POLITECNICO DI MILANO

# Introduction to PSE-Lab

# Politecnico di Milano

Politecnico di Milano (POLIMI) was founded on November, 29th 1863,

…more than 150 years ago…

The logo originates from Raffaello's fresco The School of Athens, whose cartoon is at the Ambrosiana Gallery, Milano

# Campus at POLIMI


# Faculty & Students as of 2010

## Architecture

**19%** of graduates in Italy

| Professors & Researchers | Students |
| --- | --- |
| 329 | 10.187 |

## Design

**84%** of graduates in Italy

| Professors & Researchers | Students |
| --- | --- |
| 101 | 4.630 |

## Engineering

**16% of graduates in Italy**

| Professors & Researchers | Students |
| --- | --- |
| 888 | 23.216 |

# The Nobel prize



Professor Giulio Natta received the Nobel Prize for Chemistry in 1963 for the discovery of polypropylene

## Politecnico di Milano

- Engineering School
  - **Chemistry, Materials and Chemical Engineering Department**
    - **PSE-Lab**

# PSE-Lab

The Process Systems Engineering Laboratory

# Main research activities

- Introduction
- **Design** and **Simulation**
- **Dynamics** and Control of chemical processes
- Process monitoring and soft sensors
- Data reconciliation
- On-line optimization
- Scheduling, Planning, Supply Chain Management

- **Dynamic Accident Simulation**
- **Reconstruction of Accident Dynamics**
- **OTS**
- **Performance assessment**
- **Decision support systems**

# Equipment Design

- **Equipment Design** and **Process Design**
- Both conventional and unconventional process units can be designed for optimal operation. Starting from basic unit operations up to innovative and peculiar equipment the research group can provide solutions in as different fields as **energy, separation, reaction, and utilities**.
- Examples of some delivered design projects: distillation columns, reactors, heat exchangers, furnaces, waste heat boilers, dust removal systems, Venturi scrubbers, absorbers, strippers, moving bed reactors, and fluidized bed driers.
- **Software**: PRO/II, UniSim, HYSYS, Aspen Plus, and other in-house tools

# Dynamic Conceptual Design

- **Conceptual design of chemical processes**.
- Optimal process layout as a compromise between fixed capital investment and working capital. Conventional approach based on **economic potential** and advanced approach based on **superstructures**.
- Dynamic conceptual design as a function of **price and cost fluctuations** within the short, medium and long time horizons.
- Role played by **market uncertainty** on the **revamping** and **retrofitting** of existing plant.
- Applied studies focused on the dynamic allocation of resources for energy production and heat recovery systems.
- Synthesis of **Heat Exchange Networks** (either pinch technology or superstructures)

