Ecology and Technology in the USSR

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Ever since Stalin's "revolutions from above" in the thirties, the Communist party of the Soviet Union has presented itself to the population as the purveyor of technological progress. In the Brezhnev period, the ideological slogan "the scientific-technical revolution" proclaimed the capability of the Soviet socialist system to maximize the benefits of scientific and technological progress to realize its utopian social program. At the same time, in that period, the backwardness of Soviet technology and systemic obstacles to technological innovation became increasingly evident not only to the leadership but also to broader segments of the population. Furthermore, areas where technological advances seemed most credible, in the space program and in the military sector, hardly brought direct benefits to the population. In the mid-sixties, other doubts about the benefits of proclaimed technological progress also surfaced: the application of technology in both the industrial and agricultural sectors was directed toward the realization of higher volumes of material output. Not only was quality insufficient but, at the same time, the application of technological processes contributed to the degradation of the quality of life through its impact on the natural environment. While these effects have had little influence on the practice of technology development, they marked the beginnings of awareness in the USSR that the environmental crisis placed new demands on that sector.

The author is grateful to McGill University for support to facilitate this research and to John Kramer for comments on an earlier draft of the paper.

Ecology and Technology Before Perestroika

In the pre-Gorbachev period, the actual impact of ecological considerations on technological development was minimal. At the same time, some natural scientists and economists (whom I call, loosely speaking, environmental advocates) began to factor ecological effects into their assessment of the social and economic value of technological innovation. Some of their conceptions made their way into official parlance, most notably where they were consistent with other regime goals. For example, support for recycling of the by-products of production (in Soviet terminology, "the utilization of secondary raw materials") and other measures to reduce waste of natural resource inputs have been included in planning documents since the late seventies. Such commitments, consistent with leadership efforts to improve the efficiency of production and lower production costs, also implied support for transformation of the technological base of production. Nonetheless, most proposals made by experts to alter technology in response to ecological stresses did not make their way into practice. It is important to examine some of the theoretical underpinnings and policy considerations that explain this failure and also to examine more closely the case for technological conversion made by the environmental advocates.

Soviet Marxism, Ecology, and Technology

Underlying official Marxism-Leninism in the USSR was a strong technological optimism. This assumption was derived in part from Marxist theory itself, but was also rooted in the legitimatory structures that grew out of the Stalinist period. The sacrifices endured by the population during the rapid industrialization campaigns of the thirties were justified, in part, by the scientific foundation for the policy and its proclaimed economic and technological achievements. Technology was viewed as neutral or benign in itself, but fulfillment of its positive potential was seen as possible, and indeed almost inevitable, in the context of socialist productive relations characteristic of Soviet society. In this view, under socialism any damage to nature could be overcome by some other technological innovation; nature was to be mastered—and could be. The point was to "transform" nature (*preobrazovat' prirodu*), not to adapt human technology to the needs of nature. This goal seemed more plausible, given the vast and seemingly inexhaustible expanses of nature in the USSR.

Technological optimism was expressed in theoretical conceptions developed by leading Soviet scientists as well, most notably in the thought of the late geologist V. I. Vernadskii. For Vernadskii the noosphere represented the final stage in the evolution of the biosphere. "Man, taken as a whole, becomes a powerful geological force. And before him, before his thought and labor, stands the question of the rebuilding of the biosphere in the interests of freely thinking humanity as a unified whole."[1] Vernadskii's concept of the noosphere provided scientific justification for the mastery of nature in the name of scientific communism. In the sixties, the biologist G. F. Khil'mi elaborated a similar notion, the "biotechnosphere," which depicts a symbiosis of nature and technology based on "large-scale structures transforming the atmosphere, the hydrosphere, and the lithosphere of the Earth."[2] Both of these "scientific" concepts served ideological functions, as they legitimized the regime's technological optimism and its interventionist approach to nature.

The commitment to mastering nature underlay the nature-transforming projects characteristic of the Stalinist and post-Stalinist periods. These included, most prominently, the water-management and energy systems. Huge hydroelectric complexes had a profound impact on local ecosystems (for example, eventually transforming the Volga from a river to a series of dams, reservoirs, and canals). Under Brezhnev, land reclamation and irrigation projects took on vast dimensions, particularly in central Asia and in the non-chernozem region of Russia. Ecological concerns had very little, if any, impact on the manner in which such schemes were conceived and carried out. Only in some rare instances—for example, following public outcry over the damage to Lake Baikal—were there even minimal attempts to adjust technology to reduce its harmful impact on the environment. Furthermore, gigantomania was not limited to water management. Construction of huge metallurgical, chemical, and other manufacturing complexes mirrored the planners' heady confidence in their ability to manipulate material and nature to their own ends. Even in those cases where technological equipment was installed to reduce negative environmental effects (e.g., filters or scrubbers to detoxify emissions into air or water), it was not well maintained and often was not functioning at all.

