



# Solar Analytics: Changing the World One Solar Panel at a Time (IOT2026)

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# A Few of My Data Points

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 @dean\_j\_jackson

2, 9, 4, 20



# What I'll Enlighten You With

Solar 101

Building a Splunk add-on for REST API endpoints

Splunk metrics and event to metric conversions

Splunk IoT common information model (CIM)

Leverage Splunk Industrial Asset Intelligence (IAI)

Leverage the Splunk Essentials app for Industrial Control Systems (ICS)

Solar analytics solution



# Solar 101

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A beginner's guide to some things  
photovoltaic (PV)

**Every hour the sun beams more energy onto Earth than it needs to satisfy global energy needs for an entire year.**

National Geographic

# Understanding Solar Energy Terms

A watt (W) is a unit of **power**, and power is the rate at which energy is produced or consumed.

A watt-hour (Wh) is a unit of **energy**, and it's a way to measure the amount of work performed or generated.

100W  
**Power**



24h

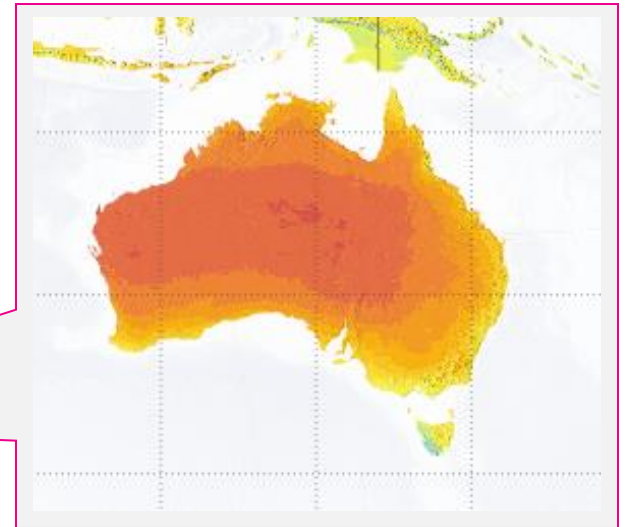
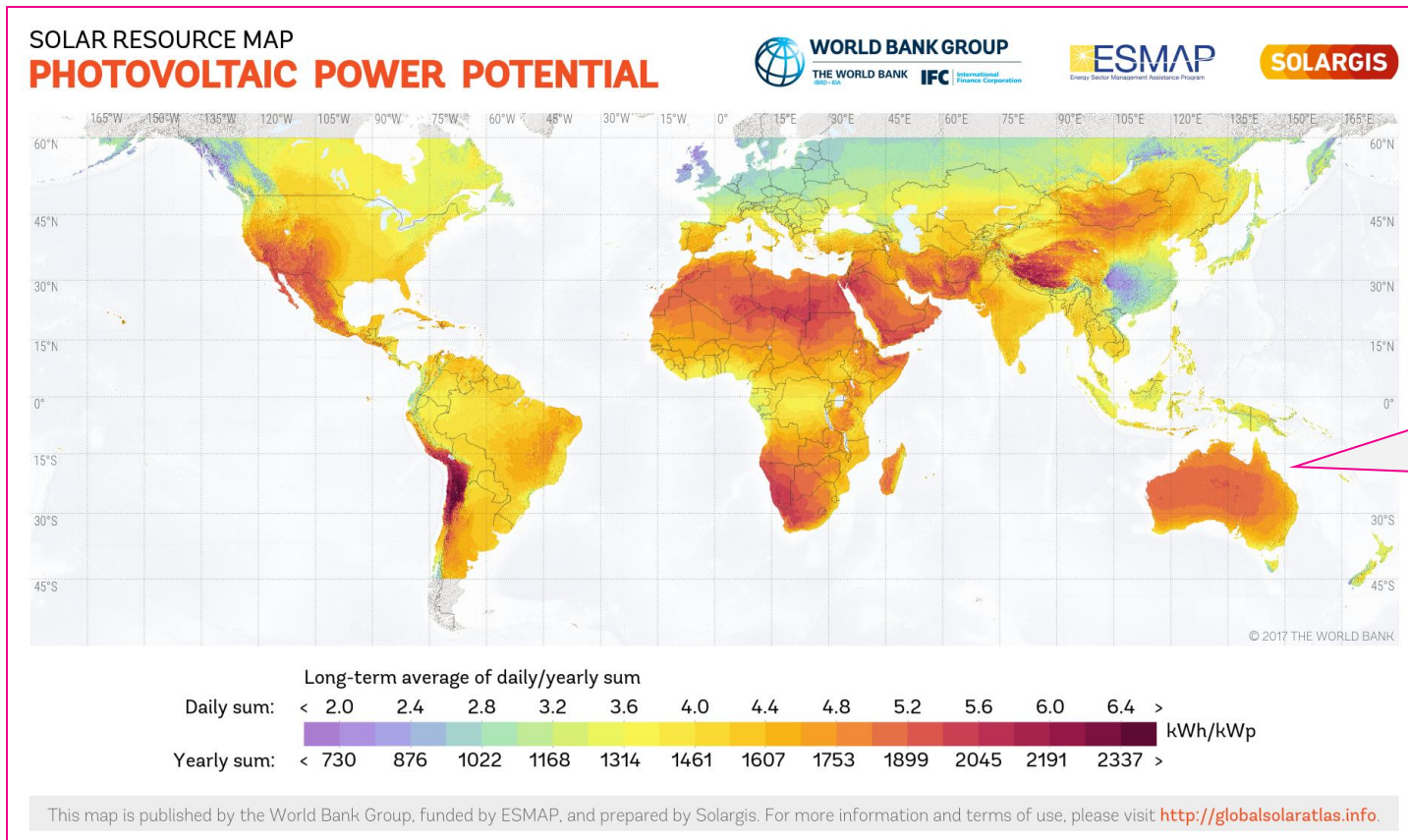


2400Wh  
**Energy**

# World Solar Energy Potential



Average home uses about **23 kWh** per day



About **4kWh** per day  
per square meter!

# Acting Locally: My Energy Solution

48 x LG Neon 2 Black (330W) solar panels  
48 x Enphase microinverters (S270 + iQ7+)  
2 x Tesla PowerWalls (gen2)



**POWERWALL**  
TESLA HOME BATTERY



# End to End Photovoltaics



15,840W

DC  
Power



12,800W

AC  
Power



900/1hr



67kg



27kWh

AC  
Energy

Energy Production

Up to 90kWh/day  
1kWh/m2

Energy Storage



# Getting Data In

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Building A REST API Add-On

# Getting Data In

- Solar production per panel
- Metering (not used)



