# Autodesk 3ds max Brings a 21st Century Power Plant to Life

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In the year 2015, power plants will not have high mounds of coal or smokestacks that belch clouds of oxides. They will be sleeker, smaller, able to be situated almost anywhere—on a tiny island in a river, or a skyscraper downtown. Their energy will be generated by hybrid fuel cells, next-generation furnaces and high-performance turbines, dramatically more efficient than anything that exists today. Along with megawatts, they will produce clean fuels and high-value chemicals, but will release zero pollutants into the environment. And their operations and emissions will be constantly monitored by a network of advanced sensors and computers.

That futuristic outlook—called "Vision 21"—is a project of the U.S. Department of Energy's National Energy Technology Laboratory (NETL). The Lab is focused on developing new technologies that will maximize U.S. fossil fuel sources such as coal, natural gas and oil, while making them burn cleaner. The Vision 21 power plant is a prototype facility that integrates all of NETL's ingenious new energy-generators and cleaners into a single, many-layered model. To get there, the Department of Energy has hired a group of contractors to conduct research and development for particular components, such as fuel cells and turbines.

Since Vision 21 is meant to serve as a realistic, functional model for researchers and the energy industry as work progresses, the Department of Energy has placed a high priority on "virtually" visualizing the plant long before any ground is actually broken. Toward that end, NETL has turned to its Simulation and Modeling Team. The team is using a range of tools such as Autodesk 3ds max™ to create lifelike 3-D environments in which researchers can walk through a Vision 21 plant, interacting with its components. The image is something out of science fiction—an energy scientist wearing stereo-goggles and gloves, performing calculations on a virtual water ionizer beamed onto a flat screen—but that's exactly what we're talking about.

**Cleaner, More Efficient Technologies**

Along with its offices Pittsburgh, Oklahoma and Alaska, NETL has a center in the coal country of Morgantown, West Virginia, a legacy of its historical work with coal as part of the Bureau of Mines. Seventy percent of the nation's power is generated from coal; while alternative energy sources such as solar and wind power are promising, the realistic expectation is that fossil fuels will continue to provide most of our energy for decades to come. But the world has finite supplies of coal, and current methods of deriving energy from coal are inefficient and create air-polluting emissions. The lab is intently focused on conceiving and realizing power plants that operate at 70 to 80 percent efficiency. Since today's plants are at 35 to 40 percent efficiency, NETL's ambitious goal is essentially to double the electricity gained from a given lump of coal.

A more efficient plant would also be smaller: gone would be the 200-foot-high pulverized-coal boilers of today's plants. In their place would perhaps be a "fluidized bed gasifier" just 40 feet in diameter—a new, environmentally friendly furnace in which crushed coal is mixed with water and sandy limestone, then heated with jets of air to power a gas turbine. Clean emissions are another top priority, so NETL's technologies suppress pollutant oxides by using sulfur-capturing limestone, burning coal at lower temperatures and finding creative ways to weed out the bad gas particles from the harmless ones.

Right now these devices would be too expensive to implement on an industry-wide scale, and a lot of science remains to be done. "There are some big challenges," said Keith Dodrill, an electrical engineer with the Lab's Simulation and Modeling Team. "But no worse than the

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ones facing the guys who wanted to land on the moon."

**Numerical and 3-D Modeling**

The Simulation and Modeling Team is based in both Pittsburgh and Morgantown, where its members write strings of computer code and algorithms for numerical models. If a researcher is doing tests on a new piece of equipment that shows commercial potential, the team will provide him or her with modeling scenarios showing how gases and fluids might move through it, thereby helping to do experiments more quickly.

This kind of modeling requires a lot of computational power, so the Lab uses "Beowulf clusters" of Pentium-based PCs linked together to form a supercomputer. Dodrill said a typical task might involve one of Vision 21's new technologies, a membrane that acts as a filter to purify the gases emitted by a hydrogen-powered fuel cell. As the cell churns out electric current, the oxygen emitted by its depleted fuel flows through a stack of tubular membranes, turning into steam and carbon dioxide. (One of the possibilities NETL envisions is that this carbon dioxide could then be "sequestered" somewhere—stored in an underground reservoir, dissolved in deep oceans, converted into rocks—instead of rising into the atmosphere as a greenhouse gas.)

