

PV Cleaning

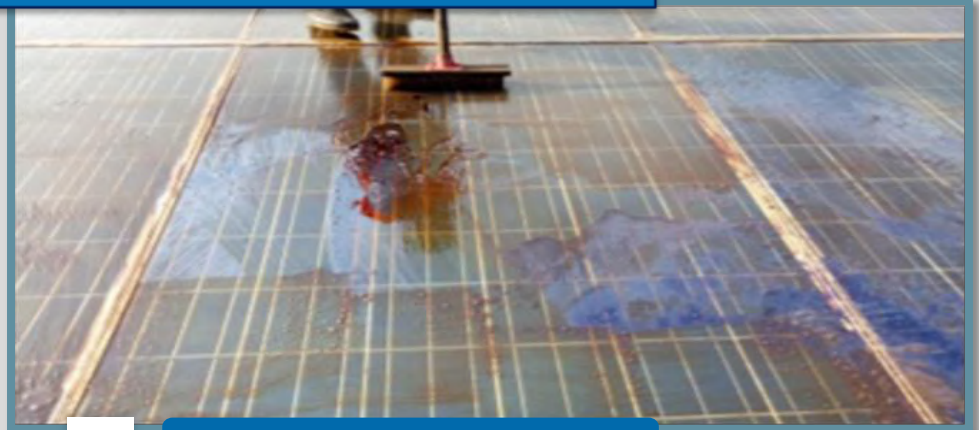


① Adverse effects of dust on modules



01

Dust accumulation



02

Industrial Pollutants



03

Corrosive pollutant
In chemical enterprise

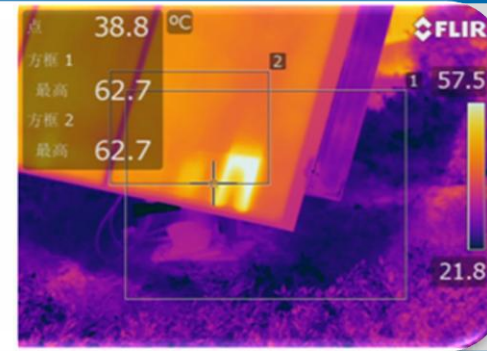


04

Solar plant after sand storm

Shade effect: the dust on the surface of the panel could reflect, scatter and absorb the solar radiation, could reduce the transmittance of the sun, which resulting in a decrease of solar radiation by the panel; accordingly, the output power is also less, which **reduces the efficiency of 10%-30%**. The effect of shade is proportional to the thickness of dust accumulation.

Temperature effect: with the accumulation of dust on the surface of the module, the heat transfer resistance of the photovoltaic module is increased, which becomes the heat insulation layer on the photovoltaic module and affects its heat dissipation. If the dust covers a long period of time, it will cause the temperature rise of the battery components, resulting in the hot spot effect which causing component damage finally.



Corrosion effects: PV panel is glass material, when moist acidic or alkaline dust attached to the glass surface, **the surface of the glass will slowly eroded to be a bumpy surface and the surface diffuse reflection**, transmission uniformity in the glass is damaged, which **decreased the PV cell generating capacity finally**. And rough, sticky surfaces with adhesive residues will accumulate more dust than smoother surfaces. Also, dust itself absorbs dust easily. More dust accumulates after initial dust, **that will accelerate the decay of PV cell generation**.



TÜV Rheinland - 沙尘对光伏发电的影响实验
 Thuwal/沙特阿拉伯, 沙尘暴引起的发电量最大达**7.7%**.



TÜV Rheinland - 沙尘对光伏发电的影响实验
 Chennai/印度, 3个月旱季沙尘引起的发电量损失达**25%**.

Soiling for various climates

Wet climate:
 Considerable dust settlement and missing rainfall lead to substantial performance loss >50%, which requires periodical cleaning for operation of a PV power plant.

Dry climate:
 Considerable dust settlement during 3-months dry season can lead to substantial soiling loss. Cleaning during dry season must be considered to improve the performance of a PV power plant.

TÜV Rheinland - 沙尘对光伏发电的影响实验
 Thuwal/沙特阿拉伯, 沙尘引起的发电量年损失 **>50%** ;
 Chennai/印度, 3个月旱季沙尘引起的发电量损失达 **25%**.

The professor of civil and environmental engineering research team of Duke university found that, “in the Arabian Peninsula, Northern & Eastern India and other arid regions, if washing panels once a month, the power generation capacity will be reduced by 17% - 25% because of the accumulation of dust; If cleaned every two months, the efficiency of power generation could be cut by 25-35%.” Because the problem of cleaning the panels still not be completely solved, the actual power generation efficiency of the panels is only about 60-70%. A 20MW solar PV power station in yulin, shaanxi province in China, loses more than \$315,000 a year due to dust shielding.

Pollutants seriously affect the system efficiency,
Robot could maintain long-term efficient power generation!



01 Dust accumulation after cleaning one month later



02 Mud , guano and other pollutants affect the system efficiency seriously



03 Residual stains after water cleaning



04 Effect after cleaning by robot

Contrast between manual & robot cleaning

Manual cleaning

Low-frequency & kept short time

High manual expense

Manual safety hazard

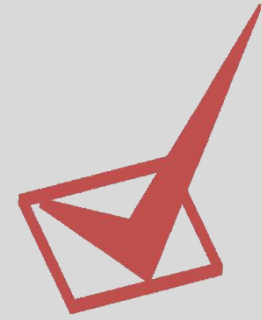
Modules Hidden crack

High water cost



VS

Robot cleaning



High-frequency to improve the efficiency always

Free of manual, control by web

Free of manual, no safety hazard

No hidden cracks by flexible material

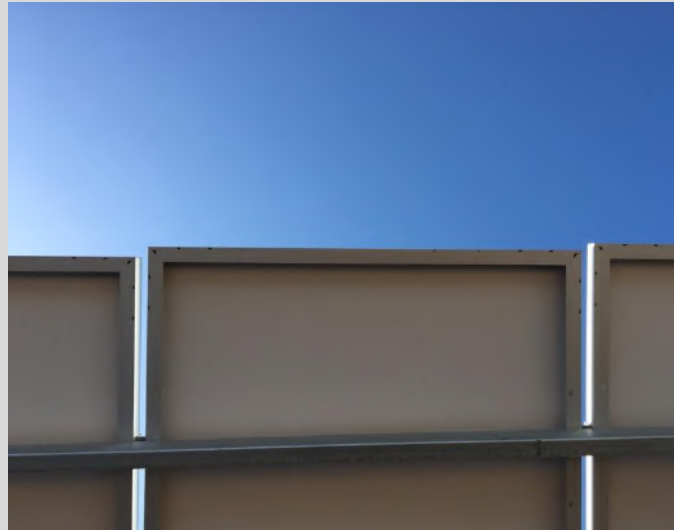
Free of water



② Influencing factors of the PV cleaning robot popularization

1

Module design installation is not smooth: the displacement of the support, the height differences of the support, and the displacement of the upper & lower track of the modules... most manufactures of cleaning robot products can not be applicable.



② Influencing factors of the PV cleaning robot popularization

2

Can not occupy the inspection pathway, one robot only clean one row; a single robot could only cover around 200pcs modules which makes the installation cost of the cleaning robot in 0.029-0.043\$/W, or even higher.



Other robot adaptability

Stuck easily

Poor adaptability

Poor obstacle crossing ability, could not cross 35°

Can't adapt the displacement of the support

Can't adapt the displacement of the upper tracker

VS

Our Robot adaptability

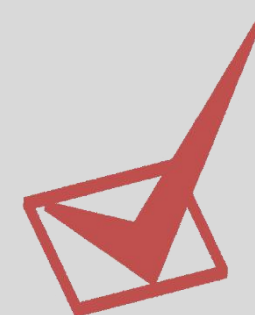
Strong adaptability, not stuck easily

High obstacle crossing ability to cross 40° installation angle

Adapt the displacement of the support within 250mm

Adapt the height differences of the support within 500mm

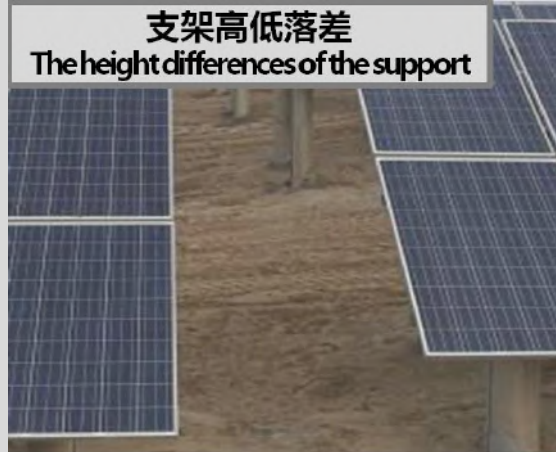
Adapt the displacement of the upper track of the module within 25mm



