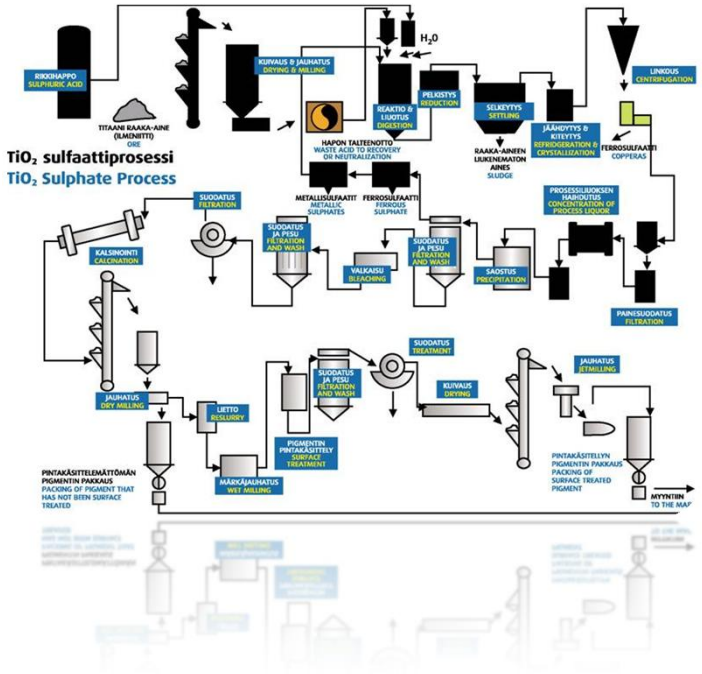
Business from technology



Systems simulation and optimisation at VTT

May 13-14, 2013

Jari Hämäläinen
VTT Technical Research Centre of Finland

SYSTEMS RESEARCH 2006-2013

Models, analyses, simulation and software for better control, safety and productivity of complex systems

Computer Simulation Models and Technology

- Large scale dynamic simulation models
- Integration of simulation and design with semantic information models
- Simulation based automation testing and training

Systems Control

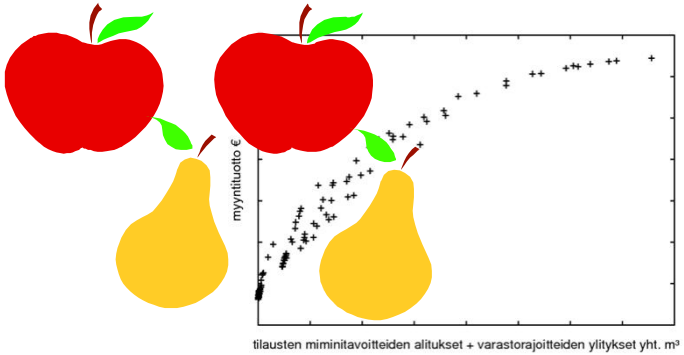
- System dynamic simulation in operations management
- Large scale optimisation in logistics and production control
- Automation architectures, design processes and requirements management

Systems Analysis

- Probabilistic risk assessment (PRA) and decision support
- Assessment of safety critical automation (I&C)
- Complex stochastic systems

Human Factors Engineering (HFE) and Systems Usability

- Human activity and Human-Technology Interaction (HTI) in control centres
- Development and evaluation of control room operations and technology
- Competence development and training

