MTSFB TR 003:2019

TECHNICAL REPORT

SMART FACTORY INDUSTRIAL IOT

MTSFB TR 003:2019

Preface

Malaysian Technical Standards Forum Bhd (MTSFB) has awarded Solnovation Analytics Sdn Bhd the Industry Promotion and Development Grant to implement the Proof of Concept (PoC) through the smart factory Industrial IoT. The duration of this PoC lasts for a period of 6 months starting January 2018.

The PoC is done at MARDEC Rubber Processing Sdn Bhd, Mentakab, Pahang. The key objective of this PoC is to demonstrate the application of IoT to automate the energy performance assessment and reporting.

The Technical Report outlines objective, benefit, scope of work, methodology and result data.

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Abbreviations

AI	Artificial Intelligence
ANPR	Automatic Number Plate Recognition
API	Application programming interface
EPIMAS	Energy and Production Information Management System
ICT	Information and Communications Technology
GPRS	General Packet Radio Service
HD	High Definition
IoT	Internet of Things
IT	Information Technology
ISP WAN	Internet Service Provider Wide Area Network
LC	Latex Concentrated
MIMO	Multiple Input and Multiple Output
M2M	Machine to Machine
PLC	Power Line Communication
PoC	Proof of Concept
POE	Power Over Ethernet
RTD	Resistance Temperature Detection
TSR	Technically Specified Rubber
USB	Universal Serial Bus
VFD	Variable Frequency Drive
UART	Universal Asynchronous Receiver-Transmitter

SMART FACTORY INDUSTRIAL IOT

1. Introduction

The Smart Factory Industrial Internet of Things (IoT) is designed to help industrial companies to integrate industrial automation and control with business systems.

The Smart Factory Industrial IoT architecture as in Figure 1 consists of sensors, data collection interfaces, connectivity and cloud portal. Several key sensors are installed in areas that impact the production and its quality. The production data is being manually recorded while the system captures the data online with the ability to correlate production information with other physical parameters.

In most cases, information related to production and energy at factories in Malaysia are looked at in isolation. Smart Factory Industrial IoT project is to automate the factory production and energy data in order to help in providing an energy and production data strategy. This would include integration of the digital factory, Information Technology (IT) tools and IoT in manufacturing in a heterogeneous IT environment to ensure data consistency. This will involve installation of sensors, hardware and the core platform through a cloud-based system at the factory. This will help to reduce cost, add value to digitisation and access to real-time information analytics and alerts.

