



# ROBOTIC MODULE CLEANING

NOV 29, 2018 – ATA INSIGHTS WEBINAR

Energy Guru®

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# AGENDA

1. About Energy Guru
2. Need for waterless cleaning of modules
3. About Water based cleaning requirements
4. Indian Soiling Conditions
5. Labour and Water Scenario In India
6. Solar Power Plants and Difficult Terrain
7. What can Indian Developers afford to buy
8. Effects of water on Solar Modules
9. SolarDuster Product Overview
10. Conclusions, Q&A



# About Energy Guru

- Founded in 2007 by CEO, co-founder, Geetanjali Choori
- Utility-scale Solar Power Plant Advisory and International Financing
- 2010-15 MNRE empaneled manufacturer of Large Aperture Parabolic Trough Concentrating Solar Thermal Boiler
- 2016 -Agriculture Solar Dryer: First Generation full cycle pilot done including market linkage for dried produce. Second generation dryer under development.
- 2017-Robotic module cleaning system





# The Team



- Electronics Engineers
- Fabricators
- Mechanical Engineers
- Assembly Workers
- Analytics
- Cloud-IT



**Geetanjali Patil Choori**

CEO & Co-Founder

- BS, MS in Electronics, Electrical/Industrial Drives Engg & GMP from IISc.
- Left high-profile job in US financial services to start Energy Guru.
- Award Winner of Hind Rattan and Nominated for CSP Today India Personality of The Year 2013.



**Unvesh Choori**

President & Co-Founder

- BS degree in Chemical Engineering from Indian Institute of Technology (IIT), MS degree in Chemical & Environmental Engg from Univ. of Oklahoma & MBA from top-ranked Univ. of Michigan, Ann Arbor.
- Leadership in start ups & large companies like GE, IBM, Capital One Finance, WIZQ



**Rohit Chavade**

Project Director

- B.Tech Chemical (UDCT), MBA - Director, Marketing
- Expertise in Chemical Dyes, Fabrication
- Leading the manufacturing plant setup.

Energy Guru Confidential





# Water Situation in India

- 60 % Population still dependent on farming.
- Biggest drought in 2014-2016 in India; especially in Marathawada
- Water to my town brought by Train
- Ground water used to be 100 ft and now it is over 1000 ft and depleting.
- When Solar grew exponentially in India, so did the farmer committed suicides in thousands of numbers!
- Water is controlled by local leader usually and so are operations folks. Agitations always on the brink.





# Soiling Levels in India

- 0.2% to 0.5% per day depending upon region
- Typical cleaning once in 15 days with ground water or well water through tankers.
- 60% of the water for cleaning of modules from bore-wells
- 3-6% drop in power generation
- RO may be a few plants might be using.





# Do we have water?

10,000 to 20,000 litres needed per MW per Wash



# Solar Power Plants in India: The Terrain Scenarios

Not so perfect for heavy robots!





# Why Robotic Cleaning?

## Water based cleaning! How many follow the guidelines?

- Pressure on the module surface should be less than 1000 Pa.
- pH value must be between 6 and 9.
- Salt concentration cannot exceed 2‰.
- Discrepancy between water temperature and module temperature should be in the range of

### Effects of water:

- Scaling on glass
- Decoloration
- Rainbow spots on glass anyone



## Additional reasons for going with robotic cleaning:

- Human intervention can increase the risk of deaths due to electrocution due to broken cables.
- Remote and harsh terrains which makes it difficult for humans.
- Space between the two row is not much for the trucks to move around.
- Establishing roads for truck movement is expensive.

# Need of the hour to save water and energy losses

Water per Wash per MW	10000	Liters
Global Installation by 2017	387,000	MW
Washing Cycles	20	Per year
Total Water Used Globally per year	77.4	Billion Liters
Soiling Losses	0.1% to 0.5%	Loss per Day
Cleaning of modules	100 to 800	USD per MW per wash

According to GTM some big incumbents get in the game, the market has a lot of headroom. It expects the total amount of robot-washed PV to grow from 1,905 MW today to 6,103 MW in 2022.