Economic goals and structures, as well as the ideological factors

discussed above, also mediated against an ecological assessment of technological choices. Environmental protection was a low rung on the ladder of regime priorities. Levels of material output were the primary concern. The low status of environmental concerns was reflected in the near absence of personnel trained in environmental amelioration and in related fields of research and technology development. Furthermore, incentive structures in the planning system itself did not encourage resource-saving techniques or recycling, let alone conversion to less polluting production technologies. Particular ministries and enterprises had almost no incentive to reduce externalities as they pursued their planned production quotas; since most natural resources were granted to them free of charge, they also had every motivation to squander water, land, or mineral resources, if such actions eased fulfillment of material output quotas.

The Critique: The Call to Ecologize Production

Despite formidable obstacles to change, beginning in the sixties scientists and economists in the USSR began to propose the main features of a new technological policy that would be responsive to environmental concerns. As they articulated their ideas, however, they were constrained by official limits on public debate. While these fledgling environmental advocates could argue for some forms of technological transformation, they had to do so within prescribed limits and could not publicly contradict certain official values. At least on an explicit level they, for the most part, cloaked their arguments in terms consistent with the prevailing norms of the system—that is, the commitment to optimal rates of economic growth, faith in new technology to generate solutions, the definitive advantages of a central planning system, and the superior capability of socialist society to realize ecological goals. At the same time a counterstrain of "ecological pessimism" pervaded some of these critiques, and one could begin to detect in the Soviet scholarly debate a subtle suggestion that technology itself is neither neutral nor benign.[3] Sometimes such ideas were smuggled into the debate by quoting Western authors whose ideas were explicitly disavowed, but whose views were actually more widely disseminated for having been quoted. Critics also emphasized that socialist society itself does not automatically make ecologically sound technological choices; rather, these must emerge through a process of ecological education, scientific research, and policy deliberation.

Environmental advocates coined their own slogan—"ecologization of production." According to this conception, human intervention in nature should serve to increase the productivity of nature, improve its capacity for self-regeneration, and reinforce its internally balanced biological cycles. The notion did not involve a retreat from human intervention, but rather an adaptation of technological methods to enhance and accommodate the needs of nature. Beyond that, ecologization of production implied that human society could learn from nature, for by studying its techniques of self-regeneration, society could try to reproduce them in technological processes. Human production would become a "technical imitation of nature."[4] This concept did not challenge the goal of economic growth in an explicit manner. But it also represented more than a simple effort to introduce ameliorative devices on already existing technology (emission controls, filters, scrubbers, etc.).

On a practical level, the most radical implication of ecologizing production involved a shift toward use of "closed-cycle production" and low-waste technology. In addition to the ecological payoff of such a strategy, economists emphasized other advantages, consistent with regime priorities. Such technology would increase the productivity of labor and stimulate more efficient use of material inputs; it would thus contribute to the much-touted goal of shifting the productive structure from an extensive strategy (the Stalinist approach based on expanding the range of material, natural, and labor inputs in the productive system) to an intensive strategy (getting more output from limited and increasingly scarce inputs). Critics of existing production patterns contrasted human productive systems with natural ones. Whereas natural processes are largely cyclical (involving the building up of new life forms and their subsequent decomposition), human productive processes have been largely unilinear, utilizing only a minuscule portion of materials extracted from nature and leaving the rest as unutilized, and often polluting, waste. The adoption of closed-cycle production was presented as particularly important because productive processes had become so intense and expansive that nature itself no longer had the capacity to break down wastes generated by society. Humans themselves would have to include organic and microbiological processes in their technology.

While this view gained numerous adherents in scholarly circles[5]

(especially among philosophers, biologists, and economists), its effect on policy was strictly limited, for implementation of the new strategy would necessitate a fundamental and broad-ranging retooling of the Soviet productive structure. Some success was achieved in instituting closed-cycle water systems in new industrial facilities. Official statistics indicate that, in 1988, 72 percent of water consumption for production needs was provided by recycled or successively used water (up from 69 percent in 1985); they also indicate a loss of 18.7 percent for irrigation water during transport to the point of discharge.[6] These figures probably overestimate the efficiency of the facilities in conserving water.

A less radical corollary of the environmentalists' blueprint gained greater official support—namely, the notion of expanded use of "secondary raw materials" (recycling of productive waste). In 1978 bonuses were put in place to encourage the collection, storage, and shipping of scrap metal; and beginning in 1981, state, ministry, republic, and enterprise plans were to include a section on the utilization of secondary raw materials. Other policies to reduce waste of materials in the production process were also instituted in the eighties with some significant results in certain sectors of the economy. Specialists emphasized the economic as well as the ecological benefits of the recycling efforts. Major shifts in the technological basis of production did not, however, occur. Rather, most progress was made in those sectors where recycling was relatively easily accommodated to existing productive structures. Programs were also put in place to gather recyclable waste (e.g., paper and bottles) from the population at large, although the incentive structure was insufficient to bring maximum response.[7]

Ideological constraints affected the manner in which environmentalists could develop their notion of ecologizing production. Methods to achieve the goals were most often discussed in terms of large-scale production complexes that could realize complex patterns of waste reuse.[8] Such schemes were consistent with the system's normative commitment to centralized production structures, gigantic production systems, and supposed economies of scale. This approach was rooted in a particular conception of the "ecologizing of production": ecology involves interdependence ("everything is connected to everything"), which implies complexity and centralization; engineered closed-cycle cybernetic systems on a large scale were suggested to capture this complexity. This logic contrasts sharply with an approach that enjoys

greater popularity in the West—the "small is beautiful" notion and concepts of "appropriate technology." This Western variant is based on a different reading of ecological demands: here ecological production seeks to imitate the self-regulation of natural processes, which then is taken to imply social self-management and local autonomy in the West. To realize this end, small-scale technology, geared to local needs, is seen as superior (composting, solar panels in homes, bicycle transport).

