

ecosense  
ET / IT EXPERT GROUP

Solar O&M System  
for Solar Power Plant Efficiency Maintenance

# Sun Robot<sup>®</sup>

ECOSENSE Solar Panel Cleaning Robot

Scan-type  
Solar Panel Cleaning Robot  
[ ES-SRS ]

suitable for large & long solar power plant

Vertical-type  
Solar Panel Cleaning Robot  
[ ES-VSM ]

suitable for rooftop or wide solar power plant

Solar Panel  
Surface Inspection Equipment  
[ ES-ISR ]

for inspect solar panels short circuits

Removable Docking Station  
[ ES-MRS ]

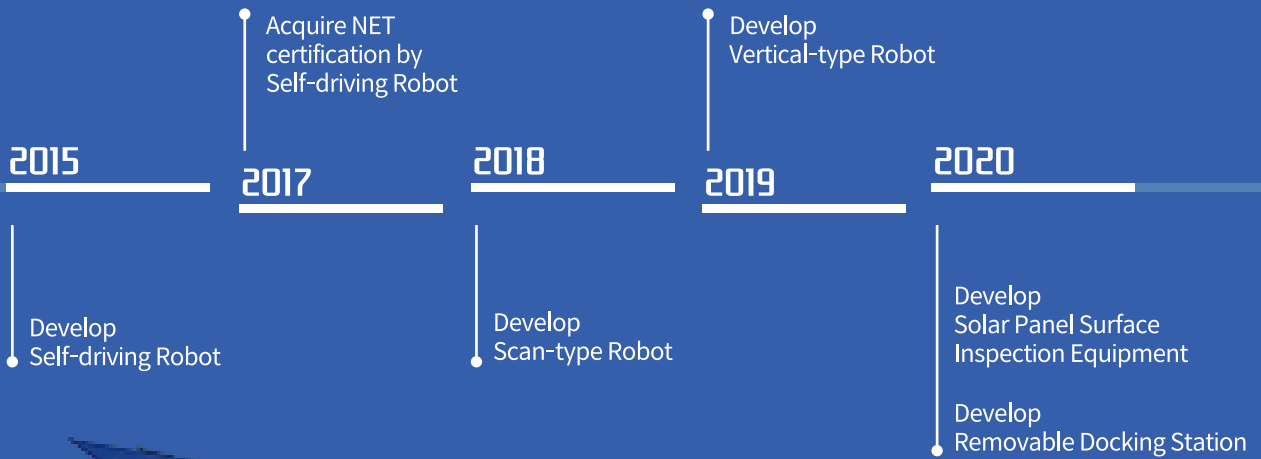
for move cleaning robot  
between solar power plant arrays



# Solar Power Plant

## It's time to focus on Maintenance

### HISTORY



### CERTIFICATION

<p>[Korea patent No. 10-1688120] Solar panel cleaning robot using adsorption power</p>	<p>[Korea patent No. 10-1829283] Adsorption device for solar panel cleaning robots</p>	<p>[Korea patent No. 10-1688122] A solar panel cleaning robot that detects cracks in solar panels using a camera</p>	<p>[KTP Certificate of Qualification] - Scan-Type Solar Panel Cleaning Robot - Removable Docking Station</p>
<p>[Korea patent No. 10-1768113] Cleaning robot for solar panels to have a balanced control</p>	<p>[Korea patent No. 10-1768108] Cleaning robot for solar panels to have the wind speed detection</p>	<p>[Korea New Excellent Technology No. 1087] Self-driving robot technology for cleaning and monitoring solar panels</p>	<p>[Trial Purchase system] Solar Panel Cleaning Robot</p>

# ECOSENSE SunRobot can...

Applicable to various environments of solar power plant

Cleaning Robot – Stationary [Scan-Type ES-SRS] & Mobile [Vertical-Type ES-VSM]

For Move Cleaning Robot between Arrays – Removable Robot Station [ES-MRS]

For Inspect Solar Panels short circuits – Inspection Equipment [ES-ISR]

We offer customized products.



