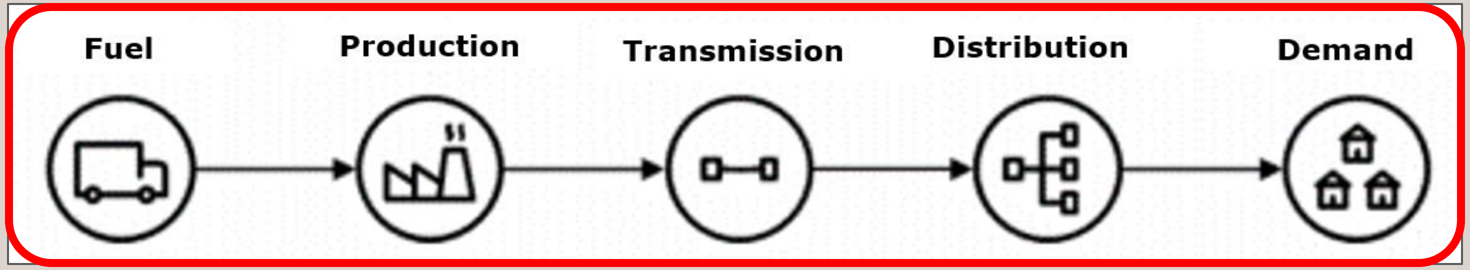
Digital Twin

From an Integrator point of view

MARCH 2022



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Digital Twin

Quoted from www article;

What is a Digital Twin?

- A digital twin is a virtual (or digital) representation of the elements and dynamics (behavior or process) of a plant or system.
- If applied properly, a digital twin will influence the design, build and operation of the system throughout its lifecycle and help optimize operation through informed insights.
- In other words, it is ***dynamic software models*** (model + machine learning) of the physical plant/system that ***pairs a live feed from the real system to the digital twin*** for ***continuous operation***.

https://waterfm.com/digital-twin-technology-becoming-a-reality-for-water-utilities/

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Why we need digital twins

We are entering the era of the digital built environment, which is unquestionably data-centric:

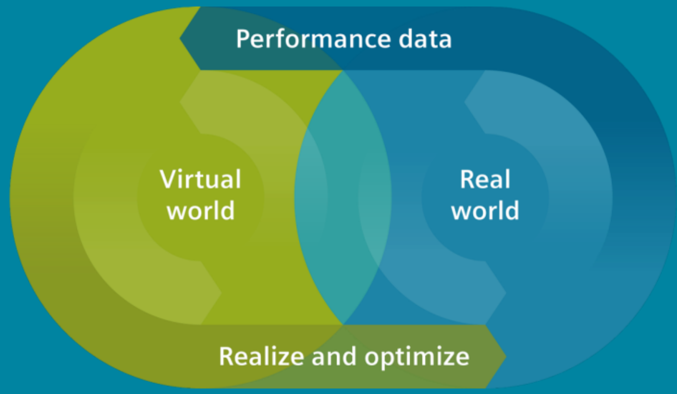
- Digital twins are made up of data. They are a **continuous, digital representation of a physical asset**—in planning, design, construction, and operations.
- They reflect the condition of an asset at any point in time, and you can use them to **effectively respond** in the present, as well as leverage advanced analytics and simulation to plan for the future.
- Digital twins can be developed for a range of purposes, and recent advancements in digital technologies are allowing organizations to combine and **leverage infrastructure data** in ways that simply could not be done before.
- Aside from the efficiency gains in planning, design, and construction, digital twins can **provide an operational picture of asset performance** that can be used for inspections, simulation, and maintenance.

Digital Twin – for what?

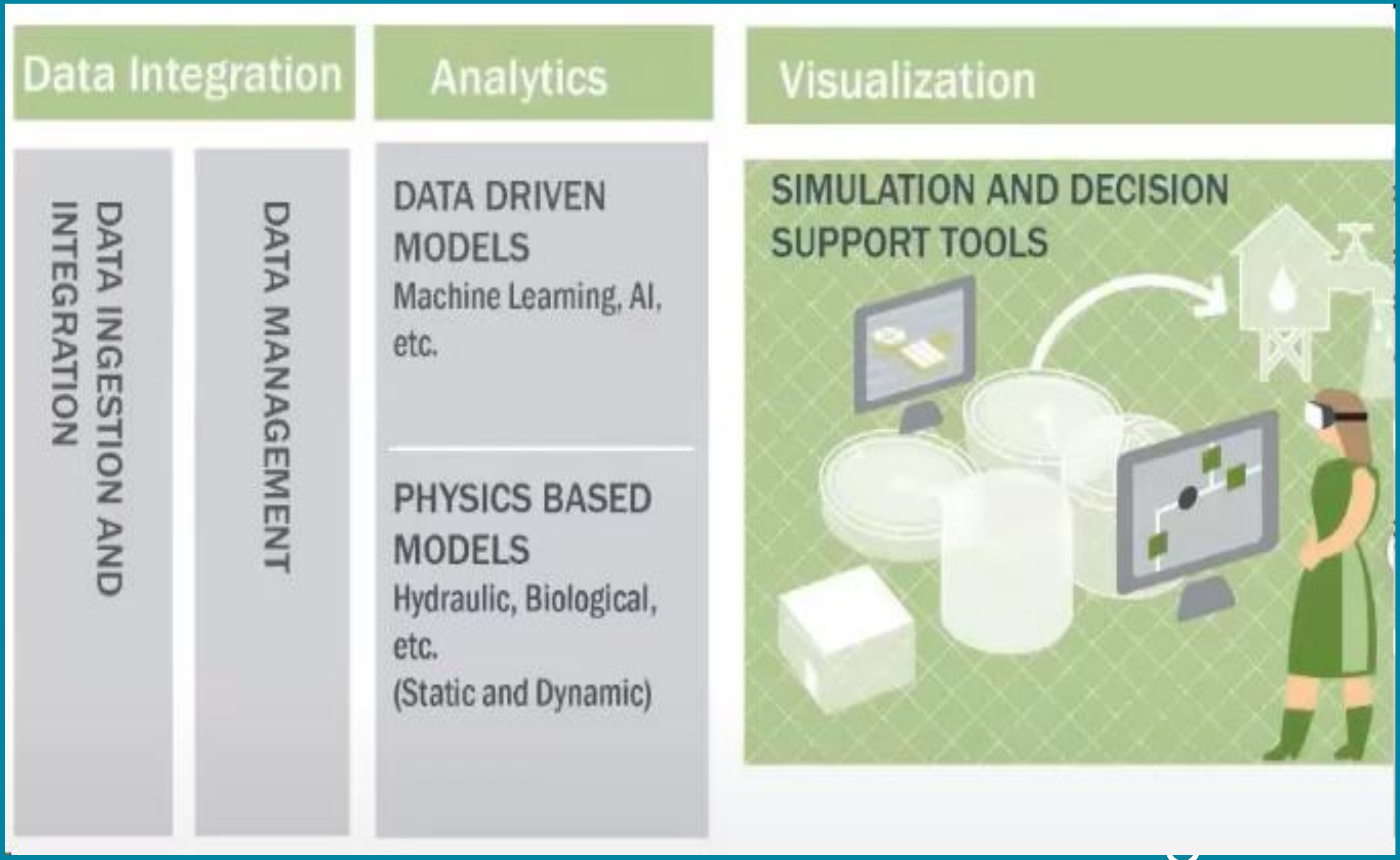
Decision support tool – test before you do.

Application	Benefits
Energy usage and benchmarking	By knowing what is normal abnormalities with respect to energy usage and losses can be detected. Input from demand model to forecast. The hydraulic model combined with network characteristics collects information that can be compared with similar networks and un-intentional usage or losses can be found and prioritized for interaction
Temperatures and pressures	Tracking supply temperature through the entire network on a near-real-time basis. Evaluating on delta T and delta P and highlights buildings with biggest impact on the overall performance.
Energy savings	Provide algorithms to optimize pump schedules for low-cost energy usage while considering critical parameters, such as pressure constraints, plant load utilization and predictive demand schedules, etc.
Asset lifecycle management	Provides holistic asset knowledge including customized maintenance schedules based on actual conditions, fieldwork, historic brand knowledge, environmental conditions, etc.
Pressure, temperature and flow optimization	Real-time anomaly detection and temperature / pressure optimization insights
Security in supply	Temperature and pressure supply can be secured during planned and unanticipated maintenance procedures by testing various operational combinations.