According to Energy Guru, the estimates are based upon non-portable kind of robots. On an average 6 robots are required per MW for current players, whereas only one SolarDuster may be enough to clean 1MW or more. Which multiplies the number of GWs served. And also existing market of 387 can be served SolarDuster like portable players and not with the current expensive one row one robot players.





# Can developers afford to buy one row one robot?

- 1GW in 2012 to over 25GW at present and is expected to go up by over 100GW in coming 5 to 6 years!
- Tariff at one of the lowest Rs 2.44 / 3.3 US Cents for large projects.
- Cost of leading robots with one robot per row per MW comes to 15 to 30,000 USD for daily cleaning.
- Jump from current 15 day cleaning to daily cleaning is a big jump for most developers and may not opt for it.
- Difficult Terrain makes it difficult to implement conventional robots.



# Human Capital of India



- Indian farmers are looking for alternate income especially from the farms where it does not grow much.
- India's 2/3 population is under 35.
- Developers are promising jobs in lieu of their lands. Robots cannot take all their jobs. Rather teach them how to use robots.



# SolarDuster: A differently thought through process



- Saves water while helping power plants make more money



- No need for infrastructure changes



- 6 Different robotic models to suit the customer needs.



- Innovative, flexible and easy to operate



- Optimize operations, remote monitoring and control of duster activity



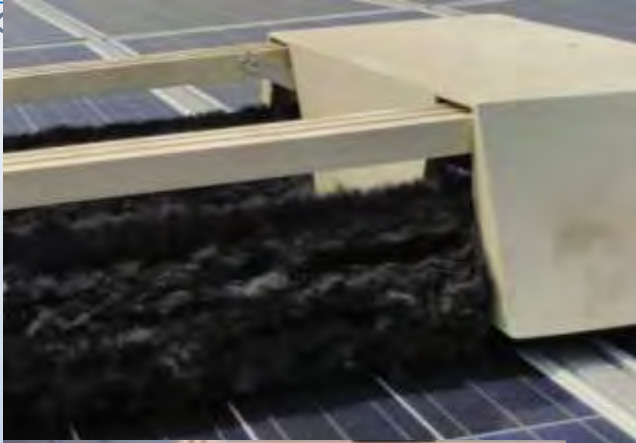
- Portable, can be moved one row to other by 2 people, attach to fixed docking station or mobile docking train



- Tracker Compatible

# SolarDuster Brush

## Soft Nylon Dense Brush: Excellent for sweeping dust softly.



- Nylon 6 with thickness 0.15mm
- Soft Nylon Bristles
- Hub (Core) - polypropylene
- Pipe - SS
- RPM: 100rpm



### Garflon Nylon Bristles



Our present Chairman, Shri C.B. Garwre was principally concerned with the development and manufacture of all the products in this Company, and he has to his credit, patents for Shrinkon Tubings, Tapered Nylon and Tublar Nylon.

"Garflon Bristles are offered in various types such as Nylon 6, 66 and 612, the most popular being the latter two. These bristles are used for tooth-brushes while Nylon 6 bristles are used for Shaving Brushes and industrial and household brushes.

Nylon Bristles are supplied in gauges ranging from .08mm to 2.50 mm, in natural and other colours. Garwares also manufacture Polypropylene Bristles.



# SolarDuster Tested with following soils

- Sandy Soil from DEWA, Dubai Site
- Karnool Solar Park: Fine dust from muddy area
- Soil mixed with cement powder
- Fine black soil
- California Sand
- Soils due large parking lots of large centre of the city plant

# All SolarDuster Models



Vertical Brush



Horizontal Brush



Motorized Manual



Robotic Train



For Frameless  
or thin film



For NEXTracker  
Brush Lifting



Thermographic  
Inspection System





# Model 1: SDH-4: **Horizontal Brush** SolarDuster



SPEED	RANGE (30 AH Battery)	WEIGHT	Time Per MW
<b>6.2</b> sqm/min	<b>230</b> Meters	<b>35</b> kg	<b>17</b> Hours
<b>1.5</b> m/min			
<b>3</b> Modules/min			

# Model 2: SDV-4: **Vertical Brush** SolarDuster



SPEED	RANGE (30 AH Battery)	WEIGHT	Time Per MW
<b>24</b> sqm/min	<b>1100</b> Meters	<b>~50</b> kg	<b>6</b> Hours
<b>6</b> m/min	<b>2200</b> Modules		
<b>12</b> Modules/min	<b>4400</b> Sqm		



# Model 3: SolarDuster™ Rover for Frameless / Glass-Glass Modules

1. Does not take support of modules frames.
2. Goes on module itself and cleans.
3. No infrastructure changes needed other than bridges, where necessary.



