18TH MAY 2022

INPEX unveils how we fully migrated PI System to Microsoft Azure

INPEX Corporation

Presented By: Naoto Yamabe & Kohei Kawamura

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

AVEVA PI WORLD 2022

Agenda

INPEX Corporation

- Introduction – About INPEX
- PI System Architectures in INPEX
  - Japan – Oil & Gas productions and Pipeline network
  - Australia – Ichthys LNG
- Migration of core infrastructure to Microsoft Azure
  - Challenge
  - Solution
  - Migration process
  - Success factors
  - Benefits
- Application Case Studies
- Conclusion & Looking Ahead

AVEVA

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

About INPEX

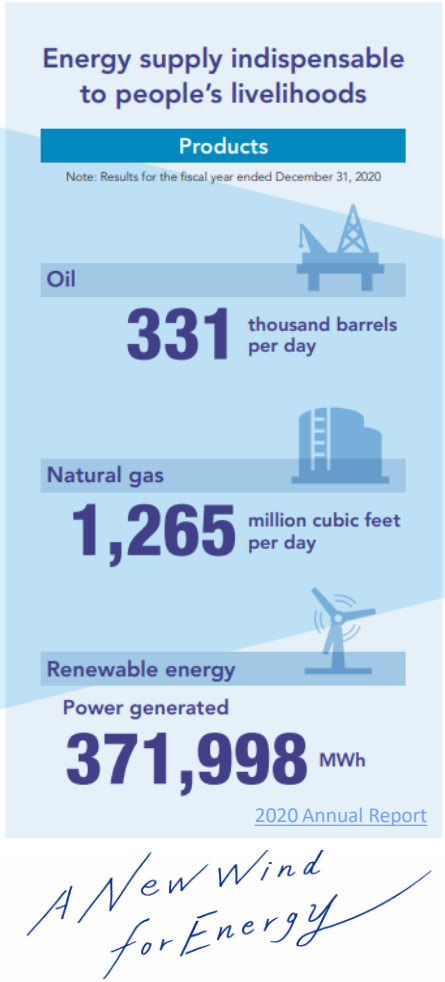
A New Wind for Energy

- **Japan's largest oil & gas exploration & production company**, with a net production volume of 573 thousands BOE (barrels of oil equivalent) per day and proved reserves of 3,730 million BOE as of December 31, 2020.
- **Leading the world-class Ichthys LNG Project in Australia as operator** and engaged in projects in approximately 20 countries worldwide.
- Operating both oil and gas production plants, an LNG receiving terminal and **a natural gas trunk pipeline network currently extending approximately 1,500 kilometers** across 9 prefectures in Japan.
- Aiming for the realization of **a net zero carbon society by 2050** while responding to the energy demand of Japan and other countries around the world, based on the recently formulated **"INPEX Vision@2022"**.

AVEVA

Introduction – About PI Systems in INPEX

Looking at figures associated with PI Systems in INPEX



Japan

300+ Users

15,000+ PI Points

290+ Screens on PI Vision

Ichthys LNG, Australia

1,100+ Users

320,000+ PI Points

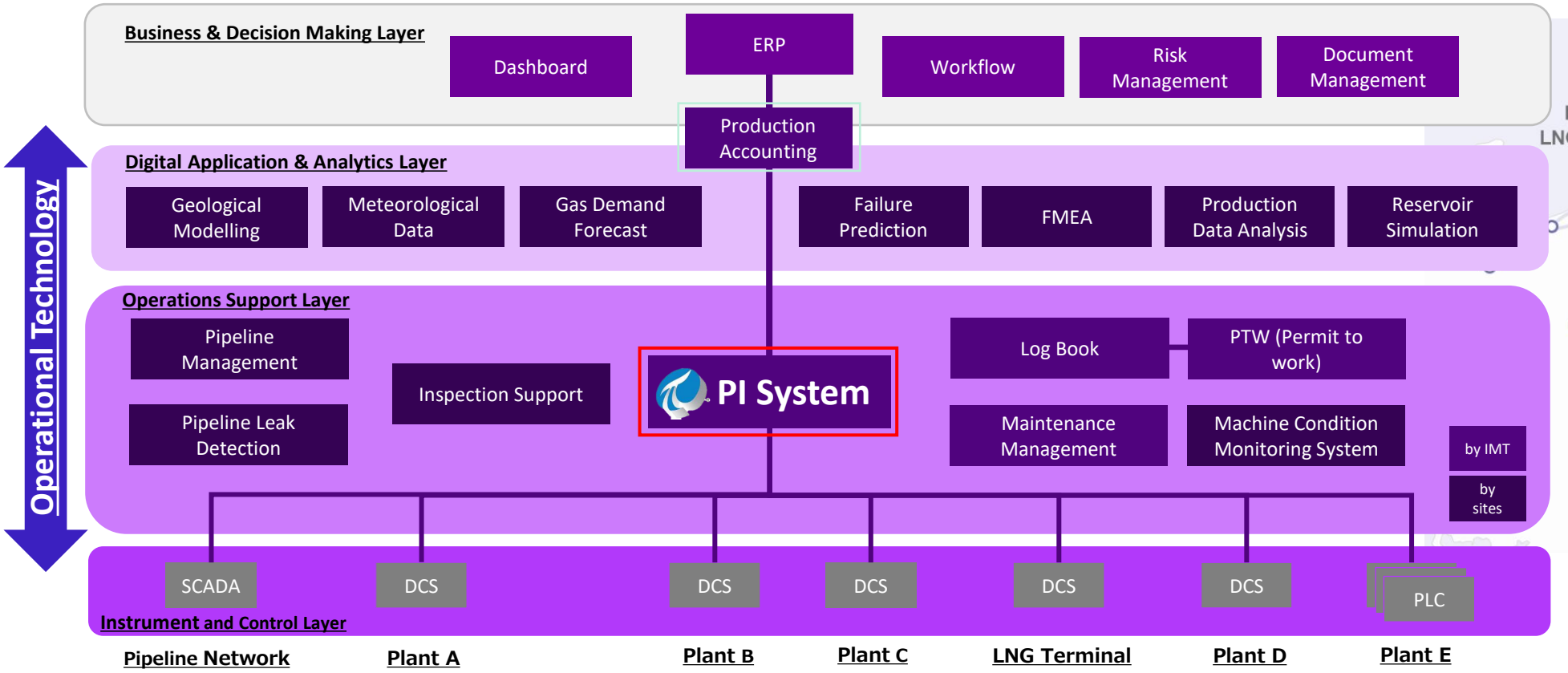
10,500+ Screens on PI Vision

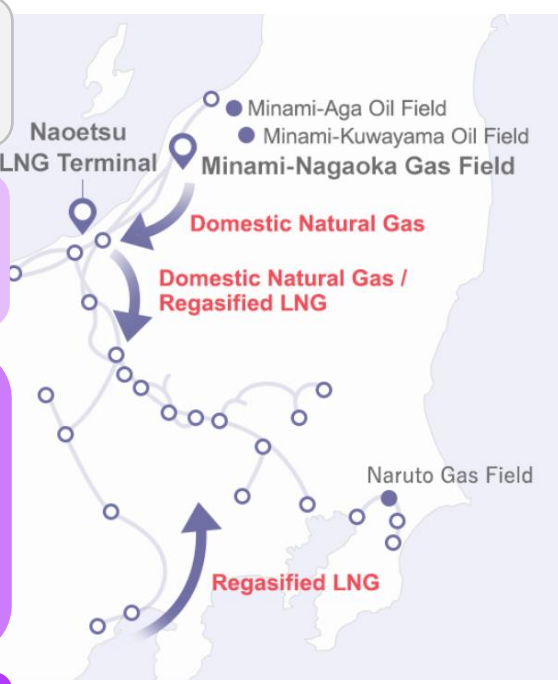
© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

