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Incremental Costs of Phasing Out Ozone Depleting Substances

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The authors are, respectively, Environmental Specialist, and Chief, Policy and Research Division, Environment Department, the World Bank. The report operationalizes the incremental cost criterion established externally by the Parties to the Montreal Protocol. The paper reports on findings that are particularly significant in the context of the overall work program of the Environmental Policy and Research Division.

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ABSTRACT

The Montreal Protocol stipulates a complete phase-out of substances that deplete the ozone layer. The Multilateral Fund has been established to provide grant finance to help developing countries that are signatories to the Protocol to meet their obligations on an incremental cost basis. Other background papers set out the broad context; that is, the mechanisms and priorities of the Fund and the role of national strategies to reduce ozone depleting substances. Within this broad context, this paper discusses the issues specific to incremental cost, the basis for eligibility for financing under the Fund.

The paper's aims are first, to highlight some of the remaining issues concerning eligibility for compensation under the Fund and to propose, in the interim, a limited number of rules of interpreting in detail the principles which have already been laid down by the Parties, and second, to set out some of the operational implications which may need to be considered further in the course of policy development.

The first three sections comprise introductory and some background material which can be skipped by those familiar with the ozone issue. Section I introduces the problem, the mechanism established under the Protocol to deal with it, and the relevant aspects of the world industry producing ozone depleting substance. Section II provides a framework within which the various incremental costs, financial losses, and compensatory payments can be identified. Section III sets out the circumstances that give rise to incremental costs. Broad categories of expenditure that are eligible for compensation by the Fund have already been determined by the parties to the Montreal Protocol at their London meeting 27-29 June 1990. These categories comprise the framework within which incremental costs are to be identified and quantified. This paper continues the exploration of the nature of these incremental costs in the context of the structure of the industry and its markets, the variety of country situations, and country policies.

Section IV interprets the incremental cost concept broadly (i.e., for countries), shows how this can be calculated, and identifies issues of eligibility for compensation under the Fund which may arise in future. While the important effect of country policies is noted, the design of appropriate national policies for implementing the Protocol is not covered in this particular paper.

Section V is the main focus: It interprets the incremental cost concept for individual economic agents (principally firms). The Parties to the Montreal Protocol clearly intend that the compensatory payments under the Fund be made at this level. Principles for calculating these incremental costs are set out, and some unresolved issues of eligibility for compensation are identified.

Section VI concludes by commenting on certain related operational matters: leverage, project and financial cost focus of the Fund, and the relationship of the Country Program Framework Papers to project selection on an incremental cost basis. Some interim rules for application of the Fund's resources are proposed.

INCREMENTAL COSTS OF PHASING OUT OZONE DEPLETING SUBSTANCES

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INCREMENTAL COSTS OF PHASING OUT OZONE DEPLETING SUBSTANCES

I. INTRODUCTION

The Ozone Issue

1.1 Chlorofluorocarbons (CFCs) were developed as working fluids for refrigerators and air conditioners, as blowing agents for foam manufacture, as specialist solvents, and as numerous other specialty chemicals. They were particularly useful compounds because they are very unreactive, chemically and biologically, making them very stable, non-toxic, non-flammable, and non-corrosive. They quickly replaced other compounds (such as ammonia in refrigeration) that were much less desirable. Similarly, halons, known for unreactivity and for poor electrical conductivity, were soon established as fire extinguishants.

1.2 Paradoxically, this very desirable characteristic of unreactivity contributes to the present problem concerning the destruction of stratospheric ozone. CFCs, halons, and certain other long-lived halogen compounds do not break down until they reach the stratosphere, where they ionize. A series of chemical reactions are believed to release chlorine or bromine radicals that catalyze reactions that destroy ozone. Each of these chemicals can be characterized in terms of its ability to do this by an index known as the "Ozone Depleting Potential" (ODP).

1.3 Ozone in the stratosphere plays an essential role in filtering out certain harmful ultraviolet rays that would otherwise endanger human health and various ecological cycles. The ozone issue is thus a global one with potentially serious implications.

The Montreal Protocol

1.4 The international community, reacting through the United Nations, recognized the danger presented by ozone destruction and decided to limit the damage and the risk by stopping the emissions of CFCs, halons, and substances having similar effects. This resolve took the form of the Montreal Protocol, signed in September 1987. The Protocol is an agreement among nations which establishes schedules for percentage reductions in the consumption of ozone depleting substances (ODSs) based on use within each participating country during 1986. The Protocol also places restrictions on trade in ODSs with non-parties to the Protocol.

1.5 To facilitate the phase out worldwide, the developed countries established a special Multilateral Fund (Fund) to provide financial assistance to the developing countries (defined in Article V as those using less than 0.3 kg of ODS per head per year). The Fund would be used to relieve the incremental costs associated with those countries phasing out ODSs.

The Structure of the World ODS Industry

1.6 The problem of phasing out ODSs is made a more manageable one by the following characteristics of the world ODS industry:

- There are very few major manufacturers of ODSs. Production is dominated by six U.S. and European multinational corporations. According to the latest issue of the Chemical Economics Handbook (1990), Du Pont owns 35 percent of the world CFC production capacity, followed by Atochem (18 percent), and Allied Signals (13.8 percent). Together with three other European multinationals (ICI, Hoechst and Montefluos), these firms control over 80 percent of world CFC production capacity, with proprietary rights over most processes. (See Table 1-1 for world CFC production and consumption.)

- There are only a few major end uses (refrigerants, foam blowers, aerosol propellants, cleaning agents/solvents, and fire extinguishants) for each of which there are technical substitutes at reasonable cost.

Table 1-1

World CFC Production and Consumption
(in '000 tonnes, 1988)

	Total	Refrig.	Foams	Aerosols	Cleaning
World	1139	342	319	216	262
U.S.A.	355	123	106	17	111
W. Europe	317	34	109	119	56
Japan	182	45	37	12	88
Rest of the World	285	140	67	68	9

Source: Chemical Economics Handbook (1990).

- Switching from ODS-based products in the dominant (i.e., industrialized country) markets is taking place rapidly. A trend noticeable in some industrialized country markets has been the switch in market demand to completely different chemical and raw material inputs (begun in the U.S. and Japan since

the late 1970s for aerosol products). Industrial analysts expect that demand switching and recycling could eliminate about 60 percent of the 1986 world CFC market. Based on the Chemical Economics Handbook (1990), the replacements expected in the U.S. in the year 2000 are likely to be approximately:

- 30% by hydrogen containing CFCs (HCFCs),
- 30% by recycling and conservation,
- 30% by nonfluorocarbons,
- 10% by fluorocarbons with no chlorine (HFCs)

- The specific question of phasing out ODSs in developing countries (principally CFC-11 and CFC-12) is simplified by the fact that few of them are producers. CFC production in Mexico, Brazil, Argentina and Venezuela is controlled by the six major multinational corporations through directly owned subsidiaries. In Asia generally, technologies have been either licensed or sold to local firms in the private/public sector (although China has developed its technology indigenously). The African market is serviced mainly by European exporters of CFC products. According to the recently completed country studies, all CFC producing developing countries (apart from China) are producing less than 9000 tons of CFCs annually, with most plants reporting considerable unutilized capacity. There are a variety of user industries though, such as refrigerator factories, which depend on CFCs either imported or locally made, and these will need to retool to use the alternatives.

1.7 Table 1-2 indicates the size of CFC markets in developing countries. By world industry standards production in any one of the developing countries appears uneconomic, and is viable only because of protection by trade or tax policies. Table 1-1 and Table 1-2 together highlight the extent of scale differences between producers in developing and industrialized countries. In Mexico, for example, Allied Signals has two plants with a combined capacity of 14,000 tons per annum, and Du Pont owns a plant with a production capacity between 4,000 and 7,000 tons per annum. The international optimum plant size, by contrast, is 20,000 tons per annum. This suggests that the major adjustment problem in developing countries is likely to be for user industries, rather than for producers.

Table 1-2

Production and Consumption of CFCs in Developing Countries
('000 tonnes/1988)

	Production	Consumption	Imports	Exports
Latin America	40	30	--	10
Asia	55	60	10	5
Africa/M. East	0	20	20	0
E. Europe	55	85	30	0
Others	0	5	5	0
Total	150	200	65	15

Source: Chemical Economics Handbook (1990).

