# NREL Energy Systems Lab

CASE STUDY | GOVERNMENT

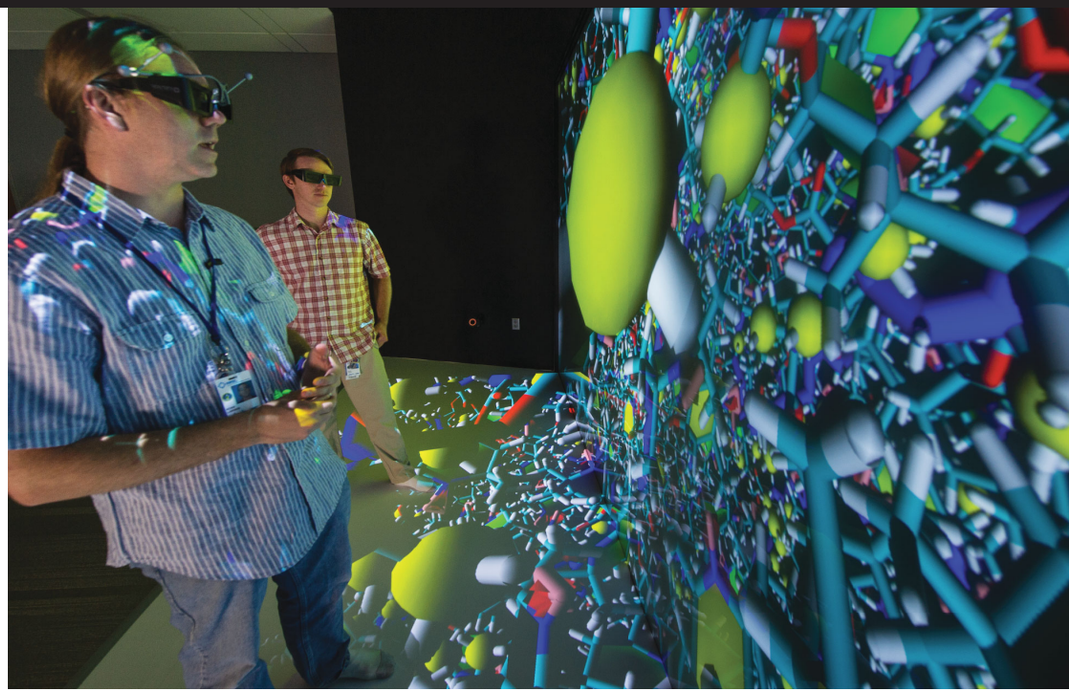
GOLDEN, CO

## Challenge

Build a visualization laboratory to help scientists use the unique power of the human brain to see and recognize patterns that computers can't.

## Solution

3D visualization spaces that allow researchers to literally walk around inside supercomputer simulations. Crestron technology controls the video systems that make that possible.



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>
> *Convergent Technologies Design Group*

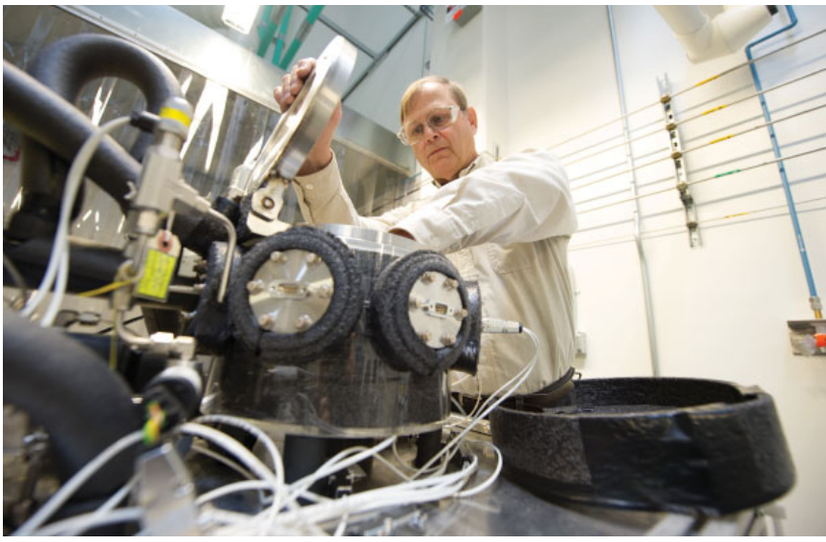
## Visualization Key to 21st Century Science

*Crestron control at work at the National Renewable Energy Laboratory's newest facility*

Visualization is becoming a crucial component of science today. The ability to capture and store very large quantities of data is creating huge challenges for researchers, requiring innovative new methods of analysis.