# Model 5: SolarDuster for NEXTracker

## 2m-Vertial Brush that can be lifted up for protrusions over module levels



SPEED	RANGE (30 AH Battery)	WEIGH T	Time Per MW
<b>38</b> sqm/min	<b>2.5 Hours</b>	<b>48</b>	<b>5.6</b> Hours
<b>9.47</b> m/min	<b>1200</b> Meters	kg	
<b>9</b> Modules/min			

Cleaning Angle remains same as that of current NEXTracker: 30° West





# One Robot for many rows!

Portable and handles act like stand



# SolarDuster NEXTracker Robot: Bringing Humans into picture





# SolarDuster Vertical Brush Robot:

Less than one min to move from one table to other.



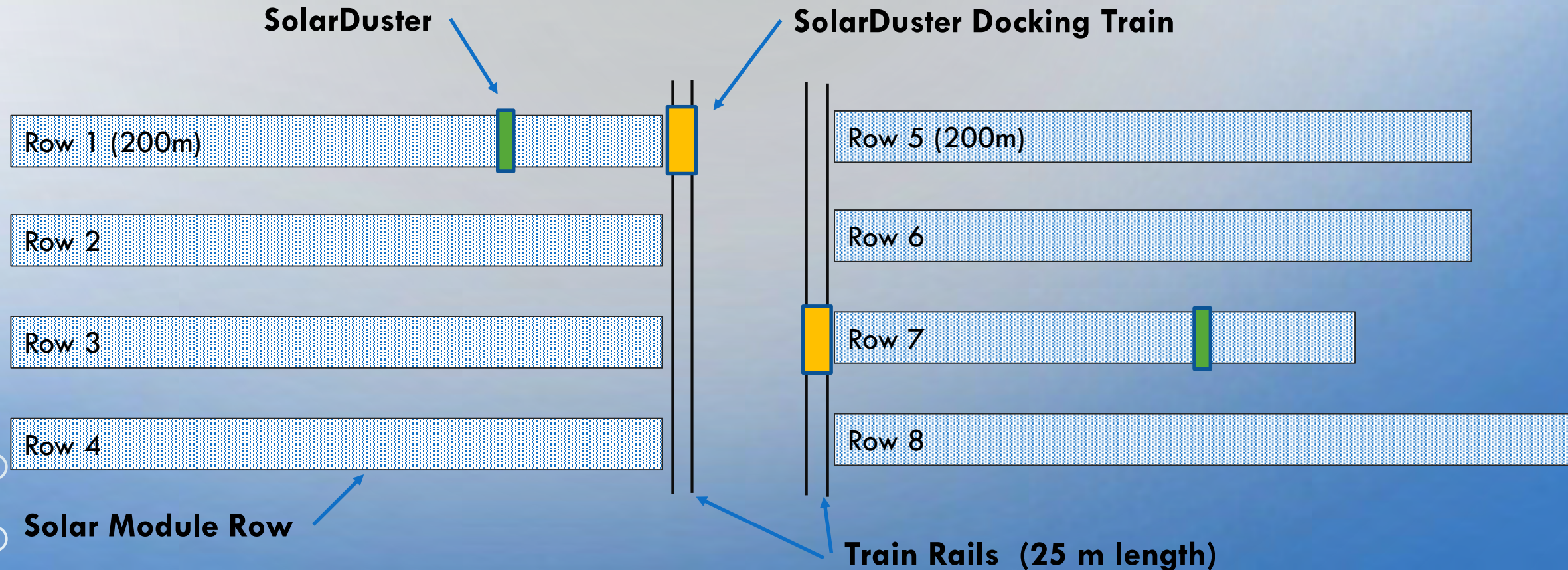
# Model 6: Full Automation for one robot multiple rows: Demonstrated at Softbank Site.