## Problems

### Characteristics and Current Problems of Solar Power Plant

- Lack of awareness of improvement in power generation efficiency (5-10%) due to cleaning
- Insufficient maintenance/management activities due to installation-oriented policies
- Safety issues occur when cleaning manually
- Shortening solar panel life in absence of cleaning
- Many panels exist that cannot be cleaned manually
- Inspection takes a long time in case of damage to the solar power plant panel

## Effect

### Effectiveness through continuous Maintenance/Management

- Extended Life of Solar Power Plants
- Improvement of solar power plant efficiency degradation due to pollution (5-10% improvement)
- Automatic panel damage check
- Extend panel life and improve efficiency through real-time panel cleaning
- Eliminate safety issues caused by manual cleaning



## Cleaning Robot

### Scan-type Solar Panel Cleaning Robot ES-SRS



- It can be installed regardless of the slope or width of the solar panel
- If there is a gap between arrays, connect it with a rail and install it
- Suitable for large solar power plants installed with high-slope and long arrays

### Vertical-type Solar Panel Cleaning Robot ES-VSM



- Suitable for wide areas
- Can be carried by humans to clean small solar plant
- Suitable for rooftop Solar Plant



## Removable Robot Station

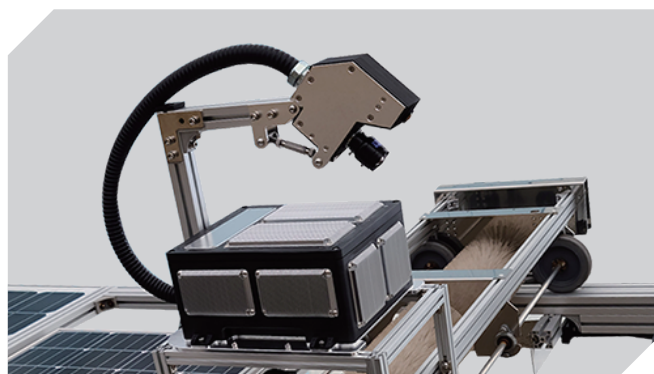
Removable  
Docking Station  
ES-MRS



- A Removable Docking Station that allows the Solar Panel Cleaning Robot to move between arrays
- It is possible to reduce investment costs by improving the efficiency of using expensive robot
- Can improve performance compared to investment
- Suitable for small solar power plants with short lengths

## Panel Inspection Equipment

Solar Panel  
Surface Inspection Equipment  
ES-ISR



- Solar Panel circuit short inspection equipment
- Manual inspection difficult for large solar power plant
- Preventing reduction in power generation efficiency due to damage to panels
- Improves loss due to drone or manual inspection

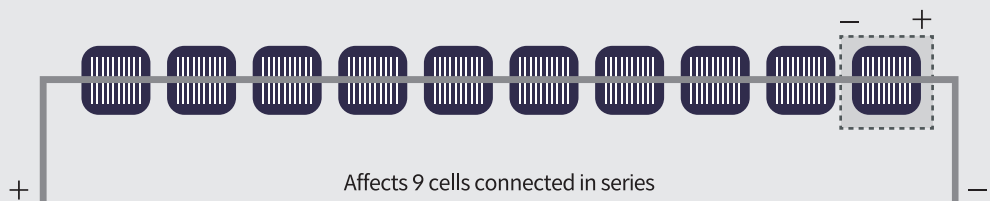
# Maintenance of Solar Power Plant,

## Problems that arise when solar panels are left unattended

### Occurrence of Overheating(Hotspot)

Shading of the panel surface due to contaminants causes overheating in which electricity is concentrated

→ It affects **whole of the solar panel** that connected in series, **causing the failure**



### Site where SunRobot application is essential



Solar Power Plant located in heavy snow area in winter



Floating Solar Power Plant



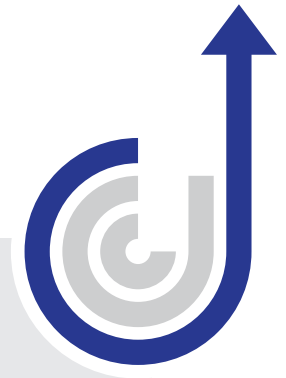
Solar Power Plant built on a high ground

