Environmental researchers at ENEL's Thermal and Nuclear Research Center (CRTN) use the IMSL Libraries to create mathematical models to measure and analyze various climatic and meteorological data daily. Using the Libraries they are able to decide the optimal conditions at the power plant for the least level of ground-concentration pollution.

**The Problem**

Last winter, Milan Mayor Paolo Pillitteri announced a one-day ban on all private cars and trucks in an attempt to relieve a five-day air inversion. Cold, windless weather conditions combined with a month of almost constant fog had trapped sulfur and nitrogen dioxides at ground level in the city, Italy's industrial and financial center.

"The air pollution was at a dangerous level, and though the automobile ban didn't have a great effect on the pollution, it was successful in making people aware of the problem," said Dr. Giuseppe Brusasca, research scientist at ENEL, the Italian Electricity Board.

Regularly, environmental researchers at ENEL's Thermal and Nuclear Research Center (CRTN) in Milan send weather information to the Italian Electricity Board. Using the IMSL® Numerical Libraries from Visual Numerics to create mathematical models, the research group measures and analyzes various climatic and meteorological data daily to forecast the quantities and dispersion abilities of pollutants in the air.

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**Quick Facts**

Environmental researchers at ENEL's Thermal and Nuclear Research Center (CRTN) use the IMSL Libraries to create mathematical models to measure and analyze various climatic and meteorological data daily. Using the Libraries they are able to decide the optimal conditions at the power plant for the least level of ground-concentration pollution.

**The random number generator routines are the core of this model, and the IMSL Libraries are very fast and very accurate. We've had good results comparing simulations with real systems, enabling us to use the model in real time.**

- Dr. Giuseppe Brusasca
  - Research Scientist, ENEL

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Ente Nazionale Per L' Energia Elettrica (ENEL) is the third-largest electricity-producing utility in the world, meeting 87 percent of Italy's energy demand. Twenty-two years ago, ENEL established the research center to study air pollution and to develop instrumentation for meteorologic and chemical detection.
The electricity board can then determine what action to take. For example, if the air is very still and an inversion is forecast, the board could opt to shut off the low chimneys at the power plant and use only the tall stacks to vent smoke. If cold weather is forecast, the electricity board knows that demands for energy will be greater and can act accordingly.

Scientists at the Thermal and Nuclear Research Center take two approaches to the forecast. One group studies the dispersion qualities of pollutants. The other analyzes the impact of weather conditions on the demand for electricity.

| The Solution |

Seventy percent of Italy's energy is produced at fossil-fuel power plants. Burning coal and oil emit noxious fumes including sulfur and nitrogen oxides and aerosol. The ground concentration of these pollutants has to be controlled around the power plants. The emissions are a major environmental concern, and Dr. Brusasca's group is involved in research that will minimize ground-level pollution.

Dr. Brusasca turned to the IMSL Numerical Libraries subroutines for air pollution modeling that simulates atmospheric dispersion and predicts ground-level concentrations. "The knowledge of the dynamic and thermodynamic fields affecting the planetary boundary layer is one of the most important aspects in studies of environmental problems and atmospheric pollution over urban and industrial areas," Dr. Brusasca said. "Ten years ago," said Dr. Brusasca, "I was developing numerical code for simulating the atmospheric circulation of local flow and needed to integrate a system of differential equations. That was the first time that I used the IMSL subroutines."

Using special functions of the IMSL Numerical Libraries, Dr. Brusasca's group simulates an analytical solution. Dr. Brusasca's group has developed an advanced particle model that simulates turbulent diffusion phenomena in the atmosphere by means of a Lagrangian particle semirandom motion.
By using suitable Monte Carlo numerical techniques, particles released by a source are scattered in the computing domain, simulating transport, diffusion, chemical reaction and ground-deposition mechanisms. "The random number generator routines are the core of this model, and the IMSL Libraries are very fast and very accurate," said Dr. Brusasca. "We've had good results comparing simulations with real systems, enabling us to use the model in real time. The digital system receives and codes data from measurement instruments such as Doppler Sonar, acoustic antennae that produce a vertical profile of the air temperature. Then particle models are created using the remote sensor data and IMSL's Monte Carlo simulation subroutines."

Because the energy utility is particularly vulnerable to meteorological conditions, the electricity board requires accurate weather reports to prepare for unusual demands on resources or a possible lack of resources. For example, 15 percent of ENEL's energy is produced by hydraulic power stations, making timely precipitation forecasts a necessity for predicting load demands.

Another group at the CRTN prepares weather charts with data received every day from the European Center for Medium-range Weather Forecasts (ECMWF) at Reading, England. The meteorological group began receiving data fields from ECMWF in 1980 for statistical processing. Using the IMSL Libraries for the statistical processing of four levels of atmosphere, humidity, temperature, wind and precipitation, the group forecasts weather conditions for the electricity board.

In September 1989, the CRTN began a cooperative project with the University of Bologna and the Regional Meteorological Service of Emilia-Romagna (Italy) to run a three-dimensional model focusing on limited-area scale features. Dr. Roberto Buizza, research scientist, said, "The aim is to have more knowledge of the meteorological fields, such as surface temperature, wind field and precipitation, with a higher resolution than the statistics given by the European Center."

Dr. Brusasca added, "We are starting a similar project in collaboration with EFT (Electricité de France) using another three-dimensional model to simulate mesoscale atmospheric pollutant diffusion. Both models need mathematical routines, and we'll use the IMSL Libraries."
In April and May 1986, the research group did a study on the Chernobyl accident, forecasting the medium- and long-range transport of radiation, to predict when the fallout would reach Italy. Using a system that had already been established to calculate the long-range trajectories of acid deposition, they analyzed the meteorological factors that characterized the transport and dispersion of the radionuclides over northern Italy from the Chernobyl nuclear power station.

Dr. Buizza explained, "The aim of our study was to test some computation procedures and specific meteorological analyses for a comprehensive study of long-range pollution transport problems. By reconstructing the particle trajectories of the radioactive Chernobyl plume, we determined the most probable starting and arrival dates of the plume and the level over the source. Analysis of the meteorological configuration up- and downwind of the Alps permitted us to explain the temporal displacement between different kinds of measured fallout."

CRTN's research group has worked on projects that measure visibility, solar radiation and acid rain. The acid rain project, detecting acidity of rain and its effect on lakes, forests and monuments, analyzed composition of chemicals in the rain.

Future projects for Dr. Brusasca include studies on the greenhouse effect. "There is increasing attention being paid to this phenomenon," said Dr. Brusasca. "We are developing a station in the Alps to measure carbon dioxide and other chemicals in the air, and we may attempt a modeling of the greenhouse effect."

Research at ENEL is often a cooperative project with other countries, universities and industries, committed to finding alternative, renewable energy, conserving valuable resources and protecting the environment.
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