THE CHANGING ROLE OF FUEL SWITCHING: IMPLICATIONS FOR ENERGY POLICY AND ANALYSIS

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Summary

This article analyzes the role of fuel switching and fuel choice in the power generation sector. A distinction is made between fuel choices in new and existing power plants. It is concluded that while fuel choice in the past mainly was an issue of new capacity choice, it has become increasingly important to consider the choice between new and existing capacity as well as fuel switching within existing power plants. Increased uncertainty about fuel prices, low electricity demand growth, deregulation of power markets, environmental policies, and technological change, has all contributed to this increase in flexibility. This has important implications, both for the way in which future research efforts should be conducted and also for how energy and environmental policies should be implemented. Future research could gain a lot by relying on the use of the real option valuation method, in particular since this approach permits the value of flexibility in fuel choices to be recognized explicitly. Future regulations and policies should, in contrast to many past policies that mandate the methods of compliance, encourage the creativity of power generators in their search for least cost control

methods. Environmental pricing, preferably in the context of tradable permit systems, is likely to be a key to efficient policies.

1. Introduction

Electricity's share of total energy consumption is growing worldwide. Data from the International Energy Agency (IEA) indicate that in 1995 around 16 percent of global final energy consumed was served by electricity, a share that has been increasing in the past and is expected to increase even more in the future. For example, in 1971 the corresponding share was 10 percent and it is expected to be above 20 percent in 2020. This is true in particular for the developing countries where electricity services have a high priority as a requisite for continued economic growth. The expanding role for electricity makes the choice of fuels for power generation one critical factor in shaping the primary fuel mix in the future. Accordingly, as has been the case in the past, electricity generation will most likely be the focus of many future policy initiatives aimed at encouraging fuel switching in primary energy use.

The fact that power generation contributes to global carbon dioxide emissions; that it is concentrated in relatively few and large facilities; and that electricity provides much more flexibility than do most other energy uses, reinforces this conception. This flexibility is not only a result of the fact that electricity can be generated with a number of diverse technologies (steam-electric, hydro, nuclear, wind, solar, etc.), but also of the fact that short-term fuel switching can occur regularly within existing power plants (see Section 2). The important role played by electric power has prompted much economic research, and there exists a large literature focusing on the different aspects of fuel choice in power generation.

The present article draws on this literature as well as on historical developments, in order to analyze the role of fuel switching in power generation. An important distinction is made between fuel choice in new and existing capacity. We note in particular that while fuel switching 25 years ago primarily was an issue of capacity choice in new power plants, it has now become increasingly important to consider the choice between new and existing capacity as well as fuel switching within existing capacity. Factors such as increased uncertainty about future fuel prices, low electricity demand growth levels, technological change, siting problems, environmental regulations, and deregulation have all contributed to the increased value of existing power plants with low operating costs and the growing demand for flexibility in the power sector. The main purpose of this article is to describe this development and discuss what the implications are for energy policy on the one hand and for future economic research on fuel procurement in the power sector on the other.

Section Two presents a rough theoretical framework describing the fundamentals of fuel choice and fuel switching in power generation. By employing this framework, Section Three analyses the changing role of fuel switching since the 1960s. It notes in particular that, over the years, the prospects for reactivating large-scale power projects have become limited, and, as a result, refurbishing and increased utilization of existing plants, as well as conversions of plants to new fuels, have gained in importance. In addition, technical progress has made possible, and deregulation has stimulated, the introduction

of more flexible and less capital-intensive investment in new power plants. The remainder of the article discusses the consequences of this development. Section Four reviews earlier economic research on fuel switching in the power sector, and seeks to find appropriate starting points for pursuing further research. In Section Five the public policy implications of the changing fuel switching situation is reviewed, while Section Six provides some brief concluding remarks.

2. The Fundamentals of Fuel Switching in Power Generation

In this section a rough theoretical framework, which focuses on a number of key points in fuel choice behavior, is presented. The capital-intensive nature of the electric power industry means that a distinction between fuel substitution in new and existing capacity has to be made. Electric power production is often assumed to be a so-called putty-clay technology. In principle, this means that *ex ante*, that is, prior to the construction of a new plant, there is clearly the possibility for substitution between all factors of production (including all fuel inputs). However, once the plant's design is fixed in terms of the specific capital equipment, the scope for substitution is substantially reduced. In other words, *ex post*, the elasticity of substitution might be very low, or even zero. Thus, according to this view, fuel choice is largely embodied in the choice of new technology.

Figure 1 illustrates the difference between *ex ante* and *ex post* substitution using elementary production theory. Here an arbitrary electric utility chooses between two fuel inputs, gas and oil. *Ex ante* it could choose any fuel combination on the curved isoquant. (An isoquant provides a representation of the underlying production technology by showing different minimum combinations of two input factors producing the same level of output). However, once it has chosen say point A, the utility will have to produce with that particular fuel ratio thereafter. For example, if it wishes to reduce output it must move back along the line 0A. Thus, the utility's *ex post* isoquant is now rectangular implying an *ex post* elasticity of fuel substitution of zero.

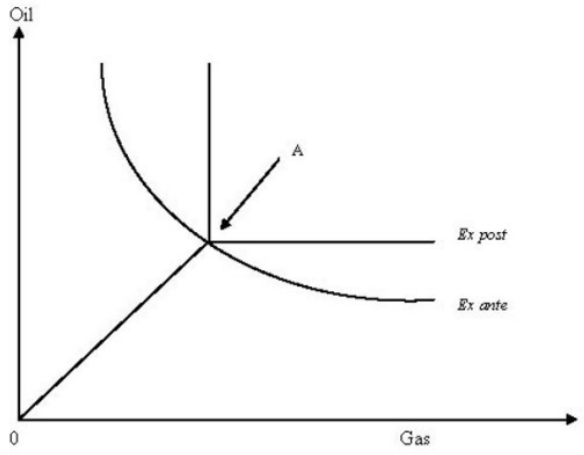

Figure 1. Fuel Substitution Possibilities in a Putty Clay Technology

The above largely represents the traditional view on fuel choice in the power-generating sector. Statements such as; "the physical capability to switch fuels is apparently a long-run investment factor and is not a short-run cost related factor," are widespread.

However, in this section we identify a number of fuel switching potentials involving existing capacity, and these may, under certain circumstances, permit only a relatively limited role for new capacity developments. Before exploring these potentials, however, we first discuss how the economic merits of different new power generating technologies can be compared.

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Biographical Sketch

Patrik Söderholm has a Ph.D. in Economics and is Associate Professor at Luleå University of Technology, Sweden. He has been a Research Fellow at the Center for Energy and Environmental Policy Research, Massachusetts Institute of Technology, Cambridge, US, and an Associate Researcher of SNS Energy, Stockholm, Sweden. His research has focused mainly on energy and environmental economics,

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