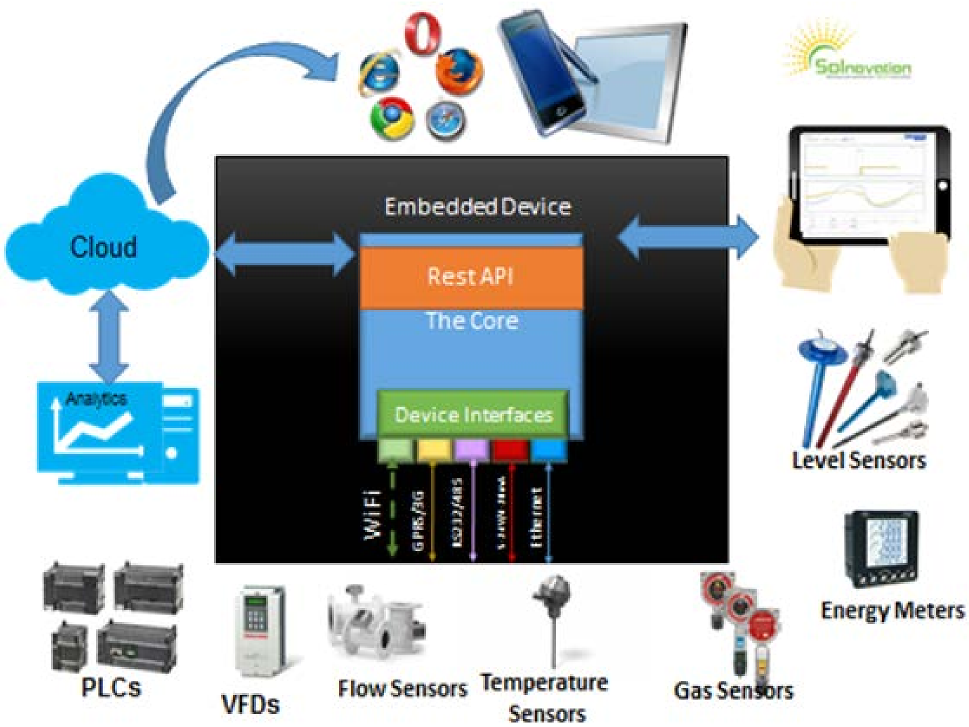


Figure 1. Typical system architecture for Smart Factory Industrial IoT

2. Target groups and benefits

2.1 MARDEC Berhad

MARDEC Berhad is one of the largest rubber processors in Malaysia in producing Technically Specified Rubber (TSR), Latex Concentrated (LC), speciality rubber products and downstream rubber product.

The Smart Factory Industrial IoT enables the industry to capture data at the manufacturing process level and enabling people at different levels of the organisation to access data in real- time and archive. Reporting and alerts are enabled on role and rule based for managed services production, planning and marketing staff. Data is reported in real-time in comparison to historical trends.

Target end users are from top management to the factory manager. It is a platform to enable transparency and real-time data across the organisation. The solution will provide energy savings for the company and the country, thereby reducing the carbon footprint.

Reporting and alerts are enabled on role and rule based on managed services and it will beneficial to the production, planning and marketing levels.

2.2 Solnovation Analytics

Solnovation Analytics is a Multimedia Super Corridor (MSC) status company leveraging an IoT technology to empower industrial IoT platform. They do automation and integration throughout the processes. They help organisations and companies improve yield, productivity, operational efficiency and thereby make holistic informed decision in real-time.

EPIMAS is a software developed by Solnovation Analytics which has the capability to analyse data received from sensors installed in the factory. It displayed all the factory machinery data in one single view (dashboard) which provide the latest and trending data.

Energy Information Management and Analytics system at industry level starting with rubber industry in Malaysia. It helping them embrace energy performance parameters driven energy performance assessment. Solnovation Analytics intended to develop similar system for the palm oil industry and other industries within Malaysia

3. Objectives

The project objectives are as follows:

a) to demonstrate the application of IoT to automate energy performance assessment and reporting;

b) to use energy and production performance indicator driven dashboards to drive energy productivity improvement initiatives; and

c) to improve security through control of network access by user and location with identity services.

4. Scope of work

The scope of work for this project is to design the customised solution that will suit to MARDEC plant that involve installation of sensors, hardware and core platform through cloud-based system at the MARDEC plant. This would also include integration of few sections in order to automate data collection in the rubber production line.

5. Methodology

A study was conducted to fully understand the system requirement of the MARDEC plant. The system designed taking into consideration of MARDEC's requirements that need to be analysed. The system requirement of Smart Factory Industrial IoT project development consists of the following items:

a) site layout;

b) sensors;

c) information technology connections;

d) cloud portal; and

e) system integration.

5.1 Site layout

The MARDEC plant is large campus and the deployment of sensors and system had to be at different locations. The installations are divided into 3 areas as follows:

a) shop floor

11 sensors and 1 network router are installed.