# Plant Layout for 1 MW – divided into 8 Rows

## 2 Robots for 4 rows each



# Solar Module Inspection System: with Testo

## Thermographic Camera

- 1] Unreached / top side modules with proper degree of thermal imager thru' robot. Hence no fault will go unattended.
- 2] No fatigue of hold camera continuously. Increases efficiency of inspections.
- 3] Thermography app extends feature of onsite reporting and onward transmission of reports.
- 4] Testo 872 give wider Field of View and 640 x 480 pixels with super resolution feature.
- 5] Auto focus
- 6] One can go behind the panel and see current, voltage and power status of faulty module along with the ambient temperature & humidity information by Blue Tooth interface of Testo clamp meter and thermos hygrometer.

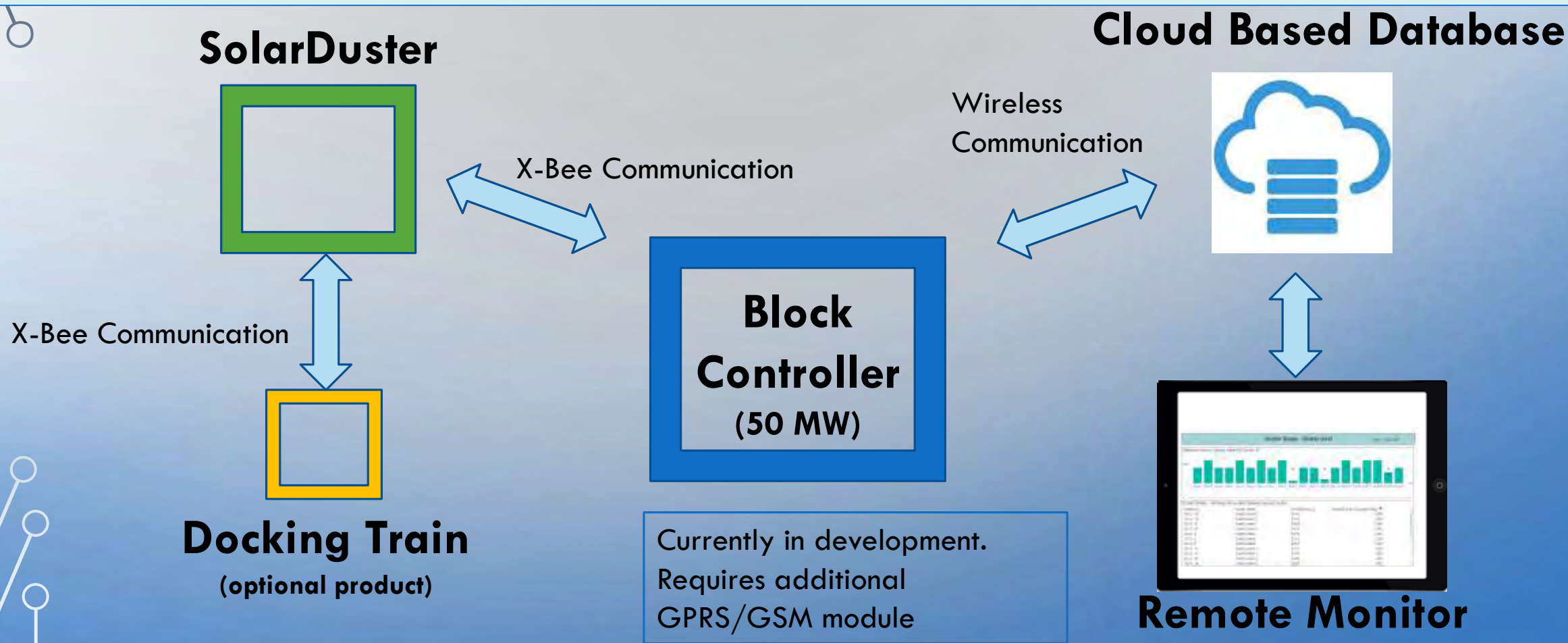


Testo  
Thermographic  
Camera  
Mounting

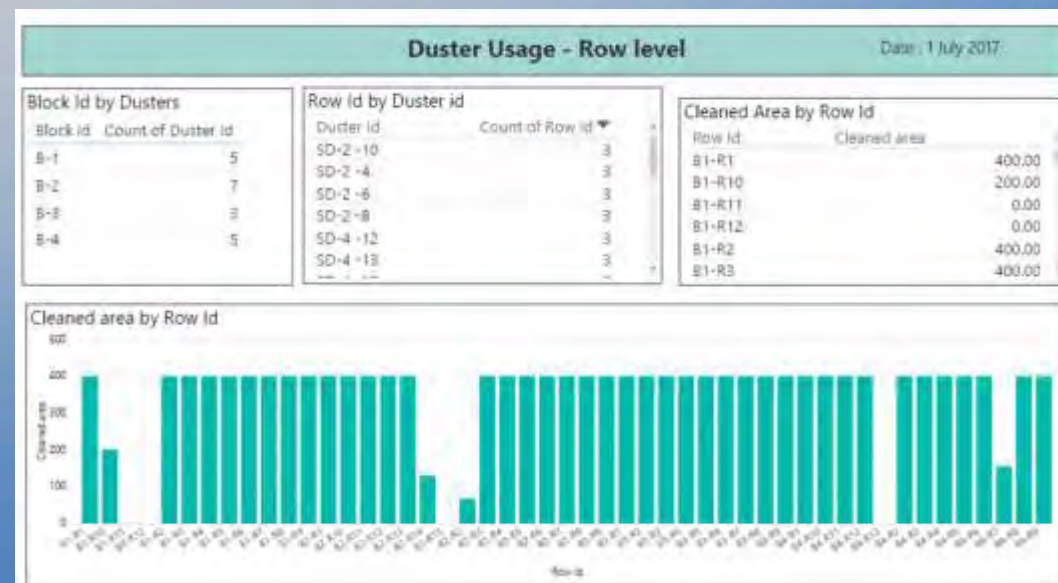
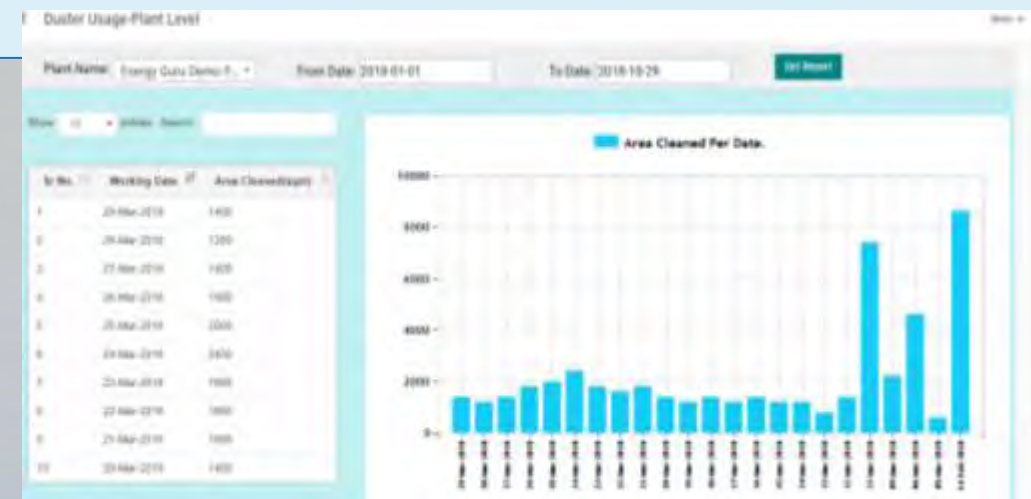




