may work hard to win a game or improve his skill, but chess and tennis are forms of play. An artist may work hard to perfect a work of art, but the work perfected is an expression of play, an energy complete in itself that shows what the work has been done for. Science and technology work hard to help achieve what would be, once achieved, a life of play, where nature is no longer conquered territory held down by man but is lived in as his home, and where the mental work of solving problems has become *scientia* or *philosophia*, the love of knowing, the play at the heart of all genuine work.

The Book of Proverbs in the Bible describes wisdom as a female principle who was a part of God's mind at the creation. The King James translation speaks of her as "rejoicing," but this is a very weak form of the tremendous Vulgate phrase *ludens in orbe terrarum*, playing throughout the earth. This world of play or spontaneous energy is the deliverance to which all religious and political ideals point, and some glimpse of it is accessible to any artist or scientist at any moment. The ordinary division of our lives into work and play makes work the endless pursuit of a donkey's carrot into the future, and play a relaxation from this that reminds us of the carefree days of our childhood. But the genuine human energy of the arts and sciences converges on a world where work and play have become the same thing. A gathering together of such people with such interests, including this one, would be in the deepest and most serious sense a play *ground*, a common meeting point where all forms of language are interchangeable, all statements of identity, whether metaphors or equations, balance out, and scientists and humanists shake the past and the future out of their bones and join together in a present life.

Iron Ore: From Depletion to Abundance

Peter J. Kakela

The massive amounts of materials consumed during World War II produced a widespread fear that America was running out of certain vital natural resources. On 6 September 1945, President Truman addressed Congress (*1*):

> We have torn from the earth the copper, iron ore, tungsten, and every other mineral required to fight a war, without regard for our future supplies. We have taken what we needed. We were not able to, and we did not, take account of tomorrow. . . . [Now] we must make a diligent effort to discover new deposits. . . . And we must develop for the use of industry new technologies so that the vast deposits of low-grade ores . . . may be put to work.

Iron ore was then seen as one of the resources most vital to our industrial way of life, whether in war or peace. An iron ore depletion scare, much like our current energy crisis, developed because of a belief that our rich, easily accessible domestic ore supplies were nearing exhaustion. More than 85 percent of the U.S. iron ore consumed during World War II came from the rich open-pit hematite mines of the Lake Superior region; more than 60 percent came from just one range, the Mesabi of northern Minnesota. In December 1945, *Fortune* magazine ran an article entitled the "Iron ore dilemma" and subtitled "Unless the U.S. is to turn increasingly to foreign sources for its ore, it must give new life to the wasting Mesabi" (*2*). *Fortune*'s dramatic description of the Mesabi must have caught postwar emotions:

> Out of this tiny strip the steel-age economy has sucked like milk from the earth mother's breast, by far the largest portion of the principal food out of which its bones and muscles have been built: its machines and tools, its buildings and bridges, its railroads and automobiles and generating plants. Blasted and gouged from the strip's awesome open pits and scattered underground mines came a full two-thirds of the iron ore for the 400-odd million tons of steel out of which the U.S. fashioned the war plants, ships, planes, tanks, guns, bombs, and shells of World War II.

The Minnesota Tax Commission took a hard look at the Mesabi open-pit reserves in 1946 and estimated that 575,000,000 long tons of hematite ore remained (*3*). Republic Steel's president C. M. White then calculated the Mesabi's expected life. The *New York Times*, reporting on his 1947 speech, wrote that "at the present consumption rate the Mesabi open pits, which may not even be as large as the Minnesota Tax Commission estimated, will be exhausted within five to ten years" (*4*). After the "cream of the Mesabi" is skimmed off, White predicted, rich hematite ore in the United States will be a "rusty memory."

By 1955, newspaper headlines and magazine articles were publicizing a different tale: "Depletion danger met" (*5*) and "Worry over predicted shortage of iron ore can be forgotten," "One more 'scarcity' ends for U.S. industry" (*6*). Today there is no problem supplying domestic iron ore to U.S. steel mills. If anything, the situation is one of oversupply.