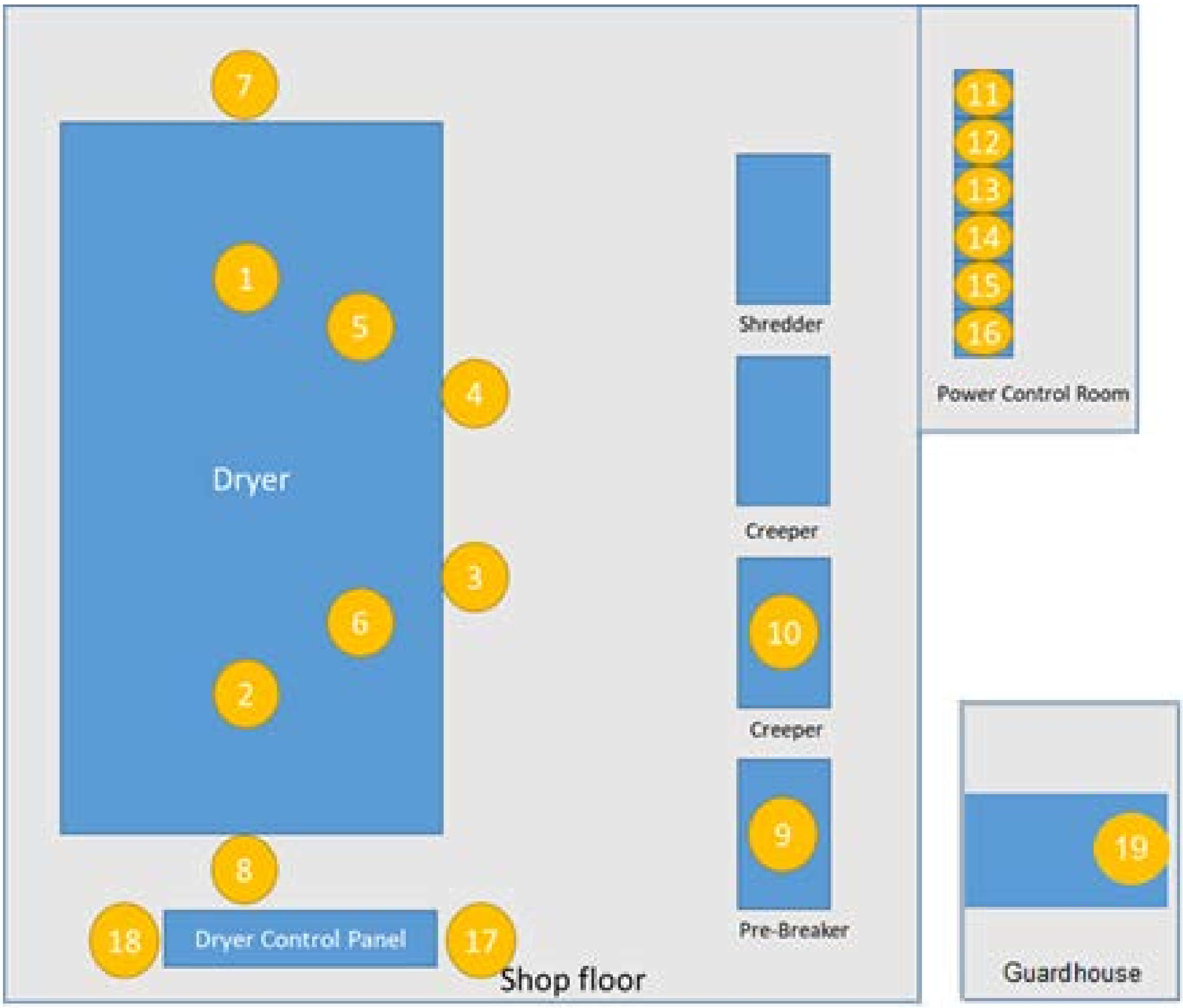
b) power control room

6 energy monitoring devices are installed.

c) guardhouse

Artificial Intelligence (AI) based Automatic Number Plate Recognition (ANPR) system is installed.

The layout for components installation is illustrated in Figure 2.



Legend

1	Temperature sensor (top incoming)	11	Energy meter (MCB 1)
2	Temperature sensor (top outgoing)	12	Energy meter (MCB 2)
3	Temperature sensor (side incoming)	13	Energy meter (MCB 3)
4	Temperature sensor (side outgoing)	14	Energy meter (creeper 1)
5	Vibration sensor (incoming)	15	Energy meter (creeper 2)
6	Vibration sensor (outgoing)	16	Energy meter (shredder)
7	Humidity sensor (incoming)	17	Airbridge sensor aggregator
8	Humidity sensor (outgoing)	18	Network router
9	Vibration sensor (pre-breaker)	19	Camera (ANPR)
10	Vibration sensor (creeper)		

Figure 2. Site layout

5.2 Sensors

There are a variety of sensing elements used in this project which each types of sensor detects and measures a different parameter(s) and make it available over the interface.