↓  
"Zero" power generation when Solar Panels **covered by snow**

↓  
Need 365 days care due to **bird droppings**

↓  
**Solar panels left unattended** due to human casualties concerns





# SunRobot can take responsibility

## Comparative Analysis Before and After SunRobot Cleaning Case

### ■ Field Demonstration Test Overview

- Test Site : **D Power Plant in Korea**
- Test Period : January 2019, for a month
- Test Result :

- power generation efficiency **7.7%** ↑ improved
- Snow removal capacity **90%** ↑ or more

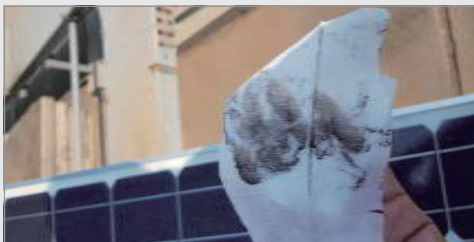
### ■ KTL(Korea Testing Laboratory) Test Result

- power generation efficiency **13.2%** ↑ improved



Installation site in power plant

### Comparison of status before and after cleaning (dust)



Before cleaning



After cleaning

### Comparison of status before and after cleaning (snow)



Before cleaning



After cleaning



Scan-type Solar Panel Cleaning Robot (ES-SRS)

## Scan-type Solar Panel Cleaning Robot suitable for large & long solar power plant

### ⚙️ Key application techniques

#### Module Assembly Design

- robot cleaner part can be connected and disconnected depending on the panel arrangement
- Simplify and lighten robot structure for easy connection and disconnection
- Easy installation and affordable entry-level robot for commercial and home use



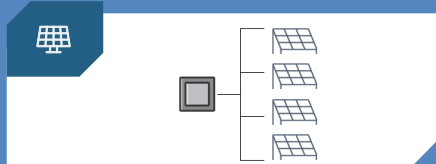


## ⚙️ Installation Site



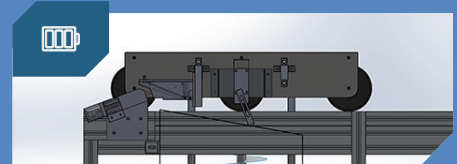
- Module type of structure allows extension depends on panel size (standard 1.5~9m)
- Automatic control cleaning speed by environment

## ⚙️ Features



### Snow/Rain Auto Detection

- Send information to SunRobot when snow/rain is detected
- Moving speed control  
standard 40m/min(2.4km/h)  
Maximum(snow) 60m/min(3.6km/h)



### Solar Power Self-charging

- Station self-charging 200W
- Movable self-charging 80W (Optional)
- Battery 2 hours charging and 4 hours using



### Module Assembly type

- Module assembly (standard 1.5~9m)
- Various width of panels available
- Customized manufacturing
- Reducing price as module type mass production (20% cheaper than other)



### Stable Moving Body

- Wheels attached in each modules to prevent bending
- Prevent slippery using stable moving in snow and rain
- High speed moving (2 to 4 times high speed compare other)



### Timer setting

- Timer function is available to automatic move in specific time
- Remote control is available using laptop, application and etc.



### Spiral type Brush

- Maximization dust removal effect
- Product design for easy brush replacement

## ⚙️ Specifications

Category	Capacity	Category	Capacity
Name	Scan-type Solar Panel Cleaning Robot	Battery Type	LiFePO4
Model	ES-SRS	Charging time	2h
Power Consumption	170W	Driving Time	4h
Rated Voltage	24V	Cleaning Mode	Manual / Auto(Timer setting)
Driving Speed(*)	25 ~ 60m/min	Cleaning Efficiency	80~240m <sup>2</sup> /min
Climbing Capacity	30 ± 5°	Total Weight	54kg (standard 1.5m X 2ea)
Operating Temperature	-20 ~ 70°C	Size	W540 X L3200 X H320 (mm)

(\*) Depends on installation site



Vertical-type Solar Panel Cleaning Robot (ES-VSM)

## Vertical-type Solar Panel Cleaning Robot suitable for rooftop or wide solar power plant

### ⚙️ Key application techniques

#### Solar Panel Cleaning Robot Drive Platform Technology

- Driving by guide
- Vertical Driving and Docking
- Slopeable Drive System
- Adsorption Drive Mechanism
- Lift Rotation Mechanism to prevent damage to Solar Panel