II. INCREMENTAL COST, COMPENSATION, AND REIMBURSEMENT

2.1 The purpose of this section is to make clear certain distinctions, as these will be important for understanding the calculational framework. The distinctions are between:

- government and public costs;
- overall incremental costs borne by the country and incremental costs borne by individual firms;
- economic incremental costs and financial incremental costs;
- expenditures and losses;
- incremental costs and recompense;
- principles for calculating the various types of incremental cost and the principles for recompense

Government and public costs

2.2 **Government costs.** The government itself may incur (economic) costs in complying with the Protocol. For example the government might finance an information and advisory service, provide worker retraining, invest directly in recycling plants and other associated infrastructure, and bear various indirect costs (such as for road extensions) made necessary by the projects undertaken by the enterprises. All these government economic costs (*govt*) can be regarded as incremental.

2.3 **Public costs.** The public at large bears economic costs in the form of welfare losses[1] (Δ *welfare*), such as those due to price rises, as well as in the form of incremental costs incurred by firms (Δ *private*) to comply with the Protocol.

[1] Note that welfare loss could conceivably be negative, for example, where National Ozone Policy effectively closes down uneconomic CFC-dependent enterprises that had been propped up by high tariff barriers or government subsidies.

Country and firm incremental costs

2.4 **Country incremental costs.** The country incremental cost is the net economic cost of compliance with the Protocol, calculated without reference to any presumed payment from the Fund,

$$\Delta\ country \equiv \sum (\ govt + \Delta\ private + \Delta\ welfare)$$

where the summation is over all affected enterprises and relevant investments. The economic cost of "capital abandonment" is reflected in the incremental costs of new investments made necessary by the stipulations of the Protocol over what would otherwise have been the case.

2.5 **Firm incremental costs.** An economic agent (such as CFC producer or a refrigerator manufacturer) will incur private incremental economic costs (Δ *private*) as a result of the Protocol stipulations. This incremental economic cost will arise (i) from that part of the capital investment and O&M expenditures on the substitute plant that is incremental to the original investment and O&M expenditures and (ii) from the economic loss associated with the accelerated replacement of the original plant.

Economic and financial incremental costs

2.6 **Economic incremental costs.** These are real resource costs.

2.7 **Financial incremental costs.** These are the costs which guide decision-makers at the firm or consumer level because they include all the transfer payments (Δ *trans*):

Financial incremental costs to the firm

$$\equiv \Delta\ private + \Delta\ trans$$

The transfer payments will include the incremental taxes and duties, net of incremental subsidies, that are made to the government.[2]

Expenditures and losses

2.8 **Expenditure.** One component of incremental cost (economic or financial) will result from the higher costs of substitutes. It is that part of the capital investment and O&M expenditure on the substitute plant that is incremental to the original investment and O&M expenditure. This incremental cost will often be borne by the firm that made the original investment, but this need not always be the case, e.g., if the original manufacturer closed and a new entrant invested in the substitute.

2.9 **Loss.** Another component of incremental economic cost is the economic loss associated with accelerated retirement of the original plant. For example, the closure of a plant before the end of its normal economic life may impose incremental costs in the form of additional imports of substitutes at a later stage or the earlier than expected investment in new capacity. Financially this is mirrored by the loss suffered by plant owners as a result of the accelerated write-off.

Incremental costs and recompense

2.10 **Incremental costs.** These are the various costs defined above and calculated without reference to any recompense that may or may not be made.

2.11 **Recompense.** This can be made in respect of the incremental costs borne by firms individually or by the country as a whole. The source would be an international transfer from the Multilateral Fund, in the case where the recipient is a firm. Recompense can be conceived as comprising both reimbursement (for the incremental expenditures) and compensation (for the losses) but this distinction has no special importance.

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[2] There may also be incremental transfers to the public, e.g., additional financing charges and product liability payments, but these are probably not significant.

Principles of calculation and principles of recompense

2.12 This report is principally concerned with establishment of principles for calculating the various types of incremental cost. Principles for setting levels of compensation and reimbursement from the Fund are matters for the Executive Committee.

2.13 However, to elucidate some options available to the Executive Committee, the following alternative principles for compensation and reimbursement are set out.

(i) **Country incremental cost.** The Fund would reimburse the government for country incremental cost and call on the government to take care of all distributional aspects. This is not the principle which is currently in operation, but may be appropriate if larger transfers are contemplated in future.

(ii) **Economic incremental cost.** The Fund would recompense governments for their expenditures and firms for their incremental economic costs. This is similar to the Bank's usual project financing, since only economic costs are financed, not transfer payments. Governments may wish to supplement the Fund transfers by waiving any incremental transfer payments due to it from the firms concerned.

(iii) **Financial incremental costs.** The Fund would recompense governments for their expenditures and firms for their incremental expenditures and financial losses.

III. INCURRING INCREMENTAL COSTS

3.1 Incremental costs in implementing the Montreal Protocol are incurred as a result of transitions away from the use of a number of different ODSs, each with its own particular applications and chain of production, use and consumption. This section is a brief technical description of those features which influence the incremental costs of each of these transitions.

Production and Use of ODSs

3.2 **ODSs.** A range of ODSs has been defined in the Montreal Protocol (see Table 3-1). The common feature in these compounds is that they are very stable and do not decompose readily until reaching the stratosphere where they release ions of chlorine or bromine which can catalyze ozone destruction. The most common ODSs in developing countries (accounting for 95 percent of ODSs use) are the chlorofluorocarbons known as CFC-11 and CFC-12, generally used as refrigerants. To a lesser extent methyl chioroform, carbon tetrachloride, CFC-113, CFC-114, CFC-115, halon-1211 and halon-1301 are also used in developing countries. As time passes, the diversity of ODS use in developing countries increases as their industrial sectors broaden. In the smaller less developed countries, the commoner CFCs are used in refrigerators, air conditioners, aerosols and foams, but as development proceeds applications broaden to include halons for fire protection, methyl chloroform for metal cleaning and electronics manufacturing, and various CFCs for medical and specialist applications.

3.3 Applications

(a) *Refrigeration and air conditioning.* CFC (mainly CFC-12) are used as working fluids. They are particularly attractive because they are cheap, non-toxic, non-corrosive and non-flammable. Alternatives, while less ozone-depleting, are less attractive on one or other of these grounds and their use will impose incremental costs. Refrigeration and air conditioning are the fastest growing applications for ODSs in developing countries and the rapid expansion of infrastructure and capital stock dependent on CFC technology will lead to higher costs of CFC replacement in future.

(b) *Foam blowing.* CFCs (mainly CFC-11) are used to form polyurethanes, polystyrene, polyolefin, and phenolic plastic products. The density of the foam can be altered by

mixing it with water. The low toxicity and flammability of CFCs reduce the handling costs in an industrial setting. However, relative to certain alternative blowing agents, CFCs are expensive and for this reason alternatives are often used where available.

Table 3-1

Controlled Substances under the Montreal Protocol
(As revised in June 1990)

- Group I: chlorofluorocarbons (CFCs) 11, 12, 113, 114, 115. These are carbon compounds containing, in addition to carbon, only fluorine or chlorine atoms but no hydrogen;
- Group II: halons 1121, 1301, 2402. These are halogenated short chain hydrocarbons containing bromine;
- Group III: other fully halogenated CFCs;
- Group IV: carbon tetrachloride;
- Group V: methyl chloroform. This chemical is more properly referred to as 1, 1, 1 trichloromethane;
- Group VI: hydrochlorofluorocarbons (HCFCs). These are one, two or three carbon compounds containing hydrogen, fluorine and chlorine atoms.

(c) *Aerosol propulsion.* CFCs were extensively used in aerosol products because they are non-flammable, have good solvency, and can provide a range of vapor pressures suitable for many applications. However, hydrocarbon propellants are generally cheaper than CFCs and have been increasingly used instead in many countries. There is also strong competition from non-pressurized packaging technologies such as pumps, pistons and brushes which are less costly but still maintain satisfactory performance. In some countries, replacement of ODSs is complete or almost complete (e.g., in Egypt, following a ministerial decree, and in Brazil, following regulations banning CFC use in insecticides and household products, and also for economic reasons). In other developing countries, the aerosol industry is not very developed (e.g., in India, where traditional remedies and cosmetics are preferred and where aerosol packaging attracts additional taxes). Replacement of ODSs is not likely to be a major problem unless there is rapid growth in this industry.