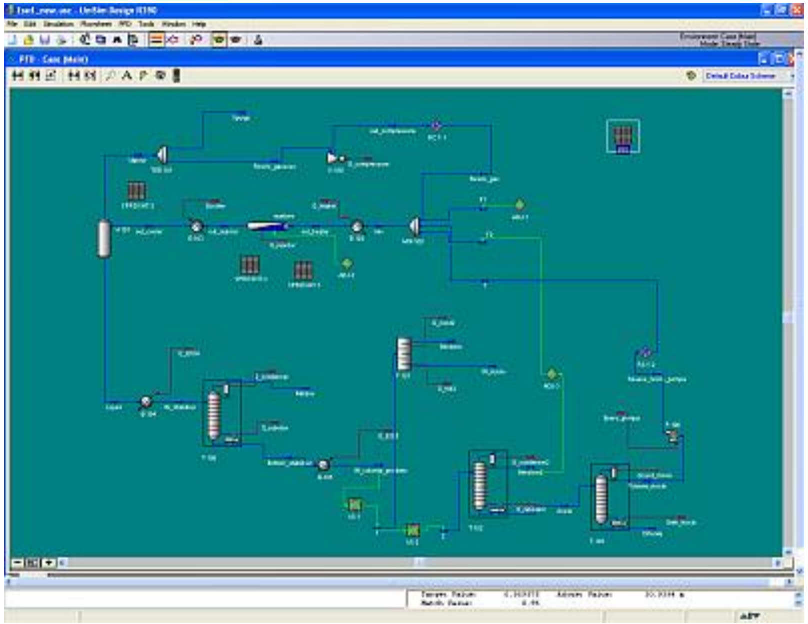
# Simulation of chemical processes

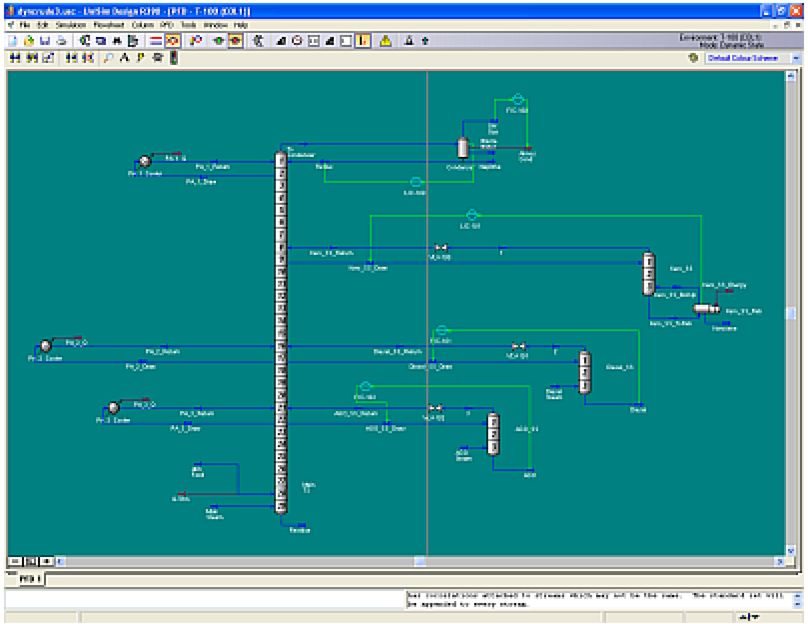


- Steady-state simulation of complex units and industrial processes
- Steady-state **simulation of nominal operating conditions**
- **Quantification of the lower and upper limits** for an efficient use of the equipment respect to the nominal operating conditions
- The Process Systems Engineering group has a long tradition in the deployment of simulation programs for chemical processes. A few examples deal with the simulation of distillation columns, reacting systems, chemical and petrochemical processes, and water treatment units.

# Dynamic Simulation

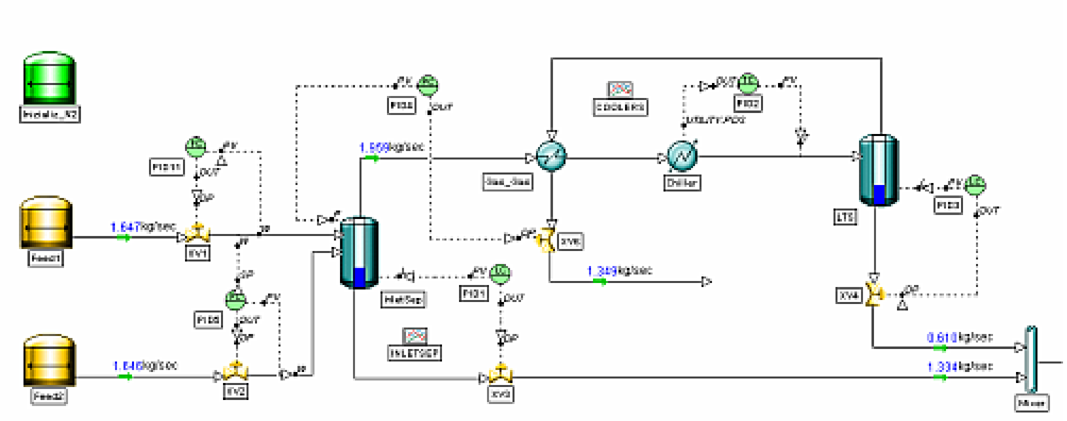
- Plant design has become increasingly complex, integrated and interactive.
- Heat integration, process recycles and minimum hold-ups are typical design features.
- These design issues optimize steady state operation. However, they present particular challenges to plant control and operation engineers.



