Supporting companies in their digitalisation transformation

AFRY E-DAP – An *end-to-end* web-app for data analytics

JULY 2024

Youtube channel → https://www.youtube.com/channel/UCa8KNDFweZPJt6KptUeH4cA
Website → https://afry.com/en/service/afry-e-dap

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Why is E-DAP unique?

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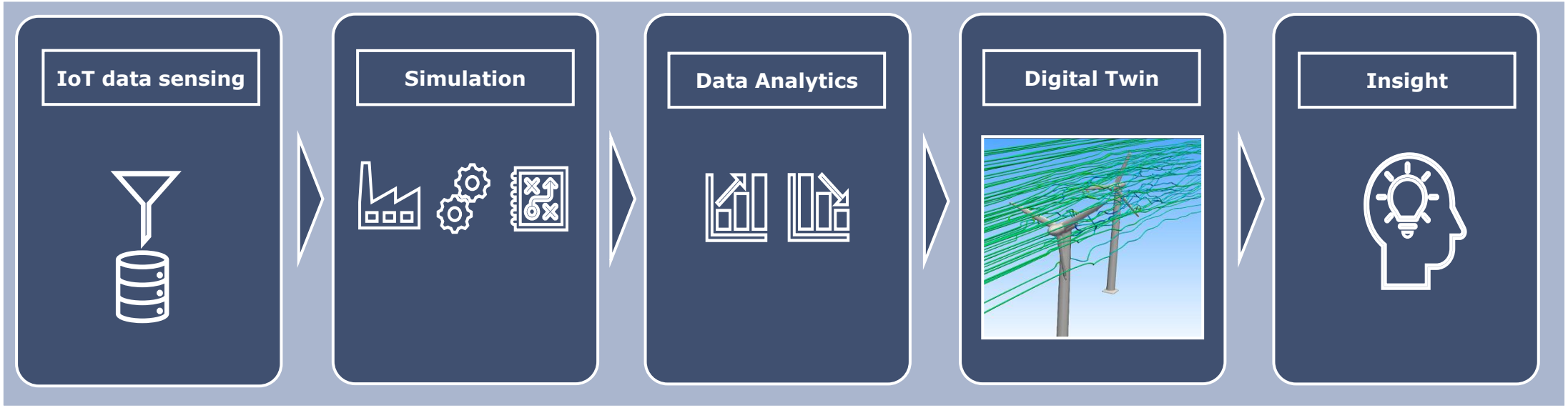
E-DAP UNIQUE SELLING PROPOSITION

An *end-to-end* workflow designed to harnessing the value of plant data, starting from IoT data sensing, to data engineering, physics simulation, ML/AI, digital twinning, to insight… All in one !



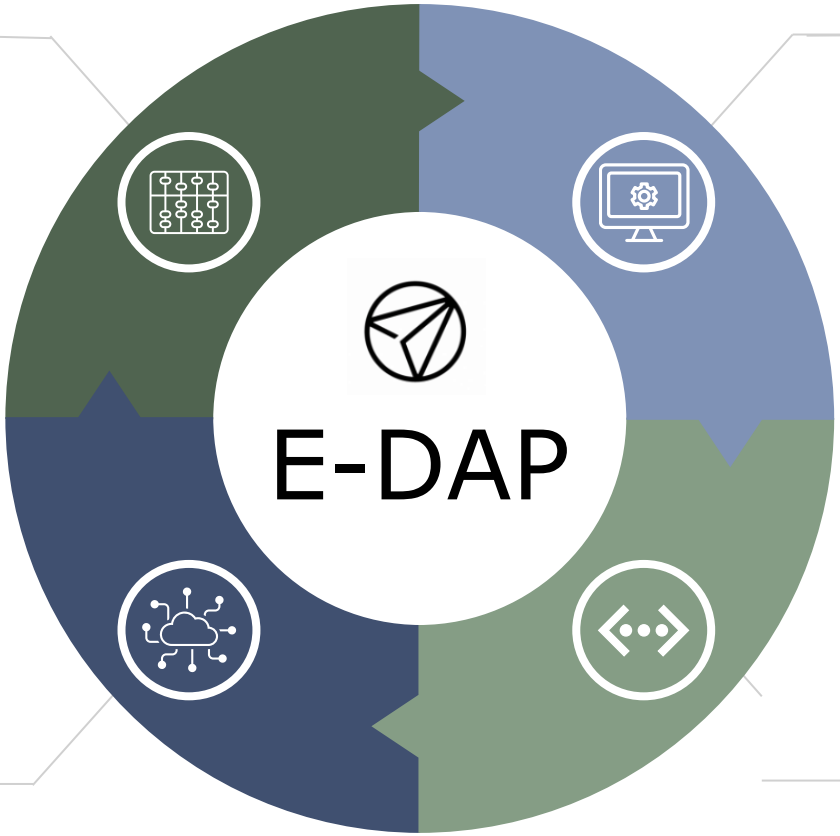
E-DAP can be either hosted on Azure Cloud (on own tenant or AFRY's tenant) or on prem!

E-DAP UNIQUE SELLING PROPOSITION

E-DAP is AFRY's data analytics platform designed for asset infrastructure owners seeking to optimise their O&M costs and capital efficiency

1 End-to-End architecture

- Encompassing all data analytics ingredients, without being distracted by other tools (Open BI, AI resources, notebooks...)
- IoT (Kepware, MQTT, Scada); data engineering & management, ML/AI, Digital twin, Insight page



2 Tailored Insight Hub

- A dedicated page for model and digital twin (DT) reporting
- The page reports KPI's specific to *Operational excellence, Predictive maintenance and Anomaly/fault detection*
- KPI's are either calculated on the IoT live data, or on the DT results

3 Extended Connectivity

Can connect to external platforms via

- Import standard ML/AI models
- Import FMU models (e.g. Modelica)
- Import BIM & GIS files
- Import HDF5 data
- Connect to data brokers with REST API

4 IoT Ingestion and Live Dashboarding

- IoT data are not always sufficient
- Combine simulation & IoT data to enrich ML-training
- Create artificial faults and extrapolate application range
- Create simulation digital twins (SDT)

