

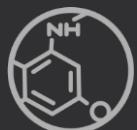


# ADVANCED PROCESS MODELLING FORUM

## 22-23 APRIL 2015

PlantOptimiser for Wastewater  
Overview and ongoing work

Leandro Salgueiro, VP of wastewater BU



- Challenges on Waste Water treatment
- How to make Modelling accessible to end-users ?
- PlantOptimiser description
- Ongoing work and Future development
- Summary and Q&A



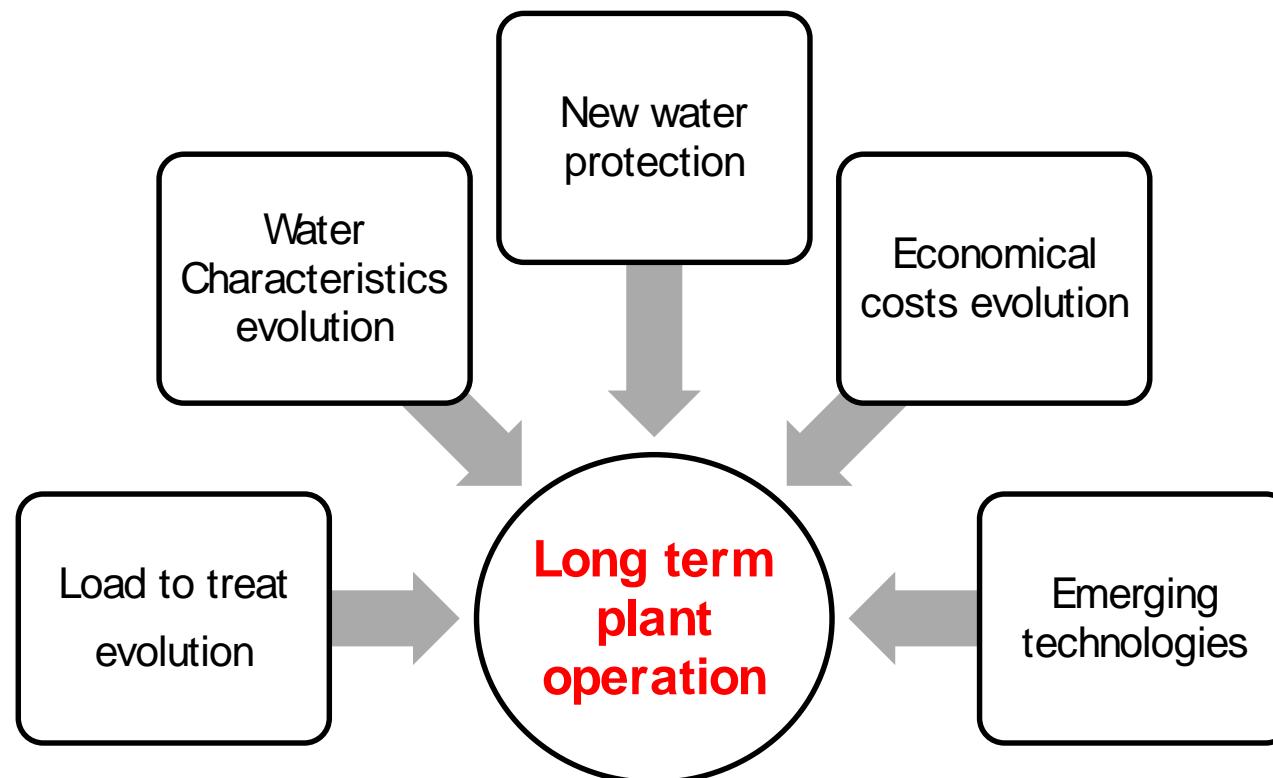
# Challenges on Waste Water treatment

## The use of first-principles models

# Challenges on Waste Water treatment

WWTP are usually built and design to treat wastewater for more than 30/40 years.

This is quite a long time, and several factors can affect the plant



Initial plant design is challenging because of long term uncertainty



Safety margins are often **important** in the initial design



**Operation is key** to efficiently treat the water

# Main drivers in Waste Water treatment

## Current situation

Less space available in cities



More compact processes

Bio-filtration (BAF)  
Moving bed biofilm reactor (MBBR)  
Membranes biological reactors (MBR)  
Sequential Batch reactor (SBR)  
...

Future :

- +20 – 50 % electricity
- Increase of chemicals usage
- Increased investment

New laws for water protection



New treatments and technologies

Ozonation  
Active carbon  
Micro-filtration  
Hydrothermal gasification  
Bio-plastic production  
...

# Why modelling for Waste Water applications ?



Traditional ways of **design** and **operates** wwtp will not give the best solution

- Improve and optimize operation and design
- Detailed evaluation of design scenarios
- Improve process understanding
- Improve process monitoring
- Support and training for plant operators

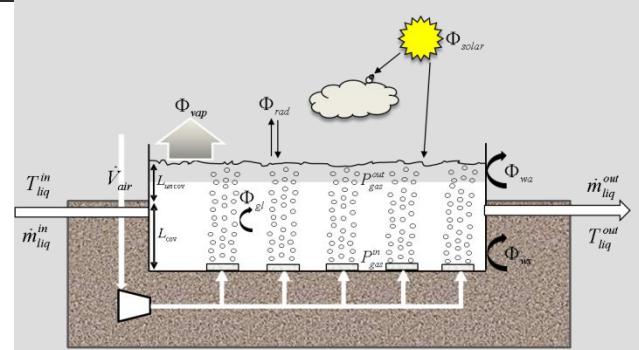
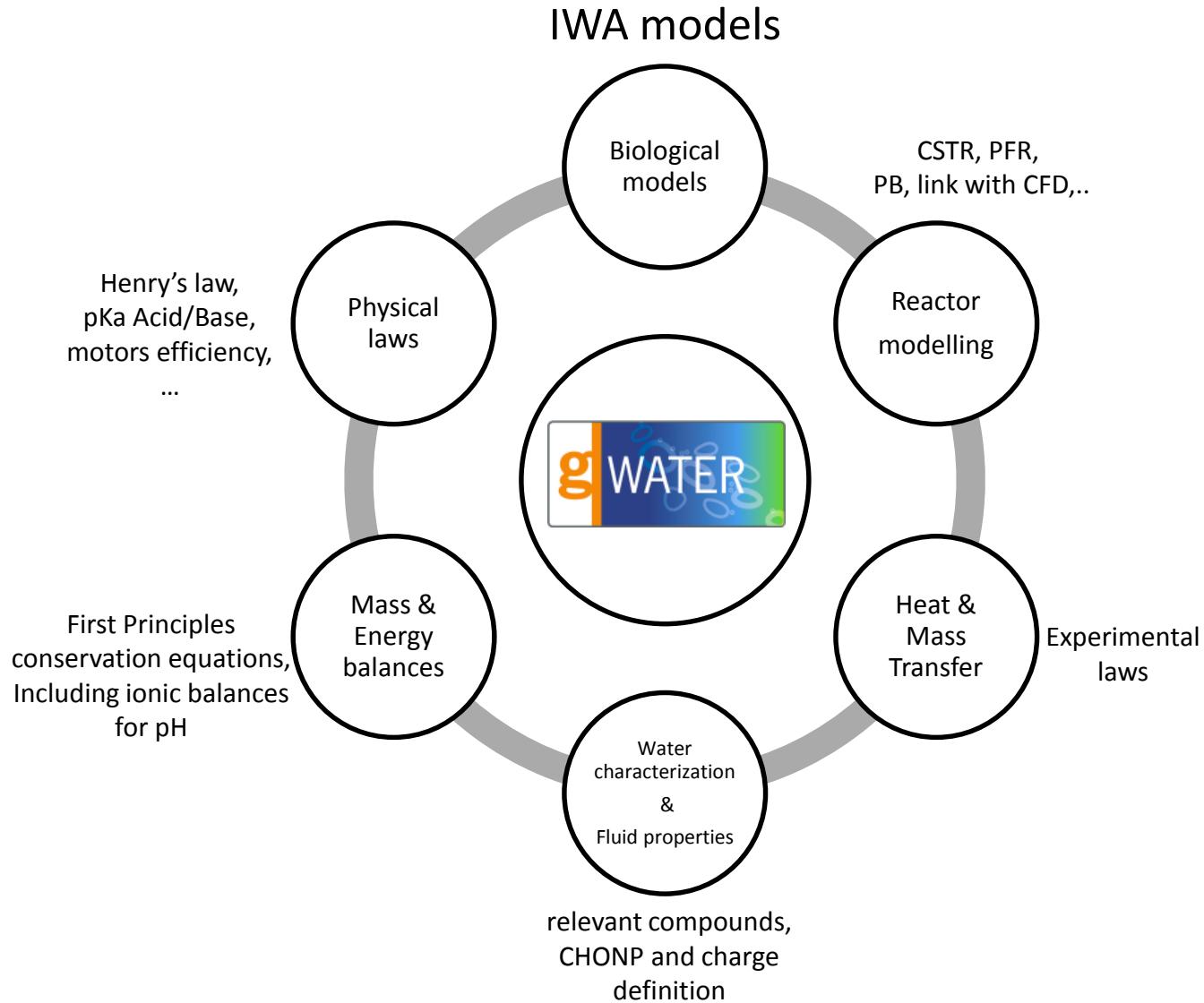
Applies to :

- *Urban wastewater*
- *Industrial wastewater*
  - Chemicals
  - Pharma
  - Food / Agriculture
  - Pulp & paper
  - Mining & minerals
  - Oil & Gas
  - others...