AVEVA

Japan – Oil & Gas productions and Pipeline network

Data Aggregation for multiple sites in Japan





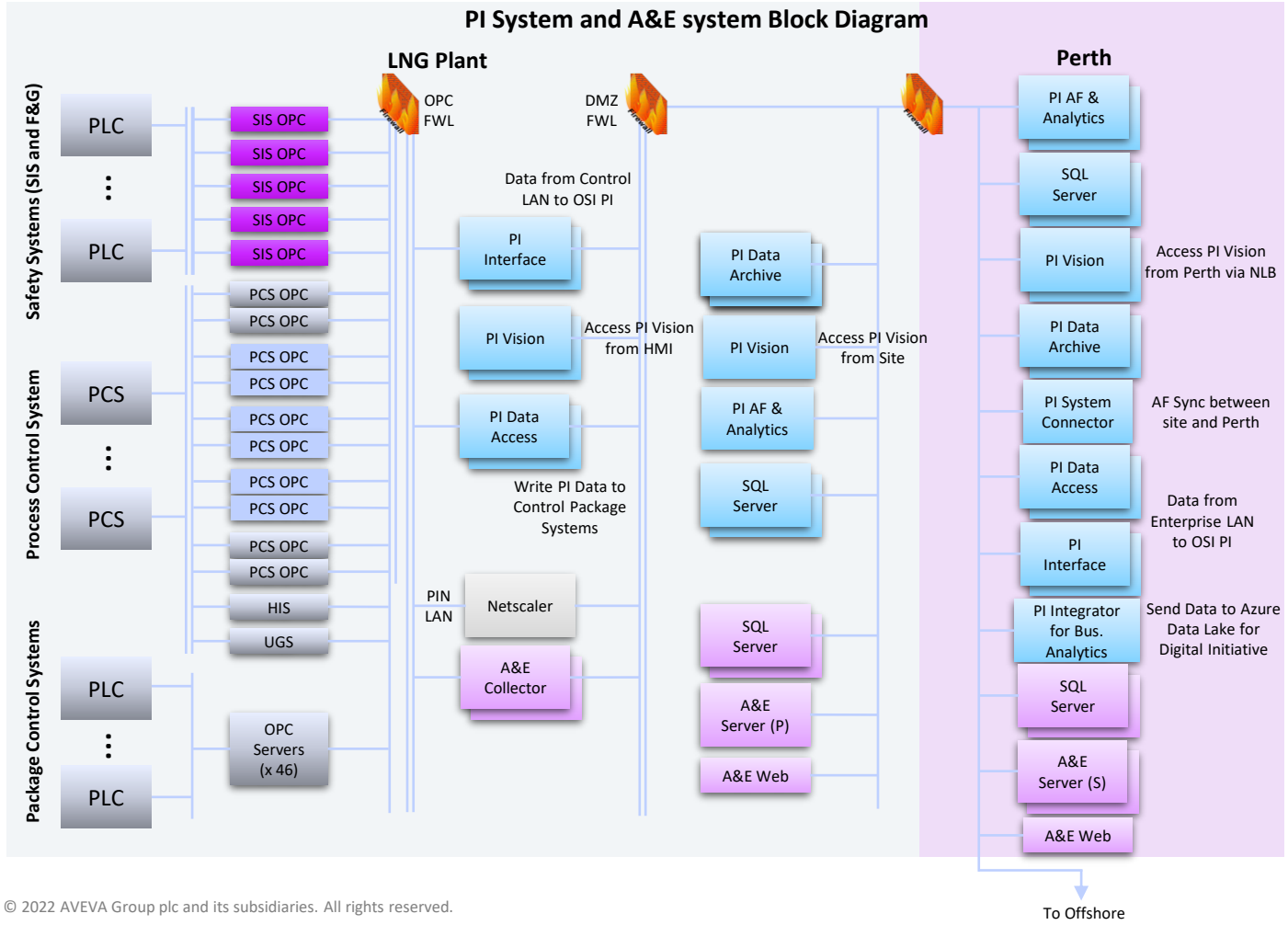
INPEX assets in Japan

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

AVEVA

Australia – Ichthys LNG – Onshore & Offshore Development

The most complex data aggregation in INPEX



© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

OIL & GAS

Upstream operations globally

INPEX

INPEX CORPORATION

Challenge

Our on-premise PI System is located approximately 300 km away from our head office.

It takes time and effort for IT experts to handle cases such as periodic replacement and troubleshooting of hardware.

EOL (End of Life) of HW and OS was supposed to be Dec. 2021.

Solution

Migrated PI System infrastructure in Japan to Microsoft Azure.

The migration was moved forward with an experienced IT vendor for 10 months, and successfully completed on schedule.

Benefits

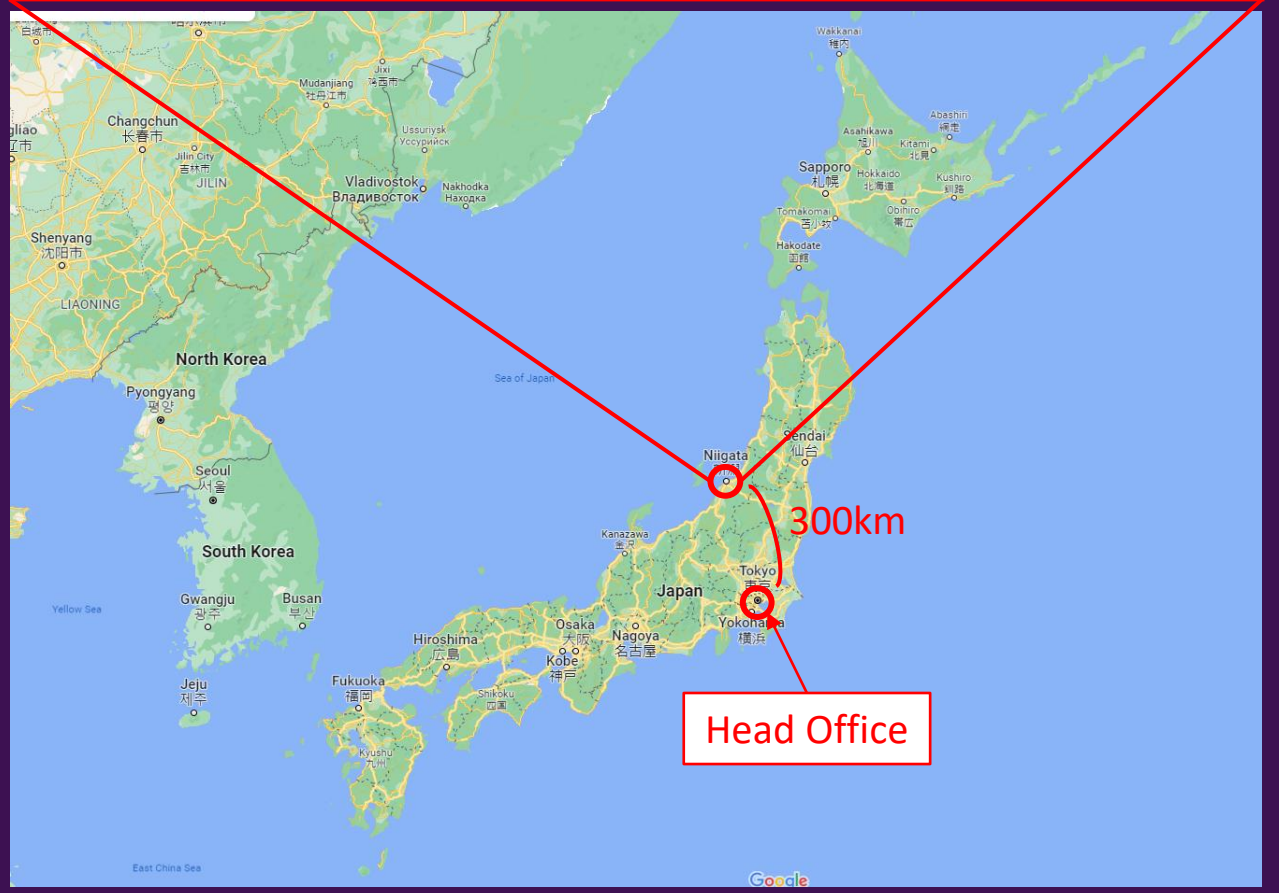
The TCO (total cost of Ownership) of Azure is almost same as that of on-premise.

