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# Market Based Instruments For The Implementation Of The Montreal Protocol In Developing Countries

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# Glossary

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## ABBREVIATIONS

CFC (class)	Chloro-fluorocarbons
HCFC (class)	Hydrochloro-fluorocarbons
MFIMP	Multilateral Fund for the Implementation of Montreal Protocol (the "Fund")
MFEC	Executive Committee for the Fund
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substance
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization

## PRINCIPAL ODS AND THEIR ODP (MONTREAL PROTOCOL VALUES)

Trade name	Formula	Relative ODP (to CFC-11)
Carbon tetrachloride (CTC)	$\text{CCl}_4$	1.1
CFC-11	$\text{CFCl}_3$	1.0
CFC-12	$\text{CF}_2\text{Cl}_2$	1.0
Halon-1211	$\text{CF}_2\text{BrCl}$	3.0
Halon-1301	$\text{CF}_3\text{Br}$	10.0
Methyl chloroform (MCF)	$\text{CH}_3\text{CCl}_3$	0.1

## NOTATIONS:

This paper's references to ODS are strictly to the five CFCs and three halons in the Protocol Annex A. References to \$ are for US dollars.



# Summary

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1. Established in 1990, the Multilateral Fund ("the Fund") for the Implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer ("the Protocol") is provided with the mandate "to meet, on a grant or concessional basis, the agreed incremental costs" of developing country Parties (those operating under Article 5.1 of the Protocol) "to enable their compliance with the control measures" of the Protocol. These control measures mandate reduction and eventual elimination of the "consumption" (defined as aggregate production plus net imports plus stock increase) of virgin (newly produced) ozone depleting substances (ODS) according to schedules established by the Protocol.

2. The Protocol's control measures are not yet binding on the developing country Parties. While many developing countries have expressed an intent to achieve an earlier compliance than the Protocol commits them to, no control measures currently apply at the level of individual firms in most developing countries. The Fund has been empowered by the Parties, however, to use its assistance "as an incentive for early adoption of ozone-protecting technologies". The Fund's assistance to date and for some more time may therefore be characterized as voluntary transactions for an accelerated phaseout, or over-compliance, with the Protocol.

3. The developed country Parties (i.e., those not operating under Article 5.1 of the Protocol) are obliged to meet the agreed incremental costs of developing countries' compliance with the Protocol. In practice, the Fund receives periodic voluntary grant contributions from the developed countries

according to the UN assessment rules. Operational authority over the use of the Fund's resources is vested in its Executive Committee (MFEC). The Fund disburses these resources via its Implementing Agencies (the World Bank, UNDP, UNIDO, and UNEP). Its financial assistance to date primarily has taken the form of grant awards to individual firms engaged in the use of ODS undertaking phaseout via conversion to permissible ODS substitutes. These grants are approved by the MFEC on a project-by-project basis according to administratively established assessment criteria for certain categories of "eligible incremental costs". Willing candidate firms have to be identified and canvassed by the Implementing Agencies, who submit the grant requests on behalf of the national governments. Considerable administrative resources at the multilateral level are expended to identify and develop the projects, calculate the "eligible" need, prepare grant proposals, negotiate the amounts, and implement the approval, disbursement, and verification mechanisms.

4. The Fund's current approach of need assessment implicitly presumes that the firm's optimal phaseout (in terms of timing and technological option) and associated capital and operating costs can be administratively determined, and that the firm's conversion project can be isolated from its overall operations and objectives. It ignores certain firm-specific parameters (e.g., remaining economic life of existing equipment, conversion project economic life, discount rate, future expectations, and collateral economic benefits of conversion) which determine the firm's incremental cost of conversion and its choice of when to convert,



because it is difficult or impossible to know these variables. There is a risk that administrative assessment distorts the firms' behavior from least-cost choice of technology and timing and that the Fund's grants meet more than the incremental costs a firm may be willing to accept for conversion.

5. The project-by-project approach, and the associated administrative determination of qualified grant level, may have been necessary in the early years of the Fund's operations when there was little experience with ODS-substitute technologies, few candidates willing to convert, and no legal limits on ODS use. Over time, these conditions have changed and will continue to change, creating greater incentives and lesser risks to conversion. Already, the demand for Fund grants have exceeded available resources, as more projects are developed. At the same time, projects approved to date have shown a wide variation (across countries and end-use sectors, project size, and over time) in project-level unit grant levels (\$/kg ODP, termed "cost-effectiveness" by the Fund) assessed and approved under current rules.

6. Beginning in 1995, the Fund has used some sector-level "cost-effectiveness threshold values" (CETV, in \$/kg ODP terms), for its grants, and has also permitted "partial funding" of assessed eligible expenditures if the beneficiary firm elects to meet the remainder so as to maintain the grant within the threshold values. While this approach has implicitly introduced partial elements of competition among firms, within particular use sectors, the projects are approved essentially on a "first-come, first-served" basis. Firms have an incentive to choose technologies and timing just so as to meet the CETV, not less; sectoral CETVs vary considerably; and, self-selection is at best limited. An explicit scheme to require firms to self-select, and to ensure that phaseout proceeds along the efficient path of achieving the cheaper reductions before the more expensive ones is desirable.

7. This paper (i) explores alternatives to the current approach that offer efficiency gains — i.e., increasing the ODS use phaseout for a given sum of money — to the Fund and an individual developing country; and (b) argues

for a national system of controls, in particular establishing enforceable firm-level limits on ODS use, necessary to ensure that the Fund's assistance, and the country's phaseout strategy, is effective. The emphasis is on a simple exposition of options at the Fund's disposal, subject to individual developing countries' consent (i.e., with no need for multilateral agreement). Design and implementation details require further analysis for specific situations.

8. Toward the first objective, the paper proposes that the Fund's assistance to firms using ODS be seen as a "market" for ODS phaseout — the firms providing a verifiable, quantifiable service in return for a unit price (\$/kg ODP) — and advances a conceptual proposal to use sequential competitive bid auctions at the national level. Such a scheme could apply to all firms across all sectors and project types (including shutdown), or could be limited to certain segments at a time. Each participating firm would submit a technical proposal and a sealed cost proposal. Evaluation of the technical proposal would be limited to the extent of verifying the amounts of ODS use the firm is entitled to, and of the verifiability of the service offered (via conversion or closing the operations). Subsequently, technically qualified firms' cost proposals would be ranked according to their "offer price" (in \$/kg ODP) and their offers accepted until the pre-set available funds are exhausted.

9. A competitive bid auction is fair in that a technically qualified firm's offer price may be rejected only if other firms' cheaper offers exhaust the available funds; the winning firms' incremental costs of compliance are met precisely as they perceive them to be. At the same time, competitive pressures would drive the participating firms to bid close to their true costs (net of expected benefits) in order to maximize the probability of winning and minimize that of losing out to a competitor.

10. A competitive bid auction is also efficient in the sense that individual firms have an incentive to choose least-cost options and that, among firms, cheaper phaseout projects are implemented before more expensive ones. Precise savings as compared to the current administrative assessment approach would depend on the design and implementation of a

competitive bid auction scheme in country-specific situations. This paper does not offer a particular model of conducting a bid auction; specific timing and rules of such auctions depend on country-specific factors (e.g., market size and composition). Examples of alternative rules that can be used in auctions include: guaranteed floor price, maximum acceptable price, “set-asides” (i.e., separate auctions with different quota) or “standard price” (i.e., fixed unit price) options for small firms, sector- or substance-specific auction without a follow-on auction, permissibility of re-bidding, and the like.

11. The essential argument rests on the following propositions:

(a) Accepting that the Fund’s assistance is to be applied at the firm level, rather than Party (country) level, and to firms engaged in ODS *use* rather than “consumption” (production and imports) only, the incremental costs that ought to be financed by the Fund are the *minimum net costs*; there is no assurance that the project-by-project “need assessment” approach under current rules does that.

(b) It is impossible to administratively determine the minimum net costs of conversion. Conversion project costs and benefits vary across firms and over time, and are influenced by variables – such as discount rate, expectations of market conditions (including for ODS, their substitutes, and final products firms sell), and market strategy – which are specific to individual firms, and best known to the firms themselves.

(c) Viewed from the overall perspective of protecting the atmosphere, a kg. of phaseout offered by one firm is no different from that offered by another; given a budget constraint, the Fund should choose cheaper phaseout before the more expensive one. The challenge is to devise a mechanism whereby *all* offerors of phaseout compete at the same time, instead of administratively selecting the offerors and then paying them the amounts deemed to be “eligible” even as other offerors may have a lower unit price. It is not necessary to separate “incremental capital costs” and “incremental operating costs”, or distinguish by use sectors, as under current rules.

(d) A competitive bid auction provides such a mechanism. In a competitive auction, a firm’s “offer price”, or “willingness to accept”, reveals its own estimate of the “incremental cost” incorporating its own expectations of the costs and benefits of conversion. It may well offer a higher price than what it is willing to accept, but in so doing it risks losing out to a competitor. If it estimates that its offer price would be lower some years hence, it could either wait until a later auction round, or enter a bid now and take a chance that its current offer is indeed cheaper as compared to its competitors. Thus, competitive bidding would come close to revealing the firms’ minimum “willingness to accept” and optimize the timing of conversion across firms.