支架前后错位
The displacement of the support



支架高低落差
The height differences of the support



组件上端面错位
The displacement of the upper track of the component



Other robot cost input

Most is single robot

Installation cost 0.017-0.043\$/W

Unprofessional design and installation

Ferry vehicle could not resist the strong wind



VS

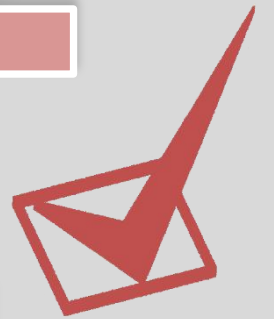
Our robot cost input

Ferry vehicle +single robot for 100% cover

Installation cost 0.011~0.017\$/W

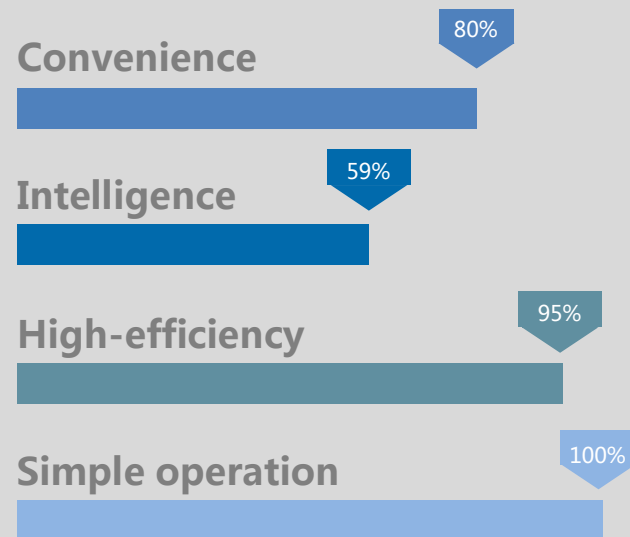
Professional design and installation

Ferry vehicle could resist the strong wind



04 Intelligent O&M Monitor system

Ability

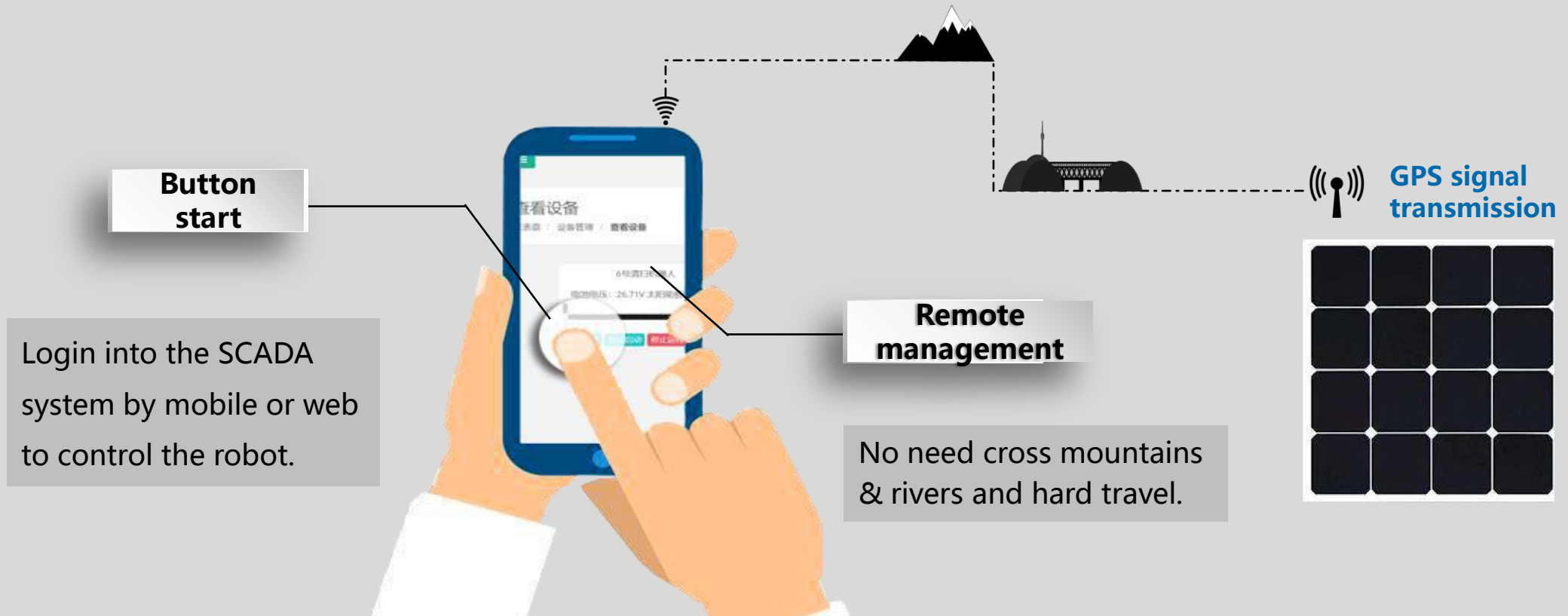


Autonomous working

- Cleaning plan be settled independently;
- Cleaning work be completed automatically without any person on duty;
- Robot status be monitored remotely;
- Working data be uploaded in time;

Five Advantages

I、Remote management

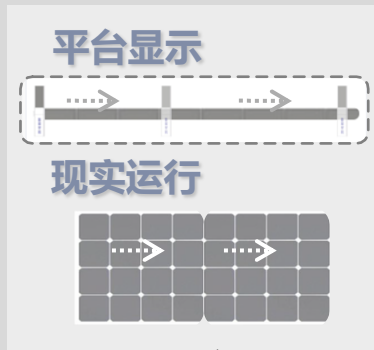


Five Advantages

II、Check the robot at any time

Actual simulator

Same display on the platform as actually after robot working



Check at any time

Device status

Check the running state & power reserve of the robot at any time

清扫机器人月度工作报表

清扫起始时间	清扫路线	耗时	清扫面积
5号18时10分	单程	2	400
10号18时11分	往返	4	800
17号18时12分	往返	4	800
28号18时13分	单程	2	400
合计	4	6	2400

Generate a report

Generate execution report automatically

Five Advantages

Ⅲ、Set working hours to clean regularly

参数设置

设备号: 8693000384374

工作模式: 单程模式 往返

开始时间: 2018 年 6 月 9 日 + 0 分 0 秒

启动时间间隔: 48 小时

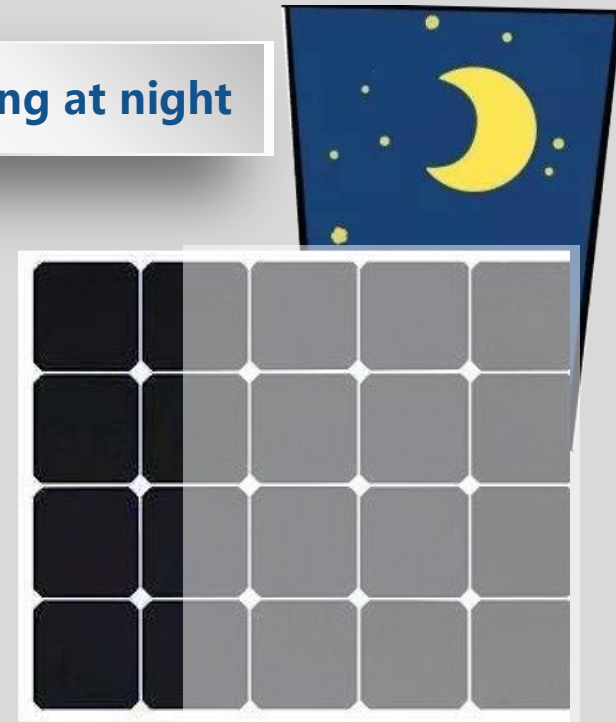
确定

Set working
time easily

Choose cleaning
time & mode freely

Cleaning time could be settled at night or anytime you want; one-way or round-trip cleaning according to your demand.