#### Location recognition and automatic control technology

- Autonomous Driving Algorithm
- Gap detection and outline detection technology



## Installation Site



- Clean more than 140m<sup>2</sup>/h
- Vertical(lift) driving minimizes panel damage
- Charged using the top auxiliary solar panel

## Features



### Cleaning Stains with Brushes

- Moving on the solar panel to zigzag driving mode, spray cleaning liquid, and clean it with a brush



### Vertical Self-Driving

- A robot that is separated from the main body and can drive vertically cleans wide solar panels



### Stable Docking System

- Adopt a guide to move the top of the solar panel
- Horizontal movement is possible through the robot's guide device without additional rail installation



### Charging with Auxiliary Charging Unit (10W solar panel)

- Auxiliarily charge the robot via a solar panel installed on the robot top

## Specifications

Category	Capacity	Category	Capacity
Name	Vertical-type Solar Panel Cleaning Robot	Battery Type	LiFePO4
Model	ES-VSM	Charging time	3h
Power Consumption	70W	Driving Time	5h
Rated Voltage	24V	Cleaning Mode	Manual / Auto(Timer setting)
Driving Speed(*)	8~11 m/min	Cleaning Efficiency	140m <sup>2</sup> /min
Climbing Capacity	5~40°	Total Weight	25kg
Operating Temperature	-20 ~ 70 °C	Size	W730 X L630 X H260 (mm)

(\*) Depends on installation site



Removable Docking Station [ES-MSR]

## Removable Docking Station for move cleaning robot between solar power plant arrays

### ⚙ Characteristics

- A Removable Docking Station that allows the Solar Panel Cleaning Robot to move between arrays
- Suitable for small Solar power plants with multiple, narrow panel arrays
- Can improve performance compared to investment



## ⚙️ Installation Site



## ⚙️ Features



### Solar Power Self-charging

- Stationary self-charging 400W
- Battery 2 hours 30 minutes charging and 5 hours using



### Move Location

- Move along installed rails
- 4-wheel motor provides high travel stability
- Position recognition using mechanical sensors
- Array position recognition via limit switch



### Angle Setting

- Adjust the station height to facilitate the movement of the cleaning robot
- Can adjust the height of the station's top and bottom at the same time



### Return to Original Position

- Auto-return after all array cleaning is complete
- Perform self-origin adjustment after return to original position
- Self-origin adjustment prevents motion errors

## ⚙️ Specifications

Category	Capacity	Category	Capacity
Name	Removable Docking Station	Battery Type	LiFePO4
Model	ES-MRS	Charging time	2h 30min
Power Consumption	200W	Driving Time	5h
Rated Voltage	24V	Cleaning Mode	Manual / Auto(Timer setting)
Driving Speed(*)	10m/min	Operating Temperature	-20~70°C
Angle Setting Time	1min 30cec	Size	W540 X L3200 X H320

(\*) Depends on installation site



Solar Panel Surface Inspection Equipment [ES-ISR]

## Solar Panel Surface Inspection Equipment that can automatically inspect all solar panels for faults

### ⚙ Characteristics

- Automatically inspect solar panel surfaces while moving
- Real-time transmission of accurate location of fault panels, such as short circuits on panels



## Installation Site



Inspect Solar Panels

## Features



### Characteristics

- Contactless inspection sensor
- Utilize multiple/multiple sensors
- Thermal imaging camera mountable
- Detachable inspection equipment



### Inspection

- Broken Circuit Inspection - Inspection of breakage
- IV TEST - Module fault check
- Inspect Panel Surface Cracks



### Accuracy

- Defect detection rate: 90%
- Diagnostic accuracy 97%
- IP55



### Defect Detection

- Save events and notify users when faults are detected
- Check the Fault Panel Image on the Monitoring Server

## Specifications

Category	Capacity	Category	Capacity
Name	Solar Panel Surface Inspection Equipment	Operating Temperature	-20 ~ 70°C
Model	ES-IRS	Size	W260 x L400 x H375 (mm)
Panel Defect Detection Accuracy	92%	Panel Diagnostic Fault Accuracy	95%
IP	55		

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