The preference for centralized ecological production expressed in Soviet writings of this pre-perestroika period had political roots (as did the "small is beautiful" idea in the West). Demands for local control over small-scale technology would have threatened central control and would, at least on the surface, have seemed difficult to implement within centralized economic structures and imperatives. The obstacles to small-scale ecological production were also rooted in the incentives that motivated enterprise behavior and in the general ideological environment. Indeed, local enterprises did often develop such "unplanned" local capacities to respond to bottlenecks in provision of inputs.[9] The problem was that this capability was not generally used for ecological ends, since there was no incentive to do so and ecological know-how was absent. Local initiatives at the enterprise level were rather geared to securing a stable base for the mandated material-output quotas in the state plan.

Thus, prior to perestroika, the theoretical groundwork had been laid by some scientists and economists for a shift in the technological orientation of production to realize a certain conception of ecological responsibility. Implementation of even this ideologically constrained strategy, however, confronted structural and economic roadblocks. Since 1985, some of these obstructions were weakened, but new problems have emerged to replace them.

Technology and Ecology under Gorbachev

Since the advent of perestroika and glasnost, possibilities for technological transformation in response to ecological demands have increased; several factors, discussed below, could, at least in theory, facilitate the adoption of more environmentally friendly technology. However the general political crisis and economic chaos have left few investment funds for technological innovation. Furthermore, while public attention was focused on ecological problems in the early years

of perestroika—especially following the Chernobyl nuclear-power accident in April 1986—since 1990 the larger economic and political crisis has lowered the relative salience of ecological demands and, thus, reduced pressure for technological conversion.

Chernobyl, Technological Pessimism, and Public Protest

The accident at the Chernobyl nuclear power plant in 1986 represented a watershed in public attitudes toward technology, especially high technology. Not only did numerous grass-roots movements grow up in opposition to planned or existing nuclear facilities throughout the USSR but the catastrophe also instilled wide-ranging skepticism toward the orthodox view of technology as intrinsically benign. Official analyses of the causes of the accident emphasized individual human error, attempting to vindicate both the technology itself and the social system in which it operated. However, following the accident a major shift in nuclear-power technology occurred; Soviet authorities withdrew plans to develop further reactors of the Chernobyl type (the RBMK, graphite moderated channel-type reactor) in favor of the other predominant model operative in the USSR (VVER, a water-moderated reactor, similar to most Western models). This shift suggested that even if the technology itself was not completely to blame for the accident, it was at least partly responsible for the failure. The implication was, then, an indirect admission to the public that indeed some technologies are less benign than others. The RBMK reactor, previously hailed as the "Soviet" type, was acknowledged, in practice, to have some inherent weaknesses. This undermined traditional claims about the uniquely positive potential for technological progress under socialism.

Not surprisingly, in the months and years following Chernobyl, large parts of the public became vocal in questioning official reassurances about ecological safety, a debate that was made possible by the expansion of glasnost from 1986. Not only did nuclear power come under attack but also other industrial processes were subject to public criticism, including those in the pharmaceutical industry, the paper industry, biochemical production, synthetic fertilizer and pesticide production, as well as factors in traditional heavy industrial sectors such as metallurgy and the chemical industry. Protests against various kinds of ecological damage sprang up all over the USSR and

led to the closing or cancellation of numerous production facilities in diverse sectors of the economy, along with the demand that plants be converted to less polluting production processes. Gigantic water-transformation projects (such as the Siberian river-diversion project and the Volga–Chograi canal) were canceled (at least temporarily), and gigantomania itself was attacked.[10] A crisis of sorts resulted because technological retooling of the existing large-scale facilities would require large capital investments, expertise in areas weakly developed in the USSR, and, in many cases, the importation of foreign equipment. The facilities that were shut down under public pressure could not be quickly retooled; therefore, these closures aggravated the chronic shortage conditions in the Soviet economy. V. Bushuev, chair of the USSR Supreme Soviet subcommittee on energy, reported in late December 1990 that "construction work has been suspended or operations have been shut down at seventy power plants with a total capacity of 150 million kilowatts, which is half the current capacity of the entire unified power system. At present, construction is not being started on a single new power plant."[11] Thus, until now, the impact of the ecological movement on technological change has been largely negative (bringing cancellations of plans or closures of numerous facilities operating with damaging technological processes) rather than positive (eliciting alternatives such as the installation of new "ecologically friendly" technological processes). In late September 1990 Gorbachev himself issued a decree mandating that delivery targets be fulfilled; some of the closed plants were to be reopened (especially in the pharmaceutical industry).