Local API



Cloud API

REST Poll

- Solar production
- Battery usage
- Grid usage
- Site (home) usage



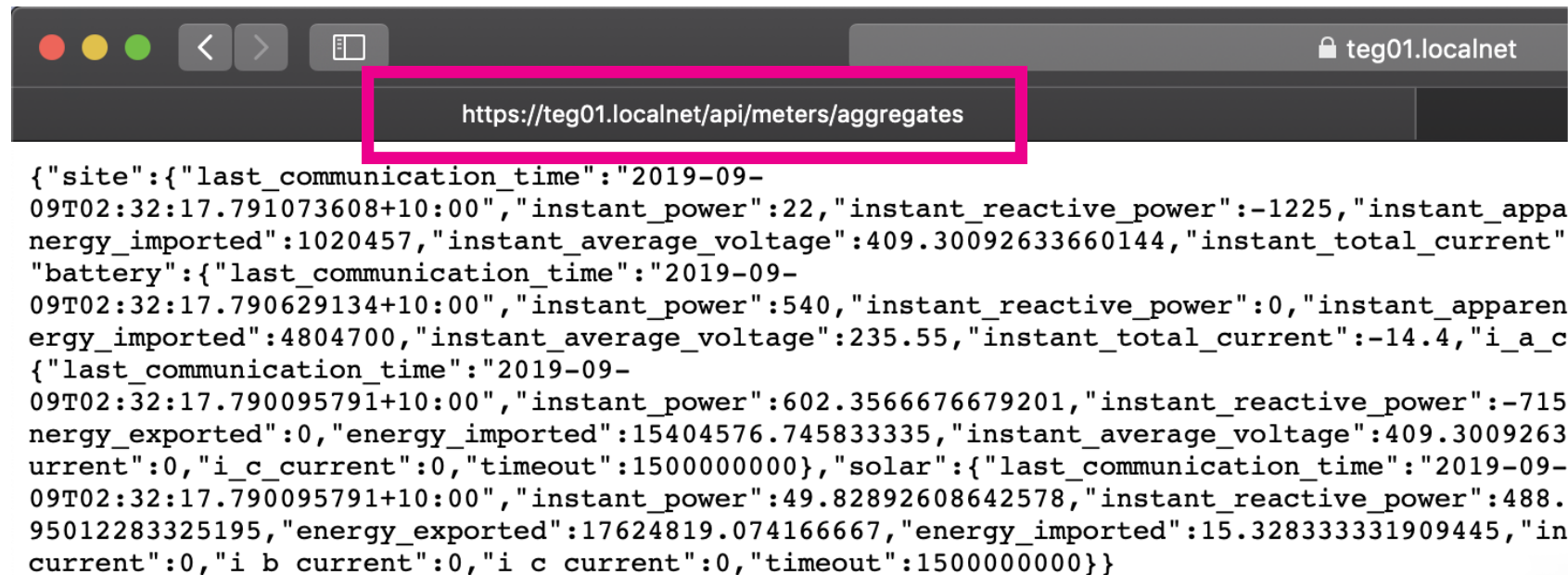
Local API



Cloud API

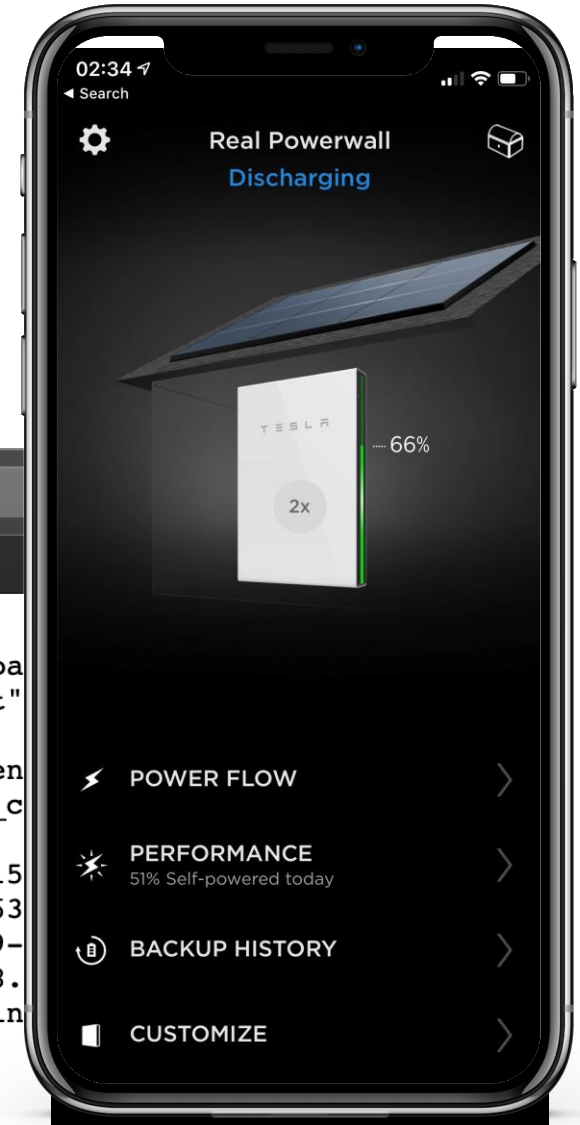
REST Poll

# Tesla Energy Gateway API



A screenshot of a web browser window. The address bar shows the URL `https://teg01.localnet/api/meters/aggregates`, which is highlighted with a red rectangle. Below the address bar, the JSON response of the API is displayed. The response contains data for the site, battery, and solar power systems, including communication times, power, voltage, and current.

```
{"site":{"last_communication_time":"2019-09-09T02:32:17.791073608+10:00","instant_power":22,"instant_reactive_power":-1225,"instant_apparent_power":22.36,"energy_imported":1020457,"instant_average_voltage":409.30092633660144,"instant_total_current":0.054,"i_a_current":0,"i_b_current":0,"i_c_current":0,"timeout":1500000000},"battery":{"last_communication_time":"2019-09-09T02:32:17.790629134+10:00","instant_power":540,"instant_reactive_power":0,"instant_apparent_power":540,"energy_imported":4804700,"instant_average_voltage":235.55,"instant_total_current":-14.4,"i_a_current":-4.8,"i_b_current":-4.8,"i_c_current":0,"timeout":1500000000},"solar":{"last_communication_time":"2019-09-09T02:32:17.790095791+10:00","instant_power":602.3566676679201,"instant_reactive_power":-715,"instant_apparent_power":602.3566676679201,"energy_imported":15404576.745833335,"instant_average_voltage":409.30092633660144,"instant_total_current":0,"i_a_current":0,"i_b_current":0,"i_c_current":0,"timeout":1500000000},"solar2":{"last_communication_time":"2019-09-09T02:32:17.790095791+10:00","instant_power":49.82892608642578,"instant_reactive_power":488.95012283325195,"instant_apparent_power":49.82892608642578,"energy_imported":15.328333331909445,"instant_average_voltage":235.55,"instant_total_current":0,"i_a_current":0,"i_b_current":0,"i_c_current":0,"timeout":1500000000}}
```



# Splunk Add-On Builder

On Splunkbase (free)

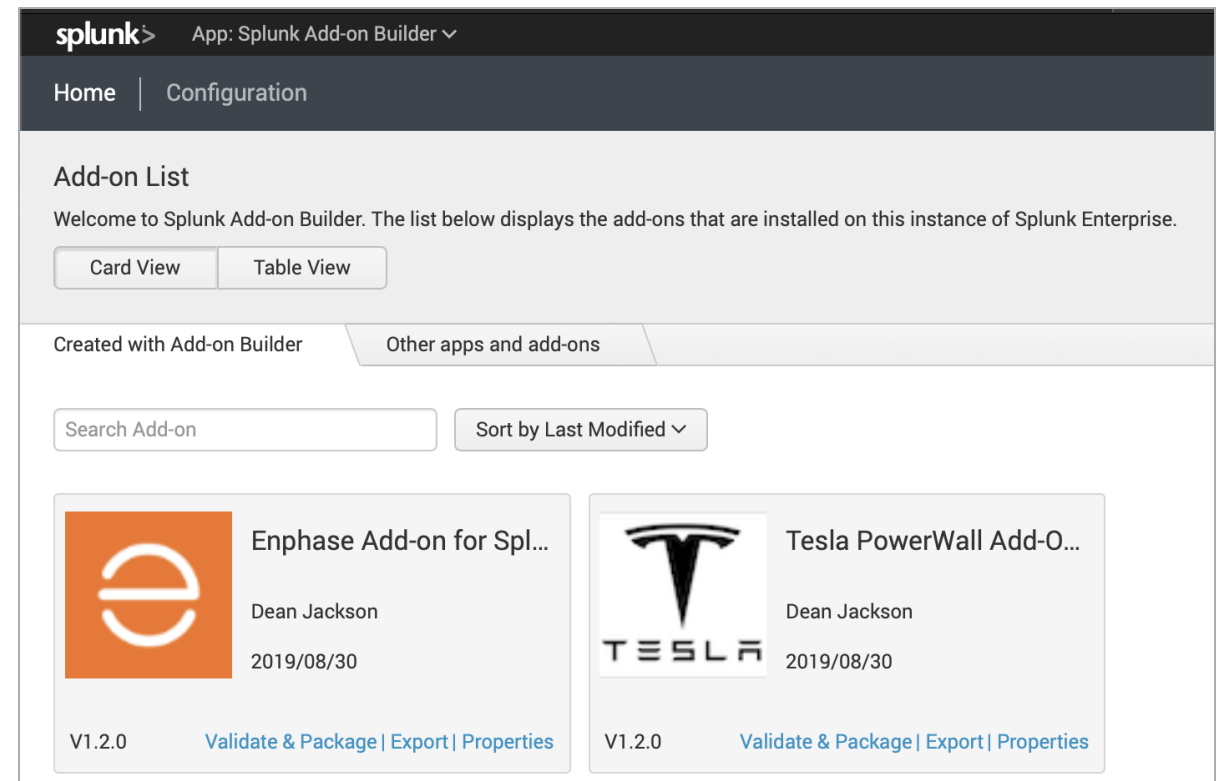
Guide you through all of the necessary steps of creating an add-on

Maintain CIM compliance

Maintain quality of add-ons

Validate and test the add-on

Also does alert actions!



