Learning from the future

By using a well-established modeling approach—system dynamics—in a new way, senior managers of power generation companies can understand how supply, demand, and the actions of competitive suppliers will interact in tomorrow's deregulated electricity markets

By Dr. Erik R. Larsen, Dr. Alessandro Lomi, and Dr. Isaac Dyner

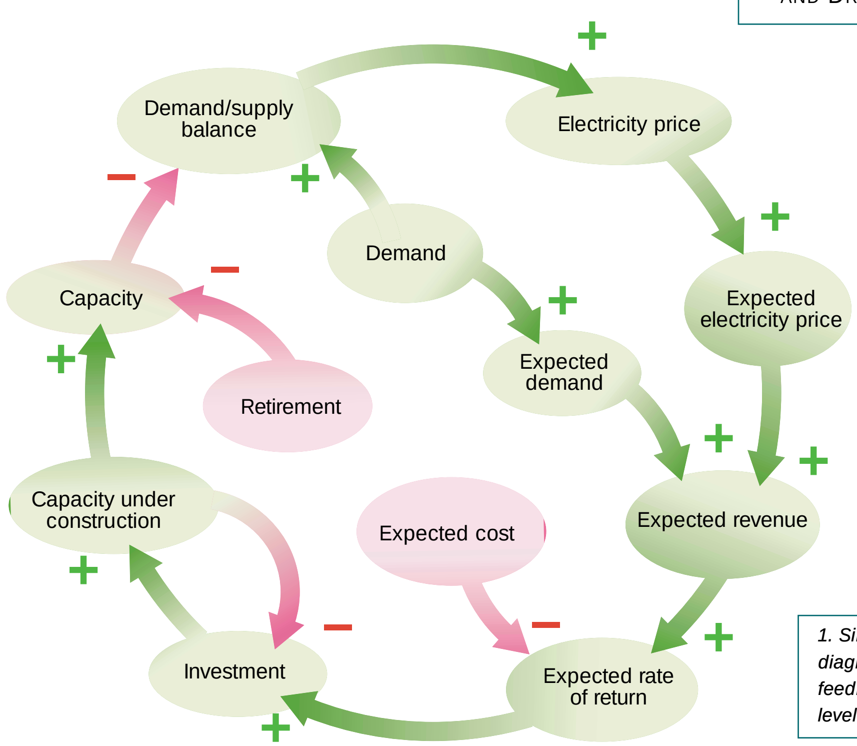
When monopolies ruled the electricity industry, the only planning a utility needed to do on the generation side was for capacity. A team of planners forecast electricity demand growth in their service territory to determine how many power plants would have to be built, by when, to meet expected demand. Under cost-plus regimes, planners only considered what types of plants to build and what fuels they would use to the extent that those decisions would affect—if only slightly—the company's profits.

The advent of retail electricity deregulation in North America and liberalization in Europe made capacity planning far more complex. Under competition:

- Generation utilities cannot expect to make any return on their capacity investments—much less recover them in full, plus a profit.
- Electricity demand is met not by one monopoly supplier, but rather by competitive generators whose choices of plant and fuel types determine who will be the market's lowest-cost producers.

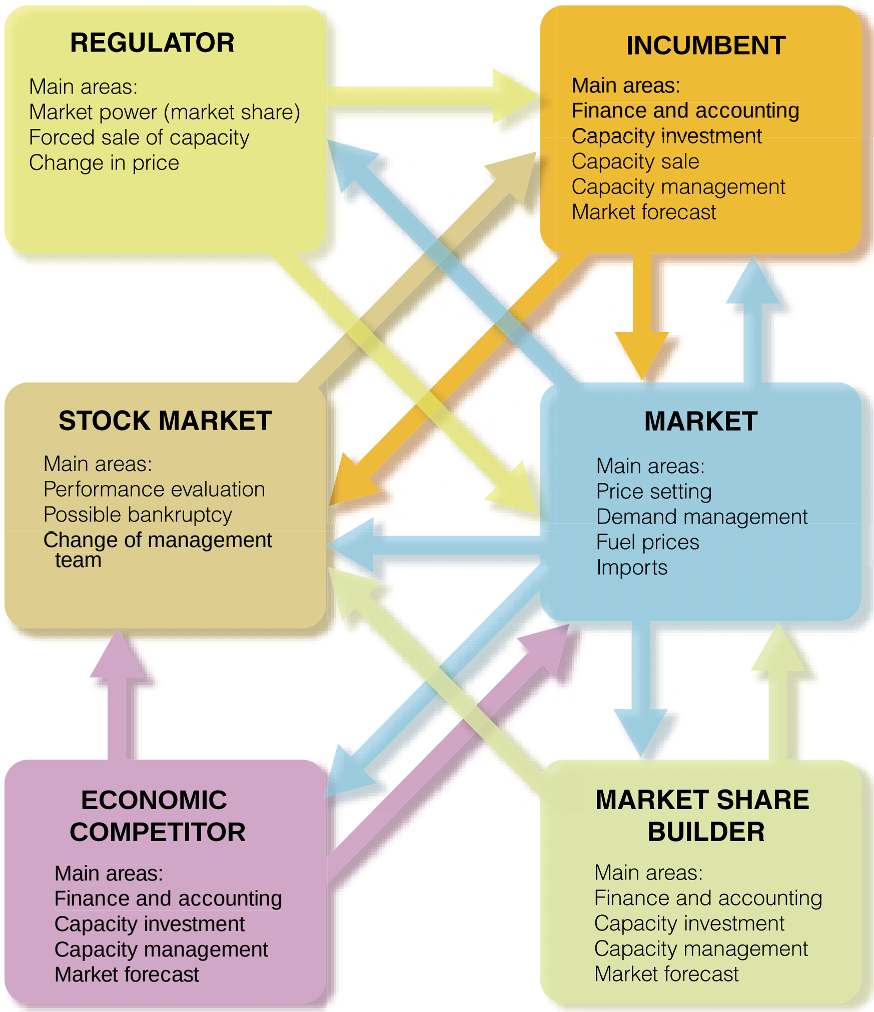
To power generation companies, then, making decisions about capacity investments now requires looking at a bigger picture of competitive and regulatory forces over time. Instead of the simple question, "How much capacity do I need to build to meet demand?" planners must now ask, "At what price can I sell the power produced by the new capacity I'm considering building and still get a good return on my investment?"