How was this iron ore scarcity reversed? What forms of government assistance, if any, brought about this dramatic turnabout? Understanding this case history may help us to think about resource scarcities we are facing now and how government policies may, or may not, help alleviate them.

Dual Response to Iron Ore Scarcity

In keeping with President Truman's 1945 suggestion, the steel industry launched a dual attack to expand iron ore reserves. First, it sought new deposits of high-grade hematite (and other rich, naturally concentrated iron ores), largely in foreign countries. Second, efforts were launched to develop new technologies capable of enriching the iron ore content of the Mesabi's abundant, but traditionally uneconomical, low-grade taconite. The government enacted policies supporting these industrial efforts, especially the development of new taconite technology.

Solution 1: Foreign ores. Initial results came from geologic explorations. Rich foreign ores exceeding 60 percent iron in the crude, with some as high as 69 percent, were developed. During the war, Bethlehem Steel Company imported iron ore from Chile, and afterward began developing large, high-grade concessions in Venezuela. U.S. Steel discovered and

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began producing ore from another rich hematite deposit in Venezeula, while Republic Steel Company went to Africa and bought a hematite deposit in Liberia.

Rich ores were discovered on Canada's Labrador-Quebec border and exploited by the Iron Ore Company of Canada, created in 1949 by Hanna Mining Company of Cleveland, Ohio. With the subsequent opening of the St. Lawrence Seaway in 1959, Canadian ore could be shipped more economically to steel mills bordering the Great Lakes.

The Mesabi ore contrasted greatly with the rich foreign hematites. The Mesabi standard was just above the 51.5 percent iron base for domestic shipments. Other domestic ores were even worse. For example, in 1949, Republic bought ore near its Birmingham, Alabama, plant that ranged between 41 and 44 percent iron (*7*). The richness of the foreign ores compensated for their higher transportation costs, creating stiff competition for the remaining domestic hematite deposits.

The foreign discoveries of rich hematite ore eased the iron ore depletion scare in the United States, but the war-nurtured fears of foreign resource dependence and cut shipping lanes remained. During World War II, Bethlehem alone had lost four iron ore ships enroute from Chile.

Solution 2: Taconite. The longer term answer to the domestic iron ore depletion fear came from the fledgling taconite technology, however, and not from the discovery of foreign ores. Today, taconite pellets account for more than 50 percent of the iron ore fed to American blast furnaces. Most hematite still used, whether foreign or domestic, is enriched and agglomerated into something like a taconite pellet. Development of lean-ore technology taught steelmakers valuable lessons and resulted in the creation of a superior product: pelletized iron ore.

Government policies fostered the development of taconite technology. Basic taconite research began during the 1910's and was successful in concentrating the low-grade magnetic taconite. Most of this work was done at the Mines Experiment Station at the University of Minnesota under the direction of E. W. Davis (*8*). By 1940, Davis' experimental plants on the Mesabi had failed financially; taconite was still considered a waste rock that might only have a use after hematite stocks were depleted. The 1945 *Fortune* article reported that "iron men clearly lack the knowledge to process taconite on a large scale now" (*2*). In 1948, Pickands Mather Mining Co. and several American steel company partners started the Erie Mining Co., a small experimental taconite plant on the eastern Mesabi. Early results, however, were unconvincing. In March 1950, U.S. Steel announced construction of a pilot plant at Virginia, Minnesota, to enrich (or beneficiate, as metallurgists say) low-grade hematite ores during the first year and to attempt to "concentrate taconite itself" during the following year (*9*).

In the early 1950's the beneficiating technology had advanced to a point where ultrahard taconite ore could be crushed and ground to the consistency of talcum powder and the iron concentrated with magnets so that it was no longer lean ore of 20 to 30 percent iron, but a rich concentrate of 60 to 64 percent iron. Technically, the last real problem was agglomeration.

