

## IWA TG on Benchmarking of Control Strategies for WWTPs

# Why is dynamic simulation useful for evaluation of control strategies ?

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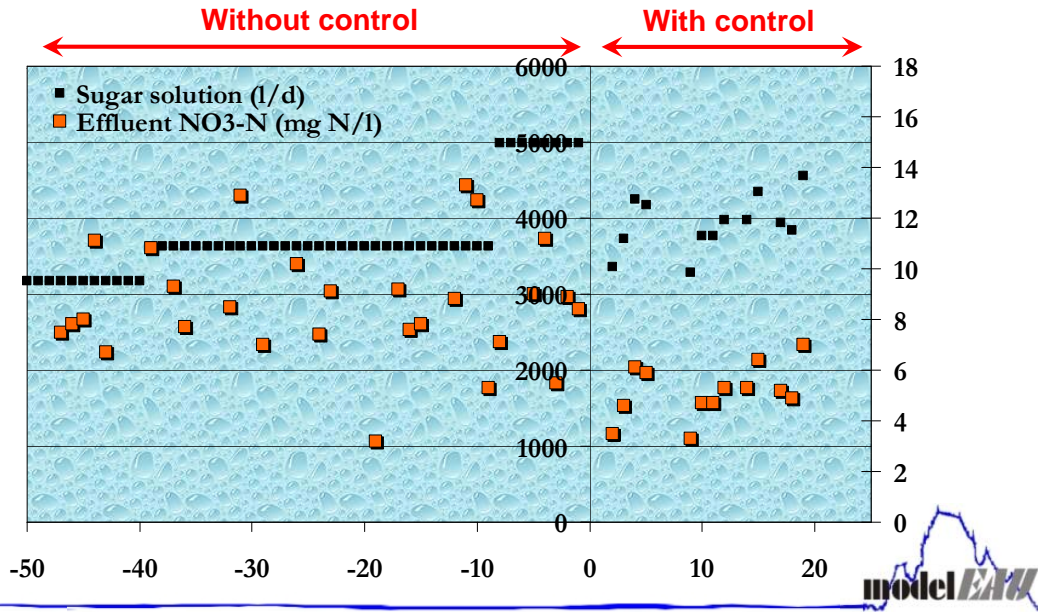
## Outline

- Ideal situation
- Actual situation
- What can we do with dynamic simulation ?

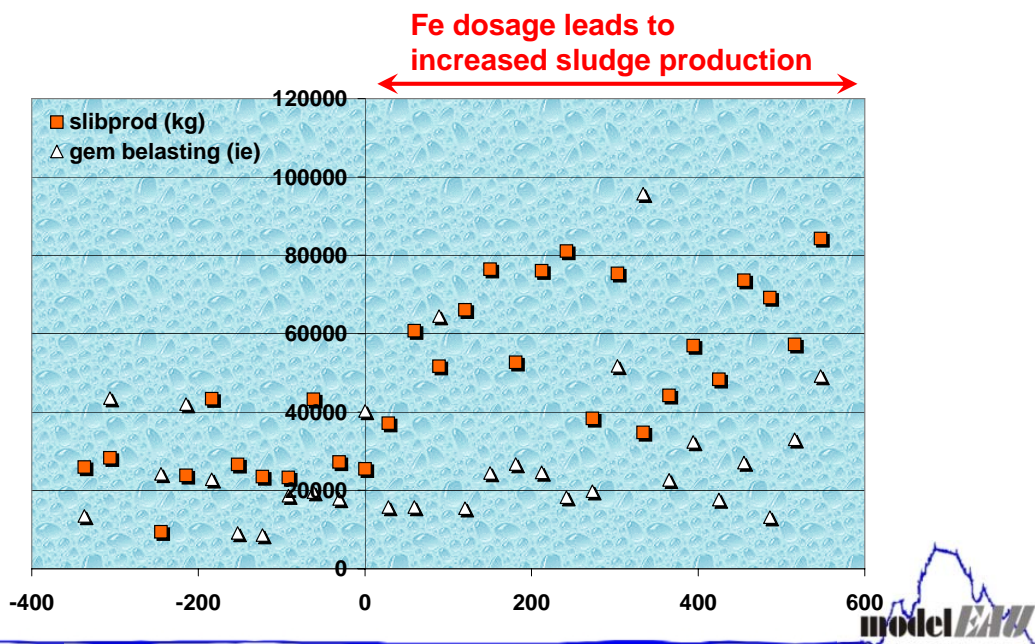
*BASIC QUESTION:  
IS CONTROL USEFUL FOR MY PLANT ?*