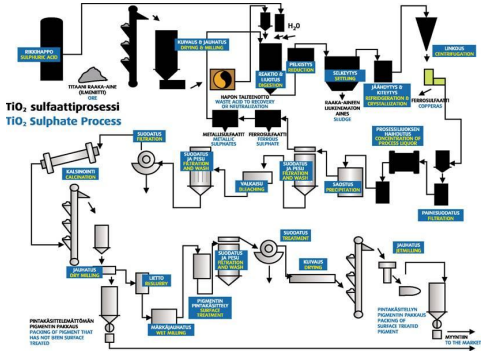


Optimisation of systems

- Multiple objectives
- Optimisation in practise

Operative systems optimisation

- Production control
- Operational optimisation - future prospects



Predictive process control

- Predictive simulation
- Dynamic optimisation

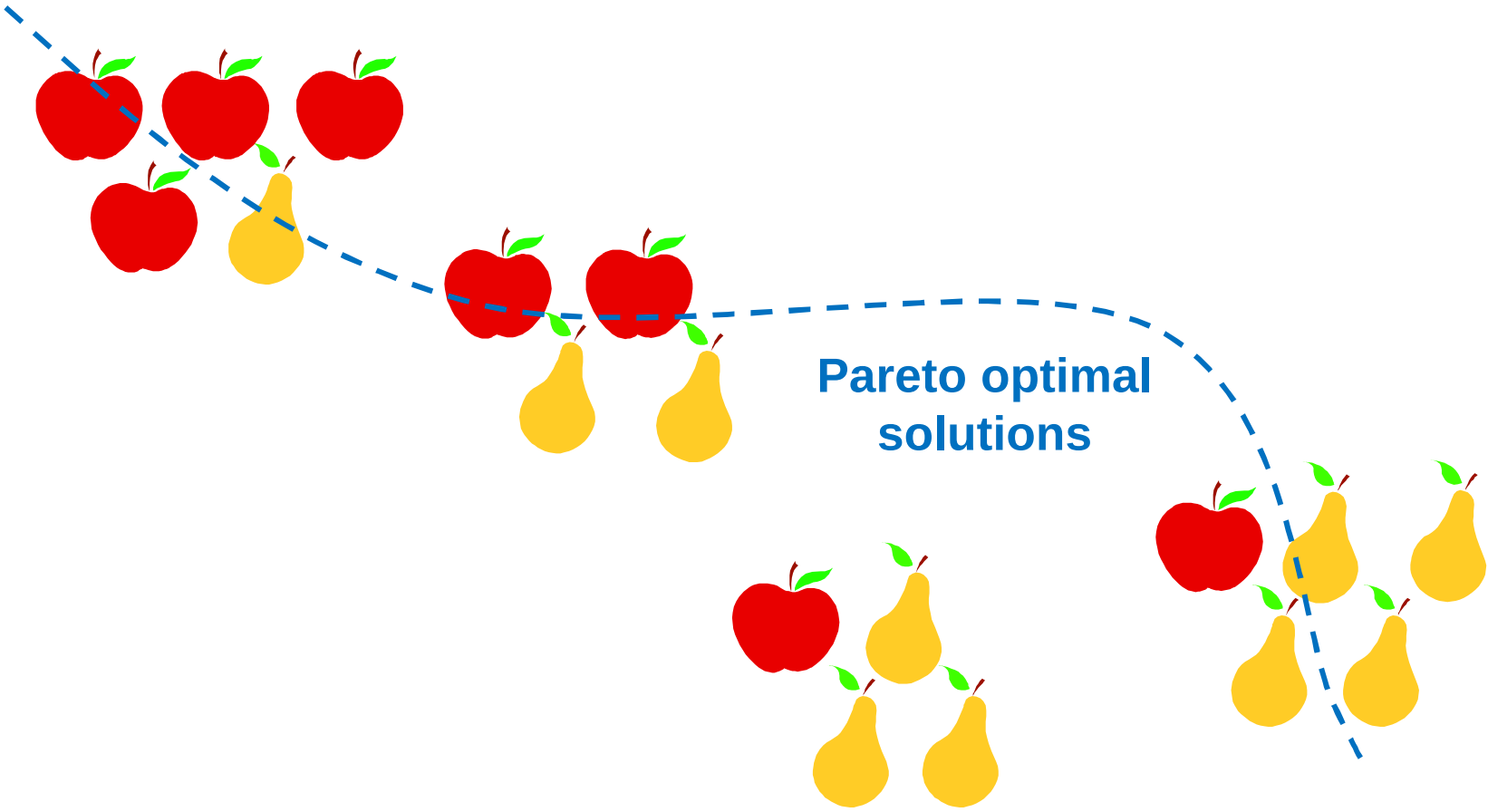
Process simulation

- Integration of simulation and process design
- Vision for industrial information management

Optimisation

Optimisation example

If you liked to have the maximum number of apples and pears, which of the four alternatives would you choose?



Optimisation

Optimisation of systems

- There are always **several goals** for optimal action
- The goals can be **formulated as objective functions, soft constraints or hard constraints**
- Mathematically and by the use of computational methods a possible Pareto optimal solution can be found **among the set of feasible solutions**
- The choice of the solution depends on the **preferences of the decision maker**
- The preferences may be **different in different situations**
- In practice, **operational processes are optimised** by using mathematical optimisation, simulation, continuous improvement, trial and error …

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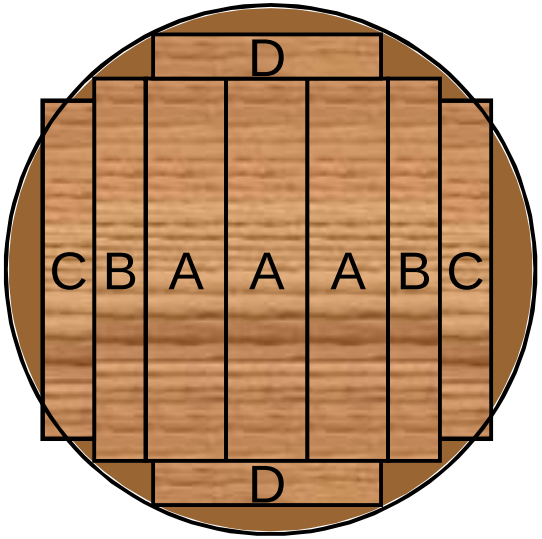
Operative optimisation

Production planning in a sawmill

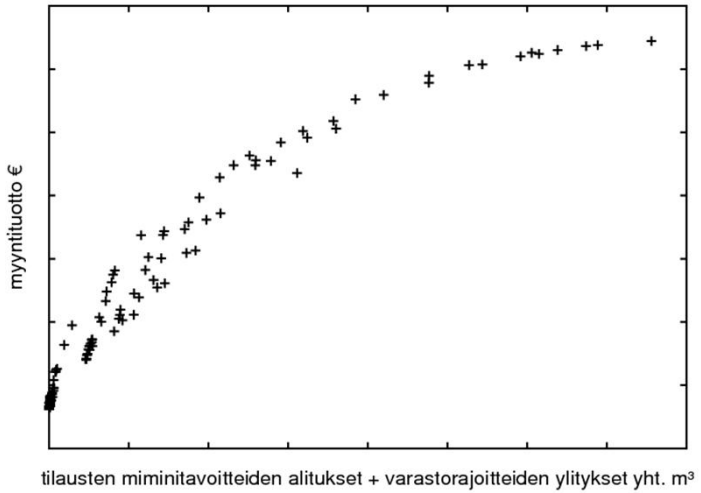


- Create an **optimal plan for sorting of logs** into batches for sawing
- The model covers the **production process from incoming logs to individual timber product deliveries**
- **Maximise customer order fulfilment and profits**, minimise unsalable production

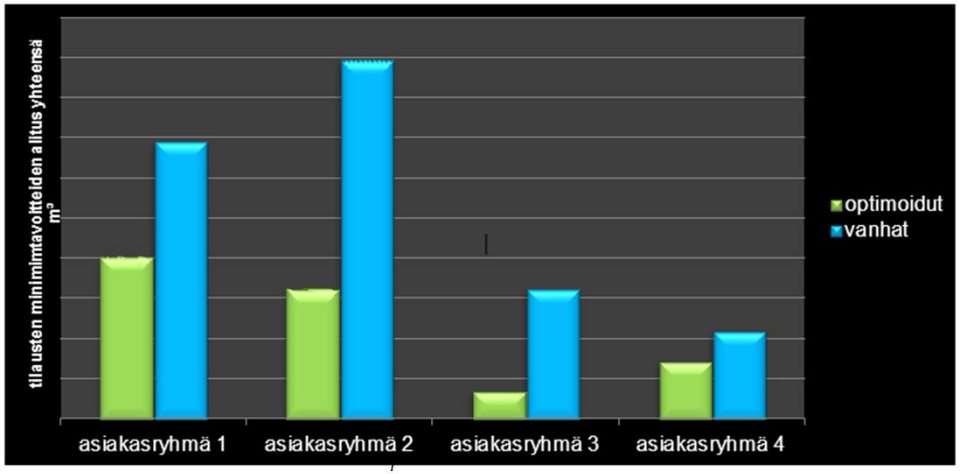
Operative optimisation

Production planning in a sawmill

- Profit is theoretically maximised when violation of order fulfilment is not penalised
- Fulfilment of all orders substantially decreases profit
- How much is a customer order worth?
- The production plans can be adjusted to market conditions



- Customers are classified to different groups
- Weights for violation of orders may be different
- Optimisation gives better fulfilment of orders than human planning