Testimony before a congressional subcommittee by Republic's president White illustrates the state of technical awareness prevailing in 1950. White explained that the concentrated taconite "is so fine that it is almost impossible to haul in cars. It is almost as fluid as water. It has to be put back into a mechanical form that will hold together. A method has been developed of mixing this with water and rotating it in a drum and just rolling it around, like a great big . . . cement kiln. It comes out like little marbles. These are mixed with coal . . . and then baked in a furnace" (*10*). But it turned out that this coal mixing method failed as it produced a weak, porous pellet. Just 5 years later, however, both Reserve Mining Company (owned in part by Republic Steel) and Erie Mining Company began shipping the first commercial taconite pellets. The agglomeration problem had finally been solved by mixing clay, as a binder, with the taconite concentrate before balling and kiln firing.

Early taconite laws. It took taconite crusaders like Davis half a lifetime simply to open the door for taconite development (*8*). Davis, as the technology advocate, and others, as boosters of Mesabi range communities, worked effectively to get the first taconite tax law passed in 1941. It amended the Minnesota statutes to tax taconite primarily on the annual production of ore rather than on the value of the mineral deposits in the ground. By delaying the major tax burden until after production started, this law represented an important concession to mining companies. Despite this enticement, it took the industry nearly a decade to make a commitment to produce taconite commercially.

Michigan also passed a law favoring taconite (or, as it was called, low-grade iron formation) prior to commercial commitment. Enacted in 1951, the "specific ore tax" shifted the tax burden away from the value of reserves held (the ad valorem approach) to the value of the mine production, similar to the Minnesota law.

Summary. Following World War II, Americans feared their iron ore supplies were depleted. The steel industry attempted to increase supplies by exploring foreign countries for new, high-grade hematite ores and experimenting with technology that upgraded low-grade domestic taconite ores into acceptable, but apparently uneconomical, pellets. Government did little at first, but the Korean War renewed fears of domestic resource exhaustion. Congress quickly enacted loan guarantees, rapid tax write-offs, and other tax policies that helped commercialize taconite pellets for national defense. These policies lingered long after the Korean War ended. Other policies bolstering taconite were enacted on the state level well after taconite had replaced hematite as industry's ore of choice. Understanding how government policies helped to develop pelletized lean iron ore may help in thinking about current policy suggestions aimed at easing our energy crisis or other mineral shortages. For taconite, too much government help came too late.

Federal Resistance to Big Steel

Despite President Truman's early lead, the mood at the federal level in the late 1940's seemed skeptical, almost critical, of the large iron ore mining and steel manufacturing companies. In 1948 the Federal Trade Commission exposed the "international steel cartels" of the 1930's and their price-fixing practices (*11*). In 1949 a "Study of monopoly power" began in the U.S. House Committee on the Judiciary. The chairman picked steel as the "natural choice" for the first industry to study in detail. Because one steel firm controlled one-third of the U.S. ingot capacity, earlier congressional hearings suggested that steel might have passed beyond the domain of a competitive enterprise and that thought should be given to treating the industry as a public utility (*12*).

The hearing on "Steel's monopoly power" started in April 1950. Oscar Chapman, then Secretary of the Interior, was the first to testify. He stressed that

U.S. iron ore reserves, especially the rich Mesabi open-pit hematites, had shrunk to a level where the "question of whether there are sufficient raw materials for any company to continue in business outranks in importance the problem of whether a new company can go into the steel business today" (*13*). Chapman, as first witness, redefined the basic question of the investigation from one of possible monopolies to how government could best assist steel companies to survive.

Steel's proposal. A major witness for the steel industry was Republic's president White. He emphasized that "we are at the crossroads. Although great new bodies of high-grade [foreign] open-pit ore have been found and commercially feasible methods of reducing known low-grade domestic reserves have been developed, large sums of money are required to develop, mine, and transport such new high-grade ores and to beneficiate low-grade ores on a commercial scale. The expenditure of such sums of money will be encouraged if the present tax structure . . . on domestic reserves is changed" (*10*). White proposed three tax changes:

1) Recognize developmental and preliminary mining expenses as operating cost, not capital investments.

2) Provide rapid depreciation of ore-mining facilities and equipment erected to beneficiate taconite ores.

3) Keep the percentage depletion allowance adequate and free from continued threats of repeal.