# Splunk Add-On Builder

Create new add-on

Configure data collection

The screenshot shows the Splunk Add-on Builder interface. The top navigation bar includes 'splunk>', 'App: Splunk Add-on Builder', and various user and system links. The main content area is titled 'Add-on: Tesla PowerWall Add-On for Splunk' and includes a welcome message. Two primary action buttons are visible: 'Configure Data Collection' (highlighted with a red box) and 'Create Alert Actions'. Below these, an 'Add-on Summary' section displays five metrics: Validation Score (-), Data Inputs (10), Extracted Fields (0), Event Types (0), and Alert Actions (0).

Add-on Summary				
Validation Score	Data Inputs	Extracted Fields	Event Types	Alert Actions
-	10	0	0	0

# Splunk Add-On Builder

Specify sourcetype

Give it a description

Set a default interval for collection

Also supports basic auth if required

splunk> App: Splunk Add-on Builder

**Edit Data Input**

Inputs & Parameters Define & Test

Data Input Properties Data Input Parameters Add-on Setup Parameters

Define the properties of your data input. [Learn More](#)

\*Source type name:  
tesla:powerwall:solar

\*Input display name:  
tesla:powerwall:solar

\*Input name:  
tesla\_powerwall\_solar

Description:  
Solar energy production. Positive numbers indicate energy production from solar to the site. Negative numbers indicate sending energy from the site to

\*Collection interval:  
30 seconds

# Splunk Add-On Builder

Specify REST URL

Can use variables, set in add-on setup parameters

Variable format is:

```
${__settings__.additional_parameters.  
tesla_gateway_ip}
```

Purpose is to setup once

splunk> App: Splunk Add-on Builder

**Edit Data Input**

Inputs & Parameters Define & Test

Define the data input

Fill out the form below to define your data input, enter variables to pass to the script, then click **Test** to preview the results. [Learn](#)

Data Input Definition	Add-on Setup Parameters	Output:								
<p><b>REST settings</b></p> <p>REST URL</p> <p><code>http://\${__settings__.additional_parameters.tesla_gateway_ip}/api/meters/aggregates</code></p> <p>REST method</p> <p>GET</p> <p>REST URL parameters</p> <table border="1"><thead><tr><th>Name</th><th>Value</th></tr></thead><tbody><tr><td></td><td></td></tr></tbody></table> <p><a href="#">New parameter</a></p> <p>REST request headers</p> <table border="1"><thead><tr><th>Name</th><th>Value</th></tr></thead><tbody><tr><td></td><td></td></tr></tbody></table> <p><a href="#">New header</a></p> <p><b>Data input parameters</b></p> <p>Enter a test value for the input parameters you defined in the</p> <p><a href="#">i</a> Input variables have not been defined</p>	Name	Value			Name	Value				
Name	Value									
Name	Value									

splunk> App: Splunk Add-on Builder

**Edit Data Input**

Inputs & Parameters

Define the data input

Fill out the form below to define your data input, enter variab


Data Input Definition	Add-on Setup Parameters
	<p><b>Additional Parameters</b></p> <p>*Tesla Gateway IP: (tesla_gateway_ip)</p> <p>teg01.localnet</p>

# Splunk Add-On Builder

Click test


Notice there are JSON path extraction capabilities

Have a look at user guide on [docs.splunk.com](https://docs.splunk.com) for details

Test to preview the results. [Learn more](#) 

Test

Save

Output:  Done

```
{
  "timeout":1500000000
},
"load":{
  "last_communication_time":"2019-09-09T02:52:11.190270024+10:00",
  "instant_power":669.1265158835619,
  "instant_reactive_power":-734.6278247066141,
  "instant_apparent_power":993.6842230264332,
  "frequency":0,
  "energy_exported":0,
  "energy_imported":15404793.272499999,
  "instant_average_voltage":408.63697352703326,
  "instant_total_current":1.6374595526885087,
  "i_a_current":0,
  "i_b_current":0,
  "i_c_current":0,
  "timeout":1500000000
},
"solar":{
  "last_communication_time":"2019-09-09T02:52:11.190270024+10:00",
  "instant_power":50.04653453826904,
  "instant_reactive_power":486.10291290283203,
  "instant_apparent_power":488.672382636781,
  "frequency":49.90053176879883,
  "energy_exported":17624835.60083333,
  "energy_imported":15.328333331909445,
  "instant_average_voltage":118.16206359863281,
  "instant_total_current":0,
  "i_a_current":0,
  "i_b_current":0,
  "i_c_current":0,
  "timeout":1500000000
}
}
```

Event extraction settings

If the response payload is an array, enter the JSON path to the array in the payload to use for breaking the data into individual events.

JSON path

solar

# Deploy Add-on

Install on Splunk HF

Enter IP address of Tesla Energy Gateway

Set inputs indexes and intervals

The image displays three screenshots from the Splunk web interface, illustrating the steps to deploy the Tesla PowerWall Add-On.

**Top Screenshot: Apps Page**  
The 'Apps' page shows the 'Tesla PowerWall Add-On for Splunk' highlighted with a red box. The breadcrumb path is 'splunk > enterprise'.

**Middle Screenshot: Configuration Page**  
The 'Configuration' page for the 'App: Tesla PowerWall Add-On for Splunk' shows the 'Add-on Settings' tab. The 'Tesla Gateway IP' field is set to 'teg01.localnet' and is highlighted with a red box. A 'Save' button is visible below the field.

**Bottom Screenshot: Inputs Page**  
The 'Inputs' page for the 'App: Tesla PowerWall Add-On for Splunk' shows a table of 10 inputs. The 'Index' column for the first four inputs ('solar', 'battery', 'grid', 'site') is set to 'tesla\_metrics' and is highlighted with a red box. The 'Index' for the remaining six inputs ('gateway\_config', 'gateway\_status', 'battery\_config', 'battery\_status', 'site\_config', 'site\_status') is set to 'tesla' and is also highlighted with a red box.

i	Name ^	Interval ⇅	Index ⇅
>	solar	60	tesla_metrics
>	battery	60	tesla_metrics
>	grid	60	tesla_metrics
>	site	60	tesla_metrics
>	gateway_config	60	tesla
>	gateway_status	60	tesla
>	battery_config	60	tesla
>	battery_status	60	tesla_metrics
>	site_config	60	tesla
>	site_status	60	tesla

# Data Ingested!

JSON format

Awesome data but these are all numeric values

And we don't need all these

Let's be efficient!!

✓ 320,010 events (before 08/08/2019 05:51:45.000) No Event Sampling ▼

Events (320,010) Patterns Statistics Visualization

Format Timeline ▼ — Zoom Out + Zoom to Selection × Deselect

List ▼ ✎ Format 20 Per Page ▼

< Hide Fields	≡ All Fields	i	Time	Event
SELECTED FIELDS a host 1 a source 2 a sourcetype 1  INTERESTING FIELDS a index 1 # linecount 1 a splunk_server 1  + Extract New Fields		>	28/07/2019 10:59:41.090	<pre>{   [-]   energy_exported: 15150596.514722222   energy_imported: 15.266944444444444   frequency: 49.95012283325195   i_a_current: 0   i_b_current: 0   i_c_current: 0   instant_apparent_power: 5865.133816729637   instant_average_voltage: 120.08288828531902   instant_power: 5824.0936279296875   instant_reactive_power: 692.6240692138672   instant_total_current: 0   last_communication_time: 2019-07-27T17:59:41.090402719-07:00   timeout: 1500000000 }</pre> <p>Show as raw text</p> <p>host = macmini.local   source = tesla_powerwall_aggregates_solar://Aggrega</p>



# Metrics vs. Events

---

So many choices!