Optimised Human planning

Operative optimisation

Future prospects of operational optimisation

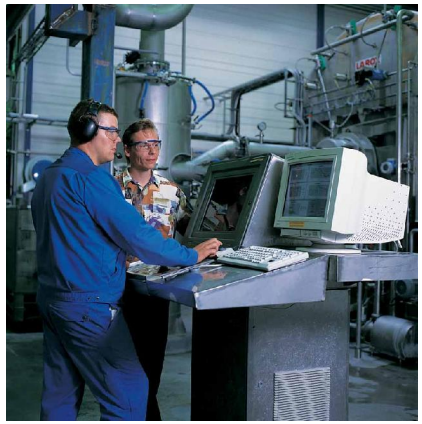
- A **detailed optimisation model** typically improves even an established way of action by a few per cent
- The **input data needed for optimisation** is obtained from enterprise information systems
- **Parallel computing with multicore processors** makes it possible to solve bigger and bigger problems in decent time
- The **participation of operational management** in specification and testing is essential
- **Large scale planning problems** are very difficult for humans especially in changing environment

Back to slide 2

PREDICTIVE PLANNING AND CONTROL OF BATCH TYPE PROCESSES

Predictive operator support

- A simulation model describes the production line
- The initial state is obtained from the plant automation and information systems
- The operator gives the operational schedule
- An optimal schedule is found by what-if-analysis or computational optimisation for, e.g., 1-7 days
- OPERCOP development environment

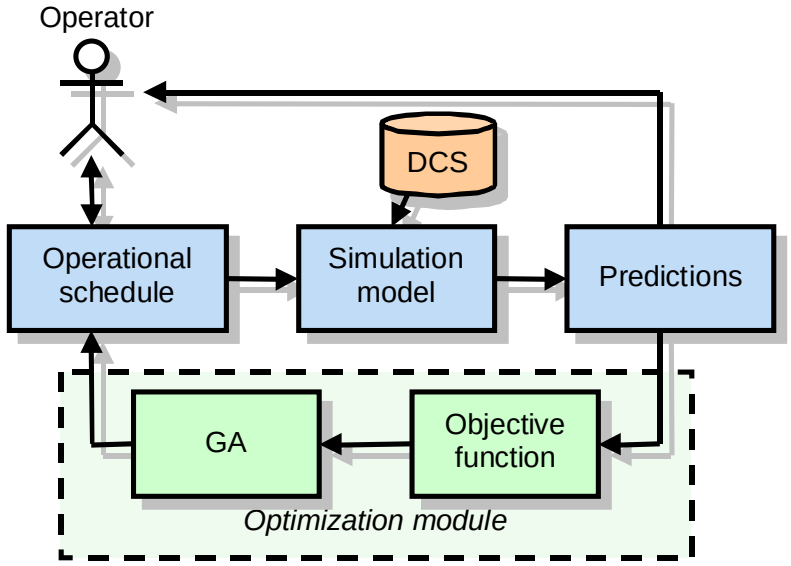


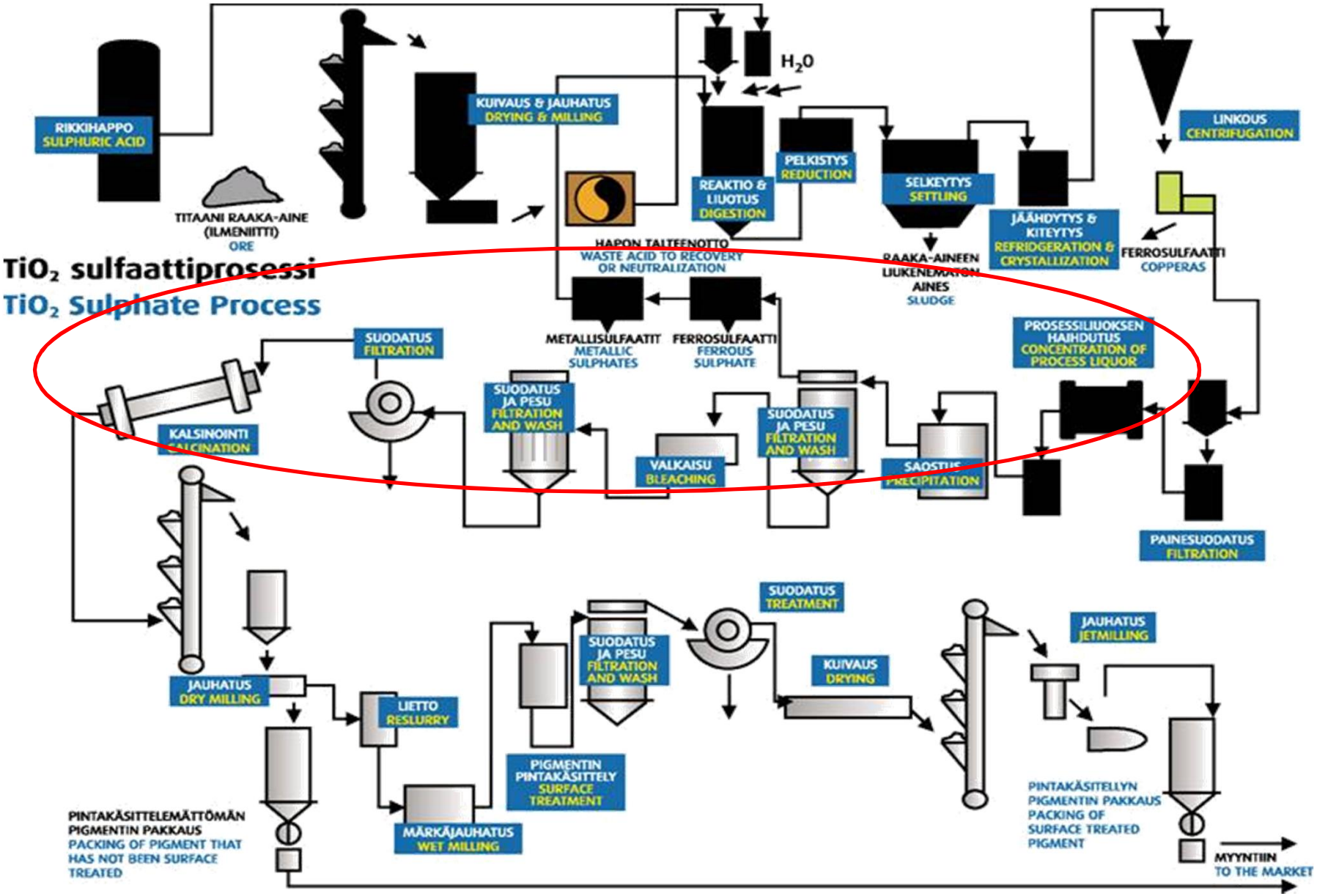
Benefits

- Steady operation of the plant, better quality
- Efficient use of the existing capacity, increase in yield
- Management of disturbances and unexpected situations
- Planning of the product changes and service intervals
- Systematic optimisation over the shifts

References

- Production of TiO2 (Kemira Pigments, daily use in 2005)
- Enzyme production, granulation (Genencor International)