# Controller and Remote Monitoring System Architecture

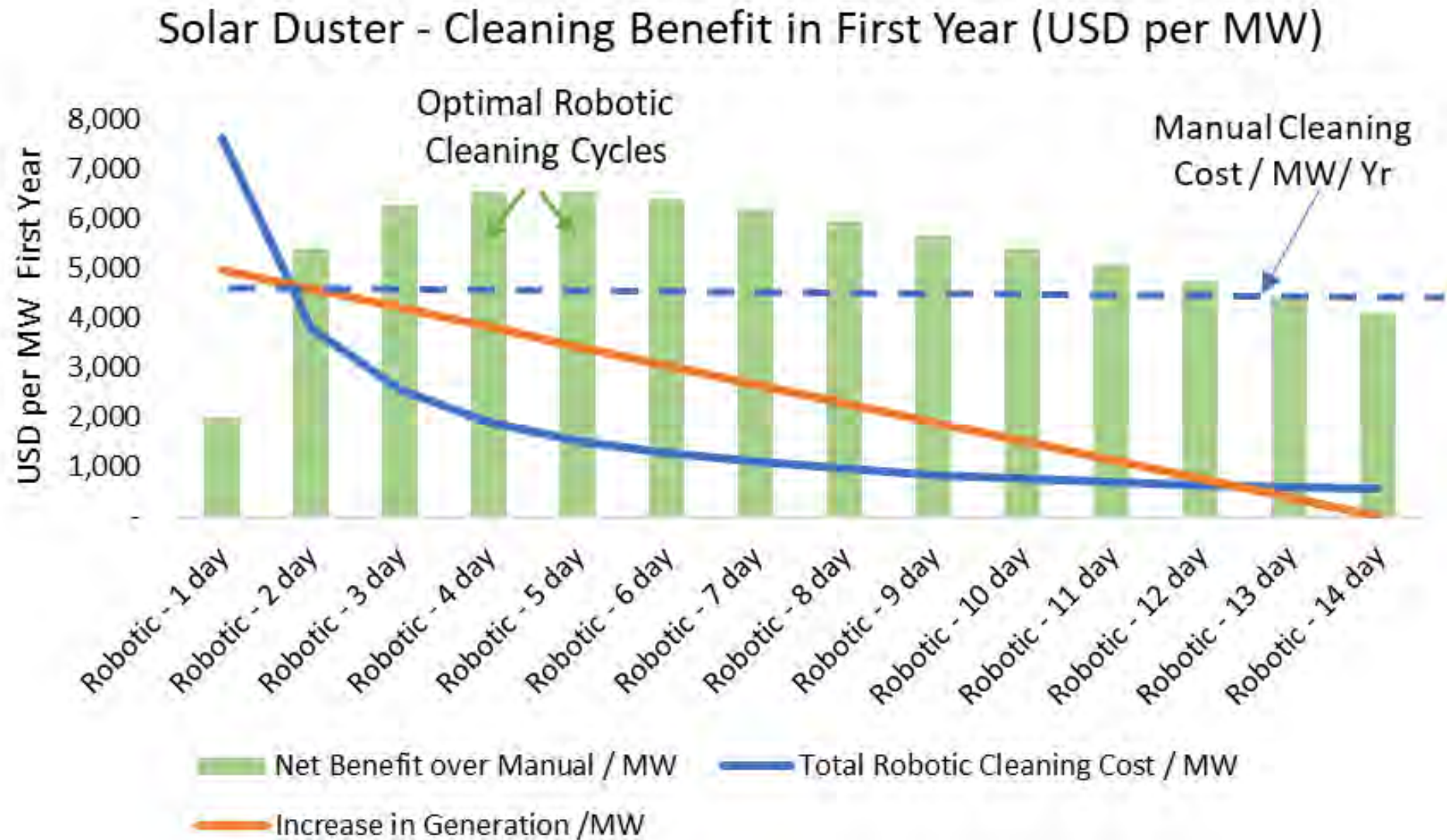


# Cloud Controlled, Remote Monitoring, Dashboards





# Economics of using Portable Robots



# Parameters to think for robotic cleaning

1. Water or Waterless
2. Cleaning Frequency
3. Labour Availability
4. Acceptable Weight of the system
5. Tracker or non tracker system
6. Cost of equipment
7. Infrastructure Changes
8. Speed of cleaning
9. Where to throw the dust
10. Kind of dust!

## Types of Robots or Waterless Systems in the Market

1. On Truck
2. On Module Frame
3. On Specially Made Rails
4. Drone Based



# Leading Global Solar Developers keen on SolarDuster NEXtracker and other Versions.



SB Energy  
SoftBank Group



Uneducated person can operate it and move around with very little training – Site Engineer Review





To reduce the soiling losses, reach out to us.

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