IoT & RENEWABLES INTEGRATION

PPA CONFERENCE, RAROTONGA 2019

ITRON & TONGA POWER LTD

Implementation of Smart Metering through Mesh Communications Technology

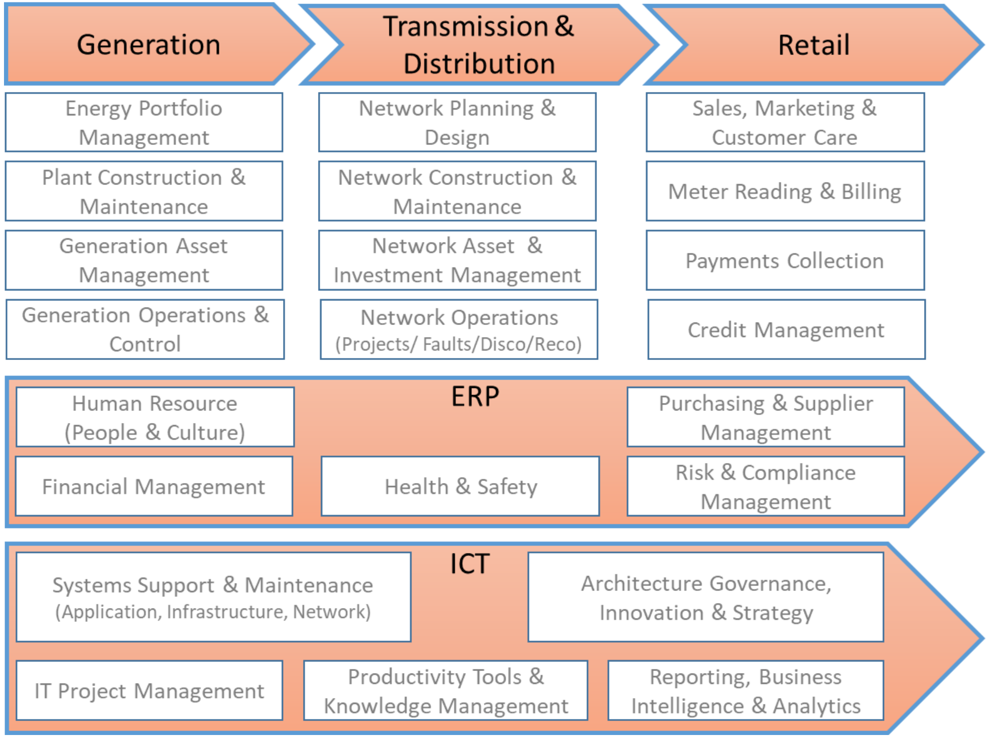
TPL MAINTAINS SUPPLY FOR 13,000 CONSUMERS