(e) An accepted bid, in turn, constitutes a mutual agreement between the firm and the Fund that the total amount awarded is adequate compensation for the service to be provided; the “agreed incremental cost” criterion is therefore satisfied, without having to externally assess the firm’s costs and benefits. (To reiterate for emphasis, it is impossible to administratively determine the minimum net costs of conversion). The potential for one firm gaining competitive advantage over others is minimized, and the country is able to fulfill its phaseout obligations in the least-cost manner.

12. Rejected bidders can compete in a subsequent round of phaseout so long as the Fund continues to assist the country in meeting its compliance obligations. Successive auctions need not result in higher offer prices, however; to the extent that over time, the cost of premature replacement of existing capital equipment declines, the price differential between ODS and its substitute declines, technological growth and adaptation reduce net conversion costs, and the firms perceive greater advantage in conversion due to market shifts, their offer prices can be expected to decline correspondingly.

13. A national-level bid auction would be based on competitive procurement practices in use in a given country, and would require only a slightly different administrative structure in ODS phaseout as compared to the current one;

for instance, expanding technical assistance activities at national and sectoral levels (so that all firms can better evaluate their options), and providing at least the first-level authority to accept phaseout offers at the national level (instead of MFEC approval for every firm's conversion). Bid auctions as proposed here should be applied only at the national level, not at the international level (whether between countries or between firms from different countries).

14. Whether or not the Fund continues with the project-by-project need assessment approach or permits the use of national competitive bidding for grants, it is imperative that national legal and regulatory structures be established to translate Party-level compliance commitments into firm-level permits or "entitlements", with legal limits on market entry (by new firms) or re-entry or expansion (by existing firms). Without such enabling legislation, there is a risk that the *net* ODS phaseout may be less than what the Fund's assistance provides for (if the aggregate use rises even if some individual firms convert). Corresponding to such controls, administrative structures to maintain registries of eligible firms and enforce the phaseout and bans are also needed.

15. Bid auctions are a particular form of market-based instrument (MBI) to achieve a regulatory goal. Other market-based instruments such as pricing policies for ODS (e.g., taxes) and substitutes (e.g., subsidies) and inter-firm tradeability of ODS production, import or use permits can be very powerful in providing the appropriate signals to firms

and limiting windfall gains or losses. While they involve flows of funds away from firms rather than to them (which is the Fund's objective), the resultant revenues may be used to supplement the Fund's resources. These instruments are not within the Fund's authority to use, and may only affect firm-level financial calculus without necessarily affecting national economic costs of compliance; however, their use may supplement the developing country government resources to implement the ODS phaseout, and provide flexibility and predictability to firms. Also, compliance with the Protocol means honoring aggregate quantity limits according to a particular schedule; therefore, pricing policies alone risk being insufficient or overshooting the target.

16. Specific recommendations are that (i) the Fund accept bid auctions as a means of grant transfer within those developing countries which wish to use them, and encourage their efforts via pilot schemes; (ii) the Fund provide incentives to national governments, perhaps in the context of a broader policy dialogue, to use other market-based instruments (pricing policies and/or use of tradeable permits for ODS consumption or use) which can offer greater overall effectiveness of the Fund's grants; (iii) developing countries establish firm-level limits (via permits) on ODS use, production and trade, both in order to monitor compliance with the Protocol and to protect the phaseout achieved; and, (iv) the Fund accord greater priority to conversion of ODS production (to substitute production) and recycling and reclamation activities than it has so far.

# 1 Introduction

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Under the 1987 Montreal Protocol (the "Protocol") on Substances that Deplete the Ozone Layer and its amendments subsequently adopted in London (in 1990) and Copenhagen (1992), the signatory national Parties have committed themselves to a gradual phaseout of the domestic production as well as consumption (defined as domestic production minus destruction plus net imports) of certain virgin (i.e., newly produced) ozone depleting substances (ODS)<sup>1</sup>. As of January 1996, the developed countries<sup>2</sup> ceased virgin "consumption" of certain ODS whose pre-Protocol "consumption" level was over 1,000,000 tons per year; the *use* of these ODS may continue for some time, depending on the inventories of previously produced (including recycled) ODS. The developing countries are granted a grace period for compliance with the Protocol, whose "consumption" control measures will become binding upon them beginning 1999 (with a freeze, followed by reductions beginning 2005). Many developing countries have expressed a desire to accelerate their compliance schedule, indicating that an accelerated phaseout may be beneficial to them.

Overall, the task is to phase out annual virgin ODS "consumption" in the developing countries of about 150,000 to 200,000 tons per year (or more, up to limits established by the average between 1995 and 1997), and a smaller quantity of virgin ODS production. In 1990, the Parties established a Multilateral Fund for the Implementation of Montreal Protocol ("MFIMP" or the "Fund"), to fulfill the Protocol mandate to "meet, on a grant or concessional basis as appropriate, and according to the criteria to be decided upon by the Parties, the agreed incremental costs" of these countries' "compliance

with the control measures of the Protocol". (UNEP 1995b, p. 1) The Fund receives assessed grant contributions from the developed country Parties (i.e., those not operating under Article 5.1 of the Protocol). Operational authority over the use of the Fund's resources is vested in its Executive Committee (MFEC). The Fund disburses these resources via its Implementing Agencies (the World Bank, UNDP, UNIDO, and UNEP). The agencies are required to "apply only those considerations relevant to effective and *economically efficient* programmes and projects consistent with criteria adopted by the Parties." (*ibid.*, p. 13, emphasis added).

While no control measures currently apply to developing countries, the Fund has been empowered by the Parties to use its assistance "as an incentive for early adoption of ozone-protecting technologies" or, in other words, for an accelerated phaseout or over-compliance with the Protocol. The Fund's assistance to date primarily has taken the form of grants to individual firms engaged in the *use* of ODS undertaking phaseout via conversion to permissible ODS substitutes. These grants are approved by the MFEC on a project-by-project basis according to administratively established assessment criteria for certain categories of "eligible incremental costs" for each firm and conversion project. As of end-1995, the Fund has approved over \$400 million of grants, expected to result in elimination of over 60,000 tons per year of ODS use. By the end of 1995, about 7,500 tons of ODS use (but a negligible amount of ODS production) had been phased out with Fund's assistance.

For the first four years of the Fund's operations, available funds exceeded the

demand for grants; beginning 1995, the situation reversed. This suggests that it would be useful to devise economically efficient methods that would bring about the greatest ODS phaseout with the available funds (including via reduction in the administrative costs of grant delivery). Also, in the absence of developing countries' adoption of domestic regulatory measures to control ODS use, there is a risk that the Fund's assistance may be frustrated by subsequent growth. Finally, because the Protocol only requires controls on domestic "consumption" (production and net imports), phasing out ODS use without corresponding reductions in production and net imports may provide perverse price signals to firms and permit an increase in ODS stockpile which may negate the gains of an accelerated phaseout<sup>3</sup>.

Certain shortcomings of the Fund's current project-by-project approach with administratively (i.e., external to the firm) assessed "eligible incremental costs" are as follows: (i) firms' phaseout decisions may be distorted away from a least-cost path; (ii) firms may be overcompensated for replacement of existing equipment with limited remaining economic life; (iii) cost savings and collateral benefits to the firms as a result of conversion cannot be captured; (iv) the incentives to minimize the grant request are at best limited; and, (v) in-depth reviews and considerable scrutiny at multiple levels increase the administrative costs of grant delivery.

This paper has two broad objectives: (a) to explore alternatives to the current approach to the phaseout of ODS use that may offer efficiency gains – i.e., increasing the ODP phasedout for a given sum of money – to the Fund; and, (b) to argue for a national system of controls, in particular establishing enforceable firm-level limits on ODS use, necessary to ensure effective use of the Fund's assistance (so that use reductions also result in consumption reductions). The specific focus is on laying out a conceptual framework for the Fund's use of market-based instruments (MBIs) that provide incentives to firms for self-selection, continued innovation, and choosing the least-cost path to phaseout.

Three types of MBIs may be considered

to facilitate the ODS use phaseout: (a) allocation of Fund grants via competitive auctions (similar to other bulk procurement schemes); (b) making use permits or entitlements tradeable, whether they are issued by an administrative mechanism or sold to firms via competitive auction; and (c) providing appropriate price signals to firms, particularly via taxes on sales or use of ODS and/or subsidies on sales or use of permissible substitutes. The primary attention in this paper is on the first type of MBI, advancing a conceptual proposal to use national-level sequential bid auctions for firms who offer "ODS phaseout" in return for Fund grants.

The essential argument for a competitive bid auction, in contrast to the project-by-project approach, is as follows: the intrinsic or "true" incremental costs, net of expected cost savings and collateral benefits, are best known to the firm itself, and cannot be determined externally by using general rules. "ODS phaseout" (measured in ODP terms) is a service of uniform quality, i.e., one kg. of ODP phaseout from one source is indistinguishable from that of another. Accepting firms' offers of ODS phaseout in the increasing order of \$/kg ODP ensures that the cheaper conversions are achieved before the more expensive ones. Also, a technically qualified firm's offer may be refused only because another firm has beaten its offer price; hence, the auction approach is likely to be seen, at least from the firms' point of view, as fairer and more transparent than the administrative project-by-project approach.