For example, researchers at the National Renewable Energy Laboratory (NREL) have been working on ways to determine the best position for turbine generators in large wind farms. According to Dr. Kenny Gruchalla, senior scientist, Scientific Visualization, "We are simulating the air flows through array fields, trying to understand the dynamics of the flows and how upstream turbines impact downstream turbines." Another challenge for NREL researchers is the development of new high-efficiency materials for solar cells. "We're studying these materials on a molecular level, trying to predict which are likely to be the most efficient."

In both cases, pattern recognition is the key to optimizing results. "Our visualization lab space capitalizes on the human brain as an instrument for pattern recognition," Gruchalla explains. "That's a trait basic to how humans see and interact with the world – and one that is so sophisticated that we have yet to match it with any algorithm."

NREL has included two supercomputer-powered visualization laboratories in its new Energy Systems Integration Facility (ESIF) in Golden, Colorado that can literally put people inside a simulation where they can see and recognize patterns that computers can't.

The ESIF is designed to conduct flexible, integrated experiments that replicate a variety of real-world conditions and integrate these technologies into end-to-end simulations of distribution and transmission grids through hardware-in-the-loop testing at actual power levels. The 182,500 sq. ft. facility contains approximately 200 office and collaboration spaces, state-of-the-art laboratories, outdoor test areas, visualization labs, and four rooms with large video walls.

Crestron technology controls the video and audio systems at the heart of these laboratories.

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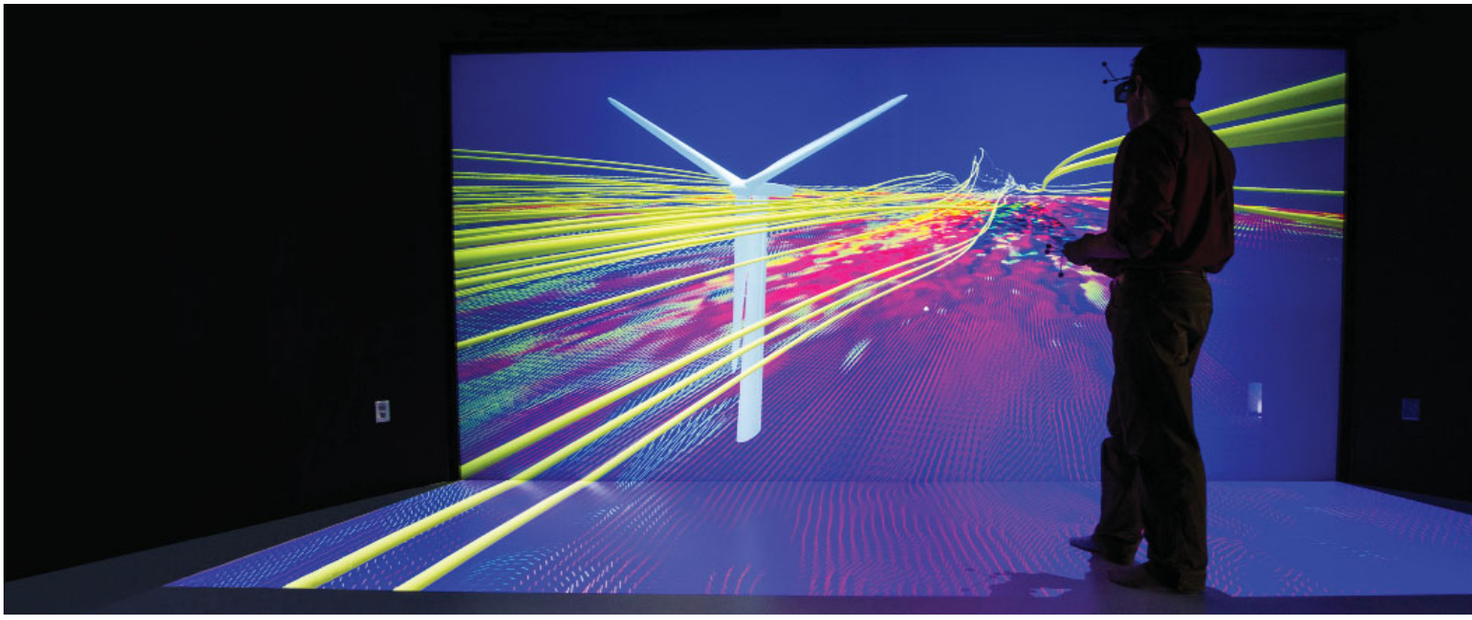
## A 3D laboratory

The most sophisticated visualization lab is the Insight Collaboration Room, an immersive 3D space where researchers can walk around inside an image built from a large data set.