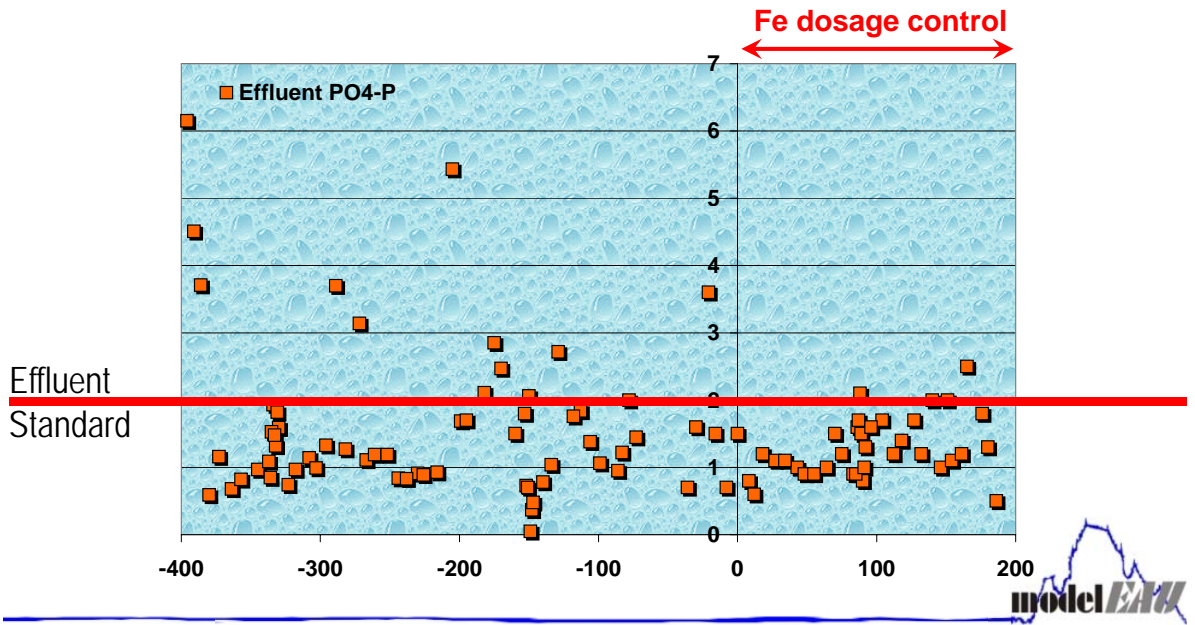
# Ideal Situation (NO<sub>3</sub>-control)



# Ideal Situation (PO<sub>4</sub>-control)



# Ideal Situation (PO<sub>4</sub>-control)



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# Ideal Situation (PO<sub>4</sub>-control)



- Cost calculations (35.000 PE):
  - Reduction in Fe-dosage : **-30%**
  - Reduction in sludge production: **-25%**
- Chemical P-removal for all plants with 30-100 kPE most of them now use this control
- NO<sub>3</sub>-control using external carbon is installed on nearly all larger plants (> 20 kPE) as well.
- On top of that: Consistent results



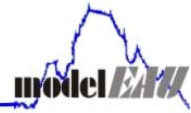
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## Actual situation

- Management doesn't allow one to perform the "Proof of principle" experiments
  - Expensive
  - Trust in the results
  - Too wild an idea
  - Why improve, it's running fine, doesn't it ?
- Vicious circle: You cannot prove the usefulness of control until you've proven its usefulness



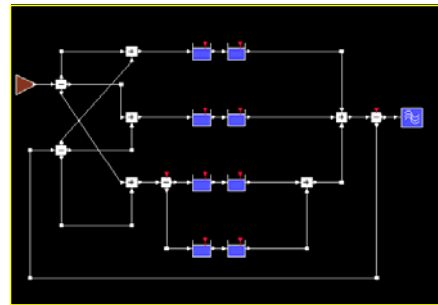
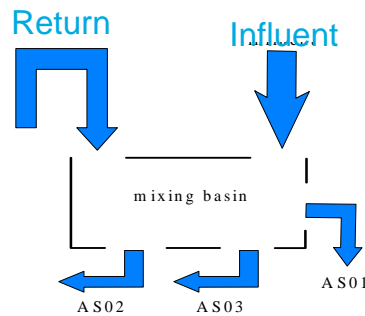
## Actual situation

- Practical problems of comparative study:
  - Comparison in time doesn't work due to time-variation in process performance



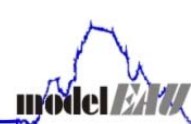
# Actual situation

- Practical problems of comparative study:
  - Comparison in parallel systems doesn't work due to problems with "parallelisation":
    - Sludges are mixed up again due to combined clarifier underflows
    - Uneven distribution of loads into parallel lanes



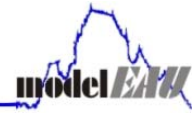
# What to do ?