(d) *Solvent cleaning.* CFCs and other chlorinated solvents such as methyl chloroform are used in the electrical, metal cleaning, biomedical and various specialist markets. Non-ODS solvents (such as water, alcohol and various other organic solvents) can sometimes be substituted.

(e) *Fire extinguishing.* Halons non-toxic, non-flammable, and non-conducting gases, have ideal properties as fire extinguishants. They are generally used where fire is a direct threat to human life and where no other agent could be effectively used. The principal ones used are halon-1211 and halon-1301.

3.4 **Sectors.** The incremental costs associated with replacement of ODSs can be attributed to the different sectors: production (new capacity or modification to or replacement of old capacity), user (retooling in industries currently using ODSs), and consumer (premature obsolescence of consumer durables and increased servicing or operating costs).

(a) *Consumer sector.* The refrigerator is a major long-term investment for those households in developing countries that have one. Ordinarily one might expect that the phase out of CFCs would impose heavy welfare losses, particularly on the middle income groups (i.e., those who can afford a refrigerator but who are not otherwise wealthy). This is because one can foresee that the inability to service the large and growing pool of CFC refrigerators and the higher costs of replacements would impose direct costs as well as other welfare losses on this class. While some studies (e.g., Box 3-1) point to this being the case, the long lead-time (including an additional ten-year grace period for LDCs) should imply that consumers can be warned well in advance and can take appropriate defensive measures. Also, because large amounts of CFC are wasted during servicing of refrigerators, and home refrigerator servicing is the largest net consumer of CFCs, training in techniques of conservation, recovery and recycling should be able to reduce these costs and welfare losses for a modest cost. Other losses (e.g., associated with aerosol use) will have very small impacts. It should be noted though that in some countries (e.g., most African countries) the consumer sector is the only one impacted as all CFCs and CFC-equipment are imported.

(b) *User sectors.* The user sectors comprise the manufacturers of refrigerators, air conditioners, foams and aerosols, the industries that use ODS solvents, and the suppliers of fire extinguishers. Their direct incremental costs will be retooling to use alternative chemicals and technologies or to make alternative products. A number of mid-sized developing countries have user sectors in addition to the consumer sector (e.g., Egypt,

Tunisia, Turkey, and Yugoslavia), although they still depend on imports for the ODSs themselves. Corporations may be either private or public.

Box 3-1

Estimates of Incremental Costs as a Function of Delay: Case of India

Case: Alternative Strategies to Implement Montreal Protocol in India

	Early Strategy	Late Strategy
	($ millions)	
Producer sector	192	82
User sector	68	50
Consumer sector	60	30

Source: World bank Seminar October 1990.

(c) *Production sector.* The producers will have incremental costs associated with new capacity or with plant modification or premature replacement. Some larger developing countries manufacture ODSs, some under license and some using domestic technology (e.g., Brazil, Mexico, India, and China). These countries also export ODSs to neighboring countries and may also import certain ODSs of a type not made locally. In most cases there is considerable excess capacity, and much of the plant is fully amortized.

(d) *Public sector.* Public expenditures on retraining, information programs, studies, databases, demonstration programs, recycling and other infrastructure, and administration would also be needed as part of an overall plan to phase out ODSs.

Factors Affecting Incremental Costs

3.5 A number of general factors will affect the incremental costs of the transition, apart from the specific factors applying to individual ODSs. These are the role of market forces, the timing of intervention in developing countries, expenditure on informational and administrative matters, and the overall strategy adopted.

3.6 **Market forces.** The significant reductions in CFC use which have occurred to date in developing countries have been market driven. In some cases the use of ODS alternatives has actually been cost effective and operating costs have been reduced (e.g., in replacing CFCs in aerosols). Export and local markets have been protected to some extent by the actions of industries stopping the use of ODSs before being required to do so by bans. Where satisfactory alternative technology exists, consumer preferences have been satisfied by non-ODS devices and preferences.

3.7 Increasingly, export markets will expect a powerful influence over the user sectors. Brazil, for example, exports compressors to the US and elsewhere and Tunisia expects to export more than half of its refrigerator production to Europe. The ODS bans and new standards in these large markets (comprised of Protocol signatory countries) will by itself force compliance in the exporting countries. Exports of foam products and aerosols will be similarly affected.

3.8 In the producer sector, the firms which are subsidiaries of the multinational chemical firms or which operate under license from them will benefit from new technology developed in and for the developed countries. However, where they exist alongside domestic competitors it may be necessary to have government policy that "levels the playing field." That is, if the substitutes will be more expensive there will be a market opportunity for an ODS competitor to continue operating until such time as all firms are confronted by a ban.

3.9 **Timing.** The developing countries have been given a ten-year grace period under the Montreal Protocol. That is, while developed countries are assigned a 1986 baseline consumption (from which the percentage reductions are computed) developing countries can continue expanding consumption until 1996 after which the reductions take effect. There is some evidence that this has introduced a note of complacency in developing countries who do not feel the urgency which is the spirit of the Protocol.

3.10 Illustrative growth rates for near term consumption of ODSs are given in Table 3-2. While the actions underway or planned in several countries will actually reduce ODS consumption, the large consumers will expand consumption. The costs of delayed action will be high in countries where ODS use is expanding dramatically (e.g., China, India, Brazil) because the capital stock that ultimately requires modification or replacement would likewise be growing rapidly.

3.11 The India ODS country study indicates that if ODS elimination is not pursued vigorously and immediately in countries with high growth in ODS use, the difficulty of ODS elimination will be greatly increased. Data in Box 3-1, presented at a World Bank Seminar in October, 1990, indicate that if implementation were delayed, overall incremental costs would increase by about 60 percent, and consumer costs would increase six-fold in the course of about a decade. This results from enormous growth in the domestic market for refrigerators and other CFC-using appliances which

more than offset declining ODS-substitute manufacturing costs resulting from steep learning curves in manufacturing these in developed market economies. Not only will the incremental costs be increased, but the relative burden will be shifted more to consumers as refrigerators are purchased. In China and India, it has been a conscious policy to increase the proportion of the population having access to refrigeration.

Table 3-2

Indicative Growth Rates a/ in ODS Consumption

Country	Current Usage b/ ('000 t)	Average Annual Growth Rate Expected
China c/	46	12%
India c/	11	15%
Brazil c/	11	8%
Mexico c/	7.9	2%
Yugoslavia d/	7.5	-10%
Turkey d/	4.6	- 4%
Egypt d/	2.7	- 6%
Tunisia d/	0.73	6%

a/ Source: Bank estimates based on various studies.

b/ Consumption in 1990 in terms of CFC-11 equivalent i.e., Ozone Depleting Potential (ODP).

c/ Based on projected change in ODP to 1996.

d/ Based on projected change in ODP to 1993.

Costs Incurred by the Various Sectors

3.12 **Producer sector.** Here the incremental costs are associated with building new plant or modifying (or replacing) old plant so that chemical alternatives to ODSs are manufactured. The most commonly cited alternatives are certain hydrofluorocarbons (HFCs) or hydrochlorofluorocarbons (HCFCs) which have much lower potential for depleting ozone.

3.13 **User sectors**

(a) *Refrigeration/air-conditioning*

- Recycling and reclamation involves expenditure on new equipment (tanks, purifying equipment etc.) and retraining.

- Chemical alternatives (such as HCFCs, HFCs, ammonia and other fluids with low ODP) involve retooling costs in the factories, new handling facilities because of toxicity or flammability (case of ammonia), or new bulk facilities and chillers, depending on the actual substitute.

- Alternative technologies, operating on a different cycle or with different configurations, are capable of using non-ODS working fluids. The costs are redesign, retooling, and retraining.

(b) *Foams*

- Recycling and reclamation can be achieved in the curing area (a major source of CFC emissions during manufacture) through a process known as carbon adsorption. This process is expensive though.

