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Finnish Industrial Ecology Forum

Analysing Material Efficiency and Recycling Scenarios with Factory Simulation Tool

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Presentation Overview

- **Introduction**
- **Experiments**
- **Results**
- **Discussion**

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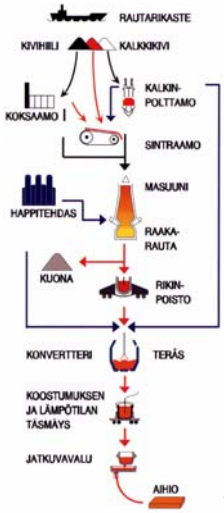
Factory History

- **Task to "create a systematic method to compare different process route alternatives for iron and steel making**
  - **Taking into account metallurgical, technical, environmental and economical issues.**
  - **And to develop a tool to utilize the method."**
- **Iron & Steel MMX**

http://www.tekes.fi/julkaisut/Osaamisella_tehokkuutta10_05.pdf Pp. 20-22, (in finnish).



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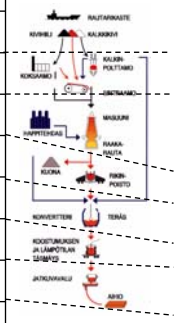
Processing Chain Steps

- **Data from alternatives in every step:**
  - **Quality and equality of data for comparison and simulations?**

⇒ **Getting and handling the data is only a beginning…**

	Step	No.
1	raw material, energy	
2	pre-treatment	4
3	raw iron	25
4	hot metal treatment	3
5	raw steel	14
6	refining	5
7	casting	7
8	rolling	7
9	finishing	7
10	products	
Combinations > 7 200 000		



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Presentation Overview

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Simulation Dreams

- **Easy to learn & use.**
  - **familiar look and feel.**
- **Simulations fast & easy to create, analyse and modify.**
- **Connectivity to other office/desktop software and possibility to combine with other simulation tools (hybrid system).**
- **Same tool easily adaptable by the USER for many different problem areas (user-written modelling).**

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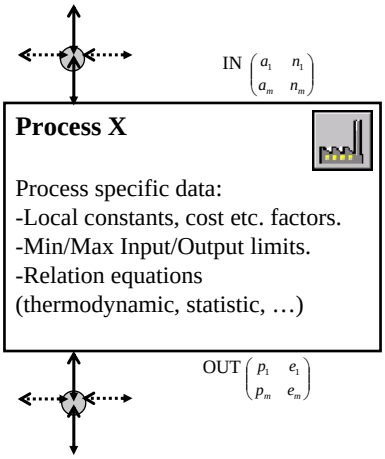
Unified Process Schema

- **Factory's open and unified process description schema helps to make simulations of different prosesses of different fields of industry comparable.**



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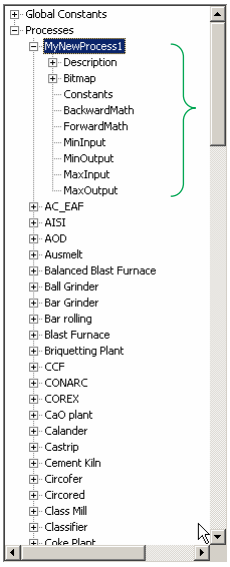
Library of processes



- **Implementation of process data handling in XML resulted further categorization and database-able process descriptions.**
- ⇒ **Manageable and extensible process library.**
- ⇒ **Editable, clear text view.**
- ⇒ **Easy to share/distribute.**

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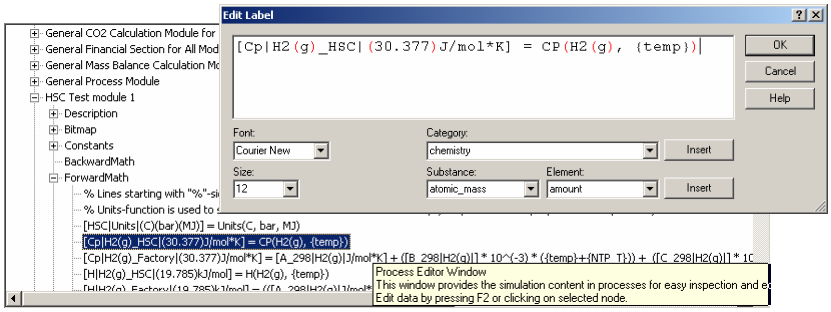
Process Editor