The key point is that, under a competitive auction or procurement scheme, firms are compelled to reveal their intrinsic incremental costs in the form of "offer price" or "willingness to accept" (WTA). An accepted bid constitutes the agreement between the firm and the Fund (or the national-level auctioneer as the Fund's representative) on the "incremental costs" of phaseout at a given point in time, and would thus qualify as an "agreed incremental cost". If the maximum acceptable bid (in \$/kg ODP) is set low enough to achieve greater phaseout for a given sum of money, the competitive auction would clearly guarantee savings as compared to the current approach. Precise levels of savings would depend on sector, country, and design of the auction/procurement scheme.

This paper does not provide a model for any particular country or scheme, nor does it propose that bid auctions be used at the inter-country level. Rather, it recommends that the Fund encourage efforts to use national-level bid auctions and other MBIs for ODS phaseout and provide incentives to countries which choose to engage in compliance strategies which offer greater overall effectiveness of the Fund's grants.

Environmental mandates which impose aggregate time-bound quantity commitments, as does the Protocol, require that corresponding obligations be imposed on individual firms which cause the environmental damage. Thus, creation of legal and regulatory frameworks establishing firm-level permits or "entitlements" for ODS use with legal limits on market entry (by new firms) or re-entry or expansion (by existing firms), is critical to an effective use phaseout, whether or not there are incremental costs associated with it and whether or not these costs are financed by the Fund and how. Such framework would at the very least ensure that the Fund-assisted phaseout is effective, and would also enable the use of other MBIs such as pricing policies or inter-firm trade of permits or "entitlements". At the minimum, a registry of user firms with a pre-determined quantity of ODS phaseout it may offer is required. (As the controls on ODS production and net imports become binding, developing countries will also need to use similar controls on the supply side).

A detailed discussion of pricing policies or a regime of inter-firm trade of entitlements ("tradeable permits") is consid-

ered beyond the scope of this paper, primarily because they are subject to the jurisdiction of national governments, not the Fund. Some limited observations are offered, however, outlining conceptual and design issues as well as political and administrative requirements of the use of these other MBIs. Used in combination with firm-level controls on ODS production and imports, they may well supplement the developing country government resources for ODS phaseout; provide flexibility and predictability to firms; and, affect the firms' "willingness to accept" (expressed in their auction offers), and thereby "agreed incremental costs" (i.e., accepted offers). Indeed, the Fund's use of bid auctions can be seen as a limited case of tradeability wherein the Fund "buys out" the entitlements and "retires" them. A full-fledged tradeable permits regime would also reveal the competitive valuation of ODS use entitlement, a very useful piece of information for the government as well as the Fund.

The rest of the paper is organized in five sections: Section 2 provides a summary of the developing country Parties' compliance obligations and the Fund's mandate, concluding with a brief discussion of the need for national firm-level controls; Section 3 discusses the Fund's current grant rules and their shortcomings in the context of compliance costs; Section 4 outlines the concepts behind a competitive bid auction for ODS phaseout; and Section 5 discusses the potential for other MBIs. Section 6 concludes with a summary and recommendations.

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1/ References to "ODS" in this paper are to the five CFCs and three halons in the Protocol Annex A, though the main argument is unaffected by including any other controlled ODS. All ODS quantities in this report are in terms of Ozone Depleting Potential (ODP) equivalent. ODP of a substance is a weighted value of its potential harm to stratospheric ozone, relative to CFC-11. (That is, ODP of CFC-11 is 1.0).

2/ Parties operating under Article 5(1) of the Protocol are referred to as "developing countries", and "non-Article 5(1) parties" as "developed countries".

3/ That is, if some firms convert but other firms expand the use or build up inventories of ODS, especially if ODS price falls as a result of the former group's conversion.



## 2 National Obligations vs. Firm-Level Controls

### Compliance Obligations

The Protocol and its Amendments impose controls on aggregate national production as well as consumption (defined as production minus destruction plus net imports) of a large number of chemicals subject to different schedules. From the developing countries' perspective, the most significant controlled substances at this stage are the five CFCs and three halons covered by Annex A to the Protocol and referred to as ODS in this paper. Table 1 shows the control schedules binding upon the developing countries for these substances.

Once the Protocol's control measures become binding, imports by developing countries are permitted only for "basic domestic needs". Net imports of used (reclaimed) ODS are to be taken into account for determining the base year quantities, but not afterwards. Many developing countries have expressed a willingness to reduce their ODS "consump-

tion" well in advance of the schedule imposed by the Protocol. Implementation of the control measures via reduction targets upon individuals or firms is subject to national jurisdiction; in most of the developing countries, no firm-level reduction targets or schedules apply as yet.

### The Fund's Mandate and Operations

The Fund has been empowered by the Parties to use its assistance "as an incentive for early adoption of ozone-protecting technologies". The primary vehicle the MFEC has opted to use is in the form of grants to individual firms engaged in the use of ODS undertaking phaseout via conversion to permissible ODS substitutes. These grants are approved by the MFEC on a project-by-project basis according to administratively established assessment criteria for certain categories of "eligible incremental costs" for each firm and conversion project. Implementing agencies submit grant proposals to the MFEC Secretariat on behalf of the firm

TABLE 1: DEVELOPING COUNTRY OBLIGATIONS FOR ODS CONTROLS	
Production and net imports of virgin controlled substances <sup>1/</sup> :	
Annex A: Group I Primary CFCs (CFC 11-12, 113-5) Freeze 7/1/1999; 50% cut by 1/1/2005; 85% cut by 1/1/2007; 100% cut by 2010.	Baseline: average of 1995-97
Annex A, Group II: Halons (1211, 1301, 2402) Freeze 1/1/2002; 50% cut by 1/1/2005; 100% cut by 1/1/2010.	Baseline: average of 1995-97
1/ Imports permitted only for basic domestic need; essential uses exempted. "Destruction" credits applicable for additional production or net imports. Sources: UNEP (1996). Also see UNEP (1993), Ahmed (1995), Parson and Greene (1995), UNEP (1995c), and Bojkov (1995), including for background to the evolution of the Protocol. It is unclear if more stringent control measures bind the few developing country signatories to the Copenhagen Amendments.	



and the developing country government; the Secretariat reviews the proposals for consistency with procedures and guidelines, and recommends them to MFEC for approval. Considerable administrative resources at the multilateral level are expended to individually identify and develop each project, have it reviewed by technical experts, select a "baseline", calculate "eligible" need, prepare grant proposal, negotiate MFEC Secretariat recommendation, and oversee the disbursement, implementation and verification mechanisms.

The principal guiding document characterizing the Parties' consensus on the *types* of expenditures that may be covered is the "Indicative List of Categories of Incremental Costs" (the "List")<sup>1</sup>. The cost categories broadly covered by the List include: costs of new capital equipment and of premature modification or replacement of existing capital equipment, and incremental operating (i.e., non-capital or recurring) costs including those of royalties, retraining, and R&D. For each end-use sector (e.g. solvents, aerosols, different types of refrigeration and air-conditioning or foam manufacturing), the MFEC has precluded certain technical options deemed to be inappropriate in expert judgment and has set operational criteria for the calculation of grant eligibility.

Four features of the Fund's operational strategy are worth noting:

Timing of assistance: While a strict interpretation of the Fund's mandate would imply that the "agreed incremental costs" to be met are those of *compliance* with the Protocol's control measures, the Parties have agreed that the Fund's resources may be utilized for ODS phaseout before such control measures become binding upon the developing countries. In other words, the Fund's grants may meet incremental costs of accelerated phaseout, not just those of compliance.

Scope of assistance: While the Protocol's control measures refer solely to production and net imports of virgin ODS, the Fund's resources are permitted to be utilized for reducing ODS *use* even as ODS production and net imports may continue to rise or stabilize as

provided by the Protocol.

Recipients of assistance: While the Protocol contemplates assistance to "Parties", the Fund's resources are provided directly to individual firms, who in most cases as yet face no control measures and, in the absence of national regulations, may have none until the ultimate phaseout date, so long as their own ODS requirements are met (This is because even as interim controls on national "consumption" are applied, some firms would be able to continue unrestricted use so long as their own requirements are met even with lower aggregate supply).

Form of assistance: The Parties have accepted "eligible incremental costs" as an operational guide, but have left it to the MFEC to determine precise rules of eligibility and have also left "agreed incremental costs" undefined. The MFEC, therefore, is permitted to choose any vehicle for grant delivery so long as an agreement is reached between the Fund and the recipient; it is not necessary that the current approach of administrative assessment of eligible incremental costs, and associated arbitrary rules, be adhered to.

A departure from the strict terms of the Protocol is understandable: the decisions to convert to ODS-substitute production or use are made and implemented by firms, not governments; also, without user firms' conversion to ODS substitutes, the market for substitutes would not exist, and producer firms would not be willing to convert. Similarly, when there was little experience with substitute technologies and no legal limits on ODS use, user firms had to be solicited, provided extensive technical assistance, and project implementation closely monitored (for information exchange and learning, in addition to verification of conversion). The "early preventive action" on the Fund's part has also served to limit the expansion of ODS consumption and associated equipment stock in the grace period allowed to the developing countries.