Cleaning at night



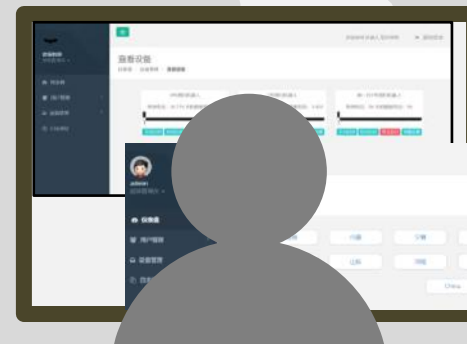
Five Advantages

IV、 Distributed management

Around the world

Multiple solar plants are managed at the same time

Group management By region, by type, or by project; One employee & a mouse to control multiple solar plants at the same time.



Five Advantages

V、Stable and compatible with most operating systems



Platform is compatible with most operating systems, such as Windows, Android, IOS...Also could incorporate into PV O&M management platform with our provided interface.

04 Intelligent O&M Monitor system

Five advantages

Remote management

1

Check the robot at any time

2

Set working hours to clean regularly

3

Multiple solar plants are managed at the same time

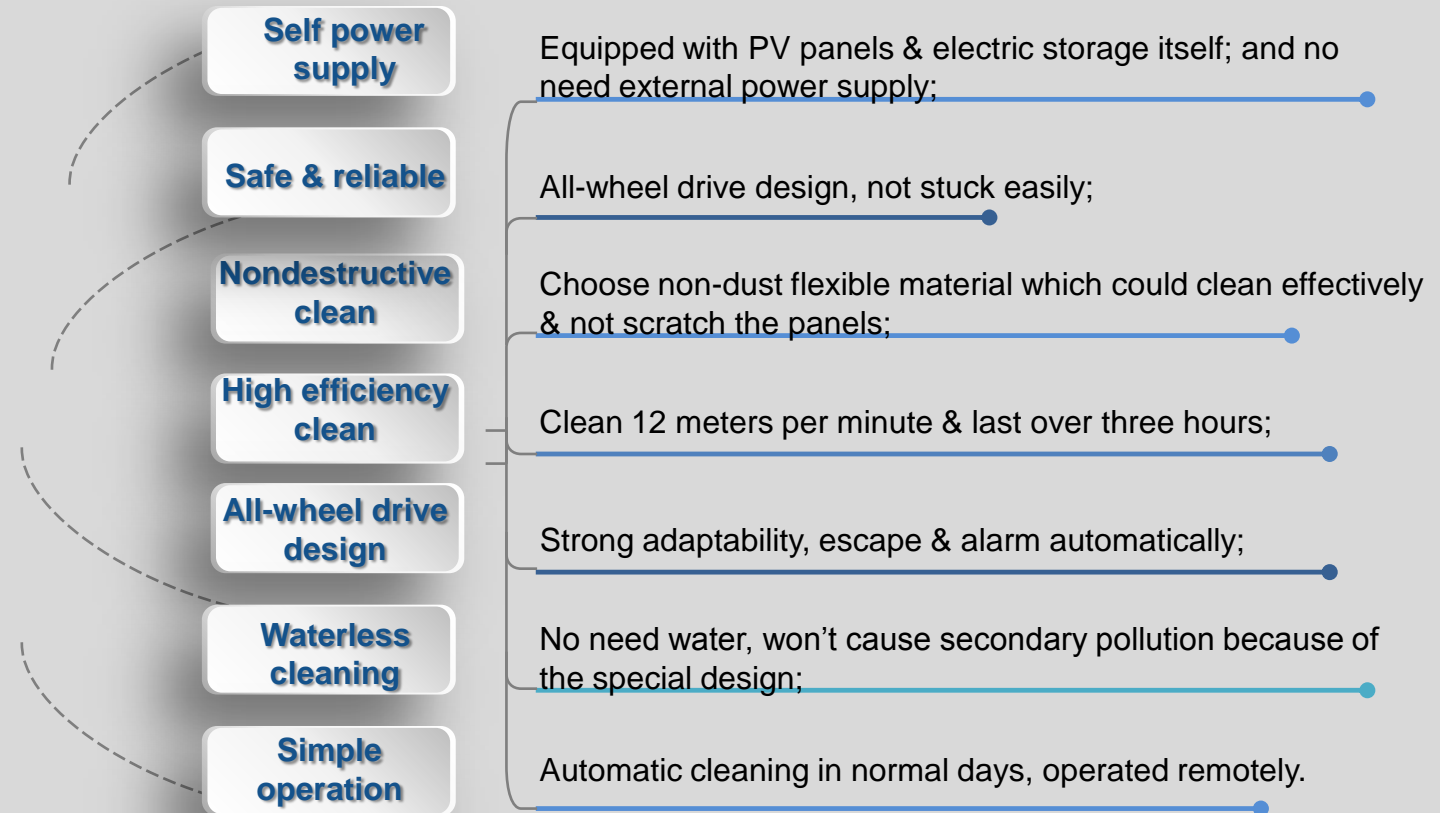
4

Stable and compatible with most operating systems

5

05 Performance characteristics

QDX-D series, single cleaning robot



Performance characteristics

QDX-HD series, for ground solar plants, QDX-HD= QDX-D cleaning robot +ferry vehicle

Self power supply

Equipped with PV panels & electric storage itself; and no need external power supply;

Safe & reliable

All-wheel drive design, not stuck easily;

Nondestructive clean

Choose non-dust flexible material which could clean effectively & not scratch the panels;

High efficiency cleaning

Clean 12 meters per minute & last over four hours;

Resist strong wind

The unique design of the ferry Vehicle resists strong winds to adapts to the hostile environment;

Waterless cleaning

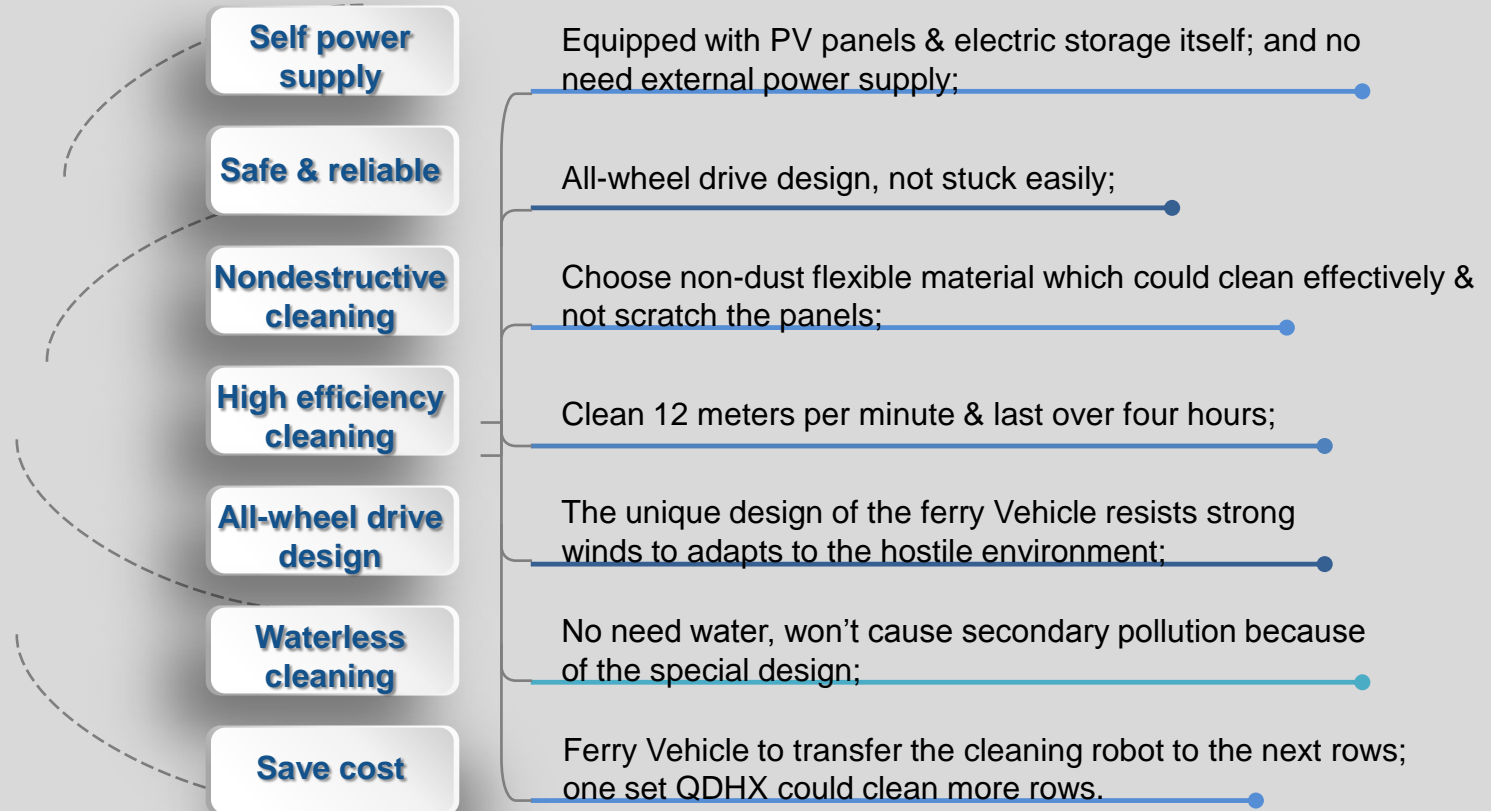
No need water, won't cause secondary pollution because of the special design;

Save cost

Ferry Vehicle to transfer the cleaning robot to the next rows; one set QDHX could clean more rows.