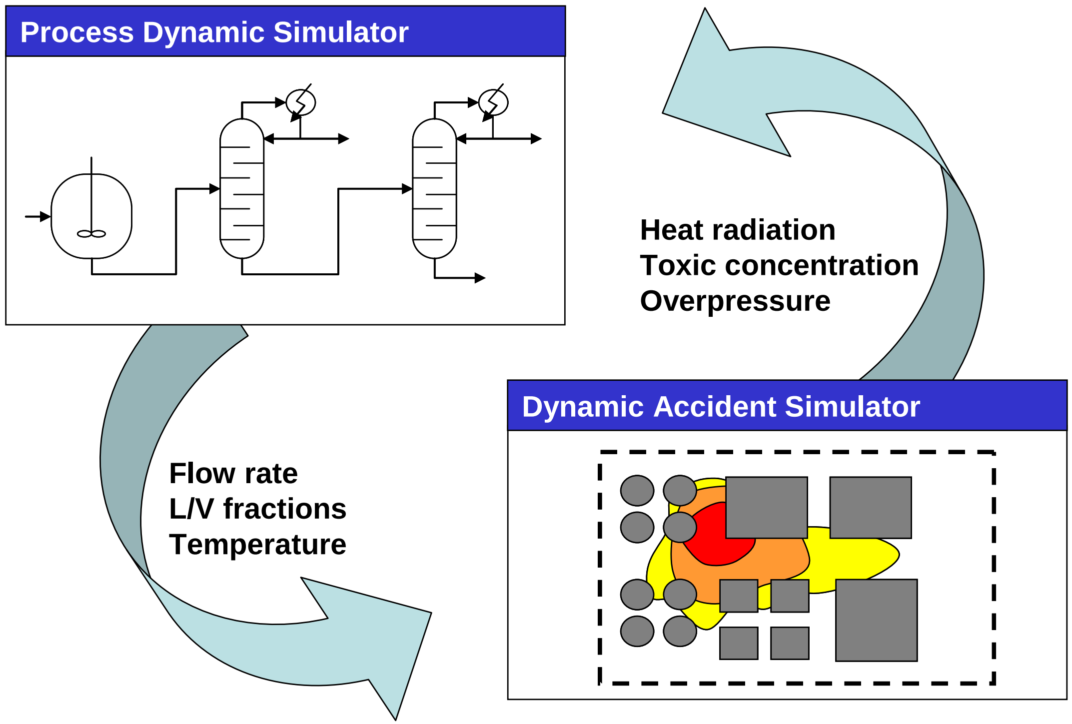


# Dynamic Simulation

- **Dynamic Simulation** for:
  - **Advanced Process Control** applications
  - a priori **inspection of control loop alternatives**
  - effectiveness of **start-up and shutdown procedures**
- The PSE group has a long tradition on dynamic simulation. A few examples are: reactor and heat exchanger networks, distillation columns, chemical and petrochemical processes.
- **Software**: Dynsim, Aspen HYSYS, **UNISIM**, and in-house tools

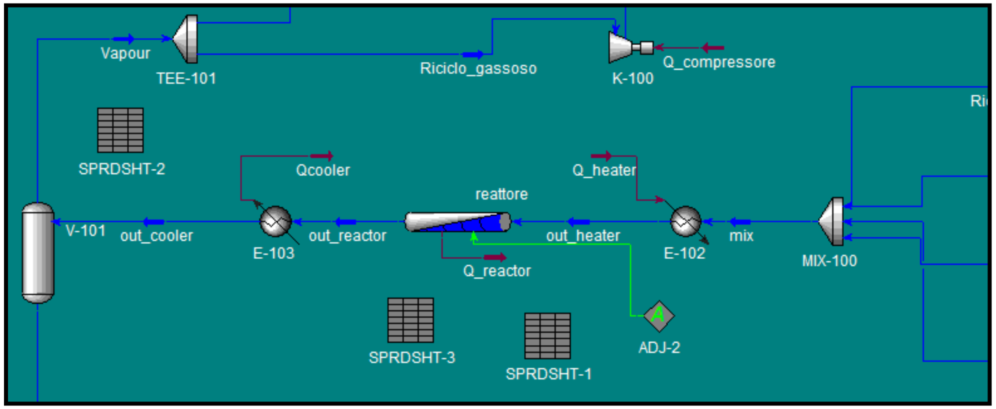


# Dynamic process and accident simulation




**AXIM™** is a dynamic accident simulator that can be either linked to a process dynamic simulator by means of **OPC** protocol, **DLL**, **OBJ** or work as a standalone package