IN 2015 COMMENCED DEPLOYMENT OF A SMART METERING

EXPANDED AMI WITH ADDED DEPLOYMENT OF SMART WATER METERING

ONGOING PV GENERATION PROGRAM

PILOT PROJECT TO ADD IOT SENSORS



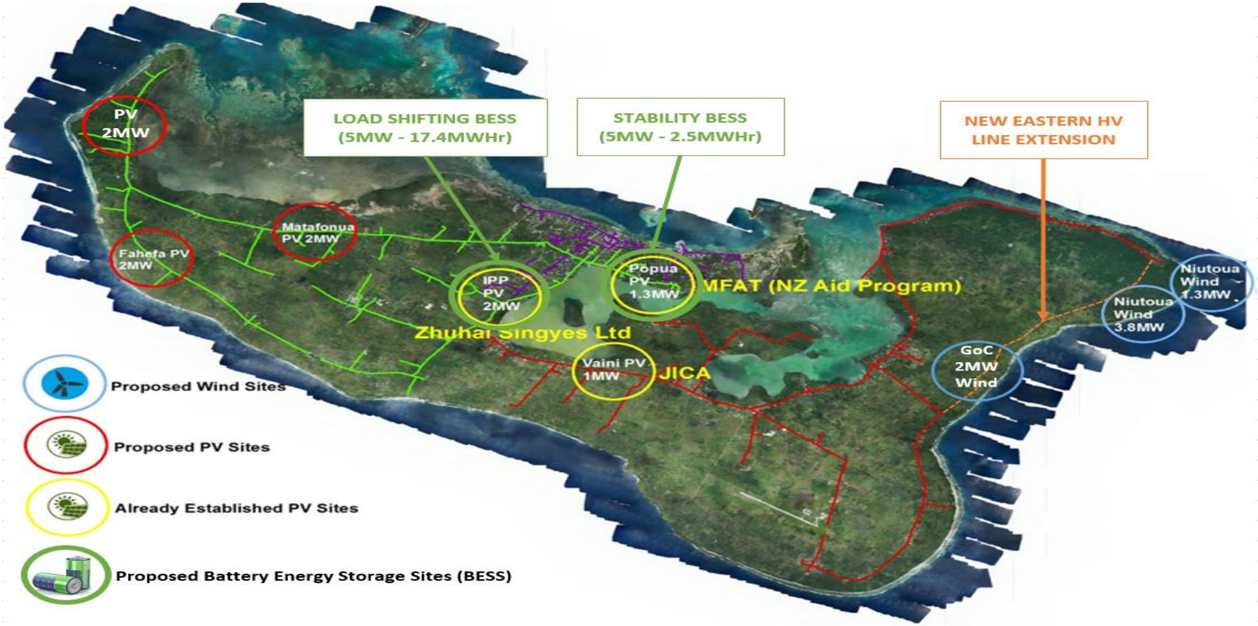
RENEWABLES INTEGRATION

Affordable & Sustainable Investments

MAINTAINING GRID STABILITY AT HIGH PENETRATION LEVELS

ECONOMIC BENEFITS OF GRID STABILITY

REQUIRES MULTIPLE LAYERS OF GRID CONTROL AND FORECASTING



THE FORECASTING PROBLEM

“Load Masking” and BTM Consumption

Today’s Load Forecast Models are based on a deep understanding of the factors that drive energy consumption.

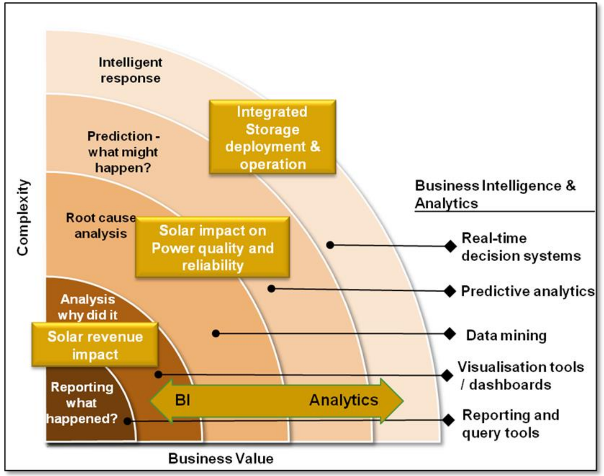
- This understanding is based on years of analysis of metered consumption patterns and their correlation with prevailing weather, calendar, and operating conditions.

Load Masking changes the data that load forecast models are constructed upon from measurement of energy consumption to measurement of energy imbalance.

- As a result, the correlation of prevailing weather, calendar, and operating conditions to what is measured is evolving.
- This leads to eroding performance of traditional load forecast models.

SOLAR AFFECTS BUSINESS STREAMS

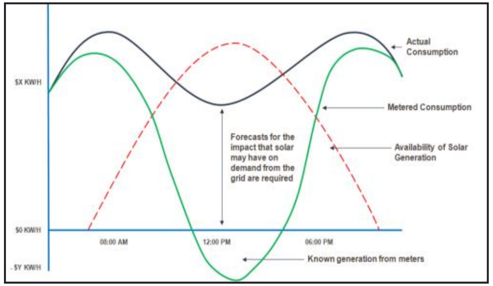
"Reconstituting loads augments statistical analysis"



» At low solar PV saturations it is difficult for a statistical model to isolate the solar PV load impact from over all load variation driven by calendar and weather conditions.

Consumption	Solar PV Generation	Solar Saturation	Estimated Coefficient
1000	0	0%	0.00
1000	7	0.7%	-0.02
1000	14	1.4%	-0.06
1000	30	3.0%	-0.18
1000	60	6.0%	-0.44
1000	119	11.9%	-0.73
1000	239	23.9%	-0.90
1000	477	47.7%	-0.97
1000	954	95.4%	-0.99
1000	1000	100.0%	-0.99

CORRECTION APPROACHES



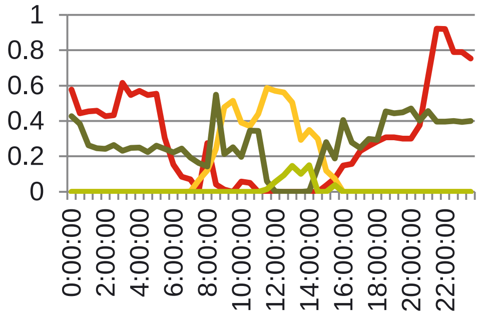
» Incorporate an externally sourced solar PV generation estimates/forecasts into an existing load forecast model.