- Simulate !
- Realistically !
- Dynamically ! (we're talking about control after all)
  
- Crazy ideas are allowed, no damage done...
- Repeatable results, hence differences are more clear



## Is dynamic simulation useful?

- Only when the model is sufficiently realistic
- Virtual experimentation yields results so much faster than actual experimenting
- It's not prone to natural variability
- Its results are repeatable and therefore comparable
- It allows to tune the controller before going to practice
- The control idea can be jeopardized under extreme conditions and safety nets can be developed



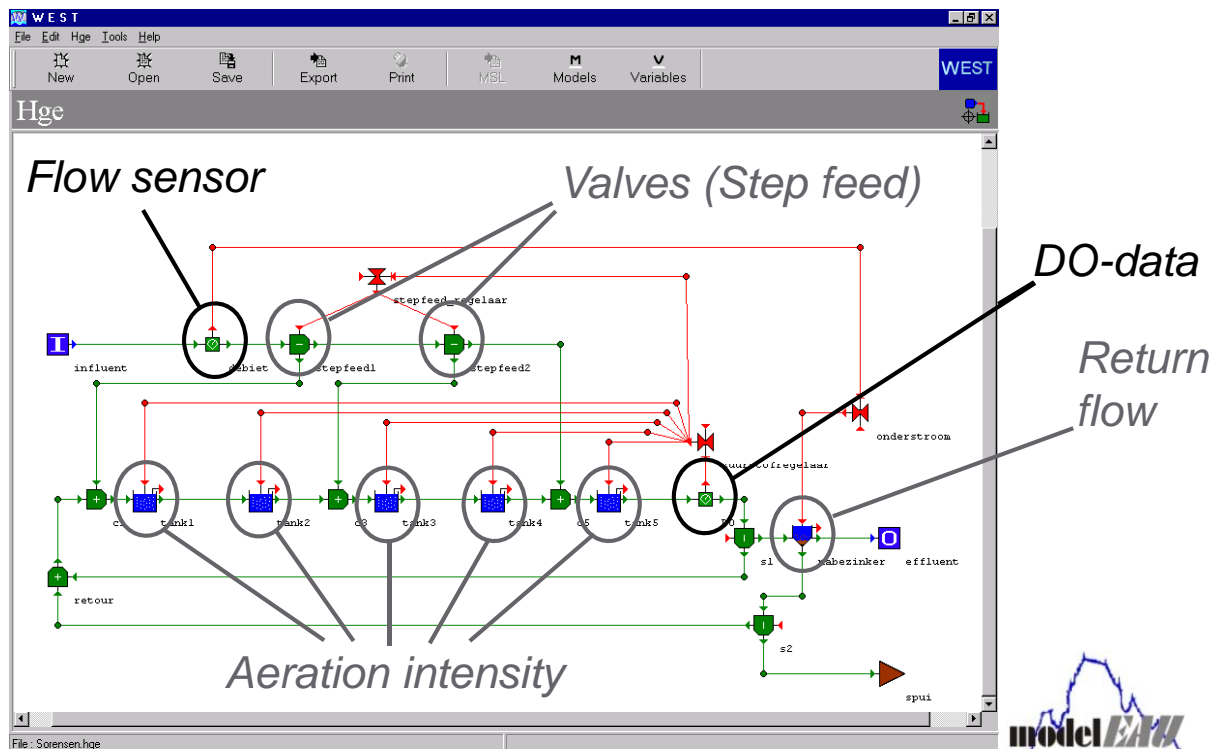
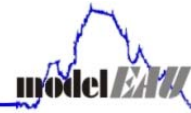
## Dynamic simulation and control ...

- Influent generator
  - with interesting sequence of events
- Fault generator
  - testing safety nets under process/equipment failures
- Stability analysis
  - e.g. when process delays exist
  - when process properties change
- To tune controllers before going in the field
  - Don't send an engineer to Vietnam for a week...



# Dynamic simulation and control ...

- Triggers creativity
- Control structure selection
  - Cause-effect relationships
  - Which sensors / actuators should I connect
  - Control authority of a proposed structure
- Allows to deduce general rules of optimal operation
  - e.g. 1 mg NO<sub>3</sub>/L is optimal at end of anoxic zone
  - rule-based or timer-based control strategies
- Optimal sensor choice and location
  - minimize delay, multiplex, ...



# Conclusions

- Ideal situation where you can prove usefulness of control by trying it out is not existing very often (Aquafin)
- Actual situation:
  - Problems (temporal and parallel comparison)
  - Vicious circle
- Dynamic simulation is a good alternative
  - "Play around" with control ideas
  - Triggers creativity
  - Test the controller under "extreme conditions"
  - Repeatable and fast