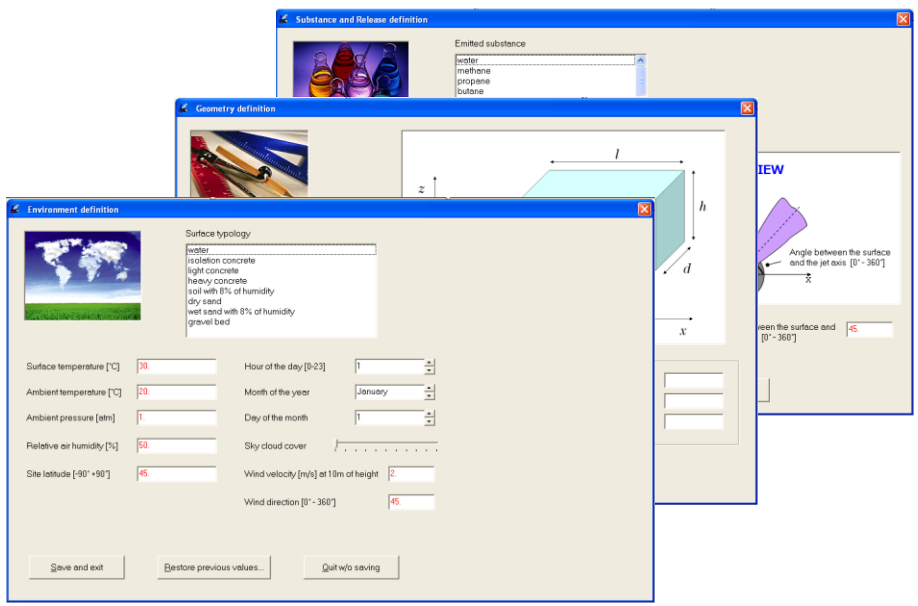
# Dynamic process and accident simulation