Maintenance and replacement of hardware are not required anymore.

IT experts can focus on supporting process engineers who work on advanced analysis with PI System.

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

AVEVA



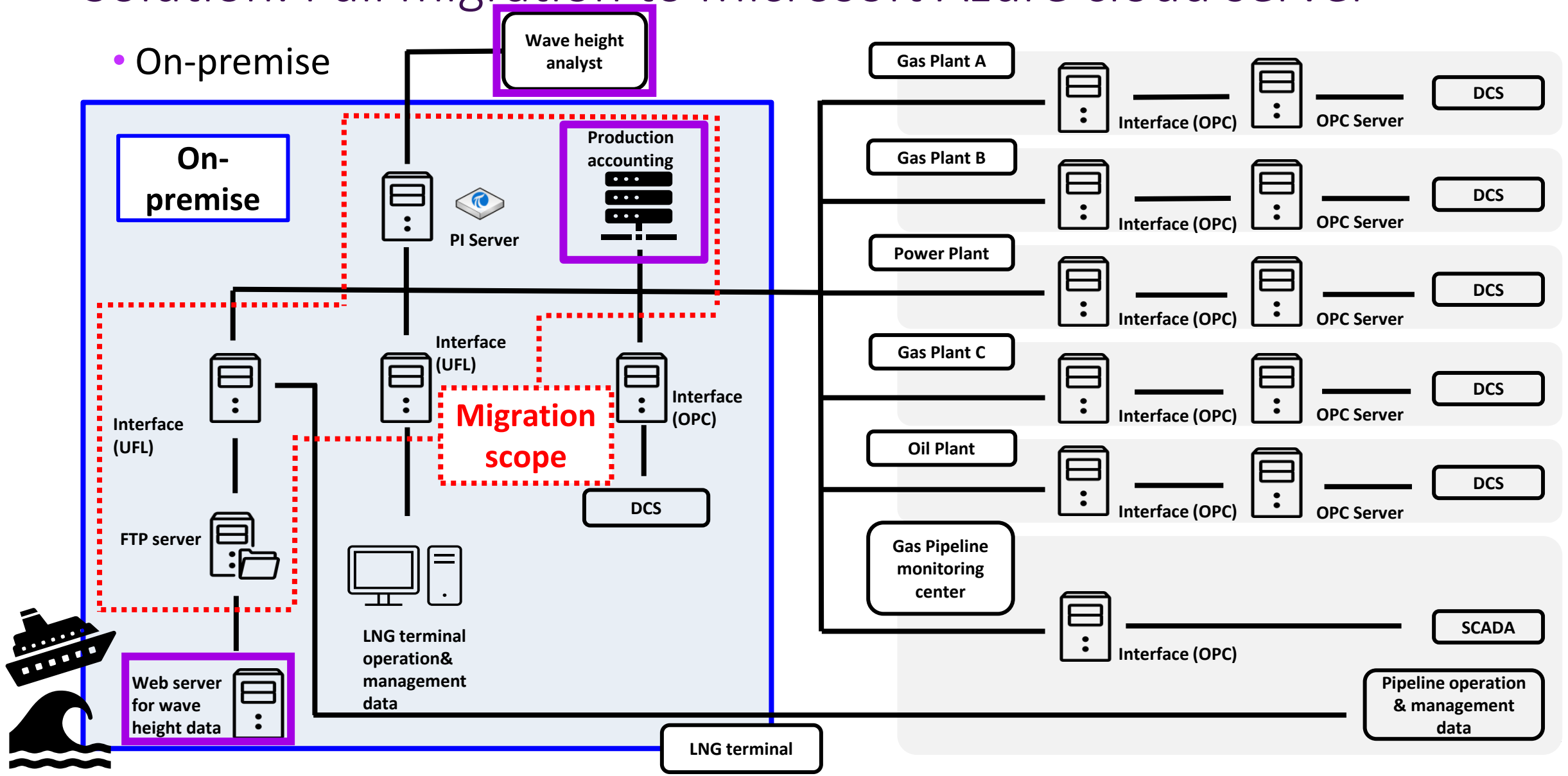
Challenge: On-premise server maintenance

- INPEX has used on-premise PI System for oil and gas fields in Japan since 2014.
- The maintenance support for HW and OS was supposed to reach an end in Dec. 2021.
- Replacing the server with new on-premise server is one of options. However,
  - It takes additional labor cost for on-premise server management due to internal IT expert shortage.
  - On-premise servers are located approximately 300 km away from INPEX head office, which makes internal IT experts difficult to troubleshoot them immediately in the case of system failure.