» Available approaches include:

- **Error Correction.** Make *ex post* adjustments of the base load forecast
- **Reconstituted Loads.** Reconstitute the historical load data by adding back estimates of embedded solar generation.
- **Model Directly**. Include Embedded Solar Generation as an Explanatory Variable in the existing Short-term Load Forecasting Models.

SOURCES OF DATA

Correction Strategy Data



Telemetry Sources

» Add a separate meter on all (big and small) solar installations
  - Not read in real-time
  - Meter Costs (or cost of meter attached device)

» Upscale real-time telemetry on big solar PV installations
  - Assumes small solar PV behaves like large system
  - Solar DB management overhead

» Eye in the Sky Camera / Satellite imagery
  - Expensive, algorithms evolving

Pilot Approach

» Deploy sensors across a geography that measure directly the irradiance incident on the ground
  - Cheap, Real-time data, not as accurate as direct measure

PILOT APPROACH

DEVELOP SENSOR

USE EXISTING DATA COLLECTION NETWORK

APPLY MACHINE LEARNING

INVESTIGATE ACCURACY

IoT Sensor technology based approach

- Leveraging the existing data collection network provides estimates at a significant cost advantage relative to metering
- Data Collection Network information (GHI and Horizontal solar PV output) provides more granular geographic and high frequency (5-minute) ground measurement irradiance data.
- Machine learning algorithms represent an improvement over engineering-based algorithms that do not have the capability to statistically adjust given measurement data.

