TECHNOLOGY TRANSFER INTO CAPITAL-INTENSIVE INDUSTRY:
I. THE PAPER INDUSTRY BY THE YEAR 2000

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ABSTRACT
Traditionally, new technology has been slow to enter the paper industry, which turns over its capital stock in about 40 years. In this paper, we will examine some of the reasons for this long transition period and the implications of such a transition period for government policy. If the turnover time could be cut in half, the potential energy savings could be 4 quadrillion Btu (Quads) in 20 years. Examples of new technologies that will become prominent throughout the paper industry by the year 2000 include vapor recompression evaporation, oxygen bleaching, twin-wire forming and extended nip pressing. We present explicit projections of production shares (based on a computer model) for selected new technologies.

New technology blends into an industry over a period of years. This paper examines some of the factors that accelerate or retard this transition in the capital-intensive ("heavy") industries. For purposes of this article, our example is the paper industry, and so the examples of new innovations are drawn from pulp and paper-making processes. (Incidentally, we use the term "paper" throughout as a shorthand for SIC 26, Pulp, Paper and Paperboard.)

The examination of paper-industry technology reported here is based to a great extent on a study of industrial energy use [1] conducted by the Office of Technology Assessment (OTA) for the U.S. Congress. The OTA study examined the four most energy-intensive American industries (paper, steel, chemicals and petroleum refining), to identify technologies to improve energy efficiency, to project industrial energy use in each industry between now and the end of the century, and to assess the impact of various policies on energy use and energy efficiency.

The study found remarkable similarities between the four industries. One notable commonality is the attitude of management towards introduction of new technology.
I. Measurement of "Technology Penetration"

Technology Transfer sometimes carries a certain image of imprecision, owing to the difficulty of determining when a transfer has been successful. Whenever a quantitative indicator of such transfer can be identified, it can clarify the discussion, and thus facilitate the assessment of cause-and-effect relationships underlying the transfer process.

In the particular case of the paper industry, we have chosen the energy intensity of the paper making process (commonly expressed in million Btu per ton of air-dried paper) as an indicator of the degree to which technology is changing throughout the industry. This choice is not perfect in that a non-energy-saving innovation will escape attention when this yardstick is used. However, because rising energy costs have been a dramatic impetus to change in paper making technology over the past 10 years, and since good data on energy intensity exist for that time period, we elect to focus on the introduction of new energy-saving technologies by using energy intensity as our measurement of innovation. Since purchased fuel costs are now 14% of the value of total shipments of paper, energy considerations are an important component of decisions to proceed with a new technology.

Figure 1. Comparison of energy use and production output by paper industry, 1972 and 1981. Both indices normalized to 100 in 1972.