# Events vs. Metrics

## An Event...

Single, multiline, different formats

Historically log data payload

Typically used for root cause and analysis

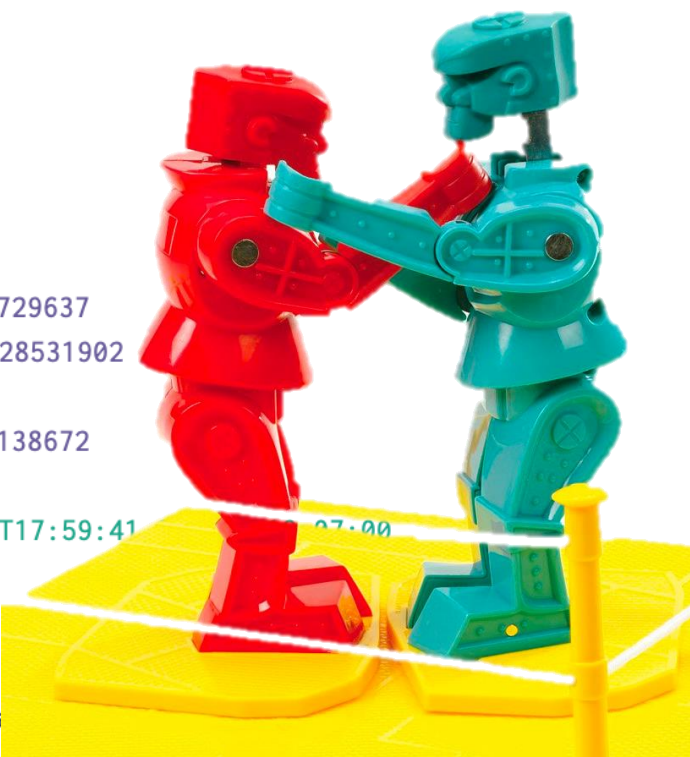
What we are used to in Splunk

Event

```
{ [-]  
  energy_exported: 15150596.514722222  
  energy_imported: 15.266944444444444  
  frequency: 49.95012283325195  
  i_a_current: 0  
  i_b_current: 0  
  i_c_current: 0  
  instant_apparent_power: 5865.133816729637  
  instant_average_voltage: 120.08288828531902  
  instant_power: 5824.0936279296875  
  instant_reactive_power: 692.6240692138672  
  instant_total_current: 0  
  last_communication_time: 2019-07-27T17:59:41  
  timeout: 1500000000  
}
```

Show as raw text

host = macmini.local | source = tesla\_powerwa



# Metrics vs. Events

## A Metric...

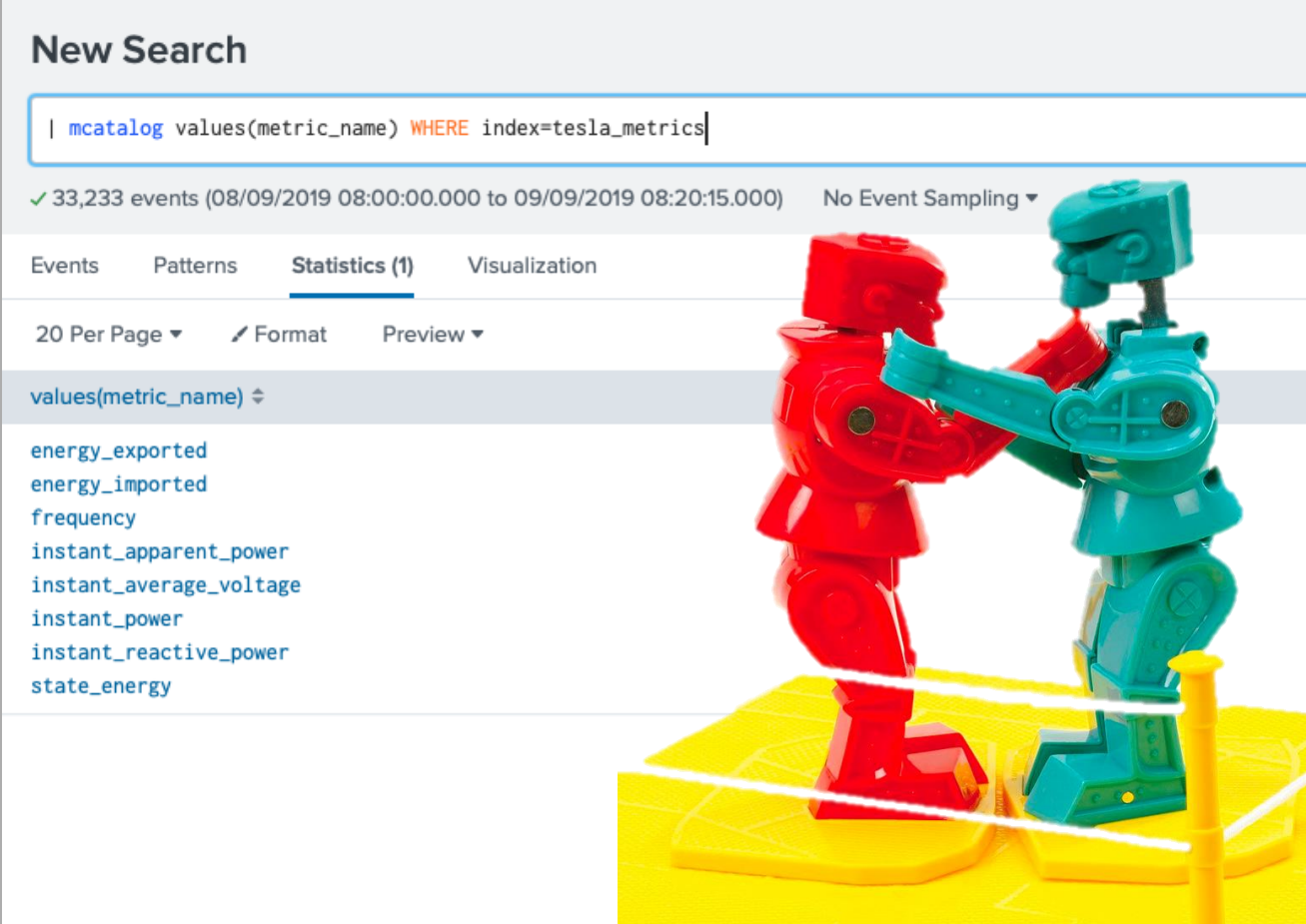
Contains:

- `Metric_name`
- `_time`
- `_value`
- `dimension`

Lightweight, numeric

SUPER FAST 😊

Used to support statistical analysis



The screenshot shows the Splunk Search interface. At the top, the search bar contains the query `| mcatalog values(metric_name) WHERE index=tesla_metrics`. Below the search bar, it indicates that 33,233 events were found for the time range 08/09/2019 08:00:00.000 to 09/09/2019 08:20:15.000, with 'No Event Sampling' selected. The interface has tabs for 'Events', 'Patterns', 'Statistics (1)', and 'Visualization', with 'Statistics (1)' currently selected. Below the tabs, there are options for '20 Per Page', 'Format', and 'Preview'. The main results area shows a list of metric names under the heading `values(metric_name)`: `energy_exported`, `energy_imported`, `frequency`, `instant_apparent_power`, `instant_average_voltage`, `instant_power`, `instant_reactive_power`, and `state_energy`. On the right side of the interface, there is a decorative image of two LEGO robots, one red and one blue, standing on a yellow base.