- Chemical alternatives such as HCFC-123 and HCFC-141b are possible substitutes, although there are others including hydrocarbons. Incremental costs will be incurred on plant modification, e.g., to handle the flammability of the agents.

- Alternative technologies are needed to compensate for the slightly poorer insulation properties of the foam produced by chemical alternatives. Costs will be incurred on modifications to pumps, pipes, filters, etc. Technologies also exist to reduce or even eliminate the CFC used as a blowing agent.

- Product substitutes may also be developed in time, such as vacuum insulation panels to replace foam. Greater use might also be made of natural and synthetic fiber materials.

(c) *Aerosols*

- Chemical alternatives, such as deodorized LPG, are available. There will be costs of providing supply facilities for the deodorized gas and for handling a flammable gas in the manufacturing process. This is already cost effective. HCFCs could also be used.

- Alternative technologies, such as mechanical atomizers, have been available since before the time that aerosols were widely used, and are still acceptable in many cases.

- Product substitutes, like brushes for cosmetics, will also be used.

(d) *Solvents*

- Conservation and recovery practices can dramatically reduce the ODS use in electronics manufacture. Management costs and the costs of engineering controls will be incurred. In the metal cleaning sector, recovery techniques have been available for many years. Capital expenditure would be needed for gravity separation, water adsorption, or single-plate distillation equipment.

- Chemical alternatives exist which in many cases provide equal or better cleaning performance at equal cost to CFC-113. Methyl chloroform and carbon tetrachloride could also be used and, although they are substances controlled under the Protocol too, their ODP is much less. Certain other organic solvents substitutes which are volatile organic compounds may be undesirable for local environmental reasons.

- Alternative technologies for cleaning such as ultrasonics, aqueous immersion etc. are available.

3.14 **Consumer sector.** Increased costs here will lead to premature replacement of CFC based refrigerators and air conditioners, higher costs for service calls where technicians have to use special techniques to avoid wasted CFC, and perhaps disposal costs for old appliances. Note that in any overall assessment of compliance costs double-counting will have to be eliminated, i.e., incremental economic costs of recycling cannot be simultaneously assigned to both the service company and the consumer.

IV. INCREMENTAL COSTS TO COUNTRIES

Country Incremental Cost Approach

4.1 Country incremental costs can be divided into economic costs met by government and economic costs borne by firms and others. One possible way in which a compensatory mechanism might operate is that countries are reimbursed for the minimum country incremental cost necessary to meet the phase-out schedule, and that the country concerned subsequently take responsibility for the distributional issues within its borders. The government would need to adopt a National Ozone Policy which, first, attempted to minimize the overall adjustment cost and, second, ensured equitable distribution of the adjustment burden and the compensatory payments among the various economic agents. This section covers the calculation of country incremental costs and highlights the issues concerning compensation/reimbursement to countries.

4.2 In principle, three estimates of country incremental costs could be given, and should be distinguished. The first is the *minimum incremental cost* which would be incurred if the country met the Protocol targets by adopting the most efficient policies possible, e.g., removed price distortions and rationalized industry and trade policies where necessary. (This "cost" might well be negative in some cases.) The second, which could be called the *compliance cost,* is the incremental cost which would be incurred against the background of existing economic and industrial policies by adopting only the most efficient policy that is specific to the phase out. (This cost could not be completely defined until the boundary between the specific and the general policies has been drawn.) The third, which could be called the *adjustment cost,* is just the actual cost incurred, i.e., it exceeds the compliance cost to the extent that adjustment is inefficient.

Effect of Country Policy

4.3 **Economic and industrial policy.** Compliance cost, as defined above, is thus strongly influenced by general economic and industrial policies. Since it is not the intention of the Parties to require general economic or industrial policy reform as a condition for assistance under the Multilateral Fund, it is only compliance cost and not the true minimum incremental cost that needs to be calculated. However it may be worth noting the extent to which a country's general policies will influence the cost of compliance. An extreme example would be the case of a country that had

encouraged small-scale, inefficient domestic production of CFC behind high trade barriers; in this case merely prohibiting CFC manufacture would actually remove a distortion and could incur a negative adjustment cost. (Outright prohibition may not be the most efficient adjustment mechanism though, and it is still worthwhile examining alternative strategies to reduce the adjustment inefficiencies.)

4.4 Key aspects of the country's economic and industrial policies that will affect compliance cost are:

- The country's development strategy (e.g., degree of outward orientation);
- Industry strategy (including trade protection and restrictions on ownership and competition);
- Regulatory and incentive structure (including legislation and the tax structure); and
- Institutional capacity to implement regulations.

4.5 **National Ozone Policy.** In addition to any compliance cost there will be inevitable additional costs introduced by inefficiencies in the adjustment process. One purpose of the government adopting a national strategy for protection of the ozone layer (the "National Ozone Policy" referred to earlier in Section II) would be to minimize these inefficiencies. The distinction between compliance cost and inefficiencies in the adjustment process is useful because these costs are related to different policies (the pre-existing industrial policy on the one hand, and the National Ozone Policy as implemented on the other) and can be controlled in different ways. It might otherwise be easy to lose sight of adjustment inefficiencies in cases, such as the example given above, where the compliance cost is negative but partially offset by costs arising out of inefficient adjustment.

4.6 National Ozone Policy would make use of a combination of policy instruments specifically targeted on the phase out. The following key instruments illustrate the difference between National Ozone Policy and general policies:

- Quotas and bans on the production and use of particular ODSs;

- Sales of permits for the production, importation or use of particular ODSs;

- Financial compensation for closing ODS capacity, e.g., from the government or through the Fund;

- Financial assistance to establish new plant or modify existing plant to manufacture or use substitutes;

- Taxes on sale or disposal of ODSs, ODS-using equipment, and products whose manufacture required ODSs;

- Subsidies on substitute products and equipment;

- Infrastructural support, e.g., for recovery and recycling of CFCs or for transport, storage and disposal of substitutes;

- Retraining, promotion, and technology transfer.

4.7 One important criterion for judging of National Ozone Policy will be adjustment efficiency, but another will be fairness since the effect of policy will be to redistribute the burden of adjustment among the various sectors (producers, users, and consumers). The redistributive effects may also affect the incentives for compliance.

Calculating Compliance Cost

4.8 The compliance cost (i.e., minimum adjustment cost given existing economic and industrial policies) can be determined, at least in principle, from a least-cost plan of adjustment comprising an optimal National Ozone Policy together with an optimal investment plan. The principle is to minimize the incremental economic costs subject to the constraints defined by the obligations under the Protocol and by the general policies of the country. In essence the economic problem is similar to that of developing a least cost investment program for (say) the power sector. Electric sector plans begin with demand forecasts and a range of technical options that meet the demand. Total capital and operating costs, appropriately discounted, are minimized using an algorithm that determines the

selection and timing of feasible investments subject to a variety of imposed constraints. The reasonableness of initial assumptions concerning demand (a function of price) can be tested by extracting estimates of supply costs from the calculation. If necessary, these assumptions can be revised and the whole calculation can be performed iteratively until a desired degree of consistency and convergence is reached. Likewise, in the case of ODS phase out, costs need to be evaluated in a dynamic framework, a program with a time dimension for each of the sectors involved. Consumers' incremental costs, for example, would include those incurred over the economic life of CFC-based refrigerators due to "premature" replacement, increased energy requirements, and higher recharge expenses, followed by the earlier subsequent replacement of the following (substitute) refrigerator. User firms may experience one-time retooling costs followed by continued higher operating costs. Producers too would need to alter the selection and sequence of investment projects and operations over a period of time.

4.9 However, in the case of ODS phase-out, there are several special features to take into account which make the problem more difficult than least-cost programming in other sectors. The first special feature concerns a compensation principle which, when it is agreed, should be reflected in the choice of the "without Protocol" scenario that is being contrasted to a "with Protocol" scenario in order to arrive at an estimate of the incremental economic cost. These scenarios are not always clearly spelled out, and this can lead to confusion. In the "without" situation, a choice has to be made whether losses connected to trade with developed countries who have ratified the Protocol are included. So, for example, if we wish to compensate a developing country because it will lose export markets or incur incremental costs in making its export goods suitable for countries which have signed the Protocol, then we need to define our "without" scenario as the one representing what would have been the case if none of its trading partners had imposed any of the Protocol's restrictions on trade or on specifications for use of imported ODS equipment within their own internal markets. If, on the other hand, we regard trade losses as non-compensable, our "without" scenario must assume that developed countries have ratified but that the LDC in question has not done so yet.

