Book Reviews

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ELECTRICITY: Efficient End-Use and New Generation Technologies and Their Planning Implications

by THOMAS JOHANSSON,
BIRGIT BODLUND AND ROBERT WILLIAMS
(Editors)
Lund University Press, 1989.
pp. 960

Imagine yourself as the diligent manager of a publicly owned electric utility. You walk into the energy minister's office for your weekly briefing and suddenly things go wrong. As you listen, you begin to hope that you are only having a dream, a dream in which you play the lead character of Mission Impossible.

"Smith, we have a new mission for you. Phase out all of our nuclear power plants over the next 20 years. Yes, of course I know they provide close to 50% of our electricity. Is that a problem? And remember Smith, no switching back to oil, it's a security risk. No large hydro projects, they're not popular. And no increase in CO_2 emissions, so forget about coal. Why are you rushing out, Smith? I'm not finished yet. I need hardly tell you that there are to be no power shortages during the phase-out. One final point Smith, I'm counting on you to keep electricity prices at moderate levels. We don't want to become unpopular now, do we? That will be all thank you. Have a nice day."

Surely this is just a bad dream. Surely it couldn't happen in a modern industrial democracy.

But it has. The Swedish parliament has decided to phase out nuclear power, which currently makes up 50% of the country's electricity, by the year 2010. With the exception of some small projects, further development of the country's major hydropower resources is forbidden by law due to environmental concerns. Since the spring of 1988 the Swedish parliament has been passing guidelines and policies intended to freeze and then reduce CO_2 emissions, thereby ruling out expanded production of electricity from coal. Finally, a reduction in dependence on oil imports continues to be another of the government's energy policy objectives, as it has been since 1974.

Sweden may not be alone. Several other countries in Europe are moving in the same direction. California recently toyed with similar policies in

its now-defeated Big Green referendum. Closer to home, there are striking parallels to the intentions of the Ontario government. Indeed, the challenge facing Ontario Hydro today does not seem so dissimilar to the dilemmas of Swedish electricity planners.

If you were the utility manager in the above scenario, what would you do? No one could blame you if a few dark thoughts crossed your mind. But before committing desperate acts, you must read the book under review here. Edited by Thomas Johansson (University of Lund), Birgit Bodlund (Swedish State Power Board) and Robert Williams (Princeton University), this volume is the product of a collaborative effort involving the Swedish State Power Board and the Institute of Environmental and Energy Systems Studies at the University of Lund in Sweden. It explores the possibility that recent and future technological advances will allow Sweden to have the electricity services upon which modern industrial societies depend, while phasing out and prohibiting those large scale electricity production technologies that are considered to pose unacceptable environmental and social risks.

A major conference was organized in Gothenburg in the spring of 1989. Leading international researchers were asked to contribute background papers outlining the engineering and economics of the latest advances in (1) the technologies that use electricity to provide services (lights, electric motors, appliances, industrial machinery, etc.) and (2) the socially and environmentally acceptable technologies that can produce electricity (photovoltaics, biomass, natural gas, etc.). Additional papers were prepared on the implications of these technological advances for electricity planning. After the conference, the papers were combined into this massive 960 page volume.

A review of a book of this length cannot do justice to the many high quality contributions in the variety of fields covered. This review provides only a brief survey of the papers on technology, before describing the book's final chapter in greater detail. The latter explores the potential for Sweden's electricity sector to meet the country's political objectives, given the technological developments presented throughout the book.

There are three sections: End-Use of Electricity, New Generation Technologies and Implications for Planning.

The First Section has chapters on specific technologies: electric motors, lights, windows (for electrically heated buildings), appliances, heat pumps, commercial and residential space heating, electro-technologies and steel making, electro-thermal processes, office equipment, and applications of superconductivity. It also contains chapters devoted to general surveys which (1) compare electricity use in Swedish and US industry, and (2) assess the overall effect of technological change on industrial electricity use. Efficiency improvements and their relative costs are estimated for each electricity service technology.

The Second Section has chapters on coal gasification for combined cycle turbines, gas turbines, pressurised fluidised bed combustion, photovoltaics, fuel cells, and biomass gasification. These technologies are assessed in terms of their efficiency advances, cost trajectories and environmental implications.

The first two sections of the book (740 pages) are dominated by discussions of thermodynamics, technology design and costs carried on by physicists and engineers. The Third Section, which could stand alone as a fascinating 200 page book, focuses on the implications of these technical advances for electricity demand and supply. Specifically, it addresses:

- the aggregate potential for economic improvements in electricity efficiency;
- some of the environmental implications of pursuing these improvements;
- public policies and utility marketing techniques to encourage investments by households and firms that improve electricity efficiency;
- the implications of these policies for corporate structure and management of the electric utility industry; and
- the implications of these policies for developing an electricity system that succeeds in meeting the economic, security and environmental objectives determined by the Swedish

political process.