The display for the lab consists of two video arrays. One uses six Christie Digital three-chip 3D projectors to create an 8' x 20' vertically-aligned image on a wall and a 6' x 20' horizontally-aligned adjoining image on a special surface on the floor. A researcher wears a set of 3D parallax shutter glasses that include optical trackers on the frames. Sensors in the room track his or her head position, sending instructions to the supercomputer, which shifts the images in a way appropriate to the researcher's head and body movements.

"The result is an immersive, 3D space that simulates a real space that you can walk around in," explains Paul Corraine of Convergent Technologies Design Group, who with partner Bill Holaday designed the projection



and tracking systems for the lab plus an integrated sound system. "It's truly amazing," he says. "The sensors track where your head moves and where it is, so that the images on those projected surfaces change to follow your perspective. It's just one step away from the Holodeck on Star Trek."

"We can use this system to explore any number of problems," Gruchalla says. For example, with the photovoltaic materials, researchers project 3D simulations based on electron microscope images. Scientists can walk into the image and observe the material's structure on a molecular level, gaining a point of view much more useful than a 2D representation of the same data on a desktop monitor. Because of the limited size of the room, they have a joystick that can transport them around different areas of the projection – a lot like flying a helicopter around Yosemite National Park, then landing at a waterfall to walk up for a closer look.

While this lab is typically used to study systems with some direct spatial component, NREL scientists can also use it to visualize more abstract problems. "We might put power on one axis, dollars on another and some other feature, say the renewability of the resource on a third, walk into this very abstract image yet still be able to recognize patterns in the data," Gruchalla explains.

## 2D visualization

The Insight Visualization Lab in the ESIF uses a 3x2 tiling of Christie 72" display cubes to create a roughly 16' wide by 6' high video wall with 5760 x 2400 resolution. This is a two-dimensional setup, but one with enough visual real estate to look at very complex problems.

NREL researchers have used this lab to study the utilization of their high performance supercomputer, which has over 38,000 cores a petaflop of compute capability and multiple petabytes of storage. "We can use this display wall to look at the utilization of all those cores, their power usage, their thermal loads, the percentage of memory being used, projecting time-series data for all of those factors at once, stacking the graphs one on top of another," says Gruchalla. "If we're having problems with the system, it makes it a lot easier to recognize when and where those problems occur."

Another example is the projection of time series data for the wind turbine fields. "Specifically, we're looking at turbine failures here, trying to understand what is correlated with those failures," Gruchalla explains. "The traditional method would be to use [statistical] regression analysis to analyze the events, but we find that if we put visuals of the data up in front of expert users, they are often able to recognize patterns or


correlations that we didn't know were there. In this way we can tease out the questions we need to ask, using the visualization to qualitatively understand where we want to do our quantitative deep dives."

The High Bay Control Room in the ESIF uses a 2' x 5' video wall most often to project real-time data from the testing of high-voltage electrical systems. It can be used to simulate an electrical utility control room, as well as to study smart grid systems and new equipment operating in nine connected experimental bays.

Video conferencing systems (using separate screens) can bring visitors from other locations into these spaces and into the other labs and conference rooms of the facility. The CERBS Visualization Room also includes a 2' x 5' video wall as a control center for all of the labs in the building.

## Designing the video systems

Holaday says Convergent Technologies chose the audio video components at the ESIF for their ability to meet or adapt to the high demands of the researchers. "Serving this mission critical application requires zero downtime, reliable systems, and a robust control system," he explains.

"We chose Crestron controls for their customizability and for their ability to integrate with multiple complex systems," Holaday adds. "There were too many unique requirements here to trust anything else." Crestron PRO2 systems in these rooms control all power functions, the various possible configurations of the video walls, the sources, audio volume levels, plus video conferencing and presentation features.

AVI-SPL's Denver office handled all of the installation and programming, and Corraine and Holaday say they did an outstanding job. The architects, SmithGroupJJR of Phoenix house all of this technology in a truly stunning structure, and one that is a model for energy efficiency and sustainability.

The project was a long one, with nearly four years of planning, design and construction. Yet its systems will help scientists visualize, develop and test the energy sources for the 21st and 22nd centuries.

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