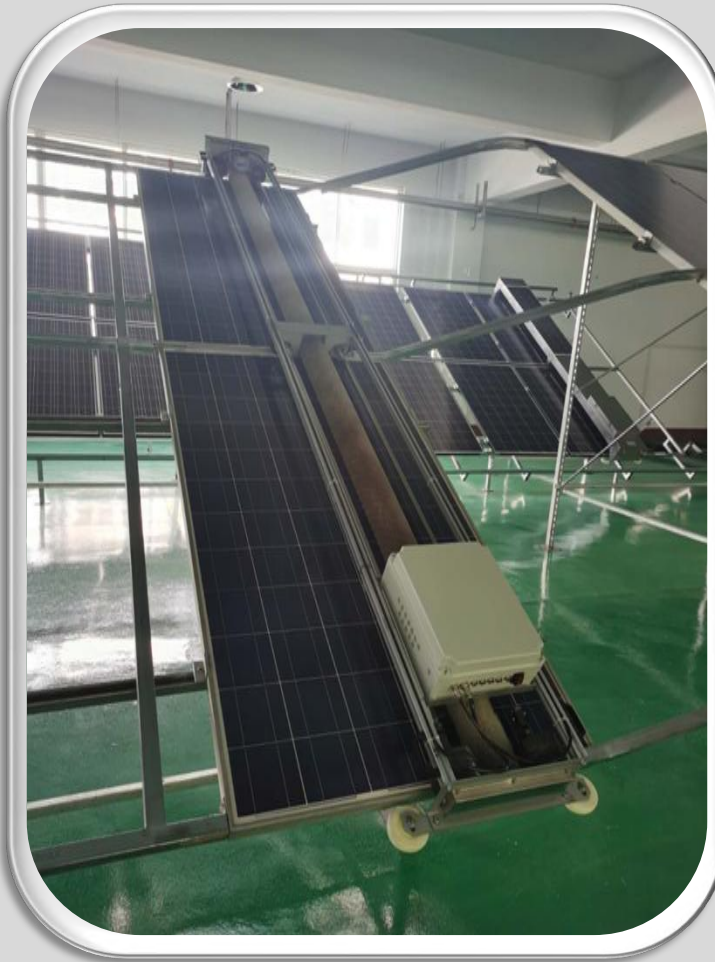
Performance characteristics

QDX-HF series, for rooftop solar plants, is, QDX-HF = QDX-D cleaning robot + ferry vehicle



Performance characteristics

QDX-M series, moveable cleaning robot



Quick charging

Use the charger for quick charging, and battery replacement quickly also.

Safe & reliable

All-wheel drive design, not stuck easily;

Nondestructive cleaning

Choose non-dust flexible material which could clean effectively & not scratch the panels;

High efficiency cleaning

Clean 12 meters per minute & last over six hours;

Light weight design

Ultra-light design, aerospace aluminum alloy material, to reduce the handling strength

Waterless cleaning

No need water, won't cause secondary pollution because of the special design;

Simple operation

Button control, operate easily

Performance characteristics

QDX-T series , for tracker solar plant



Self power supply

Equipped with PV panels & electric storage itself; and no need external power supply;

Safe & reliable

Flexible wheel design, do not press the modules, will not cause hidden cracks;

Nondestructive cleaning

Choose non-dust flexible material which could clean effectively & not scratch the panels;

High efficiency cleaning

Clean 12 meters per minute & last over six hours;

Waterless cleaning

No need water, won't cause secondary pollution because of the special design;

Simple operation

Automatic cleaning in normal days, operated remotely.

06 Economic efficiency analysis

Manual cleaning

Clean as needed, 2 to 4 times a year

Easily to damage components and site facilities

Low safety, easily to occur personal accident in the distributed solar plants

Increased 3%-7% in Western in China; 3%-5% in the distributed power station in eastern

Western: \$308-\$923(dust & soil) one time;
Eastern: \$460-\$1540 one time
(small scale of power station, dirt, dust, industrial dust particles are difficult to handle)

Comparison

Frequency of cleaning

Impact on modules

Safety

Increased of the capacity

Cost of cleaning(1MW)

Robot cleaning

Daily cleaning or as the intervals setting

Undamaged components

Safe

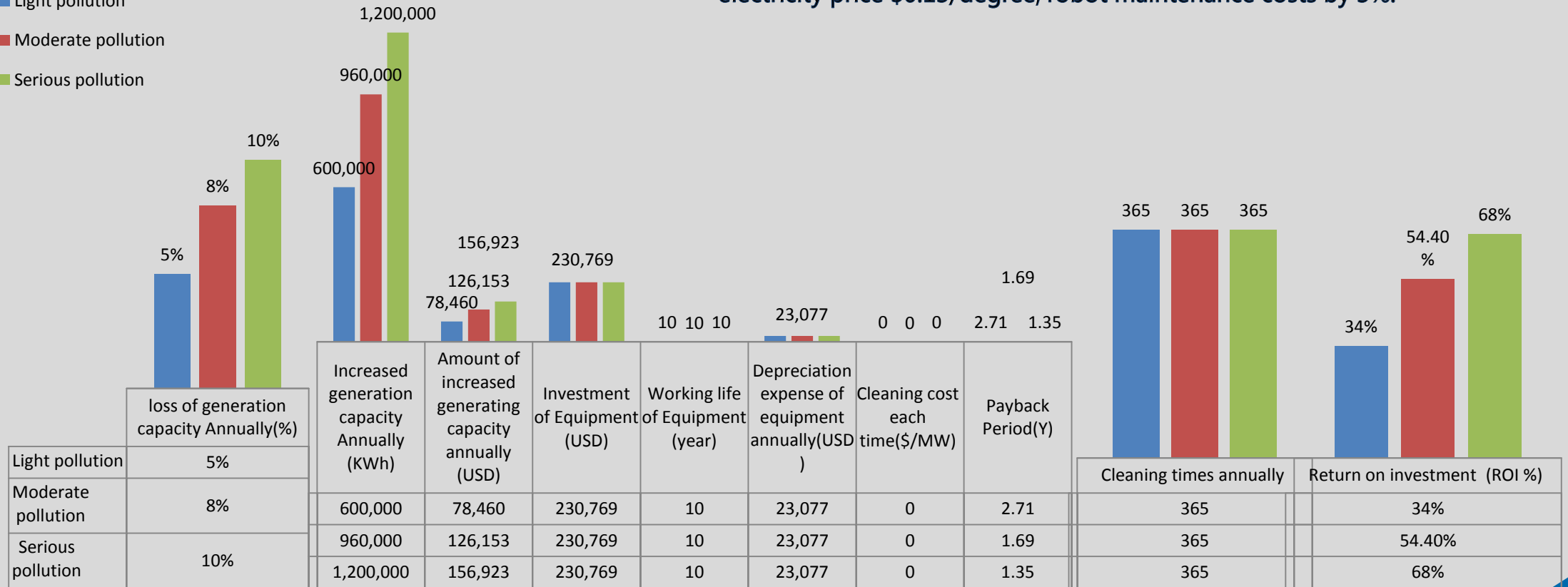
Keep the modules clean for long time ; Increased approx. 11% in western; Above 17% in the distributed power station in eastern

The investment of 1MW plant in western: \$12300-\$23100;
The investment of 1MW plant in eastern: \$7700-\$23100;
Working life :10 years; and daily cleaning