AVEVA

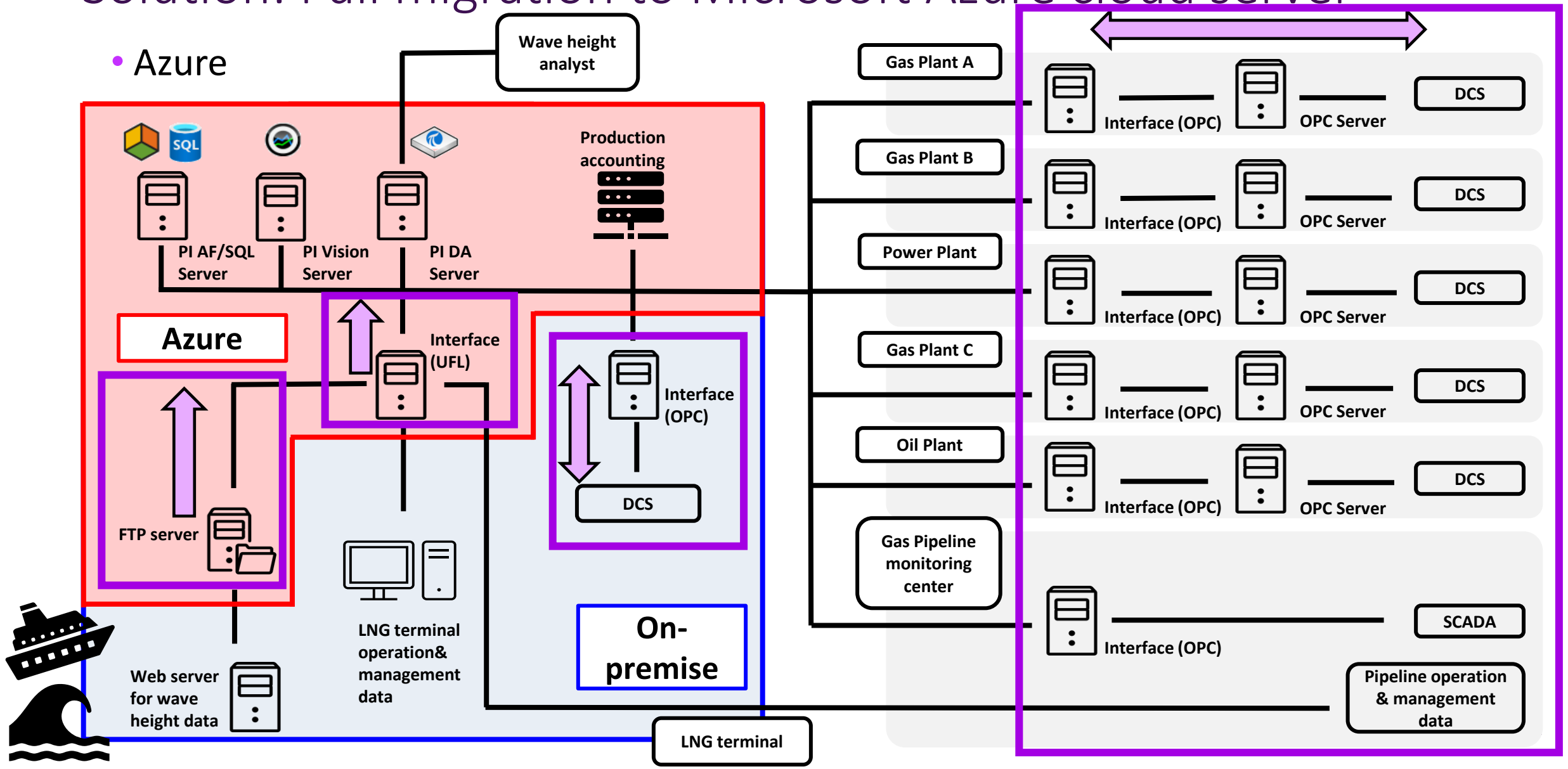
Solution: Full migration to Microsoft Azure cloud server

- On-premise



Solution: Full migration to Microsoft Azure cloud server

- Azure



Migration process

- All process was completed on schedule.

2021											2022	
Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		Jan	Feb
Kick off	Azure infrastructure document review			Application building/test document review			Decision meeting for moving to migration phase			User Acceptance Test		

Design for Azure infrastructure

Design for application building and test

Azure infrastructure building

Application building on Azure and application test

Rehearsal for migration to Azure

Transfer of data archive files to Azure

Migration procedure investigation

Main migration to Azure

Azure production Environment

Success factors

Replacement of ProcessBook with PI Vision 2020

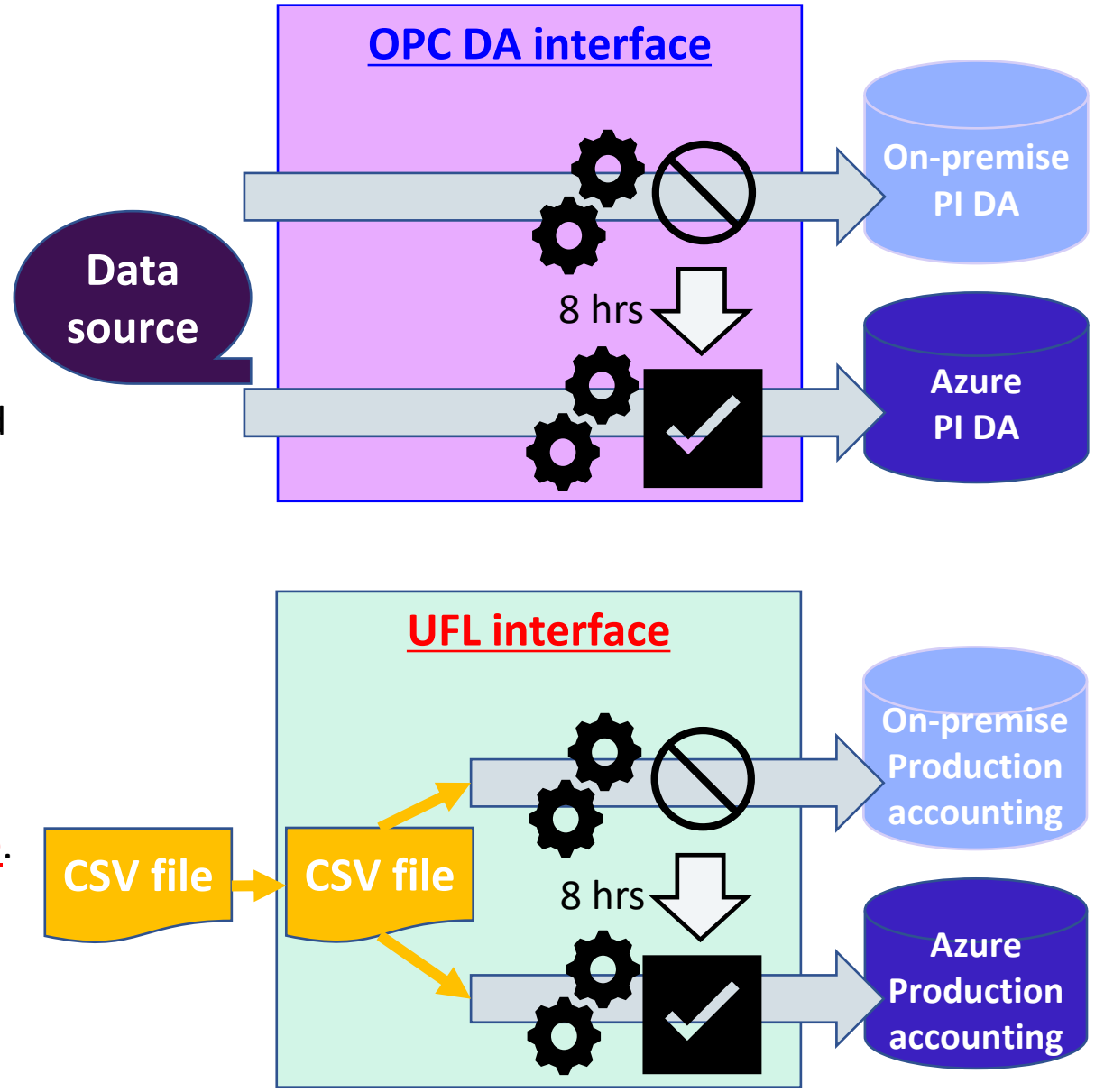
© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Success factor 1

Migration procedure investigation

- Tolerate 8 hours data loss when starting data transmission to Azure for OPC DA interface.
  - Stopping data transmission to on-premise server, followed by starting data transmission to Azure.
  - Simultaneous data transmission to both on-premises servers and Azure is one of options, but we didn't do that in order to avoid overload risk to network, database and interface machines.
- Why were we able to tolerate the 8 hours data loss?
  - LNG carrier was not approaching at this timing.
  - Production accounting collects data through UFL interface.
  - Process data at oil and gas fields can be monitored with DCS or local historian.
- When did we decide to tolerate the data loss?