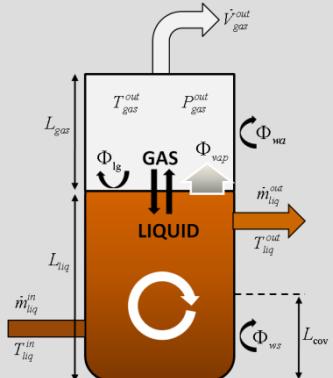
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# gWATER – phenomena



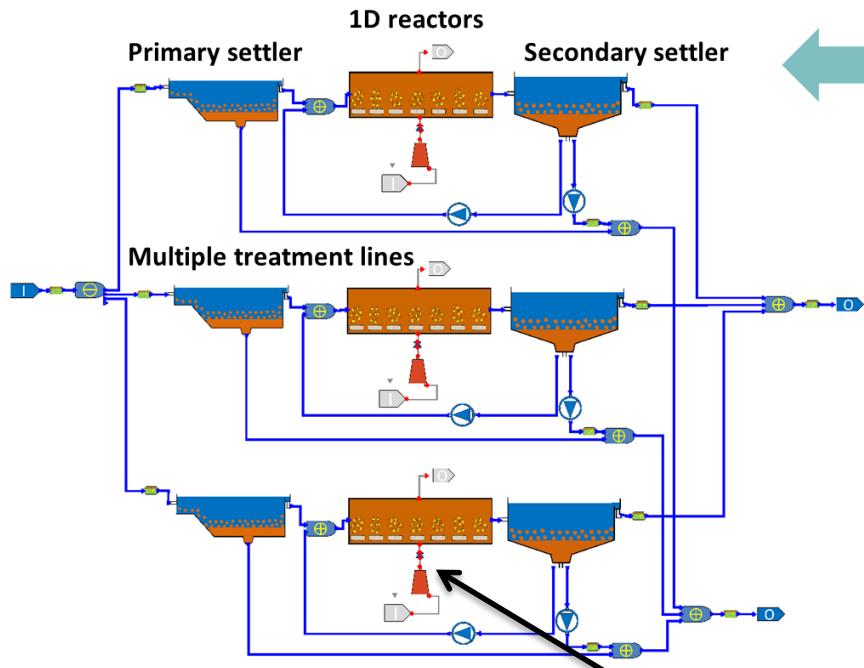
Two phases Activated Sludge  
Plug Flow Reactor

**Sub-models are combined to build process units models**



Two phase Anaerobic Digestion  
Continuous Stirred Tank Reactor

# Typical design applications



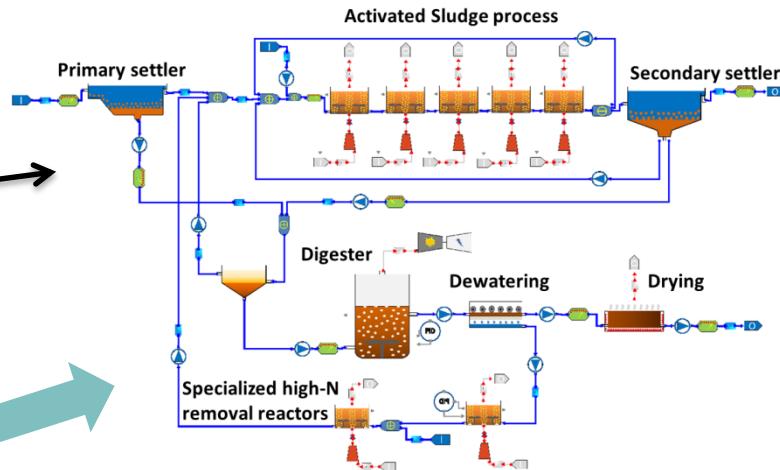
Multiples **1D Plug Flow Reactors with axial dispersion**

Systematic evaluation of  
electricity consumption / production  
and biological performances, in all  
flow-sheets

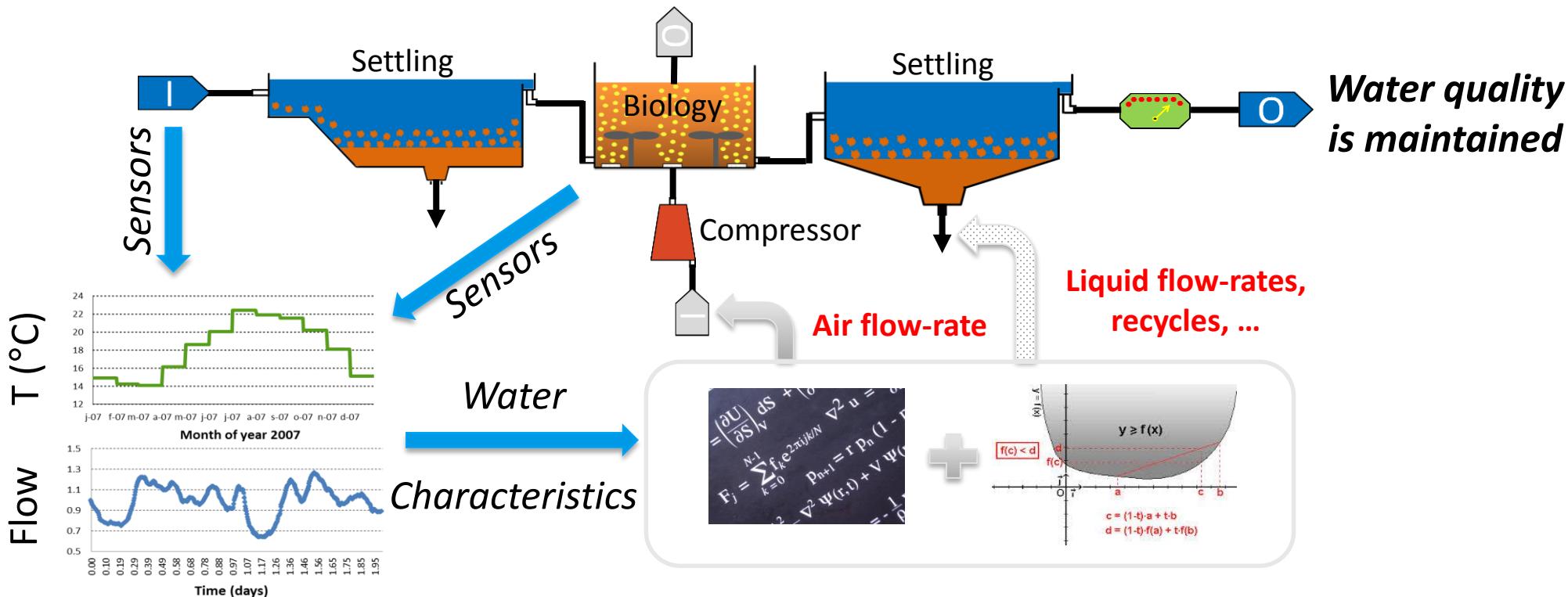
*Compressors / pumps models*

## Plant-Wide modelling

including Anaerobic Digestion and Nitrogen  
specialized treatment processes



# Model-based support tool for plant operation



- A predictive tool (short and long term perspectives)
- **Can deal with varying exploitation conditions / regulations**
- Well suited for new tech. like attached biomass processes
- Smart evaluation for energy recovery (inlet or outlet)



# How to make it accessible to end-users ?

# How to make it accessible to end-users ?



- Makes the models and optimizations accessible to plant operators and engineers has always been a challenge
  - Divergent versions
  - Non modellers engineers modifying equations
  - Make it useful to operation
- A web-based system provide several advantages
  - Models are built and calibrated by modellers
  - Simplicity for the non expert users
  - Continuous modeller support and transparent models update beyond
  - Extensively customisable
  - Possible connections to measurements and automation system
  - Version control
  - ...