10MW Ground Solar Plant Economic Efficiency Analysis

Robot cleaning data

- Light pollution
- Moderate pollution
- Serious pollution

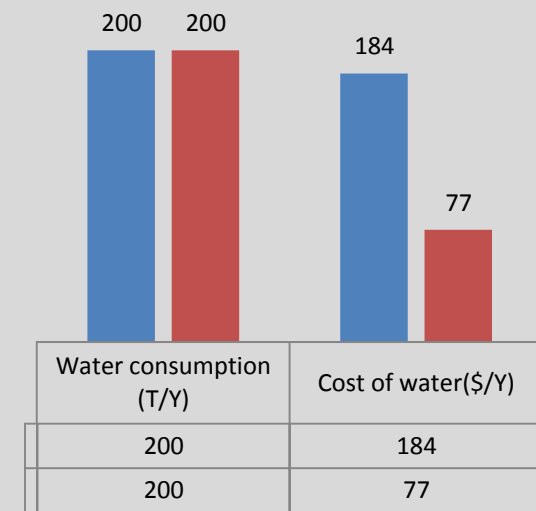
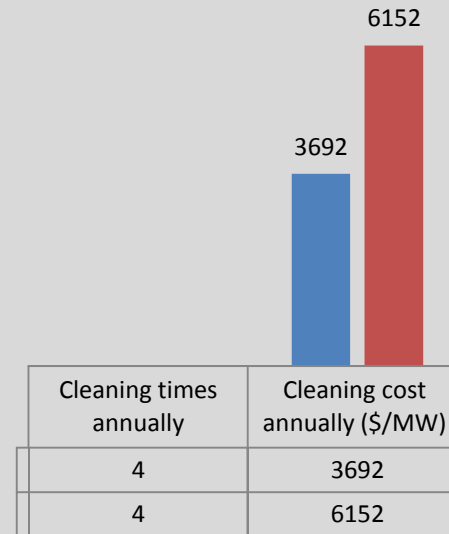
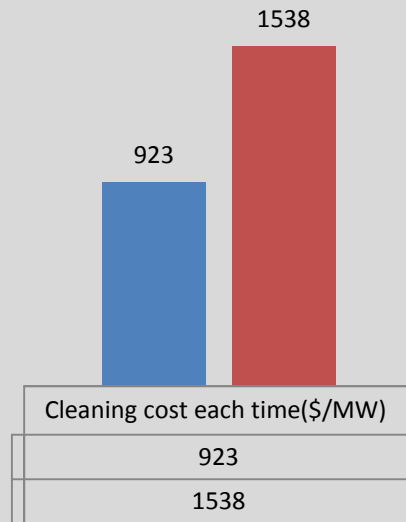
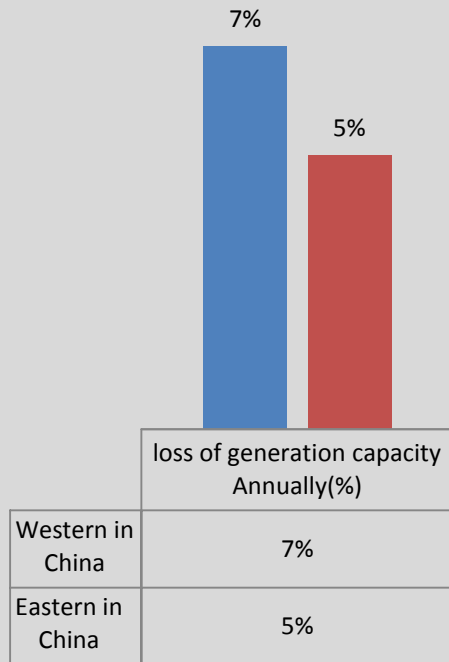


Condition: plant scale 10MW, III resource area, 1200 hours as effective utilization hours annually, 260W PV solar panels, and electricity price \$0.13/degree, robot maintenance costs by 3%.

10MW Ground Solar Plant Economic Efficiency Analysis

Manual cleaning data

■ Western in China ■ Eastern in China



Condition: plant scale 10MW, III resource area, 1200 hours as effective utilization hours annually, 260W PV solar panels, and electricity price \$0.13/degree.

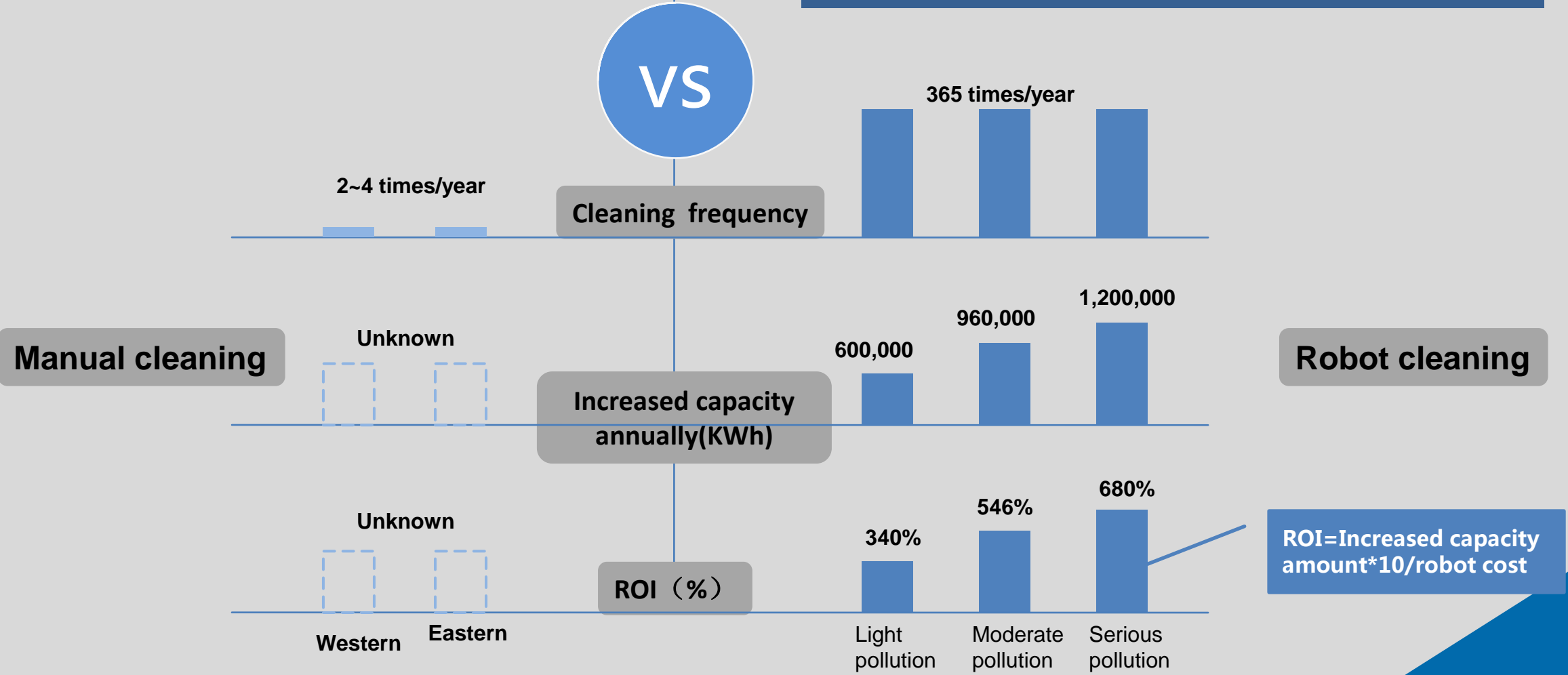
ROI : Unknown

Increased capacity annual : Unknown

10MW Ground Solar Plant Economic Efficiency Analysis

From the above, we could know robot cleaning is better than manual cleaning.