Decentralization

Environmental demands were among the first to be articulated by the popular-front movements that emerged in the Baltic republics in the late eighties, and this pattern has been replicated in other republics, including parts of Russia. These grievances have been linked to more general claims for republic or regional self-management and for local decision-making power in the economic/ecological sphere. The pressure for regional economic control represents a rejection of the power of the large centralized ministries and of their right to mandate the construction and mode of operation of productive facilities in particular localities. In practice, the collapse of central state authority that

ensued during the "parade of sovereignties" in 1990 in the USSR further undermined the capacity of central economic organs to control the course of economic development in the various regions in the USSR.

While bureaucratic wrangling leaves the fate of some projects that were canceled under popular environmental pressure at least theoretically open, a major shift in attitude has occurred. Big is no longer necessarily beautiful, for "big" is closely associated with the large central economic ministries, which have imposed their will on the various localities. Like the earlier official commitment to large engineering complexes, the new public skepticism toward these same projects is also politically based. For as local populations desire more control over their destinies, they object more strongly to large projects that necessarily imply centrally controlled investment, influxes of laborers from the outside, and massive intrusions into the local environment.

Therefore, local and regional ecological movements are now more sympathetic to the alternative ideology of "small is beautiful," with its emphasis on local control and self-regulation. Reinforcing this proclivity is the fact that some small-scale initiatives can proceed with more modest immediate investments (for example, reductions in the use of chemical fertilizers and pesticides). At the same time, assertion of local control over economic development requires that local authorities respond to numerous conflicting pressures, including demands for better goods and services. For example, the desire for energy self-sufficiency in Lithuania may make it difficult to forego the contribution of the otherwise unpopular Ignalina nuclear power station (which operates with the Chernobyl-type RBMK reactors, which is largely staffed by Russian skilled laborers, and which reflects the continuing influence of the central ministerial structure). Local autonomy may well require developmental choices, based on available natural resources, which will have negative impacts on the local environment or on ecosystems of neighboring regions. For instance, support for the Siberian river-diversion project continues to be expressed by some Central Asian elites, despite the presumed deleterious effects that project might have on the larger Eurasian ecosystem and particularly on the north. Furthermore, the start-up costs of developing some new technological options (e.g., solar power in Central Asia) may be too great for the still weak republic and local governments to bear; likewise, technological

retooling of large enterprises and the cleanup operations relating to past production involve immense costs which specific localities might not be able to bear. To address these problems, local governments would certainly need the power to extract funds from the same local industries that have caused the pollution and would most likely require central subsidies as well.

Environmental critiques emanating in Lithuania suggest some possible avenues of regional ecological restructuring. One suggestion is that obstacles to ecological innovation that result from the highly bureaucratized and centralized ministerial systems could perhaps be overcome if regional authorities were given the power to make decisions on technological restructuring. Another proposal involves technological alterations at the Mazeikiai oil refinery to increase its production of unleaded gasoline, which would be exported beyond Lithuania's borders only after personal and public-transport needs at the local level had been met, thus assuring maximal positive benefit to the local ecosystem and population.[12] Such control over local distribution of environmentally friendly production would provide the population and the republic's government with an incentive to fund somewhat costly processes of technological conversion.

Other proposals, emanating from the Lithuanian Green movement,[13] have involved technological innovations such as the development of an instrumentation network and program to monitor radioactive emissions from Ignalina, the reequipping of the Akmencementas cement factory (in Naujoji Akmene in northern Lithuania), the reduced use of chemical pesticides and termination of aerial spraying, local control over storage and distribution of chemical fertilizers, and improvement of safety features and cleaning devices for equipment at the Kedainiai chemical plant and the Jonava Azotas factory. While such demands may seem to differ little from a wide range of causes that environmental advocates championed in official media outlets even before 1985, it is their local and specific focus that is significant. Particular technological goals (rather than aggregate plan targets) are being discussed, and the decentralization of economic power would eliminate numerous obstacles to their actual implementation. Elected local authorities are not only accountable to central state organs or Party bodies, which are more likely to enforce old priorities and to allow innovative approaches to become bogged down by departmental self-interest, but are also, at least in some sense, accountable to a public constituency. This

fact changes the incentive structure for public-policy formulation. Indeed, already in some cases referenda are planned or have been held to allow expression of public opinion on developments with contested ecological effects.[14] Unfortunately, such expressions are usually "yea" or "nay" propositions and make it easy for the public to mandate plant closings without considering the opportunity costs and prospects for the resultant filling of production gaps. Furthermore, accountability of local authorities to the public can be meaningful only if the local government actually has the economic capacity to alter local development priorities and, thus, technological choices. This power, at least in most regions of the USSR, does not yet exist.[15]