However, the Fund's operations expose its program to three particular risks:

- (a) In the absence of national-level

legally enforceable limits on market entry by new firms and expansion of ODS use by existing firms, the *net* ODS phaseout may be less than what the Fund's assistance provides for.<sup>2</sup>

(b) In the absence of corresponding limits on the production and net imports of ODS, an exclusive focus on reducing the ODS *use* may lead to an imbalance in the market for ODS and their substitutes<sup>3</sup>. While the full effects of ODS phaseout in the developed countries on the prices of ODS and substitutes in the developing countries are yet to be seen, a situation of excess capacity for ODS supplies and/or capacity constraints for the supply of substitutes may lead to perverse price signals to ODS-using firms. Even as ODS use is phased out, if production and imports continue up to the limit permitted by the Protocol (to add to ODS stocks for later use), the environmental gains of "accelerated phaseout" may be negated.

(c) Since administrative procedures for project identification and development, and for associated need assessment, preclude consideration of the benefits of conversion that accrue to firms (because these cannot be externally determined or verified), or a determination of the optimal timing of conversion, there is a risk that the Fund's assistance is not as efficient as it could be — i.e., by maximizing the amount of phaseout for a given sum of money.

The third risk is the main theme of this paper, with an aim to propose a particular market-based instrument (MBI) — competitive bid auctions — as an alternative to the current administrative approach to grant allocation. But before discussing MBIs, it is necessary to recognize that government action creating a commodity or a property right and/or setting the rules of market transactions are a prerequisite to the effective use of MBIs.

Certain MBIs "e.g., pricing policies" may require no additional government action because the commodities as such are already defined; only tax levels and collection mechanisms need to be specified. However, pricing instruments alone are insufficient to achieve quantity obligations, especially time-bound obligations such as set by the Protocol; in other

words, there is a considerable risk of undershooting or overshooting the target. Other MBIs like bid auctions or tradeable permits require government action to create firm-level controls. Such controls are in any event necessary for the implementation of a country's obligations under the Protocol, irrespective of who finances the incremental costs of compliance or how. Before discussing the scope for MBIs or advancing a particular proposal for grant allocation, it is therefore necessary to describe the need for national firm-level controls.

### Need for Firm-level Controls

To effectuate compliance with the Protocol, national governments need exercise their legal authority upon firms<sup>4</sup> doing business in their boundaries to restrict, and as necessary prohibit, them from taking actions which violate the country's legal commitment. In other words, the national aggregate obligations need to be translated into firm-level obligations with the corresponding legislative and/or regulatory authority for credible enforcement. Moreover, such controls provide additional motivation (i.e., in addition to other forces such as market changes) for firms to shift from ODS production or use, and may generate a more predictable environment in which they may undertake such actions. While recognizing the conceptual or legal and administrative complexity of the design, monitoring, verification, and reporting activities that may be involved, we discuss below, in rather simple terms, the elements of firm-level control strategies.

Compliance with the Protocol requires, first, monitoring the flows of ODS into and out of the economy via domestic production and international trade, and second, imposing firm-level quantity controls on these activities. This can be accomplished by developing registries and record-keeping systems, on the one hand, and controlling the additions and deletions to the registry, in other words "entry" and "exit". The latter may be voluntary or as a result of some other scheme such as for compensation (whether or not financed by the Fund) or a mandate by the government. Additionally, if the country wishes to ensure that any conversion by use sector firms — whether or not

financed by the Fund – is “protected” (in that other firms do not expand their use), registry, record-keeping and quantity controls on use are essential.

The key to translating aggregate limits into firm-level controls is of course allocation of permits (which may also be called licenses or allowances or entitlements); as the aggregate limits change, according to the Protocol schedule or a more accelerated schedule if the country wishes to impose one, the permits have to be either re-allocated or a certain “decay rate” (reduction in the physical value of the permit) has to be built in. To the extent that historical patterns of activity are to be any guide to the initial allocation or the re-allocation processes, the registries in the previous paragraph can serve as the basis.

The first step is a statutory or regulatory requirement that only the firms holding permits for a particular activity may engage in that activity, and only up to the level permitted; all other activity is legally prohibited. In the next step, several alternatives are available for initial allocation of permits to firms: “grandfathering”, i.e., on the basis of historical patterns; competitive bidding (or auction); “first-come, first-served” basis (if it appears that the demand for permits is likely to be less than the available aggregate); or, voluntary agreements with industry associations. The permit system can be made functional once the aggregate limit and firm-level historical record for the baseline are known, or in advance, with certain lee-way retained by the government to make changes at a later time according to pre-set rules<sup>5</sup>. A simple scheme on both the “consumption” and the “use” sides, combining grandfathering and auction approaches, is described below<sup>6</sup>; some of its implications, and additional policy instruments that may be based upon it, are discussed later in Section 5.

**“Consumption” Permits:** On the “consumption” side, different firms could be engaged in just one or more of the three activities (production, imports, exports). Political expediency as well as recognition of the indivisible nature of investments in the production activities would appear to dictate that initial allocation of production permits be based on the historical record, i.e., grandfathered; be

provided over a long period (e.g., through 2010, subject to interim “decay” in accordance with the Protocol) and would apply only to the specific ODS as engaged in historically. On the other hand, since it is only the “net imports” quantity that is to be controlled, import permits in the amount of baseline “net imports” is better auctioned off, and may be granted for shorter periods (e.g., a year or two). Import permits may be substance-specific; if not, they must at least apply to the grouping of ODS corresponding to the Protocol (i.e., any of the principal CFCs or any of the halons). Both production and import permits would become effective 1999.

All import permits and at least a portion of the production permits should be permitted to be exchanged, during the period of validity, among firms (or within a firm, if it engages in more than one activity). This is because no permits are as such made available for exports; a ton of exports permits a production or import of an extra ton, and an extra ton may be imported only against a ton of production reduction or export. Because production permits are longer-term, their exchanges for import or export must be of limited duration (a year or two), after which they revert to the production account. Additional “tradeability” -- of production permits among the producing firms, between production and import permits (to firms already authorized to do either or to new firms, if at all interested) -- and “offsets” -- against reclaimed ODS or destruction of ODS -- may be permitted, but is not necessary, and may give rise to enforcement problems and high transaction costs as discussed in Section 5. Unless inter-firm exchange of production permits is allowed, a firm may permanently “return” its production permit only to the government, for re-allocation to another firm, or “retire” it by offering it to the Fund in return for Fund grants for conversion. These concepts are further discussed in Section 5; for now, it may be obvious that the situation is much simpler for developing countries who have no domestic ODS production as of the baseline period and prohibit new production.

Beyond the initial allocation, the grandfathered production permits would be subject to a “decay rate” corresponding to the control schedules of the Protocol. For example, a permit to produce one ton of a particular CFC

between 1999 and 2004 becomes a permit to produce a half a ton of that CFC between 2005 and 2006, and so on until 2010, when all production is banned (except for the amounts permitted due to verified destruction). Permits for net imports offer considerable leeway, since their allocation can be restricted to shorter periods. That is, permits for net imports may be auctioned every year or every two years, and the aggregate available quota may be re-determined as frequently.

Use permits: Controls on user firms are not necessary for strict compliance with the Protocol. Rather, they are necessitated by the Fund's choice of providing grants for use sector conversion. These controls, in turn, satisfy two needs: (a) fix the amount of ODS that a conversion project is expected to phaseout, and (b) ensure that any phaseout, whether or not financed by the Fund, is not negated by subsequent growth in use. A registry of user firms combined with prohibition on market entry or growth would essentially parallel the scheme described above, with some exceptions. First, the initial aggregate level of "use" may not match aggregate "consumption" due to stock changes at the supplier or user level, and due to lack of data on certain classes of users (e.g., especially those engaged in the service sector). Therefore, the use permits may not be able to cover all uses and all users precisely. Second, all use permits would probably have to be granted initially at a historical base year level (i.e., via "grandfathering" a particular historical level). Third, use permits need not have any reduction or "decay" from the initial level. Fourth, because of monitoring and enforcement difficulties, if inter-firm trade in user permits is allowed, its amount and frequency should probably be restricted; i.e., a firm can only offer its entire permit to another user firm, and may not buy it back or buy from another firm.

From the perspective of the Fund, any phaseout financed on either the production or the use side entails permanent removal of the beneficiary firm from the registry. However, even such a permit system may not adequately protect against risk (b) described above. ODS

stockpiling that is permissible under the Protocol (and has indeed occurred in the developed countries) is unavoidable, unless the country periodically re-determines its aggregate supply quotas in accordance with the reduction in use, or undertakes other measures (such as pricing policies to discourage stockpiling, or prohibitions on stockpiling). This matter is further discussed in Section 5.

For a variety of reasons, some governments may be willing to undertake measures that are not mandated by the Protocol<sup>7</sup>. Some alternatives for a more aggressive approach are:

(i) Accelerating the schedule and/or reduction requirements: for example, permits may be made effective earlier than 1999; 50% reduction in an individual firm's production permit or in the country's aggregate import limit to be auctioned may be advanced to 2002, say; or reductions may be phased in more gradually by placing interim limits.

(ii) Partial permitting: for example, a government may "withhold" a fraction of the aggregate import limit, and "release" it at a later date to moderate ODS price increases. "Withholding" production or use permits may require an advance ban on some firms, unless they were to cease operations and exit the market any way.