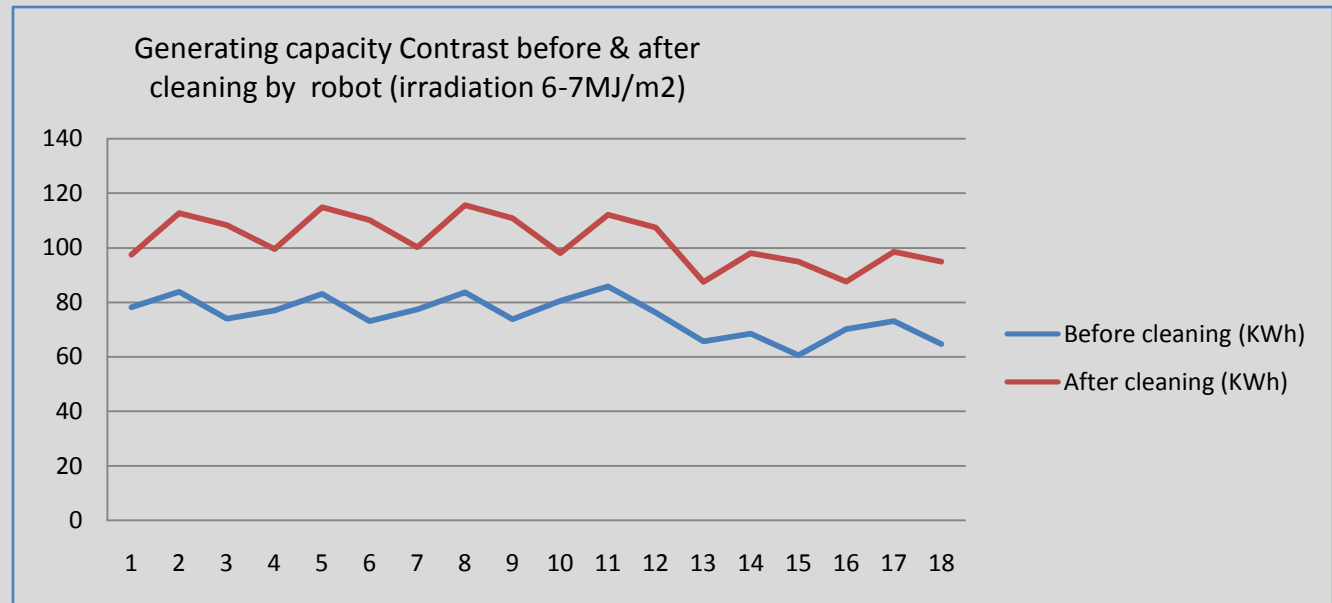
VS



Practical application verification

Take 20MW rooftop solar plant in Anyang, Henan as example, autumn & winter season, invert 89.1KW, pls check the different generating under the similar irradiation before & after cleaning.

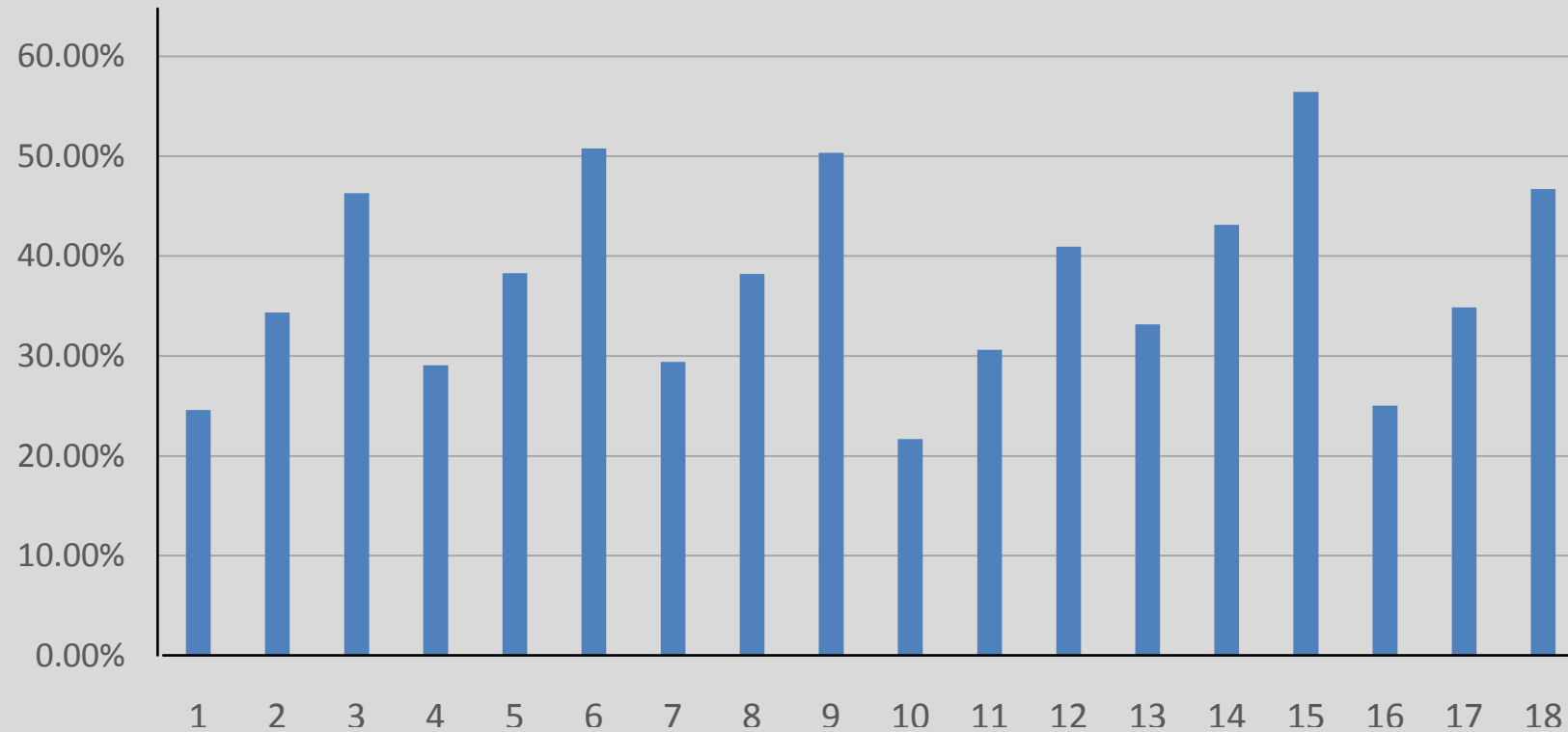
	Before cleaning KWh	After cleaning KWh	balance	Improved proportion
Generating capacity before & after using the robot	78.26	97.51	19.25	24.60%
	83.88	112.7	28.82	34.36%
	74.06	108.33	34.27	46.27%
	77.08	99.49	22.41	29.07%
	83.07	114.86	31.79	38.27%
	73.11	110.22	37.11	50.76%
	77.44	100.22	22.78	29.42%
	83.7	115.69	31.99	38.22%
	73.79	110.92	37.13	50.32%
	80.55	98.02	17.47	21.69%
	85.89	112.19	26.3	30.62%
	76.23	107.43	31.2	40.93%
	65.71	87.49	21.78	33.15%
	68.54	98.1	29.56	43.13%
	60.63	94.86	34.23	56.46%
	70.1	87.64	17.54	25.02%
	73.07	98.53	25.46	34.84%
	64.72	94.95	30.23	46.71%
Total	1349.83	1849.15	499.32	36.99%



As above, the strings (89.1KW capacity) under the similar irradiation (6-7MJ/m2), the generating capacity could improve 36.99% in average.

Improved at least 20% efficiency after robot cleaning

Improved proportion



Improved
36.99% in
average.

07 Application Case

Rooftop solar plant by SPIC in Hefei



Before Cleaning



After cleaning

Rooftop solar plant in Logistic city in Dubai



Before Cleaning



After cleaning

Tracker solar plant

By SEPCO III in Dubai



7.8MW roof solar plant
By HCIG New-energy in Neihuang, Henan



Before Cleaning



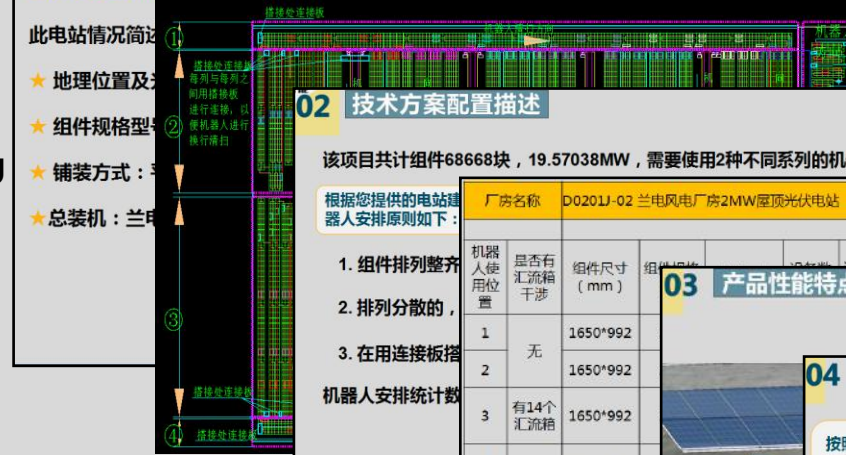
After cleaning

08 Ability of project design and planning

In order to serve customers better, we will offer the cleaning proposal according to the site environment.