-> Digital Twin



- Operators can visualize their assets, check their status, perform analyses, and generate insights to predict and optimize performance.
- In the planning phase, digital twins are used to prove constructability and model construction sequencing
- Utilize IoT data for right time monitoring and what-if analysis
- Represents the current situation on site, with a short- to medium-term look ahead to test before doing
- Management overview of performance of assets and processes to be compared and optimized



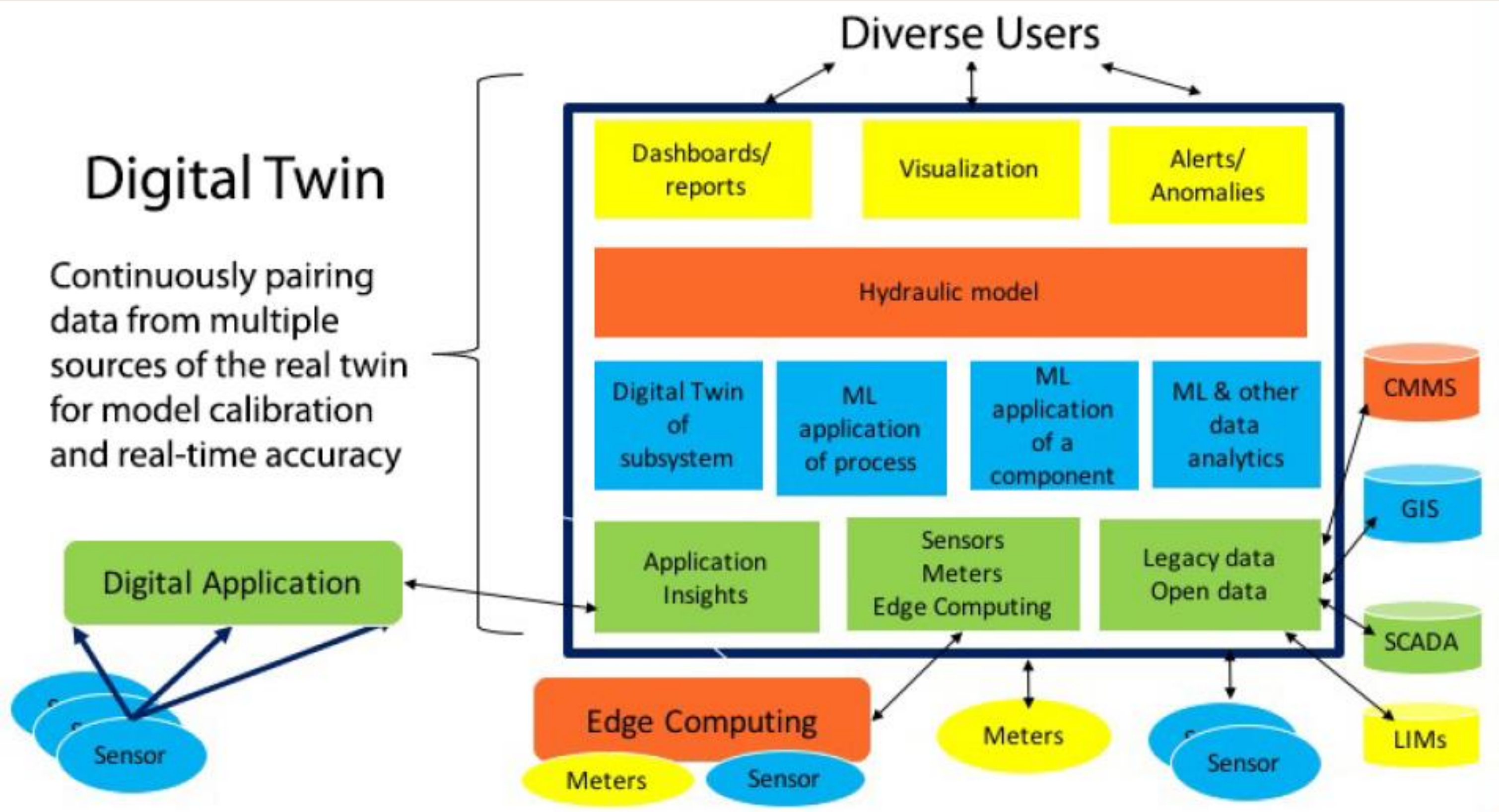
Digital Twin

Components

Many DT technologies are not yet commercially available, so it important to secure that the basis supports what can be expected in the near future.

Open interfaces (not legacy) are prefered to avoid middleware to communicate.

IoT standards becomes cheaper -> more sensors with higher frequency of data -> more data handling power.

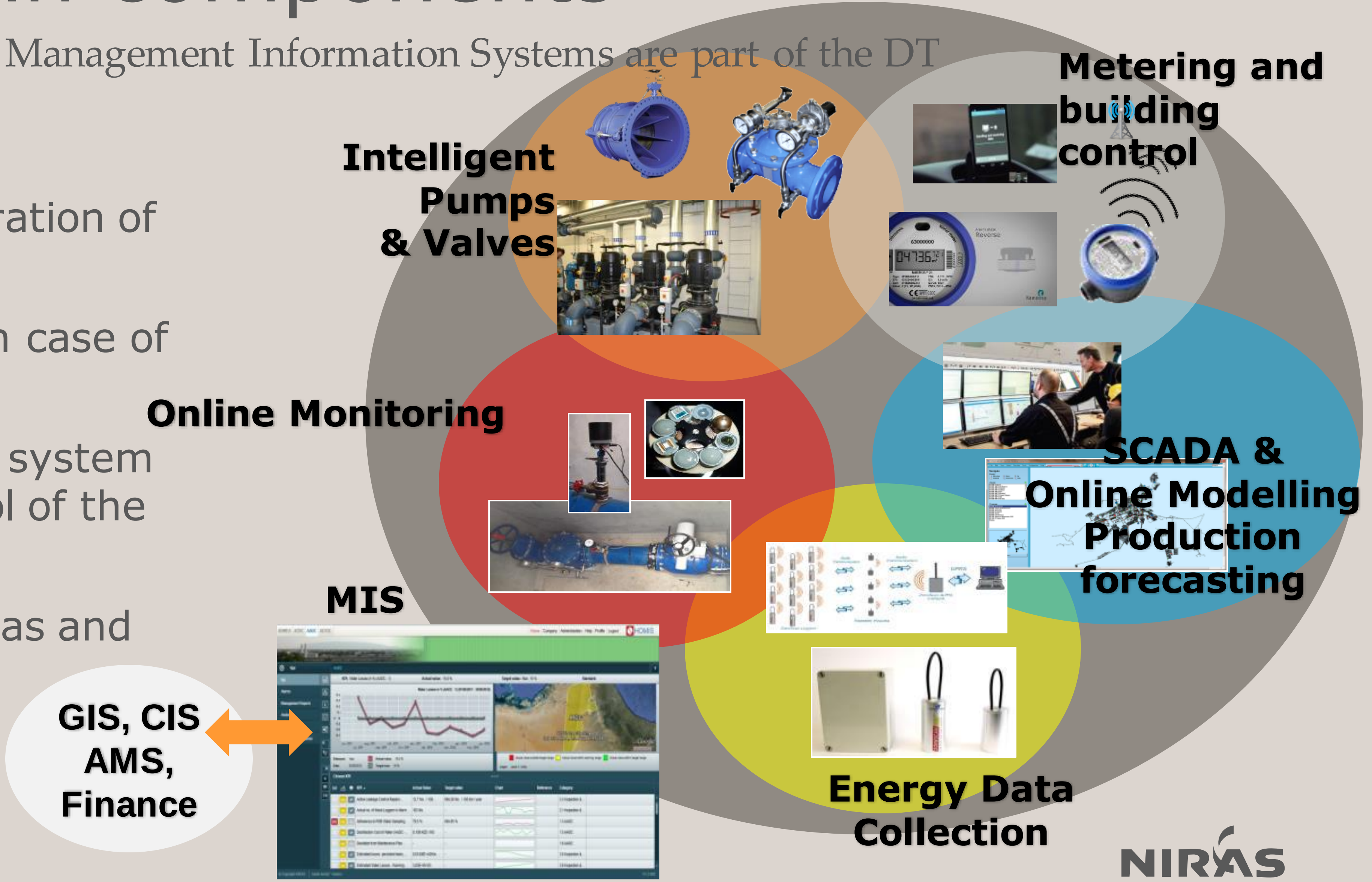


Digital Twin components

Hydraulic Models and Management Information Systems are part of the DT

The Digital Twin will:

- Assist in the daily operation of the network
- Issue early warnings in case of anomalies
- Prioritize and optimize system supervision and control of the entire network
- KPI overview of all areas and assets
- Break down data silos



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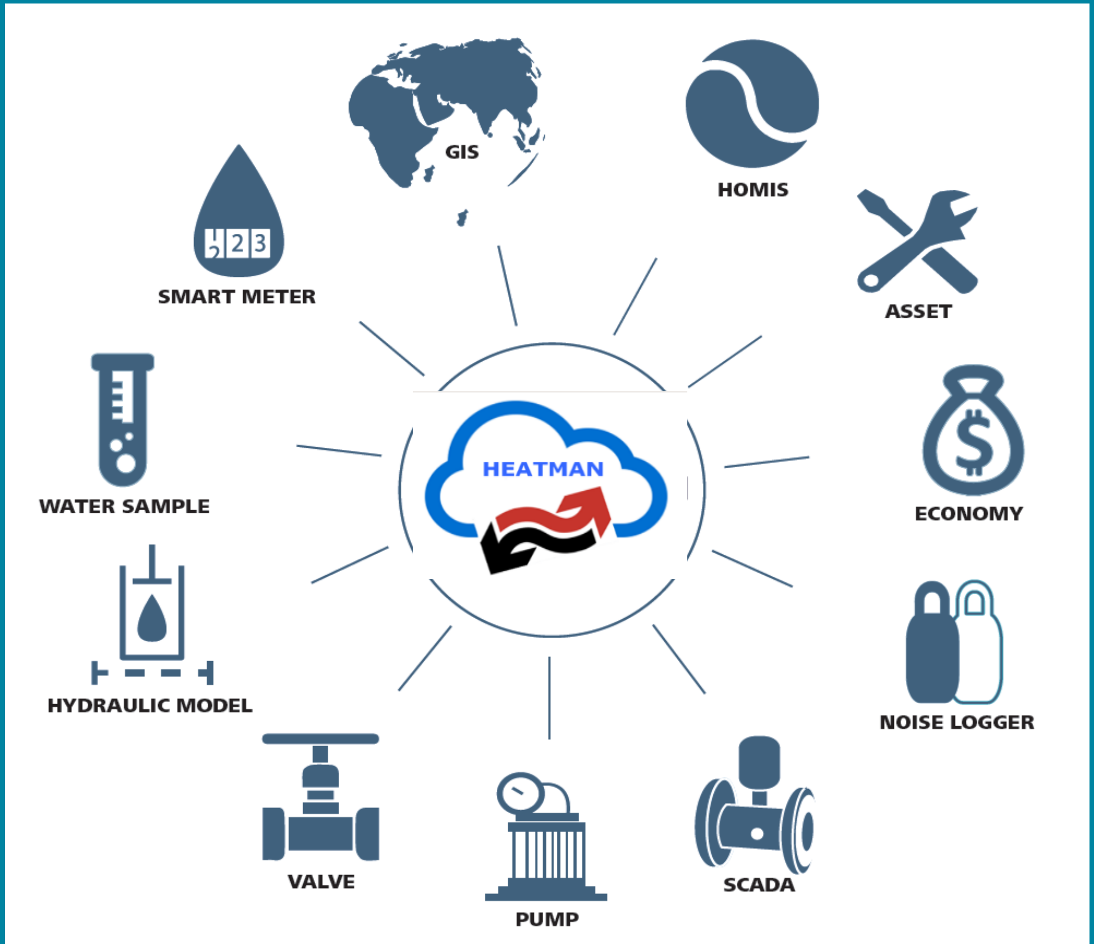
ONE SOLUTION - COMBINING TECHNOLOGIES

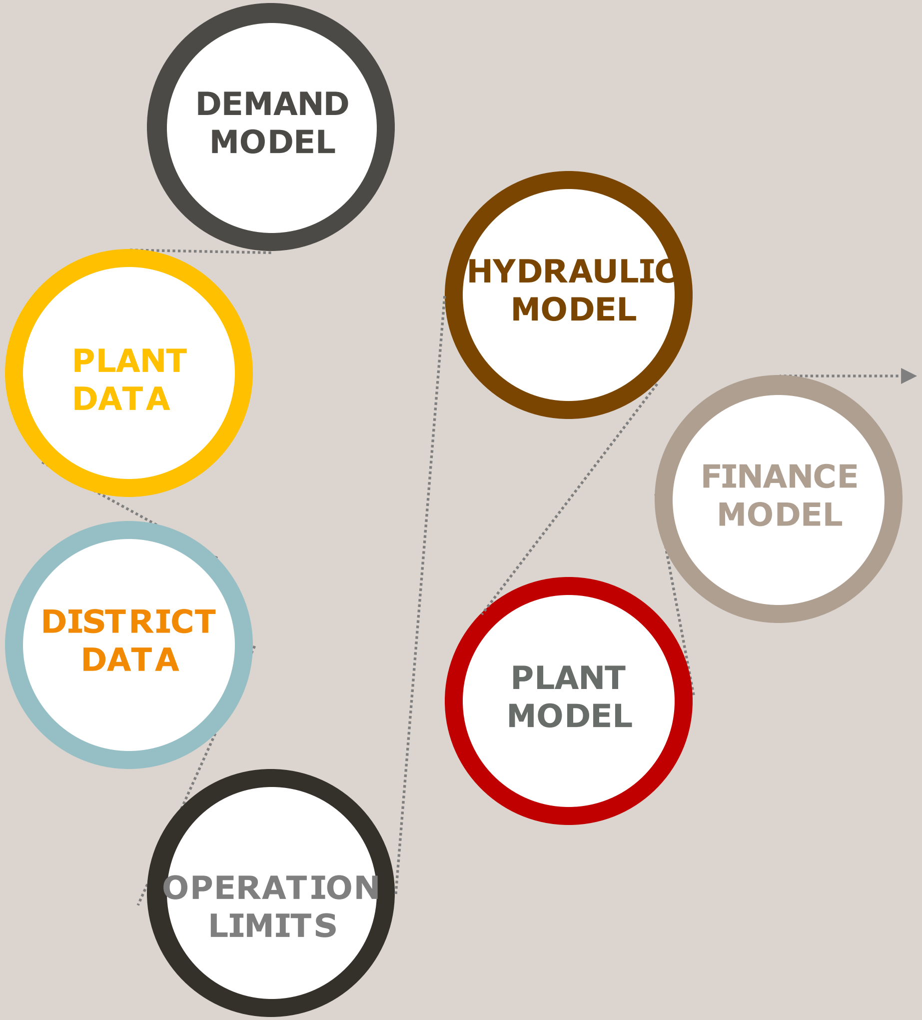


The HEATman concept provides a state of the art Energy Management System that:

- Integrates all operational systems
- Provides a dynamic overview of the state and performance of the operation
- Transform the supply system to a ***Smart System***
- Offers well proven technologies for management and control

LEAKman

Energy management



- **Needed a hydraulic modeling tool to validate existing design decisions being discussed**
- **Needed insight into system-wide hydraulic relationships**
- **Needed insight into how plant efficiencies vary with different operating regimes**
- **Needed resulting fuel, power and dispatch information to flow easily into financial models for decision making.**
- **Needed to be flexible and easy to manipulate to deal with consistent "what if" scenarios**