(iii) Substance or sectoral bans: government may impose differential reduction or "decay" rates in the production, imports or use permits, if a specific substance or class of firms is seen to have especially low cost of conversion or to benefit from it.

(iv) "Downstream" regulations: If servicing requirements constitute a high (e.g., > 20%) portion of the ODS use, a government may wish to impose additional regulations on the service sector, including for recycling, reclamation, and operator certification.

As discussed in Section 5, a firm-level control scheme is also necessary for the use of other market-based instruments. But first we turn to the discussion of the Fund's current process for grant allocation to finance use sector conversion.

1/ UNEP (1995b), Annex IV.1.

2/ Despite the MFEC's decision in July, 1995 to exclude ODS use capacity installed after that date from its assistance, the potential exists that a firm may profitably begin or expand ODS use and continue doing so as long as virgin or reclaimed ODS are available.

3/ The seventh MOP in December, 1995 made a decision that "from December 7, 1995, no Party should install or commission any new capacity for the production of CFCs, halons, CTC and MCF" (Decision VII/9(7)). Recognizing the problem of oversupply and dumping, the seventh MOP also decided that all Parties engaged in international trade of ODS "should monitor and regulate this trade by means of import and export licenses" (Decision VII/9(3)). It appears that neither of the decisions is binding.

4/ The term "firms" is meant to include all economic agents.

5/ For strict compliance with the Protocol, there is a problem in that neither the aggregate limit nor the firm-level patterns would be known until some time in 1998. On the other hand, the apparatus for registration and record-keeping would have to be prepared before then; it appears that most developing countries have already accomplished this task as a part of their "country programmes".

6/ Also see Munasinghe and King (1991), UNEP (1995a) and SEI (1995).

7/ Countries which are willing and able to carry out and implement more stringent control measures (as encouraged under Article 2, ¶ 11 of the Protocol) could be given preferential treatment by the Fund.

# 3 Scope for Market Based Instruments

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This Section briefly reviews the Fund's current grant allocation rules and process, then evaluates them in the context of different types of incremental costs. It then advances the argument that the firm-level incremental costs depend on economic parameters which (i) are best known to the firm itself, and (ii) vary across firms. Characterizing the Fund's program as a market in which the Fund buys ODS phaseout offered by different firms provides the conceptual context for discussing market-based instruments discussed in the following two sections.

## Current approach for grant allocation

Under current rules (applying to user firms' conversion), the "eligible incremental costs" are assessed as the sum of:

(i) Eligible Capital Costs These are defined to be all the gross capital expenditures of the new equipment that needs to be installed (subject to guidelines and technical experts' approval), in general without regard to the remaining economic lifetime of the existing equipment to be replaced or to the firm's discount rate.

(ii) Eligible Operating Costs These are defined as the excess of the operating costs associated with the use of the ODS substitute over those with the use of ODS, for a limited period of time<sup>1</sup>. Except when demonstrated and quantified, the benefits that may accrue to the firm as a result of conversion are ignored, as are changes in operating costs (e.g., due to changes in the price differentials between the ODS and its substitutes) beyond the initial qualifying period.

The MFEC approves an *estimate* of these two components when a project is presented to it; the disbursement takes place upon the actual, demonstrated value of the gross capital expenditures and the incremental operating cost for the pre-defined duration<sup>2</sup>. While any "budgetary savings" due to lower actual costs than estimated are returned to the Fund, and any "cost overruns" due to higher actual costs have to be approved by the MFEC, essentially the Fund absorbs the entire risk of errors in cost estimation. (Such an approach is worthwhile when project implementation is in doubt and costs are expected to decline over the implementation period). Finally, the Implementing Agencies are reimbursed for their administrative costs, and sometimes financial intermediaries in the developing countries are provided a fee.

Projects approved to date have shown a wide variation (across countries and end-use sectors, project size, and over time) in unit grant levels (\$/kg ODP) assessed, as shown in Annex Table A.2 for projects implemented by the World Bank. This suggests that there are no "model" projects as such (to establish a fixed average grant, for example), and that some firms indeed find cheaper conversion options than some others. If so, it is in principle possible to choose cheaper projects before more expensive ones if firms are provided the opportunity to self-select, instead of the current "first come, first served" approach.

The MFEC has defined "cost-effectiveness" as the unit grant level approved: total approved grants divided by the annual quantity of ODS to be phased out. Until 1995, the

Fund's available grant resources exceeded the demand for grants from candidate projects in the implementing agencies' pipeline, and grants were approved without specific consideration for "cost-effectiveness".

Beginning in 1995, when the potential demand for grants as expressed in the project submissions to MFEC exceeded the Fund's available budgetary resources, the MFEC set specific "cost-effective threshold values" (CETVs) as cut-off points to be used to select from among project submissions for certain sectors. (See Annex Table A.1, along with a comparison to MFEC's prior estimates of average grants for the purposes of budgetary programming). In most cases, the 1995 CETVs were selected in such a way as to match a uniform portion of the projects in the Implementing Agencies' pipeline against the funds deemed to be available to the MFEC for approval during 1995; conceivably, the CETVs could have been different if the Fund's financial situation or the composition of the projects in the pipeline were different.

One result of the MFEC's announcement of CETVs in March 1995 was that a number of project submissions were revised so as to lower the grant requests to match the unit grant levels to CETVs. It appears that in some cases, the beneficiary enterprises searched for lower-cost alternatives while in some other cases they were willing to accept a lower level of grant (corresponding to CETVs) than that corresponding to the "eligible costs" criterion (meeting the rest of the costs by themselves). At its July, 1995 meeting, the MFEC decided to permit such "partial funding" of assessed eligible expenditures. In response, some firms claimed they were willing to accept only a portion of their eligible capital costs, while some claimed they were willing to accept only a portion of their eligible operating costs, confirming that the total amount of grant is the determining factor, not its administrative characterization.

While the use of CETVs and "partial funding" have implicitly introduced some elements of competition among firms *within* certain sectors, the projects are approved essentially on "first-come, first-served" basis, and there is no particular incentive for firms to limit their unit grant requests *below* the CETVs,

or reveal their willingness to accept a lower unit grant which would give them a priority over (by being less than the unit grant requests of) other firms.<sup>3</sup> Combined with the administrative identification and selection of participant firms, and preparation of project scope, there is at best limited room for self-selection by firms, or for firms' own assessment and selection of project scope and timing. There is a need for a mechanism providing for self-selection and competition among firms. Before proposing one such mechanism, however, it is useful to address certain conceptual issues relating to incremental costs and the implications of the Fund's current rules.

#### Costs of compliance vs. accelerated phaseout

As noted earlier, the Fund's mandate is to meet the "agreed incremental costs" of "compliance" with the Protocol, but it has also been empowered to provide its grants for an accelerated phaseout via broad guidelines for "eligible incremental costs". The Protocol imposes no controls on ODS use, and an individual user firm may in principle continue ODS use so long as its existing capital equipment permits it to<sup>4</sup>. The incremental costs of over-compliance can be higher than those of strict compliance, but different firms would still have different incremental costs. The project-by-project approach does not allow for covering lower-cost phaseout before higher-cost ones at a given point in time, and the administrative grant assessment rules may risk meeting more than the incremental costs and providing incentives to individual firms to choose higher-cost options and timing. This is because, even if an accelerated phaseout gives rise to a higher cost, that cost should still be minimized<sup>5</sup>.

Following King and Munasinghe (1991), we can define minimum cost of compliance ("MCC") as the difference in the economic costs incurred by the country in two scenarios: (i) *without* the Protocol, and (ii) a compliance scenario *with* the Protocol in which the country has devised and implemented the least-cost path to meeting the requirements imposed<sup>6</sup>. To the extent that a country or a firm does not adopt the least-cost path, its actual cost of compliance ("ACC") may be greater than its

MCC<sup>7</sup>. While recognizing that country incremental costs also include government costs of compliance and changes in public welfare, we focus on the firm-level incremental costs, since that is the primary target for the Fund.

Several features of these concepts need to be emphasized:

(i) Both the MCC and ACC concepts are based on *economic* costs, i.e., cost of the resources used in the process, and not on financial costs, which may be affected by market distortions. One implication is that a country's MCC or ACC is not reduced by any grants provided by the Fund, since such grants are *financial* flows that do not affect the cost of the underlying resources.

(ii) Both are *net* of the benefits of compliance actions. That is, if conversion to the use of substitutes lowers the cost and/or improves the quality of the final product or service, those benefits are, at least in principle, to be subtracted from the cost of compliance. This may be impossible in practice, in part because the benefits may not be measured in advance, and in part because they may well pass on to consumers.

(iii) Both refer to the costs which are *incremental* to a baseline scenario of no firm-level restrictions on continued ODS use. For example, to the extent that conversion to substitute use involves premature replacement of existing capital equipment, the incremental cost is not the full amount of gross capital expenditures, but only that part which is due to premature investment (including the difference in the cost of the two types of equipment)<sup>8</sup>. Similarly, if the post-conversion operating costs are higher than those under current practice, the difference over the entire duration of the new project is incremental. These points are further elaborated upon below.