RIKKIHAPPO
SULPHURIC ACID
TITAANI RAAKA-AINE
(ILMENIITTI)
ORE
KUIVAUS & JAUHATUS
DRYING & MILLING
H_2O
REAKTIO & LIUOTUS
DIGESTION
PELKISTYS
REDUCTION
SELKEYTYS
SETTLING
JÄÄHDYTYS & KITEYTYS
REFRIDGERATION & CRYSTALLIZATION
LINKOUS
CENTRIFUGATION
FERROSULFAATTI
COPPERAS
HAPON TALTEENOTTO
WASTE ACID TO RECOVERY
OR NEUTRALIZATION
RAAKA-AINEEN LIUKENEMATON AINES
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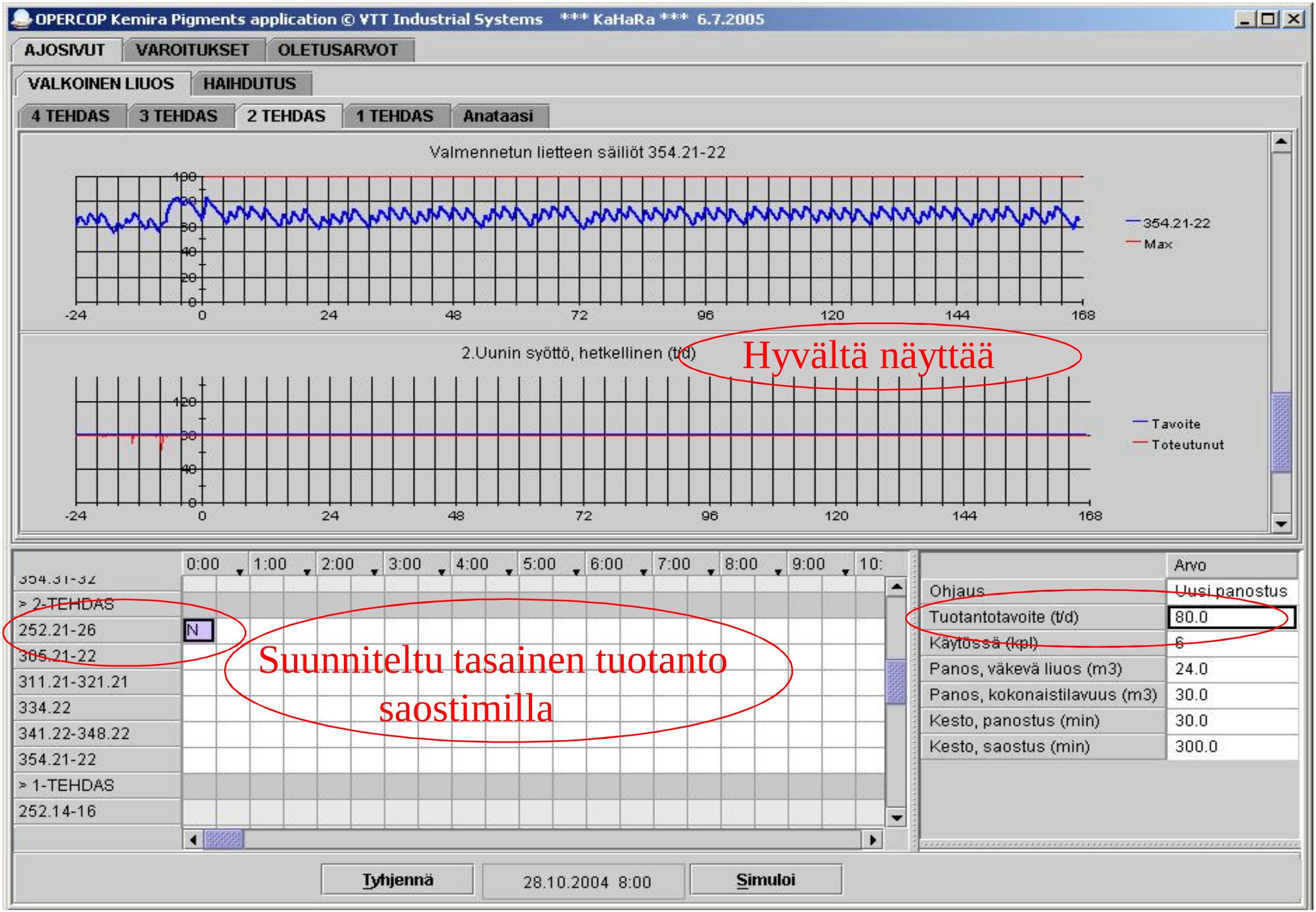
TiO_2 Sulphate Process
METALLISULFAATIT
METALLIC SULPHATES
FERROSULFAATTI
FERROUS SULPHATE
SUODATUS
FILTRATION
KALSINOINTI
SUODATUS JA PESU
FILTRATION AND WASH
VALKAISU
BLEACHING
SUODATUS JA PESU
FILTRATION AND WASH
SAOSTUS
PRECIPITATION
PROSESSILIUOKSEN HAIHDUTUS
CONCENTRATION OF PROCESS LIQUOR
PAINESUODATUS
FILTRATION
JAUHATUS
DRY MILLING
LIETTO
RESLURRY
MÄRKÄJAUHATUS
WET MILLING
PIGMENTIN PINTAKÄSITTELY
SURFACE TREATMENT
SUODATUS JA PESU
FILTRATION AND WASH
SUODATUS
TREATMENT
KUIVAUS
DRYING
JAUHATUS
JETMILLING
PINTAKÄSITTELEMÄTTÖMÄN PIGMENTIN PAKKAUS
PACKING OF PIGMENT THAT HAS NOT BEEN SURFACE TREATED
PINTAKÄSITELLYN PIGMENTIN PAKKAUS
PACKING OF SURFACE TREATED PIGMENT
MYYNTIIN
TO THE MARKET