01 电站情况简述

国家电投甘肃兰电20MW屋顶电站



02 技术方案配置描述

该项目共计组件68668块，19.57038MW，需要使用2种不同系列的机器人共计79台。

根据您提供的电站机器人安排原则如下：

1. 组件排列整齐
2. 排列分散的，
3. 在用连接板搭

机器人安排统计数

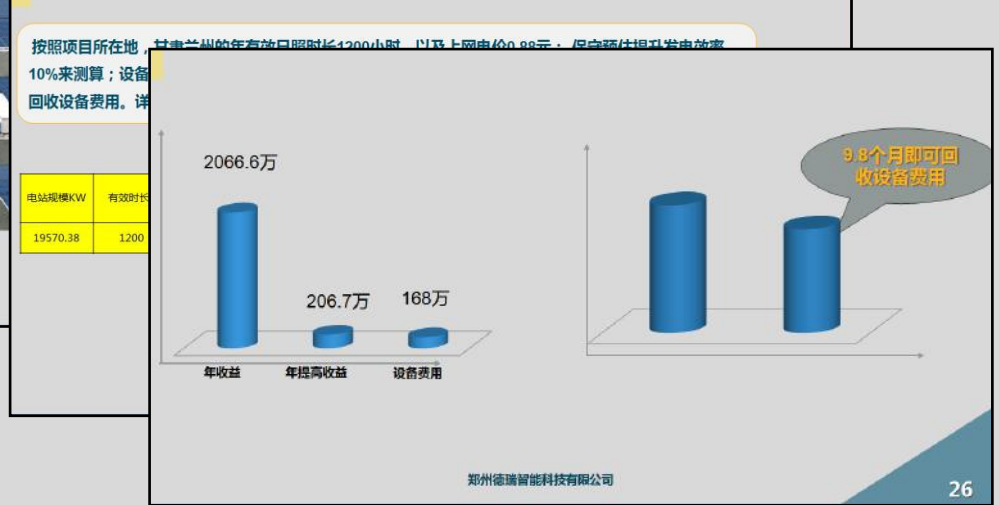
机器人使用位置	是否有汇流箱干涉	组件尺寸 (mm)
1	无	1650*992
2		1650*992
3	有14个汇流箱	1650*992
4		1650*992
5	无	1650*992
6		1650*992
合计		

03 产品性能特点描述

QFP系列屋面平铺轻型清洁机器人性能特点

按照项目所在地，甘肃兰州的年有效日照时长1200小时，以上网电价0.88元/度，保守估计提升发电效率10%来测算；设备回收设备费用。详

04 经济效益分析



SPIC 40MW roof solar plant in Gansu

Cleaning proposal

Ability of project design and planning

Project B; QDX-4000 cleaning robots.
The cleaning robot will be installed on the solar panels by fixed frame; one robot per row. It's mainly used for the sites which with complex environment and more modules per row.



5. Economic efficiency analysis

From below we could see clearly, Project A should input RMB5598000, @6.4 to be USD874687.5; and payback period is only 9.8months; but installation & debugging cycle will be long with higher fees.
Project B should input RMB9870000, @6.4 to be USD1542187.5; and payback period is 17.2 months; but installation & debugging cycle will be short with lower fees.

	Plant Scale (KW)	Sunshine Duration (h)	On-grid Power Tariff(\$)
Project A	52232.4	2500	0.0935
Project B	52232.4	2500	0.0935

1. Description of the schemes

According to the installation construction from you, we could offer two different schemes for your reference.



Project A, Ferry vehicle + cleaning robot FVR-4000.
The ferry vehicle is used to transport the robot in different rows of photovoltaic, one cleaning robot could work between different rows to reduce input of the number of cleaning robots in the solar plants.

4. Configuration contrast

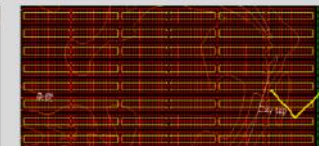
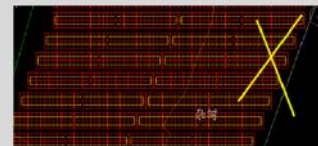
We disassemble the plants as eight parts from A to H;
Project A needs 151 sets of QDX-FVR-4000 and 96 sets of Ferry Vehicles; totally RMB 5598000;
Project B needs 658 sets of QDX-4000 but no Ferry Vehicles; totally RMB 9870000;
The price is EXW Xuchang, Henan; and without the installation & debugging fees.

	Modules (Pcs)	Total Price
A	7200	2.1
B	7200	2.1
C	20100	6.3
D	8640	2.6
E	43140	14.1
F	28860	9.5
G	14340	4.7
H	28800	9.4
Qty total	158280	52.2
Unit Price		
Total Price		
Project Price		

2. Site environment requirements

	Project A	Project B
Ground	Flat, free of fullies and uneven	None
Pathway	No height differences in operation direction	None
Array	Aligned rows, no angle or distance differences Basically same angle between the PV array and the ground in different rows	Basically neat installation

For Project A, the right one will be correct; but the left one is hard to install.



**POWERCHINA 50MW
Mountain solar plant in Vietnam**

Ability of project design and planning

01 电站情况简述

此电站情况简述如下：

- ★ 地理位置：位于青
- ★ 铺装方式：地面电
- ★ 总装机：21.4687
- 情况，为最大化的利
- 机器人设置：（详图
- ★ 组件参数：260W
- 约21.7m.



02 技术方案配置描述

根据光伏组件铺设情况和机器人单次工作时长，为提高清扫效率，采用摆渡车清扫方案：使用 QDHX-3300机器人

02 技术方案配置描述

- A区域分为①②
- B区域分为①②③④⑤
- CDEFG区域的
- H区域分为①②③④⑤⑥⑦⑧⑨⑩
- 共计8个区域，40台摆渡车和40台

机器人配置区域	组串数量及功率			清扫机器人配置			摆渡车配置			接插件数量 (套)	
	行数 (行)	总数量 (个)	总功率 (MW)	数量 (台)	往返清扫距离 (m)	清扫时间 (min)	数量 (台)	运行距离 (m)	运行时间 (min)		轨道数量 (条)
A区域	①	19									
	②	19									
	总计	38									
B区域	①	9									
	②	9									
	③	9									
	④	8									
	⑤	8									
	总计	43									
C区域	①	7									
	②	7									
	③	7									
	④	7									
	⑤	7									
	⑥	8									
	总计	43									
D区域	①	7									
	②	7									
	③	7									
	④	7									
	⑤	7									
	⑥	8									
	总计	43									
E区域	①	14									
	②	14									
	③	15									
	④	15									
	⑤	15									
	⑥	15									
	⑦	15									
	⑧	15									
	⑨	15									
	⑩	15									
	总计	43									
F区域	①	14									
	②	14									
	③	15									
	④	15									
	⑤	15									
	⑥	15									
	⑦	15									
	⑧	15									
	⑨	15									
	⑩	15									
	总计	43									
G区域	①	14									
	②	14									
	③	15									
	④	15									
	⑤	15									
	⑥	15									
	⑦	15									
	⑧	15									
	⑨	15									
	⑩	15									
	总计	43									
H区域	①	14									
	②	14									
	③	15									
	④	15									
	⑤	15									
	⑥	15									
	⑦	15									
	⑧	15									
	⑨	15									
	⑩	15									
	总计	43									
总计		330									

03 产品性能特点描述

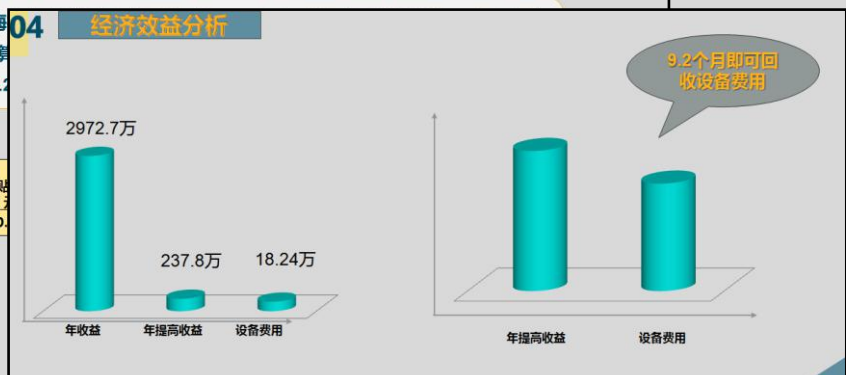


跨行车+QDX清洁机器人“方案”的性能特点

04 经济效益分析

按照项目所在地，青海提升发电效率8%来测算，共计1824000元，约9.2个月即可回收设备费用

电站规模 (千瓦)	有效时长 (小时)	补贴 (元/千瓦/小时)
21468.72	1629	0.07




20MW Ground solar plant in Qinghai

Ability of project design and planning

02 Description of the Proposal A

- > **Solar plant**; Rows are well-arranged and distributed evenly.
- > **Bridgework**; No need bridge there are no any gaps from strings.
- > **Robot**; QFHP-1000 which is the cleaning robot & ferry vehicle the robot to different rows.
- > **Quantity**; One set of QFHP-1000 vehicle will be fixed together each 10 rows, total 33 sets for row.




