

Russell J. deLUCIA
Henry D. JACOBY
and others

ENERGY
PLANNING
FOR
DEVELOPING
COUNTRIES:
A Study of
Bangladesh

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PREFACE

Rapidly rising oil prices are placing a serious burden on the resource-poor less-developed countries. The planning and management of the energy sector in these countries is of growing importance to their prospects for growth, or even survival. This book is about the task of investment analysis and planning in this circumstance. Our intended audience includes those responsible for these energy-sector decisions: the practitioners in LDC planning bureaus and their counterparts in the international and bilateral aid agencies, and the analysts in consulting firms active in the field. We also hope the book will be useful in training those who will take on this urgent task in years to come.

This book is drawn in the main from an energy sector study of Bangladesh that was carried out in 1975 and 1976 under sponsorship of the United Nations Development Program (UNDP) and the Asian Development Bank (ADB).¹ Referred to here as the BES, this study was one of the first to take a sector-wide view of the energy problems of an LDC, and it provides a rich store of material for discussion of how such analysis should be done, and where some of the pitfalls may lie. Using the BES experience and the work of similar studies elsewhere, we examine the various components of investment planning in the energy sector. The book is relatively heavy on analytical methodology, but we have tried to go beyond analytics to consider the social and institutional context in which this type of work is often done, and to be self-conscious about the process in which we, as the analysts in this study, were involved. Not surprisingly, we found it difficult to be reflective about the overall planning process and our peculiar role in it, but it is our hope that this attempt will contribute to a clearer understanding of the role of analysis, and of foreigners, in LDC planning.

The Bangladesh study was initiated by a government committee organized shortly after the war of independence to examine the country's energy resources. External support was sought from the United Nations Development Program for a project to be administered and partially supported by the Asian Development Bank. With this assistance, a terms of reference was prepared for a consultant study and a set of firms was invited to submit proposals. Ultimately, the work was carried out by a consortium of firms which

1. *Bangladesh Energy Study for the Government of the People's Republic of Bangladesh*, administered by the Asian Development Bank under United Nations Development Program Project BGD/73/038/B/01/45, prepared by the Montreal Engineering Co., Ltd., Snamprogetti S.p.A., Meta Systems Inc., and C. Lotti e Associati S.p.A., November 1976.

included Meta Systems Inc., Cambridge, Massachusetts; Montreal Engineering Co., Ltd., Montreal, Canada; C. Lotti and Associates, Rome, Italy; and Snamprogetti, Milan, Italy. Snamprogetti had prime responsibility for the gas development and associated facilities studies, including the one domestic refinery; C. Lotti and Associates provided supporting service in agriculture and river hydraulics; and Montreal Engineering had responsibility for the electric power, coal, and nuclear studies as well as the management of the overall group effort. Meta Systems Inc. conducted the economic and systems analysis studies. The authors of this book were members of the Meta team, and it is from their work that much of this volume is drawn.

After the BES was completed, there began a set of discussions of the possibility of using it as the basis for a book on energy planning. There was encouragement both from our professional colleagues and from the representatives of the Bangladesh ministries, and the UNDP and ADB, with whom we had worked. Also, we were gratified to receive formal government approval to use the study material in this way. Given this support, we approached the Rockefeller Foundation for funding to cover editorial and production costs. The aid from Rockefeller has been crucial; but even beyond financial aid, the interaction has had a substantial effect on the content of the effort. It was Mason Willrich and Edwin Deagle of the Rockefeller staff who encouraged us to try to capture the process of planning and to be reflective about the role of analysis and analysts, and the resulting chapters are to our view both different and more informative than they otherwise would have been.

The book begins with two chapters that introduce the concept of energy sector planning and give some background on the Bangladesh example. For individual projects and energy subsystems, planning is a natural component of capital choice and operations management, as evidenced by the now common application of systems analysis to electric power networks. At an aggregate level, many countries also carry out macroeconomic analyses to guide decisions regarding fiscal, monetary, and trade policy and investment allocation. In the hierarchy of planning activities, "sector" analysis lies somewhere between these two extremes, usually with active links to economy-wide issues and to studies of project details. The discussion of these analysis components, and the flows of information among them, provides a preview of what is to come in the Bangladesh case. It also is intended to serve as a framework whereby our experience can be interpreted in the light of conditions in other countries.

Also, in chapter 1 we introduce some of the institutional factors that come into play in an effort such as the BES. An energy sector study is likely to involve several organizations from the host country, one or more foreign national or international aid agencies, and some collection of domestic and foreign consultants. The outside observer usually sees only the final report with its tables and figures and rarely is party to the undercurrents of the relationships among the players. To describe this process is a delicate and diffi-

cult task, but we attempt it in order to put the analytical work in context, and to set the stage for later chapters, where occasionally we pause to reflect on the BES work and comment on its applicability elsewhere.

Chapter 2 tells about Bangladesh—its economy, its energy sector, and the key investment choices—and presents a summary of the data gathering efforts and analytical models that were brought together in the study. The most efficient way to get a quick idea of the components of the BES—and of the way this book is put together—is to look at section 2 of this chapter, “Analytical Models and Information Flow,” and at figure 2.2.

Chapters 3 through 10 present the analysis step by step, proceeding from the agricultural and rural sector analysis to the macroeconomic work and demand estimation and finally to investment planning. The analytical work begins with agriculture because the Bangladesh economy is so dominated by this sector; in our analysis of economic growth (and associated energy demand) it is the key driving force. Moreover, the farm sector is simultaneously the major source of energy supply to the economy, in the form of agricultural residues, and an important sector of energy demand. A special analysis of agricultural growth was carried out, using an analytical model of investment, technical change, and crop choice. This analysis, described in chapter 3, was facilitated by previous data development and modeling work in the country.