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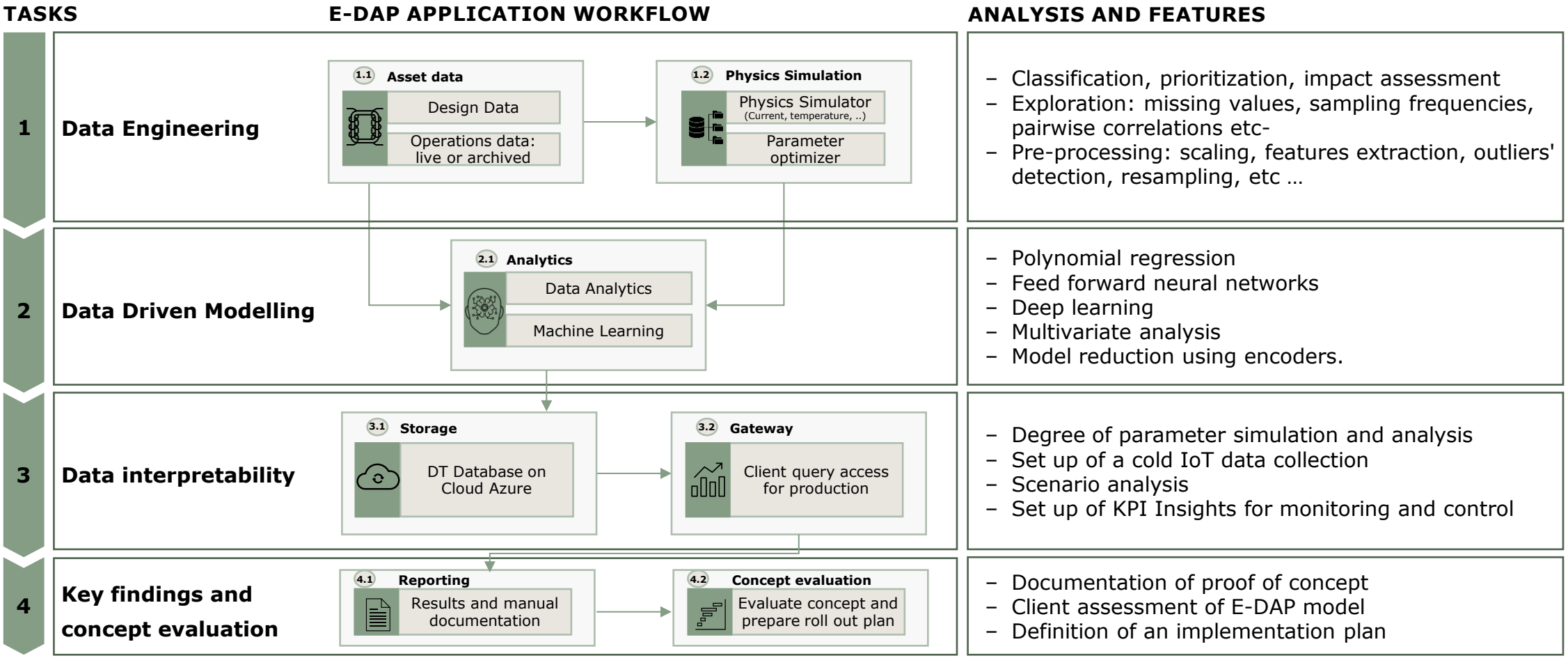
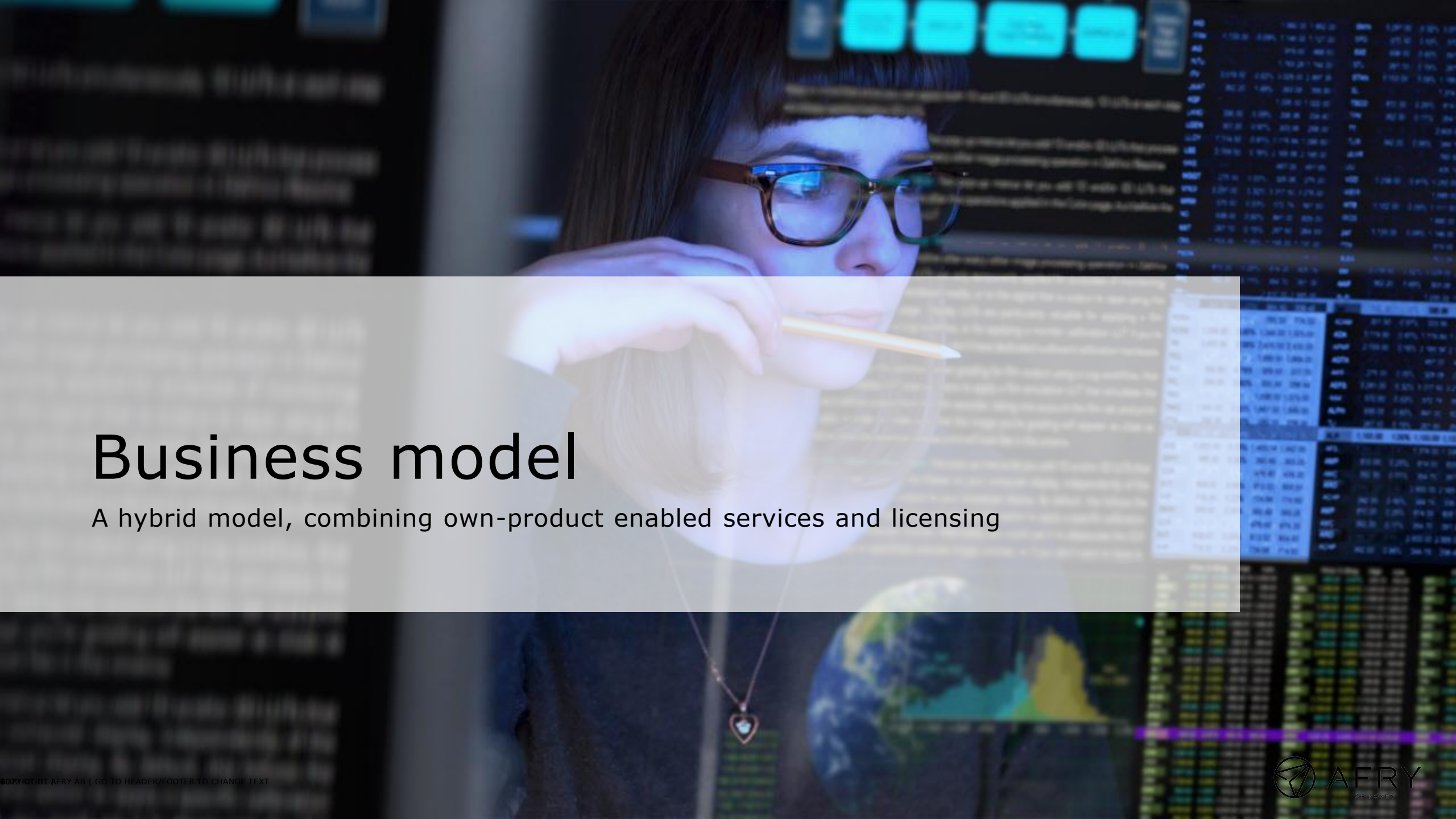
AFRY follows a structured workflow to engineer the data and build a digital twin of the asset with machine learning algorithms for behavior prediction



 COPYRIGHT AFRY MANAGEMENT CONSULTING | SWISSGRID TRANSFORMER AGING MODEL



Business model

A hybrid model, combining own-product enabled services and licensing

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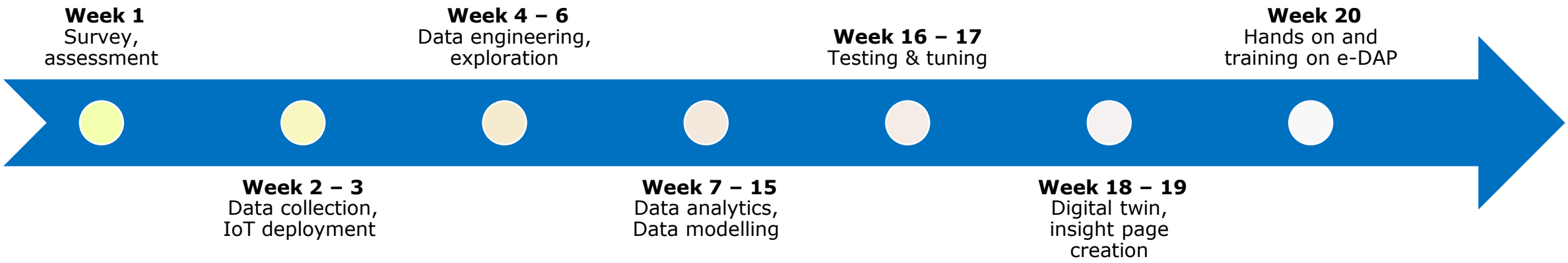
BUSINESS MODEL

Business model : Services (e.g. typical project)



AFRY Team	• **1 FTE** • **10% onsite** • **90% office**	• **1 FTE** • **20% onsite** • **80% office**	• **1 FTE** • **5% onsite** • **95% office**	• **1 FTE** • **5% onsite** • **95% office**	• **1 FTE** • **10% onsite** • **90% office**	• **1 FTE** • **5% onsite** • **95% office**	• **1 FTE** • **50% onsite** • **50% office**
CLIENT	• 1 FTE • 10% onsite	• 1 FTE • 20% onsite	• 1 FTE • 5% onsite				• 1 FTE • 10% onsite

AFRY

How & where E-DAP is applied ?