OPERCOP Kemira Pigments application © VTT Industrial Systems *** KaHaRa *** 6.7.2005
AJOSIVUT
VAROITUKSET
OLETUSARVOT
VALKOINEN LIUOS
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4 TEHDAS
3 TEHDAS
2 TEHDAS
1 TEHDAS
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354.21-22
Max
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311.21-321.21
334.22
341.22-348.22
354.21-22
> 1-TEHDAS
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Arvo
Ohjaus
Uusi panostus
Tuotantotavoite (t/d)
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Käytössä (kpl)
6
Panos, väkevä liuos (m3)
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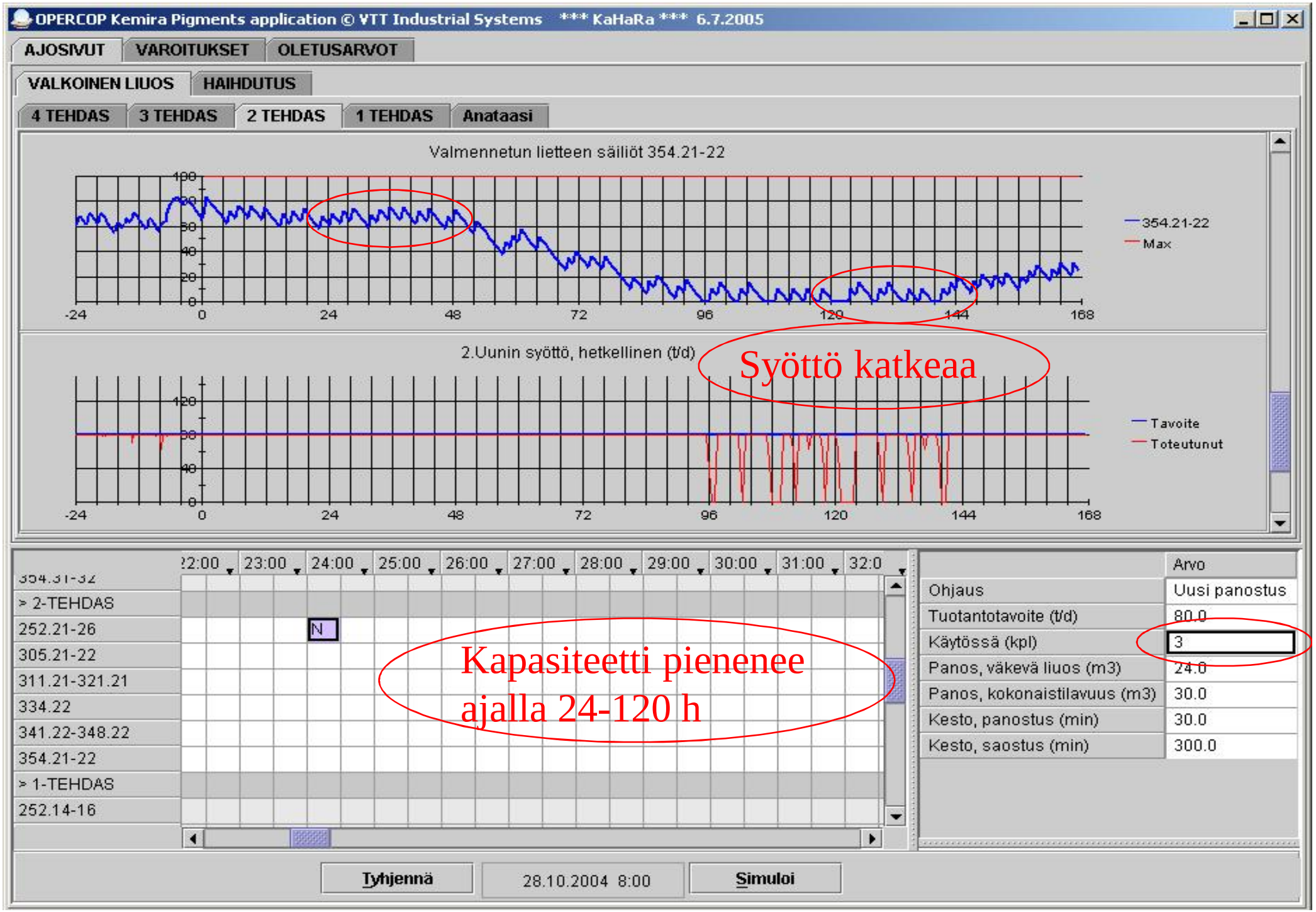
Kesto, saostus (min)
300.0
Tyhjennä
28.10.2004 8:00
Simuloi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VALKOINEN LIUOS
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Ohjaus
Uusi panostus
Tuotantotavoite (t/d)
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Käytössä (kpl)
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Panos, väkevä liuos (m3)
24.0
Panos, kokonaistilavuus (m3)
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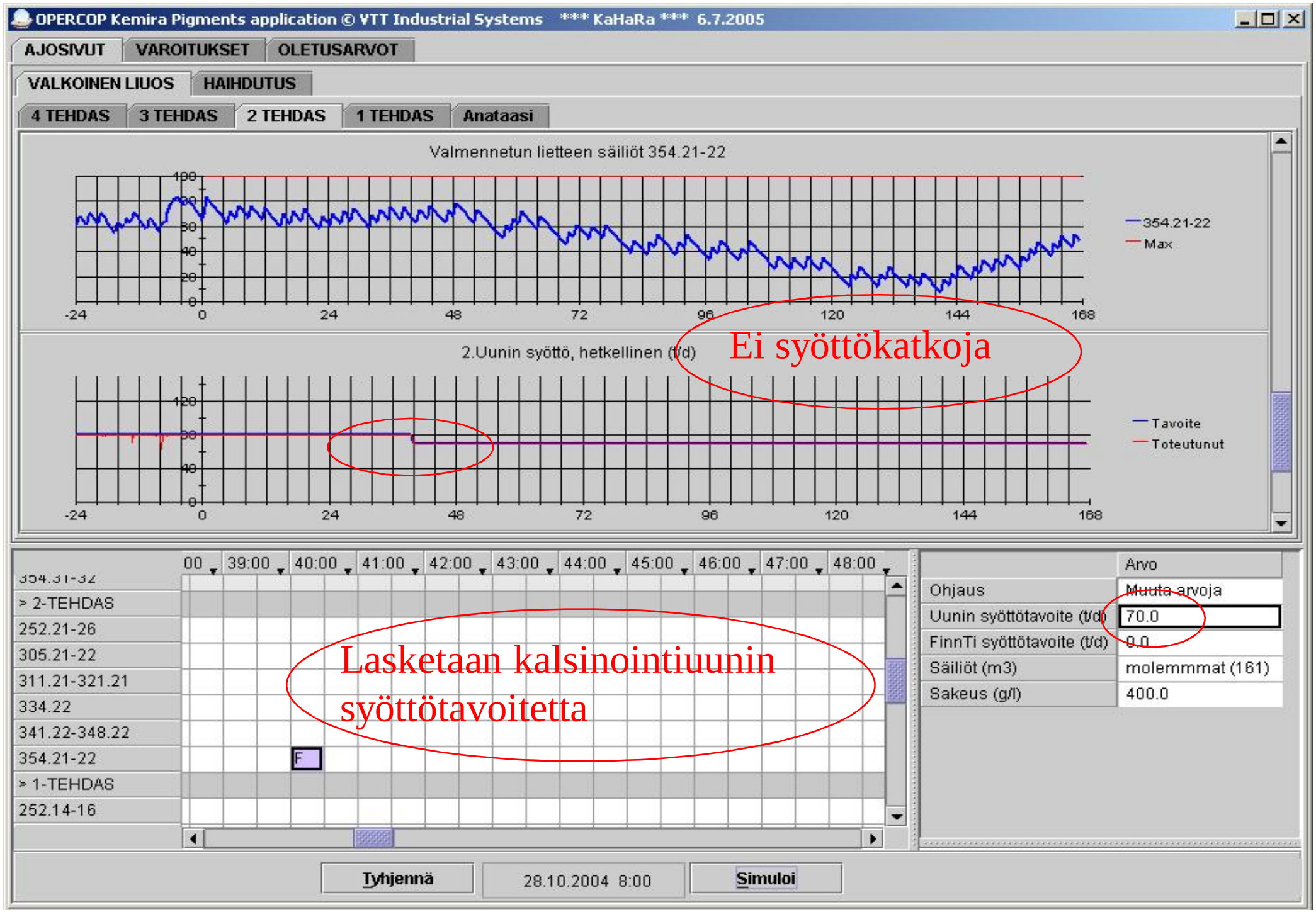
Kesto, panostus (min)
30.0
Kesto, saostus (min)
300.0
Tyhjennä
28.10.2004 8:00
Simuloi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1 TEHDAS
Anataasi
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354.21-22
Max
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Ei syöttökatkoja
Tavoite
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305.21-22
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334.22
341.22-348.22
354.21-22
> 1-TEHDAS
252.14-16
Arvo
Ohjaus
Muuta arvoja
Uunin syöttötavoite (t/d)
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FinnTi syöttötavoite (t/d)
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Säiliöt (m3)
molemmmat (161)
Sakeus (g/l)
400.0
Tyhjennä
28.10.2004 8:00
Simuloi