# Metrics Requirements

Supported Splunk 7.0+

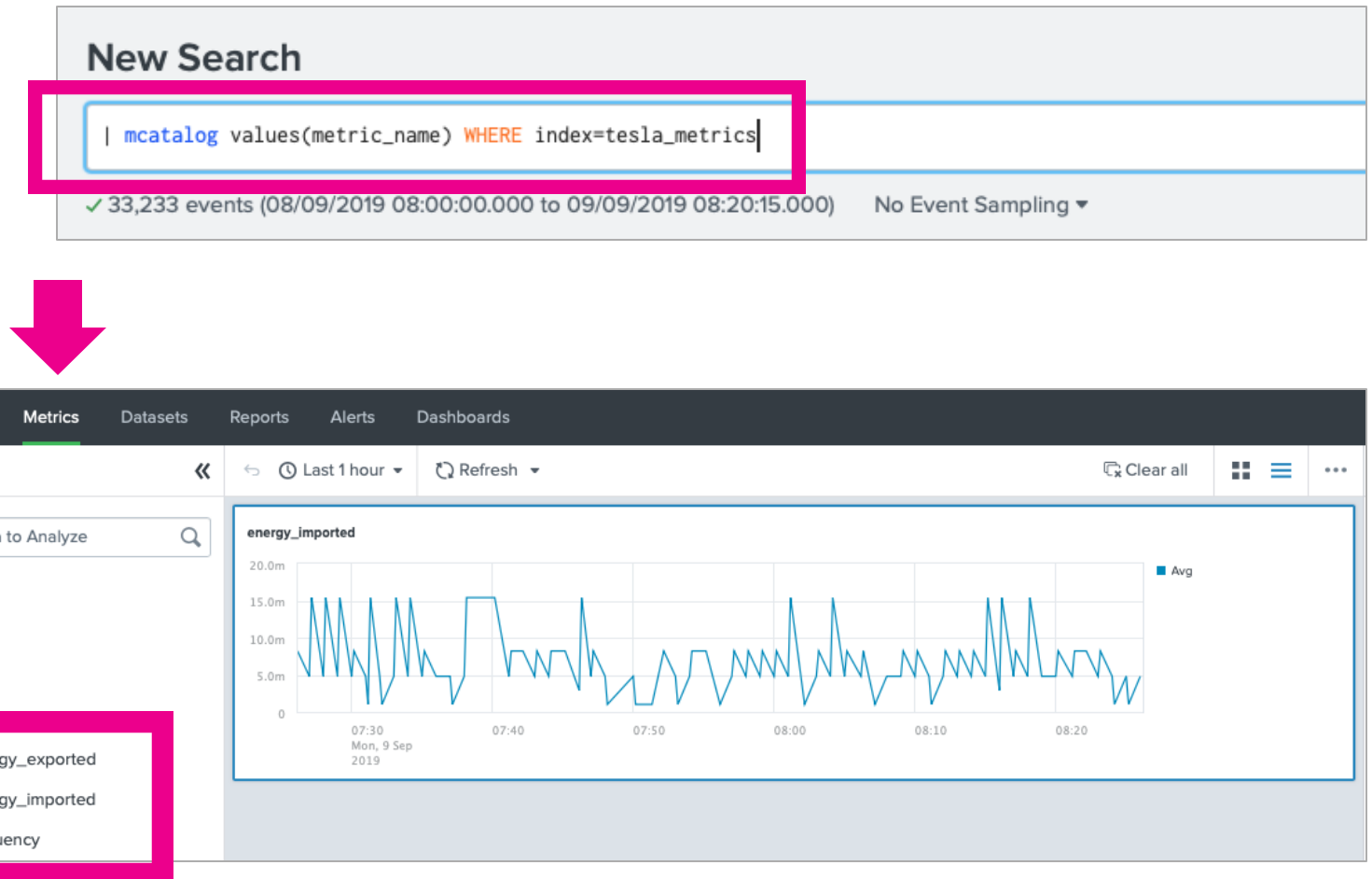
Require a metrics index

For ingest time log to metrics,  
require 7.2+

Forwarder version and type	Type of data	Indexer version required	Location of log-to-metrics configuration files
7.2+ Universal Forwarder	Structured	7.x	Universal Forwarder
Any Universal Forwarder version	Unstructured	7.2+	Indexer
7.2+ Heavy Forwarder	Structured	7.x	Heavy Forwarder
7.2+ Heavy Forwarder	Unstructured	7.x	Heavy Forwarder

# Did You Know...

There's a **metric workspace** in Splunk, it was an app, now embedded in search and reporting as of 7.3



# Did You Also Know...

Licensing was previously calculated at 150 bytes per metric

Licensing in 7.3+ is calculated based on ingestion and capped at 150 bytes

## How data is metered

For **event data**, data volume is based on the amount of raw external data that the indexer ingests into its indexing pipeline, after any filtering. It is not based on the amount of compressed data that gets written to disk.

For **metrics data**, each metric event is metered by volume on a scale similar to the scale used for event data. However, this scale is capped at 150 bytes. Metric events with volumes over 150 bytes are metered as if they are only 150 bytes. Metrics data does not use a separate license. Rather, it draws from the same license quota as event data.

**Summary indexing** and metric rollup summaries do not count against your license. Internal indexes, such as `_internal` and `_introspection`, also do not count against your license.

<https://docs.splunk.com/Documentation/Splunk/7.3.1/Admin/HowSplunklicensingworks>

# Event to Metric Conversion

Only need a few values

There are all numerical and will be used with stats (mstats)

Done at Splunk forwarder (UF or HF)

## Event

```
{ [-]
  energy_exported: 15150596.514722222
  energy_imported: 15.266944444444444
  frequency: 49.95012283325195
  i_a_current: 0
  i_b_current: 0
  i_c_current: 0
  instant_apparent_power: 5865.133816729637
  instant_average_voltage: 120.08288828531902
  instant_power: 5824.0936279296875
  instant_reactive_power: 692.6240692138672
  instant_total_current: 0
  last_communication_time: 2019-07-27T17:59:41.090402719-07:00
  timeout: 1500000000
}
```

Show as raw text

# Event to Metric Conversion: Splunk Web

Edit Source Type: tesla:powerwall:solar

Description: optional

Destination app: Tesla PowerWall Add-On for Splunk

Category: Log to Metrics

Indexed Extractions: json

Event Breaks | Timestamp | Metrics | **Advanced**

Name	Value	
CHARSET	UTF-8	x
DATETIME_CONFIG		x
INDEXED_EXTRactions	json	x
METRIC-SCHEMA-TRANSF-	metric-schema:solar_metrics	x
SHOULD_LINEMERGE	false	x
TRANSFORMS-solar_asset	solar_asset	x
category	Log to Metrics	x
disabled	false	x
pulldown_type	true	x
LINE_BREAKER	(\\r\\n)+	x
NO_BINARY_CHECK	true	x

New setting

Cancel Save

Measures

Blacklist

Edit Source Type: tesla:powerwall:solar

Description: optional

Destination app: Tesla PowerWall Add-On for Splunk

Category: Log to Metrics

Indexed Extractions: json

Event Breaks | Timestamp | **Metrics** | Advanced

Define measures and dimensions in your incoming data. [Learn More](#)

**MEASURES**  
Provide at least one measure. Unlisted measures are treated as dimensions.

instant\_average\_voltage, instant\_power, frequency, energy\_exported, instant\_apparent\_power, instant\_reactive\_power

Separate multiple measurements with commas.

**BLACKLIST**  
Provide one or more dimensions that should be omitted from the results.

energy\_imported, i\_a\_current, i\_b\_current, i\_c\_current, instant\_total\_current, timeout, last\_communication\_time

Separate multiple measurements with commas.

Cancel Save

# Event to Metric Conversion: Conf Files

## Props.conf

```
[tesla:powerwall:solar]
SHOULD_LINEMERGE = 0
category = Energy
pulldown_type = 1
INDEXED_EXTRactions = json
TRANSFORMS-solar_asset = solar_asset
METRIC-SCHEMA-TRANSFORMS = metric-schema:solar_metrics
```



Call transforms

## Transforms.conf

```
[metric-schema:solar_metrics]

METRIC-SCHEMA-BLACKLIST-DIMS = energy_imported, i_a_current,
i_b_current, i_c_current, instant_total_current, timeout,
last_communication_time

METRIC-SCHEMA-MEASURES = instant_average_voltage, instant_power,
frequency, energy_exported, instant_apparent_power,
instant_reactive_power
```



Ignore



Metric Name(s)

# Bonus!! – Adding Dimensions

## Props.conf

```
[tesla:powerwall:solar]
SHOULD_LINEMERGE = 0
category = Energy
pulldown_type = 1
INDEXED_EXTRactions = json
TRANSFORMS-solar_asset = solar_asset
METRIC-SCHEMA-TRANSFORMS = metric-schema:solar_metrics
```