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# Objectives of PlantOptimiser (web-based solution)



- Any gWATER model can be used in the same way

Typical applications looked for are:

- *Daily support for plant operation*
- *Optimal and predictive control*
- *Advanced monitoring of plants (connections with measurements)*
- *Operator training / education tool*

- Tailored-made interfaces (industry needs)
- It can be either hosted on own servers or internally to industry (confidentiality or communication problems)
- Has to be User friendly



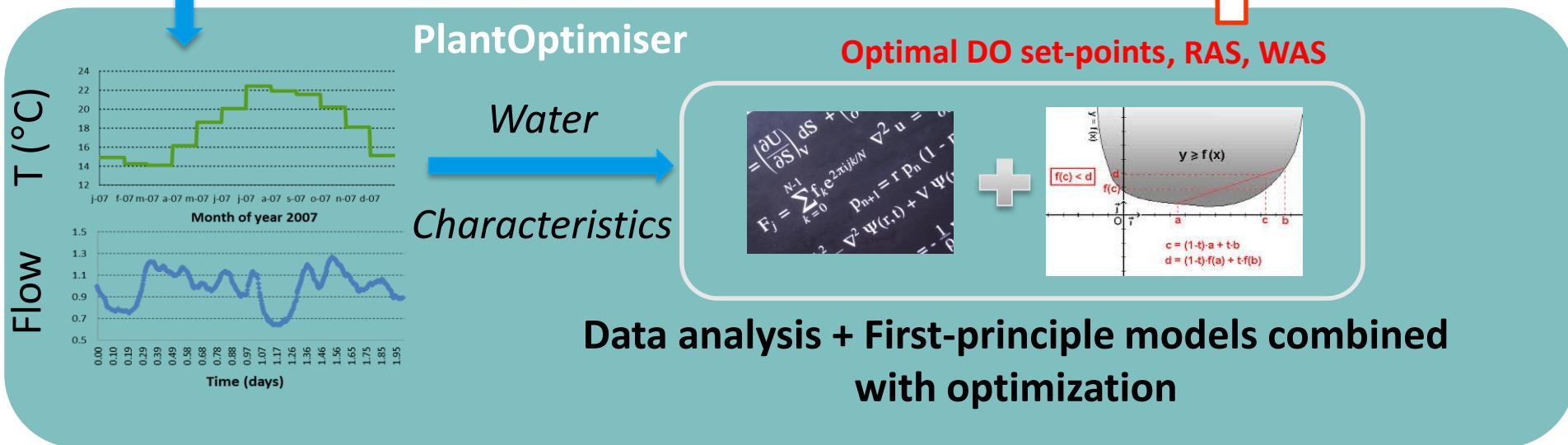
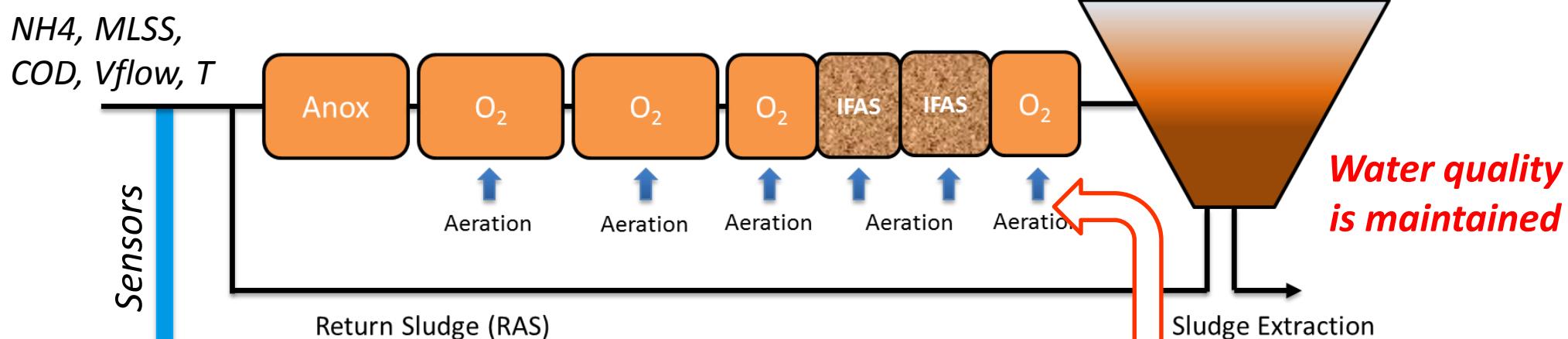
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# PlantOptimiser description

A tool for safe and optimal operation

# General principle



# Energy optimization set-up

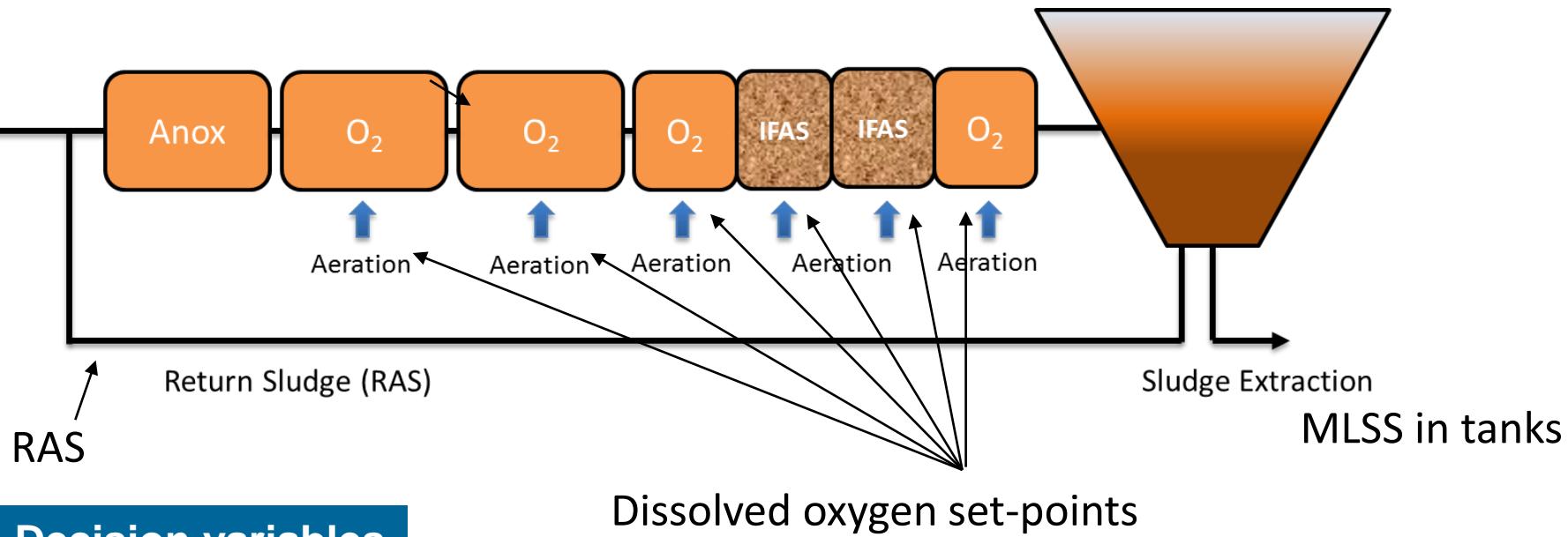
Optimization based on 95<sup>th</sup> percentile, concentration or load values

## Objective

$$\text{Minimize } \dot{E} = \dot{E}_{aer} + \dot{E}_{pump}$$

## Water quality constraints (based on 95<sup>th</sup> percentile)

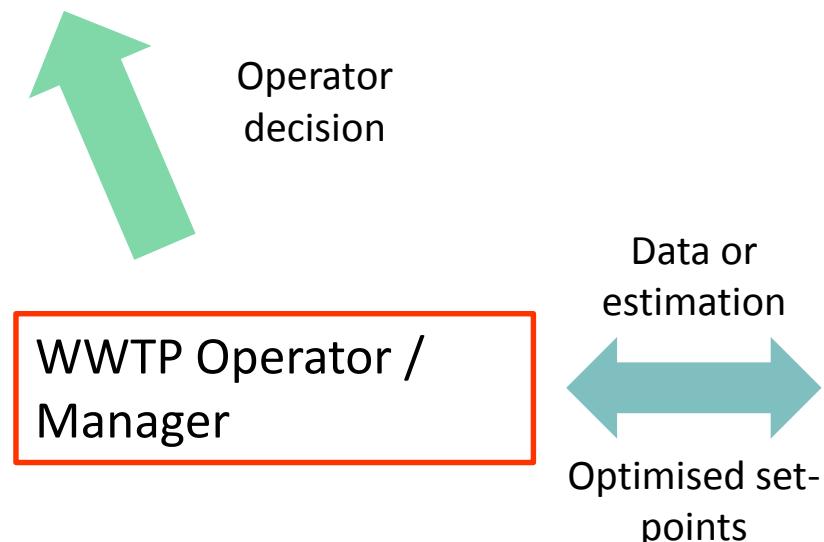
- N-NO<sub>3</sub> : tdb
- COD : tdb
- N-NH<sub>4</sub> < 0.8 gN/m<sup>3</sup>



# PlantOptimiser On-demand Mode



- “What if” simulation scenarios
- Compute optimal set points
- Support to determine best operating modes
- Operator training