Käyttökokemuksia

”Pystymme hyödyntämään tehtaan kapasiteetin kaikissa tilanteissa optimaalisesti ja toteuttamaan lasketut tuotantotavoitteet luotettavasti.”

-tuotantopäällikkö Ilpo Harju

- Tasaisempi tuotanto – tasaisempi laatu
- Työvuorojen yli ulottuva objektiivinen ennuste
- ”Riittävän tarkka ja yksinkertainen”

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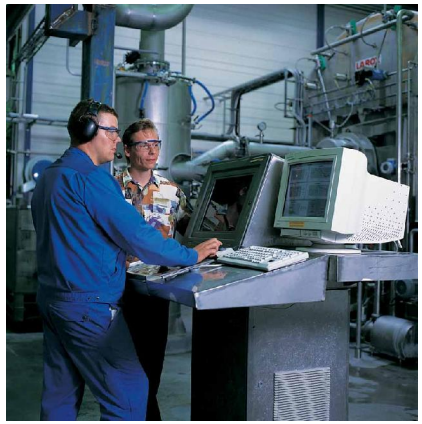

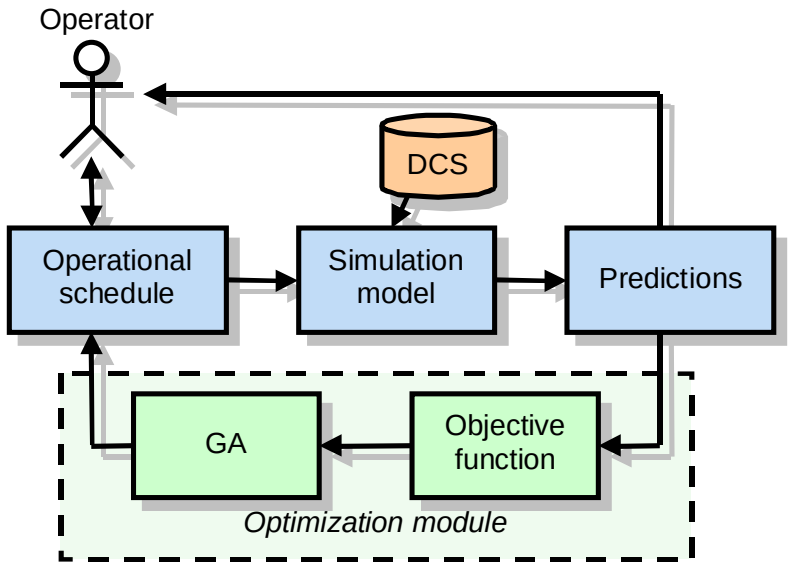

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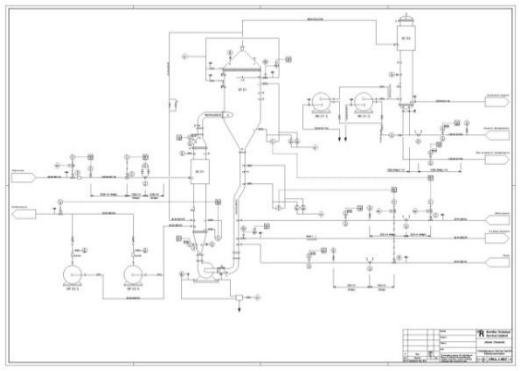
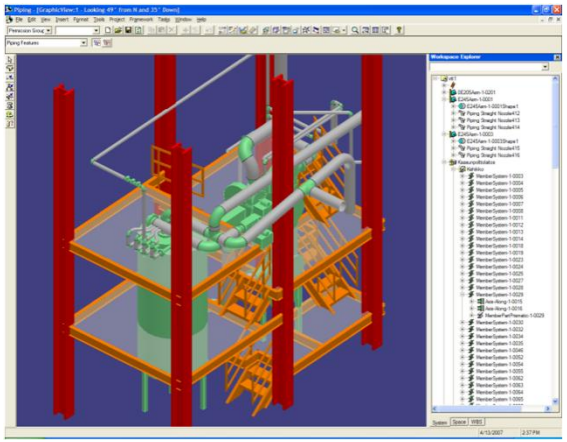
Process simulation