4.10 The second special feature concerns a technical question in constructing the "with" scenario. The question is whether the cost structure (and hence the price signals and resulting demand patterns) have been seriously affected either by the Protocol restrictions or by assumed levels of compensation (whether government transfer payments or grant finance from the Multilateral Fund).

To do a least cost analysis (rather than an analysis where both costs and benefits are fully integrated) it is necessary to assume that benefits, including those resulting from the use of ODSs or their substitutes are the same, i.e., that the level of services provided by ODSs in the "without" scenario are the same as those provided by substitutes in the "with" scenario. As the Protocol specifies fixed targets, it also assumes implicitly that any of the "with" scenarios meeting these targets will deliver the same global benefit.

4.11 The third special feature is that the demand for the services of existing ODSs must be disaggregated by ODS. There are six groups of controlled substances defined by the Protocol, each with its own chemical properties, type of use and sector of application. In principle, one should compare total cost and benefit streams obtained in an integrated framework, (i) using the benefits specific to the reduction of each particular ODS, say by weighting emissions in terms of their Ozone-Depleting Potentials, (see Table 4-1),[3] and (ii) discounting future benefits of reduced emissions, which would value more highly the earlier reductions and encourage earlier compliance. In practice, the Protocol stipulates phase-out schedules for the substances and hence the reduced benefits of ozone depletion are fixed, only the costs need to be minimized. Furthermore, the phase-out schedules are applicable on a group basis: this means the problem is the sum of six separate reduction strategies with no tradeoffs allowed between substances in different groups.[4] Ideally one should trade off reduction rates among all the ODSs until the marginal benefit of a unit reduction in ODS is the same for all.[5] Also, because the Protocol stipulates reduction targets (e.g., a 50 percent reduction on baseline consumption for Group II ODSs by year 2006) there is no acknowledgement of any additional discounted benefits resulting from earlier than normal compliance.

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[3] Because of some scientific uncertainties and data gaps on proposed weights (such as Ozone Depleting Potential and Chlorine Loading Potential) this may not be practical in all cases.

[4] Within groups, tradeoffs are implicitly allowed as the consumption subject to control under the Protocol is calculated as the ODP-weighted sum of consumptions in each group.

[5] While there is some flexibility of substitution within a group (e.g., reducing relatively more halon-1211 than halon-1301 while still maintaining the overall target reduction for Group II as a whole) substitution between groups is not credited for compliance purposes, even between groups having the same target reduction profile.

4.12 The fourth special aspect concerns data adequacy. In the case of (say) power and water sector development plans there are reasonably accurate demand forecasts and good technoeconomic data for costing alternative supply options at different scales of operation. This is not the case for ODS substitution where (i) demand patterns and price elasticities have not been extensively researched; (ii) rapid technical change is expected to have a large but unknown impact on supply costs within the planning period; (iii) supply costs from sources outside the country or from domestic producers affiliated with multinational producers are not easily obtainable; and (iv) the cost reductions due to learning and the scaling up of new techniques can only be guessed at. While several alternative technologies are commercially available and have good cost data (e.g., aqueous cleaning as a substitute for CFC-113 cleaning and CFC-12 recycling system for mobile air conditioners), the cost of emerging technologies (e.g., HCFC-141b for solvent cleaning and HFC-134a for refrigeration) are less certain. Furthermore, the substitute products are likely to have more specialized applications than existing products. Industry sources, for example, expect about eight chemicals to replace the many applications made at present using CFC-11 and CFC-12. There is, therefore, considerable uncertainty about whether the substitutes will be able to benefit from the same economies of scale as the existing ODS. In any case, the decline in prices of ODS substitute manufacturing and utilization equipment would also depend on economies of scale in production in industrialized countries. Markandya (1990) notes that CFC prices in the past have declined by constant percentages each time production doubled and cites industry sources to describe this relationship -- the price elasticity with respect to cumulative production -- to range between -.02 to -.03 for CFCs. As the substitute products are being developed by the same multinational firms (Du

Table 4-1

Ozone Depleting Potentials of Controlled Substances

Group Protocol	Substance	Ozone Depleting Potential
Group I	CFC 11	1.0
	CFC 12	1.0
	CFC 113	0.8
	CFC 114	1.0
	CFC 115	0.6
Group II	Halon 1211	1.0
	Halon 1301	10.0
	Halon 2402	5.5
Group III	CFC 13	0.45
	CFC 111	Not Available
	CFC 112	0.96
Group IV	Carbontetra-chloride	1.11
Group V	Methyl chloroform	0.11
Group VI	HCFC 21	0.04
	HCFC 22	0.05
	HCFC 31	0.05
	HCFC 121	Not Available
	HCFC 122	Not Available
	HCFC 123	0.02
	HCFC 124	0.02
	HCFC 131	Not Available
	HCFC 132b	0.05
	HCFC 133a	0.05
	HCFC 141	0.09
	HCFC 141b	0.10
	HCFC 142b	0.06
	HCFC 151	Not Available
	HCFC 224	Not Available
	HCFC 225	Not Available
	HCFC 226	Not Available
	HCFC 234	Not Available
	HCFC 235	Not Available
	HCFC 242	Not Available
	HCFC 243	Not Available
	HCFC 244	Not Available
	HCFC 252	Not Available
	HCFC 253	Not Available
	HCFC 261	Not Available
	HCFC 262	Not Available
	HCFC 271	Not Available

Note: Groups I, III and VI include isomers under main name

Pont, Atochem, Allied Signals, ICI) which are price setters for specialty chemicals world-wide, one could expect past trends to continue.

4.13 The fifth special feature is that the costs of ODS phase out will be highly distributed; they are not borne by one or two utilities or corporations but by a variety of producers, users and consumers. There may also be costs imposed on the government in the form of incremental administrative costs and additional infrastructure, and on the economy as a whole to the extent there is (say) consequential unemployment, although these may not be large (or easily quantified).

4.14 Finally, since we are interested in *incremental* costs, the calculations of cost have to be performed twice; once for the least-cost, Protocol constrained (or "with") solution and once for the unconstrained (or "without") case. Incremental cost is the difference in cost between two scenarios.

4.15 The analysis requires a projection of demand for ODS services, a description of the constraints placed on individual ODS use (i.e., phase out profiles), a technically feasible program of appropriate substitutions and alternative technologies to meet the demand for ODS services within the constraints set for the ODSs themselves, cost data on the current technologies and the alternatives, and the choice of the least-cost approach. (See Box 4-1 for a summary of these steps.)

Step 1: Demand projections

4.16 The projected demand for the services required of ODSs/ODS substitutes is required. Current ODS use may need to be ascertained from industry surveys or analyses of existing statistics if available. Projections can be made on the basis of near-term expectations of industry leaders and current users and projections of industry development.

4.17 Ideally the comparison of the "with" and "without" cases would be performed in a general equilibrium framework to capture all the tradeoffs and the full adjustment costs to the economy. In particular this would require different demand projections for the baseline and phase-out scenarios and a measure of the benefits of ODS reduction. If a country adheres to the Protocol, the use of higher price alternatives will of course alter the demand for the services provided by ODS alternatives and the adjustment costs will be diffused throughout the economy. (There will also be costs

associated with unserved demand, since one might expect that the implementation of a substitution program will not always be smooth.)

4.18 In practice of course the technical and economic uncertainties and the paucity of data will not permit such a sophisticated approach, and so a partial approach will be necessary. In some cases it can be assumed that the demand for the services that ODSs provide will be approximately the same for the alternative as for the ODS and that only the supply costs of the "with" and "without" scenarios need to be compared. In the case of aerosol propellants (where the alternatives are already competitive) and solvent cleaning (where ODSs and their substitutes are responsible for only a small fraction of total production costs in the industry concerned) this is likely to be a good approximation. In other cases (perhaps air conditioning/refrigeration), price rises will affect demand. For example, the substitute for the CFC-12 currently used in refrigerators will be more expensive than CFC-12, and the equipment using it will also be more expensive than the prevailing models, at least initially. The higher cost of refrigeration will depress the demand for refrigeration somewhat. Incremental costs for importing the alternative fluid and converting (say) a refrigerator factory to make equipment that uses it should be based on the demand expected at the higher price.[6]

Box 4-1

Calculating Country Compliance Costs

Step 1: Project demand for ODSs

Step 2: Ascertain the Protocol's constraints on consumption

Step 3: Technically assess the most appropriate substitutes and alternative technologies for replacing ODSs.