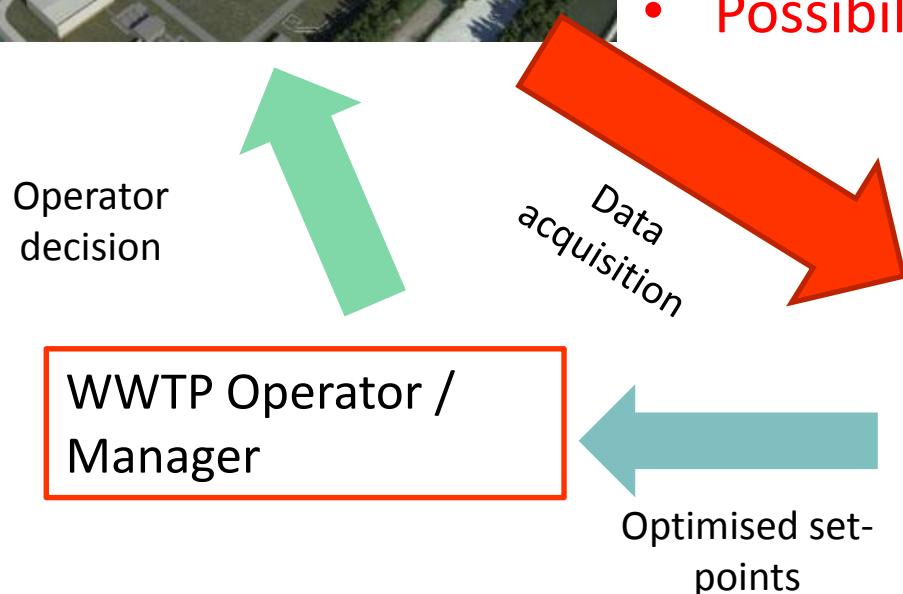


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# PlantOptimiser Surveillance Mode



- Advanced soft sensoring
- Continuous optimal set points generation
- Determination of models confidence interval
- Possibility to use online calibration

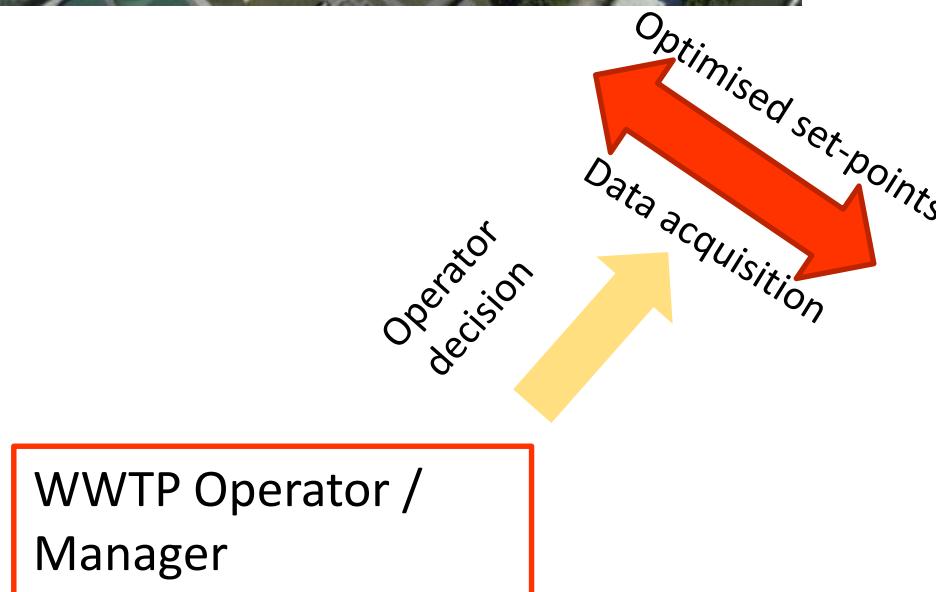


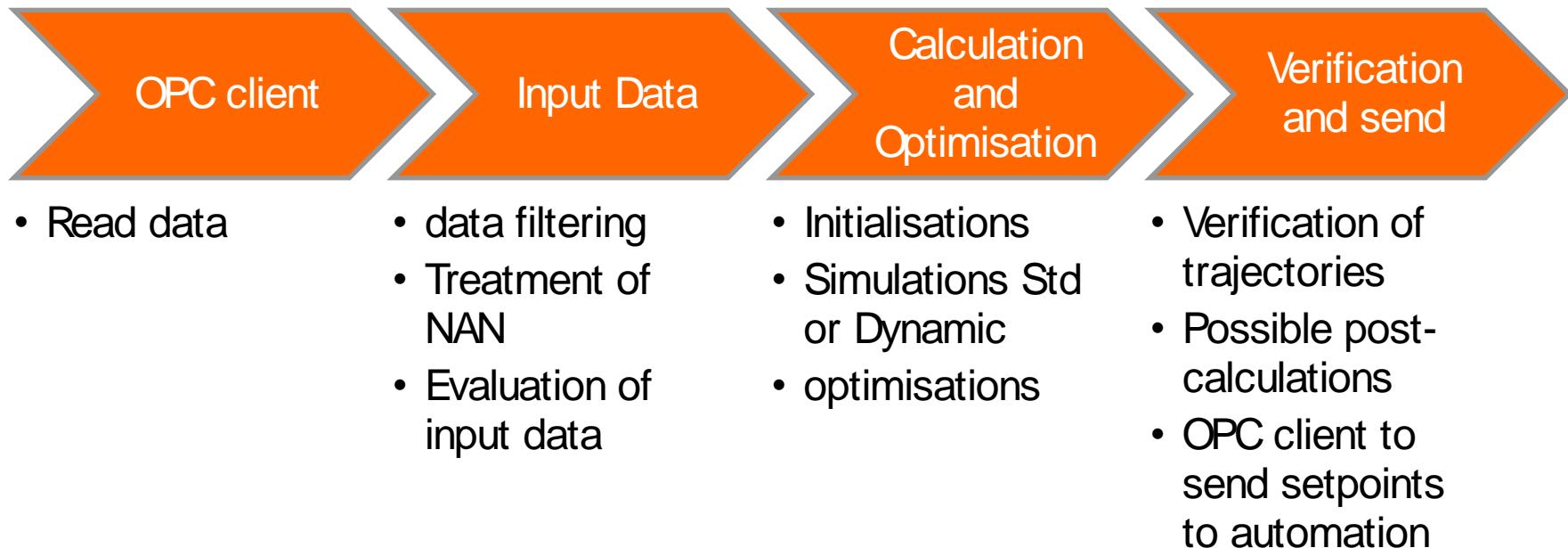
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# PlantOptimiser online Mode (with safe mode)