Economic Reform

Introduction of market mechanisms in the economy should, overall, have a positive impact on incentives for technological innovation.[16] So far, however, the reform has not progressed sufficiently to realize this advantage. Despite the generally positive prospects that market reform presents for technological innovation, the likely impact in the environmental sector is less clear. The initial capital investment for a shift to environmentally friendly technology may not be rewarded in a market environment. Rather, the market may more likely encourage the externalization of environmental costs, as it does in the West when specific state regulatory mechanisms are inadequate. Soviet legislation[17] envisages the introduction of certain regulatory mechanisms, such as charges for routine and excessive pollution and charges for natural-resources use, which would implant an incentive structure to make it economically advantageous for enterprises to act in an environmentally responsible manner. Measures that have been proposed, however, would more probably encourage simple ameliorative responses rather than more thoroughgoing processes of technological conversion. Only where resource saving would be substantial enough to justify initial investment costs would the market encourage such conversion to new technological (closed-cycle or low-waste) production processes. Integration of the Soviet economy into the larger world market might also, through both joint ventures and imperatives to meet world standards in exports, encourage some technological upgrading. However, by the same token, in an effort to make investment opportunities attractive to foreign partners, Soviet authorities may just as well be tempted to lower environmental standards, as has happened in many third-world countries. All of these factors suggest that the implications of market reform (questionable as its achievement appears in early 1991) may be more ambiguous in encouraging environmentally sound technology than it would be in realizing other goals of technological innovation.

Technological Conversion: Selected Issues

In this section, I will examine two specific aspects of production where pressures for technological conversion have grown in the past three decades, but since 1985 in a more open and widespread manner. These involve (1) agricultural technologies specifically related to the widespread use of chemical pesticides and fertilizers (2) and waste reduction in the industrial, energy, and extractive sectors.[18] Here I will try to clarify the nature of the environmental demands and prospects for their realization in light of the factors discussed in the previous section.

Chemical Fertilizers and Pesticides

Environmental advocates in the USSR generally acknowledge that chemical pesticides and fertilizers have been overused in the USSR, leading to adverse health effects on both agricultural workers and the local population, declines in soil productivity, and toxic residues in water and produce.[19] The latter have in turn been linked to elevated rates of illnesses and mortality, particularly in Moldova, Armenia, and Central Asia.[20] Careless aerial spraying represents another hazard. In addition, local environmental pollution resulting from production of chemical preparations has also been a cause for concern. Environmentalists in Lithuania claim that 82.4 percent of residents within six kilometers of the Jonava Azotas plant (a chemical plant whose output includes chemical fertilizers) suffer from eye and nasal-passage irritation. Furthermore, higher than normal levels of respiratory disease, angina, and conjunctivitis characterize the region. Bronchitis is reportedly nine times above the republic's average for children in the Jonava region. An accident at the Jonava facility on March 20, 1989, occurred when a reservoir tank containing ammonium leaked and exploded. Toxic gases escaped, local residents were evacuated, and several hundred people reportedly suffered ill effects.[21]

Despite official recognition of the problem of overuse of chemical

preparations in agriculture, plan targets for their production and application continued to rise in the late eighties. Bitofus, a pesticide used in cotton production, was banned in the late eighties, owing to its high toxicity and adverse health effects on the agricultural work force. On the other hand, residues of DDT exceed maximum permissible levels on more than 10,000 hectares of agricultural land;[22] some critics believe that DDT is still being applied in some areas, despite its prohibition. The report on the state of the environment issued by Goskompriroda (the newly created State Committee on Protection of Nature) indicates that in recent years use of chemical pesticides has declined. "In comparison with 1986, by 1988 the area of their application declined by 21 million hectares and the area using biological methods increased by 2.3 million hectares." Still, in 1988, only 26.7 million hectares saw use of biological methods compared to 165.7 million hectares of sown area utilizing chemical methods.[23] Research on microbiological processes of pest control is being pursued in various institutes in the USSR, but its translation into practice has been scattered.[24]

The statistical handbook on environmental issues and natural-resource use, issued for the first time in 1989, indicates that average consumption of mineral fertilizers per hectare of tilled land continues to rise in the USSR, although levels in 1987 were modest compared to some East European countries (Bulgaria, Hungary, the GDR, Czechoslovakia) and not excessive by Western standards.[25] (See Table 2, p. 166.) Recent criticism has centered not only on the volume of chemicals applied but also on their careless methods of storage and application, resulting in contamination of surrounding ecosystems and leakage of chemical components in the surrounding region, leading specifically to nitrate pollution of water resources. The application of organic fertilizers increased more slowly between 1980 and 1987 than did the application of mineral fertilizers. Thus, no technological shift is visible in this sector, despite vocal public criticism.

Republic authorities in several regions of the country have acknowledged the importance of improved control over and reduced use of chemical fertilizers and pesticides;[26] since 1980 the greatest advances in application of organic fertilizers have been achieved in Ukraine, Lithuania, Moldova, and Latvia. Obstacles include insufficient supplies of alternative preparations and continued pressures to fulfill plan mandates. The opening of independent cooperatives, privatization of agricultural land (enacted in the Russian republic in December 1990),

the greater force of consumer preferences, and elimination of pressure to fulfill irrational plan quotas for chemical applications would all be factors encouraging technological conversion in this sector, should market reforms proceed. Public pressure, particularly in light of the evident health effects of overchemicalization, will likely continue, and public information about residue levels in food has expanded. Yet at this point, no major technological impact of the environmental movement is evident.