The Smart Factory Industrial IoT solution uses the following sensors:

a) temperature sensors;

b) humidity sensors;

c) vibration sensors;

d) energy measurement sensor; and

e) motion sensor security camera.

The types of analogue and digital interfaces are as follows:

a) analogue output (4 mA - 20 mA, 0 Vdc - 5 Vdc); or

b) serial output (RS232/485/Modbus/USB); or

c) digital input or output.

5.2.1 Temperature sensors

The temperature at the 4 different points of the dryer is collected using a Resistance Temperature Detection (RTD) sensor. The location of the temperature sensors are as follows:

a) side incoming;

b) top incoming;

c) side outgoing; and

d) top outgoing.

5.2.2 Humidity sensors

The humidity sensors are installed at 2 points of the dryers:

a) incoming; and

b) outgoing.

The sensor measures the ambient humidity in the respective sides of the dryer. The sensor's specification are as follows:

a) humidity range: 0 % rH to 100 % rH;

b) humidity output: 1 Vdc to 3.6 Vdc;

c) maximum operating temperature: 0 °C to 100 °C;

d) output: 4 mA - 20 mA (2 wire); and

e) supply: 24 Vdc based.

5.2.3 Vibration sensors

The vibration sensors give information about when the machine is in operation and can also be used to determine faults in the machine that cause excessive vibration or the lack of it. The vibration sensors are installed to identify whether a particular machinery is operational. In addition, it can be used to gauge the health of the machinery as well. 4 vibration sensors are installed to monitor the following machines:

a) pre-breaker;

b) creeper;

c) dryer fan (incoming); and

d) dryer fan (outgoing).

The vibration sensor's specifications are as follows:

a) output: 4 mA - 20 mA;

b) output range: 0 mm/s - 25 mm/s;

c) mounting: 1/4 UNF - 28 UNF female; and

d) connector: 2 pin MS connector.

5.2.4 Energy measurement sensors

The energy consumption data is used to determine the motor efficiency. The following 6 energy measurement sensors (energy meter) are installed to measure the energy consumption at the following points:

a) MCB 1;

b) MCB 2;

c) MCB 3;

d) creeper 1;

e) creeper 2; and

f) shredder.

5.2.5 Motion sensor security camera

A High Definition (HD) camera is installed to monitor the vehicular traffic to the plant. The system consists of a HD camera feeding into AI based ANPR system to identify the plate number of the incoming or outgoing vehicle. This data is pushed to cloud server over a 3G/4G network.

5.3 Information technology connections

The levels of information technology connections (interfaces) are as follows:

a) sensor level;

b) system level; and

c) interaction level.

5.3.1 Sensor level

The 2 types of data collection are as follows:

a) distributed collection

A single data point is collected from the sensors and transmitted wirelessly. For each sensor, there is one transmitter. The energy measurements and temperature parameters are gathered this way.

b) aggregated collection

Gathers multiple data points and aggregates them and is transmitted wirelessly. Vibration sensors input and humidity parameter are gathered over the wired current loop and sent wirelessly. The router is used to interface 6 different sensors and transmit the sensor’s data over WiFi.

The specifications are as follows:

a) analogue interfaces: 8 channels analogue input (4 mA - 20 mA, 0 Vdc - 5 Vdc);

b) serial interface: RS485/Modbus RTU;

c) wireless interface: WiFi - 802.11N, 2.4 GHz; and

d) operating voltage: 9 Vdc - 12 Vdc.

5.3.2 System level

Multiple wireless technologies are used for communication of data from the sensor interface units to a gateway. The data from temperature sensors, humidity sensors, vibration sensors are communicated using a WiFi/802.11 network. The data from energy meters are communicated using ZigBee.