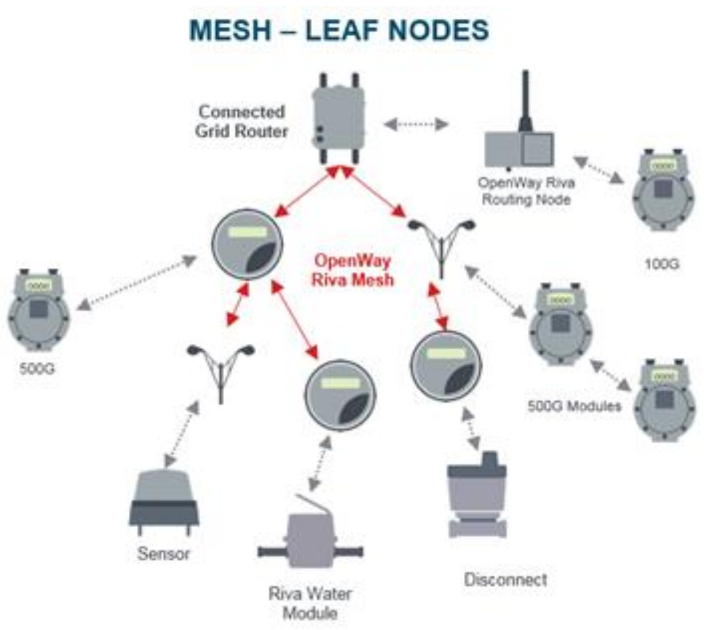
TPL AMI INFRASTRUCTURE

Already possess infrastructure to capture and deliver data

ALGORITHM REQUIRES SMART METER DATA AND SOLAR IRRADIANCE DATA

TPL GATHERS SMART METER DATA FROM EXISTING SINGLE-COMMS AMI RF MESH NETWORK

ADDITIONAL SENSORS / CONTROLS CAN BE ADDED



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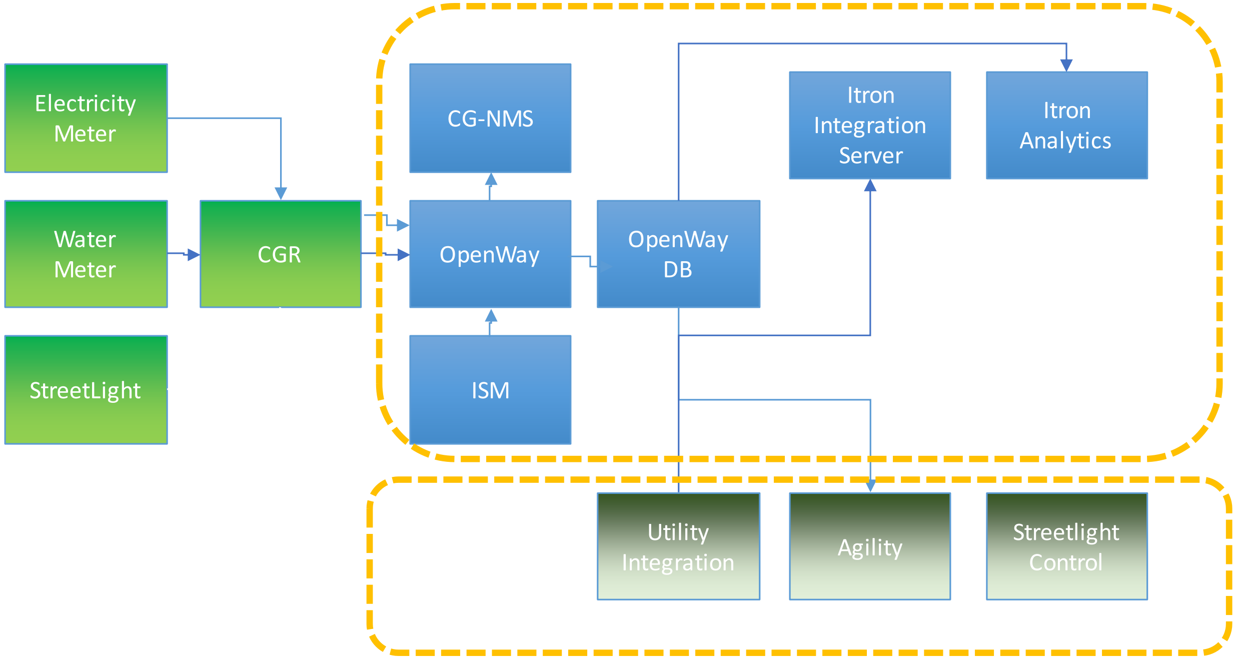

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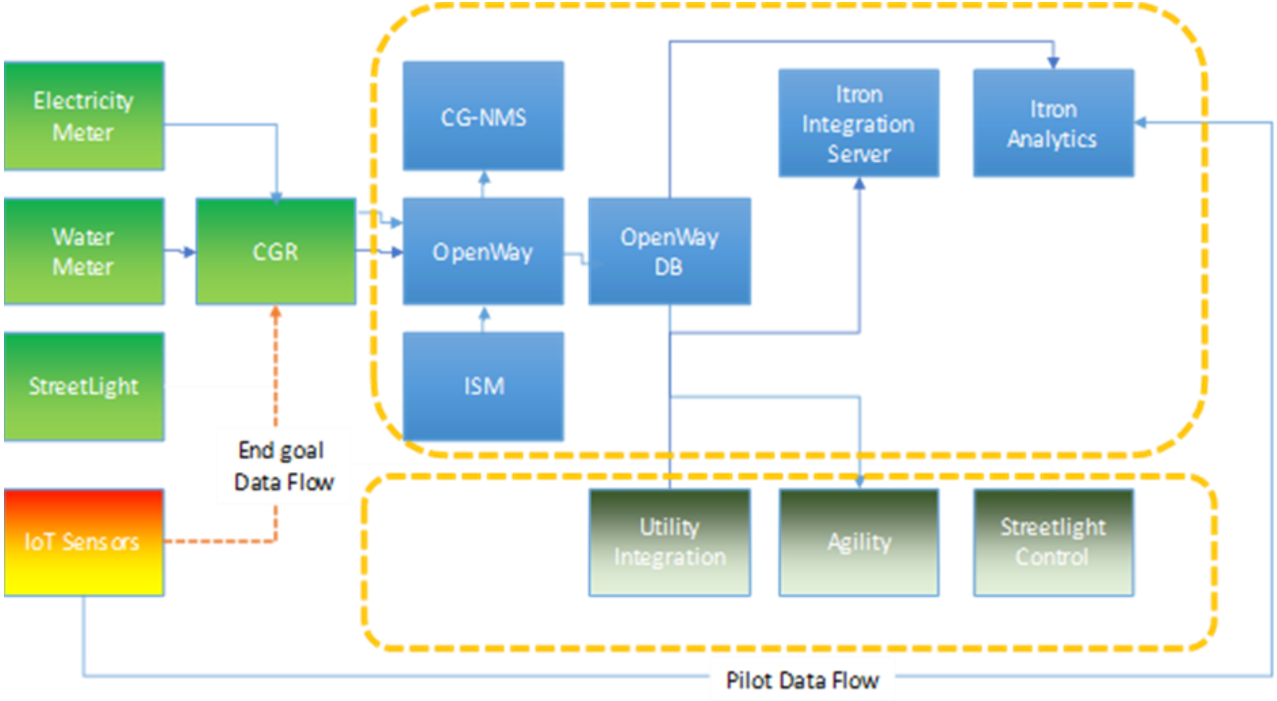