Waste Reduction

Reduction of productive waste has also proceeded relatively slowly in the USSR, although progress has been made in some areas in the past decade. The USSR's complex program for scientific-technical progress for the period 1991–2010 includes attention to resource-saving technology and waste reduction with its concomitant environmental advantages. Gorbachev himself announced in December 1990 that there would be an assertive effort in 1991 to enlist foreign capital to help upgrade technology in the raw-material and fuel and power sectors, and "in utilizing colossal amounts of waste products—with consideration for ecological requirements, of course."[27] Also in late December, the chair of the USSR Supreme Soviet subcommittee on energy reported losses of 30 percent in the energy sector. Based on estimates from the Siberian branch of the Academy of Sciences, he suggested that 17 billion rubles would be needed for gas scrubbers until the year 2000 to keep atmospheric emissions in the energy sector at present levels. Furthermore, "developing and adopting energy-saving technologies requires one-time capital investments of 50 to 100 percent greater than the cost of expanding traditional energy production."[28]

Goskompriroda's report cites several examples of achievements in this area, most notably in reducing the loss of raw materials in the process of extraction. In certain enterprises (e.g., some metallurgical and mining-enrichment combines), progress has been made in the complex use of mineral resources. Also, the extraction of sulfur from emission gases has improved in zinc- and copper-smelting factories. All of these technological improvements have reduced stress on the environment and have provided economic benefits.[29]

Inadequacies in waste reduction are even more striking than achievements, however. The most highly polluting industrial sectors

Table 1

Installations Put in Operation, by Economic Branch

Branch	Installations to capture and render harmless emission gases from stationary sources (1000s of M³ of gas/hour)			Installations to purify waste water (1000s of M³ daily)			Systems of water recycling (1000s of M³ daily)		
	1981–85 (average for year)	1987	1988	1981–85 (average for year)	1987	1988	1981–85 (average for year)	1987	1988
Energy-fuel complex	12,522	16,564	8,915	569	504	324	17,571	23,433	11,425
Metallurgical complex	15,592	21,633	8,742	413	158	1,125	2,561	1,750	1,675
Machine-building complex	3,405	1,850	1,806	522	394	346	285	769	217
Chemical-forestry complex	2,191	3,008	3,523	849	1,089	1,217	3,324	3,409	1,688

Source: Okhrana okruzhaiushchei sredy i ratsional'nye ispol'zovanie prirodnykh resursov v SSSR: statisticheskii sbornik (Moscow: Gosudarstvennyi komitet SSSR po statistike, Informatsionno-izdatel'skii tsentr, 1989), pp. 151-52.

(energy, petrochemical, metallurgical, chemical) continued to underfulfill plan directions for utilization of productive wastes throughout the eighties and have failed to utilize all available capital-investment funds for this purpose. Installation of purification devices has also been consistently below planned levels in these sectors.[30] (See Table 1, p. 164.) Recycling efforts involving the consumption sector have also shown only slow improvement. Recycling of used paper showed only a minimal increase between 1985 and 1988 (and no improvement in terms of percent of volume of production of paper and cardboard). Relative to other East European countries, the USSR ranks last in paper recycling. In the late eighties, levels were approximately comparable to those achieved by the US.[31] (See Table 2, p. 166.) Use of other secondary raw materials follows a similar pattern, with only minimal gains in some areas (use of worn tires, polymeric secondary raw materials, wood waste, furnaces, scrap, and wastes of ferrous metallurgy), significant gains in the use of slag from blast-furnace production, and an actual decline in recycling of glass.[32] Other indicators of development of resource-saving technology show the USSR lagging substantially behind developed Western countries.[33] Statistics provided by Soviet sources generally suggest that the general economic crisis, which has been intensifying under conditions of perestroika, has had a neutral or somewhat negative impact on the capability of the system to reduce waste from the production process.

The weakness of the consumer sector in the USSR has had some beneficial side effects for the environment: less waste from throwaway goods; fewer automobiles and greater reliance on public transport; and less packaging. On the other hand, the shabby quality of many goods means that they do not have a long useful life; furthermore, shortage conditions encourage hoarding of goods, which may go unused or spoil before they find any useful life at all. Production of solid waste in the USSR still falls far behind that of most Western industrialized countries, although, as Table 2 indicates, methods of disposal rely more heavily on solid-waste dumps, with lesser use of incineration or composting.[34] Given the present economic crisis, it seems an academic question to ask about the ecological spin-offs of a transition to a consumer society in the USSR. On the other hand, there seems to be little discussion of the broader developmental/ecological issues at stake in forging a new economic-reform program. The prevailing goal, articulated both by the public and the leadership, is to increase production of