The choice of a network depends on various factors like wireless range, the physical condition of the site, power requirement, bandwidth required, available sensor interfaces etc. The solution demonstrated the capability of working with multiple connectivity mediums.

5.3.3 Interaction level

The Smart Factory Industrial IoT deployment is capable by using high speed wired Internet Service Provider Wide Area Network (ISP WAN) link or 3G/4G wireless backhaul. Figure 3 illustrated sample of the network card used for this project.

The router specifications are as follows:

a) indoor/outdoor client and station mode device with an integrated antenna;

b) AP 2.4 GHz, Smart Multiple Input and Multiple Output (MIMO);

c) single stream, 10 dB - 12 dB antenna gain;

d) Power Over Ethernet (POE) injector; and

e) 3G/4G wireless to ethernet convertor.

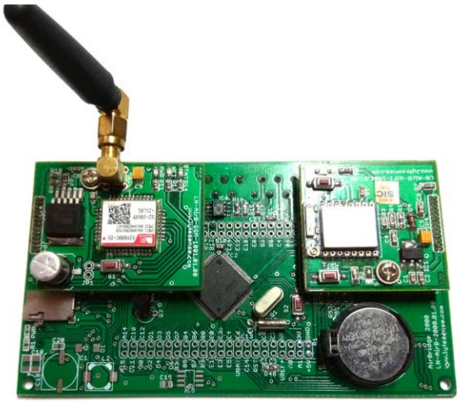


Figure 3. Network card

5.4 Cloud portal

There are 5 elements utilised through a cloud portal service as follows:

a) data processing;

b) data alert;

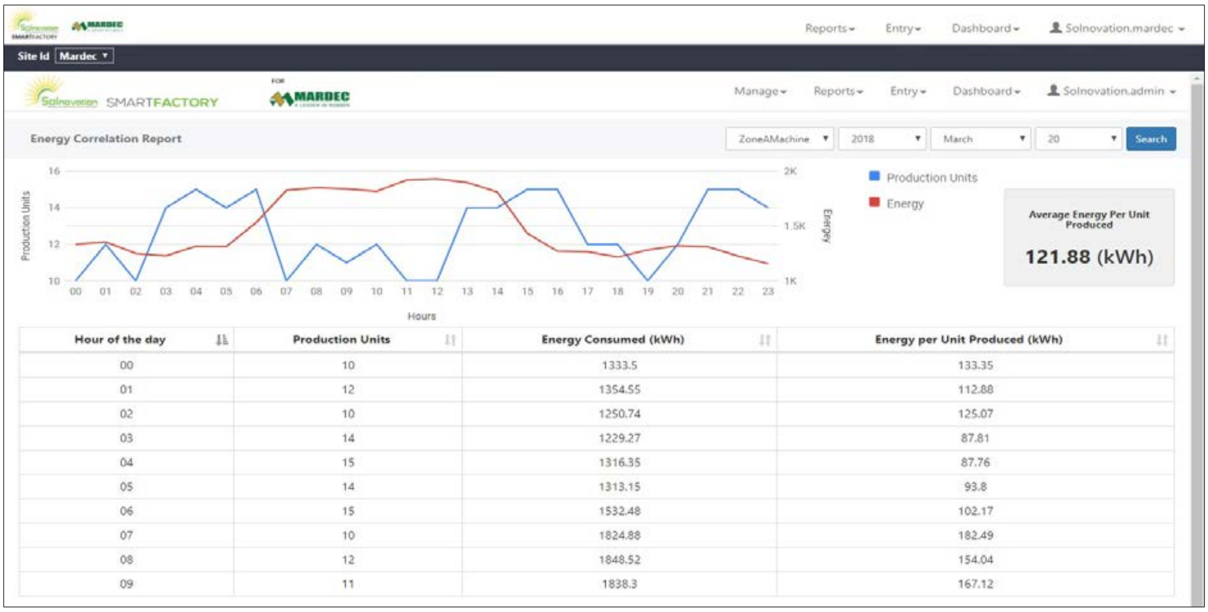
c) reporting; and

d) dashboard.

5.4.1 Data processing

Few algorithms are implemented to digest the data feed in order to determine the computation and efficiencies.