One reason that this question is more complex is the unpredictability of future electricity prices; they can rise and fall in response to competitors' changing market shares, seasonal imbalances in supply and demand, and new regulatory rules. Another is that the information now needed for decision support must come from questions



1. Simplified causal loop diagram shows feedback from industry-level investment

In the illustration above, a plus sign indicates that the two variables 'move' in the same direction; that is, if the first becomes bigger, then the second one will also become bigger and vice versa. A minus sign indicates that the two variables move in different directions; that is, if the first variable becomes bigger then the second variable will become smaller and vice versa. The number of plus and minus signs around a loop indicate the polarity of the loop (an even number indicates a positive or reinforcing loop while an odd number indicates a negative or balancing loop)



2. In this sector map of an investment scenario model, each box can be explored in more detail

whose answers reflect the effects of feedback and delay—for example: What will our competitors do? If we make a certain move, how will our competitors react to it? If we make our decision in today's regulatory climate, will the outcome be positive if the climate changes?

Learning, not predicting

Ever since the U.K. opened up its electricity market to competition a decade ago, utility executives worldwide have tried to learn from the experience of other industries that were deregulated. However, understanding how transportation, banking, and telecommunications changed with competition has limited value, and not just because commodity kilowatt-hours are different than air fares, checking accounts, and phone calls. What makes such exercises ineffective is that they look to the past for hints about the future. Because deregulation is a revolutionary process that introduces new rules, it renders history irrelevant.

Does this mean that electricity executives must step into the unknown territory of competition completely blind, with no map? Not necessarily. Instead of building models of the future based on history, proponents of system dynamics advocate building models that exploit the combined expertise, shared experience, and collective insight of senior decision-makers. System dynamics models do not attempt to "predict" the future, but instead generate sets of future, possible scenarios that can be studied to generate additional insight. Such models allow executives to test their hypotheses about the effects of different decision strategies and how competitors and customers will react to them.

"Modeling for learning" differs from the traditional, "black box" style of predictive modeling in one very important way. Because a simulation based on system dynamics requires senior decision-makers to specify, build, test, validate,

System dynamics: A brief history

Invented and developed by one of the first computer scientists, Jay Forrester, at the Massachusetts Institute of Technology in the 1960s, industrial dynamics (as it was called then) was a way of modeling dynamic systems using non-linear control theory. Its unique selling point was its capability to capture the time delays and feedback mechanisms exhibited by such systems.

Originally used for inventory control and other operational management decisions, the modeling technique remained exclusive to the small system dynamics community during the 1970s and 1980s. With the explosion of computer processing power in the early 1990s, its uses expanded to industry and market simulation. The arrival of user-friendly system dynamics packages in the last decade moved model building to the desktop and put model specification in the hands of end users. Peter Senge's best-selling book, *The Fifth Discipline,* popularized system dynamics in the management arena. As consultants—such as PA Consulting, London, and McKinsey, New York—jumped on the bandwagon, system dynamics became a standard subject taught at leading business schools.

and run models personally, it demands much more of their time. That commitment fosters pride of ownership of the models, which in turn makes the decision-support information they generate more likely to be acted on at annual top-management strategy sessions.