  --> Migration rehearsal

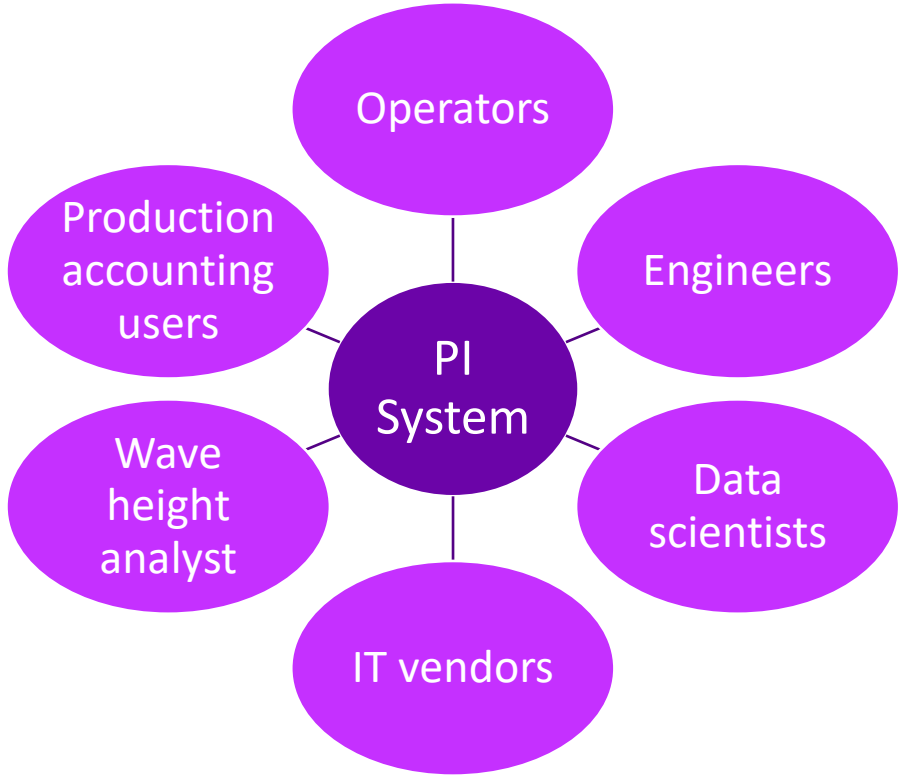


© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Success factor 2

Migration rehearsal

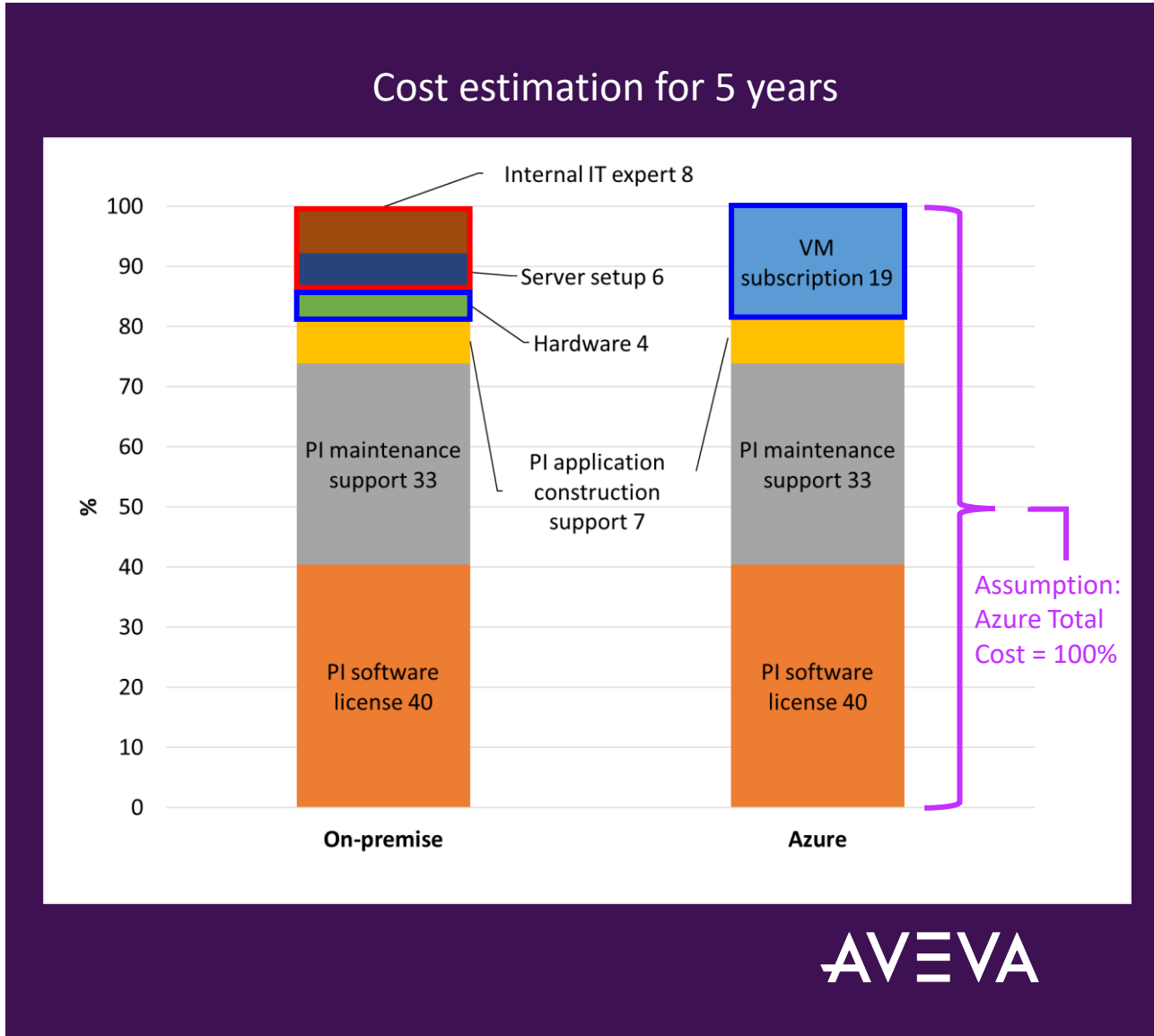
- Migration rehearsal was conducted to estimate how long main migration takes.
  - Note: There are lots of stakeholders for our PI System. It was better to complete migration all at once, not a step-by-step procedure.
- This rehearsal helped us consider time schedule for main migration, and share the plan with stakeholders at an early stage.
- The mindset for success of migration project is not only replacing servers with integrity but also building a relationship of trust with stakeholders.



© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Benefits: Same cost as on-premise and no requirement of hardware maintenance anymore

- Right figure shows the cost estimation comparison for 5 years between on-premise and Azure.
- Hardware cost is much less expensive than VM subscription cost. However, on-premise needs additional cost such as server setup and labor cost for IT expert.
- Considering TCO (Total Cost of Ownership), both cases show almost same cost.
- Maintenance and replacement of hardware are not required anymore by our own.
- IT experts can focus on supporting process engineers who work on advanced analysis with PI System.

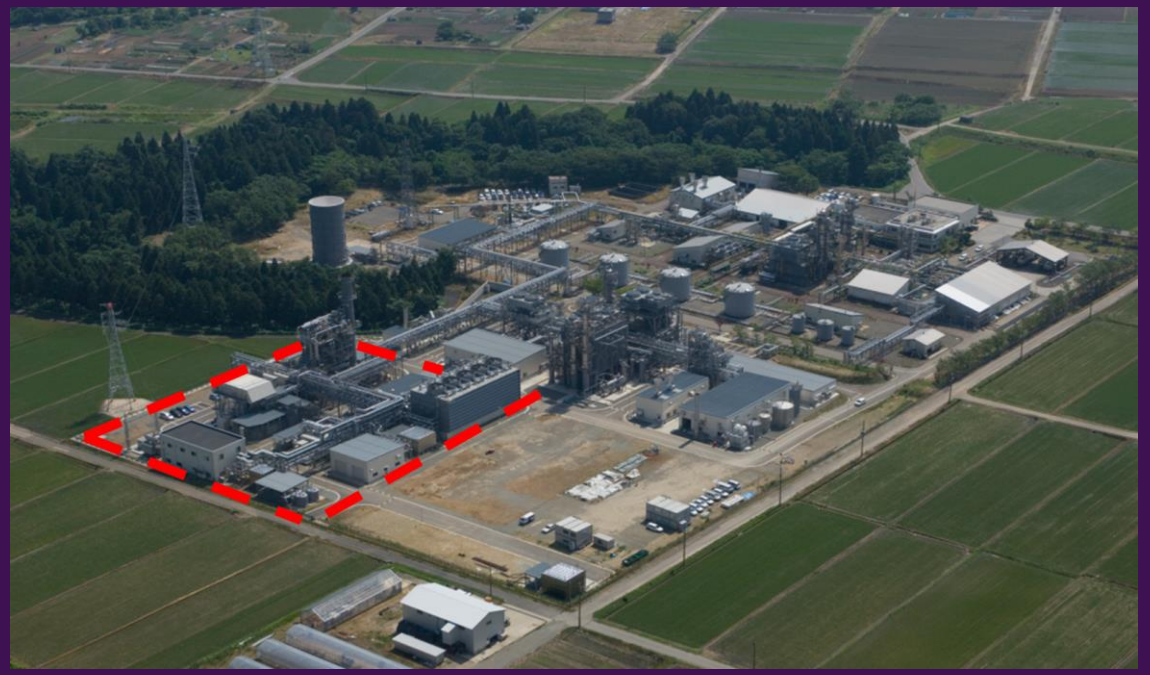


© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Application Case Studies

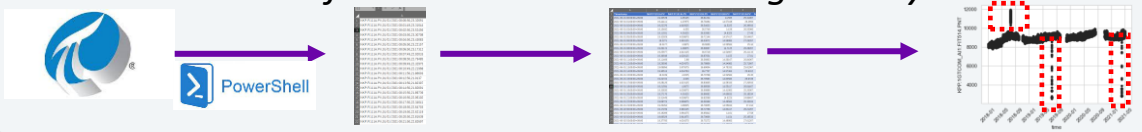
Anomaly Detection with ML for Aeroderivative Gas Turbine in Combined Cycle Power Plant

- Challenge
  - INPEX has been operating a Combined Cycle Power Plant for about a decade at Minami-Nagaoka Gas Field in Japan, where unexpected shutdowns have been one of the operational issues as it could cause a cumbersome tasks for rescheduling and unplanned maintenance.
- Solution
  - A data-driven approach was found to be a potential resolution. Organized a taskforce team incl. data scientists and applied ML to the bulk data extracted from PI to demonstrate how it works for anomaly detection.
- Benefit
  - Identified suspicious anomalies before the shutdown events. Needs more PoC to determine the benefit.

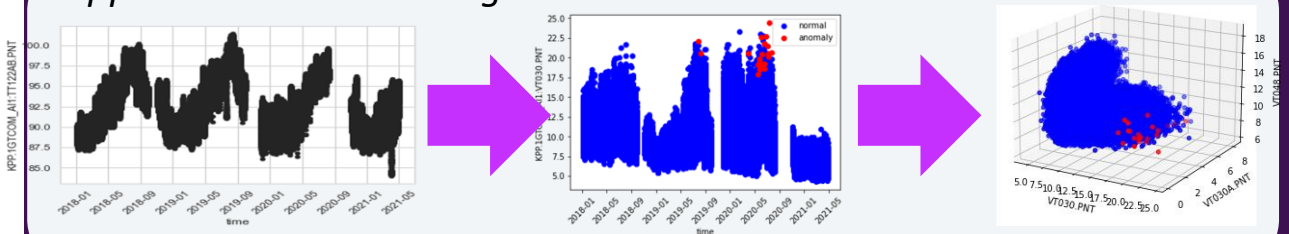


Koshijihara Power Plant, Nagaoka, Japan

Bulk data collection from PI and data cleansing with Python



Applied machine learning to the conditioned PI data



© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Application Case Studies

Condition Based Maintenance using PI Data with AspenTech's Process Simulator, HYSYS

- Challenge
  - Various optimization has always been a challenge. Accurate estimation of the condition of a heat exchanger is difficult only from calculating UA value*, resulted in calendar-based maintenance.
- Solution
  - Combined with AspenTech's process simulator, calculated a fouling factor of the heat exchanger using rigorous calculation.
- Benefit
  - Visualizing the trend of fouling factor would contribute on maintenance (cleaning) planning especially for Shell & Tube heat exchangers.