The federal government responded slowly. At first, the only action was no negative action: the "percentage depletion" for iron ore was not cut. It remained, as it is today, 15 percent for ores produced in this country and 14 percent for U.S. companies producing foreign ores. Percentage depletion dates back to 1913 and the first federal income tax law. It is a deduction from gross corporate income; 15 percent of the domestic ore reserve value can be subtracted from gross income before taxes are calculated. In theory, it compensates for the exhaustion of the nonrenewable natural resources on which extractive industries are based. Extractive industries present two main arguments for it. First, they say depletion of ore reserves is comparable to the depreciation on capital investments allowed to manufacturing companies. As a mining company's major investment (the ore in the ground) is depleted, miners contend, the value of their operation similarly decreases. (Percentage depletion differs from depreciation, which goes on regardless of use.) The second argument is that percentage depletion encourages capital investment in an inherently risky business. There is high risk associated with supply, plus the more recent risks of foreign dependence and potential substitutions.

The Korean War Emergency

The Korean War broke out in June 1950, 3 months after the start of the congressional hearing on "Steel's monopoly power." The new war emergency reversed the congressional mood. Congress quickly gave President Truman special wartime powers under the Defense Production Act of 1950 (passed on 8 September 1950). Part of the new power was to "encourage the exploration, development, and mining of critical and strategic minerals and metals" (*14*). On the following day, Truman ordered his Secretary of Interior, Chapman, to "develop and promote measures for the expansion of productive capacity and of production and supply of materials and facilities necessary for the national defense" (*15*). Under the Defense Production Act the government had four new powers regarding mineral production; it could (i) make and guarantee loans, (ii) purchase materials and create stockpiles, (iii) install equipment in privately owned mines and plants, and (iv) rapidly depreciate mining and manufacturing capital investments.

An "Amortization of emergency facilities" section was added to the Internal Revenue Code. It allowed 5-year (instead of 20-year) write-offs for major portions of specifically approved capital investments made to increase productive capacity required for defense purposes. Rapid-depreciation tax write-offs allow companies to deduct large portions of capital investments before and during the period of low production. They reduce the drain of money on company balance sheets during the construction and start-up periods, thus maintaining higher rates of return to corporate investors. Ironically, White had vainly argued for these in Congress just months before.

Early approval of rapid depreciation for taconite plants caught the attention of the press. In 1952; *Time* magazine reported on the "Taconite boom" (*16*):

> In the drive to expand industrial production, the Defense Production Administration last week ok'd the biggest single quick tax-write-off in its history; a $298 million project for Minnesota's Erie Mining Company. Most businessmen had never heard of the company, and they were baffled by its purpose, which is to "beneficiate" an ore named taconite.

The article described the vast supplies of "inferior" taconite ore that could be developed on the Mesabi and how "all this construction will make taconite ore more costly than the ore being used."

The steel industry felt such a rapid-depreciation policy would allow companies to abandon equipment and facilities more easily by fully amortizing them in a short time period, thus giving industry greater flexibility to adopt rapidly improving technology. Conservative-minded opponents, however, argued that such a policy downgrades the importance of equipment over time and discourages maintenance.

Lingering Policies

Well after the Korean War ended in July 1953, and even after many news stories headlined the end of our iron ore scarcity, the defense production administrator approved another rapid tax write-off for taconite. In September 1955, U.S. Steel's Oliver Mining Company in Mountain Iron, Minnesota, was allowed a 5-year amortization of 75 percent of its $165 million project to "form taconite into pellets . . . because production levels [were] needed for defense" (*17*).

Some policies linger long after their original intent is fulfilled. In defining the emergency period declared during the Korean War for the quick amortization of emergency facilities, the Internal Revenue Code stated: "For purposes of this section the term 'emergency period' means the period beginning January 1, 1950, and ending on the date on which the president proclaims that the utilization of a substantial portion of the emergency facility is no longer required in the interests of national defense." This section of the Internal Revenue Code was not repealed until 4 October 1976 (*18*).