Table 2

Some Soviet Comparisons of Selected Data for Selected Countries

Country	Average consumption of mineral fertilizers [1]	Percent of paper and cardboard from recycled material (1987)
USSR	122	27
Czechoslovakia	311	32
GDR	367	50
Hungary	268	53
Poland	224	34
Canada	51	11
FRG	427	43
France	298	42
Great Britain	380	55
Italy	169	41
Japan	378	52
USA	106	26

Disposal of Solid Domestic Waste (SDW)[2]

Country	Vol. of SDW (million tons/year)	Estimate per capita[3]	Percent stored in dumps	Percent incinerated	Percent composted[4]
USSR	27.0[5]	.190[5]	97.0[5]	2.3[6]	0.75
Czechoslovakia	2.4	.144	89.5	8.0	2.5
GDR	4.5	.270	96.5	3.3	0.2
Canada	6.0	.236	80.0	19.0	1.0
FRG	28.0	.459	61.0	34.0	5.0
France	16.0	.291	46.4	41.0	12.0
Great Britain	16.5	.301	88.5	10.0	1.4
Italy	15.0	.263	67.0	18.0	10.0
Japan	32.0	.265	27.0	70.0	0.3
USA	235.0	.985	85.0	14.0	0.1

Sources: Gosudarstvennyi komitet SSSR po okhrane prirody, *Doklad: Sostoianie prirodnoi sredy v SSSR v 1988 gody* (Moscow, 1989), p. 77; *Okhrana okruzhaiushchei sredy i ratsional'nye ispol'zovanie prirodnykh resursov v SSSR: statisticheskii sbornik* (Moscow: Gosudarstvennyi komitet SSSR po statistike, Informatsionno-izdatel'skii tsentr, 1989), pp. 99–156.

Note: Sources of and methodologies for collecting data are not clarified in the Soviet sources.

[1]Average per hectare of tilled land.

[2]No year provided.

[3]Ton/year, based on estimated 1985 population.

[4]The three columns may not add up to 100% as in some countries other methods are also used.

[5]Data for RSFSR (Russian Republic) only.

Western-style goods. (Big Mac packaging in the USSR does at least have some redeeming value as a souvenir.) While improved public transport has official support, average Soviet citizens still aspire to an automobile culture. There has been little public reflection on the preferability of reusable over disposable products, probably because the latter do not, at the moment, seem a real option. In the search for sufficiency, the consumers' "green" instincts are understandably weak. Pressure for waste reduction in the consumer sector is likely to appear only in the far future. Thus, the technology underlying any transition to an economic mechanism more sensitive to consumer preferences may well overlook ecological concerns unless cost considerations, resource shortages, or a demand for better quality produce ecological benefits as unintended consequences.

Conclusion

While technology has had an immense and largely destructive impact on diverse ecosystems in the USSR, ecological considerations have not yet had a major influence on technological development. A major constraint inhibiting introduction of more ecologically sound technology is economic. Investment capital is simply not available from domestic resources, and foreign investors or partners are likely to resist avoidable costs to realize ecological goals, given the already considerable risks associated with doing business in the USSR. The one advantage the USSR may have is that so much of its capital equipment is outdated; its replacement, when it occurs, may allow Soviet firms to move to a new generation of technology more reflective of ecological concerns. This assumes that, in the interim, the USSR generates a research capability and trained personnel to develop new methods or that hard currency is available to buy them. These weak points in the ecological infrastructure pose as great an obstacle as the purely economic considerations, and here collaboration with Western research institutes and firms could be extremely important.

More likely, the old technology will stay in place for some time, despite public protests and criticism. The sheer scope of the problem will make it difficult for government leaders, planners, or enterprise directors to shut down or convert existing plants and processes at any but a most incremental pace. In some regions, such as the Baltic republics, the picture may appear a bit brighter because local initiative, the

greater legitimacy of the local government, and the efficacy of popular pressure, along with an ability to attract international support, may facilitate an innovative search for local "small is beautiful" solutions.

Notes

1. M. N. Rutkevich and S. S. Shvarts, "Filosofskie problemy upravleniia biosferoi," *Voprosy filosofii,* 1971, no. 10, p. 62. This discussion of Vernadskii and Khil'mi draws heavily from my book *The Environment and Marxism-Leninism: The Soviet and East German Experience* (Boulder, CO: Westview Press, 1985), p. 93.

2. See G. F. Khil'mi, *Foundations of the Physics of the Biosphere* (Leningrad: Hydrometeorological Publishing House, 1967), p. 281; G. F. Khil'mi, in "Global'nye problemy," *Voprosy filosofii,* 1974, no. 9, p. 82; and M. M. Kamshilov, "Chelovek i zhivaia priroda," *Priroda,* 1969, no. 3, p. 33.

3. For more on these debates see my piece, "Optimists and Pessimists: The Ecology Debate in the USSR," *Canadian Slavonic Papers,* vol. 26 (1984), no. 2, pp. 127–40.

4. This notion is explicitly stated by the East German economists Horst Paucke and Günter Streibel in "Zur Verflectung von Naturprozessen und volkswirtschaftlichen Reproduktionsprozess," *Wirtschaftswissenschaft,* vol. 28 (April 1980), pp. 404–409.

