No. 6 / November 2005 / Research & Development

The magazine of the Scientific Chronicles

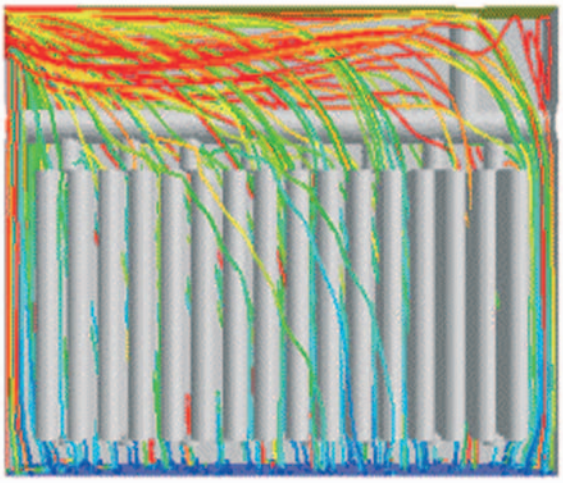
Modeling
an essential Research tool

Modeling is used in a variety of areas. In this magazine, we will limit our presentation to modeling fluid flows in structures. This type of modeling is applied in particular to our Water, Energy Services and Waste Management businesses.

Introduction to modeling

Initially designed by physicists, modeling is a **virtual representation of real phenomena** using **algorithms** and **mathematical models**.

Modeling can be used to repeat an experiment "virtually" as many times as needed, while changing all the operating and geometric data.



Modeling of a membrane reactor.

Research objectives

Veolia Environnement has R&D programs in place to develop tools to model, among others, the processes involved in its various businesses.
The modeling program aims to:

- Analyze existing modeling tools,
- Progress the definition of these tools,
- Broaden the fields of application,
- Speed up innovation cycles by reducing the number, duration and cost of experimental trials by using modeling tools.

Michel Dutang
Director of Research, Development and Technology, Veolia Environnement.
"Modeling is a technological tool that provides a method for improving the effectiveness of the technological solutions used in our businesses. Developing and optimizing the applications of this tool within our divisions is thus of major strategic relevance to Veolia Environnement R&D."

Jérôme Contamine
Executive General Manager, Veolia Environnement.
"Modeling has become an essential Research tool. In particular, it cuts the construction and operation costs for our processes, but above all it enables us to understand the physical processes that govern them. This knowledge, that exceeds empirical understanding, will undoubtedly enable us to invent totally unprecedented solutions in complete rupture with what is currently available."

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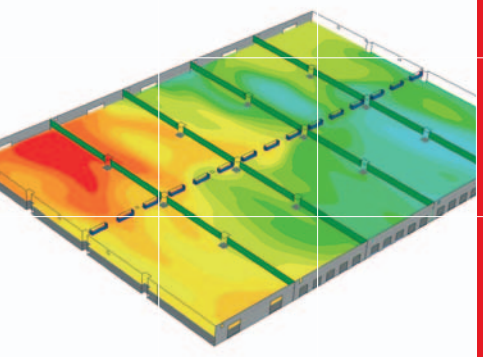
VEOLIA ENVIRONNEMENT



Modeling of the temperature field in a cold store.

Modeling

Need to know about…

Modeling

There is particular emphasis on modeling the mechanics of fluids* in our Group, as a great many of our activities are linked to the flow of fluids (essentially air and water).
The laws of physics governing these flows are extremely complex. While the principles were first described more than a century ago, the ability to apply these principles in a concrete manner is far more recent.
The progress made with computers now enables us to use calculations to simulate the behavior of fluids, whether in simple or complex structures.
The most widely known application is weather forecasting, which has become increasingly accurate thanks to the use of models.
Similarly, for the past ten years, Veolia Environnement's businesses have been using these models in a realistic manner, while continually expanding the scope of their application.

Progress in the design of our water treatment structures and waste sorting is moving ahead at a faster pace thanks to this tool.

*__Fluid__ : a body (liquid or gas) the molecules of which are loosely bonded thus enabling it to adopt the form of its containing vessel.

*__Mechanics of Fluids:__ the part of mechanics that studies fluids considered as continuous deformable environments.
(Source: Petit Larousse Illustré 2004)

What is modeling used for?

More particularly used in the various environmental activities, modeling makes it possible to:
- Predict structure performance before construction or upgrade,
- Reduce the number, duration and cost of experimental trials,
- Reduce process construction and operation costs.

The main advantage of modeling is that it can be used to test a variety of scenarios without limitation of scale (pilot, prototype, industrial-scale structure) or feasibility.