The machines such as creepers and shredders all are operated on large motors and two important parameters which are vibration and energy consumption are gathered in the energy correlation report. The report shows the increasing in the units of production, will decrease the energy per unit consumption. Figure 4 shows the snapshot of correlation report from the dashboard.



Hour of the day	Production Units	Energy Consumed (kWh)	Energy per Unit Produced (kWh)
00	10	1333.5	133.35
01	12	1354.55	112.88
02	10	1250.74	125.07
03	14	1229.27	87.81
04	15	1316.35	87.76
05	14	1313.15	93.8
06	15	1532.48	102.17
07	10	1824.88	182.49
08	12	1848.52	154.04
09	11	1838.3	167.12

Figure 4. Energy correlation report

5.4.2 Data alert

The alarms were configured to ensure the system constantly monitor the parameters. When the reading goes beyond the set threshold the alarm will trigger. For example, the reading of the multiple alarms will raise when the temperature of the dryer at various zones exceed the set threshold.

5.4.3 Reporting

There were few types of reports that generated by the systems including energy report, temperature report, humidity report, vibration report, alarm log report and camera log report. The reports are generated on a daily, weekly and monthly basis, depending on the requirement sets by relevant group.

5.4.4 Dashboard

The EPIMAS dashboard displayed all the factory machinery data in one single view which provide the latest data and trending data of the last few hours. It shows a quick view of the factory status including the temperature levels of the dryer, energy consumption, current motor efficiency and whether all the machines are in operation. It also shows the incoming and outgoing vehicles of the factory premises. Figure 5 shows the layout of the EPIMAS dashboard. All the reports are generated in this dashboard.

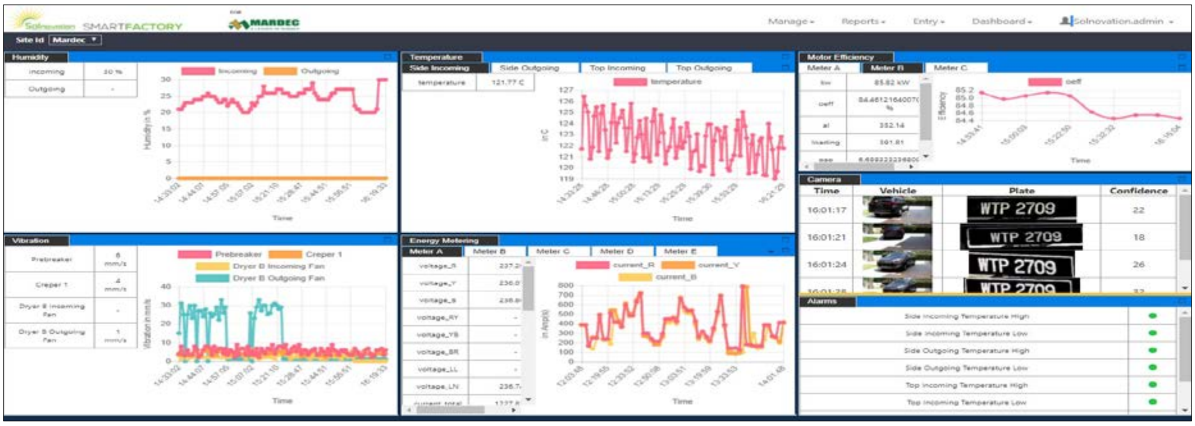


Figure 5. EPIMAS dashboard

The EPIMAS software has the capability to analyse the data in order to plot custom charts as per user's requirement. For example, a user wants to see and compare energy consumption and the dryer temperature as illustrated in Figure 6, the user can create a custom chart. This can be done by selecting the parameters from the energy meter and appropriate temperature sensors to automatically generate a custom chart which can help in understanding data trends and correlations.

