Oil drilling in Wyoming: computers can help determine the viability of an oil or gas field Photograph: Larry Lee/Corbis

Linux helps to squeeze the last drop out of oilfields

Grid computing makes modelling of energy sources very accurate and helps manage them as efficiently as possible

William Knight

With oil prices nudging all-time highs, oil companies are considering how to extract the very last drops from wells, having been unable to increase production for the past 10 years.

The oil majors are being helped in their deliberations by detailed simulations run on high-performance computer grids. "There is a huge effort in getting more from the reservoirs," says John Hybertsen, principal engineer at Norwegian oil giant StatoilHydro.

"In some reservoirs they started out by saying that current production technology would get only about 45% of the oil. But we have aims of 55% or up to 60%, and you don't do that without controlling the production and knowing what is happening in the reservoirs."

Understanding how oil flows

For most reservoirs, it's not as simple as drilling a hole and fitting a large tap. Oil must be coaxed from the ground – pumped, pushed and pulled using complex techniques – and only an accurate map of the reservoir's rock structure and a dynamic model, or simulation, of how oil is released can prevent drilling in the wrong place.

Before reservoir simulation, oil companies put wells in the ground and started draining, says Hybertsen. "They had no idea what happened down there, but sooner or later they pulled up water. Water flows easier than oil. Once you have water, only water will flow from the well. That's it; then it's done with that well."

But understanding how oil flows through miles of rock before finally emerging through a 10-inch bore hole is complicated by the enormity of the problem.

Neil Pickard, consultant geologist at Cambridge Carbonates Ltd, spends much of his time building models that form the basis of reservoir simulations. He says there is "often an astounding amount of data. We try to build a very detailed static image of the reservoir with surfaces and layers, and with those layers divided into three-dimensional cells. A typical cell may be a couple of metres thick, by 50 to several hundred metres across. We may end up with ten of millions of cells.

"Each cell gets a porosity, a permeability and an oil saturation value. Then there's the composition of the oil. Information is gathered from core samples, seismic data, and from evaluation tools measuring radioactivity, density and porosity."

Even with this ocean of data, the picture is completed slowly. Each new seismic survey, borehole or production record adds more data to the model, and each day the engineers extend their knowledge of the reservoir.

Predictions are compared with actual results and the model refined continuously, but, as Hybersten explains, knowledge is never perfect. "The engineers know the most about the reservoir on the day production ends."

Accurate simulations predicting oil production over many years can take days to run, and for statistical evaluations many hundreds of simulations may be required, each testing a range of possibilities. And yet each morning StatoilHydro expects to take production decisions based on the very latest simulations.

So a year ago the company embarked on a project to link five of its Linux clusters – four in Norway and one in Houston, Texas – into a multi-cluster grid using Platform Computing's LSF workload management software. The result was an 850-CPU grid capable of running thousands of simulations each day, and many different simulations, each with subtly different properties, can execute at once. The grid manages the capacity, moving the workload to wherever there is spare processing power so that reservoir engineers do not have to be aware on which processors or machines their simulations run.

Crunch point

Deadlines are the crunch point, says Pickard. "Anything that helps run these things faster means you can do more sensitivity studies and more development scenarios, and therefore really understand the impact if you put 200 horizontal wells in, as opposed to 100 vertical wells."

Speed and accuracy helps maximise the profitability of a reservoir over its lifetime. "We have thousands of simulations every day. They are run to forecast, control, to get statistics and simulate different scenarios. It costs about $100m (£48.4m) to drill a well, so we have to get it right," Hybertsen says.

"Grid computing is making this impact on oil companies because we've reached the point where the technology simply works," says Ian Osborne, project manager for the government-funded Grid Computing Now! Knowledge Transfer Network, IECnet.

"Grid computing has given them orders of magnitude more accuracy in their modelling. There is a trend that people want to model their business more and more for many reasons; sometimes to help mitigate risk, sometimes to make sure of compliance with regulation. It comes down to knowing more about your business as it runs, and therefore making better decisions."

Many of the 39 operating oil and gas fields operated by StatoilHydro, which produces 1.7m barrels of oil equivalent per day, are past their peak and have entered tail production. Accurate simulations can help a company manage this phase of an oil field's life.

Oil companies may no longer be making giant finds, but computer simulation is helping extend the life of existing fields and, combined with record oil prices, making the exploitation of marginal reservoirs commercial. Simulation can increase the lifetime of a field "maybe as long as five to 10 years," says Hybertsen. "If you get 5% extra out of a reservoir, that will mean billions of dollars. They produce less, they pull up more water, they pull up more sand, but they make huge efforts to get the oil out."

Each day the world demands more oil – but technology is pushing back the hour when the petrol stations run dry forever.

Oil numbers

$100m

The cost to Norwegian company StatoilHydro of drilling an oil well

1.7m

The number of barrels of oil equivalent per day produced by StatoilHydro

39

The number of operating gas and oilfields run by StatoilHydro