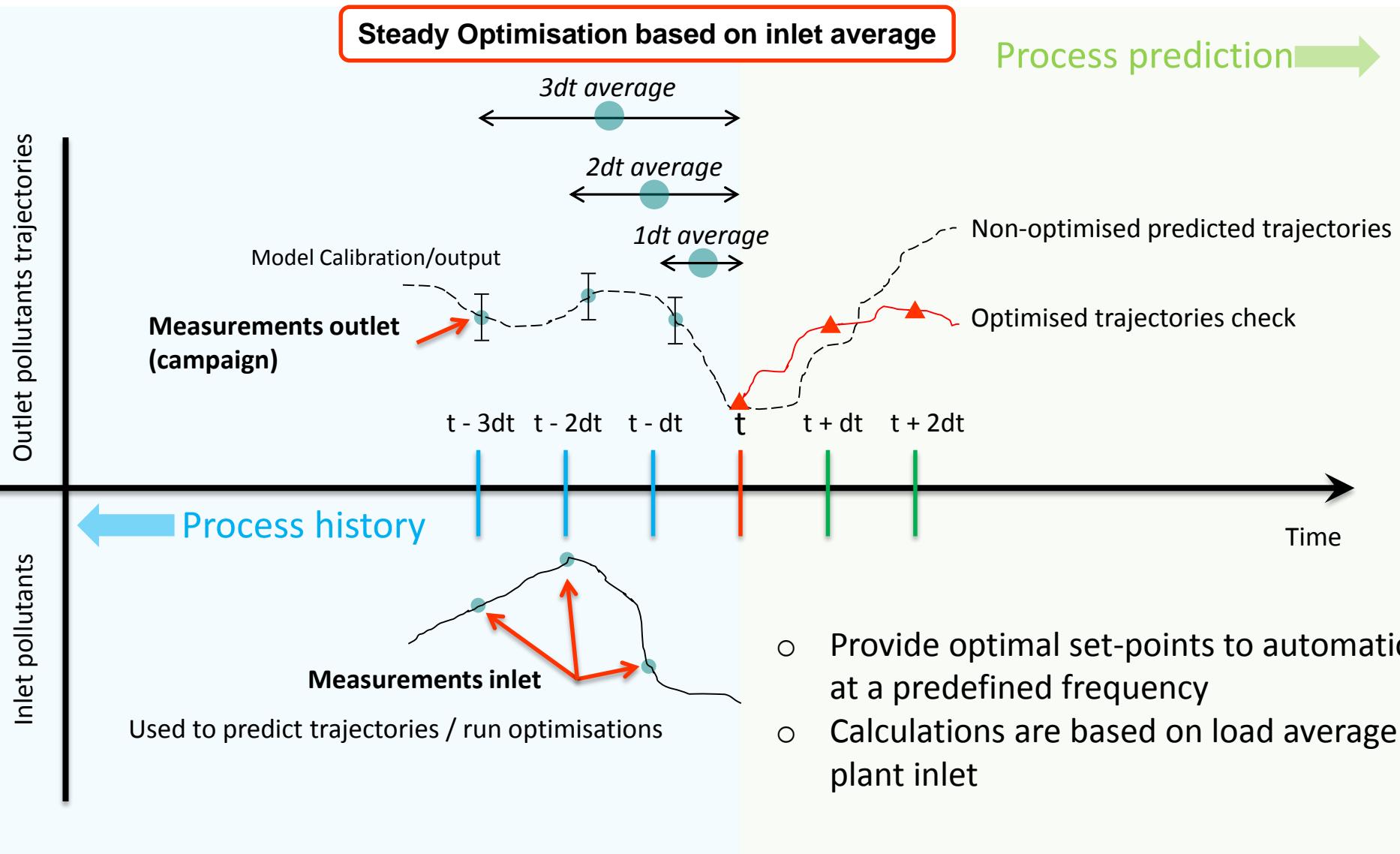


- Direct connection to automation
- Push the system to better **water quality & minimise electricity consumption**
- **Safe mode** will permit to go back to standard operation



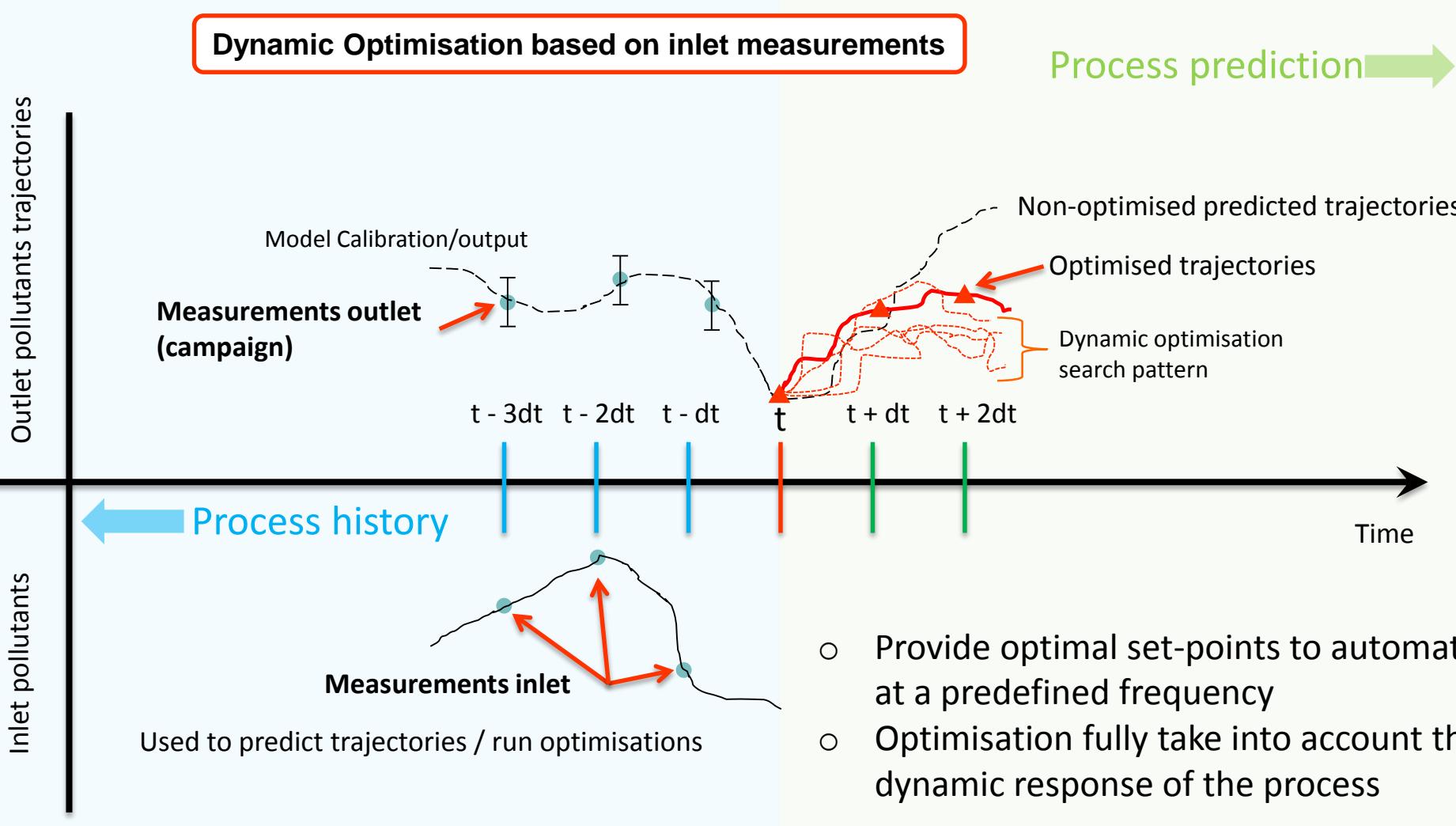


# Optimisation using average inlet pollutant load



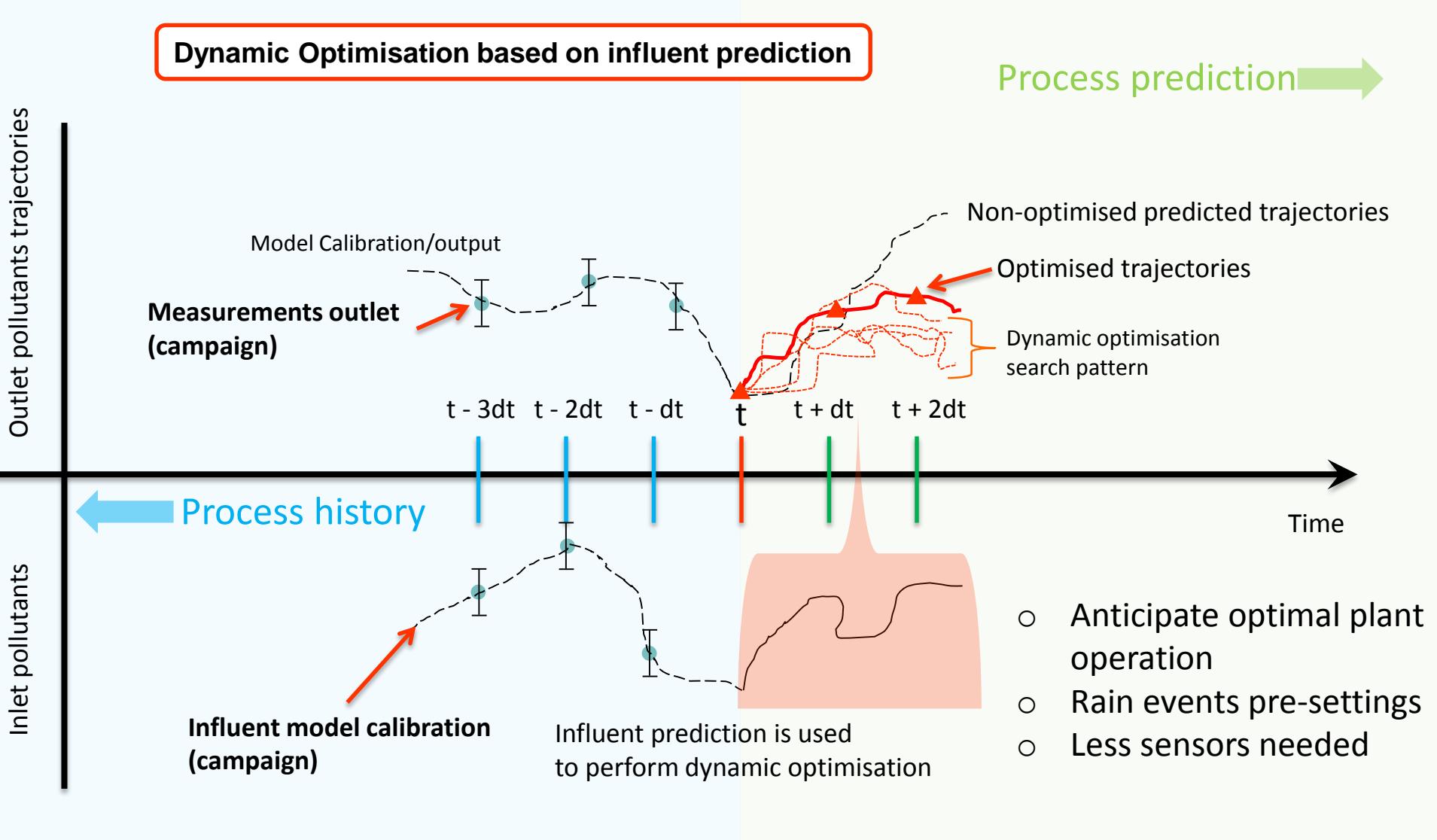
- Provide optimal set-points to automation at a predefined frequency
- Calculations are based on load average at plant inlet