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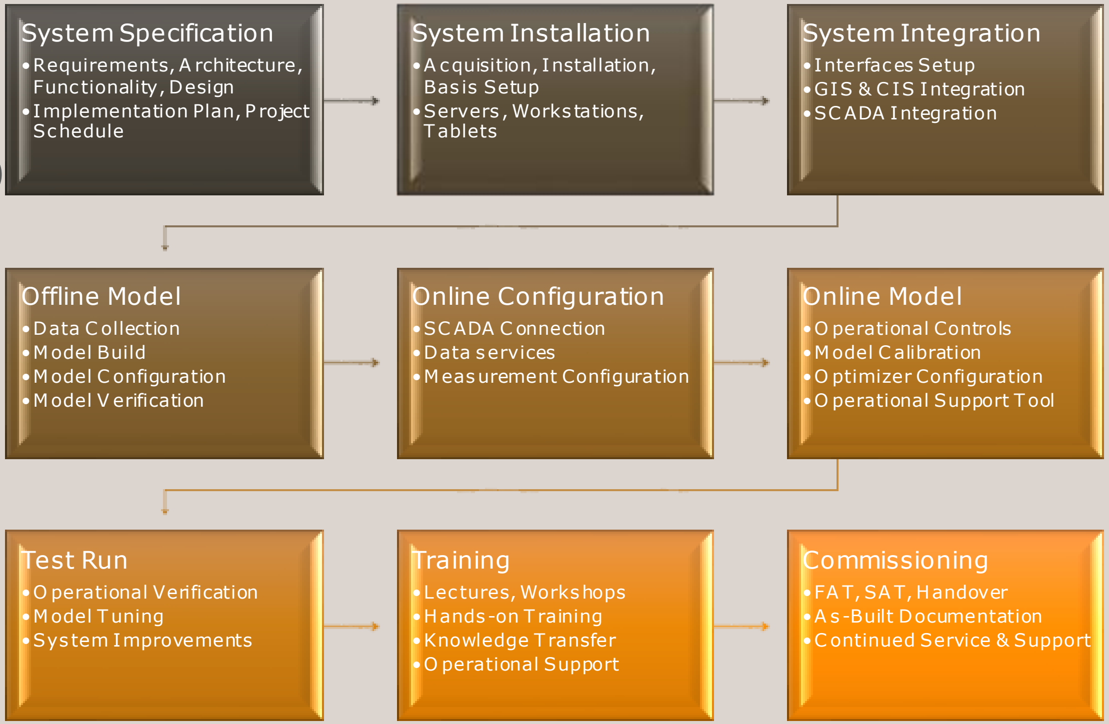
Online model – The way to get there

- Data collection for the system
- Data verification
- SCADA dump (flow, temperatures and pressures)
- Software installation
- Model building
- Configuration of applications and data collection
- System calibration
- Test run
- Training and knowledge transfer
- Commissioning
- Reporting and documentation
- On-going assistance and support



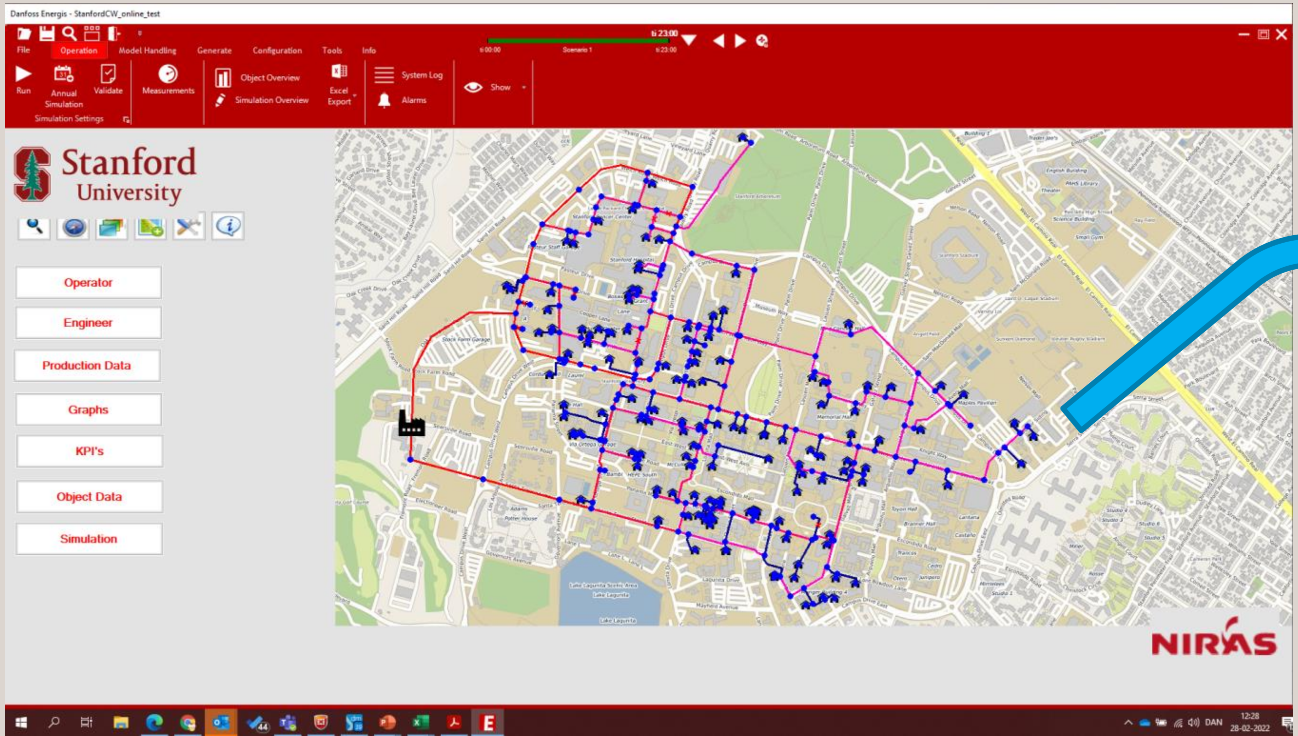
Online Hydraulic Modelling

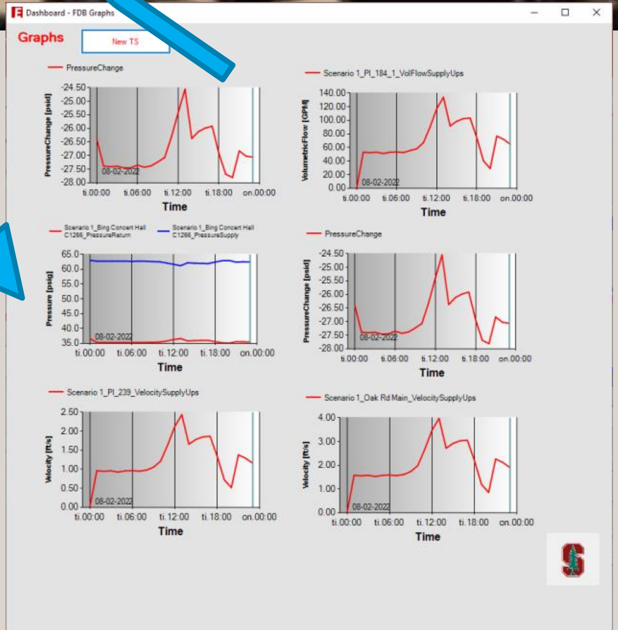
An overview of the whole network – virtual metering

In SCADA only measured values can be seen – no validation

In HMS data are calculated all over and measured values can be validated.

SCADA – Control room





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Project @ Stanford University

This presentation is a Stanford University case study showing the results and value of hydraulic modeling for building the business case, design and real-time hydraulic for the operational phase of a new low temperature hot water system and chilled water system. Stanford University invested USD $500 million in transforming their energy systems to one of world leading low temperature hot systems and chilled water systems.