Call transforms

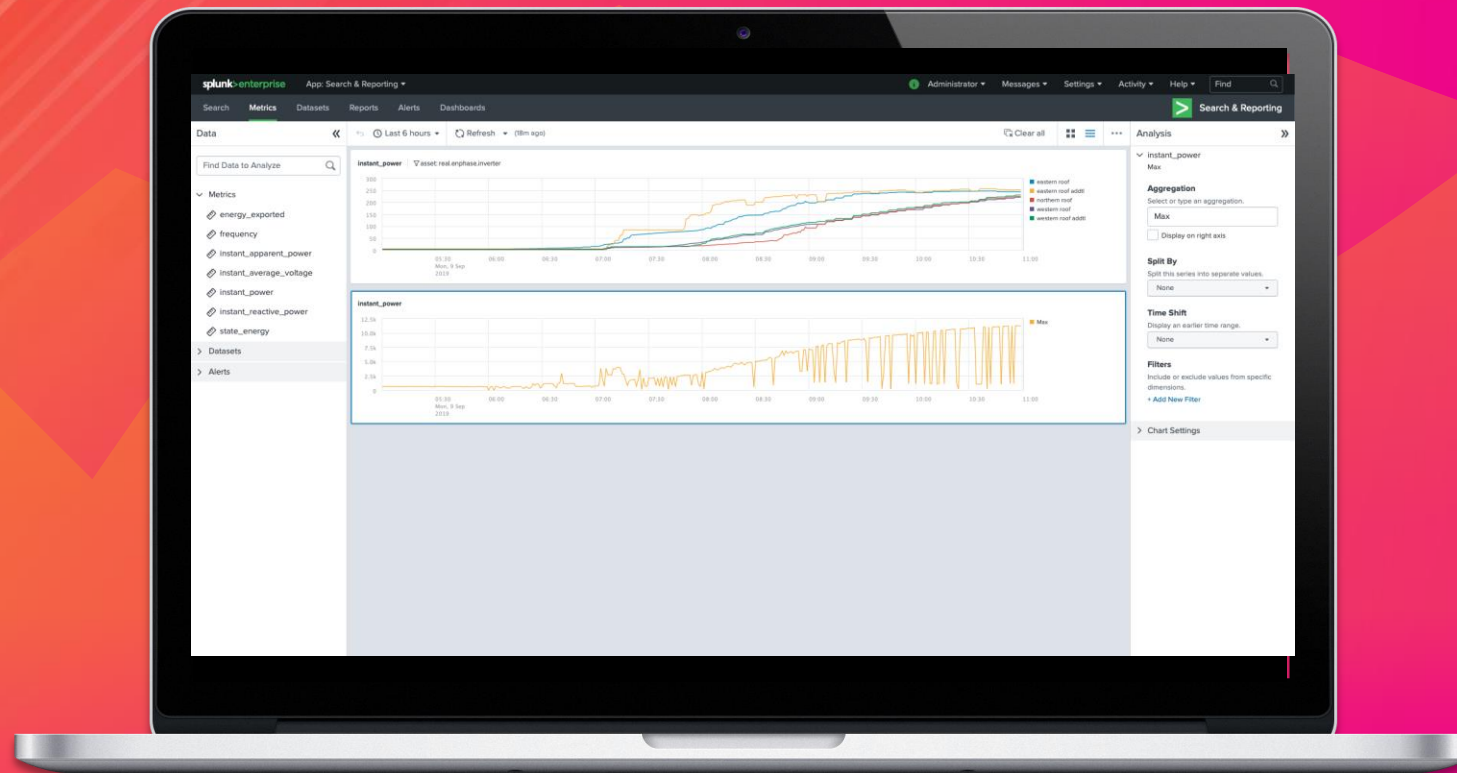
## Transforms.conf

```
[solar_asset]
INGEST_EVAL = asset="powerwall.solar", category="solar",
location="real"
```



Dimensions

# Demo: How To Browse Metrics



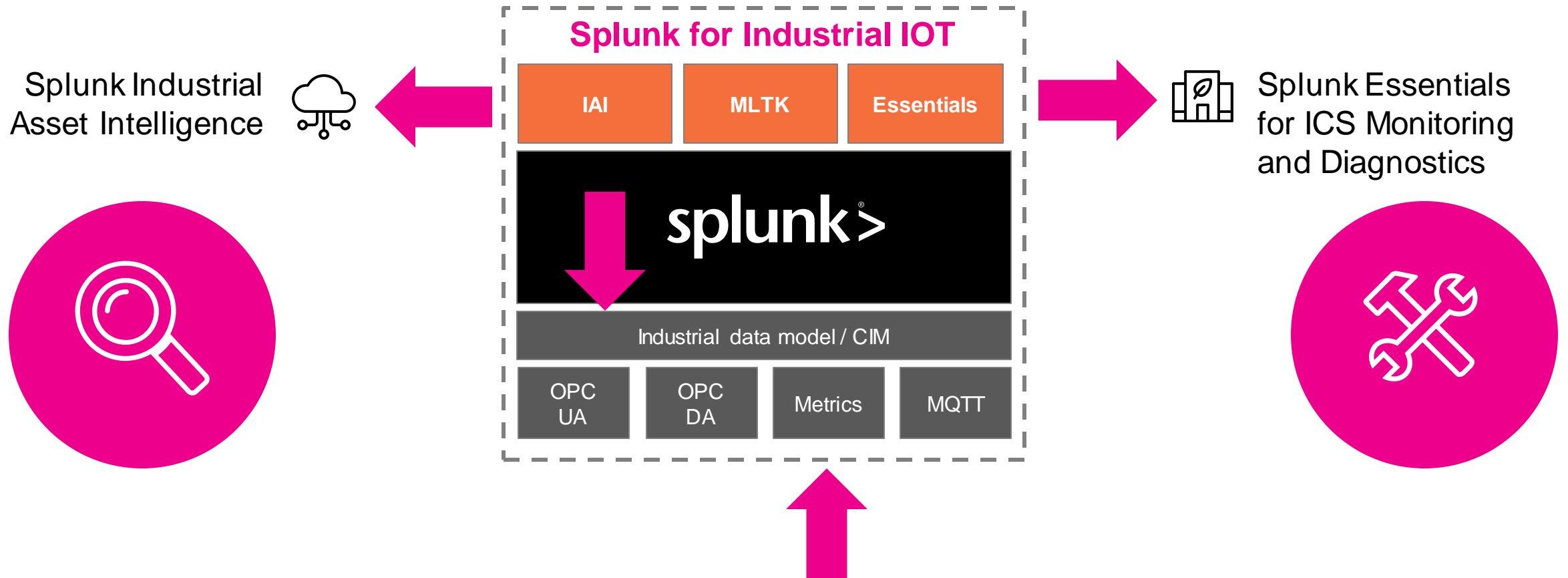


# Splunk IAI

---

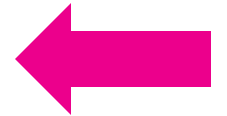
Monitor and investigate Metric Data

# Using Splunk for Industrial IoT Suite



# Splunk IoT Common Information Model

Field	Type	Required?	Description
_time	time	Required field for all metrics data.	The timestamp of the metric in UNIX time notation.
_value	string	Required field for all metrics data.	The numeric value of the metric. This field is a 64-bit floating point number, which supports precision between 15 and 17 decimal digits.
metric_name	string	Required field for all metrics data.	The name of the metric. In Splunk IAI, the metric_name must not contain dot notation.
asset	string	Required dimension field for IAI.	Represents the name of the asset, device, or sensor that is generating or monitoring the metric. To facilitate data association in Splunk IAI, you can use dot notation to describe the full path to the asset as defined by your asset hierarchy, but this is not required.
quality	string	Optional dimension field for IAI.	Quality associated with the generated metric.
metric_type	string	Optional dimension field for IAI.	Type of metric. Defaults to "gauge", the only supported type of metric.
status	string	Optional dimension field for IAI.	Captures the status of the asset when the metric was generated.
unit	string	Optional dimension field for IAI.	Unit of the metric.