- **Process descriptions in user editable text.**
- **Cut-copy-paste, move, import-export => productivity & convenience.**
- **Changes take effect on the fly.**
- **Syntax is validated and feedback to correct errors is provided.**

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Desciption building blocks

- **Arithmetic operations: +, -, *, /, ^**
- **Functions, e.g. sum, product, avg, exp, log,...**
- **Nearly all HSC® Chemistry routines**
- **User defined constants e.g. {NTP_T} = 273,15**
- **Substances and their properties e.g.**

  [Herndon|S|%]

  for sulphur content of coal Herndon
- **Recursive combination, wild card *, matrix operations, e.g.**

  [in|S|kg/t] = sum ([rm_*|amount|kg/t] * [rm_*|S|%]) / {hehto}

  for calculation all incoming sulphur from raw material category starting with letters "rm_"

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Equation example

- **Heat capasity of hydrogen at T °**

  $Cp\ x = Ax + Bx*10^{-3}*T + Cx*10^{5}*T^{-2} + Dx*10^{-6}*T^{2}$

  by using Factory's own database only:

```
[Cp|H2(g)_Factory|J/mol*K] =
  [A_298|H2(g)|] + ([B_298|H2(g)|] * 10^(-3) *
  ({temp}+{NTP_T})) +  ([C_298|H2(g)|] * 10^(5)
  * ({temp}+{NTP_T})^(-2)) + ([D_298|H2(g)|] *
  10^(-6) * ({temp}+{NTP_T})^(2))
```

  by using integrated HSC routines:

```
[Cp|H2(g)_HSC|J/mol*K] = CP(H2(g), {temp})
```

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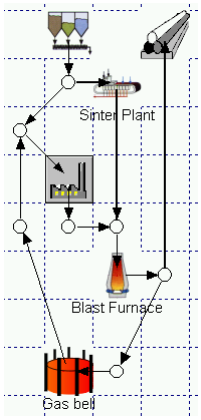
Simulation building blocks

- **Starting & Finishing points**
  - **For raw material feeding & product mix**
- **Process modules**
  - **Initially undetermined**
  - **Determined for simulations**
- **Pipes to connect modules**
  - **For transferring data, splitting and combining stream**



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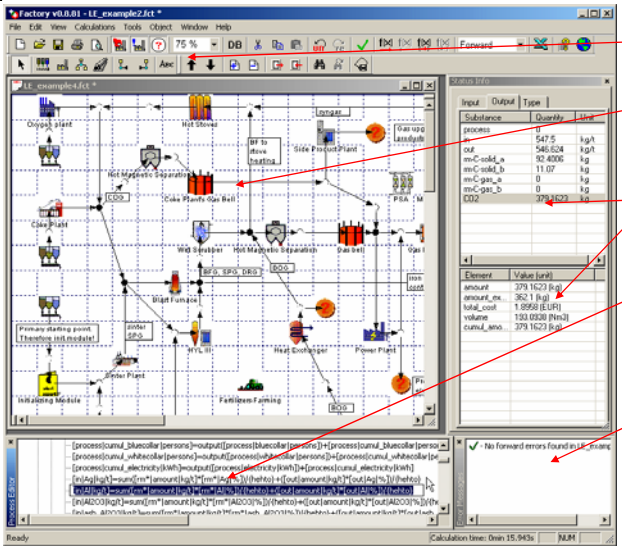
Factory overview



- **Toolbars & menus**
- **Worksheet to create simulations**
- **Process info & immediate results view**
- **Calculation content visible and editable**
- **Validator instructs user if necessary**

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Factory Simulation Tool

- **Steady state simulator for balance analyses of complex entities like plant level simulations of process industry.**
- **Helps save time, awakes awareness and increases know-how in:**
  - **Performance assessment.**
  - **Feasibility and what-if scenario studies.**
  - **Industrial ecology studies.**

FOR MORE INFO...