Heat radiation
Toxic concentration
Overpressure

Flow rate
L/V fractions
Temperature

**AXIM™**



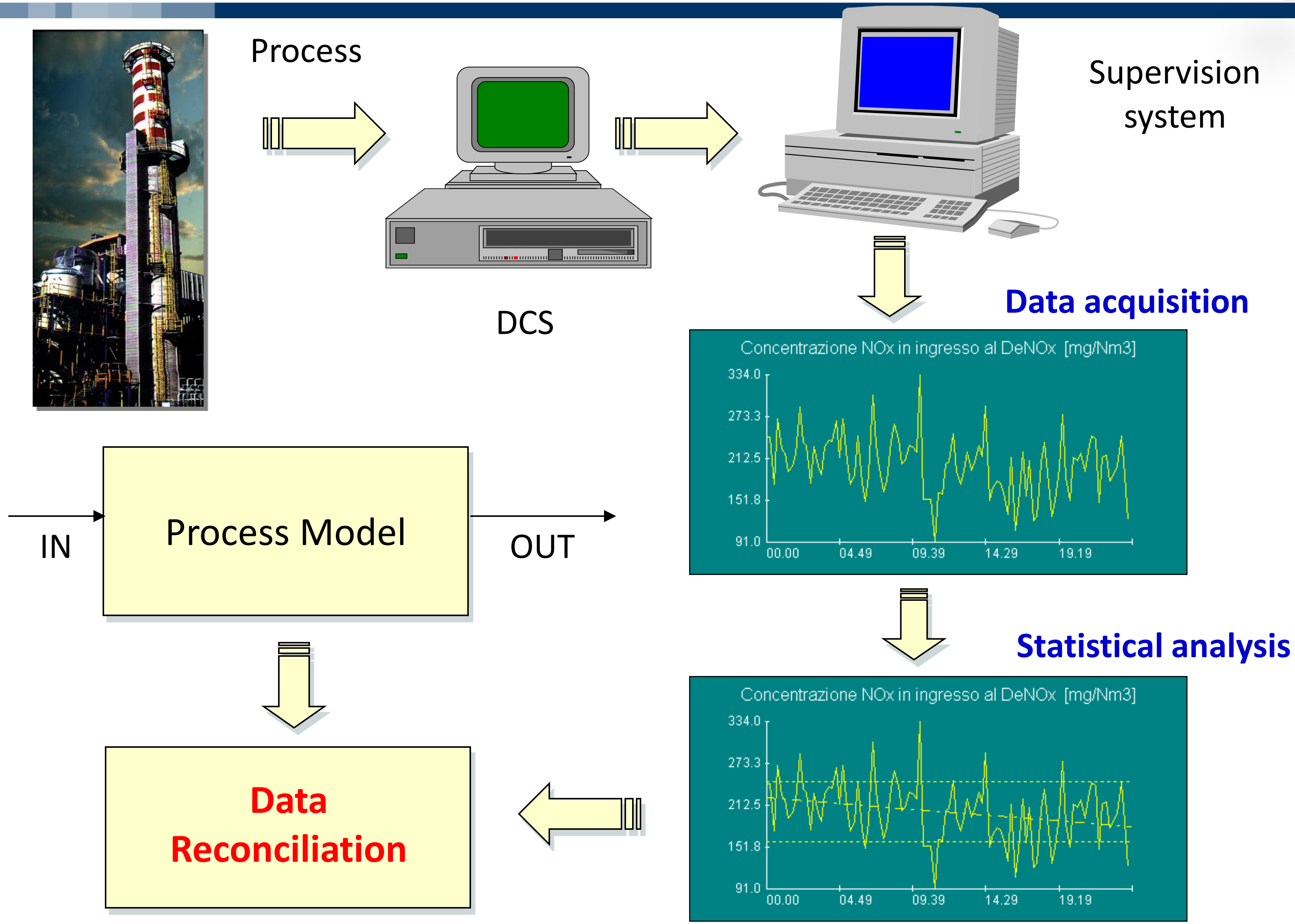
# Process monitoring

- Process monitoring
- **Data acquisition**
- Process identification: ARX, ARMAX, NARX, ANN
- **Soft sensors** for:
  - **Inferentiation of unmeasurable quantities**
  - **Instrumentation redundancy**
  - **Replacement of off-line measures**