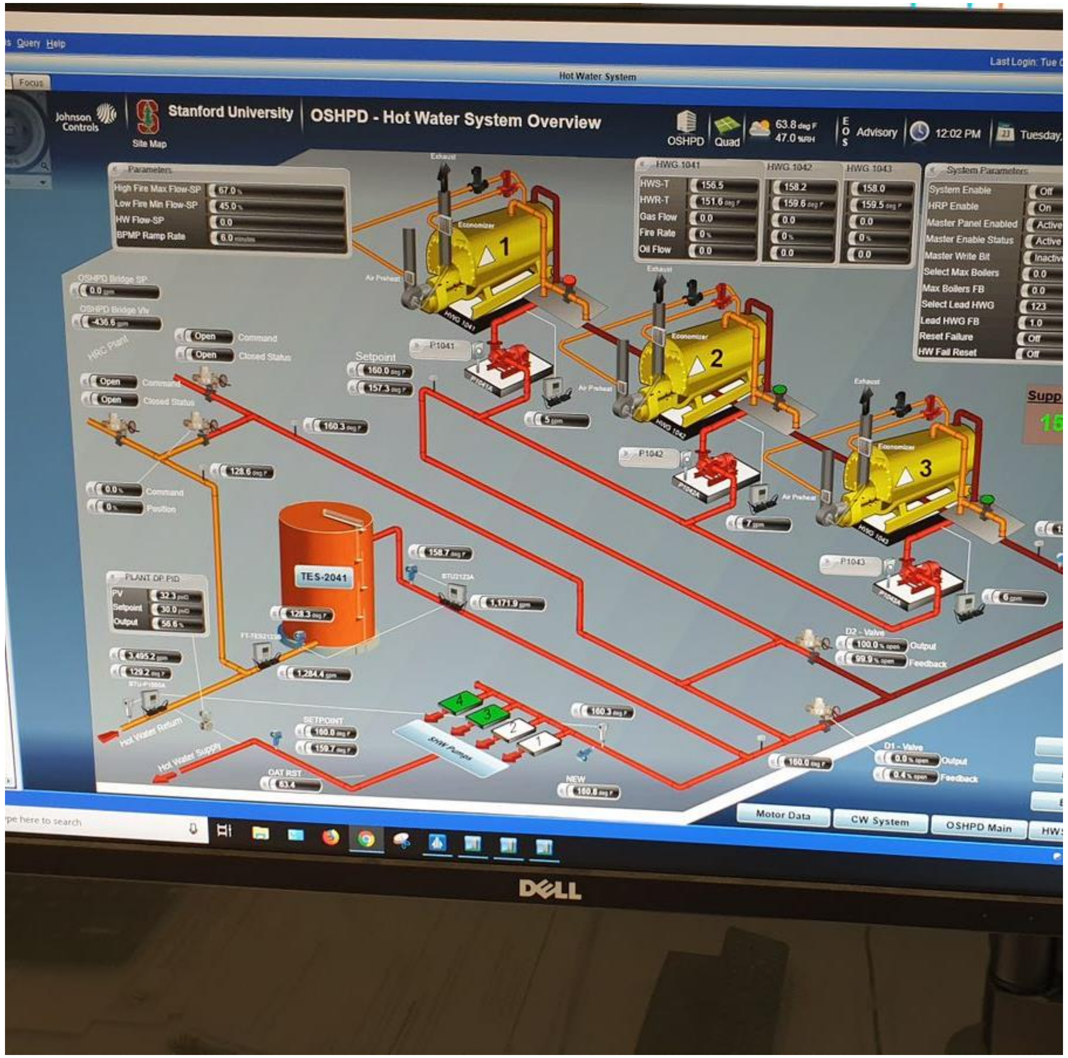
Hydraulic modeling was a critical component in this process and Termis real-time hydraulic modeling has become a critical component to maintain top efficiency to pay back the investment as a decision support tool.

Real-time hydraulic modeling is used for the day-to-day operational management, troubleshooting, engineering, planning for changes and additions of new buildings. The investment of real-time hydraulic modeling solution has paid itself back in less than 24 months.

Thermal Energy System

Stanford provides heating and cooling to the campus and Medical Center buildings and facilities through extensive hot and chilled water loops that originate at the Central Energy Facility (CEF).

- Underground hot and chilled water supply and return piping that circulate from the CEF for more than 20 miles around campus.
- Underground piping system is ductile iron piping with some small branch lines using PVC. Typical building laterals are 4”-6”
- Peak cooling loads from 50 tons for smaller buildings up to 800 tons for research centers and 2000-4000 tons for main hospitals,
- Peak heating loads that range from small buildings that draw less than 500k BTUs to the campus swimming pools, which can draw up to 10 million BTUs.



Thermal Energy System

- Chilled and hot water enter each building from underground into the basement mechanical room where the flow, as well as supply and return temperatures are measured, resulting in an energy use rate in cooling tons and btu's, respectively.

- In the building mechanical rooms, secondary pumps then send the water on to cooling and heating equipment throughout the building.

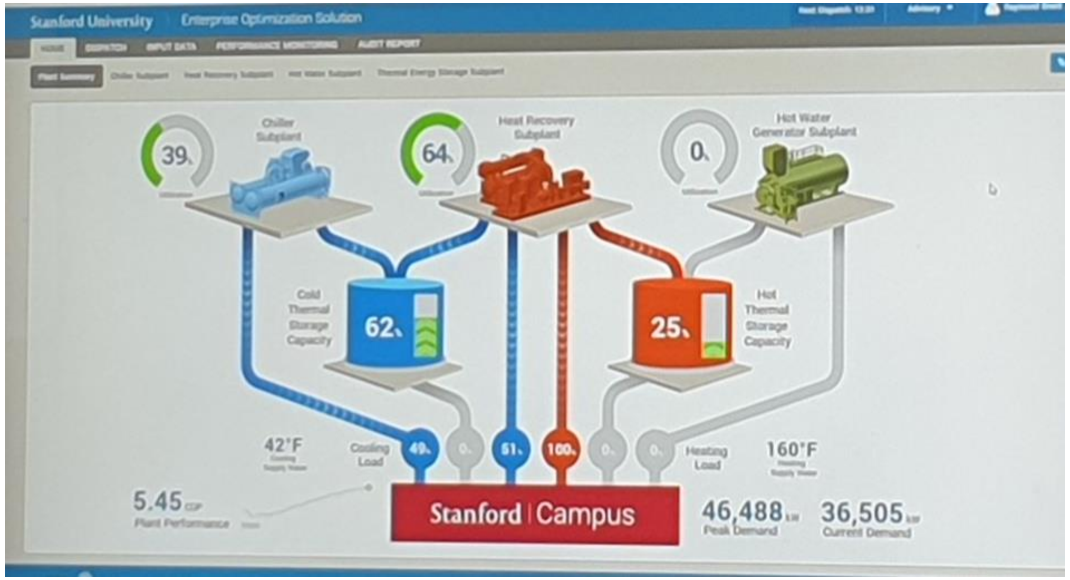
- Both the hot and chilled water systems are closed loop, with water makeup for leakage and treatment being done centrally at the CEF.

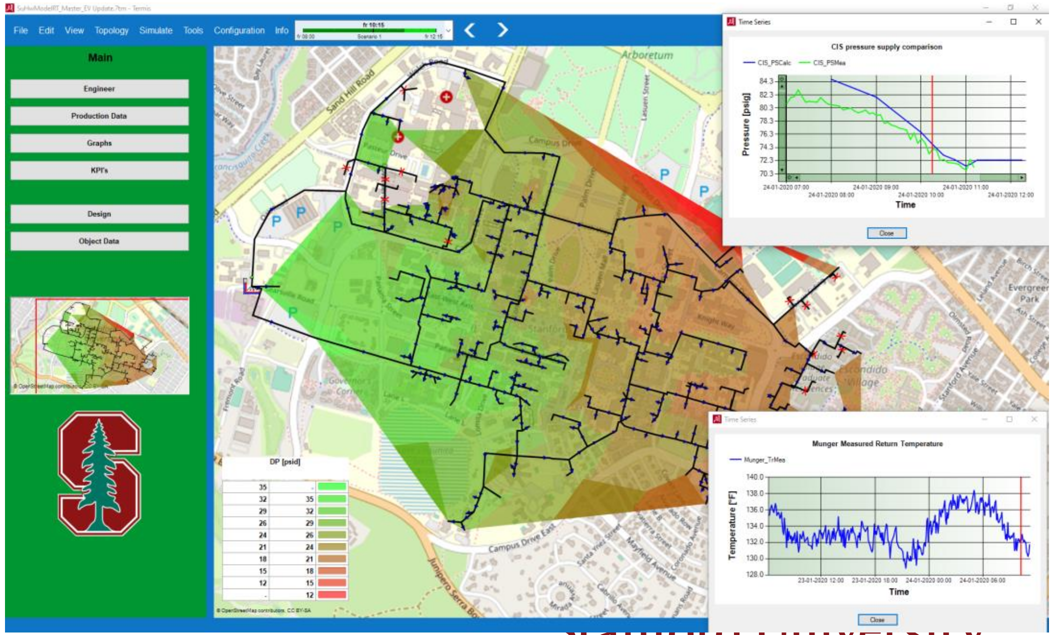
Results, benefits and savings

During proof of concept in 2016 and through Feb. 2018, real time data has been obtained and analyzed reflecting unknown issues and detailed "What-If scenarios" showing the impact of adding new buildings and changes in the distribution system including valve management