Step 4: Propose alternative scenarios using these substitutes/alternatives to satisfy the demand for the services of ODSs, but within the constraints for ODS consumption.

Step 5: Calculate the incremental cost of each scenario relative to the without Protocol case.

Step 6: Select the scenario with the minimum incremental cost; this is the country

Step 2: Constraints

4.19 The problem is one of constrained cost minimization: the costs are the incremental costs and the constraints are the series of phase-out schedules for each ODS. See Table 4-2 for the constraints stipulated for Article V countries (developing countries). Other constraints may exist due to the existing general policies.

[6] This effect is calculated prior to, and partly as a justification for, compensation for the increased capital and operating costs available from the Fund. Of course this compensation itself (and any government transfers) will alter the financial costs borne by various groups and may alter the price and demand structure for ODSs and related goods.

Step 3: Technical substitutes and alternatives

4.20 This step is a technical appraisal of all feasible alternatives in each of the affected producer, user and consumer sectors and for each ODS. Examples include:

Producer - Modify or build CFC plant to make substitutes

User - Recover and recycle CFCs

- Use alternative propellants, e.g., LPG (fireproofing, relocation of aerosol plants)

- Manufacture air conditioners and refrigerators to use alternative refrigerant (retooling.)

- Introduce water-based cleaning (new facilities)

- Use air for foam blowing (minor modifications)

Consumer - Accept ban on recharge of refrigerators and air conditioners with CFCs (early replacement of appliances, higher energy costs).

Table 4-2

ODS Consumption Constraints
(Developing Countries)

ODS Group	Constraint
I, III, V & V	Unconstrained growth until 1996
	50% reduction of 1996 consumption level by 2003
	85% reduction of 1996 consumption level by 2007
	Phase out by 2010
II	Unconstrained growth until 1996
	50% reduction of 1996 consumption level by 2006
	Phase out by 2015
VI	No agreement announced yet -- may be used to substitute for other Groups.

Step 4: Alternative scenarios

4.21 There may be several different feasible ways of obtaining the desired reduction. These should be specified.

Step 5: Incremental Costs

4.22 Costs will arise in the different sectors -- producer, user and consumer -- and may be passed on from one sector to another. There are four important analytical issues: ensuring no double-counting, recognizing costs at the time they are incurred, discounting, and treating premature obsolescence.

4.23 **Double counting.** Incremental economic costs recognized as having arisen in (say) the producer sector cannot also be regarded as incremental costs in a user sector if they are passed on in the form of price increases.

4.24 **Timing.** The calculation is an economic not a financial one. It is appropriate to include costs as they are incurred beginning with capital expenditure and continuing with incremental operating costs and overheads in each year of operation. Depreciation is not included as the capital cost of the plant or modification is included and the discounting of future expenditures makes an appropriate allowance for the return on capital.

4.25 The timing of investments may turn out to be a very important aspect of the strategy. Developing countries may be able to benefit by delay because of unit cost reductions that occur later when the global market for substitutes has expanded to the point where economies of scale are realized or when developed countries have wrought significant technical progress. On the other hand, in a rapidly expanding domestic market, delay could increase the size of the capital stock requiring premature replacement, as suggested by the results of the study on India shown in Box 3-1.

4.26 **Discounting.** Future economic costs need to be discounted. A typical real discount rate of 10 percent p.a. may be used unless there are compelling country reasons for selecting an alternative rate.

4.27 **Premature obsolescence.** By projecting future incremental economic costs and discounting, the economic loss arising from any premature obsolescence of plant is taken into account as the cost of having to modify plant and equipment or to replace them with new technology alternatives.

Step 6: Least cost

4.28 The scenario with the lowest incremental cost should be selected. This cost is the "compliance cost." As it is unlikely that sophisticated linear programming techniques can be supported by the available data, this step would probably be performed by inspection and adjustment.

Compensation and Reimbursement Issues

4.29 Several issues concerning compensation are highlighted by this discussion that merit consideration in any future re-interpretation of the eligibility principles of the Fund:

(i) *Is compensation to be made on the basis of some calculation of overall "country incremental cost"?*

(ii) *If so, is the compensable amount the "compliance cost" (i.e., the minimum adjustment cost possible given the pre-existing generally applicable economic and industrial policies) or the actual "adjustment cost"?*

(iii) *Are costs due to market-induced changes compensable?* Whether or not a country joins the Protocol it will suffer incremental costs due to the change in international market conditions. In the example given earlier, a compressor exporter such as Brazil would find that export markets in the United States will close unless the exported equipment meets new requirements for the ODS alternatives being adopted by the United States as a Protocol signatory. As another example, an Eastern European country, depending entirely on imported CFCs for a local refrigerator factory, would suffer the costs of transition if trade in CFCs is successfully reduced by the concerted action of signatory countries. These losses may be sudden and direct (e.g., closure of factory because of sudden loss of existing export markets) or longer term (e.g., loss of expected market development). Eligible costs certainly include all self-imposed costs (since Fund compensation is intended as an incentive for countries to join) and, as a concession on equity grounds, might conceivably be extended at a later date to include short-term

trading losses[7] (due to import and export bans, and the increased cost of imported substitutes).

(iv) *Over what time horizon are costs compensable?* For the cost calculations, projected demands are required until at least the year 2010 (the phase out date for developing countries). A longer period would be needed if the discounted value of incremental costs continuing beyond that date are expected to be significant. Although this is unlikely given the economies of scale and the technical progress possible within the next twenty years, the principle for compensation should be clear lest there be cases where significant losses continue past the phase-out date.

4.30 There are also "follow-up" issues, so characterized because they are not so much matters of interpreting eligibility, but matters for consideration if there is any restructuring of the Fund. One such issue is that of how to encourage phase-out of ODSs earlier than currently scheduled, where the cost of doing so is modest.

[7] Those that are incurred before (say) 1995. "Short term" is an arbitrary period reflecting the inability of firms to make immediate adjustments to sudden changes in order to avoid losses. The judgment will have to take into account the economic life and alternative uses of production capacity dedicated to serving export markets.

V. INCREMENTAL COSTS TO FIRMS

5.1 An alternative way in which a compensatory mechanism might operate is that individual economic agents ("firms") are reimbursed for their incremental expenditures and compensated for their financial losses by some combination of the Fund finances and government transfers. (In fact the London Agreements, which clarified aspects of the Multilateral Fund, have a definite project orientation that clearly indicates this is the approach to be taken initially. See Appendix.) This section covers the calculation of such incremental costs. Refer to Section II for distinction between the incremental expenditures and the financial losses, the latter acting as a proxy for the economic loss of early plant closure.

Similarities to and Differences from the Country Incremental Cost Approach

5.2 Many of the issues that arise in the calculation of incremental costs to individual economic agents (referred to as "firms" for convenience) also arise in the case of countries (see Section IV) and are not repeated here. For example, in attempting to calculate the least cost adjustment path of a firm over a given planning period, one would encounter similar problems of data adequacy, baseline definition, and degree of disaggregation needed.

5.3 However there are some important differences from the case of country incremental costs:

(i) Decision-makers in firms are guided by costs that are financial rather than economic. This makes it important to decide on a principle for reimbursing transfer payment component of incremental expenditure and compensating for financial losses.

(ii) Financial costs of the firm may be greater than or less than economic costs of the firm.

(iii) The analysis of incremental costs of the firm is at best partial, it leaves out associated government expenditures (e.g., on retraining) and external costs.

(iv) Total country incremental cost will likely be very different from the sum of the financial incremental costs of all eligible firms because the latter includes various transfer elements and excludes costs borne by the public.

(v) Finally, complex questions of distribution will arise: the incidence of the initial adjustment costs, the impact of adjustment policies and payments, and the passing on of incremental costs from one group to another through price changes.