LIVE DEMO, ARCHITECTURE, PROJECT REFERENCES

Youtube channel → https://www.youtube.com/channel/UCa8KNDFweZPJt6KptUeH4cA
Website → https://afry.com/en/service/afry-e-dap

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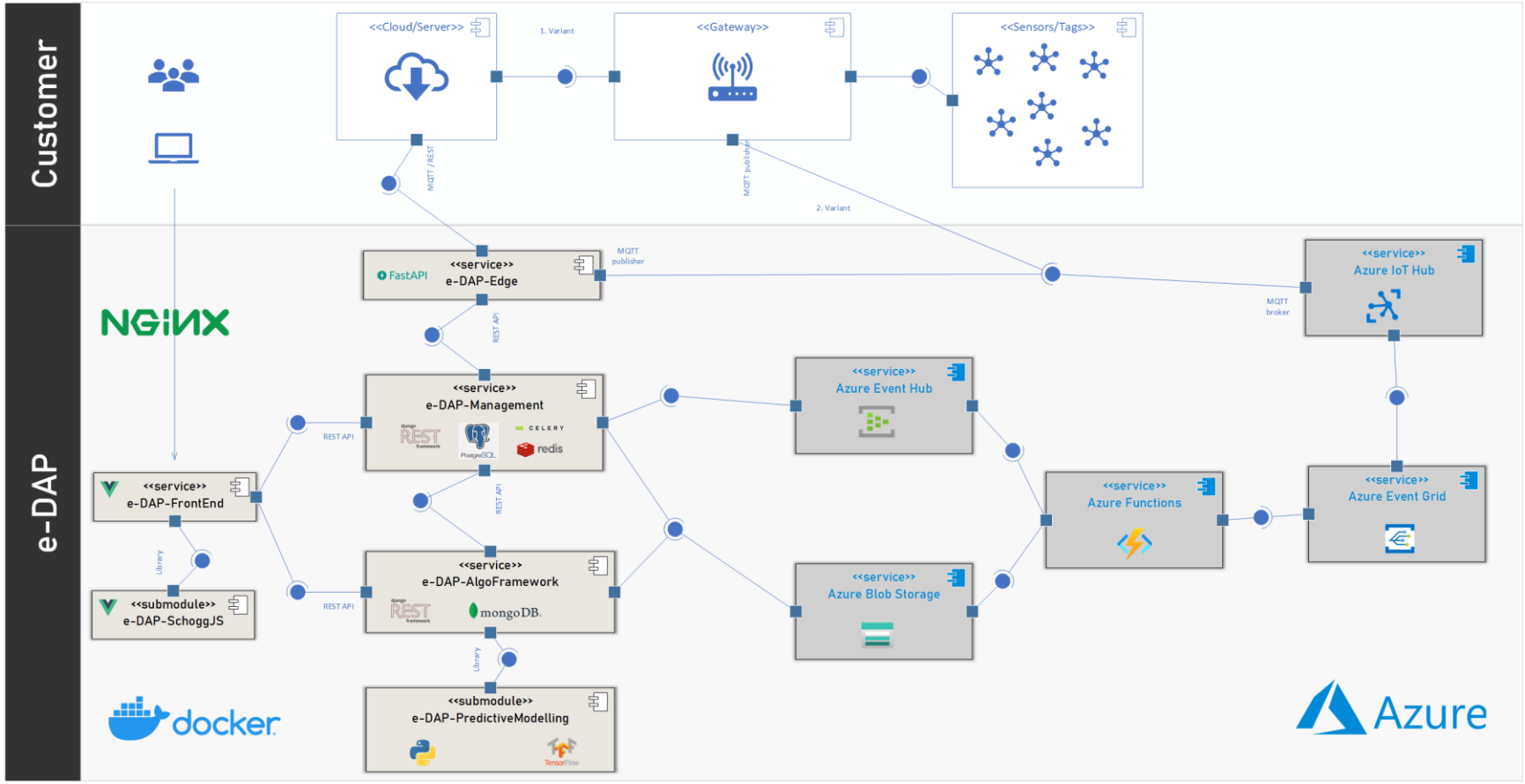
We use Microsoft Azure to connect E-DAP to our clients IT Enterprise Level through which IoT information of field devices can flow securely upwards to

E-DAP ARCHITECTURE



COMMENTS

- While e-DAP main architectural components are in-house developed, it uses Azure databases and functions
- We assume that your industrial control system security is equipped with data diodes that guarantees secure unidirectional information flow from OT field devices to the enterprise IT level
- We are developing an alternative on premise architecture for clients who have stringent OT data security requirements

AFRY
ÅF PÖYRY

E-DAP is application agnostic: it applies across different industry sectors with different complexities, and succeeded in demonstrating value added

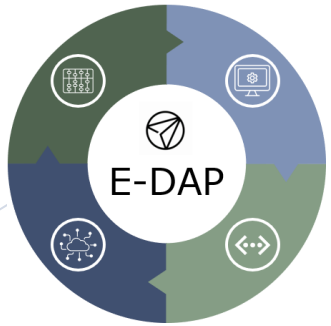
Engineering Data Analytics Platform (E-DAP) – overview

1 Process industry

- Chemicals & vegetal oil
- Food & Pharma
- Pulp & Paper

2 Energy industry

- Generation
- Distribution
- Transmission



3 Infrastructure assets

- Buildings
- Tunnels
- Transportation (road, train & airports)

4 Manufacturing industry

- Power plants
- Turbines & compressors
- High-tech & electronics

5 Environmental assets

- Wastewater Treatment
- Hydrology

REFERENCE: ENVIRONMENTAL ASSET

E-DAP for wastewater systems optimisation: From digital controlling to predictive maintenance and operational excellence

Project Metrics

- 2021-22
- AFRY AMS Zurich

Client

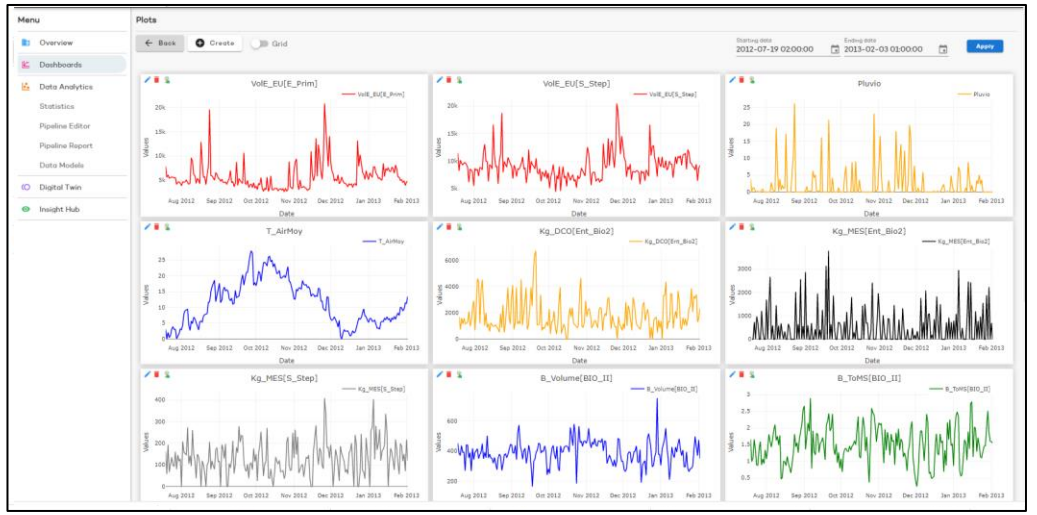
- WWPT, CH

Situation and Challenge

- Need to know the exact operation parameters of urban and industrial WWTPs, at the 04 main steps: primary & secondary treatments, bio treatment and sludge disposal.
- Need to respond to external constraints, e.g. evolution of treatment load due to increase of population, special events, meteorological conditions, changes in economics of operation.

Service and Approach

- AFRY's IoT system connects to the operator's data repository system via an MQTT protocol. Sensors can be placed then connected to e-DAP.
- The system collects and ingests live data in the platform (water and waste partition, temperature, humidity, energy consumption, bio-chemicals)
- Once sufficient data is collected and engineered, appropriate ML/AI algorithms are used. Legacy data can be used as well.
- The model - engine of the 'WWTP Digital Twin'- is then used to forecast daily operation in the future (energy and chemicals needs, sludge age…) and predict the water-quality KPI's : content of COD, N-NH4, N-NO3
- E-DAP is employed as an asset management tool of several WWTP's.



Client Impact and Value Added

- The client can access an on-line business intelligence tool for predicting and monitoring the operation and performance of its WWTP assets.
- The client is capable to monitor the operation parameters of the plants and take remedy decision in advance in response to external constraints.
- Next step is to onboard of several train/metro stations and tunnels.