Key information

Modeling makes it possible to, for example:

- **Reduce the construction cost of our facilities,** by saving on the cost of full-scale, onsite testing
- **Cut operating costs,** by optimizing operation conditions

→ By 10% to 50%

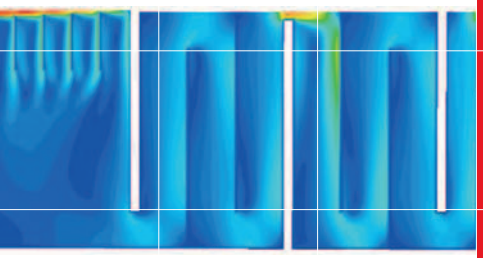
- **Improve treatment quality,** by optimizing the various parameters involved

→ Up to 90%

A little history

Over the years, and in the light of research, scientific methods have continued to progress. While chance and intuition have played a significant part in many discoveries (Archimedean thrust or Newton's universal gravitation, for example), they were then proven through a series of experiments. The appearance of computers completely revolutionized scientific experimentation, as virtual experiments displaced real experiments.

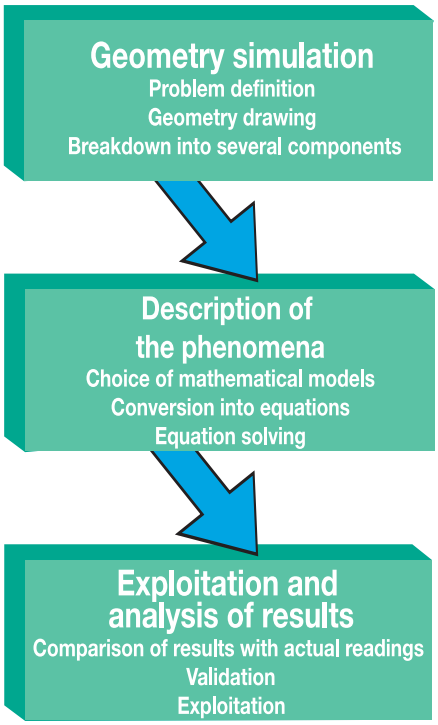
While the first calculator was created in 1642 by Pascal, it was only from the mid-20th century that computers really experienced significant growth. Since then, calculation capacities and speeds have continued to increase: by 2008, a capacity of 1 petaflop is expected (i.e., 10^{15} floating point operations per second).
The use of process modeling has progressed apace with computer technology. This highly effective tool will progress further as a result of research in the areas of application, and the increase in computer processing capacity.



Modeling

Modeling of an ozone tank.

Need to know about …



The three stages in implementing modeling.

How is a process modeled?

There are three stages for the optimum use of a modeling tool, once the objective has been stated.

■ Simulate the process geometry using the modeling software.

■ Describe the physical phenomena involved (heat transfer, oxygen transfer, combustion, etc.) by selecting the appropriate mathematical models (Naviers-Stokes average equation). These equations derived from the mechanics of fluids are then solved by computation (the calculation time required ranges from several minutes to several days).

■ Exploitation and analysis of the computational results for the various parameters that define the process. To validate the model, these results are compared against empirical findings.

Once the digital model of the process has been validated against actual readings, it can be used to predict the performance of a treatment unit, whether a one meter cube pilot or a 60,000 cubic meter unit (that is about 25 times the volume of an Olympic swimming pool).

Computational Fluid Dynamics (CFD)

This modeling process applies to all fluids whether in liquid or gaseous form. Veolia Environnement uses it across all Water, Energy Services and Waste Management businesses.

The applications of this tool include:

■ **In the Water Division**

Drinking water production
- Oxidation tanks (ozonation and chlorination)
- Lamellar settling tanks
- Mixing tanks
- Membrane reactors
- UV reactors

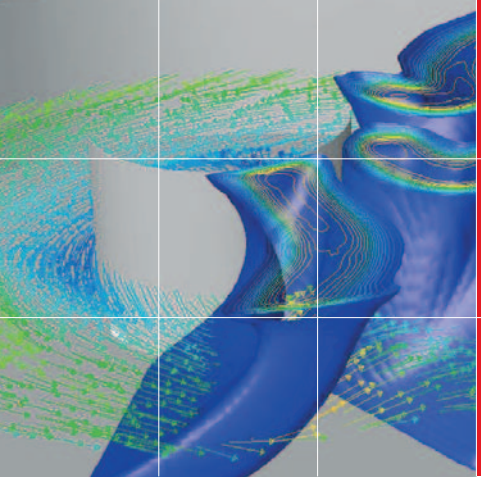
Distribution
- Storage tanks

Wastewater systems
- Stormwater outfalls

Wastewater
- Distribution systems
- Activated sludge tanks
- Secondary clarifiers

■ **In the Waste Management Division**
- Municipal waste incinerators
- Municipal waste sorting centers

■ **In the Energy Services Division**
- Cold stores



Modeling

Close-up on Research & Development program

At the Research Division, Veolia Environnement's modeling experts apply their skill to aid research, builders and operators. This program is at The service of all the others.