SENSOR TECHNOLOGY

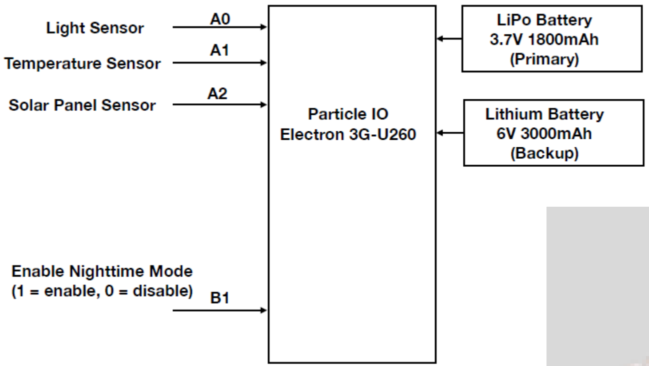
SENSOR DEVELOPMENT CONDUCTED IN TWO PHASES:

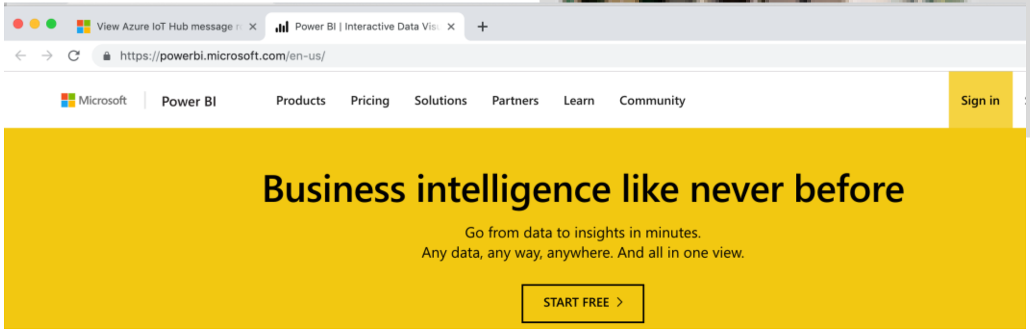
- COMMERCIAL – 3G
- ITRON RIVA EMBEDDED TECHNOLOGY – RIVA MESH

IOT COMMS STANDARDS

AZURE IOT HUB HOSTING

AZURE STREAMING ANALYTICS





FIELD TESTING

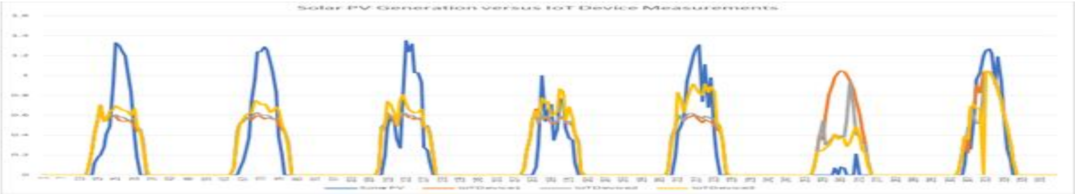
Turning Concept into Usability

THE REALITIES OF MANAGING AN IOT SENSOR ARE MORE THAN AN ALGORITHM:

- **COMMUNICATIONS**
- **SAMPLING RATE**
- **POWER MANAGEMENT**
- **DATA BANDWIDTH**

ACCURACY

- 4 Sensors deployed for a period of testing alongside a known PV installation
- Power Management is the immediate issue with 5 min sampling rate & cellular communications
  - Night-mode management
  - Solar charging from detector panel



  - Validates the target deployment model of lower powered RF mesh comms as opposed to Cellular or NB-IoT