# Moving horizon and dynamic optimisation



- Provide optimal set-points to automation at a predefined frequency
- Optimisation fully take into account the dynamic response of the process

# Influent prediction and dynamic optimisation



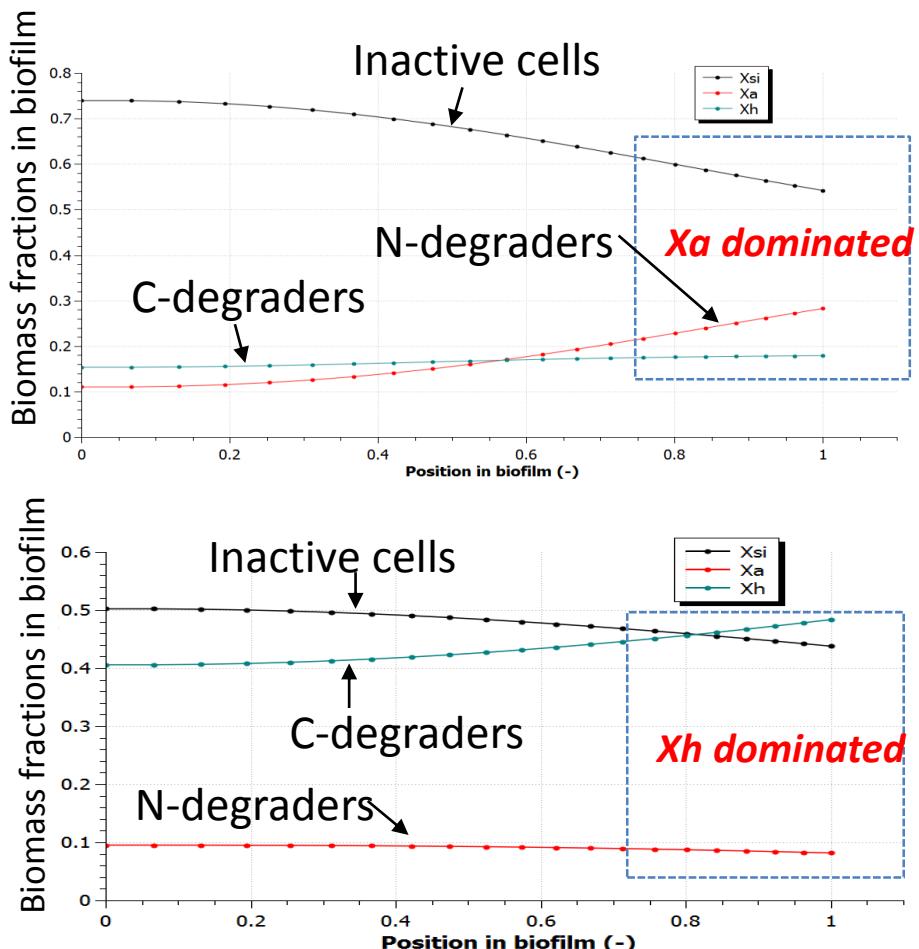
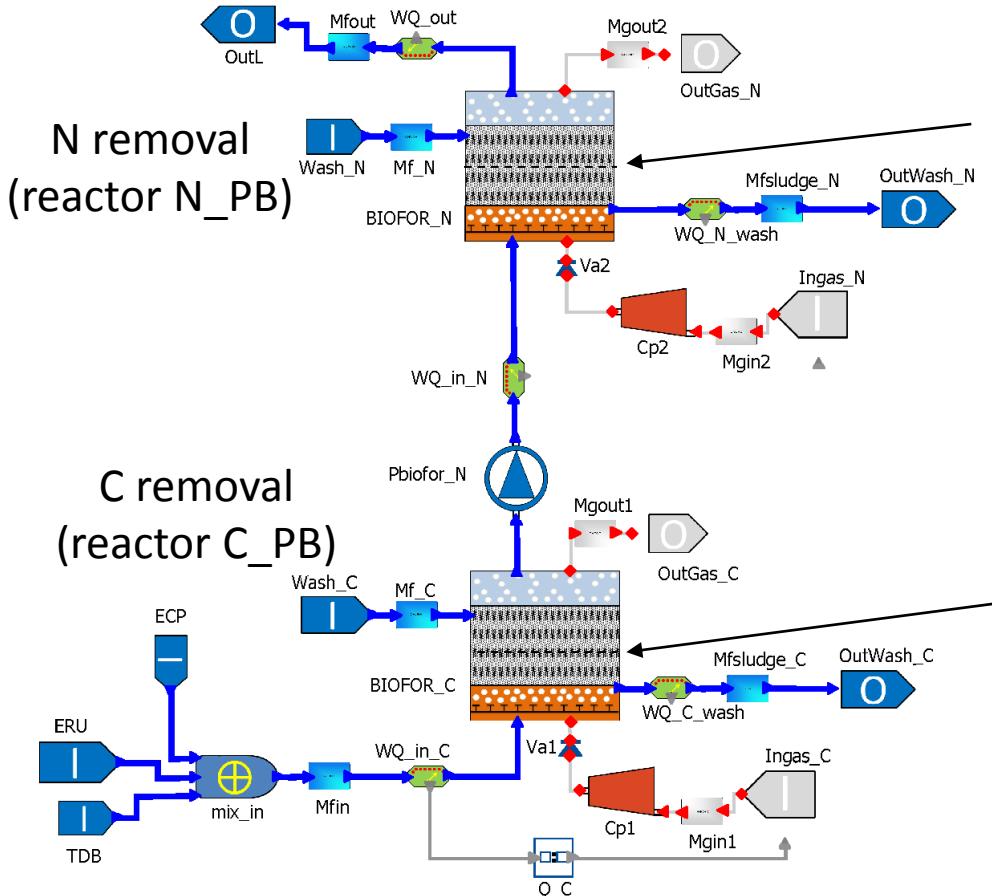


Ongoing work and results

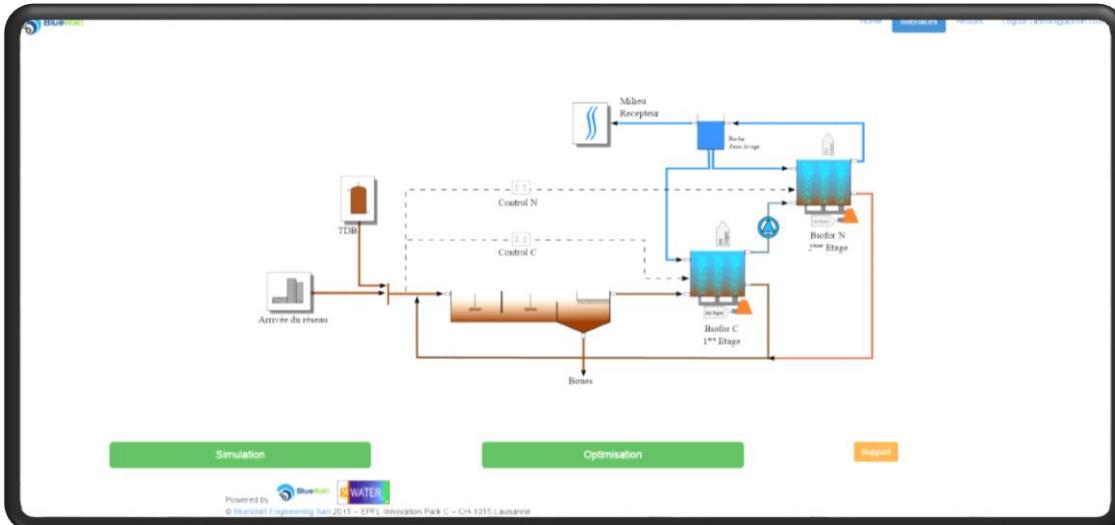
Some application cases...

