performance.
- Also the color of dust can change the performance as we saw.