  - **Replacement of measuring devices with high time delays**

    (*e.g.* gas-chromatographs)

# Data reconciliation





# On-line process optimization



Identification of the **optimal set points** subject to the dynamically changing process conditions

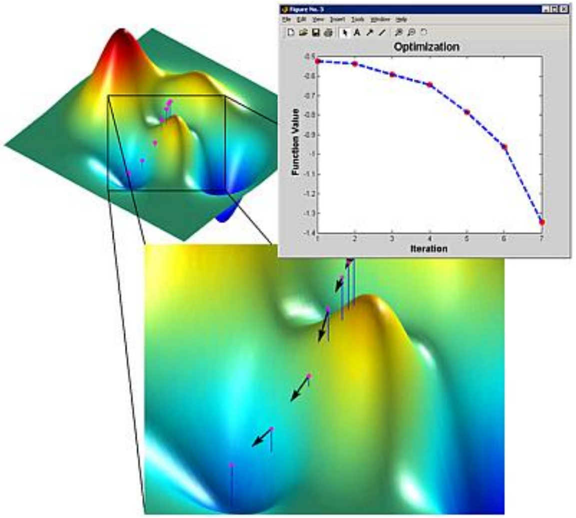
**Advanced Process Control**

Allocation of raw materials

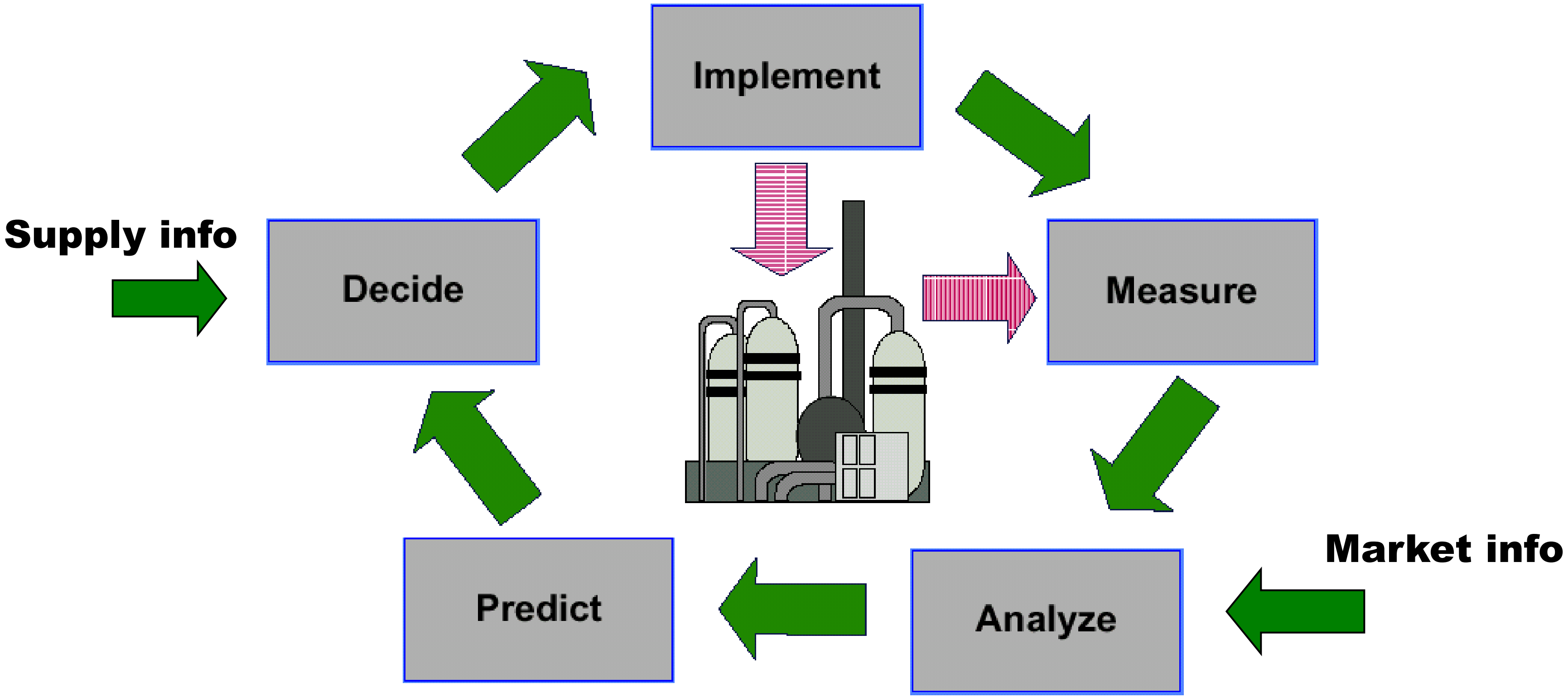
**Minimization of utilities and energy requirements**