# Example: Municipal WWTP near Vevey (Switzerland)

## Bacteria competition and stratification



# OnDemand Mode



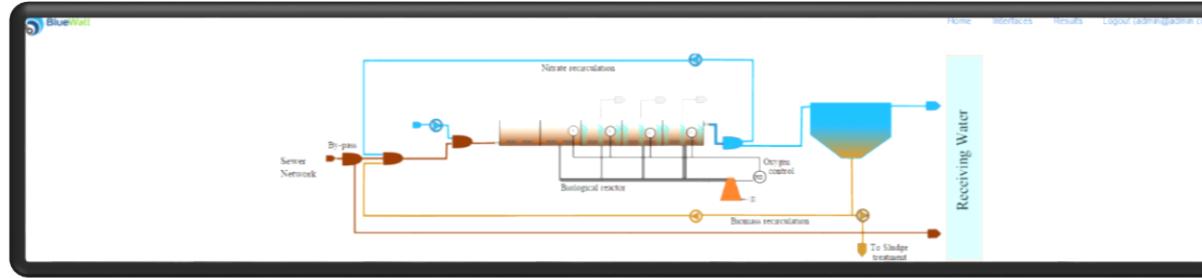
[Link to demo](#)



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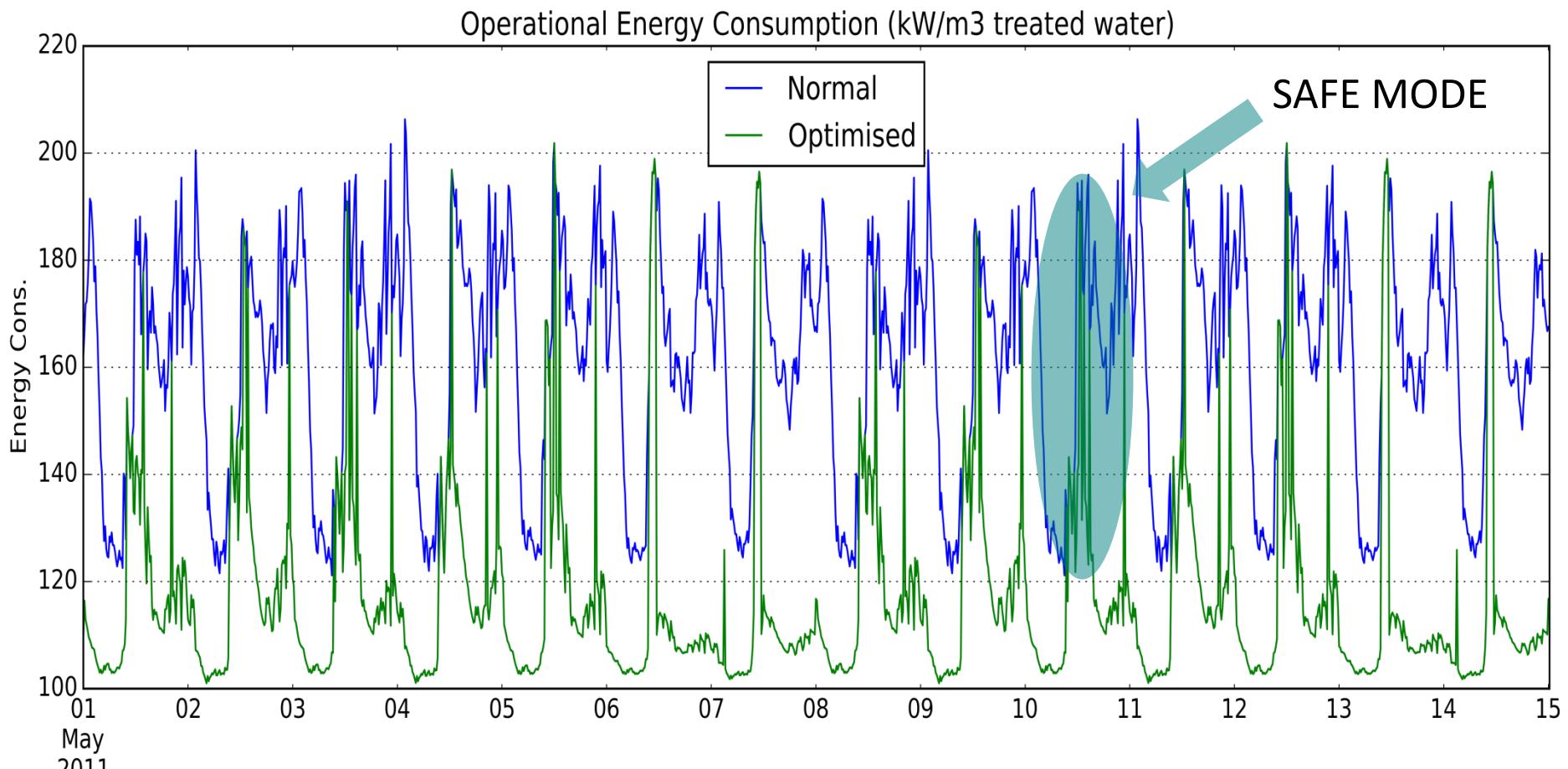
# Surveillance Mode (demo)

On going Work...

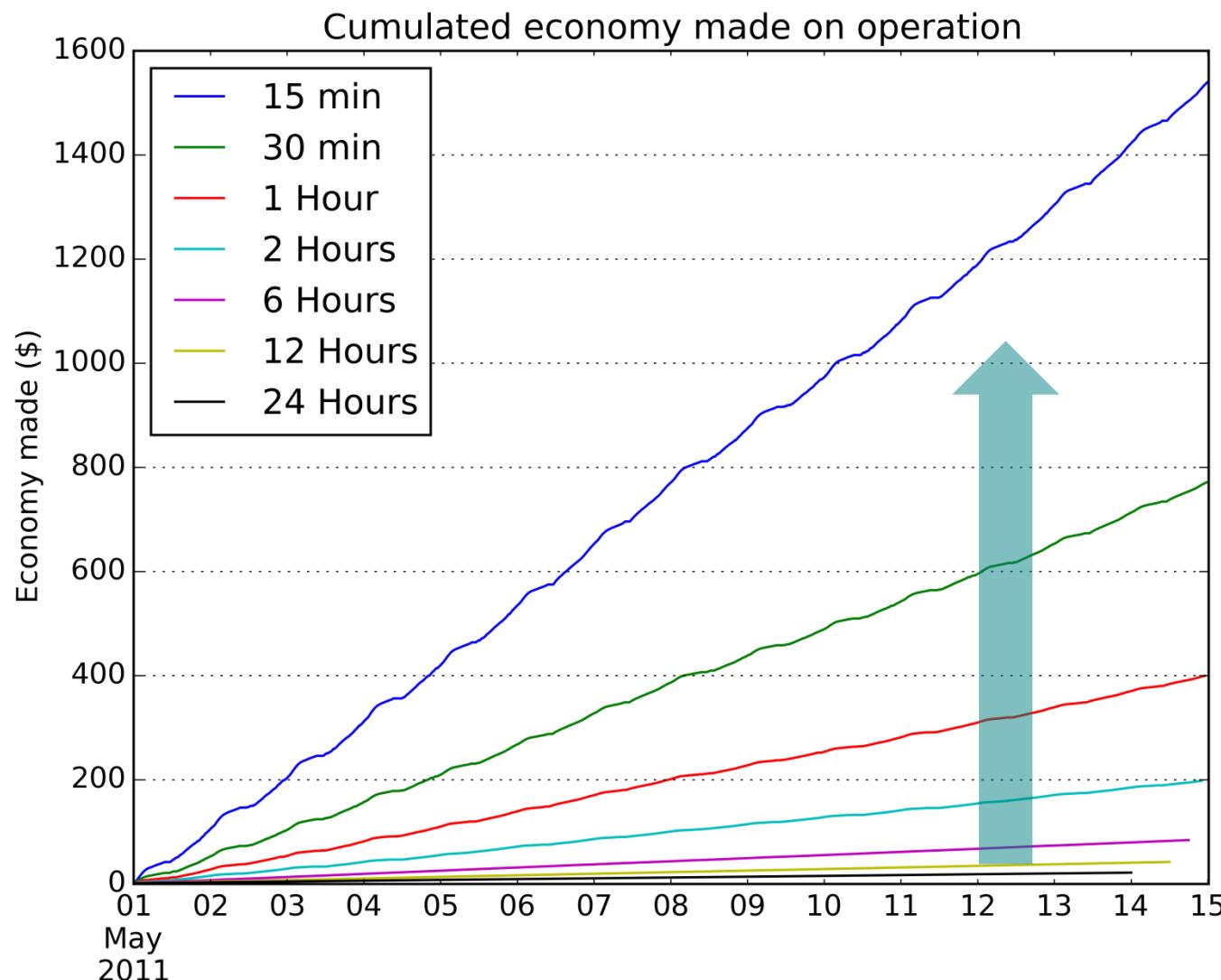


[Link to demo](#)