The Defense Production Act of 1950 itself has been extended by Congress on numerous occasions and is still in effect today. Now it is being used to stimulate productive capacity of other resources. For example, Representative Moorhead introduced, and Congress recently passed, the Energy Security Act (Public Law 96-294) to support synthetic fuel production with government loans, loan guarantees, price guarantees, purchase agreements, joint ventures, and, as last resort, government purchase with lease-back agreements of synfuels projects (*19*). Moorhead (and Congress) found the Defense Production Act the most useful vehicle for initiating the synfuels program. An Energy Security Corporation

was subsequently established to administer this program.

There were other policies besides the Defense Production Act that helped to quench the iron ore depletion scare. For example, the foreign oil and mineral tax credit of 1954 allowed steel companies producing foreign ores and paying taxes in other countries to count these taxes as dollar-for-dollar deductions from their U.S. corporate income taxes. Also, the St. Lawrence Seaway, approved by Congress in the early 1950's, helped steel companies bring foreign ores, especially Canadian ores, to the lower Great Lakes steel mills. These policy actions tended to favor importation of the newly discovered rich hematite ores found abroad. Today, however, we rely on domestic taconite, which has proved more attractive than the foreign stocks.

Taconite Costs and Politics

During the initial commercial commitment to domestic taconites, the high cost of producing pellets was stressed. For example, in 1953 the Federal Reserve Bank of Minneapolis explained that the "taconite program is a costly but inevitable outgrowth of rising steel consumption and declining ore supply. . . . Costs are a crucial problem for taconite. Only if mining *costs* are kept as low as possible can this new industry expect to be competitive with other sources of high-grade ore concentrated by nature" (*20*). And a news article extolling the 1955 end to the iron ore scarcity cautioned that there is "still the problem of cost but five steel companies are betting half a billion dollars that this, too, can be solved" (*6*).

In general taconite was viewed as a domestic necessity (*21*) in the early 1950's, but uneconomical (*22*) and therefore deserving strong government subsidies.

In 1955, the *New York Times* hailed the start-up of the first two commercial taconite mines (Reserve and Erie) as a "Cinderella story" brought to life by modern technology turning a "poor rock into rich iron ore" (*5*). The fact that high-grade taconite pellets could be made on a large scale was impressive in itself, but the full story of taconite benefits was just beginning to unfold.

In 1960, *Iron Age* (an industrial trade journal) announced that the steel industry was "stunned" by the increased productivity pellets caused in blast furnaces (*23*). By this time, enough high-quality pellets had been stockpiled by Armco Steel (the other half-owner with Republic Steel of Reserve Mining Company) to run sustained blast-furnace tests with a high percentage of pellet feed. Armco's 28-foot furnace in Middletown, Ohio, was rated at approximately 1500 tons of molten iron per day. Fired with almost 90 percent pellets, it achieved record productions of 2700 and 2800 tons per day. Pellets nearly doubled blast-furnace productivity (*24*).

Pellets also save a great deal of energy in the blast furnace by reducing coke requirements (*25*). Net savings of energy and labor (with increased productivity) occur because pellets improve the permeability of the blast-furnace burden, thus distributing heat more uniformly and improving efficiency. Enough coke is saved to more than compensate for the elaborate and energy-intensive beneficiation process at the iron mine. The physical advantages of taconite pellets over hematite ore reduced total costs of molten-iron production. The lean taconite ores began to raise the minimum standards of acceptable iron content for hematite ore (*26*).

Shortly after the steel industry realized the overriding benefits of taconite pellets, it initiated a campaign to hold down Minnesota taconite taxes. In the early 1960's, the Mesabi range was just beginning to prosper again. Three taconite plants were operating and others were being discussed. The companies claimed that continued prosperity and expansion hinged on tax stability. In order to maintain the prosperity of the range, they appealed to the voters to amend the Minnesota constitution. One rust-colored brochure, for example, introduced "Minnesota's good luck bird, Taconite, the little red goose [that] lays little black eggs. Please don't kill me. If you let me grow big, I will lay millions of dollars in golden eggs for Minnesota" (*27*).