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Browse the use-case video → https://youtu.be/W1O7KZOg0-w

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REFERENCE: INFRASTRUCTURE ASSET

AFRY extends its train/metro/tunnel ventilation services during construction and operations: From digital controlling to predictive maintenance

Project Metrics

- 2022-23
- AFRY AMS Zurich

Client

- AFRY Zurich

Service and Approach

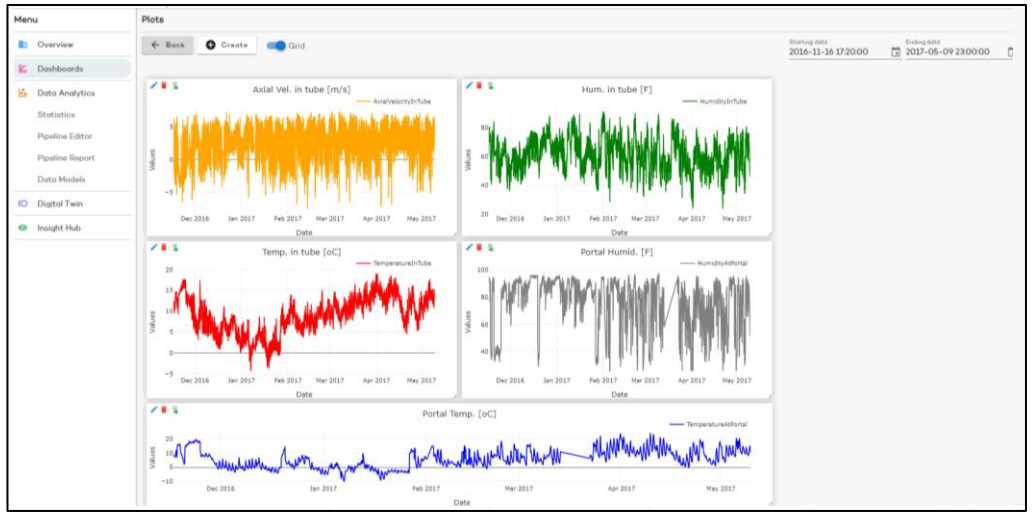
- AFRY's IoT system can be connected to the client's SCADA repository system via an MQTT protocol (or any other protocol).
- Sensors can be placed by AFRY then connected to e-DAP
- The systems collects and ingests live data in the platform at a modulable frequency (temperature, pressure differential, humidity, energy consumption)
- Once sufficient data is collected and engineered, appropriate ML/AI algorithms are used for the treatment of these legacy data
- We then use the model as the engine of the 'Tunnel Digital Twin', to be used to forecast the VAC & TVS daily operation in the future
- The platform is used as an asset management tool for various stations and tunnels along several lines at the same time.

Client Impact and Value Added

- The client now has on-line business intelligence tool for predicting and monitoring the operation and performance of all its assets
- The client is capable to live monitor the train/metro stations HVAC and tunnel ventilation systems (TVS), and take remedy decision in advance
- Next step is to onboard of several train/metro stations and tunnels.

Situation and Challenge

- Live monitoring of the climatic data in train/metro stations and tunnels, during construction and operations.
- Monitoring the daily operation of the train/metro stations HVAC and tunnel ventilation systems (TVS)
- Rely on a predictive maintenance tool to act in advance, covering all the assets of the client simultaneously.



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REFERENCE: INFRASTRUCTURE ASSET

AFRY helps broaden operator’s services in tunnel lighting: Our module serves as a digital control system and a predictive maintenance tool

Project Metrics

- 2020-23
- AFRY AMS Zurich

Client

- Phoenix

Situation and Challenge

- Live monitoring of the lighting data in the tunnel and the aging of the light points.
- Monitoring the risk associated with aging and any anomalies
- Rely on a predictive maintenance tool to intervene in due time.

Service and Approach

- AFRY’s IoT system is connected to the client’s SCADA repository system via an MQTT protocol (coded into e-DAP).
- The systems collects and ingests live data in the platform at a frequency of 5-to-10 seconds (luminance, energy, scenes, lumgates)
- Appropriate analytical models for predictive maintenance were implemented, based on literature and regulatory norms
- AFRY used the model as the engine of the ‘Tunnel Digital Twin’ (TDT)
- The TDT is to be used to forecast the daily operation and probable health of the lighting system
- The platform is used as an asset management tool for various tunnels, with focus on predictive maintenance.

Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset’s performance
- The client is capable to live monitor daily operations and probable health of any tunnel lighting system equipped with its system
- Next step is to onboard of several tunnels worldwide.

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REFERENCE: ENERGY ASSETS

AFRY designed for a Europe-based TSO a modular and reliable predictive maintenance model to optimize the maintenance plan of its HV transformers

Project Metrics

- 2022, 2 months
- AFRY Management Consulting Berlin & AFRY AMS Zurich

Client

- Swissgrid

Service and Approach

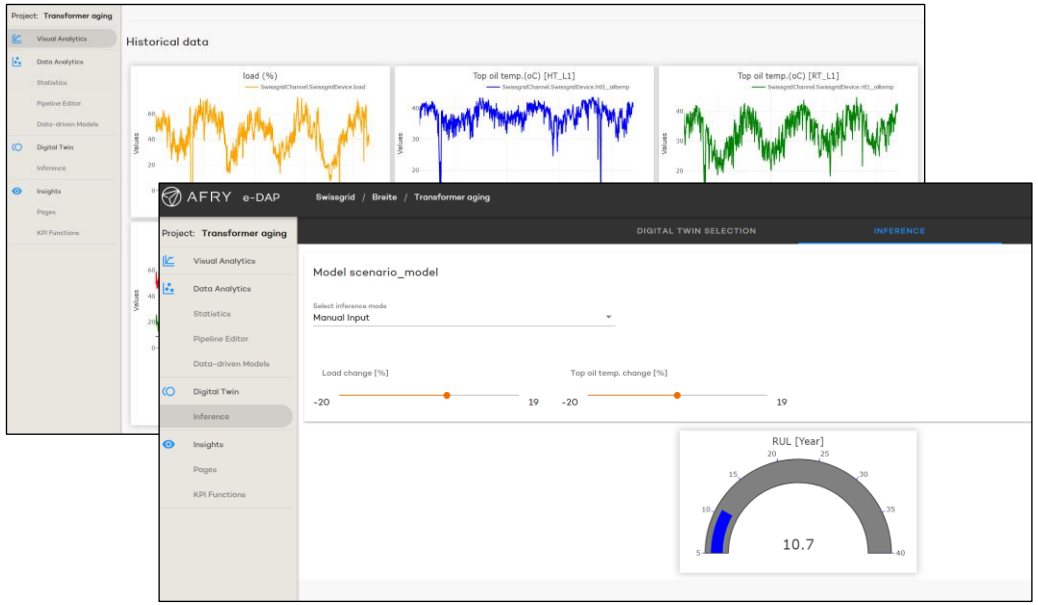
- AFRY used E-DAP to build a predictive maintenance model for the aging of the transformer
- AFRY used existing data (both frequent and seldom) to understand how the maintenance has been conducted over the last 40 years.
- AFRY analyzed any indication of oil degradation from the inspection analysis conducted by the client to feedback patterns in e-DAP
- AFRY identified the paper polymerization as the main cause of degradation for the transformer useful life
- AFRY used analytical modelling relating the collected data to the health index and resorted to machine learning to predict future trends

Client Impact and Value Added

- Swissgrid holds a license for a modular and reliable predictive maintenance model that can predict the remaining useful life of its HV transformers and optimize as such its maintenance plan
- Swissgrid is capable to conduct scenario analysis changing temperature, load, and oil cleaning periodicity and assessing their sensitivity to the asset health index update

Situation and Challenge

- The client has measured and stored the temperature condition of the oil windings and the load of the transformer every 5 minutes for the past five years
- It is unclear if and how the client can correlate the condition measurement data of its transformer with its physical aging and move to a reliable and holistic condition-based maintenance strategy !



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Browse the use-case video → https://youtu.be/KsskhHsNS_4

REFERENCE: PREDICTIVE MAINTENANCE

AFRY designed for a swiss NPP a modular data predictive model to detect faults in the neutronics signal, augmented by a causality analysis module

Project Metrics

- 2021, 4.5 months
- AFRY AMS Zurich

Client

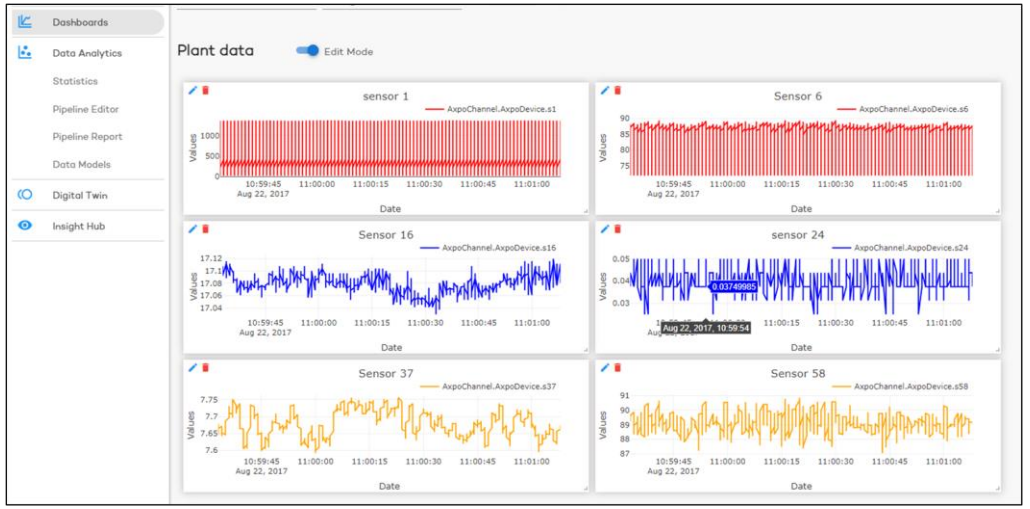
- Axpo

Situation and Challenge

- Client seeks a framework for anomaly detection in neutronics signals during plant start-up and its relationship with the steam production and plant instabilities.
- 'Deterministic' causality analysis were not fully conclusive in predicting faulty signals relating to flow instabilities and potential dry-out in the reactor pressure vessel.