(iv) Individual firms operating in a competitive market seek to minimize their net financial costs of conversion. In the absence of serious economic distortions, which would bring about significant differences between economic and financial costs, this would also tend to move the individual firms in the

direction of the MCC path. In other words, even if there is a wedge between financial and economic costs, minimizing the former would also minimize the latter, absent serious market distortions.

There are practical problems with estimating the country-level MCC, and also with applying the concept of country incremental costs, embodied in the Protocol, to the level of individual firms<sup>9</sup>. At a minimum, estimating the country-level MCC requires knowledge of firm-level costs and benefits at different points in time and, to the extent that one firm's actions influence another firm's decisions, the knowledge of all firms' likely behavior.

On the other hand, even as the Fund's assistance has been made available in advance of the Protocol's compliance schedules, administrative assessments of "eligible costs" have an inherent limitation in that only gross expenditures can be observed externally. To derive the net costs from the gross expenditures, and the incremental costs from the total costs, requires information that is best known to the firm, may not be in its interest to disclose, and may not be subject to verification or control. Even from the firm's viewpoint, some of this information is quantifiable — for example, its discount rate and its expectations of costs of all its inputs and prices for its products — whereas some is not — for example, product development and marketing strategy<sup>10</sup>. However, any firm uses both types of information in making any decision to invest, including that to convert to ODS substitute. As argued next, the Fund's current rules of grant calculation provide no incentives to firms to minimize their own ACC, which is best known to the firm themselves; may indeed distort the firms' behavior from least-cost choice of technology and timing; and may provide more than the net incremental costs of conversion.

#### Limitations of current Fund rules

Ideally, the Fund would structure its grants so that: (a) an individual firm deems the Fund's grants to be adequate, based on its own assessment of overall costs and benefits of conversion; (b) the individual firms are moved in the direction of the MCC least-cost path; and,



(c) at any given time, the Fund maximizes the ODS phaseout with the available resources. The Fund's current approach (including use of CETVs) certainly meets the first objective, but falls short of meeting the other two.

First, calculation rules for "eligible incremental costs" are only weakly related to the firm's net incremental costs of conversion, and provide incentives to increase the ACC as well as permit higher grant levels than ACC. This can be shown as follows. Conceptually, the firm's incremental costs of conversion are the sum of: (a) the costs of premature replacement of its equipment, and (b) the net present value of the incremental operating costs, net of benefits, over the economic life of new investment. Considering that

(i) the investment for conversion typically involves *substitution* of existing capital stock rather than *addition* to it; and,

(ii) the remaining economic life of its existing equipment is finite, and some firms may well have to invest in replacement capacity before they have a legal obligation for compliance with the Protocol<sup>11</sup>, indeed whether or not the Protocol existed; and, further assuming that,

(iii) at the time of such replacement, a firm will choose the non-ODS using equipment<sup>12</sup>,

it follows that the policy of funding gross capital expenditures creates differential "rents" – the difference between opportunity cost to the firm and the grant amount it is awarded – to the firms depending on the distribution of remaining economic life of existing capital stock. Under current rules, the Fund generally covers all the gross capital expenditures, and not just the costs of premature replacement which constitute the *incremental* costs of conversion. This willingness to over-compensate provides incentive to the firm to both accelerate its replacement decision and to prefer capital-intensive options.

On the other hand, the Fund restricts duration of financing incremental operating costs. Inasmuch as the economic life of new investment in ODS-substitute technologies is likely to be longer than the period covered by

the Fund, the user firm may be seen to bear the entire burden of incremental operating costs for the remainder period. Obviously a firm would rationally convert only if (i) it sees this burden as minimal or even negative, i.e., if it expected the incremental operating cost to vanish and/or the conversion to provide it with collateral benefits (such as higher overall productivity, improved product quality, higher market share); or, (ii) it believes its under-compensation for the incremental operating cost to be matched by an over-compensation for the capital costs.

Current rules do not permit a determination of what the firm's "true" incremental capital costs or incremental operating costs (net of collateral benefits) are, and, more importantly, what choice of timing and technology would minimize these costs. This is because the necessary variables – which the firm itself would use in making such determinations – are ignored and in any event may not be accurately available for an external assessor. For example, the cost of premature replacement is a function of the firm's discount rate and the remaining economic life of existing equipment, the latter in turn being an elastic measure influenced by changes in market conditions, technologies, and government policies. Similarly, the benefits of conversion that may reduce or outweigh the firm's incremental operating costs are in turn dependent on the firm's expectations, and procurement and marketing strategies. Even if some of these variables could be obtained – for example, the discount rate and price forecasts – it is impossible to disentangle the firm's conversion project from its overall operations and objectives<sup>13</sup>.

Second, the project-by-project approach does not permit the Fund to discriminate in favor of firms with lower phaseout costs. Not only are incremental costs of conversion dependent on firm-specific variables, but there need be no uniformity in such variables across firms, even within a sector or size grouping. Given the lengthy process of project identification to approval under the current approach, it is practically impossible to permit firms to self-select or for the Fund to reject project proposals. The use of CETVs and "partial funding" partly addresses this problem. However, even the use of CETVs does not provide any explicit incentives for the firms to minimize the grant re-

quested from the Fund, nor does it permit the Fund to explicitly recognize that the firm may well benefit from conversion and that such benefits are not a part of "incremental costs"<sup>14</sup>. At best, this is a "satisficing" approach in the sense that projects that meet the threshold value are said to meet, *prima facie*, the cost-effectiveness criterion. In any case, there is no assurance that the project cost data upon which CETVs are based reflect incremental cost minimization calculus at the firm-level.

Finally, the current approach requires an in-depth external assessment of "eligible incremental costs" but does not require that each firm's phaseout decision is optimized with respect to time, or that grant decisions are optimized across users within an end-use sector and across end-use sectors<sup>15</sup>. As the firm-specific incremental costs are best known to the users themselves, efforts to collect and analyze information by the implementing agency involves a duplication of effort and additional administrative costs.

Despite these shortcomings, administrative need assessment and the associated project-by-project approach, is not only appropriate but sometimes the only practicable one in certain situations. These are where firms are being asked to adopt technologies which are in experimental or demonstration stage with little experience of performance, their costs and benefits to firms are difficult to predict reliably. Even if firms seem to demand more than their incremental costs of adopting new technologies, it may be argued that the apparent over-compensation is actually a proper compensation for the risk premium the firms place on adopting new technologies. Over time, some technologies are rejected and others mature, i.e. more operating experience with them is gained, their costs and benefits become reliable. More importantly, market expansion and learning effects lead to cost reductions for new technologies. Correspondingly, firms' "search costs" and "transaction costs" are reduced, and they increasingly find it in their own interest to adopt new technologies and develop further changes<sup>16</sup>. There may still be incremental costs associated with the use of new technologies as compared to the older ones, but firms then self-select according to their own cost calculus.

In the early years of the Fund's operations, ODS substitute technologies were entirely new and risky, sometimes even in the developed countries. This may still be true with some technologies and some developing countries, but clearly not so for some others, judging at least from the Implementing Agencies' project pipeline. An alternative mechanism to the Fund's current "micro-managing" approach then becomes necessary; this alternative should (i) permit firms to self-select, i.e., let the firms determine their incremental costs of compliance they seek the Fund's financing for, and (ii) introduce competition among firms in the grant allocation process. A competitive bidding mechanism would permit these objectives and would naturally guide firms to choose phaseout strategies consistent with the least-cost path using their own values for economic parameters and market expectations, because by doing a lower-cost route, a firm improves its own competitive position. This would ensure that even with an accelerated phaseout at the country level, individual firms' — and therefore, the country's — actual cost of compliance is as close to the minimum as possible, and that the Fund would be able to obtain cheaper phaseout before more expensive one. Additional efficiency gains accrue to the Fund because such a mechanism would also obviate the duplication of effort inherent in the project-by-project approach with multiple levels of decision-making, avoid the need for external hypotheses about firm-level behavior<sup>17</sup>, and reduce the associated administrative costs. As will become clear in the subsequent discussion of designing and implementing various MBIs, the project-by-project approach provides critical initial information on which such MBIs can be based.

### Characterizing the Market for ODS Phaseout

In a situation where firms self-select and compete as described above, the firms offer to "produce" a verifiable service called "ODS phaseout", and the Fund offers to "buy" this service. The flow of funds is from the Fund (via the government) to the firm, and the amount of the Fund's grants must be acceptable to the firms that convert. Two alternatives in these transactions are:

(i) the Fund offers to buy "ODS phase-out" at a certain price (\$/kg ODP) and the firm has the option of accepting or rejecting the offer. If the grant is lower than what the firm perceives to be its incremental cost (net of collateral benefits), it would be irrational for it to convert.

(ii) the firm offers to sell "ODS phase-out" at a certain price and the Fund has the option of accepting or rejecting the offer. If another firm offers a lower price, it would be inefficient for the Fund to accept the first firm's offer.

The Fund is the sole buyer from many offeror firms of ODS phaseout. In a competitive auction, described in detail in the next section, the offerors decide when and at what price they wish to offer their phaseout; the Fund accepts firms' offers up until the point that the available funds are exhausted.