Simulation and process design integration

Design Engineers





Process design

Automation design

3D design

Plant design systems: SmartPlant Foundation, Comos, …

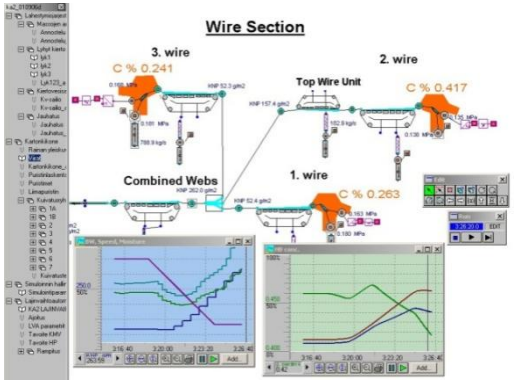
Engineering Information Management

Simulation Engineers

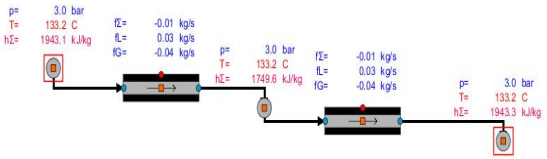
Common user interface environment

Apros Process Simulation

Other simulators: Balas, DEVS, sd, Fluent, Modelica, company specific



Simantics

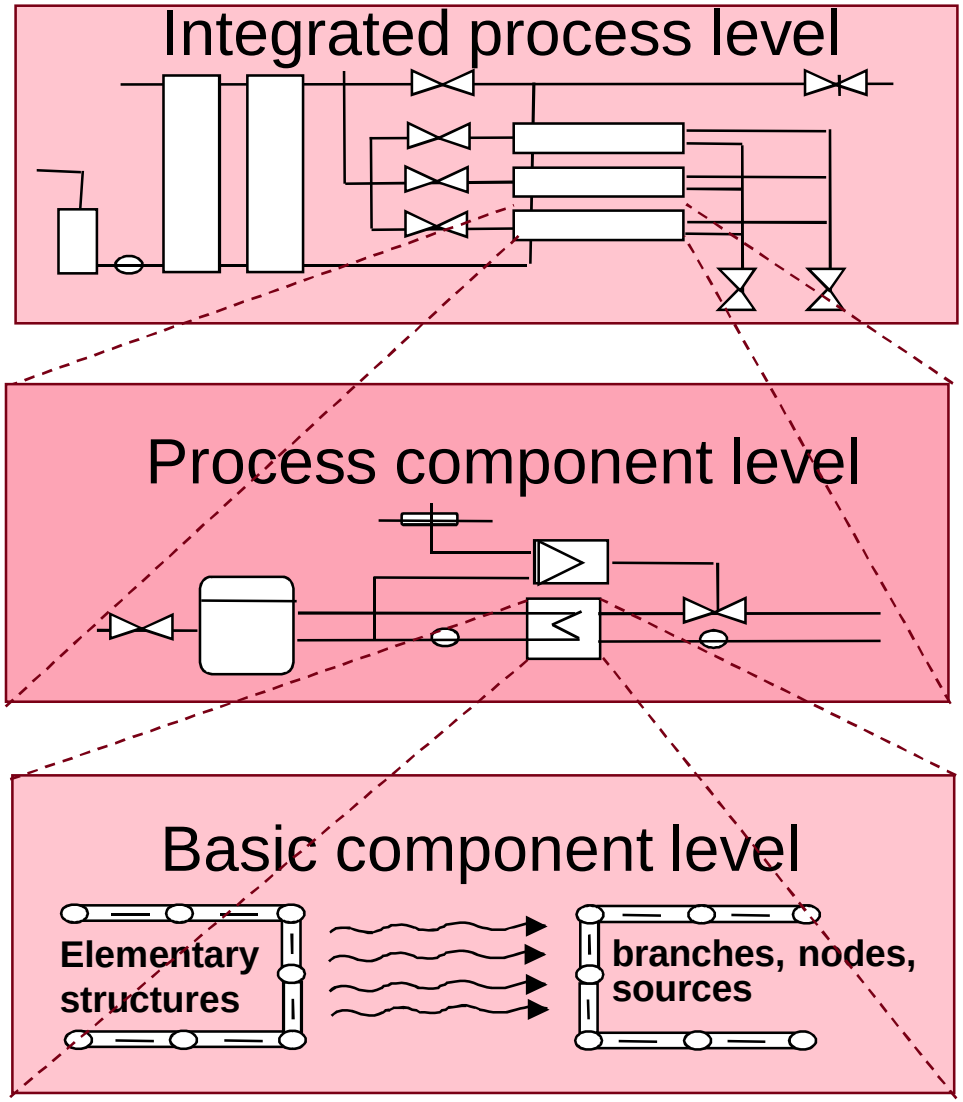


Simulation Information Management

Apros - Hierarchical Modelling

Application modelling without the need to write equations: draw the PI diagrams and input the parameter values

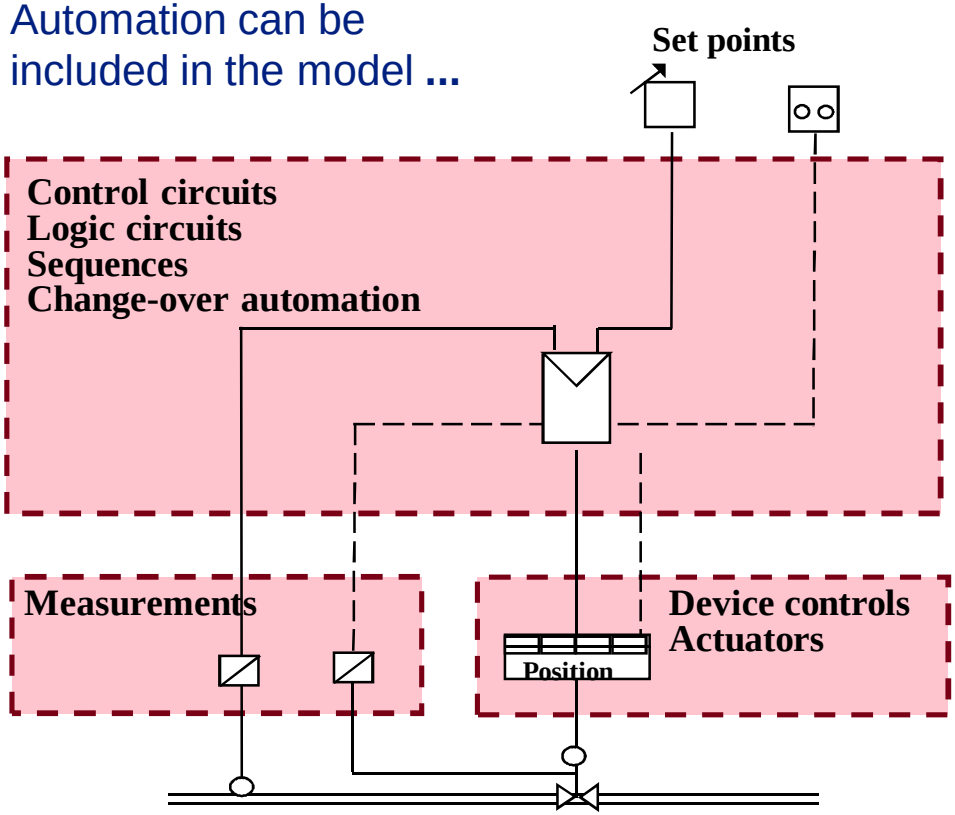
New instances of process components can be composed with the new Modeller Interface