Service and Approach

- AFRY conducted on-site survey of plants and infrastructure.
- AFRY collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY created a fully-fledged anomaly detection module in e-DAP, based on autoencoding algorithms
- AFRY analyzed various startup-cycle data from the plant to show changes in the causality and cross-correlation in the system that occur over time
- AFRY built an online framework accessible to the client, in which both visual analytics of real data is provided, together with a live inference of the digital twin using sensor data.



Client Impact and Value Added

- Client gained disposal of on-line business intelligence tool, providing a daily inspection of operations and predicting and monitoring the asset's health under defined KPIs
- Client is capable to infer potential failure scenarios in the asset using real time data (once their IoT is connected to e-DAP Edge) as input to the asset's digital twin.

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REFERENCE: PREDICTIVE MAINTENANCE

AFRY built a component digital twin for predictive maintenance of a jet turbine

Project Metrics

- 2021, 1 month
- AFRY AMS Zurich

Client

- Benchmark

Service and Approach

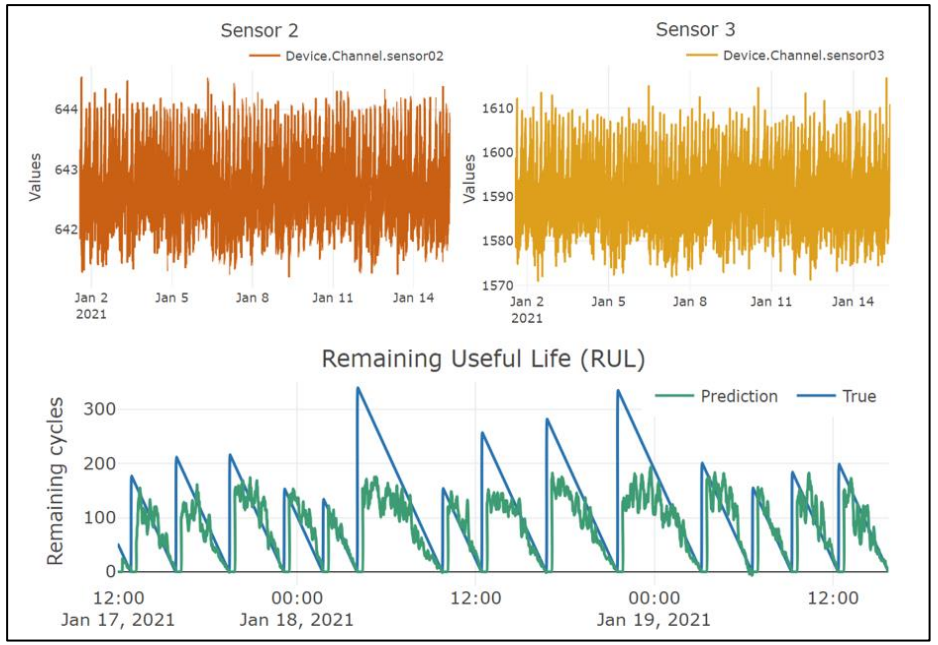
- Legacy data was collected, ingested, and engineered (feature selection, windowing, PCA, etc.).
- Selected ML algorithms targeted the Remaining Useful Life (RUL) for predictive modeling.
- Leveraging real-time sensor data, the model can predict the RUL and determine turbine maintenance needs, achieving excellent accuracy.
- An online workflow was integrated into e-DAP, embedding the data-model and associated KPIs.
- The platform was used to infer RUL and KPIs under future conditions.

Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset's health under defined KPIs.
- The client can infer possible failure cases using real time data as input to the asset's digital twin. Next step is to connect the IOT to e-DAP Edge.

Situation and Challenge

- The challenge is to monitor in time the asset's health before the next fault to occur.
- The idea is to be capable to predict the maintenance of the turbine through the simulation of its Remaining Useful Life (RUL).



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Browse the use-case video → https://youtu.be/WMDPDWGnOJU

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AFRY designed a component digital twin of a wind farm for operational excellence, Wind-Energy Operator, Sweden

Project Metrics

- 2022, 4.5 months
- AFRY Management Consulting Paris & AFRY AMS Zurich

Client

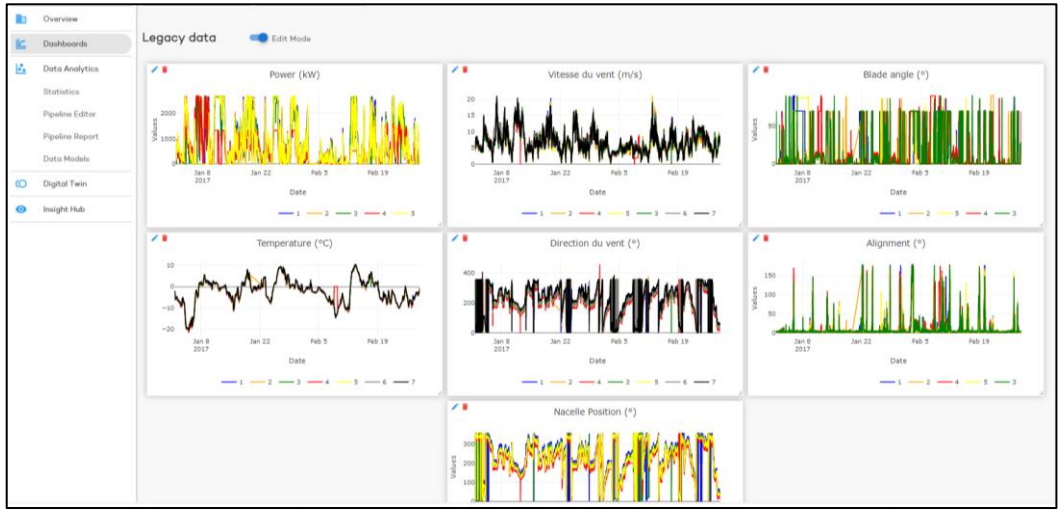
- Wind Energy Operator, Sweden

Situation and Challenge

- Establish a digital control system to forecast power within days.
- Identify and explain deviations that might occur since the start of production, highlighting specific issues, their locations and interdependence.
- Enable predictive maintenance capabilities.

Service and Approach

- An on-site survey of plants and infrastructure was conducted; legacy data was collected, ingested, and engineered (feature selection, windowing, PCA, etc.).
- The 5-year legacy data (wind direction and speed, blade angle, turbulence, orientations, etc.) was used to predict power.
- An online workflow was integrated into e-DAP, embedding the data-model, digital twin, and associated KPIs on a dedicated insight page.
- The digital twin was utilized to analyze production losses per turbine and determine other KPIs for future operational conditions.



Client Impact and Value Added

- The client now has on-line business intelligence tool for predicting the asset's health under defined KPIs.
- The client can now monitor the production data from the plant.
- The client can act on the critical issues and infer potential failure scenarios using real time data as input.