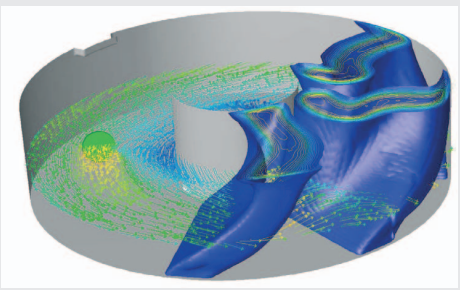
The Veolia Environnement internal network is comprised of modeling experts in the areas of research, construction, and operation. This network is a means to share good practices and to boost knowledge in this area of research.

These experts use the proprietary FLUENT software, which is published by the world leader in software for the mechanics of fluids.

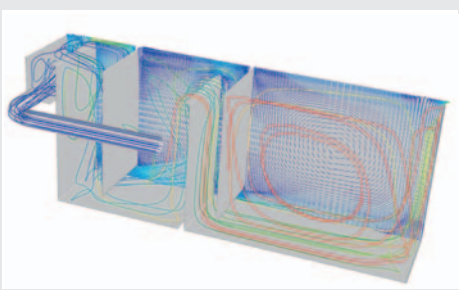
They enrich this tool with their expertise and their knowledge of the technology involved to provide each of their customers with the solution that best equates to their particular needs.

Anjou Recherche has been certified by the European Commission as a Marie-Curie Center of Excellence for the Hydraulic and Biological Modeling of Processes.

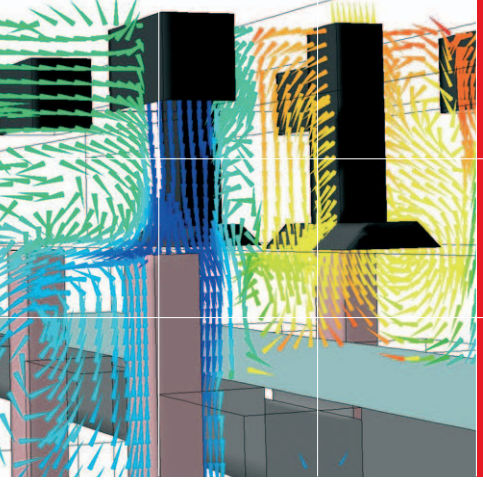
Modeling is one of the tools of **Veolia Environnement** R&D. It is used to implement applied research programs quickly, realistically and economically.



Modeling of the flow of drinking water in an ozonation tank.



Modeling of the flow of water and air in an aeration tank.



Modeling

Close-up on Research & Development programs (continued)

Examples of major results

Enhanced performance

Technological

In the Water Division, experts in the modeling of fluids mechanics (in liaison with the various R&D teams) are seeking to optimize water production and distribution and wastewater processes.

■ **For drinking water**, for example, an improvement of:
• **56 %** in the hydraulic efficiency of the ozone tanks at the Annet-sur-Marne plant (France);
• **89 %** in the hydraulic efficiency of the ozonation unit at the Neuilly-sur-Marne plant (France);
• **36%** in the hydraulic efficiency of the Sandhurst plant, Victoria, (Australia).
■ For wastewater treatment
• Water flow rate improved by 50% in the aeration tank at the Rodez plant (France);
• Demonstration of the efficiency of the UV treatment reactors compared with the competitors' processes, in particular as a result of the improved microorganism reduction rate.

Environmental

Committed to protecting the environment, Veolia Environnement has been able to achieve notable progress, through the use of modeling, in the following sectors:

■ Electricity consumption:
20% reduction in energy consumption in a cold store in Marseille (France);

■ Greenhouse gas emissions:
distinct reduction, by improving greenhouse gas combustion (**10%,** increase in the retention time of the gases in the combustion zone in the Le Mans (France) incinerator);

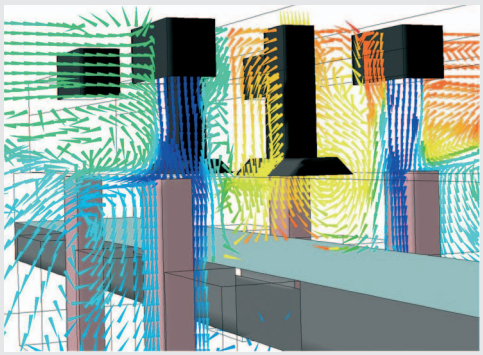
■ Municipal waste incinerators:
• Reduction of carbon monoxide in the combustion offgas;
• Reduction in the dust concentration in emissions;

■ Municipal waste sorting centers:
Reduction of the bio-contamination risk for personnel (work on ventilation).