http://factory.oulu.fi

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Factory features

- **All simulation content in clear text for user to fully edit with built-in editors:**
  - ⇒ **no ”black boxes”, everything open for easy checking.**
  - ⇒ **easily modifiable to new application areas.**
  - ⇒ **flexible multi-purpose product.**
  - ⇒ **easy to learn and fast to use.**
- **Exports results to office programs:**
  - ⇒ **strengthens communications.**
- **Simulation content and result exchangeable:**
  - ⇒ **speeds up the problem solving process.**
- **Utilizes extensive thermodynamic database (>17000 species) and routines of HSC Chemisty.**

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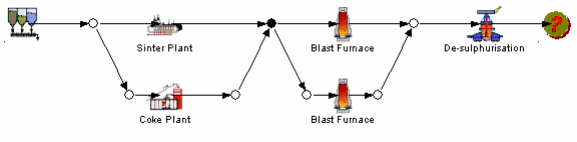
Building Factory Simulations



- **Basic ironmaking process chain**
  - **Raw materials as delivered on site.**

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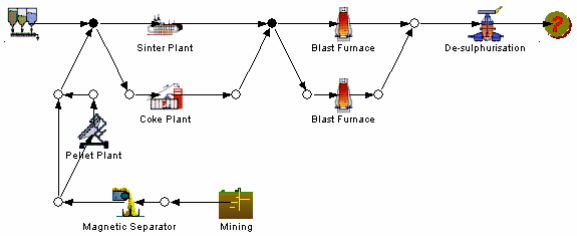
Building Factory Simul...s



- **Chain continued to mines.**

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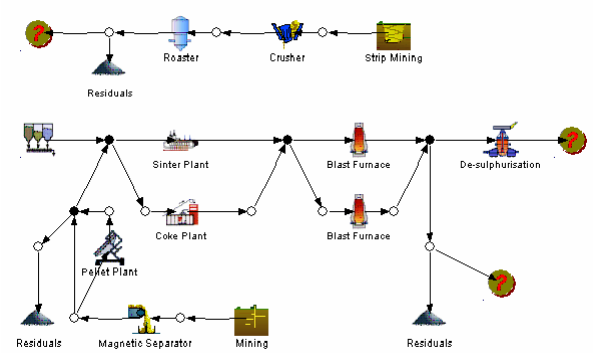
Building Factory Simul...s



- **Chain continued to residuals and other industries.**

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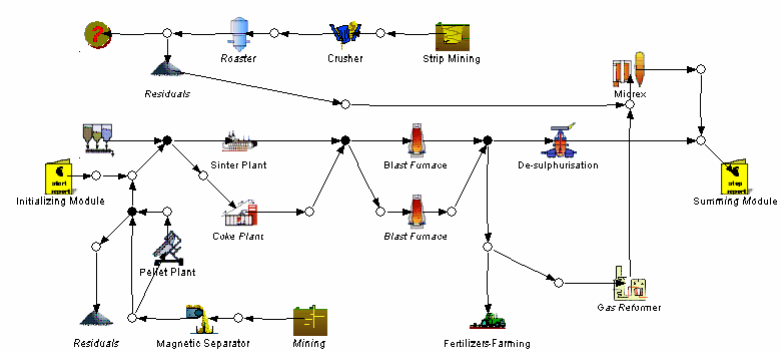
Building Factory Simul...s



- **Chains combined and economics added.**

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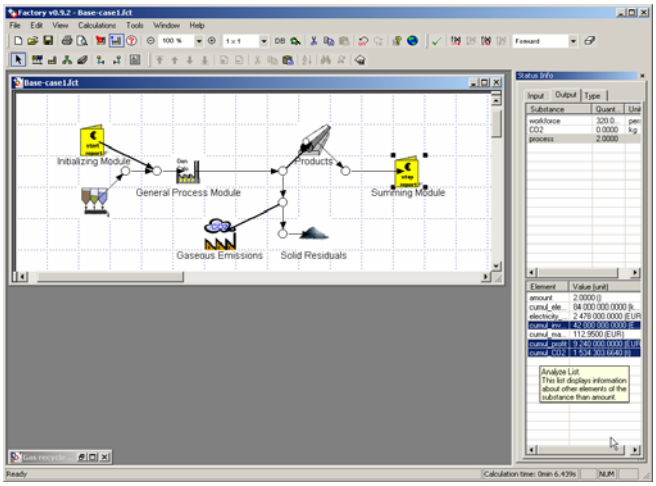
Simulation Example