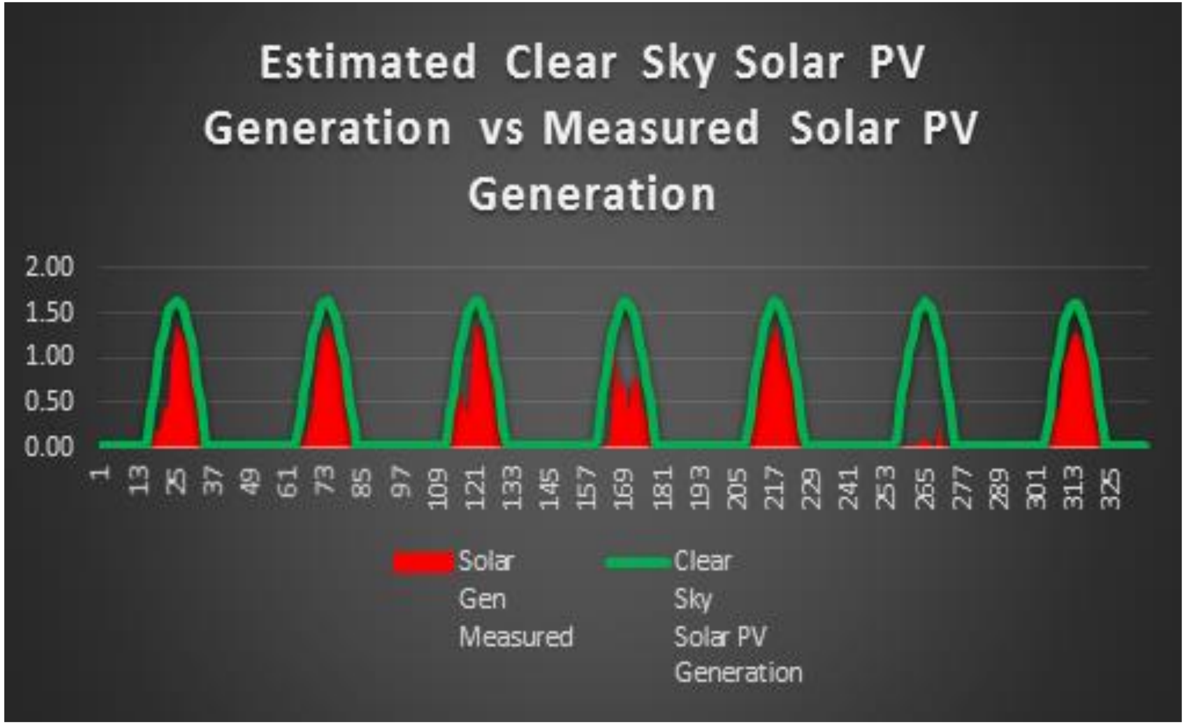
FIELD TESTING

First Results for the Sensors

DATA FROM SOLAR POWER INSTALLATION CONSIDERED OVER A VARIETY OF WEATHER CONDITIONS

METRIX IDR FORECASTING MODEL USED TO ANALYSE RESULTS

THE OBVIOUS IMPACT OF CLOUDS!

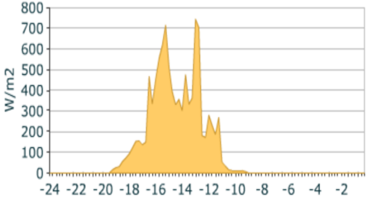


LOAD RECONSTRUCTION

ACTUAL SOLAR IRRADIENCE FIGURES COLLECTED

USED TO BASELINE IRRADIENCE MODEL FOR EMBEDDED PV SITES

LOOK TO CREATE A “GOOD ENOUGH” APPROXIMATION OF RECONSTITUTED LOAD

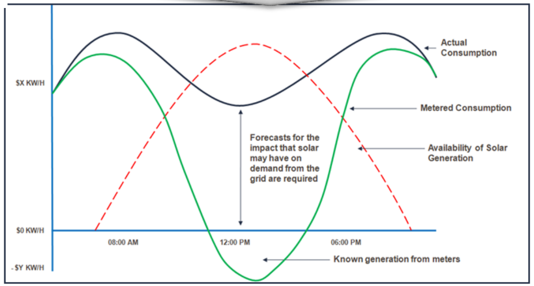


Macro

- *Location (Latitude / Longitude, Daylight hours, Air Mass Index)*
- *Weather*
- *Pollution*
- *Time of Day*

Input Data

- **Itron RIVA (½ hourly) consumption (net) data (kWh)**
- **Irradience Sensors data**
- **Installed Solar Consumer List**



Output Data

- **Generation (½ hourly) equating to “missing” usage**
- **Actual PV output**
- **Accurate Modelling**

Micro factors

- *Cell Efficiency - 11 – 20%*
- *Configuration of Panels*
- *Local Vegetation, Shade and local geography*
- *Age of Installation (~5% loss in efficiency)*