The output of the agricultural model includes the sector's contribution to national product, and energy demands associated with pumping and fertilizer use. It also produces estimates of the shifting output of various crops. Chapter 4 probes the larger issues of traditional and renewable energy resources and, with the addition of special studies of firewood, shows how estimates of energy supplies from the rural sector are developed using the agricultural model results. Most of the now-developed countries have gone through a transition whereby wood and agricultural residues have been replaced by various fossil fuels and perhaps nuclear power. Traditional sources have by and large gone out of use as sources of heat. However, for countries like Bangladesh with low incomes and a dominant agricultural sector (and considering current relative prices of fossil substitutes), the development pattern will likely be very different, with traditional sources remaining as an important component of the energy balance. Moreover, changes in crop mix and in patterns of traditional versus commercial energy use may have significant implications for the conditions of life in many rural villages. As noted in chapter 4, the BES was an early and primitive attempt to integrate these considerations into an energy sector study, and we include some views of how this type of work might be better done in the future.

Chapter 5 contains the macroeconomic analysis. To understand energy demand it was necessary to have some way of analyzing future economic growth and its likely sectoral composition. In Bangladesh, because there were no macroeconomic studies appropriate to the particular needs of energy forecasting, a set of simple models had to be constructed. This part of the

BES included a forecast of population growth, an analysis of macroeconomic growth given the agricultural results and assumptions about other parameters, and a breakdown of economic activity by sector.

The resulting macroeconomic scenarios, plus the pumping and fertilizer data from the agricultural analysis, then became the basis for preparation of demand estimates. In the BES, the demand analysis involved the estimation of coefficients of energy use (in Btu's and kilowatt-hours) per unit of economic activity in various sectors, and the aggregation of these data into regional and national figures. Chapter 6 describes the procedure, and some of the difficulties associated with it.

Another step in preparation for planning calculations is the estimation of key planning parameters, such as the discount rate and the shadow exchange rate, and the calculation of shadow prices for certain input commodities and project outputs. Prices related to the macroeconomy are covered in chapter 5. Others are described in chapter 7, where particular attention is given to the valuation of indigenous resources of natural gas. Chapter 7 also contains discussion of the very problematic topic of governmental policy regarding energy tariffs.

The investment analysis is divided into three chapters in order to display the various components that are combined in the sector-wide systems studies. Two additional models were applied in the study. Both are simulation models using internal linear programming algorithms to approximate the results of system operation. Both also rely on the analysts themselves to formulate the investment plans to be evaluated. Particular projects and system changes are studied by comparison of sets of plans "with and without" particular components. Chapter 8 treats the electric power analysis. For simplicity, its form is illustrated by a choice between hydroelectric and thermal generation, which does not involve complex interaction with the fuels sector. Chapter 9 then presents the model applied to the fuels and fertilizer systems. Illustrations include choices regarding urea plant construction and investment in biogas facilities. Again these choices do not involve close interaction with the power analysis.

In chapter 10, the overall systems analysis is put together, using as an example a major east-west energy transmission system that does require joint consideration of the electric and fuels network. Also, we describe the way the systems studies, and various sensitivity tests, can be used to prepare an overall sector investment plan. The analytical discussion closes with a brief return to the institutional realities through a review of what has happened in terms of implementation of study results.

Finally, in chapter 11, we provide some brief afterthoughts on the BES and the implications we would draw for subsequent efforts at LDC energy planning. It is a personal note, reflecting both our sense of the importance of these types of studies and some thoughts about how they might be improved.

This book owes much to both individuals and institutions. It is impossi-

ble to name all the colleagues and friends who assisted us, but we would be remiss without giving some acknowledgments. First and foremost, we would like to thank our colleagues who are the authors of many of the chapters of this book, and give a special word of appreciation to Richard Tabors who bore more than his share of the load in the final stages of preparation.

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Several people worked on the economic and systems studies but did not participate in writing this book. Besides Dr. Islam—who contributed generously of ideas, time, organizational leadership, and support—other government staff helped enormously. Dr. A. Matin worked full-time with us as a contributing colleague, and the study benefited from his intellectual and organizational contributions. From the executing agency, the Asian Development Bank, Mr. V. V. Desai was a source of ideas and constructive criticism. Dr. Mohiuddin Alamgir from the Bangladesh Institute of Development Studies provided a rare blend of personal friendship, support, and insightful criticism. H. Brammer, the senior adviser of the Food and Agriculture Organization in Bangladesh, contributed ideas and his vast knowledge of the Bangladesh farm sector; his previous work formed a key building block in the agricultural analysis.

Naturally other members of the consultant team were crucial to the study. From our Canadian colleagues, two people deserve special notice. J. H. Diddens, the project director of the BES, brought long experience with development studies, project analysis, and Bangladesh itself. M. Murchison was leader of the technical work on electric power. From the Italian component of the team, E. Pimpinelli, A. Momesso, and E. Torielli deserve special mention for their work on agriculture and the technical aspects of fuels studies. Without the extensive knowledge and close cooperation which were forthcoming from the engineering consultants, much of the economics and systems work would have been impossible. We also owe much to Douglas Smith, who was part of the Meta team but did not participate in writing this book.

There are many others who have contributed to our broader understanding of energy planning through our work together on other projects, but par-

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