Effect of Country Policy

5.4 The differences in approach can be illustrated by an re-examination of the impact of country policies (this was discussed earlier in connection with country incremental costs in Section IV).

5.5 **Economic and industrial policy.** General economic policy (e.g., on taxes and duties, fuel subsidies etc.) significantly affects private financial costs (as shown by the example in Box 5-1). Incremental financial and incremental economic costs differ substantially due to transfer payments and costs borne externally by the government and the public at large, as shown in the "balancing" column in the example. Industrial policy that offers generous depreciation provisions is a particular policy that can make a substantial difference (see example in Box 5-2).

5.6 **National Ozone Policy.** National Ozone Policy seeks to implement the Protocol and, in the process, may redistribute the incremental costs between groups. This will have to be considered in the calculation of the incremental costs actually experienced. For example, ozone tax credits or subsidies will lessen the burden for some, perhaps even affecting the incentive structure and the demand. (As mentioned, one important part of National Ozone Policy will be the provision of a "level playing field," so that those firms undertaking incremental investments for compliance purposes will not be disadvantaged in a competitive market for their goods and services vis-a-vis more tardy firms.)

Calculating Incremental Costs to Firms

5.7 A fully integrated, dynamic cost-benefit analysis, or even a least-cost programming exercise at the firm level,

(i) would involve similar procedures and raise similar issues to the treatment of country incremental cost (Section IV);

Box 5-1

Financial and Economic Incremental Costs

Example: Modified plant to produce substitutes

Incremental Cost Component	Private Financial/ Rs million	Economic/ Rs million	Public Financial (and Welfare Loss) Rs million
	Categories of Cost		
Capital a/	862	862	---
Taxes and duties b/	141	---	-141
Additional fuel c/	71	187	116
Retraining d/	43	43	---
Labor	---	---	---
Electricity e/	20	38	18
Industry subsidy f/	-110	---	110
Road widening and new local government waste disposal method	---	4	4
Pollution damage	---	10	10
Total incremental	1027	1144	117g/

a. All incremental capital expenditure made in a single year.

b. Customs duties on imported components and other taxes paid are financial transfers but do not represent economic value-added.

c. This is an oil exporting country where internal (financial) petroleum product prices are below world (economic) prices, as part of national industrial strategy. In this example, future financial and economic costs are discounted at the same rate.

d. These are one-time worker retraining costs.

e. The financial cost of electricity to the firm is below the (economic) long run marginal costs of production to the country.

f. The government stimulates investment in manufacturing with a tax rebate offset against income from any source.

g. This "balancing" cost is borne by the government and public at large.

(ii) would not, however, be very practicable, given the problems noted above (para. 5.2); and

(iii) may not prove to be necessary unless the guidelines on compensation and reimbursement subsequently indicate that longer-term losses (e.g., lost market opportunities, reduced future profits) are to be considered.

5.8 Therefore the following outline of the calculation of incremental cost is limited to the static situation; basically one-time losses and investments together with the present value of associated incremental operating and maintenance expenditures. The approach highlights the financial nature of the cost calculation and focuses on the way it differs (paras. 5.3-5.6) from the country incremental cost approach. As a financial calculation it must provide for matters such as amortization, salvage value, and the appropriate private rate of discount. But in addition, there are certain financial issues that are particularly important in the phase-out problem, namely:

(i) the existence of both financial loss and incremental expenditure as components of the incremental financial cost facing firms;

(ii) the need to separate out losses that had already been occurred for non-Protocol reasons (e.g., in relation to pre-existing overcapacity) and incremental expenditures that are to be incurred for commercial reasons (i.e., capacity expansion or modernization rather than capacity replacement); and

(iii) the need to assess carefully any tax benefit in relation to the plant written off or to the new investment, not only for the usual reason that the present value of such a benefit will reduce the incremental cost, but also because it may contain a particularly concessional element introduced through the National Ozone Policy.

Box 5-2

Incorporating Depreciation Provisions

Suppose a country's tax laws allow exemptions to a CFC manufacturer who elects a straight line depreciation of 20 percent per year. Incremental investment costs in financial net present value terms are thus offset partly by the depreciation allowance, as illustrated in the example below.

FY	Cash Flow/ $ million	Net Present Value (at 10 percent p.a.)
1991	10.0	10.0
1992	(2.0)	(1.82)
1993	(2.0)	(1.65)
1994	(2.0)	(1.50)
1995	(2.0)	(1.37)
1996	(2.0)	(1.24)
	TOTAL	2.42

Thus the incremental financial cost is only $2.42 million (in 1991 dollars) against an incremental economic cost of $10.0 million.

Calculating Incremental Cost

5.9 Incremental expenditure

Let I = original capital cost of ODS plant

M = annual O&M costs of ODS plant

r = annuity factor (reflecting selected discount rate and time horizon for differences in O&M costs)

I' = capital cost of replacement plant

M' = annual O&M costs of replacement plant

E = incremental expenditure

Then

$$E = (I'-I) + r\,(M'-M)$$

5.10 Financial loss

Let a = amortized fraction of the original investment

S = salvage value of plant (including any tax benefit of the residual amortization)

L = financial loss due to the Protocol

The financial loss is the unamortized fraction of the original investment less the salvage value, that is

$$L = I\,(1-a) - S$$

5.11 Incremental cost. The incremental cost is the sum of the incremental expenditure and the financial loss.

$$\boxed{E + L = (I'-aI) + r\,(M'-M) - S}$$

5.12 Original overcapacity. One complicating factor arises when the capacity of the original plant is not fully utilized. In such a case

- the incremental expenditure due to the Protocol would relate only to the replacement of the utilized capacity; and

- the financial loss due to the Protocol would be less than the overall loss which also includes the pre-existing loss due to overestimated demand.

Let

c = fraction of original capacity utilized

Then

$$E = (I' - cI) + r\,(M' - cM)$$

and

$$L = c\,[I\,(1-a) - S]$$

where the salvage value has been prorated between the utilized and unutilized capacity. Thus the incremental cost would be

$$E + L = (I' - caI) + r\,(M' - cM) - cS$$

5.13 **Capacity expansion and plant modernization.** A second complicating factor arises when the replacement plant exceeds the capacity of the original because the manufacturer wishes to supply a larger market. In such a case

- the incremental expenditure due to the Protocol would be less than the total which also includes expenditure needed for capacity expansion; but

- the financial loss would be unaffected.

Let k = ratio of old (utilized) to new capacity

Then

$$E = (kI' - I) + r\,(kM' - M)$$

and

$$E + L = (kI' - aI) + r\,(kM' - M) - S$$

Similar considerations apply in the case of plant modernization because not all the incremental expenditure can be attributed to replacing existing capacity.

5.14 **Overall calculation.** Combining both original overcapacity with capacity expansion, the incremental cost is given by

$$\boxed{E + L = (kI' - caI) + r\,(kM' - cM) - cS}$$

Refer to Box 5-3 for a worked example.

Compensation and Reimbursement Issues

5.15 The above discussion concerns the calculation of the incremental costs of firms. Decisions about which of these costs should be compensated and by whom (the government or the Fund) need to be taken by the Executive Committee. However the discussion above will help clarify the essential issues involved.

Box 5-3

Worked Example

I = \$100 (for capacity of 100 units)

c = 60% (i.e., 60 units utilized)

a = 70% amortized

I' = \$120 (for capacity of 80 units)

k = 75% (i.e., 60/80)

S = \$10 (including tax benefit)

r = 3

M = \$10

M' = \$12

$$E+L = 0.75 \times \$120 - 0.6 \times 0.7 \times \$100 + 3\,(0.75 \times \$12 - 0.6 \times \$10) - \$6 = \$51$$

(i) *How would replacement capacity be allocated among new entrants for purposes of calculating reimbursable incremental costs?* A (practical) difficulty would arise if these were several new entrants because it may be necessary to allocate the compensable share of the pre-existing utilized capacity among them. For example, if Firm A with utilized capacity of 100 closed and Firm B and Firm C both entered the substitutes market with capacity 100 and 50 respectively, only a proportion of the capacity of B and C would be a replacement of A's capacity, the rest would represent capacity expansion for which reimbursement may not be eligible. Some allocation principle would thus be necessary.