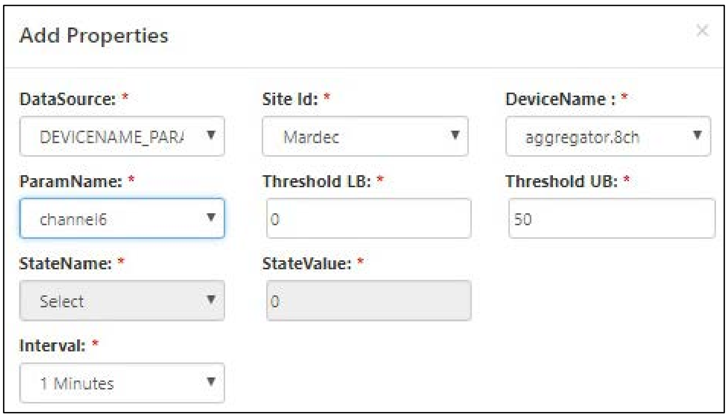


Figure 6. Analysis data

5.5 System integration

A study and survey on the equipment was conducted to understand about the equipment layout, location and process parameters. This include the internet connectivity at the factory for WiFi, GPRS, 3G and 4G. The energy meters, temperature, humidity, vibration sensors are installed at the factory using 4G WiFi dongle.

EPIMAS solution dashboard are developed and installed. Training on EPIMAS software was provided to MARDEC's staff followed by project handover.

6. Installation

The system installation of all the devices has completed as follows:

6.1 Temperature sensors

There are 4 temperature sensors installed as in Figure 7.

Figure 7a. Incoming side

Figure 7b. Outgoing side

Figure 7c. Top incoming

Figure 7d. Top outgoing

Figure 7. Temperature sensors

6.2 Humidity sensors

There are 2 humidity sensors installed as in Figure 8.

Figure 8a. Incoming

Figure 8b. Outgoing

Figure 8. Humidity sensors

6.3 Vibration sensors

There are 4 vibration sensors installed as in Figure 9.

Figure 9a. Dryer fan (incoming)

Figure 9b. Dryer fan (outgoing)

Figure 9c. Creeper

Figure 9d. Pre-breaker

Figure 9. Vibration sensors

6.4 Energy meters

There are 6 energy meters installed as in Figure 10.

Figure 10a. MCB 1

Figure 10b. MCB 2

Figure 10c. MCB 3

Figure 10d. Creeper 1

Figure 10e. Creeper 2

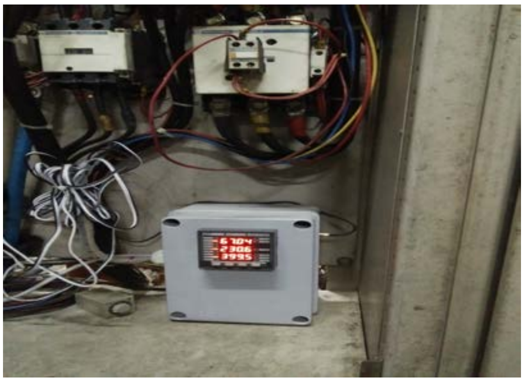
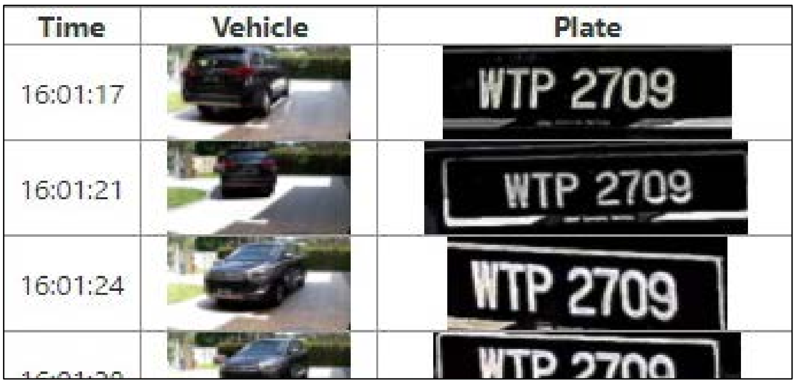


Figure 10f. Shredder

Figure 10. Energy meters

6.5 Motion sensor security camera

The motion sensor security camera was installed at the main entrance of the MARDEC plant. The camera is capable to capture any vehicle plate number as shown in Figure 11. The picture of the in-coming and out-going vehicle through the main entrance will be captured. The plate number of the vehicle will be recorded via artificial intelligence.