Termis is used to lower cost of operations and maintenance for both HW and CW systems as well as for any engineering related to these distribution systems

Termis is a valuable tool with potential for optional additional efficiency and optimization features enabling the highest possible efficiency and lowest possible cost





Results, benefits and savings

- Hydraulic Modeling for design new hot water system - Offline data
    - Overview and collection of all relevant data
    - Applying loads from existing Building System
    - Design network, plants and operational parameters

- Improving operational conditions by real-time modeling
    - Real capacity and capability versus design
    - Improving / maintaining dT at a high level
    - Dispatch strategy to ensure low dP to minimize plant pumping
    - Management of piping losses – energy as well as pressure drop
    - Identify system bottlenecks
    - Measurements; accuracy watch-dog and location
    - Managing campus building expansions
    - Managing valves and by-passes
    - Visual overview

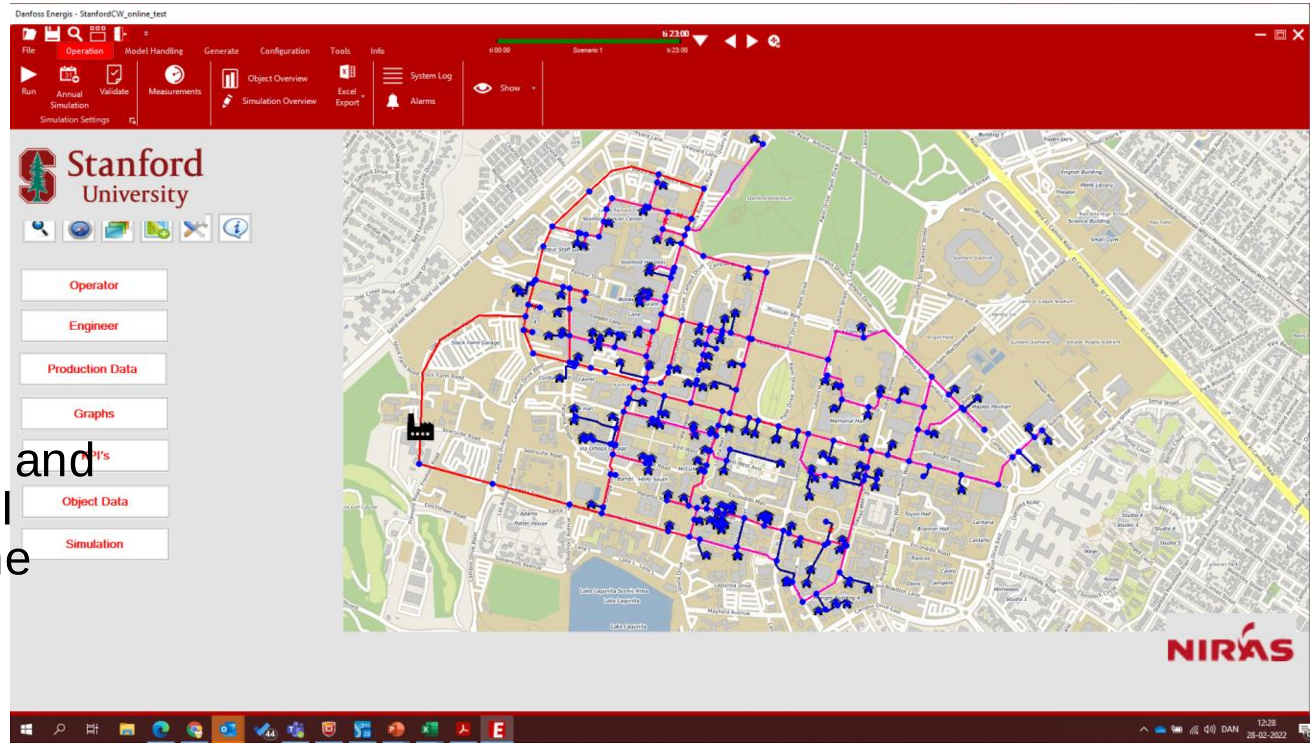
Estimated cost savings of $300,000

Next steps

For 2020-2022:

Phase 6:

Upgrade models to Leanheat Distribution software. Enable management, operational, and maintenance staff to use the Thin Client HMI (View Only) as well as tablet and smartphone devices.



Phase 7:

Setup Leanheat as dynamic supply pressure and supply temperature reset in **advisory mode**. In addition study the benefits and savings of load forecasting based production scheduling.

Phase 8:

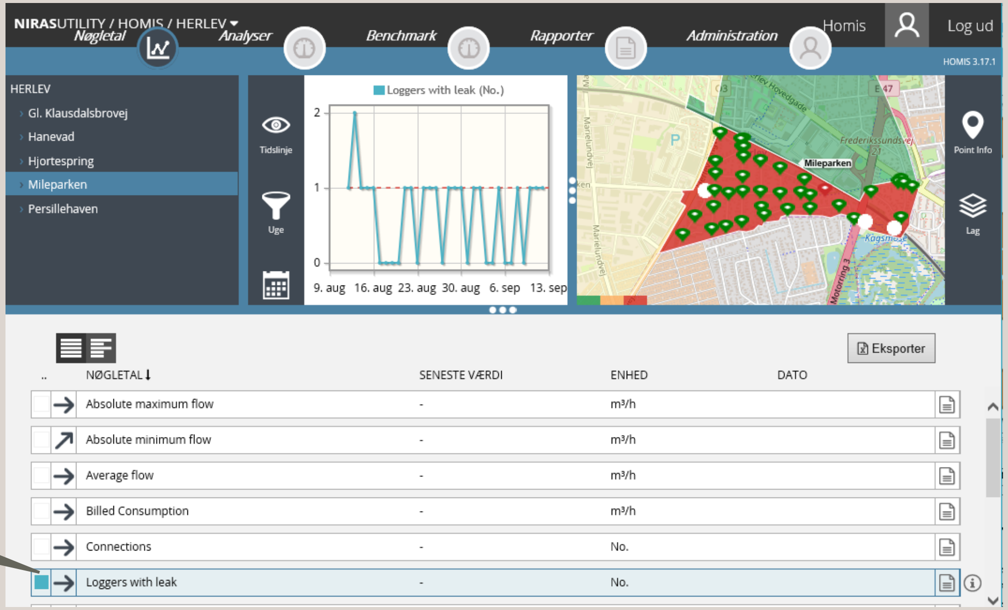
Potential implementation of the recommendations of Phase 7