(ii) *Would reimbursement be reduced to the extent that costs are passed on?* Under competitive conditions, compensation for financial loss only would not distort the market for substitutes: investment in substitutes would be equally attractive to the compensated firm and new entrants which would pass on the costs of making or using the substitutes to the users and consumers. However, if the incremental expenditures are reimbursed as well, either the price of substitutes will be kept artificially low (assuming a competitive

domestic market) or (in the case of imperfect competition) the firm could be overcompensated: fully by the Fund or government and at least partly again by passing on the incremental expenditures. Under the imperfect market conditions in many LDCs, firms compensated for incremental expenditures are likely to be overcompensated to the extent they can also pass on such costs.

(iii) *Would compensation or reimbursement be reduced to the extent that losses and costs can be covered by a multinational partner in a joint venture or wholly owned subsidiary company?*

(iv) *What part of the compensation and reimbursement due a firm should be met by the concerned government?* The total compensation received by the firm would comprise payments from the Fund and additional payments from the government as a consequence of its National Ozone Policy. The division between the two needs to be made clear. One possibility, suggested in Section II, is that the government waives additional transfer payments due to itself (e.g., incremental taxes).

(v) *Can reimbursement be retroactive in a situation where a firm chooses to invest in substitutes as soon as possible?*

VI. OPERATIONAL CONSIDERATIONS

Context

6.1 The operational context comprises the provisions of the Protocol, the decisions of the Executive Committee of the Multilateral Fund, and the Bank's usual procedures. The current exigencies and strictures of the Fund define the character of the "Pilot Phase," within which a number of departures need to be made from the ideal way of computing incremental costs (described in Section IV and Section V). The possibility is left open, however, for a longer term approach which, based on substantially greater resources, could more closely approach the ideal. The operational considerations in the Pilot Phase and their implications for incremental cost calculations are set out below.

Leverage

6.2 The total allocation of funds in the Pilot Phase is limited to $240 million. It is clear therefore that the availability of funds for any one country is small. Thus it is not possible to obtain any general policy reform and existing distortions will have to be accepted as part of the background. Developing countries will also resist policy conditionality on what is seen as compensation rather than development assistance. At the Second Meeting of the Parties in June 1990 it was decided that financial and technical assistance would take into account the national industrial strategy of the recipient party.

6.3 The implication of this is that the Fund cannot be used to achieve general policy reform. National Ozone Policy is still required to facilitate the phase out, ensure efficient adjustment, and provide necessary support for individual projects, e.g., by providing regulations on phase out so that firms making the necessary incremental investments are not penalized in the marketplace. It is also clear that the thrust of project selection should not undermine policy reform being undertaken for other reasons, e.g., where an economy is already in transition from a "command-and-control" industry strategy to an incentive-based system. In this case, task managers may wish to avoid production-oriented projects and emphasize investments that shift demand. (This issue concerns project selection and the content of National Ozone Policy, which are not the main focus of this paper.)

Focus on Projects and Financial Costs

6.4 Another aspect of the operational context is the project focus given to the Fund by the Parties. Financial assistance is to be provided not only in relation to specific projects (for which eligibility criteria have been devised) but also for defined categories of eligible incremental expenditures. (Eligible categories of expenditure, defined in the London Agreements, are attached as Appendix.) Certain costs other than project-specific incremental costs may also be incurred under other functions defined by the Parties to fall within the purview of the Fund (e.g., clearinghouse functions). However these are relatively minor. These costs could include studies, distribution of information, workshops, training, and coordination.

6.5 One implication of this is that initially the Fund will not compensate countries for overall economic compliance costs, as calculated in Section IV, but individual firms (or state corporations) undertaking specific eligible investments. A second implication is that this compensation is made for incremental financial costs, since it is financial incentives to which these agents respond. (The total compensation payment could however be made partly from government sources and partly from the Fund.)

Country Program Framework Paper

6.6 The general objective of the Country Program Framework Paper (CFP) is to provide an integrating framework for ongoing and planned studies, policy analyses, investment and other project preparation.[8] Among other things the initial CFP would describe briefly the indicative and prioritized investment program for ODS reduction and the strategy for implementing the Protocol (i.e., the initial National Ozone Policy).

6.7 Eventually, an updated and refined CFP would contain sufficient information to estimate overall compliance cost (which would assist country programming) and to rank alternative measures in terms of their cost-effectiveness even if a comprehensive economic cost minimization (such as described in Section IV of this paper) is not possible. General economic and industry policy is taken as a given

[8] A more detailed account is provided in the companion document, "Country Program Framework Papers" (CFPs).

but the investment program should be supported by a National Ozone Policy which aims to keep adjustment costs as low as possible.

6.8 The outputs of the CFP would be used by Bank staff as follows:

- The project rankings would be used to select projects for appraisal.

- The estimated compliance cost of the program could be used as one criterion for determining total Fund assistance to that country.

- The attribution of incremental costs to various sectors and firms would be used to avoid double-counting and possible over-compensation. For example, incremental costs of imports would not also be attributed as incremental operating costs for various industries. The role of National Ozone Policy (in relation to transfer payments and to any constraints on the affected groups' ability to pass costs on) is crucial in this regard.

Proposed Interim Compensation and Reimbursement Rules

6.9 Prior to specific consideration by the Executive Committee of the issues in compensation and reimbursement highlighted in this report, a small number of interim rules are proposed for the Pilot Phase which are consistent with the general thrust of the existing agreements among the Parties to the Fund:

(i) Compensation from the Fund is made for once-only financial losses at the firm level

(ii) Reimbursement from the Fund is made for once-only incremental capital expenditures and for the present value of the incremental O&M expenditures for the ensuing three years (both net of incremental taxes and duties) at the firm level, and for direct incremental expenditure at the government level over the next three years.

(iii) National Ozone Policy as a minimum should

- demonstrate how Protocol targets will be met;

- show how the instruments selected will minimize adjustment cost;

- allocate the "replaced capacity" among new entrants where necessary; and

- address other distributional issues arising out of the adjustment process or out of the compensation and reimbursement payments.

(iv) Financial loss and incremental expenditures are to be calculated as set out in Section V of this paper.

(v) Eligible categories of incremental cost are as set out in the London Agreements (refer to the Appendix to this paper).

6.10 Nothing in the above precludes the possibility or diminishes the desirability of adopting the more flexible and efficient country incremental cost approach in due course. Perhaps the time to consider this is when more experience has been gained by the implementing agencies and when the Fund resources available more closely match the total financing requirement. At such a time, the losses to the Fund from an inefficient approach would be much higher than they are now and less offset by any benefits such as "incremental experience."

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APPENDIX

Eligible Categories of Expenditure
(defined in the London Agreements)

(a) Supply of substitutes

(i) Cost of conversion of existing production facilities:

- cost of patents and designs and incremental cost of royalties;
- capital cost of conversion;
- cost of retraining of personnel, as well as the cost of research to adapt technology to local circumstances.

(ii) Costs arising from premature retirement or enforced idleness, taking into account any guidance of the Executive Committee on appropriate cut-off dates:

- of productive capacity previously used to produce substances controlled by existing and/or amended or adjusted Protocol provisions; and
- where such capacity is not replaced or converted or new capacity to produce alternatives.

(iii) Cost of establishing new production facilities for substitutes of capacity equivalent to capacity lost when plants are converted or scrapped, including:

- costs of patents and designs and incremental cost of royalties;
- capital cost;
- cost of training, as well as the cost of research to adapt technology to local circumstances.

(iv) Net operational cost, including the cost of raw materials.

(v) Cost of import of substitutes.

(b) Use in manufacturing as an intermediate good

(i) Cost of conversion of existing equipment and product manufacturing facilities.

(ii) Cost of patents and designs and incremental costs of royalties.

(iii) Capital cost.

(iv) Cost of retraining.

(v) Cost of research and development.

(vi) Operational cost, including the cost of raw materials except where otherwise provided for.

(c) End use

(i) Cost of premature modification or replacement of used equipment.

(ii) Cost of collection, management, recycling, and, if cost-effective, destruction of ozone-depleting substances.

(iii) Cost of providing technical assistance to reduce consumption and unintended emission of ozone-depleting substances.