Dynamic process simulation with Apros

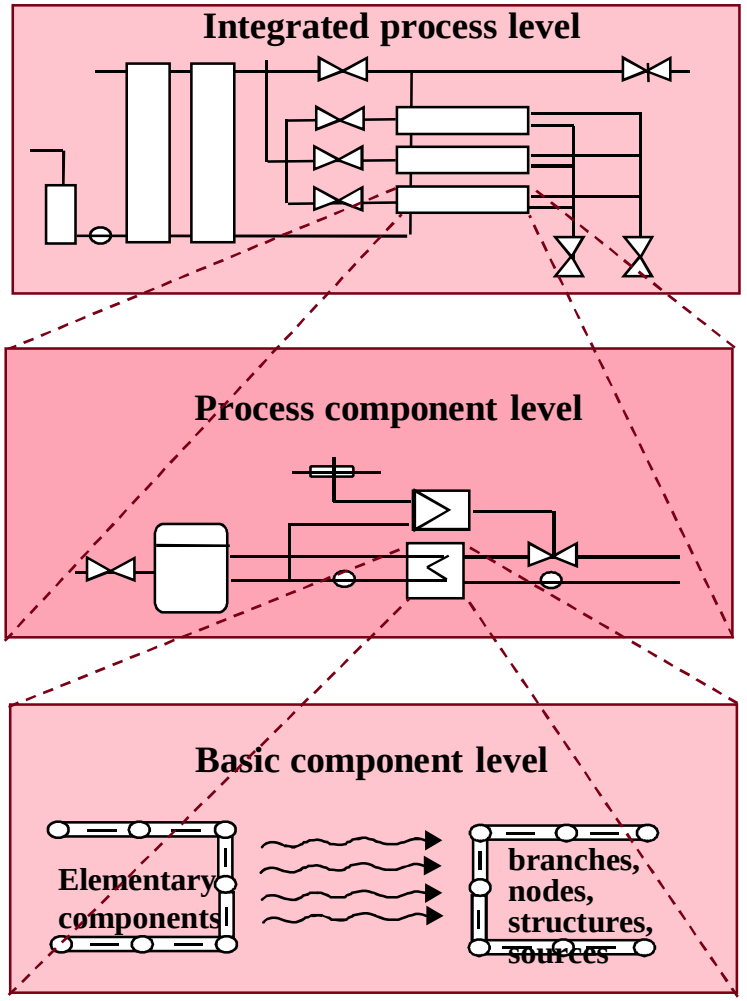
Control system model

Automation can be included in the model ...



… or real/virtual automation application can be connected to the process model.

Process model



Conservation equations for mass, momentum and energy

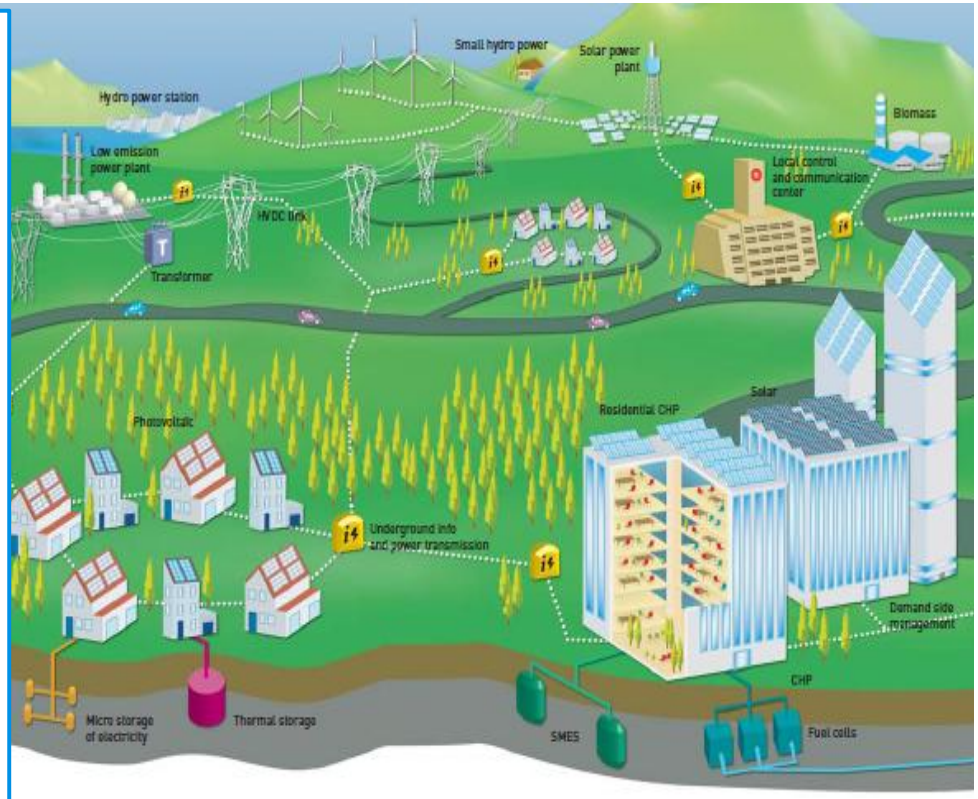
District Energy Planning

Integration of new energy production or regeneration concepts, network concepts, energy storage concepts, behaviour patterns, peak handling, control concepts, testing of local market concepts…

VTT District Energy Planning

Detailed smart city & district energy planning, integrating

- Building types, new & retrofit
- Behaviour patterns
- Generation units:
  - Heat, Power, Combined (CHP), Heat Pumps
  - Building or Process Integrated - e.g. Solarthermal, Photovoltaics
- Energy Storages:
  - Various Thermal,
  - Gas, Electric
  - Electric car integration
- Grids:
  - Electrical, Gas, Steam, Heating and Water networks



Based on APROS and Simantics platform

APROS has users in 26 countries: Power plants, Paper mill engineering, Engineering offices, Safety authorities, Research organisations, Universities, Plant manufacturers: Andritz, Daewoo, Doosan, Foster Wheeler, Metso, Alstom, ..

Process simulation

Vision for information management

Generation 5: 'Simulation as Part of Semantic Product Model'

Knowledge management

Generation 4: 'Semantic Product Model'

Information management

Generation 3: 'DocHotel'

Document management

Generation 2: Filing cabinet

Path of evolution

Infromation legacy

Generation 1: Camp fire stories

Information value

f(completeness, correctness, accessibility)

1000's 100's 10's 1 years ago

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VTT - 70 years of
technology for business and society