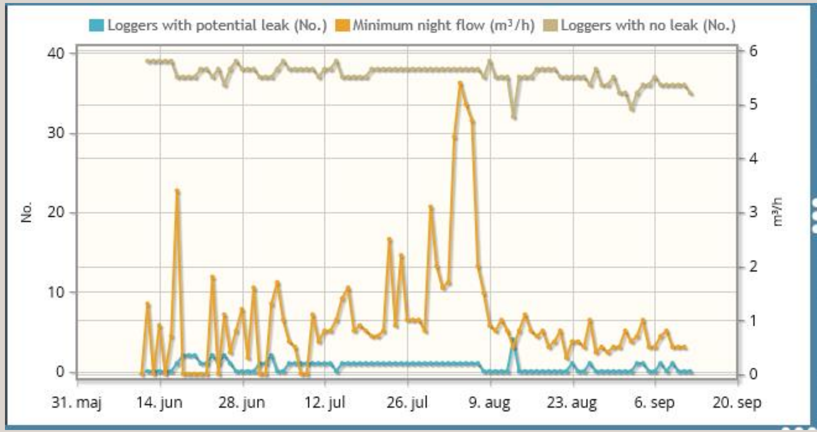
Holistic Management Information System

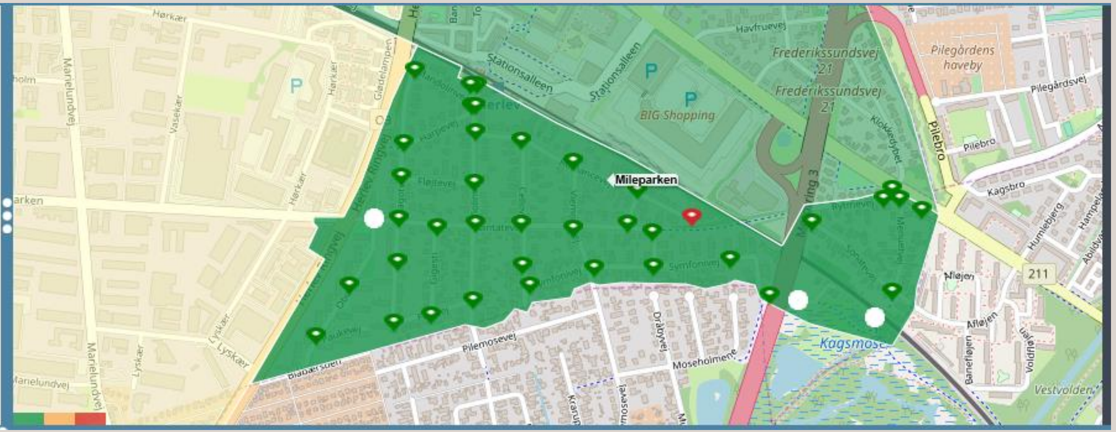
Decision making based on multiple data sources

SCADA

What we can measure we can control
What we can control we can optimize...