"So when the design engineers are working on the membrane, the modeling folks will point them toward which types of concepts are available—flow patterns, gradients, particle sizes," Dodrill said. "We can model things very accurately down to the smallest detail, like a chemical reaction, or we can go up to the level of a component like a nozzle, or even show how different components will interact within the entire power plant."

In addition to computational modeling, Dodrill and others have designed 3-D visualization models as well. They have used Autodesk 3ds max, a modeling and animation platform commonly used by Hollywood special-effects houses, for a number of efforts—natural gas infrastructure or solid-state lighting, molecular models, homeland security projects and promotional presentations. But Vision 21 is one of the highest priorities for NETL, and Dodrill's biggest 3-D project right now is a wall-high interactive model of a prototypical Vision 21 plant that gathers all the Lab's bells and whistles.

"We felt that we needed a model for the plant, to see what it might look like," Dodrill said. "We decided that an animation package like 3ds max, geared to the entertainment industry, would help us build a world that you could interact with. It has platforms, grates, everything…. Our goal was to develop an environment you could walk around in, with physical components, to house the real meat of the process—the computer models behind the 3-D visual models."

**Designing the 'Multi-Wall'**

Moving into the third year, Dodrill and others at NETL have been building a 3-D "multi-wall," an 8-by-10-foot box enclosure with glass walls that show images displayed by rear projection. Modelers, scientists or engineers can move through the enclosure, pausing at lifelike images of a solid-oxide fuel cell, or a coal prep facility, or cleanup components or a circulating fluidized bed (CFB) furnace.

Tim Fouts, an NETL contractor whose background is in computer programming and chemical engineering, said each station in the multi-wall has a control panel for adjusting mechanical aspects of the models, and a way to run mathematical calculations as well. "You can increase the temperature, or raise the pressure or open a valve more," he said. "Or you can launch an external program to view the results of a model running computational fluid dynamics, for experiments."

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A similar four-wall, virtual-reality environment developed by researchers at Iowa State University is called a CAVE. Dodrill said that after NETL was charged with building "an immersive environment," his team did three years of research and development before its multi-wall first went operational in summer 2002. Fouts said the team hopes to have all of the "plant's" physical features drawn up with Autodesk 3ds max by the end of 2003; marrying the 3-D imagery with the underlying numerical models will be more complicated. "We're still figuring out what the obstacles will be," Fouts said. "Historically it has been hard to visualize numerical models. These two processes are pushing our machines to the limit."

Eventually, NETL expects that users in the multi-wall will wear stereo-goggles for maximum 3-D viewing, and gloves with motion sensors—similar to what Demi Moore and Michael Douglas suited up with in the film "Disclosure," when they maneuvered around a virtual-reality environment.

**'We Wanted Rusting Pipes'**

The Lab has been using Autodesk 3ds max for two years. Previously, most of its modeling was done with CAD packages such as Intergraph. "It's easy to learn and well tutorialed," Fouts said. "You can morph, animate, dissolve, hide things or make them transparent. You can import things from other people. It's flexible; when you work in CAD, if two walls don't meet up, you have to snap them together, but not in 3ds max."

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Even though these researchers dwell daily among technologies the rest of us won't see for 15 years, the total immersion of virtual reality seems to be good for a shot of adrenaline. "An engineer walked through the multi-wall model and said he could never have seen it the same way on a regular computer screen at his desk," Dodrill said. "He got really excited, and a lot of people react that way.

The Department of Energy National Energy Technology Laboratory's Autodesk solutions were implemented and supported by AtlantaCAD of Norcross, Georgia. For information, please visit www.atlantacad.com or call 770-368-8704.

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