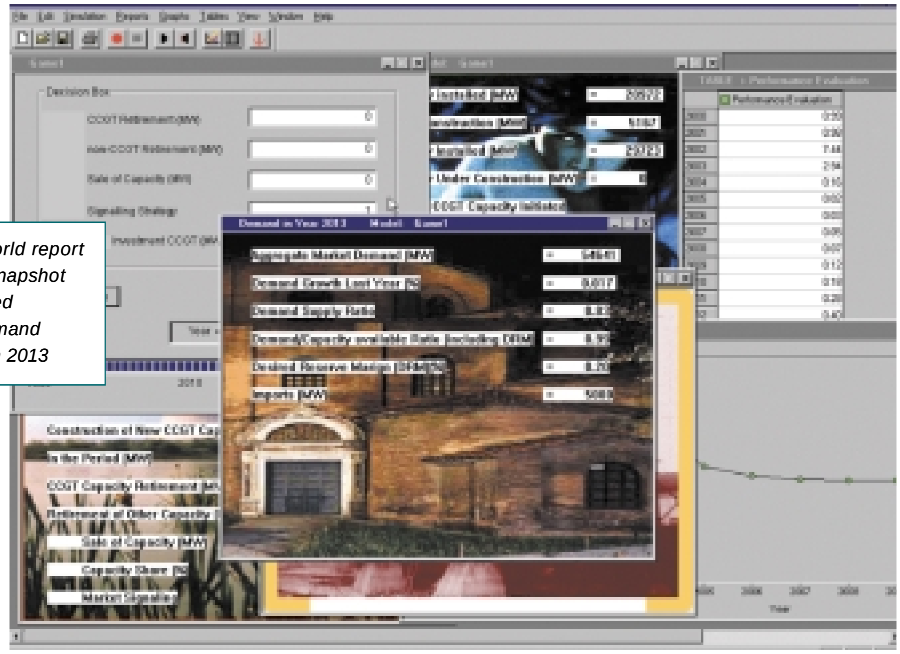
System dynamics in practice

Senior managers of a large European power generation company, which insists on anonymity, recently completed such a "modeling for learning" exercise. Using a simulation tool developed in the 1960s, they specified and built a model of the interactions of participants and forces likely to occur in their market. A facilitator extracted specialist knowledge, mental models, and other insights from these managers in the form of complex but ambiguous causal narratives.

These narratives about relationships and influences between drivers of change were then mapped onto a so-called causal loop diagram (Figure 1). Then, the facilitator converted the rate and direction of change into differential equations. Once specified, the computer program was then run and tweaked to produce different future scenarios.

Because they were intimately involved with the model building, the managers got a better understanding of the different ways that future scenarios could play out. One such scenario explored various strategies for plant investment. The model (Figure 2) depicted the six entities whose actions could not be predicted:

- The incumbent (themselves).
- The local regulator.
- The local retail electricity market, including customers.
- The stock market on which the incumbent is listed.
- One group of "economically rational" independent power producers (IPPs) which will only invest in new capacity if assured of a desired rate of return.
- A second group of "market-share-building" IPPs willing to accept a lower than average rate of return—at least at first.



3. Microworld report provides snapshot of simulated supply/demand situation in 2013

Reading the tea leaves

Could system dynamics simulation have predicted the electricity supply/demand imbalance that still plagues California? The answer is yes. Using the technique in the early nineties, the authors demonstrated how a deregulated market might easily become pawn to construction cycles that would have a profound effect on reserve margins and, by extension, retail power prices. The results from their early studies, which focused on the U.K. market, reflected the actual pattern of development of the U.K. market in subsequent years.

Problems like those California is now experiencing did not arise in the U.K. because its reserve margin was initially high and the rate of demand growth was much slower there. However, in a separate system dynamics study of California performed in 1999 (www.wsu.edu/~forda/bbust.html), Andy Ford found that the Californian market might show similar cycles in capacity and investment. One can conclude from Ford's study and others that deregulated electricity markets will behave similarly to other mature, capital-intensive industries, such as commodity chemicals and office construction.

From models to Microworlds

After the executives built and validated the model, the facilitator added a user-friendly interface to it. This allowed decision-makers with no experience in modeling to interact with the model using an underlying technology called a "Microworld." A Microworld, often called a management flight simulator, has become the generic name for this class of "what-if" tools for strategic thinkers and planners.

For executives and others, a Microworld serves as a risk-free environment in which they can "play out" their thinking about a complex business situation closely related to their daily experience. Many companies use Microworlds as simple but effective visual communications tools for helping personnel to make corporate strategies less abstract by actualizing them.

Microworlds extend senior managers' knowledge and understanding of strategic issues to middle management. Their graphical interfaces simu-

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late actual decision-making environments, and give middle managers and others opportunities to "see" the consequences of their strategic decisions and test their business intuition. Feedback is provided by a variety of reports generated from the data base of the simulation model. Such reports (Figure 3) provide summary information on a wide range of financial, economic, operational, competitive, and strategic aspects of the business.

Changing cultures and competitiveness

Although system dynamics could have predicted the blackouts in California, the technique is perhaps most effective as a tool for helping utilities change their culture from that of a monopoly to that of a competitor. Few other decision support systems give senior managers comparable power to share their expertise and improve how personnel understand corporate strategies.

System dynamics simulation of the kind discussed could add much-needed insight to decision-making in today's electricity industry, where the facts are few and the uncertainties are many. Even regulators can use it to make sure that they put the right incentives for investment in place soon enough to give generation firms and their investors sufficient time to build new capacity. As deregulation makes history increasingly irrelevant, all members of the electric power industry can learn from the future through modeling for learning. ■

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