02 Description of the Proposal A

QFHP-1000 working method;

- Automatic--Fixed on the frame of the panels.
- Without water.
- Charge itself by solar panel.
- All gaps will be fixed connection vehicle will be fixed together row.
- Robot will clean the module automatically.
- No need any workers, the Cleaning at night when the t

01 Background of the solar plants

- > 10MW in Tunisia; Single Axis Tracking;340Wp, 992*1987*40mm;
- > In drought & remote region
- > 1*30 panels as one string row, within one tracker; to between strings & strings & rows is 5.5m.
- > Uniaxial beam & tracker robot walking.

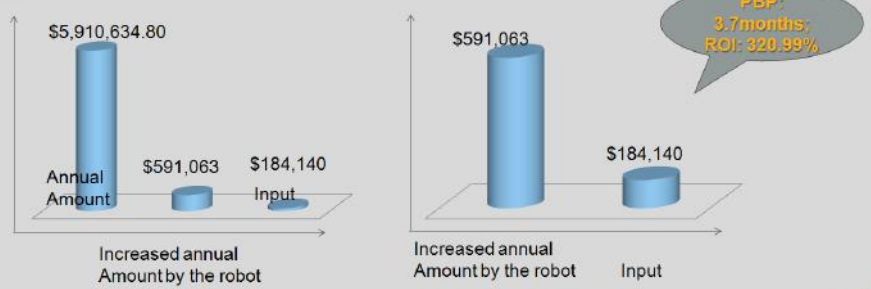


04 Economic efficiency analysis

According to the situation of the solar plant, annual sunshine duration 1825hours, tariff is \$0.324/KWh, 9400pcs modules means 9996KW, the annual generating capacity is 18242700KWh which means \$5910634.80 as annual amount of electricity, if the electricity price is 0.324\$ (conservative estimate), the

04 Economic efficiency analysis--Proposal A

	Plant Scale (KW)	Sunshine Duration (h)	Tariff(\$)
Proposal A	9996	1825	0.324
Proposal B	9996	1825	0.324



Annual Amount: \$5,910,634.80
Input: \$184,140

Increased annual Amount by the robot

PBP: 3.7months; ROI: 320.99%

10MW Ground solar plant In Tunisia

Ability of project design and planning

01 电站情况简述

此电站情况简述如下：

★ **地理位置：**位于汝州市，年有效利用小时数1234小时；

电价0.9元/度来估算；

★ **铺装方式：**地面电站，安装分布不均，且前端离地面较近；

★ **总装机：**32MW，考虑电站实际情况，角度和高度问题，选用图中①区域作为首批试点范围，装机量约3.9MW；

★ **组件参数：**1640*992*35mm，两排组串间隔0.2m间距，每个组串长度约10m。



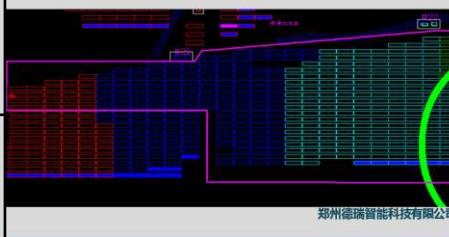
01 电站情况简述

区域①情况简述如下：

★ 约681个光伏组串，功率约为3.9MW；组件排列共24行，每行使用一台QDX-3300机器人清扫，共计24台；

★ 每行中，组串间隔区域需要搭接，以供机器人运行通过，共需646个搭接件；

★ 组串间隔落差比较大的区域，若边缘处直接搭接导致机器人无法通过，增大搭接的距离，使机器人在搭接件上平滑顺畅的行走通过即可。另外，根据现场情况会对搭接进行调整和修改。



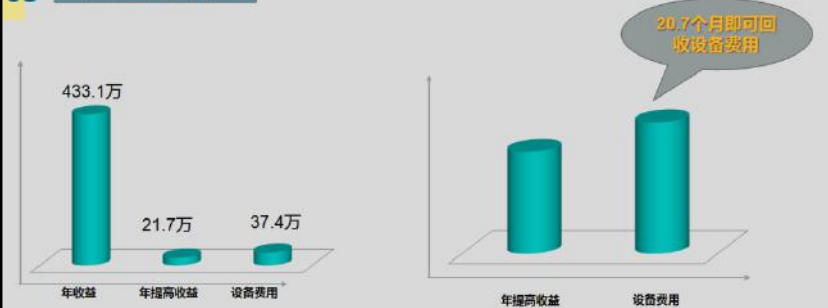
03 经济效益分析

按照项目所在地，河南汝州市的年有效日照时长1234小时，以及上网电价预估0.9元；预估提升发电效率5%来测算；每年提升

37.4万元，约20.7个月可以收回成本。

电站规模 (千瓦)	有效时长 (小时)	补贴电价 (元)	年发电量 (度)
3900	1234	0.9	4812

03 经济效益分析



郑州德瑞智能科技有限公司

China Pingmei Shenma Group
32MW Ground solar plant in Ruzhou

Ability of project design and planning

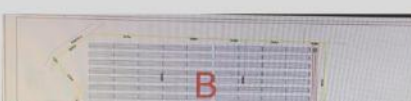
01 Background of the solar plants

Layout 1

- > Jordan, 7.32105MW, 22185 pcs modules, 255 tables, 990*1960mm, 330W;
- > Effective sunshine utilization about 1560hours, Fit 0.025\$; Tariff 0.025\$/Kwh;
- > PV Tables 29*3=87pcs

Tables length:
990*29+20*28=29270mm
29.27m per table.

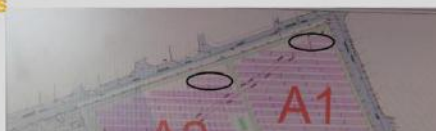
> **Robot length:** 1960*3=



01 Background of the solar plants

Layout 2

- > Jordan, 6.8904MW, 20880 pcs modules, 990*1960mm, 330W; As 17 tables are shorter than 100m(the black circle in right picture), we won't use fixed QDX to clean, which means cleaned 6.40233MW, 19401pcs modules.
- > Effective sunshine utilization hours about 1560hours, tariff 0.025\$/Kwh;
- > PV Tables 29*3=87pcs; 0.02871MW; Tables length: 990*29+20*28=29270mm, which means 29.27m per table.
- > **Robot length:** 1960*3+20*2=5920mm;

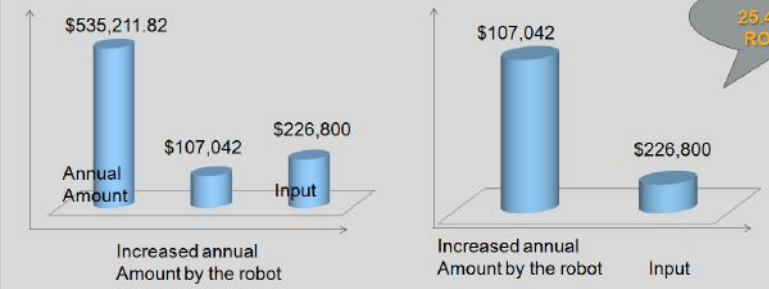


03 Economic efficiency analysis--Fixed

According to the situation of the two solar plants, annual effective sunshine utilization hours 1560hours, tariff is \$0.025/KWh, 41586pcs modules means 13.72338MW, the annual generating capacity is 21408472.8KW which means \$535211.82. The proportion of improvement as 20% by the robot cleaning robot will be \$107042.

	Plant Scale (KW)	Sunshine Duration(h)	Tariff(\$)
Layout1	7321.05	1560	0.025
Layout2	6402.33	1560	0.025
total	13723.38		

04 Economic efficiency analysis--Proposal A



The first chart shows the fixed scenario with an Annual Amount of \$535,211.82 and an Input of \$226,800. The second chart shows Proposal A with an Annual Amount of \$107,042 and an Input of \$226,800. A callout bubble indicates: PBP: 25.4months; ROI: 47.2%.

Zhengzhou Derui Intelligent Technology Co., Ltd

7.3MW Ground solar plant in Jordan