The Minnesota voters viewed the tax amendment as solely an ore production issue. They knew hematite mines were being replaced with new taconite mines and the associated pellet manufacturing plants. The pellet process was more complicated and employed more people. Therefore, to the Minnesota voters, pellets were obviously more expensive. But this is true only if the production of ore is considered in isolation; the savings with pellets come at the blast furnace and overcompensate for higher mining costs. The major steel companies generally own both the blast furnaces and the mines. The industry, with its broader perspective, recognized the substantial savings possible with taconite pellets. There is a problem, therefore, in where one draws the system boundaries.

On 4 November 1964, the Minnesota Taconite Amendment was approved by four of every five voters in a statewide referendum. The amendment (i) prevented the state from singling out taconite production companies for any new or "inordinate" taxes, (ii) pegged tax increases to rise with the consumer price index as they would for other "manufacturers" in the state, and (iii) prohibited the "amendment, modification, or repeal for a period of 25 years" of existing tax laws for taconite, semitaconite, and their facilities for mining, production, and beneficiation (*28*). Within a week of passage, plans to build several additional pellet plants in Minnesota were announced. The amendment was successful, at least in part, because the Minnesota voters were not aware of the full taconite story.

While the amendment had been promoted as a tax stability measure, in reality it amounted to a tax break. The 1964 taxes paid per ton of iron-in-ore for taconite production were only one-fifth those paid on hematite ore (*25*).

Recent State Actions

Despite the stability guaranteed by the Taconite Amendment, the Minnesota legislature began raising taconite taxes in the 1970's. For example, the tax rate jumped more than fivefold between 1970 and 1976. The increases are now being contested in the courts by industry as violations of the amended constitution.

In increasing the tax, the Minnesota legislature created several new funds. First, a "boom and bust" fund was created to transfer taconite tax dollars to economically depressed towns where hematite mines had recently closed. Second, a "rainy day" fund was established that will help taconite mining towns adjust if, at some future time, their taconite mines should close. Although money is accumulating in this fund, nothing can be withdrawn until after the year 2000. Third, an "environmental correction" fund was created to finance repairs caused by mining activities. These earmarked funds are an attempt to internalize some of the newly recognized external environmental costs, as well as some of the social costs that have typified mineral extraction.

The Minnesota legislature's sharp increase in taconite taxes during the 1970's came at the same time Reserve Mining Company was repeatedly attracting national attention because of its environmental prolems. In 1976, for example, *Business Week* wrote, "Reserve Mining Company, under fire from environmen-

talists for eight years for dumping asbestos[-like fibers contained in its] wastes into Lake Superior, got another black eye" (*29*). Other national press headlines reported "Reserve Mining discharges ruled illegal, but court says health risk not imminent" (*30*) and "Order to close Reserve Mining is upheld on appeal, along with fines for firms" (*31*). At one point, then-governor Wendell Anderson proposed "raising state taconite-production taxes to help pay for an on-land taconite-tailing's disposal site" for Reserve Mining Company (*32*). The Reserve court case began in 1972 and "engaged the time and attention of the Federal and state courts for nearly six years" (*33*), ending with the Minnesota Supreme Court decision of 8 April 1977, allowing the company to dispose of its taconite wastes at a land site. Former lieutenant governor Rudy Perpich, a native of the Mesabi range, was now governor. Perpich had shown a willingness to challenge the mining companies earlier, but decided not to appeal this decision and protract the case further. He signed an agreement with the company on 7 July 1978, approving the "mile post 7" on-land disposal site. In raising the taconite taxes during this controversy, the Minnesota legislature was motivated more by new awareness of the environmental costs of taconite than by recognition of the technical benefits of pellets.

Michigan's mineral tax policies are also changing in response to new perceptions of taconite benefits and costs. In December 1978, the Michigan legislature revised the "specific ore tax" on taconite (*34*). It increased the production tax rate slightly and applied it to the price of pellets rather than the price of hematite. No regional equalization to help depressed mining towns exists in Michigan.