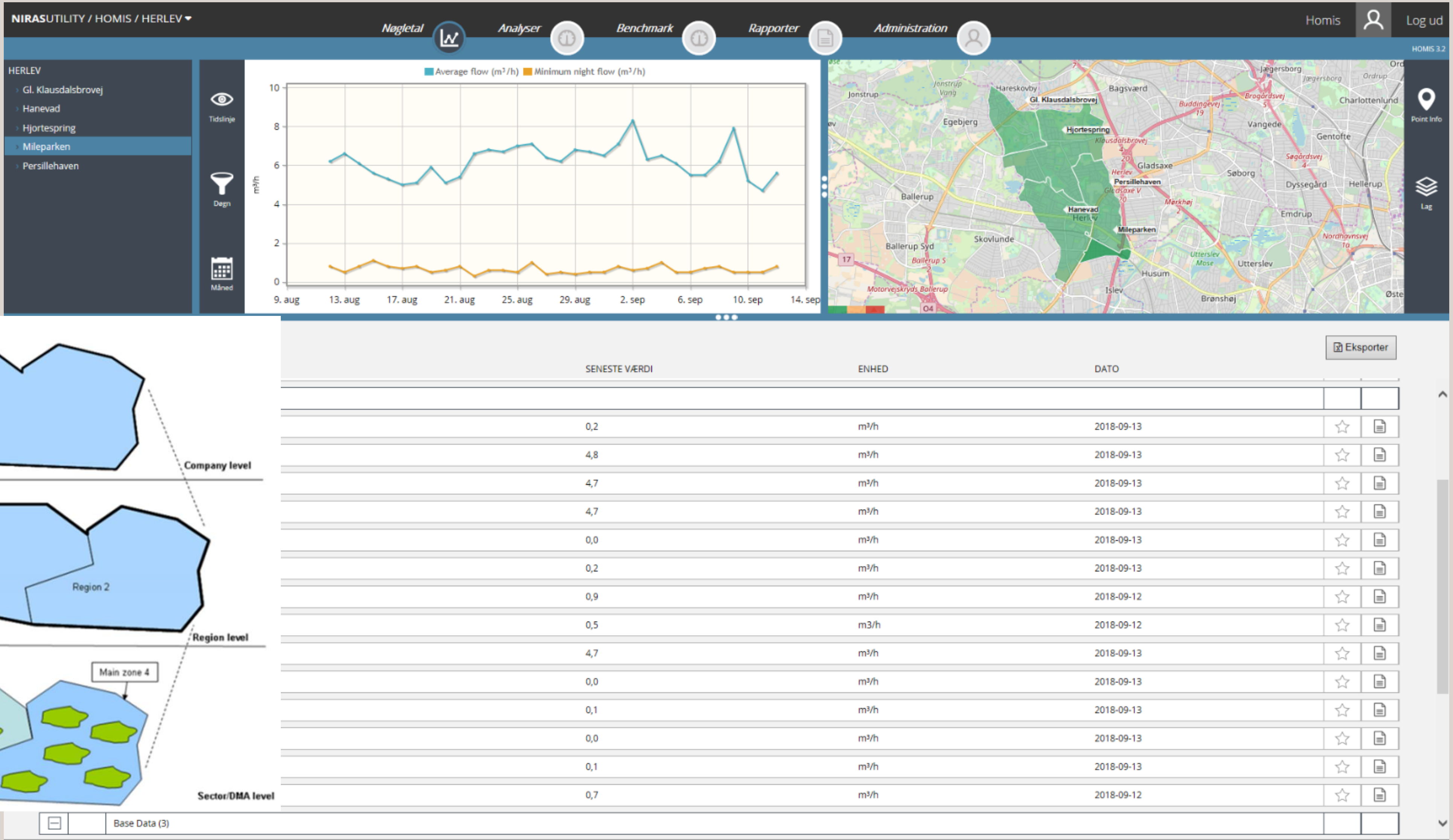


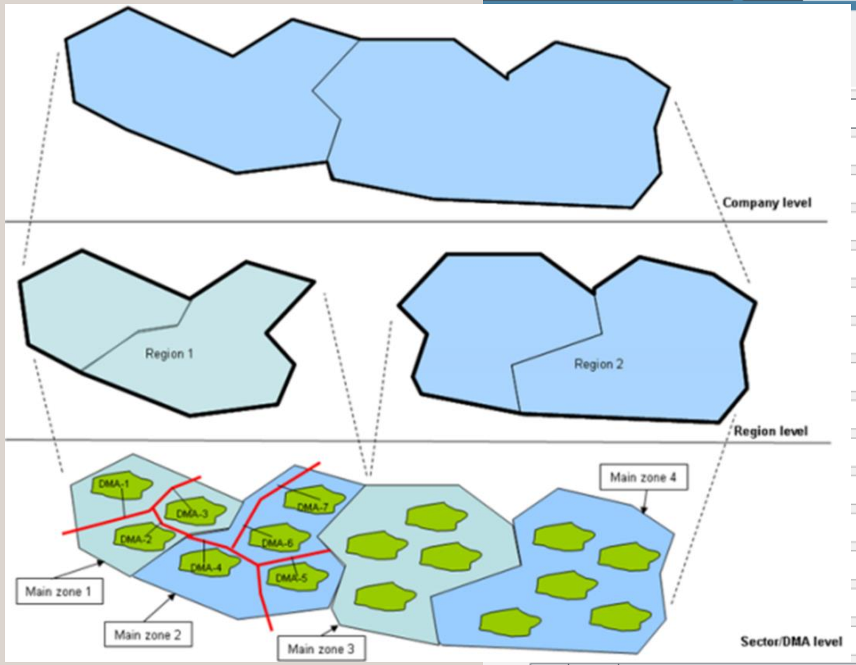


Performance Indicator System

Best Practice plus customer priorities

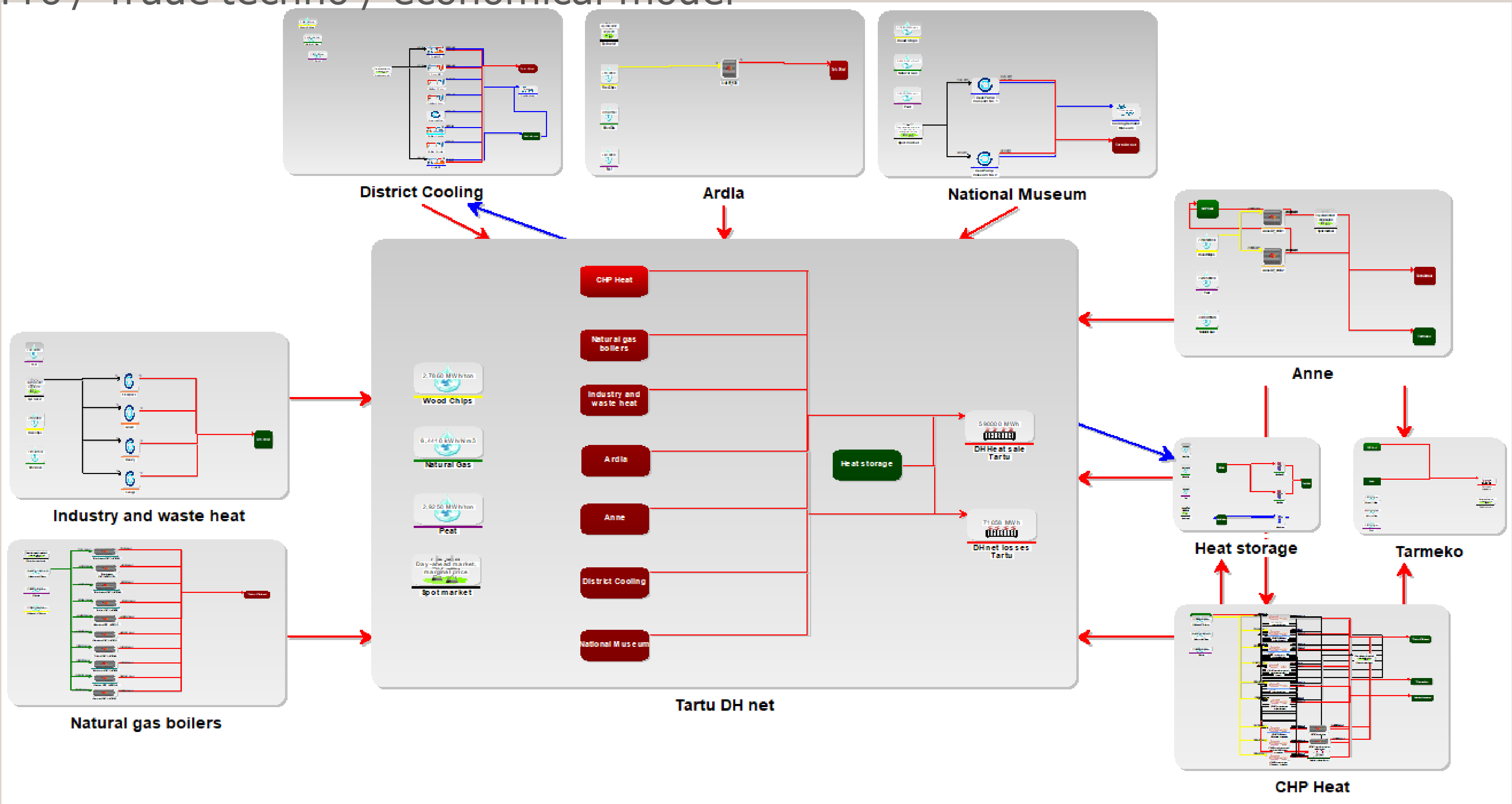
- Compare across districts
- Adaptive alarms
- Combination of events





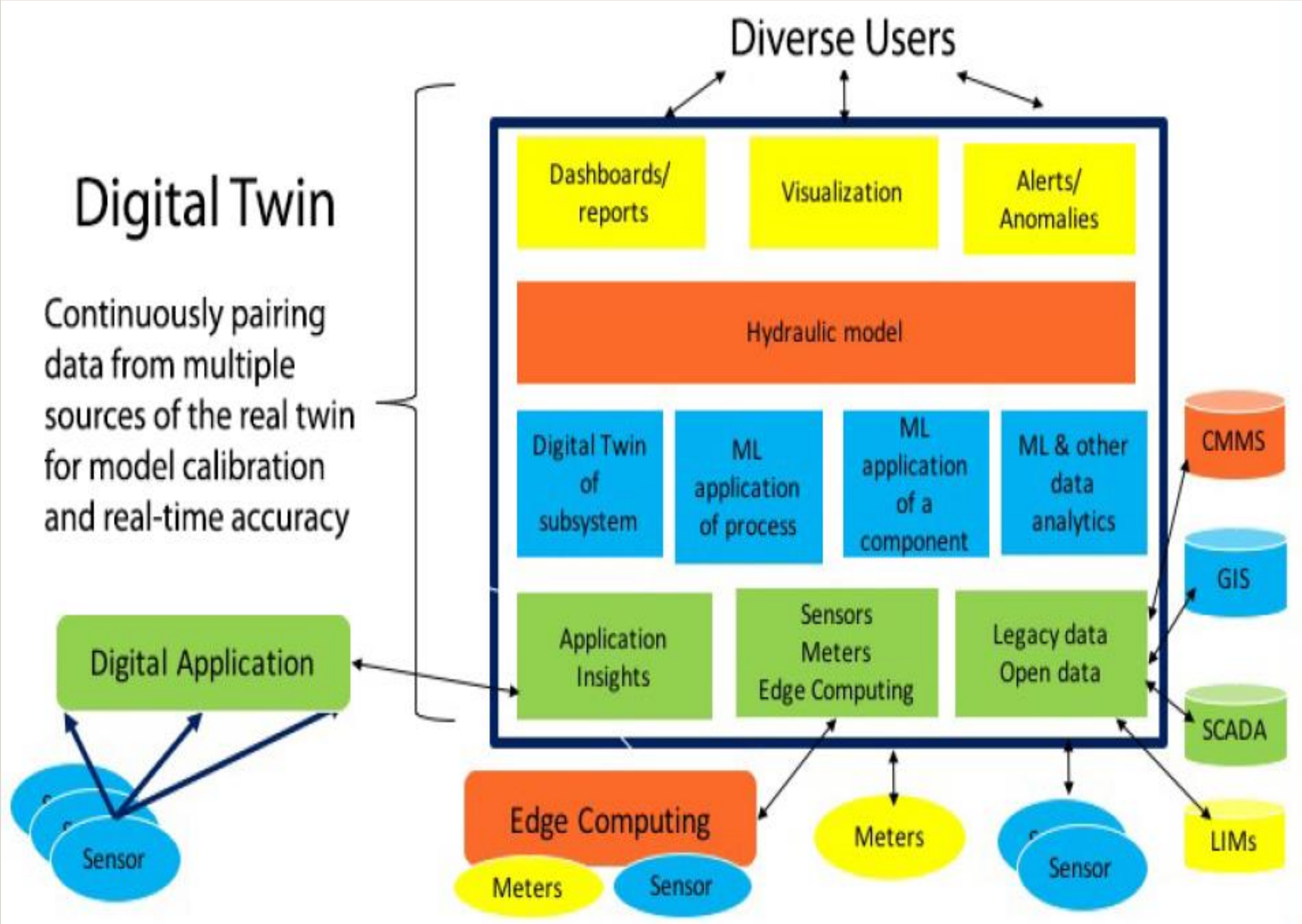
Production planning and forecasting

energyPro / Trade techno / economical model



With NIRAS On the road to a Digital Twin

- Intelligent Pumps control
- Smart Metering
- Smart building control
- Real-time Hydraulic Modelling
- Load Forecasting
- Production planning and scheduling
- Management Information System
- Online Benchmarking
- Machine Learning
- What If and prediction
- **Best Practices!**



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A digital twin require a multi-phase plan that considers not only how the digital twin will be established and delivered, but also how it will be consistently maintained, curated and consumed. If a digital twin is allowed to become stale, it will of course lose its value and will undermine an organization’s digital strategy.

Questions