Time	Vehicle	Plate
16:01:17		WTP 2709
16:01:21		WTP 2709
16:01:24		WTP 2709

Figure 11. Vehicle plate number record

6.6 IoT control panel and router box

The IoT control panel and router box as shown in Figure 12 are installed at the MARDEC plant. It serves as an IoT device control that securely monitor, control, provision and stream data between internet-connected devices.

Figure 12. IoT control panel and router box

7. Results

The EPIMAS dashboard as in Figure 10 shows a real-time data of all energy meters, dryer temperature meters, vibration meters, dryer humidity meters. The EPIMAS dashboard constantly track energy consumption across dedicated locations. This would lead to the comparison of consumption for the various locations of the plant by analysing the data.
Table 1 shows some of the data collected from the Smart Factory Industrial IoT system during the test period. The data was extracted from the EPIMAS at the end of each day as indicated in the table below. The extracted data consist of an average measurement from energy meters, temperature, humidity and vibration. These data would be as an input for the analysis of the trend for any required parameter. The days and parameters must be specified to display these data.

Table 1. Collected data

Device	Days						
	Day 1	Day 2	Day3	Day 4	Day 5	Day 6	Day 7
Energy meters (average of kWh/day)							
MCB 1	18.77	28.11	56.85	66.66	43.38	54.49	80.88
MCB 2	2.92	3.93	8.54	7.06	9.28	7.27	4.64
MCB 3	12.07	20.52	28.38	27.31	17.20	16.39	25.72
Creeper 1	1.98	3.86	9.01	11.87	14.31	8.59	6.67
Creeper 2	0.13	0.17	0.36	0.35	0.35	0.29	0.23
Shredder	5.10	12.00	3.80	12.40	35.50	14.10	12.80
Temperature (°C)							
Side Incoming	94.23	76.57	89.31	89.9	91.39	85.15	93.04
Top Incoming	86.4	73.98	77.58	47.23	25.63	70.96	53.33
Side Outgoing	101.19	98.49	96.72	98.88	100.46	95.74	98.72
Top Outgoing	92.11	92.32	105.18	60.89	98.69	96.11	66.24
Humidity (%)							
Incoming	23.39	60	63.06	54.03	51.77	58.93	64.01
Outgoing	27.59	68.79	71.75	62.47	66.31	67.93	72.2
Vibration (mm/sec)							
Pre-breaker	2.97	3.43	0.83	3.85	1.24	4.11	5.02
Creeper	2.83	3.11	0.57	3.43	1.38	4.09	4.36
Dryer fan (incoming)	0.75	0.88	0	1.12	0.39	0.91	1
Dryer fan (outgoing)	7.5	7.15	1	6.81	3.19	6.55	13.77

Alerts are trigger when the temperature in the dryer reaches above 150 °C or below 100 °C. The real-time data can be monitored by the MARDEC headquarters staff or the management who has access to an internet enabled device.

Vibration measurement is an important factor in predictive maintenance. It is used as a tool for monitoring the condition of the different types of production machinery.

The trends of the consumption and changes in the machine setting will form a benchmark that bring the savings. The pattern of consumption allows healthy check of energy wasting on a daily as well as during shutdown hours.

8. Conclusion

The Smart Factory Industrial IoT project shows the availability of real-time data and integration of different data sources via EPIMAS. An ability to identify real-time energy, production and environment inefficiencies leads to operational efficiencies.

A single dashboard is used to compare performance of its plants in real-time. The data helps to collaborate within departments and build transparency across the organisation.

Being a cloud-based system ensures very low cost per unit of production. The solution is cheaper compared to other technologies or solutions currently available in the market.

Now the company has the ability to apply the system to be used in its other factories across the region, hence provides information sharing in multiple locations. The system support Green ICT and sustainable practices by reducing carbon emission in their factories.

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