** Overall heat transfer coefficient to measure how well heat is conducted*

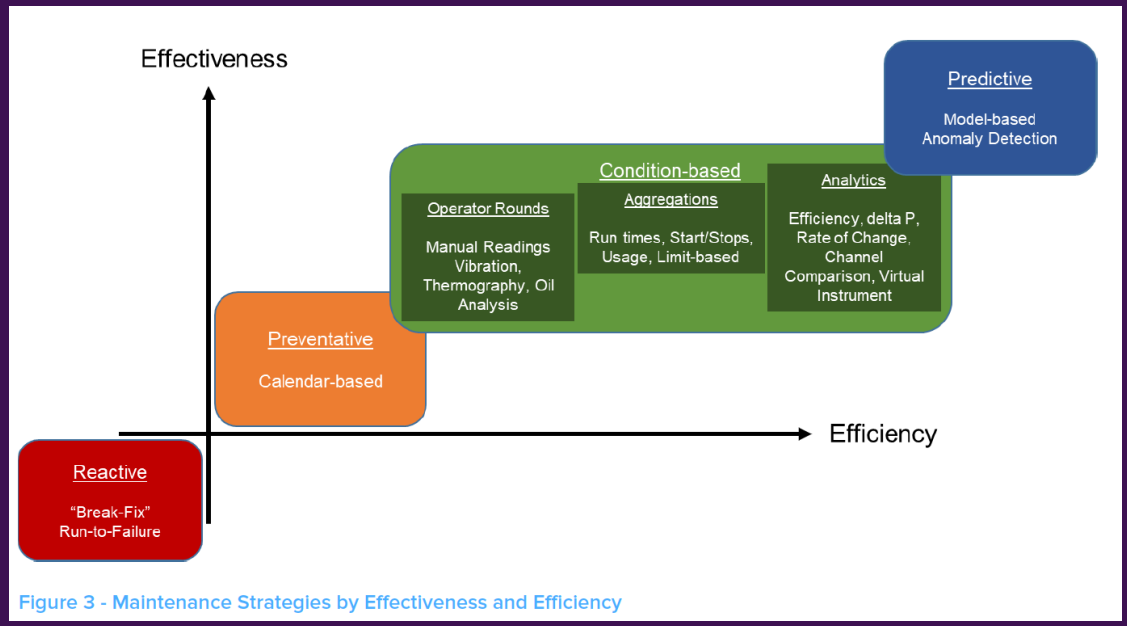
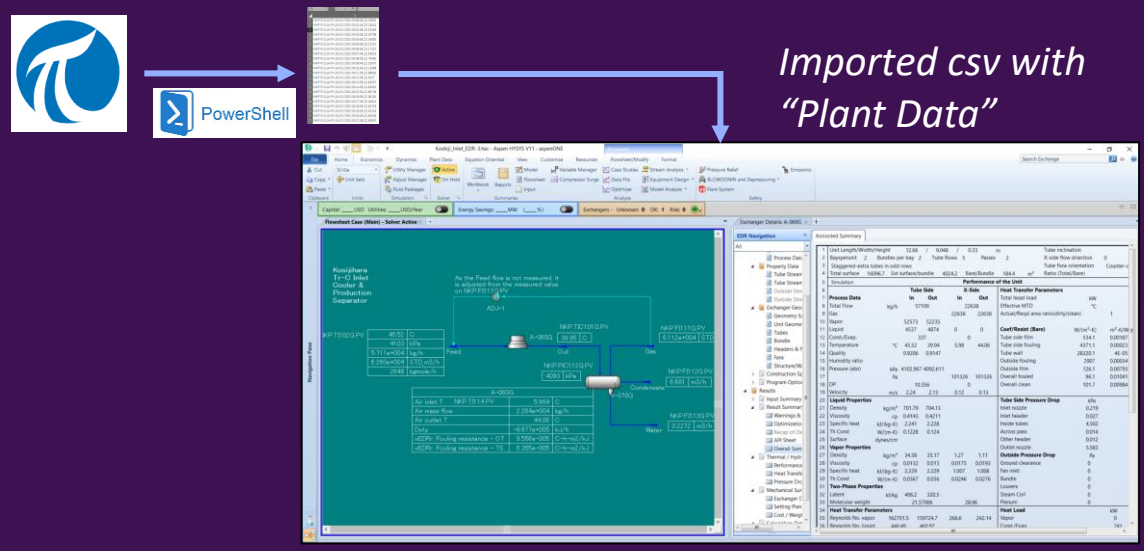


Figure 3 - Maintenance Strategies by Effectiveness and Efficiency

Quote: OSIsoft's CBM Workbook



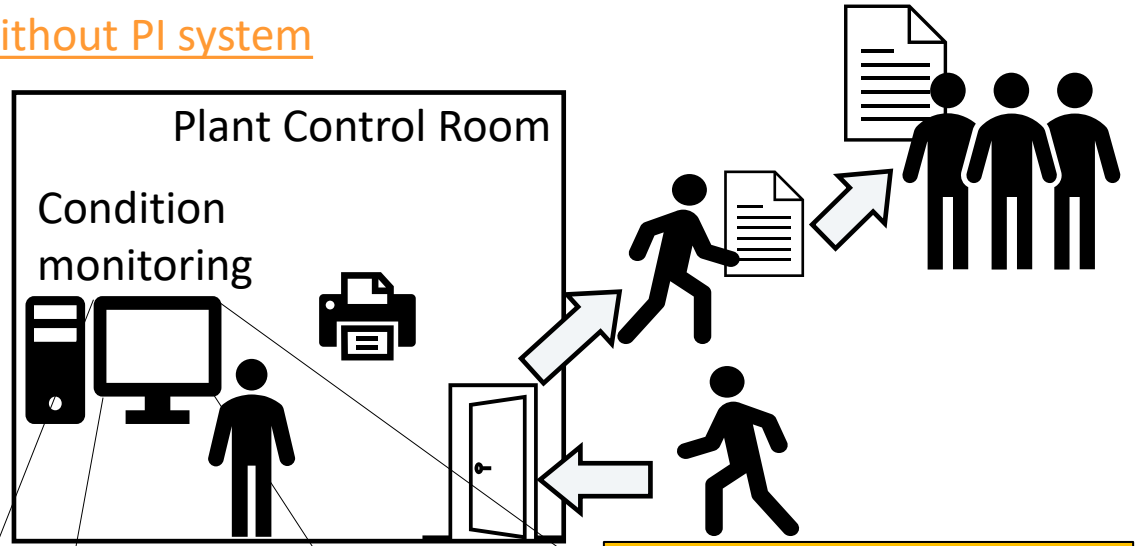
Calculated heat exchangers' fouling factor using EDR (Exchanger Design and Rating)

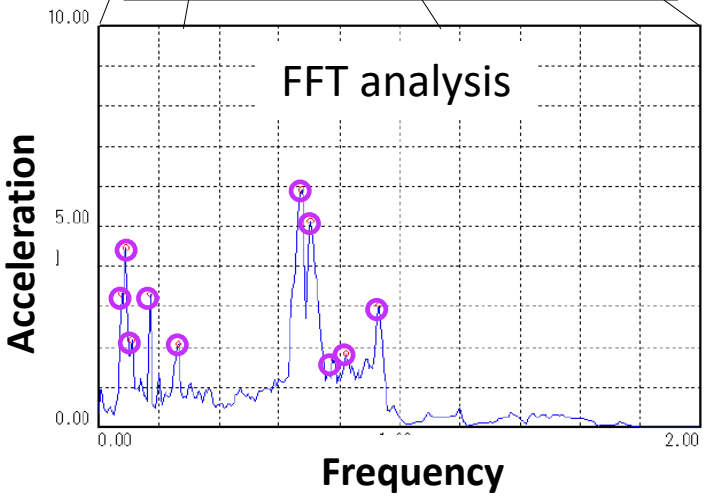
© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Application Case Studies

Accurate but Reasonable Condition Monitoring for Rotating Machineries in Naoetsu LNG Terminal

