Case Study 1: "Clean Coal" and the Future of Electric Power

The United States is richly endowed with coal, a form of carbon-based fossil fuel. Much of the coal in the Western US is low in sulfur content (lignite), while that found in abundance in the Midwest is higher in sulfur content (bituminous). The trick is to balance the blends of these two coals to optimize power production while limiting air emissions, particularly of sulfur dioxide (SO_2) and nitrous oxides (NO_x). In 1986, the US Department of Energy (DOE) launched the "Clean Coal Technology Program" to demonstrate a new generation of innovative coal processes. We can envision a coal "fuel chain," along which steps can be taken that affect the amount of sulfur and nitrogen emissions released to the atmosphere from the production system. In industrial ecology, the goal is to minimize these emissions. Advanced technologies include precombustion cleaning (through physical, chemical, or biochemical means); fluidized bed combustion and advanced combustors (which clean coal in the process of its combustion); post-combustion "scrubbing" of SO_2 and catalytic reduction of NO_x, and integrated coal gasification combined cycles (which use turbines that run on conventional steam *and* waste gas).

Suggested sources of information:

- Center for Energy and Economic Development, 1800 Diagonal Road, Suite370, Alexandria, VA 22314. Tel (703) 684-6292; FAX (703) 684 -6297; online at CEEDNet via http://www.conx.com/ceed. An 11-minute video called *America's Fuel* is available online which describes clean coal technology.
- National Mining Association, 1130 17th St. N.W., Washington D.C. 20036-4677; telephone (202) 463-2665.
- Electric Power Research Institute (EPRI), P.O. Box 10412, Palo Alto, CA 94303;telephone (510) 934-4212.

Case Study 2: The Future of Steel Production -- Minimills

Once the world's leading producer of steel, the United States saw its market share drop precipitously during the 1970s and 1980s. Midwestern cities were hurt by steel mill closures, as jobs vaporized and an increasing stream of foreign-manufactured products entered the marketplace. The large steel mills that lined the south shore of Lake Michigan and elsewhere in the southern Great Lakes region -- belching smoke and acidic emissions and consuming vast quantities of coke, iron ore, and other inputs -- attested to the failure of Big Steel to adapt to a changing economic landscape and technological developments. For many years, Big Steel failed to modernize its plants, even though the adoption of new production technologies could have lessened the industry's environmental impacts and improved its efficiency. Big Steel and its industrial-social culture seemed destined -- in the US at least -- to go the way of the dinosaurs.

The integrated steel mill of the past serves as a perfect example of an immature industrial ecology -- closer to the Type I than Type II model of Graedel (1994). Its problem was waste, including wasteful material inputs (virgin ore and coke), wasteful conversions of energy (reliant on high-sulfur coal for coke in blast furnaces), wasteful outputs (sulfurous emissions and other atmospheric pollutants), and wasteful human inputs (top-heavy management and low productivity).

During the 1980s, a new model developed that turned the tide for American steel manufacturing -- the steel minimill. Richard Preston (1991) traces the rise of the minimill in a series of articles published in the *New Yorker*. Preston's particular focus is the Nucor Steel Corporation and its revolutionary process for continuous strip production of sheet metal. The phenomenon is important both from an economic geography perspective (with its implications for international trade, regional development, and location theory) and from an industrial ecology perspective. From the latter perspective, minimills represent small-scale installations whose material inputs come from scrap steel; hence, minimills serve as materials recyclers. They use electric arc furnaces instead of coal-fired blast furnaces, greatly reducing the energy inputs per unit of steel output, and having the potential to reduce atmospheric emissions.

Suggested Sources of Information (see *References to All Units* for complete citations)

- On the future of the steel industry in general: Baker, 1994b, 1995a; Boyd, et al., 1993; Clash, 1994; Church, 1994; Hogan, 1991; Miles, 1988; Ohasi, 1992; and Smith, 1995.
- On Nucor Steel Corporation in particular: Alexander, 1994; Baker, 1994a, 1995b; Boston, 1990; Brody, 1988; Lubove, 1993; Pare, 1991; Schroeder and Konrad, 1990; Wofford, 1995.

Case Study 3: Recycling Scrap: Municipal Solid Waste and Waste-to-Energy

There has been a growing recognition that the “waste stream” of municipal solid waste (MSW) represents an abundance of materials that can be reused or recycled. In particular, organic materials comprise a significant proportion of MSW and can provide a source of fuel. The process of turning waste material into an energy source is known in the industry as “waste-to-energy”(WTE). The industrial ecology cycle involved in WTE is fairly straightforward. Organic material in MSW is separated from non-combustible material, then incinerated in a WTE plant. Combustion of this organic fuel produces thermal energy that is harnessed using a steam turbine to drive an electric generator. Advanced technologies are used to capture the sulfur and NO_x byproducts, preventing them from leaving the plant.