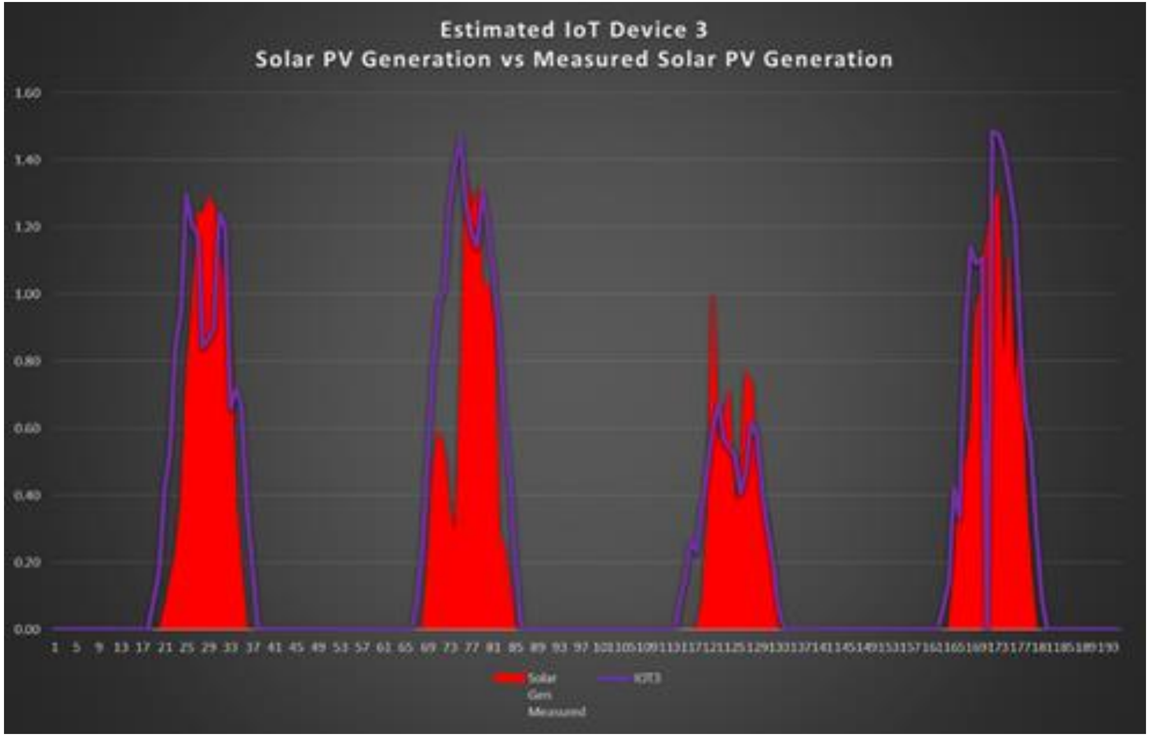
FIELD TESTING

Comparing IoT Solar Measurement to PV Generation

PV GENERATION MODEL IS BUILT FROM SOLAR IRRADIANCE AND IS COMPARED AGAINST MEASURED

OVERALL CORRELATION HIGH

30 MIN LOAD VS 5 MIN SAMPLING VARIANCES APPEAR IN PROCESSING



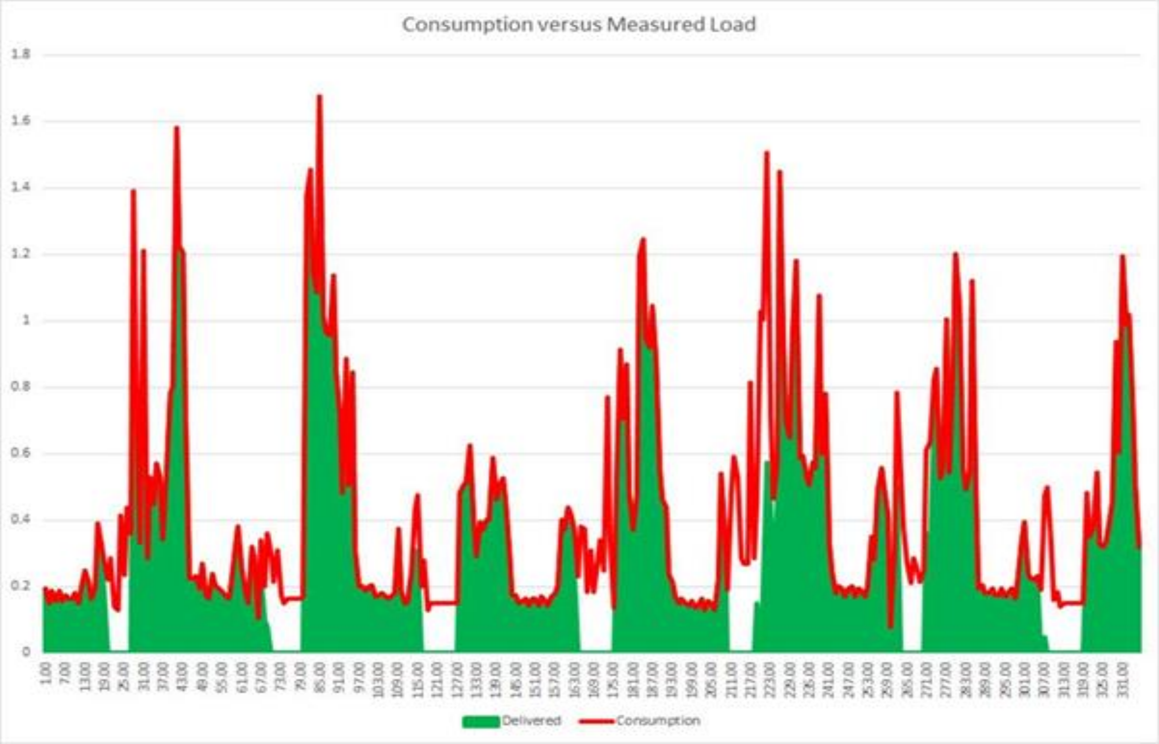
LOAD RECONSTITUTION RESULTS

Seeing “Behind the meter”

WITH AN ESTIMATE OF THE SOLAR PV GENERATED IT’S POSSIBLE TO RECONSTITUTE THE ACTUAL LOAD “BEHIND-THE-METER” FROM NET

HIGH CORRELATION BETWEEN MEASURED AND ESTIMATED PROFILES

PROVIDES LOAD PROFILE & GROWTH OVER TIME WITHOUT ADDITIONAL METERING / COSTS