The firms' "supply price for ODS phaseout" – i.e., the minimum unit grant (in \$/kg ODP) that each present user deems adequate – cannot be precisely assessed administratively. This is because the firms "produce" not merely ODS phaseout but other products in conjunction (such as refrigerators, foams, aerosols), so that the activity of "producing" phaseout also influences their costs and benefits overall. In any event, the Fund has no way of knowing or separating or controlling for all the costs and benefits. In general, where a regulator seeks to administratively determine the price of a product, economic theory

recognizes the impracticality of the regulator being able to (i) allocate a multi-product firm's costs among product lines, (ii) disentangle operating expenditures from investments, and (iii) disentangle the cost associated with producing the product whose price is being regulated from that associated with producing a non-verifiable benefit.<sup>18</sup>

It is the *overall* amount of grant (in \$/kg ODP) that expresses the firm's "offer price" or "willingness to accept" (WTA). Different firms would compete on; whether or how its components are characterized is immaterial and unnecessary. This was implicitly recognized in the MFEC decision in 1995 to permit "partial funding" of projects whose assessed eligible grants came in above the CETVs. If the assessed eligible grant were itself in excess of the firm's unrevealed "true" incremental costs, the so-called "partial funding" by the Fund may well cover *all* of the true costs (or more).

In the conventional language of economics textbooks, each firm's WTA is a point (because the decision to convert is of a "yes/no" type), and all such points together reflect the market supply curve for ODS phaseout at a given time. Granting a fixed price provides an excess to all the suppliers of phaseout with WTA below the fixed price; a competitive bid auction – similar to bulk procurement – is the mechanism to encourage the suppliers to bid close to their WTA, and is explored in the next section.

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1/ Ranging from six months for halon projects to four years for aerosol and solvent projects; see footnote below for domestic refrigeration sector. Source: UNEP/OzL.Pro/ExCom/19/64.

2/ With the exception of domestic refrigeration sector projects where firms are given the choice among: 10% of the eligible capital costs up-front; 6 months of eligible incremental operating costs at *ex ante* prices, up front; or, 12 months of eligible incremental operating costs at actual prevailing prices).

3/ There is also the risk that the CETVs set for 1995 may be perceived as "model" values to apply over a longer period, essentially as the Fund's "offer price" against which the firms should prepare their phaseout plans.

4/ That is, if other firms' phaseout actions sufficed to meet the interim aggregate reduction target. If sufficient quantities of reclaimed quantities were available, an individual firm could go on using the ODS indefinitely. It may be argued that the government need resort to regulating the end-user firms only if it cannot meet its Protocol obligations by just regulating the firms engaged in production and trade.

5/ As argued later in the paper, it is impossible to externally determine a firm's "true" incremental cost; accordingly, no *a priori* determination can be made about whether an accelerated phaseout *necessarily* increases all firm's incremental costs.

6/ They use the term "compliance cost" for this concept (least-cost phaseout against the background of existing economic and industrial policies) and point out the difficulties in distinguishing it from what they call "minimum incremental cost" (least-cost phaseout in the absence of market distortions and failures). We have called it the *minimum* compliance cost in order to emphasize the least-cost aspect, and also to clearly differentiate it from the actual cost. For further details, also see Munasinghe and King (1991), and King and Munasinghe (1995).

7/ King and Munasinghe (1991, 1995) use the term *adjustment cost* for this concept.

8/ Because we are dealing with *economic* measures, merely the fact that a plant may be fully depreciated in the financial accounting sense does not mean that its remaining economic life is zero.

9/ See UNEP/OzL.Pro/ExCom/7/21 for an elaboration.

10/ To put this differently, the model of incremental cost calculation that can, in principle, be applied to a closely regulated industry (e.g., public utilities) is not useful in industries without such close regulation of price and/or product quality.

11/ If ODS-using firms – whether in final use, such as solvents, or in intermediate use, to produce consumer equipment charged with ODS – generally have capital stock with an economic life of less than 10 years, it is plausible to argue that the 10-year grace period allowed to the developing countries sought to limit their incremental cost. Ignoring search, royalty, and training costs, the incremental capital cost for some user firms may well be zero, especially if no new investments in ODS-using technologies were made since the country ratified the Protocol.

12/ This assumption is made only for the convenience of abstracting away from the question of differential costs of user firms' capital equipment for alternative technologies with and without the Protocol. Similarly, we abstract away from the possibility that the existence of the Protocol itself may affect the remaining economic life of a firm's existing equipment - e.g., consumer awareness about the ozone depletion issue and the Protocol may have led to shifts in consumer preferences.

13/ ODS phaseout is very different from the traditional utility regulation where a regulator could obtain information on all the firm-specific cost variables *and* is in a position to regulate the firm's profit rate as well as make adjustments in allowed costs at a later time.

14/ The report under Article 5.8 of the Protocol (ICF et al., 1994) did, however, point to the potential to reduce Fund grant requirements if firm benefits could be captured. Model calculations of aggregate (i.e., for all firms) incremental costs are subject to the same limits as the project-by-project need assessment approach due to their inability to capture all significant parameters that affect firm-level choice and the variations in such parameters across firms. This is a familiar problem with technology adaptation modeling, and shows up, for example, in costing energy efficiency gains.

15/ With the exception of the MFEC's acceptance of a "sectoral approach" for China.

16/ It is often argued that the actual costs of compliance with environmental mandates turn out to be less than the *ex ante* estimates of such costs. In the context of MP compliance, see Ahmed (1995) and Cook (1996). There may well be inherent upward biases in any *ex ante* external assessments of compliance costs where technologies for compliance change rapidly.

17/ For example, about what the firm would have done in the absence of the Protocol, which can easily deteriorate to exercises in persuasion.

18/ See Laffont and Tirole (1993).



# 4 Bid Auctions for ODS Phaseout

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In this Section, we first introduce the concept of accepted bids in a competitive auction as “agreed incremental cost” corresponding to the Protocol requirement, followed by an illustrative example for the domestic refrigeration sector and comments regarding implementation of such an auction.

## Equivalence of accepted bids and agreed incremental costs

Because “ODS phaseout” (measured in ODP terms) is a service of uniform quality – one kg. of ODP phaseout from one source is indistinguishable from that of another – it is ideally suited to competitive bid auctions or bulk procurement. Here the buyer’s (i.e., the Fund’s or its agent’s) budget is assumed to be fixed at the national level for a particular period, say a year or two. Competing firms indicate their quantity of ODS phaseout as well as the unit grant level (in \$/kg ODP) that they are willing to accept from the Fund. Bids are ranked according to their “offer price” and accepted until the pre-set available funds are exhausted. Auctions of varying complexity can be devised, and may be repeated at specific time intervals.

The use of competitive bidding in grant allocations is similar to the traditional system of Government procurement, with the product being procured – ODS phaseout – classified as a verifiable service. Competitive procurement is also used by private firms for a wide variety of goods and services. The approach has a number of precedents in the energy sector. For example, power utilities interested in measures to manage their loads may invite bids from their customers to reduce their power loads; it pays its customers

to reduce their load according to a ranking based on, say, \$ per megawatt of load reduction offered. By accepting the lowest bids, the utility is able to meet its load-management target in the least-cost manner<sup>1</sup>. The situation in ODS phaseout is similar, with the Fund corresponding to the power utility, and the ODS using firms corresponding to the power utility’s customers.

The basic idea behind bid auctions is simple: different firms have different willingness to accept (WTA, in terms of kg of ODS phased out per \$ of Fund grant) depending on a variety of factors<sup>2</sup>, many of which are only or best known to the firms themselves, and that a given firm would also have different WTA at different points in time. An administrative calculation of firm-level incremental costs is necessarily arbitrary and fails to capture the difference between the firm’s willingness to accept and the administratively calculated grant. In a bid auction, a firm’s “offer price”, or “willingness to accept”, reveals its own estimate of the “incremental cost” incorporating its own expectations of the costs and benefits of conversion. An accepted bid, in turn, constitutes a mutual agreement between the firm and the Fund that the total amount awarded is adequate compensation for the service to be provided; the “agreed incremental cost” criterion is therefore satisfied, without having to externally assess the firm’s costs and benefits<sup>3</sup>.

In preparing its bid, each firm would consider its WTA in comparison with its *estimate* of the competing firms’ WTA<sup>4</sup>. If it indicates a higher offer price than what it is willing to accept, it risks losing out to a competitor. If it estimates that its offer price

would and take a chance that its current offer is indeed cheaper as compared to its competitors. Thus, competitive bidding would come close to revealing the firms' minimum WTA and optimize the timing of conversion across firms as seen from their own perspective.

Further, a bid auction approach preserves all of the firm's incentives to minimize its incremental financial cost. When a firm's bid is accepted by the Fund, the assistance flowing from the Fund to the firm is a direct grant<sup>5</sup> that is not tied to any particular aspect of the firm's operations. Consequently, it does not introduce any distortionary incentives such as over-compensation for capital costs or under-compensation for incremental operating costs; there is no tendency for the Fund's support to increase the firm's and the country's ACC.

Apart from leading to economic efficiency, the bid auction approach has several practical advantages. It could be implemented within the existing administrative framework of conventional procurement, and its administrative costs would be lower than under the current approach, since many of the expensive functions, such as project preparation and need assessment, would no longer be necessary<sup>6</sup>. Most importantly, it is fair in that a technically qualified firm's offer price may be rejected only if other firms' cheaper offers exhaust the available funds; the winning firms' incremental costs of compliance are met precisely as they perceive them to be.