The last chapter, "The Challenge of Choices," responds to the key objective of the book by integrating the findings from many of the preceding chapters as part of an exploration of alternative electricity supply and demand choices for Sweden to the year 2010. In all of the scenarios considered, nuclear power is phased out by 2010, hydropower expansion is not permitted, GDP and all associated electricity services grow by 1.9% per year, and electricity prices increase by 50% in real terms. Scenarios differ in their assumptions about the efficiencies of electricity-using technologies and the degree of reliance on fossil fuels. Results differ in terms of total electricity consumption, the total costs of electricity services and emission rates of CO_2.

The methodology of this final chapter provides a valuable template for electricity planners in other jurisdictions and is worth looking at in some detail. First, five demand scenarios are developed and run to the year 2010, using the end-use electricity demand models of the Swedish State Power Board. In all scenarios the energy services currently provided by electricity in Sweden are assumed to grow in step with the 1.9% annual growth rate of GDP. In 1987 Sweden used 129 TWh of electricity. For each of the following scenarios, the figures in parentheses show the forecasted electricity demand:

1) In the **frozen-efficiency scenario,** new technologies are assumed to have the same electricity efficiency as the present average, such that a 10% increase in the demand for steel would lead to a 10% increase in the electricity used to produce it. (194 TWh)

2) In the **reference scenario,** efficiency improvements are limited to those induced by a 50% real increase in electricity prices (assuming estimated price elasticities) and by existing information, regulatory and incentive programs. (140 TWh)

3) In the **efficiency scenario** the best commercially available and cost-effective technologies (based on a real discount rate of 6%) that improve energy efficiency achieve high penetration levels. (111 TWh)

4) The **high-efficiency scenario** assumes a high penetration of technologies that are not yet commercially available, but soon could be. (96 TWh)

5) The **advanced technology scenario** assumes a high penetration of technologies that are not yet designed or costed, but that are technically possible. (88 TWh)

Three contrasting electricity production scenarios are also developed: (1) a coal/natural gas mix, (2) a natural gas/biomass mix, and (3) an environmental package that selects electricity generation technologies primarily on the basis of CO_2 emission rates. The last production scenario is also dependent on biomass, but has a much larger share from cogeneration and district heating.

The three supply and five demand scenarios are then integrated into 15 least cost electricity supply curves: supply curves in which electricity saving and electricity generating investments are combined in order of their levelized per KWh costs (using a 6% real discount rate).

The results at this stage represent 15 possible choices for Sweden in terms of supply and demand options. In each choice the magnitudes of end-use services provided by electricity are the same. However, from one choice to the other the balance between electricity supply and efficiency improvement varies, as does the mix of supply sources.

When the 15 choices are compared in terms of cost, the levelized cost decreases as the share of efficiency investments increases. Thus, scenario (4), the high efficiency one, has total levelized costs ranging from 2.1 to 2.3 cents/KWh,[1] while the costs for scenario (3) range from 2.3 to 2.6 cents/KWh. This is because the new supply options are on average more expensive than conservation, with levelized costs ranging from 3.2 to 5.8 cents/KWh.

The different demand/supply choices contrast dramatically when emissions of CO_2 are tabulated. These range from 13.6 million tonnes per year, when the reference demand scenario is combined with the coal/natural gas supply scenario, to 1.9 million tonnes per year, when the high efficiency demand scenario is combined with the environmental supply package. Of particular interest for energy analysts are the relative costs. The high CO_2 combination is actually

more expensive (2.6 cents/KWh) than the low CO_2 combination (2.3 cents/KWh). This counter-intuitive result reflects once again the high cost of non-nuclear electricity production (some of which emits CO_2) relative to energy conservation.

These results from the last chapter provide a small taste of the massive amount of useful information and innovative analytical techniques found in this book. Energy analysts throughout the world are being asked by policy makers to develop methodologies and collect data to address the types of questions for which the research summarized in this book has already done so much of the groundwork. Before running out to hire consultants, who are often also low on the learning curve, an energy analyst faced with this kind of challenge would be better to first read this book, at least the last chapter.

However, despite its size, this book addresses only part of the issue, a fact which the authors readily admit. *ELECTRICITY* maps out for energy analysts in Sweden (but with lessons for analysts in other industrialized countries) a range of choices for electricity futures. But it does not explore in detail the pros and cons of alternative ways of realizing these choices. While implementation strategies are discussed in some of the chapters of Section Three, this question is largely left unanswered.

And perhaps it should be. Technologies are essentially transferable between countries. But public policy strategies can vary significantly. One might expect, for example, that in Sweden government regulation will play a larger role in achieving the desired electricity future than in the US, where the responsibility to capture cost-effective conservation has been largely left to private electric utilities.