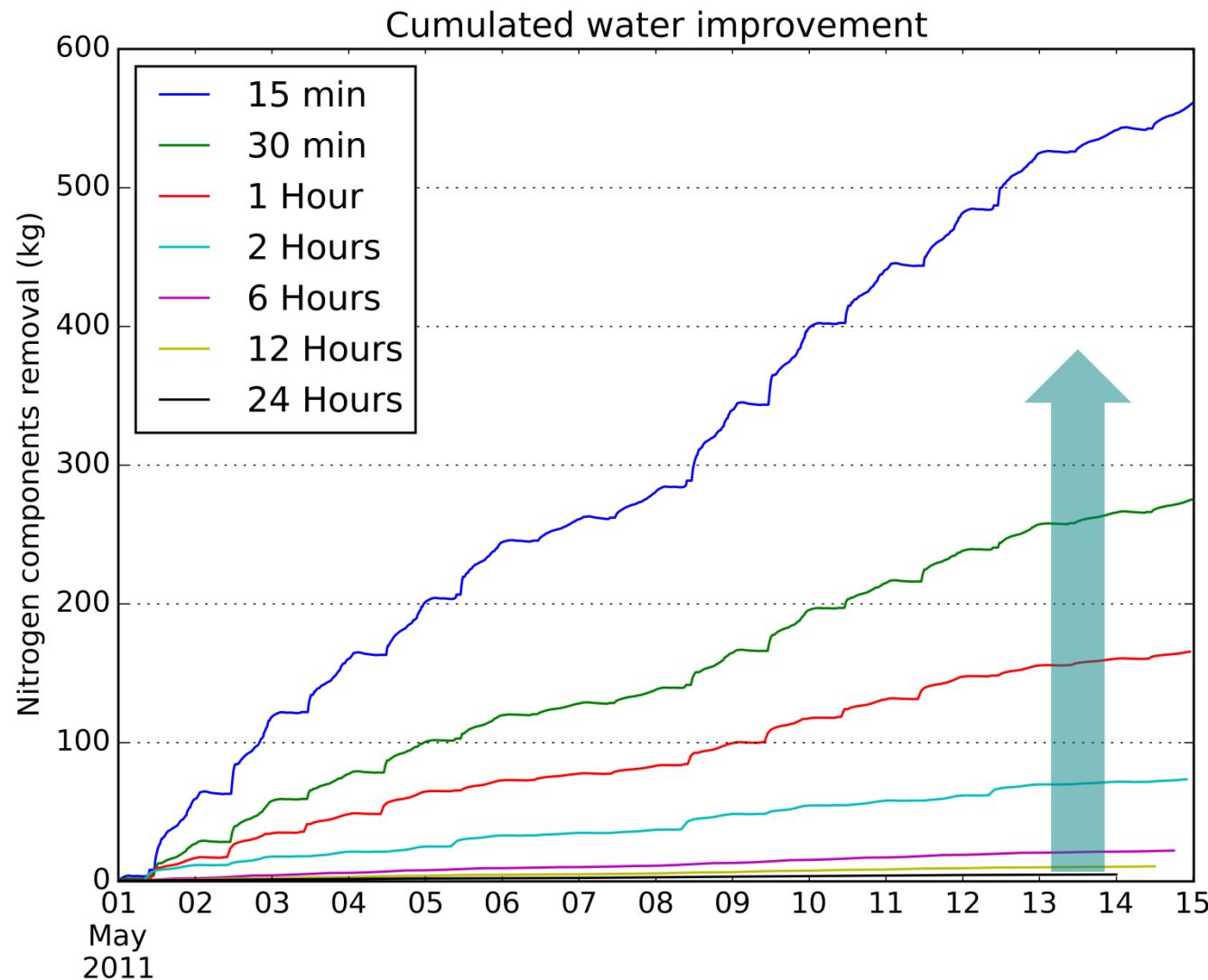
# Results for Surveillance Mode



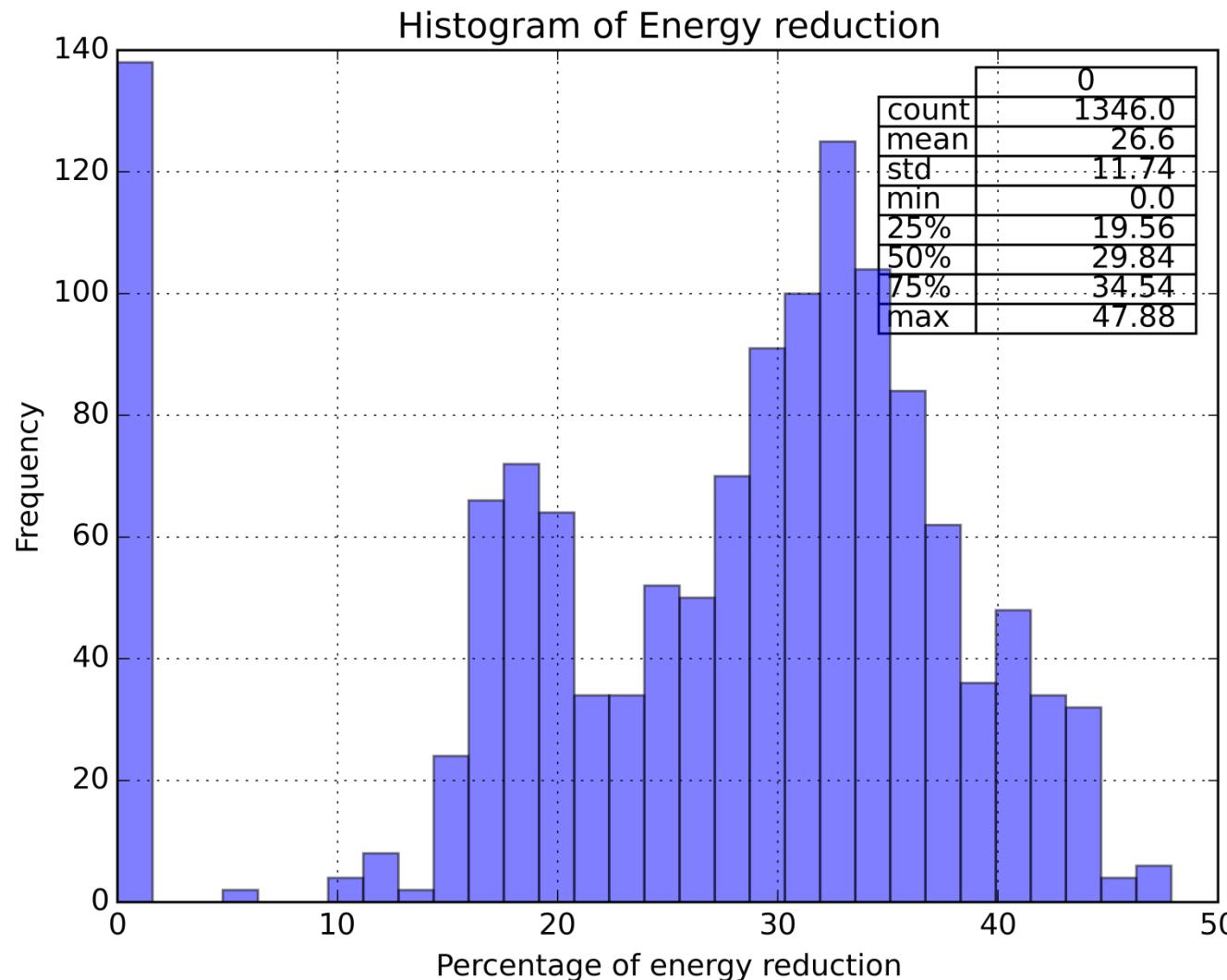
# Results for Surveillance Mode



# Results for Surveillance Mode



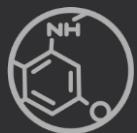
# Distribution of percentage of energy reduction



# Summary

- PlantOptimiser is one way to deploy complex models to operation people.
- Taylored to daily industry needs.
- In wastewater the use of such tool guarantees an operating cost reduction but it also gives a better control and less risks on operation
- The connection with automation gives mayor benefits than ‘what-if’ scenarios
- The information of the models can be used as soft-sensors to avoid innecesary CAPEX.
- The integration with other models can give further benefits (ex. sewer network models with weather predictions)

Thank you





# gPROMS product family



## General mathematical modelling



gPROMS ModelBuilder  
Advanced process  
modelling environment

## Sector-focused modelling tools

### Chemicals & Petrochemicals



gPROMS ProcessBuilder  
Advanced process  
simulation

### Life Sciences, Consumer, Food, Spec & Agrochem



Solids process  
optimisation



Crystallization  
process optimisation



Oral absorption

### Power & CCS



CCS system modelling

### Oil & Gas



Flare networks &  
depressurisation

### Wastewater Treatment



Wastewater systems  
optimisation

### Fuel Cells & Batteries



Fuel cell stack &  
system design



## The gPROMS platform

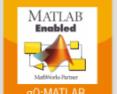
Equation-oriented modelling & solution engine

### Materials modelling



### Model deployment tools

#### Enterprise Objects



Deploy models in common engineering software

# Logos & icons



## Corporate



## APM Forum



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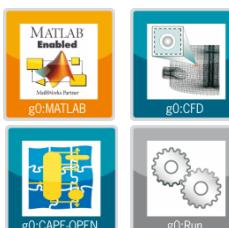
## Products



## Sector icons



## gPROMS Objects



## Enterprise



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