# Energy Data in IAI

## Asset Hierarchy

L0	L1
powerwall	grid
powerwall	site
powerwall	battery
powerwall	solar

## POWERWALL

TESLA HOME BATTERY

Metric\_name: instant\_power

Location: real

Asset: powerwall.solar

Category: solar (battery, grid, site)

L0	L1
enphase	inverter

## [e]enphase ENERGY

Metric\_name: instant\_power

Location: real

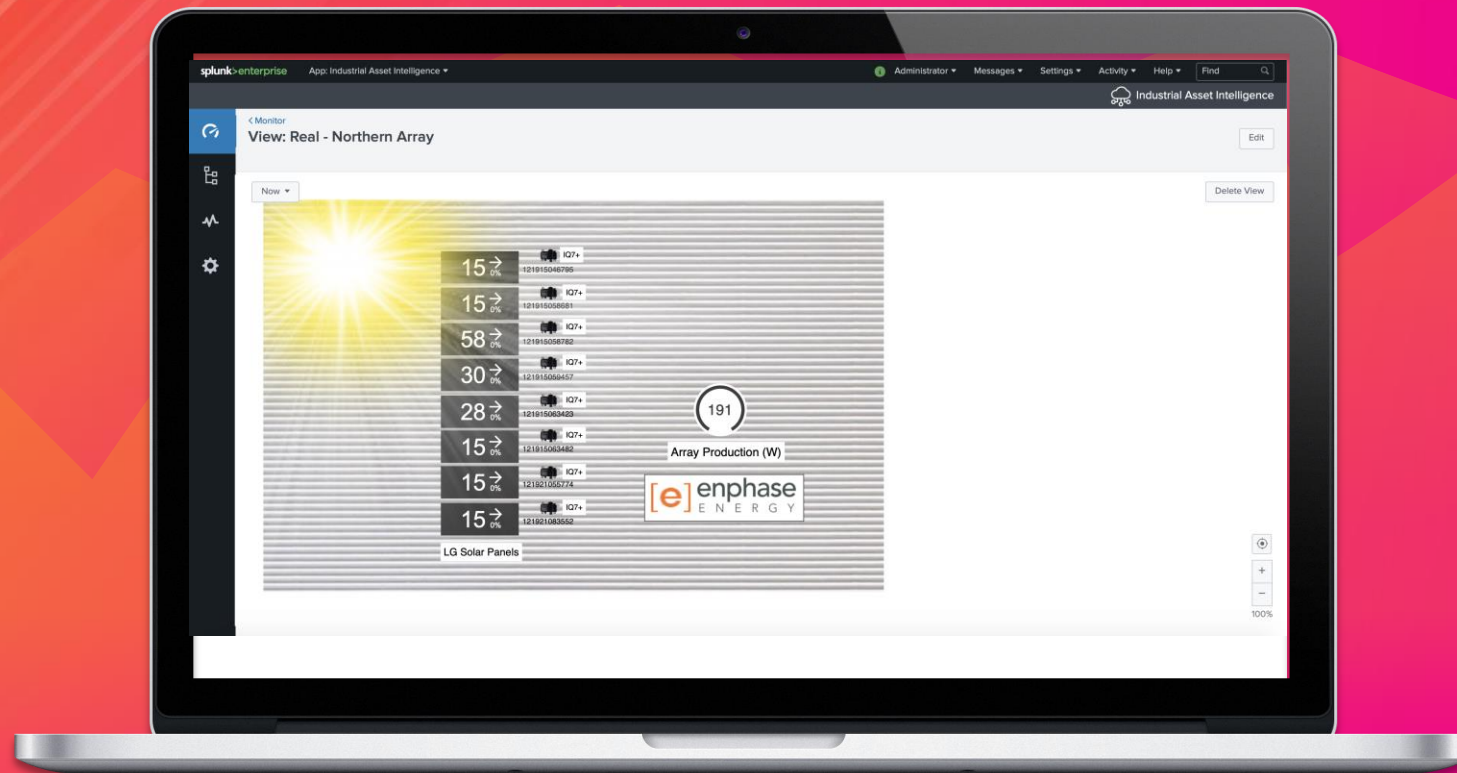
Asset: enphase.inverter

Category: inverter

Serial: 121813038357

Solar\_array: western roof

# Demo: Monitor and Alert with IAI





# Splunk ICS Essentials

---

Help with use cases

# Splunk Essentials For Industrial IoT

## Splunk Essential for Predictive Maintenance

- Created for maintenance reliability leaders and engineers who are looking for ways to improve and optimize their current preventive maintenance program.

## Splunk Essentials for ICS Security and Compliance

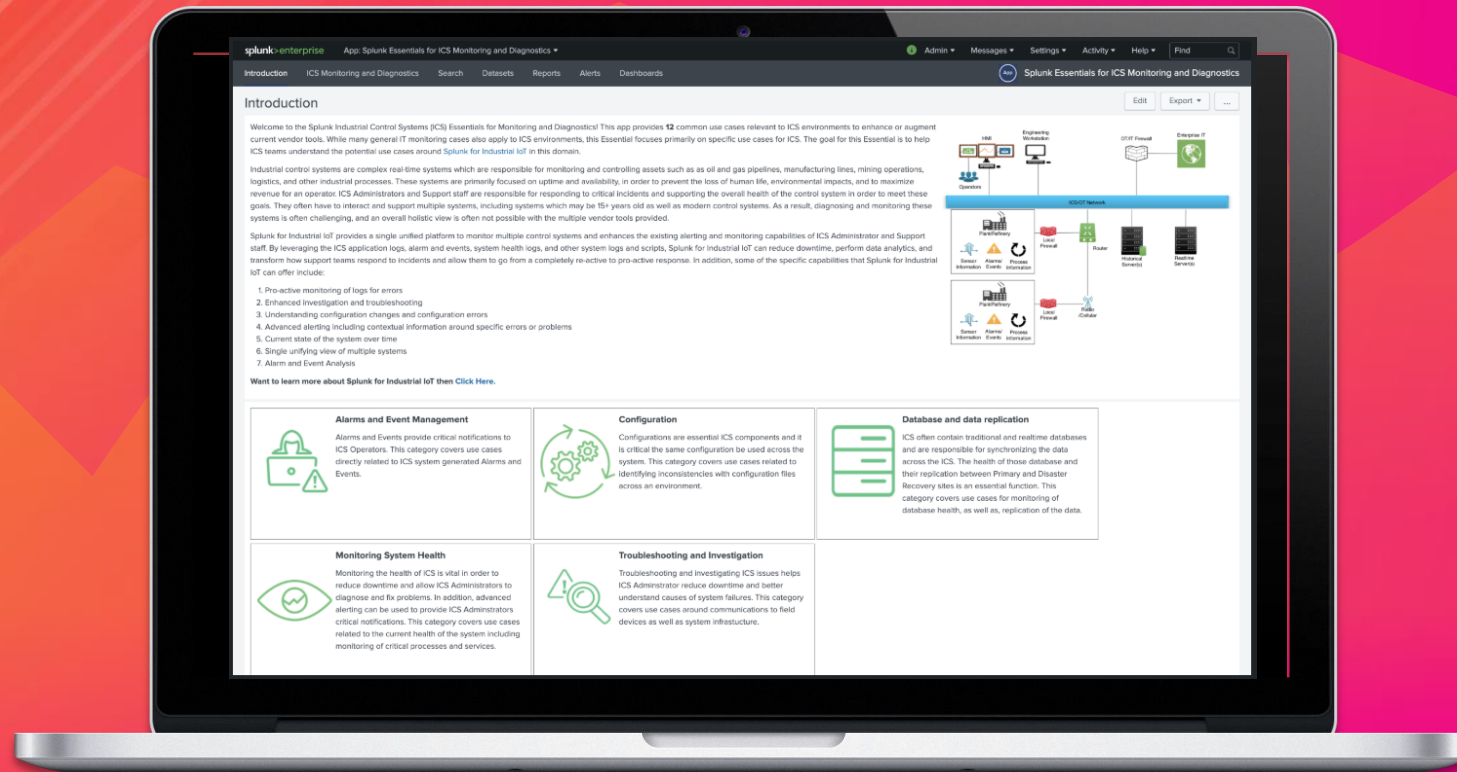
- Designed to help you gain a clearer understanding of the impact of security incidents on Industrial Control Systems.

## Splunk Essentials for ICS Monitoring and Diagnostics

- Provides common use cases relevant to ICS environments to enhance or augment current vendor tools.