Electric utilities and government agencies that claim to be serious about least cost electricity planning would be wise to spend the $100 it takes to buy this volume — it may be the most cost-effective expenditure they make.[2]

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Energy: Production, Consumption and Consequences

by JOHN L. HELMS (ed.)
Washington, DC: National Academy Press, 1990
pp.296

Prior to the 1970s, energy discussions were generally uninteresting and predictable, largely because little distinction needed to be made between energy demands and energy resources. After all, converting energy in the ground (coal, oil, gas, uranium) or on the earth's surface (surface mining, damming rivers) into energy at the bus bar involved nothing more than some mining and refinery activities, a power plant or two, and a string of transmission lines across the countryside. The old saw that a bird in the bush could not be equated with a bird in the hand did not seem relevant.

The simple equating of an energy demand with an energy resource has changed dramatically since the power play of OPEC, the breaker failure at Three Mile Island, and the circuit dynamics of environmental awareness. Now the issue of energy resources is overshadowed by the complexity of energy delivery.

The book in question is based on contributions by "...a group of leading authorities on energy and related environmental issues..." under the sponsorship of the US National Academy of Engineering. With few exceptions, these "leading authorities" are senior executives of some of the largest and most influential energy corporations (e.g., Electric Power Research Institute, Commonwealth Edison, Shell Oil, British Petroleum, Consumer Power, Norwegian State Oil) and re-

1/ All costs are in 1987 US dollars. The costs are for KWh saved and/or produced when referring to a combination supply/demand choice.

2/ In case it should be difficult to place orders through normal channels, the book can be acquired from Dr.Thomas Johansson at the Institute of Environmental and Energy System Studies, Lund University, Gerdegatan 13, S-22362 Lund, Sweden.

lated institutions (US Office of Technology Assessment, Ford Motor Co., etc.). According to the Preface, the focus of the papers is to be on "...demand and supply interactions, environmental effects, and evolving vulnerabilities and opportunities..." as these factors affect energy systems.

The 16 papers involve some similarities of approach: a subject is identified, some technical issues are placed into context, an analysis of historical data is presented and discussed, and careful (or hedged) projections suggested. With few exceptions, the tone of each paper is cautious and conservative; if it were not for the graphical displays and tabular information, this book could well be confused with the proceedings of a conference on national monetary policy by leading bankers and government officials.

At the same time, it does contain some islands of novelty and some new perspectives. Weinberg's classification of "schools of thought" on energy demand forecasting is refreshing; Starr's identification of historical electrification paradigms conveys, by implication, an interesting aspect of US social history; Graedel provides a compact and informative listing of first-order effects on the atmosphere brought about by energy production; Sand provides a well-documented and integrated perspective on the European struggles with transboundary air pollution; but a closing article, that attempts to make Machiavelli and Buddah relevant, appears jarringly out of place.

The continuing publication of papers on energy unavoidably regenerates some material found elsewhere. It is a little recognized challenge for energy analysts to extract, from such a mountain of observations and interpretations, the molehill of knowledge that is universal and time invariant. Here and there, throughout this volume, one does find references and allusions to themes deserving emphasis for further analytical development:

- the consistent appearance of different energy supply/demand elasticities over the long and short terms;
- the apparent need for an objective framework of risk/reward symmetry;
- the difference between the rates of diffusion of technological developments and the policies associated with them;
- the important role of small-scale versus large-scale domains of statistics.

Publications such as *Energy: Production, Consumption and Consequences* can serve a useful role, but their value would be enhanced if more emphasis were placed on findings and interpretations which translate more readily in space and time.

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Empirical Modelling of Canadian Petroleum Exploration Activity

by CATHERINE M. DESBARATS
Oxford: Oxford Institute for Energy Studies, 1989
pp.81

A fundamental problem involved in an attempt to design an empirical model of exploration in the petroleum industry is the uncertain nature of the activity to be modelled. This book reviews and evaluates some of the existing models of Canadian exploration activity and then presents another empirical model in an attempt to resolve some of the problems with the earlier models.

In the empirical literature on exploration activity there are models with distinct approaches. Two common methods are distinguished by viewing exploration activity either as a form of *production* (using reserves additions or discoveries as the dependent variable) or as a form of *investment* in productive capacity (using exploration expenditures as the dependent variable). Desbarats performs a number of statistical tests on existing models of both types to determine their validity for statistical inference. The test results indicate that the first approach results in

specification problems. These arise, at least in part, because, while the theoretical literature asserts that production and exploration are jointly determined, they are modelled separately using this approach. Although there are also problems with models that use the investment approach, it is argued that it is a more fruitful area for further research.

The book then proceeds to present a new empirical model of exploration activity using the investment approach. A major difference between this model and previous ones is the inclusion of additional variables, particularly those relating to the real cost of acquiring reserves. A number of diagnostic statistical tests were performed on this model; they indicate that, despite some remaining problems, the new model specification is preferable to the other models evaluated in the book.

With such positive results, the book is a worthwhile addition to the empirical literature on exploration activity. One drawback is that the model is based on the time period 1949-1982. It would be interesting to see if the model is equally successful when the sample is extended beyond 1982.

The general reader should note that, apart from some background information, the book is written for an audience interested in the technical econometric analysis of exploration activity.

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