The electrical power thus produced can be sold to the local power grid, and the uncombusted solid wastes (recyclable metals, compostable matter, glass, rock) can be sold elsewhere making the WTE business lucrative. The overall reduction in solid waste that has to be sent to a landfill is a credible environmental benefit. The appeal of WTE from MSW is great, given our industrial ecology perspective, and our recognition that technology change can serve as a positive guiding force for global change. There were approximately 125 WTE plants in the United States in 1995 and they appear to be growing in popularity (Arrandale 1993; Charles and Kiser 1995; Hocker 1991; Williams 1990).

Additional Sources of Information

- *Solid Waste Technologies* (formerly *Solid Waste & Power*) is a trade journal with a wealth of information on the solid waste industry including companies, services, and products. Each year, its annual special issue *Industry Sourcebook* provides company profiles and a guide to over fifty organizations that provide technical assistance, information, or other support functions for the solid waste industry.
- *Power Plays*, by Susan Williams, is a database of renewable energy developers, with particular focus on MSW WTE producers ($150 softbound, $200 hardbound available from Investor Responsibility Research Center, P.O. Box 50, Plainfield, NH 03781; telephone 603-675-9274)
- A catalog of government publications is available from the US Environmental Protection Agency, *Catalog of Hazardous and Solid Wastes Publications* (EPA 530-B-95-001 Sept. 1995)
- Online Sources:
  - EPA Fact Book (http://www.epa.gov or http://www.cal.net/recycle//index.html)
  - Recyclers World (http://www.recycle.net/recycle/index/index/html)
  - Use Less Stuff (http://www.com.ch.as.msen.com:70/1/vendor/cygnus/uls)
  - Also, the US Department of Energy (DOE) and the Solid Waste Association of North America (SWANA) maintain websites; access may be gained by typing “municipal solid waste” in a netsearch.

Case Study 4: Energy Crops and a New Role for Industrial Agriculture

A promising alternative to unsustainable hydrocarbon fuels may come from the farm. The biomass produced by plants represents stores of chemical energy, fixed through their metabolic processes and powered by the photosynthesis of CO_2 and H_2O. Plant tissues can be converted into thermal energy through combustion, which releases CO_2. In biomass energy conversion, however, there is the possibility of achieving a Type III ecology: if the CO_2 released during combustion is balanced by CO_2 taken up by growing plants, then biomass energy can "close the loop" and qualify as an industrial ecology.

Biomass energy stocks are derived from two principle sources -- the production of energy crops and organic wastes. Various grasses, conventional row crops that are rich in starches (e.g., corn and sorghum), fast-growing trees (or short-rotation woody crops such as hybrid poplar and honey locust in North America), and wetland species such as cattails and reeds (often used for wastewater treatment) can serve as energy crops. To provide liquid fuels that are especially attractive for use in transportation, the carbohydrates in biomass may be distilled to yield alcohols such as ethanol, which is already in use in many parts of the American Midwest and throughout Brazil. Biomass energy production has the potential to protect against soil erosion, establish wildlife habitat, provide versatile and modern energy carriers (in the form of solids, liquids, or gases), and to protect the viability of agricultural communities against increasing urbanization.

Additional Sources of Information (for complete citations, see *References to All Units*)
On ethanol production:

- *More for Less* is a video from the Annenberg/CPB Project film series *Race to Save the Planet*; it describes the ethanol program in Brazil (approx. 60 minutes in length).
- See also Goldemberg et al. (1993); Reddy and Goldemberg (1991); and Wyman et al.(1993).
- On technical problems with biomass conversion, see Hohenstein and Wright (1994); Wright (1994).
- On economic problems see Turhollow (1994).
- On environmental problems see Ramney and Mann (1994) and Williams (1994)
- Also useful is *NREL in Review*, the periodical produced by the National Renewable Energy Laboratory, Golden, Colorado.
- Oak Ridge National Laboratory has a Website on the biofuels feedstock development program (BFDP), URL is http://www.esd.ornl.gov/bfdp/bfdpmosaic/binmenu.html
- The addresses of the DOE's five regional biomass energy programs are listed below; *Biologue* is the industry's trade journal.
    - Northeast Region

      Richard Handley
      CONEG Policy Research Center, Inc.
      400 North Capitol Street, N.W., Suite 382
      Washington, DC 20001
      (202) 624-8454
      (202) 624-8463 FAX

- Northwest Region
  Jeff James
  U. S. DOE Seattle Regional Support Office
  800 5th Avenue, Suite 3950
  Seattle, WA 98104
  (206) 553-2079
  (206) 553-2200 FAX

- Southeast Region
  Philip C. Badger
  Tennessee Valley Authority
  Southeast Regional Biomass Energy Program
  435 Chemical Engineering Building
  Muscle Shoals, AL 35660
  (205) 386-3086
  (205) 386-2963 FAX

- Western Region
  Dave Swanson
  Western Area Power Administration
  1627 Cole Boulevard
  P. O. Box 3402
  Golden, CO 80401
  (303) 275-1706
  (303) 275-1707 FAX

- Great Lakes Region
  Fred Kuzel
  Council of Great Lakes Governors
  35 East Wacker Drive #1850
  Chicago, IL 60601
  (312) 407-0177
  (312) 407-0038 FAX