5. See, e.g., V. G. Markhov, "Naucho-tekhnicheskaia revoliutsiia i prirodnaia sreda," *Voprosy filosofii,* 1974, no. 8, p. 100; and A. A. Arakelian, "The Scientific-Technical Revolution and the Biosphere," *Voprosy ekonomiki,* 1976, no. 5, translated in *Problems of Economics,* vol. 19 (March 1977): pp. 73–77.

6. *Okhrana okruzhaiushchei sredy i ratsional'noe ispol'zovanie prirodnykh resursov v SSSR: statisticheskii sbornik* (Moscow: Gosudarstvennyi komitet SSSR po statistike, Informatsionno-izdatel'skii tsentr, 1989), pp. 76, 108.

7. For further discussion of these policies and some early results, see DeBardeleben, *The Environment and Marxism-Leninism,* pp. 59, 162–63.

8. The discussion that follows draws heavily from my book, *The Environment and Marxism-Leninism,* pp. 189–90.

9. Geoffrey Hosking's book, *Awakening of the Soviet Union* (Cambridge: Harvard University Press, 1990) suggests a tradition of such methods of local adaptation in other dimensions of Russian life. See especially chapters 2–3.

10. See, e. g., criticism of proposed petrochemical complexes in Tiumen' by Valentin Rasputin, "Giants: Hard on the People, the Pocketbook, and the Environment," *Moscow News,* 16–23 April 1989, p. 15; and the discussion in *Kommunist,* 1989, no. 1, pp. 23–33, and no. 5, pp. 76–77.

11. *Pravda,* 24 December 1990, p. 3 (translated in *Current Digest of the Soviet Press* [*CDSP*], vol. 42, no. 51 [1990], p. 18).

12. See Kaunas Economic Institute, "Urgent Ecological Problems in Lithuania," A Brief Submitted to the Council of Ministers of the Lithuanian Soviet Socialist Republic, November 1988, pp. 11–15.

13. See. e.g., "Brief of the Lithuanian World Community and the Lithuanian Green Movement to the Conference on Security and Cooperation in Europe: Meeting on the Protection of the Environment," Sofia, Bulgaria, October 1989.

14. On a successful referendum to close an agrochemical association in Odessa see *Izvestiia,* 23 December 1990, p. 6; on a referendum in Cheliabinsk to block the South Urals Atomic Power Station and to stop burial of radioactive wastes in the Southern Urals, see *Izvestiia,* 8 December 1990, p. 2.

15. See Tatiana Zaslavskaia's interesting analysis in *Izvestiia,* 17 December 1990. Referring to the local level, she suggests that "it appears that the democrats were too hasty in taking power into their own hands. . . . political power must invariably be backed by economic power" (translated in *CDSP,* vol. 42, no. 50 [1990], p. 10).

16. See the contribution of Susan Linz in this volume for discussion of this topic.

17. On this subject, see my article, "Environmental Protection and Economic Reform in the USSR," *Soviet Geography,* vol. 31, no. 4 (April 1990): pp. 237–56.

18. For an excellent discussion of these and other issues related to specific types of technology see Philip K. Pryde's book, *Environmental Management in the Soviet Union* (Cambridge, England: Cambridge University Press, 1991).

19. Gosudarstvennyi komitet SSSR po okhrane prirody (hereafter Goskompriroda), *Doklad: sostoianie prirodnoi sredy v SSSR v 1988 godu* (Moscow, 1989), pp. 82–83.

20. Ibid., p. 158; on Uzbekistan, see N. Skripnikov, "Khimizatsiia, zdorov'e i zakon," *Pravda vostoka,* 4 March 1989; on Tadzhikistan, see "O 'bezopasnykh pestitsidakh'," *Nedelia,* 1988, no. 47, p. 3; see also "Pestitsidy: vred i pol'za?" *Argumenty i fakty,* 1989, no. 11, p. 6.

21. "Brief of the Lithuanian World Community," pp. 12–13.

22. Goskompriroda, p. 83.

23. Ibid., p. 88. See also *Okhrana okruzhaiushchei sredy,* p. 101.

24. Goskompriroda, p. 188.

25. *Okhrana okruzhaiushchei sredy,* p. 100.

26. See, e.g., "V postoiannykh komissiiakh Verkhovnogo soveta TSSR," *Turkmenskaia iskra,* 6 May 1989, p. 3.

27. *Izvestiia,* 18 December 1990 (translated in *CDSP,* vol. 42, no. 51 [1990], p. 13).

28. *Pravda,* 24 December 1990, p. 3 (translated in *CDSP,* vol. 42, no. 51 [1990], p. 18).

29. Goskompriroda, pp. 93–94, 187, 191.

30. Goskompriroda, pp. 62–74, 94–99.

31. *Okhrana okruzhaiushchei sredy,* p. 156.

32. Ibid., p. 153.

33. Ibid., p. 154.

34. Goskompriroda, p. 77.