# Demo: Leveraging ICS Essentials



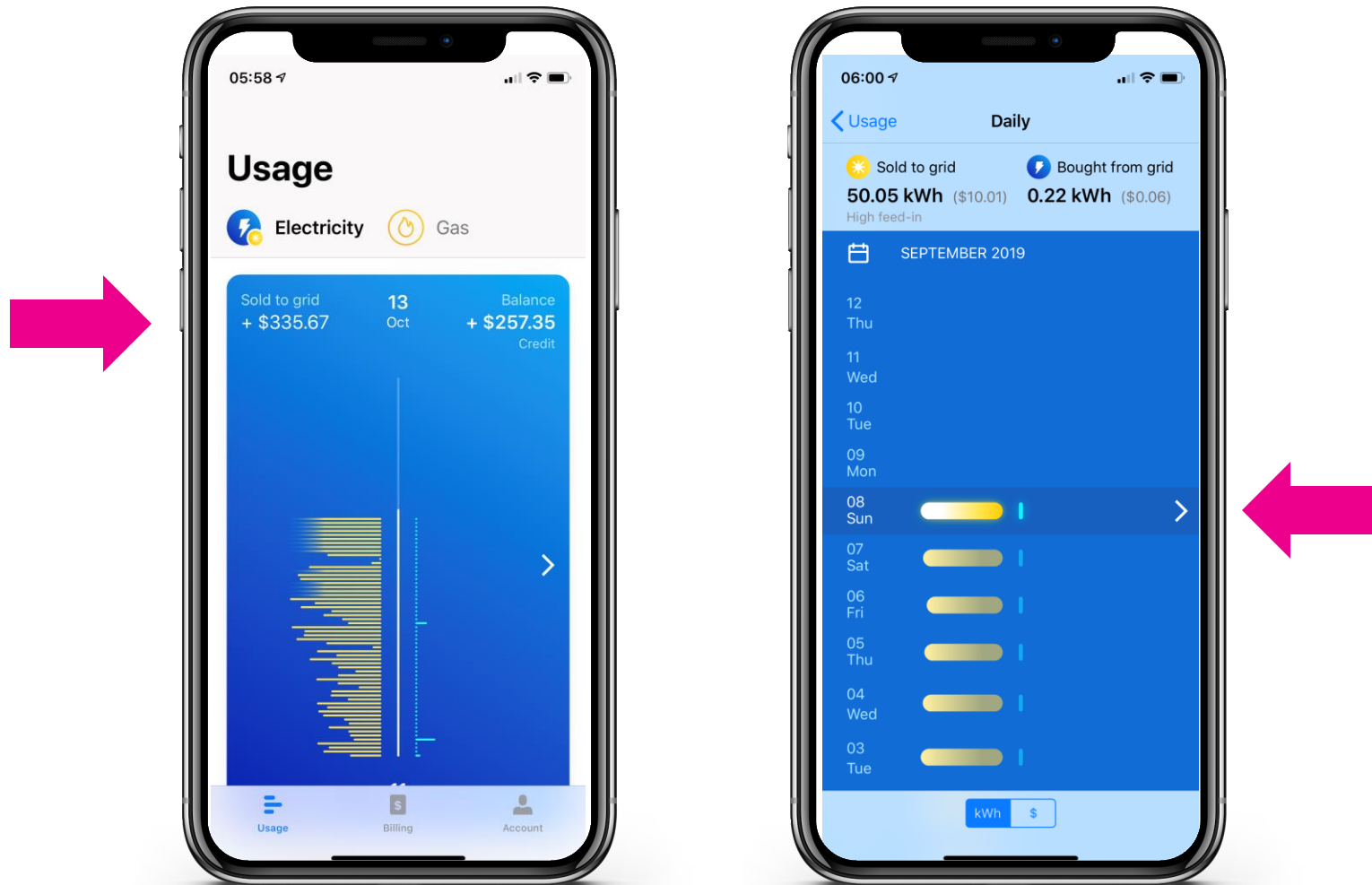


# Solar Analytics

---

It Will Never Be Finished 😊

# Calculating Costs, ROI, CO2



# Viewing Data Across Many Platforms

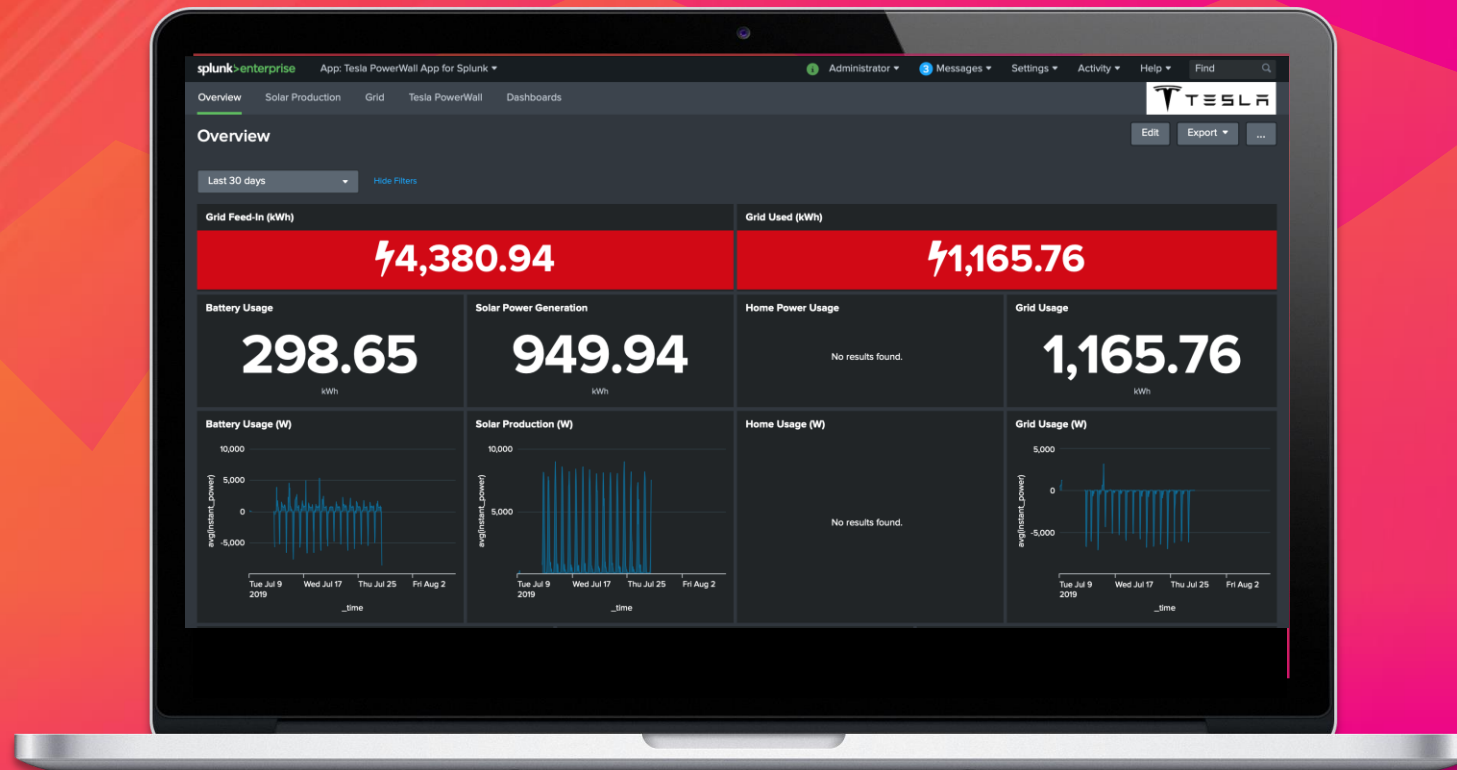
**POWERWALL**  
TESLA HOME BATTERY



**[e] enphase**  
ENERGY

# Demo:

# Putting It All Together



# Were You Enlightened?

Easy to build REST API add-ons for Splunk with the add-on builder.

Metrics are easy to use and awesome!!

Bringing different industrial technology data into one place is really useful.

This can be done at scale with the Splunk IoT Suite.

Solar generation is cost effective and energy effective.

ROI for solar energy for your home is better than you think 😊

We shouldn't do everything in life on ROI – sometimes just do the right thing!



splunk>

# Thank

# You!

Go to the .conf19 mobile app to

**RATE THIS SESSION**