Wisconsin recently revised its mineral taxes and now assesses a progressive tax on net proceeds (*35*). As value of production increases, the tax rate increases from 0 percent below $100,000 per year to 20 percent over $30 million per year. The progressive rate is intended to slow down the boom phase of mining and spread production over time. This should ameliorate the bust periods associated with extractive industries. Thus small mines are encouraged and large production discouraged by Wisconsin's new law. Interestingly, that state's only taconite mine has in the past operated under very lenient tax laws. Its managers now claim the new tax law has shortened the mine's anticipated life.

Conclusions

After World War II the United States faced a scarcity of a vital domestic resource—iron ore. Aided by financial incentives, the steel industry succeeded in the early 1950's in exploiting foreign ores and developing domestic taconite technology to cause the iron ore depletion scare to vanish almost overnight. In this case, technology proved the superior solution. I conclude that we were "saved" from the iron ore depletion dilemma by government assistance spurred by the Korean War. Indeed, we were oversaved. Government policies helped an industrial effort that was already under way. Industry's own momentum was larger and more timely. Viewed in retrospect, therefore, I believe iron ore illustrates a case where too much government help came too late.

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18. U.S. Statutes at Large, *Internal Revenue Code of 1954*, vol. 68A, chap. 1, sect. 168 (d) (2), p. 53, repealed by Public Law 94-455, title XIV, sect. 1951 (G) (4) (A), on 4 October 1976, 90 Stat. 1837; see *Internal Revenue Code of 1976*, chap. 1, sect. 168, p. 257.
19. W. S. Moorhead (D–Pa.) originally introduced H.R. 602 (15 January 1979) as an amendment to the Defense Production Act of 1950 to commit the government to purchase alternative fuels for national defense and use up to $3 billion to pay the difference between contracted price and market price. This bill and others were amalgamated into S. 932, a more comprehensive "synthetic fuels" bill still linked to extension of the DPA of 1950 and involving more federal support. This bill was signed into law (PL 96-294) 30 June 1980 and appropriates $20 billion for synfuel projects over the first 4 years and up to $88 billion over the next 12 years. The law also aids alcohol production, and biomass energy, sets energy targets, and expands several other existing energy laws.
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22. This "uneconomical" view was not unanimous within the steel industry, however. Reserve Mining Company is owned as a 50-50 joint venture of Republic Steel and Armco Steel. It was the first commercial-scale taconite plant; its pellet shipments began in early summer of 1955. Experimental operations had gone on for some 20 years before Republic and Armco purchased the leases in late 1950. It was reported that in early 1950 the previous owner-manager company, Oglebay-Norton, "had been casting about Washington for government money to help finance this [large expansion] project. However, the new owners have shown no interest in such financing" [*Business Week* (11 November 1950), pp. 76–78]. Shortly after, C. M. White of Republic and others put together Reserve's new financing with "a group of leading life insurance companies taking an issue of $148 million of Reserve Mining Co. bonds" [*New York Times* (12 June 1955), sect. 3, p. 2]. As early as November 1950, *Business Week* concluded that "the general opinion in the industry today is that a taconite plant turning out 215 million tons a year would be able to compete commercially with direct shipping ore" [*Business Week* (11 November 1950), p. 78].
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29. *Business Week* (30 August 1976), p. 30.
30. *Wall Street Journal* (17 March 1975), p. 14.
31. *ibid.* (29 October 1976), p. 7.
32. *ibid.* (6 October 1976), p. 15.
33. J. Otis, Judge of Lake County, Minnesota, Opinion 50 involving *Reserve Mining Company* v. *Minnesota Pollution Control Agency* (14 April 1978), p. 1.
34. Representative D. Jacobetti introduced H.B. 6725 in the Michigan legislature in November 1978; it passed both chambers and was signed into law by Governor W. Milliken on 21 December 1978 (PA-537).
35. Wisconsin Senate Bill 111, "Taxation of metalliferous mineral mining," was signed into law on 30 June 1977 (*Wisconsin Laws of 1977*, chap. 31).

36. I thank Kenneth Murray and William Patric for help in revising the manuscript. This is Michigan Agricultural Experiment Station journal article 9320.