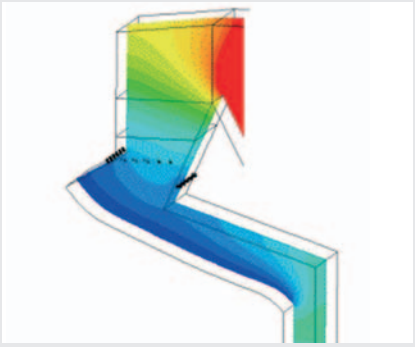
Economical

Modeling research programs have enabled Veolia Environnement to **reduce its energy expenses**.

Operation costs have generally been reduced by extending the lifespan of facilities and decreasing the quantity of products used.



Air injection modeling in a municipal waste incinerator.



Ventilation modeling in a municipal waste sorting center.

Modeling

During filming…

For more information…

Video fact sheet

The Scientific Chronicle No. 6

Log onto the Group Intranet to view the 4-minute video about the research carried out by **Veolia Environnement** on modeling.

Expert:	**Karim Essemiani** Director, Hydraulic Modeling Program, Veolia Environnement
Witness:	**Qing Guo** Veolia Transport
Scenario:	Marie-Odile Monchicourt / 3B Conseils
Duration:	4 minutes
When:	September 26 and 27, 2005
Where:	Rouen (Emeraude) and Maisons-Laffitte (Anjou Recherche, Water research center), France
Preparation:	Fanny Demulier, Alice Dubos, Caroline Bellecourt, Edith Weitz Research, Development and Technology Communication Department Veolia Environnement
Directors:	Steeve Sierra, Martin Geisler
Delegate producer:	Bruno Plasse, Dawa Productions
Magazine design and production:	3B Conseils
Graphic design:	Bernadette Coléno/3B Conseils
Producer:	Veolia Environnement
Date released online:	November 2005

Thanks to the team at the Emeraude wastewater treatment plant, City of Rouen (France); and to David Mouquet, Modeling Project Leader (Waste Management and Energy Services), and Jérôme Chartier, Research Engineer, Modeling Unit (Waste Management) at the CREED research center (France).

The previous scientific chronicles
1 – Legionella
2 – The biroreactor
3 – Fuel cells
4 – Seawater desalination
5 – Managing water resource quality

Partnerships

Waster Division
- **European Marie Curie Fellowships**
www.cordis.lu/
- **INSAT – Toulouse National Institute of Applied Sciences** (France)
http://www.insa-toulouse.fr
- **ENGEES – Strasbourg National School of Water and Environment Engineering** (France)
www-engees.u-strasbg.fr/ -
- **CNRS – French Scientific Research Center**
www.cnrs.fr/

Waste Management and Energy Services divisions
- **University of Sheffield** (UK)
http://www.shef.ac.uk/
- **Alès School of Engineering** (France)
www.ema.fr/
- **INSA – Rouen Institute of Applied Sciences** (France)
www.insa-rouen.fr/

Documentary resources
Veolia Environnement

Audiovisual
- **The Scientific Chronicle No. 6: Modeling** (see box)

Corporate documents
Veolia Environnement
- 2004 Sustainable Development Report.

Publications

- Essemiani K., de Traversay C., Lesavre J. "Prédiction et optimisation des performances hydrauliques des clarificateurs secondaires par la mécanique des fluides numérique." L'eau, l'industrie, les nuisances, No. 253.
- Levecq C., Felier C., Cervantes., de Traversay C., "Avantages de l'utilisation de deux approaches complémentaires pour l'évaluation des performances des réacteurs UV". Second International Congress on Ultraviolet Technologies 2003. Vienna, Austria.
- Lipeme Kouyi G., (2004) "Expérimentations et modélisation tridimensionnelles de l'hydrodynamique et de la séparation particulaire dans les déversoirs d'orage." Doctoral thesis. ENGEES, France
- Vermande S. (2005) "Modélisation hydraulique et biologique des bassins d'aération." Doctoral thesis, INSA de Toulouse, France.
- Chartier J., Guernion P.Y., "CFD Modeling for Incineration Optimization," IT304 Cconference, 2004, Phoenix, United States
- Chartier J., Goddard C.G., Swithenbank J., "Optimization study of a large waste-to-energy plant using computational modeling and experimental measurements," Journal of the Energy Institute.

Specialist website

FLUENT
http://www.fluent.com

Contact

Department of Research, Development and Technology
36, rue de Liège 75008 PARIS - France
Tel.: +33 (0) 1 71 75 06 60
Fax.: +33 (0)1 71 75 10 40
EMail: fanny.demulier@veolia.com