- **Base case created and calculated.**
- **Some results selected.**

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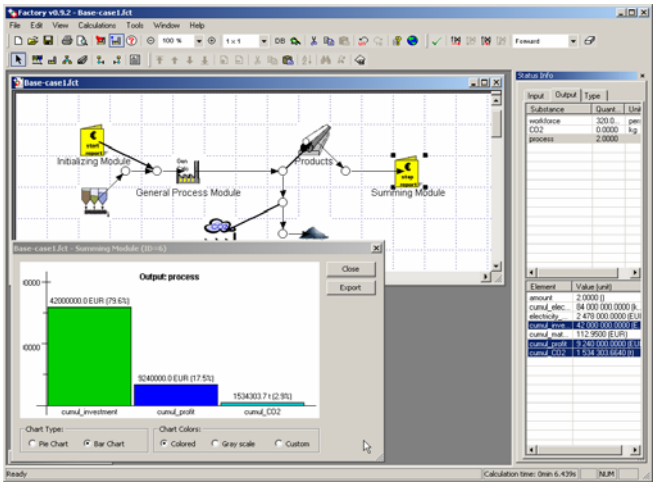
Simulation Example...



- **Chart of selected results.**

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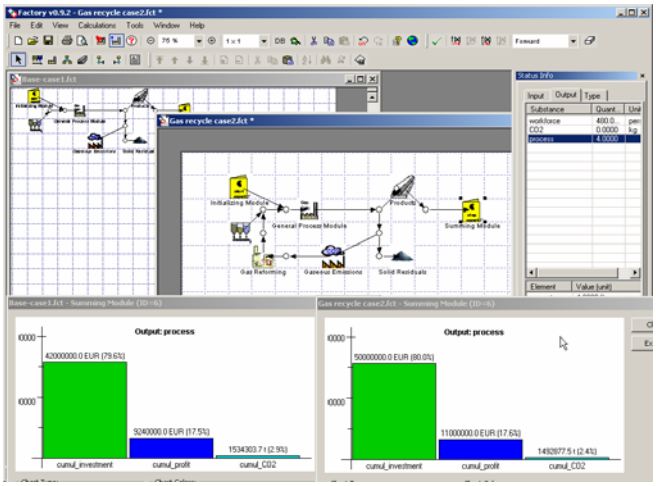
Simulation Example...



- Another altered case created on workspace and calculated
- Same results charted for quick analysis.

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Factory Use Cases

- **University of Oulu:**
  - **Process gas recycling studies.**
- **Helsinki University of Technology:**
  - **Process integration studies in steel plant.**
- **Ciru (http://ciru.oulu.fi/):**
  - **by-product quantification studies for recycling scenarios.**

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Factory Usefull in

- **Steel industry**
- **Other metals industry**
- **Mining industry**
- **Chemical industry**
- **Food processing industry**
- **Building material manufacturers**
- **Environmental officials**
- **Research organizations, academics**
- **Engineering & consulting**
- **Pulp & paper industry**
- **Electronics industry**
- **Oil & petrochemical, biotech**

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Factory As a Tool

- **Process models can be made to monitor also environmental effects as well as technical and economical performance.**
  - **Need for another derived index, just add an equation...**
  - **write existing Excel calculations to Factory for simulations.**

MORE INFO & DOWNLOAD

http://factory.oulu.fi

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The Next Steps

- **Complex simulation case in hand?**
  - **email to factory team at *factory@oulu.fi* and we'll put up a model for you to get you started!**
- **New users are welcome to commit calculation ideas and experiences.**

...because: "Sustainable development is good for business and business is good for sustainable development."

The World Business Council for Sustainable Development.

Factory Simulation Tool

Acknowledgements

- National technology agency of Finland (TEKES)
- University of Oulu
- Rautaruukki Group

- Thank you for your interest!
  - Any questions?

Factory Online

http://factory.oulu.fi