Scheduling and Planning of industrial production

Supply chain management of crude-oil. From reservoir to final products distribution

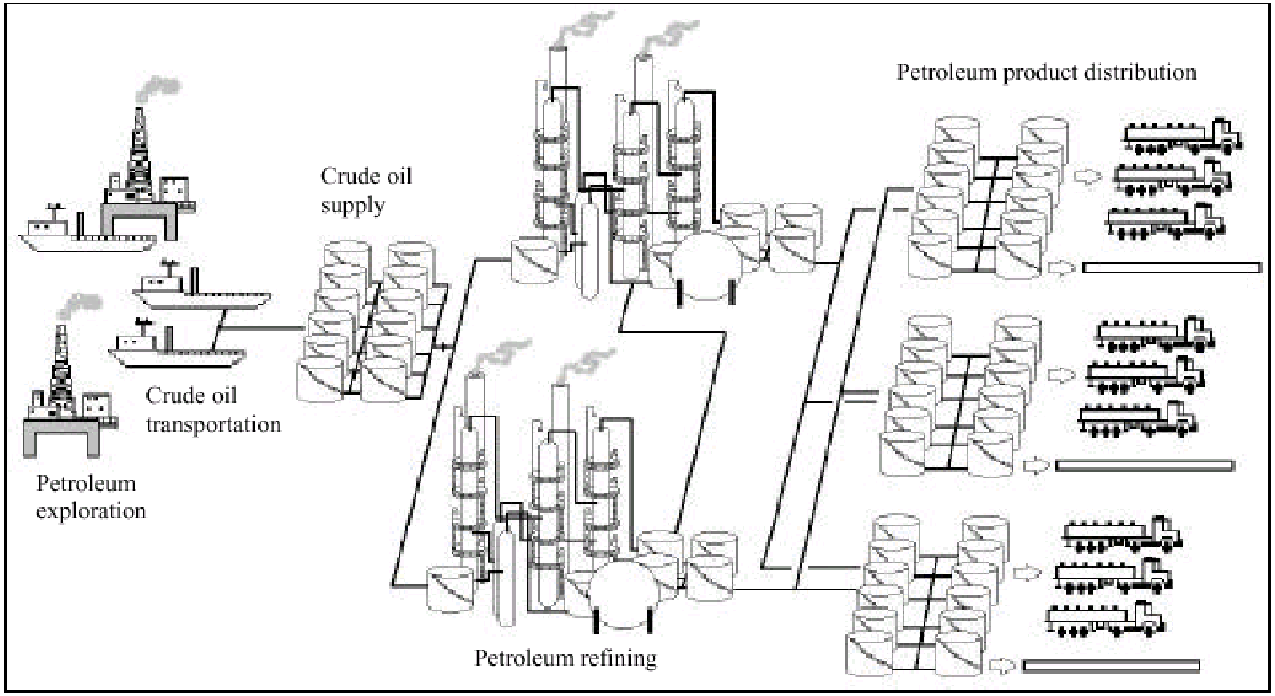


# Process supervision

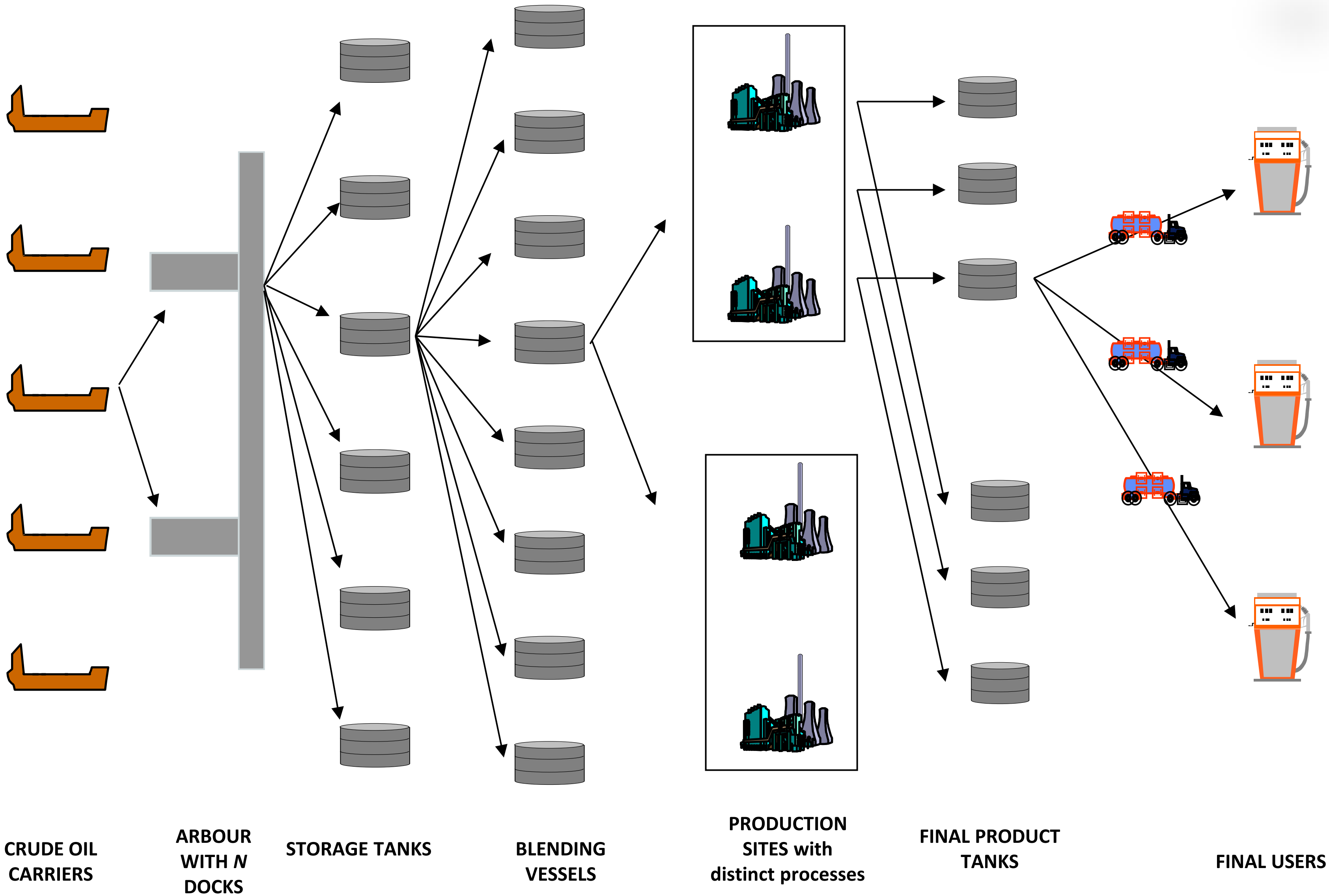



**Control Performance & Business Performance**

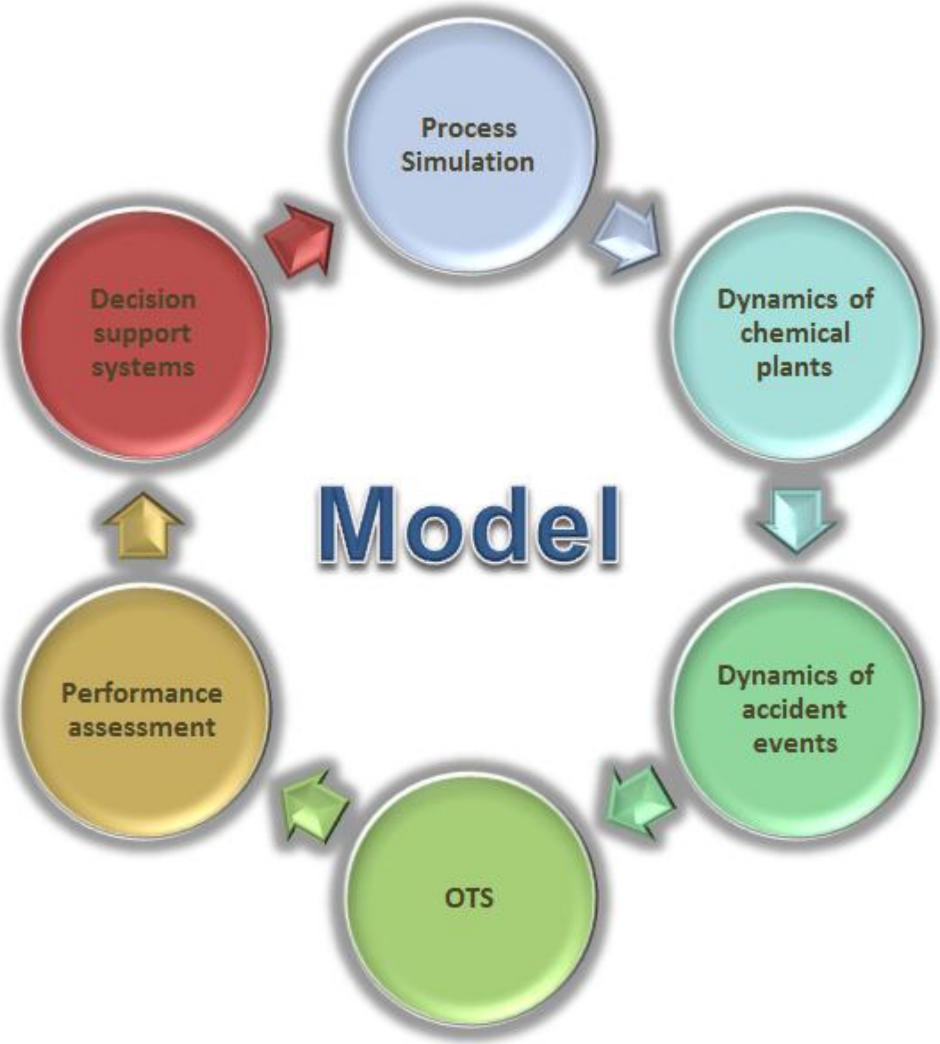
# Supply chain management



# Supply chain management



# Operator Training Simulation



## Conventional Operator Training Simulation

From the design realm to the **on-line** process control domain

The main reason for OTS is **training from scratch the operators**

Training of specialized manpower

Usually **focused on control-room operator** training

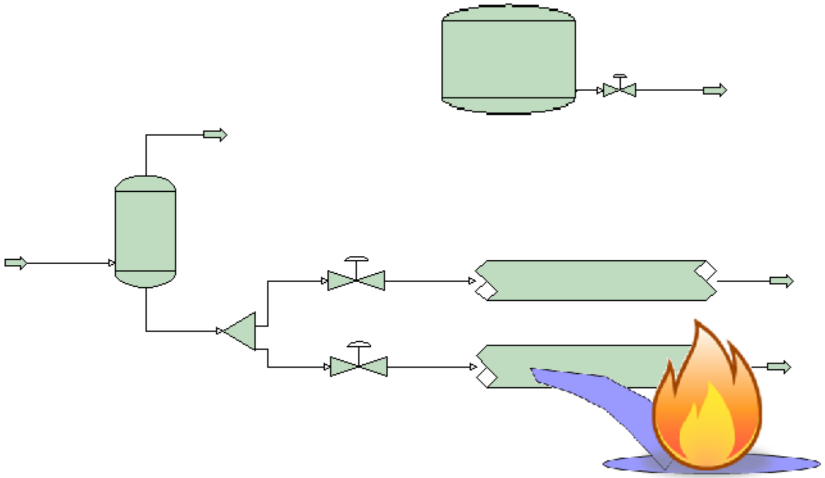
Important for simulating both rare and unconventional events:

- off-spec conditions
- grade changes
- start-up and shutdown procedures
  - planned shutdown
  - emergency shutdown

# Operator Training Simulation

**Need for field operator training**

- conventional OTS are not so good at training field operators
- **Conventional OTSs are not capable of simulating accidental events**
- Need for a dynamic process simulation of industrial accidental events
- **Coupling of Dynamic Process and Accident Simulation**



# Process and Accident OTS



**Benefits** of coupling Process and Accident dynamic simulators:

- improvement of the operator knowledge
- **analysis of very rare accidental events**
- understanding of **process behavior under emergency**
- quantitative evaluation of accidental outcomes
- **slow-motion** and **fast-motion** analysis of accidental events
- recording and playback of operator actions
- **performance evaluation of operator actions**

**Outcomes**

- Quantification and visualization of iso-radiative flux curves
- Quantification and visualization of iso-concentration curves
- Evaluation of the toxic dose absorbed in a point of the plant
- …