Without PI system

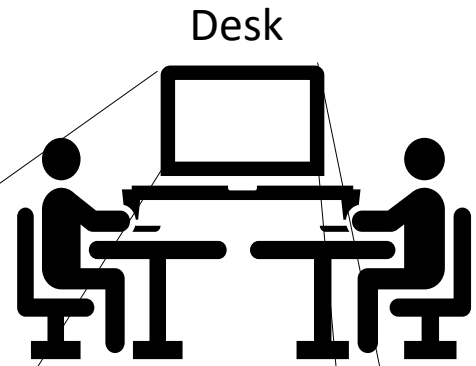




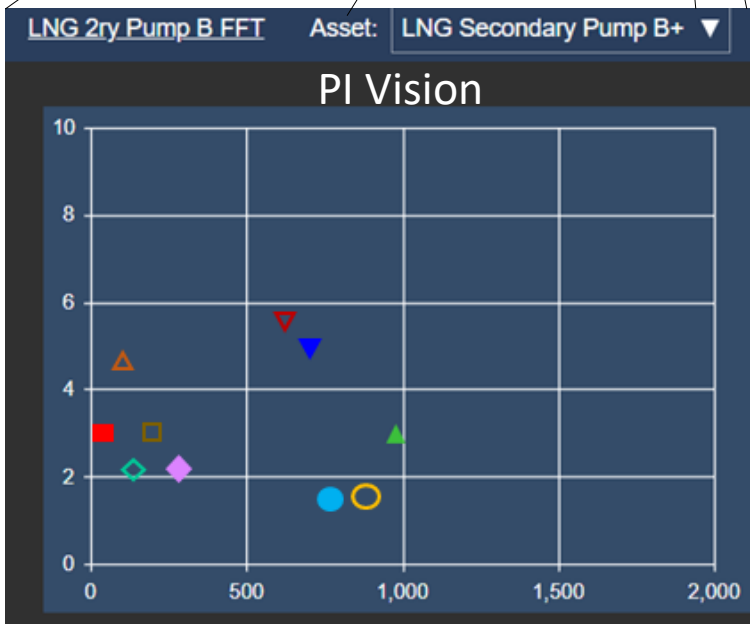
Engineers needed to access the local machine and print out the result to share with others every time due to our security policy.

With PI system

PI Vision enables us to monitor FFT analysis remotely with sufficient reliability.
Engineers check with Control Room Operator only when a trouble occurs.

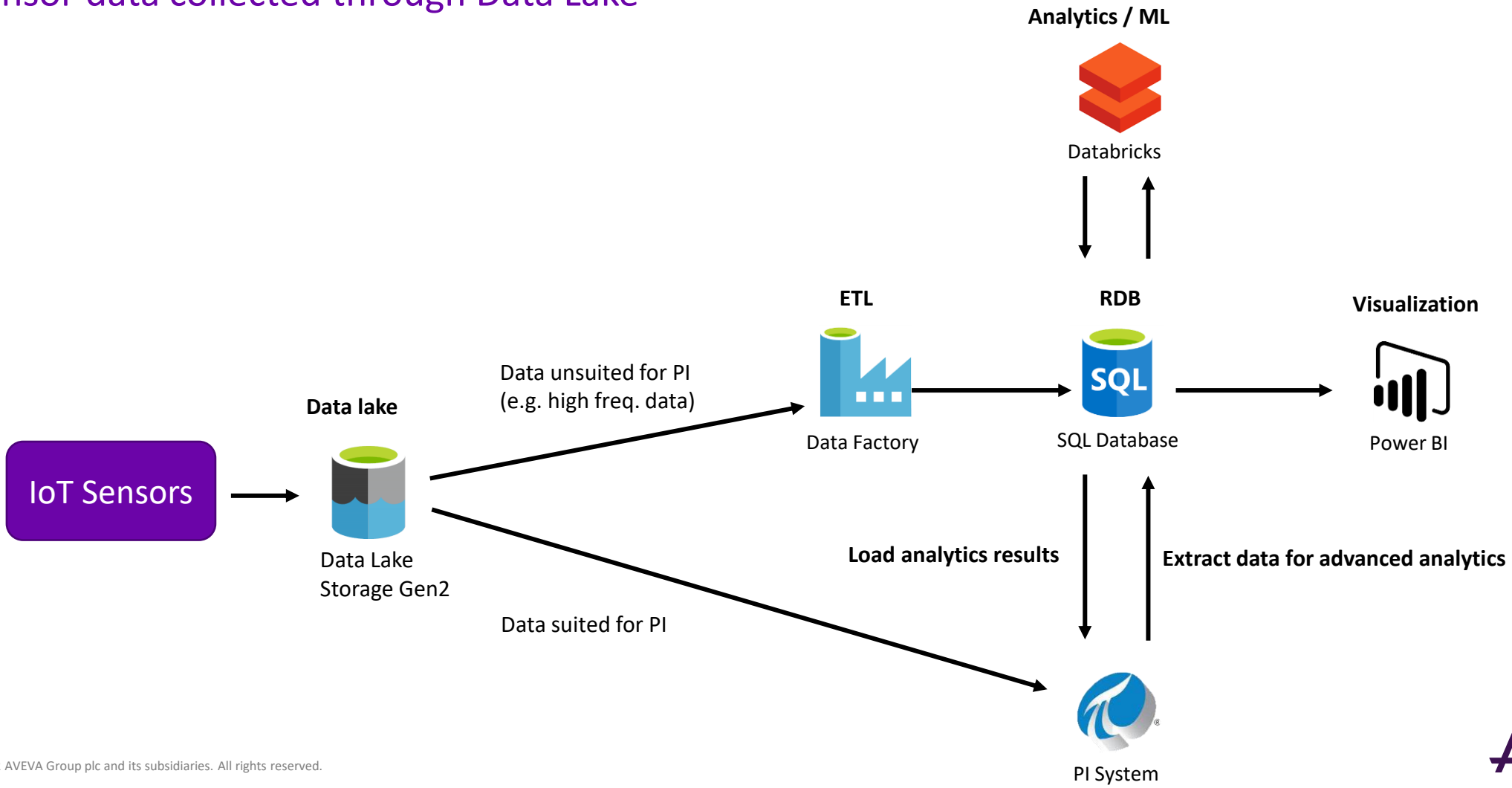


Connect only top 10 points to PI System.



Application Case Studies

Sensor data collected through Data Lake



© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

Conclusion & Looking ahead

Migration to Azure is not our goal, we have just begun a new journey

- **Successfully migrated the key infrastructure of PI Systems in Japan, to Microsoft Azure**.
- At the same time of the migration, PI Vision 2020 was introduced as a replacement of ProcessBook. Yes, we never leave a customer (users) behind, but we decided to switch to PI Vision without a step-by-step transition.
- Needs more discussion to migrate PI Systems of Ichthys LNG in Australia as there are much more considerations due to the complexity of the PI Systems, and the ”zero data loss philosophy. However, we believe **our achievements in Japan will contribute on a scaled-up “hot” cutover for Ichthys LNG**.
- With the PI Systems deployed in Azure-based environment together with other systems such as production accounting, we expect there will be **more chances to accelerate digital transformation in INPEX**. **INPEX will pursue a power of utilizing cloud by integrating various applications within Azure**.
- **INPEX is committed to a net zero carbon society by 2050**, and will seek to develop offshore wind farms off Japan islands, and many more sustainable energy development plans. Our ambition is to implement PI Systems in the new facilities INPEX will construct in the future with **a high-level data integration**.

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

AVEVA

Naoto Yamabe

Process Control Engineer

- INPEX Corporation
- naoto.yamabe@inpex.co.jp

Kohei Kawamura

Solution Engineer

- INPEX Corporation
- kohei.kawamura@inpex.co.jp

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.

© 2022 AVEVA Group plc and its subsidiaries. All rights reserved.