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Browse the use-case video → https://youtu.be/N8qfgybTGzE

AFRY ÅF PÖYRY

AFRY designed a component digital twin for a process engineering plant for operational excellence, Process Eng. OEM, CH

Project Metrics

- 2022, 6 months
- AFRY AMS Zurich

Client

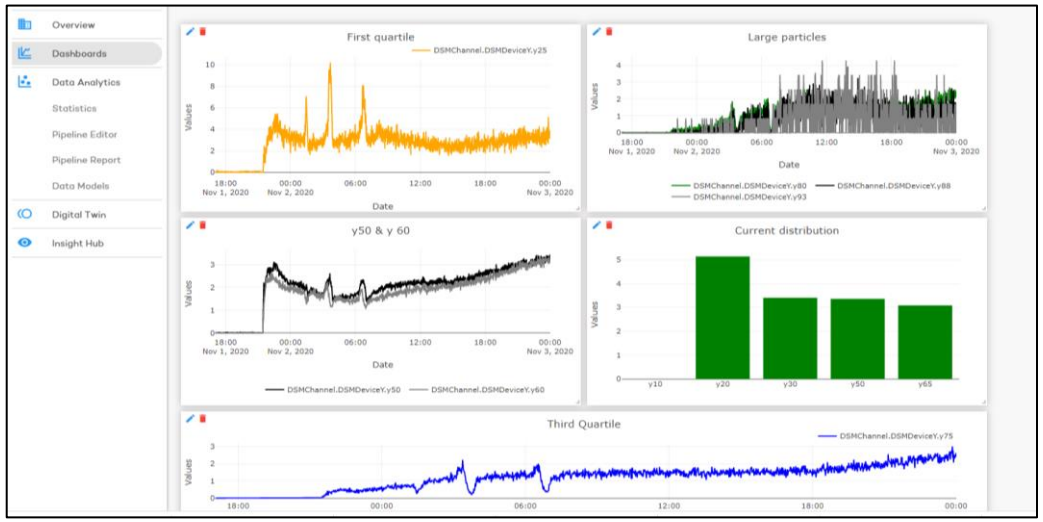
- Confidential

Situation and Challenge

- The challenge is to predict the particle distribution at each batch-phase of the crystallization process ahead of time, and thus the quality of the yield
- The case explores the effect on the yield of changing the raw material properties.

Service and Approach

- AFRY collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY selected the appropriate ML algorithm for predictive modelling, incl. developing a dedicated sensitivity analysis tool for the purpose
- AFRY used the model as the engine of the 'Component Digital Twin – CDT-' to predict the crystallization process of the raw material.
- AFRY used the CDT to forecast the particle distribution at each batch-phase (thus the quality of the yield), and other KPI's
- AFRY used the platform as an asset management tool, with focus on production control.



Client Impact and Value Added

- The client now has on-line business intelligence tool, for predicting and monitoring the asset's performance
- The client is capable to control the production on a daily basis and optimize the process for the best outcome (act at the level of the process batch)
- Next step is to transition from a cloud-based to an on-premise solution.

Browse the use-case video → https://youtu.be/d4b6E8csbDY

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AFRY ÅF PÖYRY

REFERENCE: OPERATIONAL EXCELLENCE

Predictive maintenance of hydroplants, Hydropower Utility, CH

Project Metrics

- 2023, 2 months
- AFRY AMS Zurich

Client

- Emosson Hydro plant, CH

Situation and Challenge

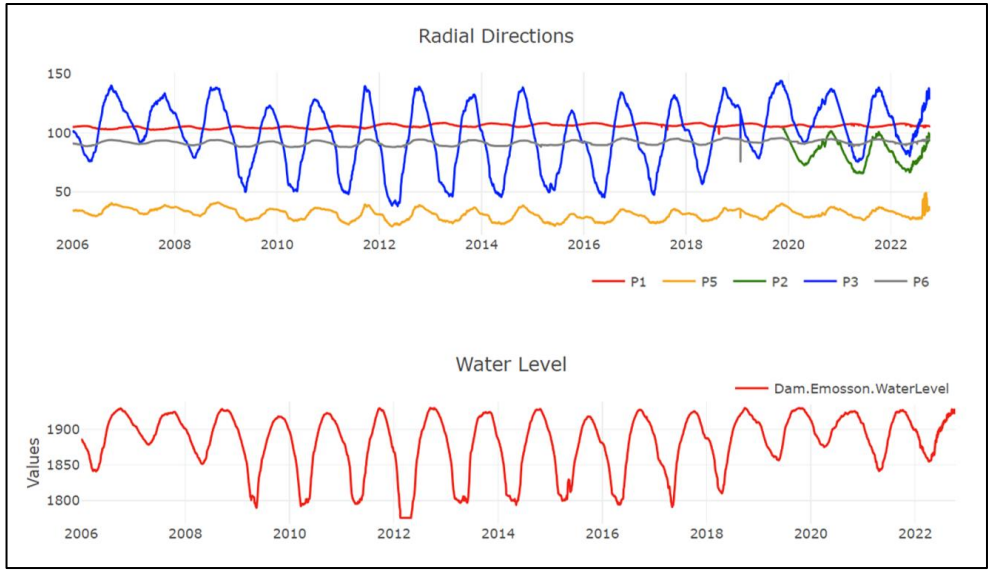
- Monitor and forecast dam behavior effectively, e.g. radial displacement.
- Utilize the model to autonomously identify anomalies by comparing predicted values against actual measurements.

Service and Approach

- AFRY collected and ingested legacy data in the platform and engineered the data (feature selection, windowing, PCA, etc.)
- AFRY selected the appropriate ML algorithm for predictive modelling, incl. developing a dedicated sensitivity analysis tool for the purpose
- AFRY used the model to predict the dam's radial displacement based on water level and surrounding temperatures.
- AFRY used the expected displacement to compare with actual measurements to detect anomalies.
- AFRY used the platform as an asset management tool, emphasizing the detection of abnormal behavior.

Client Impact and Value Added

- Implement an online intelligence tool for real-time prediction and monitoring of asset behavior.
- Empower the client with proactive asset management, receiving alerts upon anomaly detection.
- Transition from a cloud-based platform to an on-premise solution in the next phase.



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REFERENCE: OPERATIONAL EXCELLENCE

Scale-up of an organic waste treatment plant, FI

Project Metrics

- 2023, 3 months
- AFRY AMS Zurich

Client

- EVAC, FI

Service and Approach

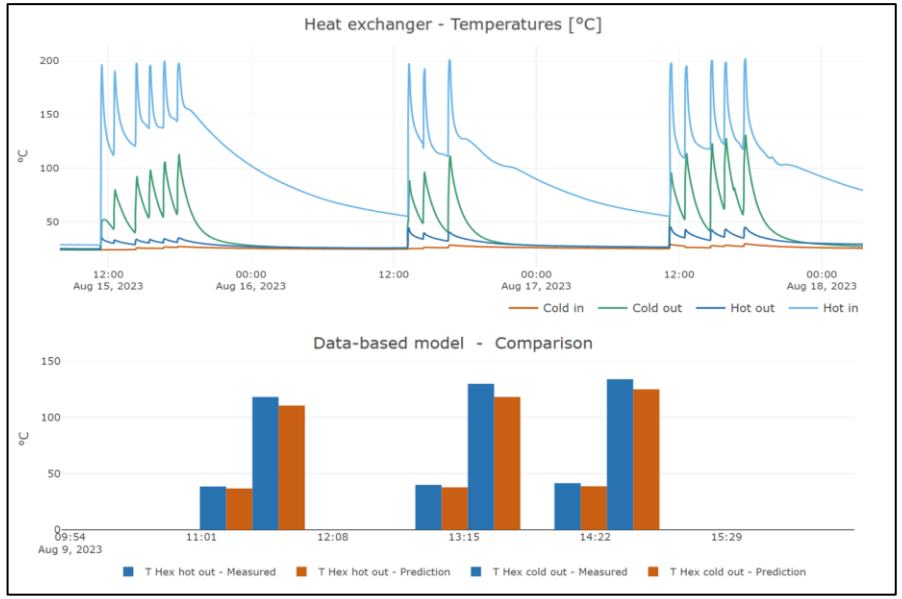
- AFRY created a process simulation using DWSIM, exploring various input parameters like flow, reactor temperature, and cooking time.
- AFRY ingested these simulation data into e-DAP where a machine learning model was developed and trained to generate a comprehensive model.
- AFRY used the sensors installed on the pilot facility and developed a data-based model to predict outputs similar to the process simulation model, enabling a comparison between the two approaches.

Client Impact and Value Added

- The company can now anticipate the behavior of the hydrotreat process as they scale it up.
- Anomalies in the process can be swiftly identified by contrasting measured values with predicted ones, ensuring operational efficiency and safety.
- This hybrid-model approach not only provides a roadmap for scale-up, but also instills confidence in the process's reliability and effectiveness.

Situation and Challenge

- A company has designed an innovative biowaste treatment process, currently undergoing testing in a pilot facility.
- The ultimate goal is for the process to operate on a boat, managing the vessel's waste.
- Client aims to scale up the prototype, questions arise as to how the system will behave with increasing flow and yield process.