DEPLOYMENT PATTERN FOR TONGA

Accounting for Cloud Movement

SENSORS USED TO PREDICT PV FOR LOCAL AREA SITES

SENSOR DEPLOYMENT MAY ALSO ALLOW PV DEPRESSION BY TRACKING CLOUDS

PILOT WILL ALSO CONSIDER CORRELATION OF READINGS VS TIME & WINDSPEED

THE NEXT STEPS

To Tonga & Forecasting model refinement

SENSORS CREATED (& LESSONS LEARNT)

FORECASTING ALGORITHM UPGRADED

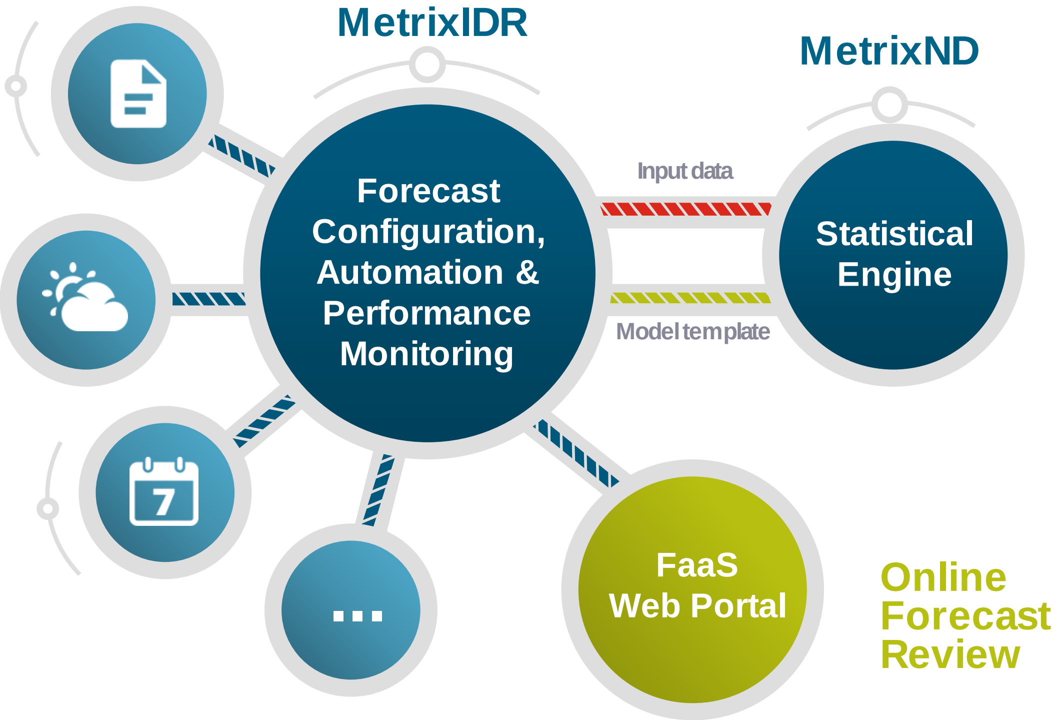
DEVICE COMMISSIONING

DATA INCOMING FROM TONGA TEST SITES

…..SENSORS TO SHIP

….. RETRIEVE RESULTS AND REFINE MODEL

…. BENEFITS ANALYSIS



THANK YOU

Itron

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