Summary

1. EDF R&D presentation
2. Context
3. Actual tools
4. Different studies
5. The needs in advanced method
An R&D Department (130 persons staff) aimed at supporting power plant operation:

- helping the operators better operate, monitor and maintain the facility (including meeting environmental constraints and regulation compliance)
Relying on:

- **academic competencies:**
  - Applied Mathematics: Dynamic Systems, Data & Image Processing
  - Data Processing: Knowledge Management, Safety Assessment of Computer-based and Digital Systems

- **...and technical competencies related to power generation:**
  - Process: operation of fossil-fired and nuclear power plants
  - Equipment Monitoring Techniques
  - Radiation Protection and Management

Aiming at providing the operator with the best possible methods/tools for an optimized operation:

- Measurement chains
- Control Systems
- Information Technologies
- Operation Aids
Advanced control for Utility

Objectives R&D

- Develop optimization tools for multi energy and multi criteria
- Transfer the optimization tools to operationnal units

Goal: optimize the process design; increase the flexibility, maximize the revenue and minimize the maintenance costs;

Partners

- **Design study**: EDF Optimal Solution, EDF Energie Nouvelle
- **Exploitation**: EDF Energy; EDF Fenice; EDF R&D Polska

Departments R&D

- EPI (process); STEP; MFEE (weather forecast) et OSIRIS (Load forecast)
Advanced control for Utility: Multi-energies

Priority for Heat energy – profit with electricity sells

**Advantages**
- Energy efficiency (> de 10 to 30 %)
- Flexibility (peak load)
- Distributed Generation (transportation loss)
- Local economy development

**Drawbacks**
- O&M cost increase (gas contract, management, maintenance cost)
- Depends on the heat or cold demand (network, process)

Different power stations (Cogeneration, Tri generation) : 1 MW to 1 GW
- **Boiler**: gas - oil - biomass
- **CCPP**
- **Engine**: gas – biogas – fuel
A global vision of the plant: *Multiple constraints to be considered*

**Prices of primary energies:**
- Contract limitations
- Market price

**Atmospheric emissions:**
- Regulation (VLE, TGAP)
- CO2 market

**Industrial process « customer »:**
- Loads
- Technical constraints

**Wastes**
- heat
- wastes

**Valorization:**
- Heat
- Wastes

**Production of utilities**
- Electricity
- Oil
- Natural gas
- Coal

**Multi-Energy Plant**
- Primary energies
- Electricity
- Oil
- Natural gas
- Coal

**POLLUTING EMISSIONS**
- NOx
- SO2
- CO
- CO2

**Industries utilities**
- Electricity
- Steam
- Hot water
- Compressed air
- Cold

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USED TOOLS
Different Tools for different use

1. First studies of optimum design (Dymola Physical model);
2. Commissioning of power plant (Dymola Physical model);
3. Help for exploitation: optimal functioning, estimation of losses in operation (Dymola Physical model);
4. Optimal power plant operation (Optimization software PILOT);
5. Predictive maintenance (Smart monitoring Tool);
Physical based modeling of utility

✓ Tool: DYMOLA/Modelica
  ✓ static and dynamic simulation
  ✓ physical equation foreach module

✓ ThermoSysPro Open Source Library
  ✓ All cogeneration can be modeled
  ✓ Optimize the design, assess the technical performance for new projects,…
Process design optimization

Tools: OMOptim (Open Source) et Dymola (option)

Ex : Sizing of a biomass cogeneration

Optimization :
- Minimize investment cost
- Maximize profits (electricity sales)
Utility operation optimization

Minimize the variable operation cost

= Fuel consumption + maintenance cost – electricity sales

Forecast of needs
Model of the plant
Prices of energy

Unforecasted need

Boiler failure

Optimal plannings
For each equipment
For each time-step
On/Off
Levels of generation
-> Optimal cost
Utility monitoring

Tool Smart monitoring

- **Principe**
- Normal behavior model by learning.
- **To**
- Detect anormal signals early before the alarms, the trip or damage of components

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**Total Deviation (Playback Mode)**

Overall Model Residual

- **Percent**
- **Date and Time**

- **1999 2000 2001 2002 2003 2004 2005 2006 2007**

- **Predicted Signal (Operational Profile Model)**

- **CUSCINETTO COMPRESSORE (87)**

- **CUSCINETTO COMPRESSORE (Actual)**

- **CUSCINETTO COMPRESSORE (Upper)**

- **CUSCINETTO COMPRESSORE (Lower)**

- **REGGISPINTA (L.SCARICO) (66.5)**

- **CUSCINETTO COMPRESSORE (87.5) (Upper)**

- **CUSCINETTO COMPRESSORE (87.5) (Lower)**

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SOME EXAMPLE OF STUDIES
Barilla power plant with FENICE

Combined cycle of Barilla

- Engineering (Technical economic)
- Power plant control
- Exploitation help
Barkantine with EDF Energy

Heat and power plant optimisation

- Driving with model
- Exploitation help
- Maintenance help
NEEDS IN ADVANCED TOOLS
Needs of actual tools

Used of detail thermo-hydraulic physical model for real-time optimization

- Model simplification (linearization, interpolation), using physical model, usable by mixed integer linear optimization tools like PILOT
- Use homotopie method included in Modelica library
- Use of new non-linear optimization methods for complex physical model

Integrated the influence of the control for realistic optimization

- Allow to respect the fidelity of the model with installation behavior

Global optimization of the process design (sizing and control)
THANK YOU VERY MUCH