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REFERENCE: OPERATIONAL EXCELLENCE

Thermal building management, ZH, CH

Project Metrics

- 2023, 1 week
- AFRY AMS Zurich

Client

- AFRY Zurich

Service and Approach

- Integrated temperature and humidity sensors strategically placed around the building collecting real-time environmental data.
- Legacy data, combined with fresh data inputs, was processed using feature selection, normalization, and other data engineering methods.
- Once sufficient data is collected, appropriate ML/AI algorithms are used to prediction the next day's temperature and humidity within the building.
- Utilizing the predictive model, we optimized the power consumption of the AC unit, ensuring that the PMV (Predicted Mean Vote) remains within comfortable bounds (-0.5, 0.5)

Client Impact and Value Added

- Incorporated a state-of-the-art thermal building management system for proactive comfort adjustments.
- Facilitated an environment where occupants experience optimal thermal conditions, while minimizing the energy consumption HVAC system.

Situation and Challenge

- Optimize energy consumption while maintaining the thermal comfort withing comfortable bounds.
- Monitoring and forecasting temperature 24 hours in advance poses complexities due to varying internal and external factors.

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Browse the use-case video → https://youtu.be/_kh4aOIOhLk

Data-Driven Aerodynamics Optimization, CH

Project Metrics

- 2024, 1 week
- AFRY AMS Zurich

Client

- Benchmark

Service and Approach

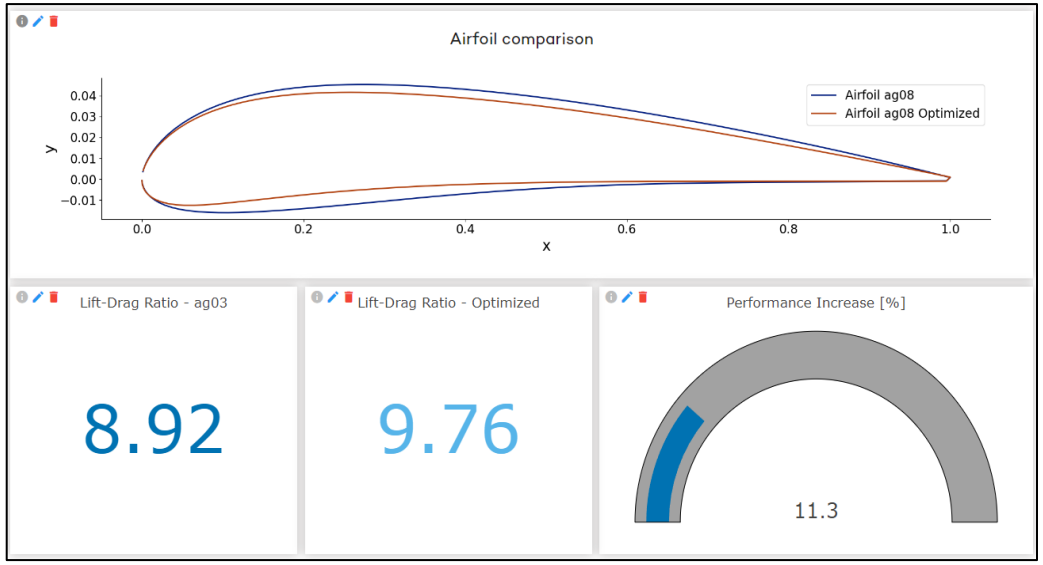
- Collected a dataset with various airfoil designs and aerodynamic conditions, alongside simulation results detailing coefficient forces
- Employed advanced data engineering techniques, including data normalization and feature engineering, to prepare the dataset for analysis.
- Developed a high-fidelity Simulation Digital Twin (SDT) capable of accurately predicting aerodynamic forces based on input shape parameters of airfoils.
- Utilized the SDT to systematically explore and optimize airfoil shapes, aiming at enhancing performance by maximizing lift-to-drag ratio.

Client Impact and Value Added

- Provided clients with a cutting-edge aerodynamics simulation tool, enabling rapid prototyping and optimization of airfoil designs.
- Achieved significant improvements in aerodynamic efficiency, resulting in enhanced performance and reduced fuel consumption for aviation.

Situation and Challenge

- Addressing the need for efficient aerodynamic design to improve performance while reducing environmental impact.
- Overcoming the complexity of accurately predicting aerodynamic forces across a wide range of airfoil shapes and flow conditions (angle of attack and speed).



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CFD & ML Hybrid solution for a data center cooling predictive maintenance

Project Metrics

- 2024, 3 months
- AFRY AMS Zurich

Client

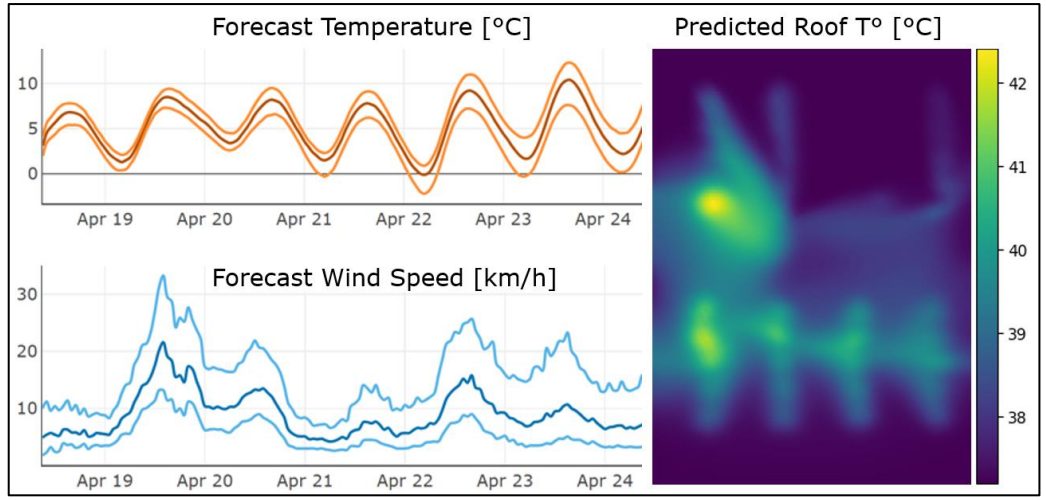
- Benchmark

Situation and Challenge

- Unexpected heatwave conditions can affect the efficiency of cooling of data centers using chillers.
- A live monitoring and predictive maintenance online system is critical to avoid irreversible hotspots.

Service and Approach

- 3D CFD were first performed for various weather conditions and chillers operations (on/off, power).
- Legacy plant data were collected and analyzed, then used to feed the ML surrogate model.
- A hybrid simulation/ML model was then built for the optimization of the process of cooling.
- Client can monitor the data live in e-DAP, then
- Predict the behavior of cooling system using live data, plan maintenance based on weather prediction.



Client Impact and Value Added

- The online solution can be licensed (ported on Azure Cloud) and maintained by AFRY's data team.
- The behavior of the cooling system can be predicted, and maintenance planned using weather prediction.

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Browse the use-case video → https://youtu.be/0aXuGVEomjM

AFRY ÅF PÖYRY

Hybrid simulation & ML solution for the optimization of wood drying in kilns

Project Metrics

- 2024, 3 months
- AFRY AMS Zurich

Client

- UPM

Service and Approach

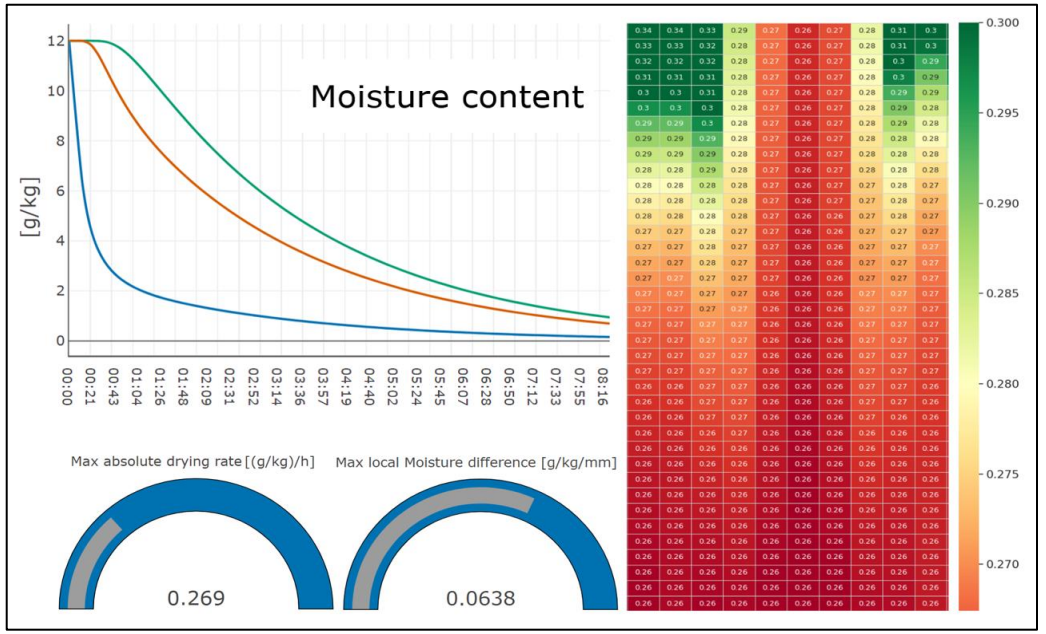
- CFD simulations were first performed for several operational conditions and internal modifications.
- Legacy kiln data are collected and analyzed, then used to feed the ML model.
- A hybrid simulation/ML model was then built for the optimization of the wood drying in the kiln.
- Client can monitor the data live in e-DAP, then
- Predict the behaviour of the system using live data, plan operations or maintenance if needed.

Client Impact and Value Added

- The online solution can be licensed (ported on Azure Cloud) and maintained.
- The client predict the behaviour of the system using live data, plan operations or maintenance if needed.

Situation and Challenge

- Dry kilns are energy-intensive industrial processes.
- The potential of optimizing the air flow via simulation and data modelling is big, reducing resistance and energy while enhancing drying efficiency.



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Connecting the urban environment for improving city resilience & livability

Project Metrics

- 2024, 3 months
- AFRY AMS Zurich

Client

- Confidential

Service and Approach

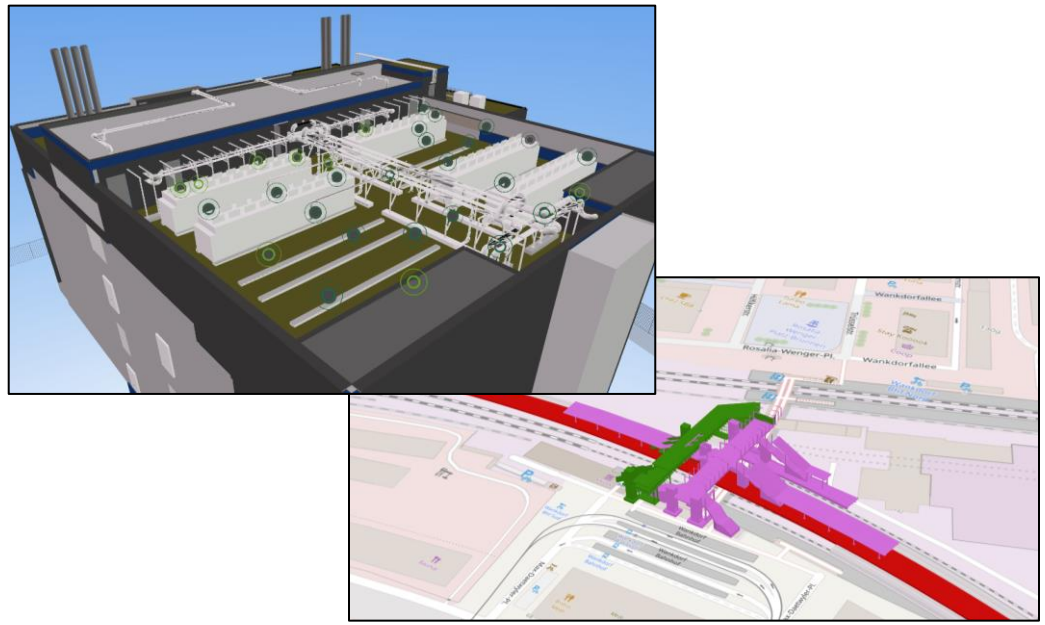
- Providing the possibility to load/read GIS files comprising city networks of rails, roads, electric lines, waste & water, etc.
- BIM models of constructions can be loaded on top of the GIS model, with all the embedded features.
- Data can be dashboarded, collected and engineered, then used for predictive modelling (ML).
- The ML models can thus be used to (1) detecting correlations and causalities; (2) emerging hidden patterns; (3) testing intervention hypotheses and predict scenarios; and (4) deploying engineering and artificial intelligence tools for planning.

Client Impact and Value Added

- Rail Operators (e..g SBB) and Roads Offices (e.g. ASTRA) can ensure safe mobility. Grid Operators (e.g. Swissgrid, BKW, etc.) could assure a sustainable energy supply. Cities can predict degradation of the public infrastructure and plan for investement, e.g. leakage of the drinkable water network, blockages in wastewater channels, etc.

Situation and Challenge

- At AFRY, the digitalization in urban environment is perceived as a priority in the main network industries : Rail, road, water and electricity. This encompasses the processes by which digital technologies and information can be used by business sectors and public administrations to modify their organizational models, improve their performance and create new value.



Browse the use-case video → https://youtu.be/OzVVJFuWunQ

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A Data-Driven Solution for Optimizing Water Quality in Aquaculture

Project Metrics

- 2024, 3 months
- AFRY AMS Zurich

Client

- Benchmark

Service and Approach

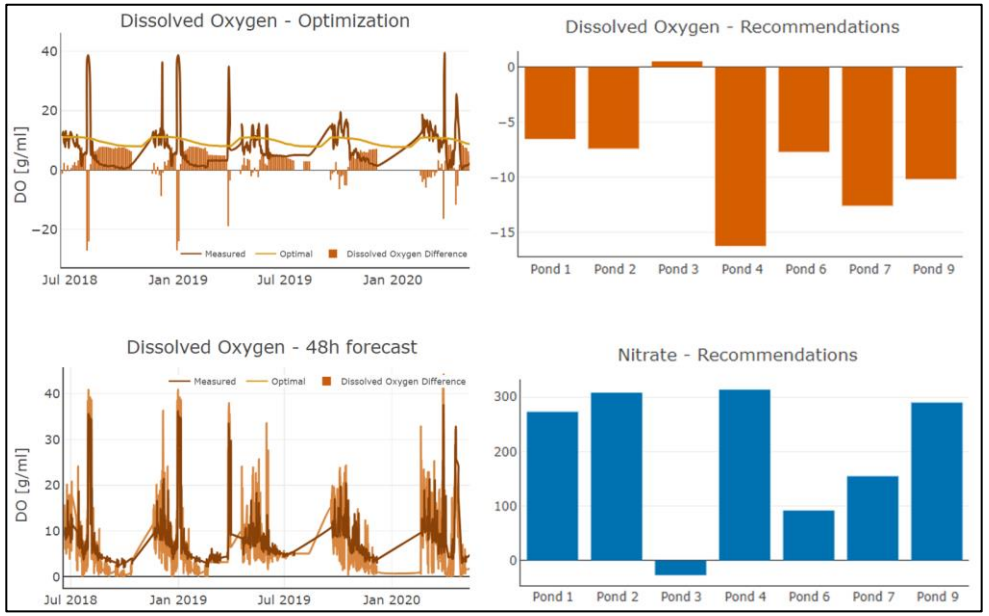
- Water quality sensors can be deployed in each basin to continuously collect data of operational parameters such as temperature, pH, dissolved oxygen, and turbidity.
- The collected data is presented live in a versatile dashboard, combined with an alert system in case of deviation from the KPI's.
- A ML model combining sensor data and weather forecasts was built to predict water quality. Output of the model are Oxygen and nutrition needs 48 hours ahead of time, as shown in the right panel.
- The system advises on necessary actions (e.g. O2 and NO3 injection) to assure water quality and optimize fish growth and health (size, weight).

Client Impact and Value Added

- Sensors can be placed on premise by ourteam, with an IoT connection.
- E-DAP can be licensed (on Azure Cloud or on premise) and maintained by the e-DAP team.
- Water quality can be predicted, and measures can be planned to ensure optimal conditions for fish health.

Situation and Challenge

- Variable weather conditions and other external factors can affect the water quality in aquaculture.
- A live monitoring and predictive modelling system is required to maintain optimal water conditions and ensure fish health during all growth cycles.



Browse the use-case video → https://youtu.be/uiGCt3BNeds

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