Rejected bidders can compete in a subsequent round of phaseout so long as the Fund continues to assist the country in meeting its compliance obligations. Successful auctions need not result in higher offer prices. To the extent that over time, the cost of premature replacement of existing capital equipment declines, the price differential between ODS and its substitute declines, technological growth and adaptation reduce net conversion costs, and the firms perceive greater advantage in conversion due to market shifts, their offer prices can be expected to decline correspondingly.

### Illustration: Domestic Refrigeration

The bid auction proposal relies essentially on differential "willingness to accept" across firms (and for a given firm, over time). Before discussing the proposal, we first discuss the hypothetical *revealed* "willingness to accept" constructed from selected domestic refrigeration manufacturing conversion projects recently approved by the MFEC. These projects range from 22 to 165 ODP tons per year of ODS use, and while all used HFC-134a as the substitute for CFC-12, the substitute for CFC-11 (as foaming agent) was HCFC-141b or hydrocarbons.

Table 2 shows calculations of incremental costs as a function of changes in four variables -- each of which are firm-specific and best (or only) known to the firm itself -- for a hypothetical project. This hypothetical project was constructed from the average of the "representative" sample in Annex Table A.3, a list of all domestic refrigeration investment projects approved by the MFEC at its 13th, 15th, and 17th meetings<sup>7</sup>. The average unit capital grant (gross capital expenditure) is \$14.3/kg ODP and average unit first-year incremental operating cost (IOC) is \$9.9/kg ODP. Under the MFEC's current rules, the firm would obtain a grant of \$19.2/kg ODP.

The Table compares this grant with incremental conversion cost computed from the firm's viewpoint: the sum of incremental capital cost (computed as the carrying cost for premature replacement) and the NPV of incremental operating costs, under alternative assumptions. For simplicity, it is assumed that the replacement cost of existing equipment when it reaches the end of its economically useful life is equal to the gross capital expenditure for the non-ODS using equipment; the argument remains the same even if this assumption is relaxed.

The current rules ignore the expected remaining economic life of existing equipment, discount rate, collateral benefits, expected project life, and expected change in the IOC. Even when implementing agencies such as the World Bank adopt a particular discount rate or project lifetime for their

calculations, such assumptions are necessarily arbitrary and may bear no relation to the firm's own cost of capital or business development plans. On the other hand, the neglect of such variables essentially implies a presumption that the remaining economic life of existing equipment is infinite, the discount rate is zero, there are no expected collateral benefits of conversion and expected change in IOC is also zero. In other words, only this combination of these (ignored and unobservable) parameters would equate the Fund's

in IOC 30% p.a., assuming that the firm does not derive any savings or collateral benefits from conversion over the project life. If it also expects to earn such savings or benefits, then it ought to be willing to accept less than \$19.2/kg ODP. The point is that firm-level economic parameters which are ignored under the administrative rules strongly influence the choice to convert, and that these parameters vary across firms. A corollary is that government actions which influence the firm's valuation of incremental costs would

**TABLE 2: FUND-APPROVED DOMESTIC REFRIGERATION PROJECTS - "REPRESENTATIVE" AVERAGE APPROVED GRANT VS. INCREMENTAL CONVERSION COSTS**

Hypothetical values based on average of "representative" projects				\$/kg ODP abated		
(a) Gross capital expenditure				\$14.3		
(b) Incremental operating cost (IOC), Year 1				9.9		
(c) Total grant approved (a + b/2)				19.2		
Calculated conversion cost = [incremental capital cost (ICC) = net present value (NPV) of the carrying cost of premature replacement] + [NPV of IOC over project life], at						
Remaining economic life	Discount rate	Project life	Annual change in IOC	ICC	NPV of IOC	Total
Infinite	0% p.a.	10 years	0% p.a.	\$14.3	\$99.0	\$113.3
10 years	10%	10	-10%	8.8	42.8	51.6
5	20	5	-20%	10.8	26.3	37.1
0	25	4	-30%	2.9	16.2	19.1
Revealed "willingness to accept" = "agreed incremental cost" as % of calculated conversion cost (range)				17% - 100%		

grant with the firm's own valuation of incremental cost (i.e., its willingness to accept)."

When would the firm be willing to accept \$19.2/kg ODP? This question can be examined by varying the assumed parameters of expected remaining economic life, discount rate, project life, and expected change in IOC. A number of combinations of these parameters may show the calculated total conversion project cost to be close to \$19.2/kg ODP. One such combination is when the remaining economic life is zero, the discount rate 25% p.a., project life 4 years, and expected change

also affect its "agreed incremental costs" — for example, the economic life of its existing and replacement equipment via accelerated depreciation allowance or investment tax credits; discount rate via concessional financing; and, the IOC via an excise tax on ODS and/or price subsidy for substitutes.

Table 2 also shows that if this hypothetical firm's "willingness to accept" were to be measured as the ratio of accepted grant (\$19.2/kg ODP) to total project cost, it can range from as little as 17% to over 100%. The "true" costs and collateral benefits as perceived by the firm can never be known



precisely, nor is it at all necessary to know them. However, once the firm has agreed to accept \$19.2/kg ODP, it represents at least 100% of its "agreed incremental cost". If its own valuation of the incremental costs results in a lower "willingness to accept", or "offer price", say \$10/kg ODP – based on its perceptions of expected savings or collateral benefits, say – then the \$19.2/kg ODP grant provides it an excess over what is needed to buy phaseout from that firm.

The illustration in Table 2 also shows that by covering the entire capital expenditure, rather than the incremental capital cost, the Fund's current rules provide an incentive to firms to phaseout their ODS use prematurely. If the price difference between ODS and substitutes is expected to decline over time, there are additional costs of premature replacement. The costs of premature replacement can be quite high, unless offset by incremental operating *savings*. If there are no such savings, the chemical (ODS vs. substitute) price differentials dominate the conversion costs, suggesting that the user firms' "willingness to accept" may be significantly lowered if these price differentials can be narrowed (e.g., by pricing interventions, as discussed in the next section).

In order to examine the implications of firm-specific differences in costs and implied "willingness to accept" at a country-wide level, a simulation exercise was undertaken for the "investment" subsectors (i.e. those projects where investments for conversion are to be made)– domestic refrigeration, commercial refrigeration, and rigid polyurethane foams – for Brazil. A number of simplifying assumptions were made for the exercise; these include: (i) each firm operates in one end-use sector and its quantity of phaseout offer is fixed and known in advance; (ii) each firm knows its technological alternatives and associated costs (i.e. each firm finds a particular substitute to be the cheapest); (iii) the firm will convert to the non-ODS option at the earlier of when the economic life of existing equipment ends<sup>8</sup>, which is known in advance, or at a fixed date in future, dictated by the national policy on Protocol implementation<sup>9</sup>; (iv) the replacement cost of existing ODS-using capital equipment is the same as

the cost of non-ODS-using capital equipment<sup>10</sup>; (v) incremental operating costs are positive for the foreseeable future<sup>11</sup>; and, (vi) collateral benefits to the firm and local environmental externalities are negligible. The main argument – that the "willingness to accept" is determined by the firm-specific parameters known to the firm itself, and that it would differ across firms – does not depend on any of these assumptions; the design of a specific bid auction, however, would need to examine each of the assumptions.

Table 3 shows an illustrative calculation similar to that in Table 2. Unit gross capital expenditure is taken to be \$9/kg ODP because safety and training costs are abstracted from (and because a typical firm in Brazil is larger than those represented in Table 2). First year IOC is taken to be \$10/kg ODP, in part based on the chemical price data for Brazil (see Annex Table A.5)<sup>12</sup>. Both these variables – gross capital expenditure and first year IOC – and only those variables are assumed to be observable. For simplicity, all cost estimates are presented in unit (\$/kg ODP) terms.

Under the current approach, the firm would qualify for a grant of \$14/kg ODP, which is roughly equal to the CETV set for 1995/96 for this sector. Whether the firm's "willingness to accept" would be higher or lower than this amount depends on other economic variables which are either known only to the firm or cannot be verified independently. Some of these variables – strategic market interests, or risk aversion, for example – are difficult to quantify and model; following the example in Table 2, let us assess the influence of remaining economic life, discount rate, and expectations of decline in annual IOC.

Remaining economic life depends in part on firm's discount rate, market strategy, and expectations; the same applies to "project life", i.e., the firm's expectation of how long the conversion investment in non-ODS technology is going to last before it has to be replaced. To keep the illustration manageable, Table 3 shows calculations based on the assumption that the firm determines the

**TABLE 3: ILLUSTRATIVE EXAMPLE OF SAVINGS UNDER COMPETITIVE BIDS  
(DOMESTIC REFRIGERATION)**

Assumptions				
Schedule				
- Mandated conversion at the end of			7 years	
- Remaining economic life of existing equipment			4 years	
Cost				
(a) Gross capital expenditure				\$/kg ODP abated
(b) Incremental operation cost (IOC), Year 1			\$ 9	
(c) Of which, price differential between ODS and substitute			10	
			8	
(d) Total grant under current rules (a + b/2)			\$ 14	
Calculated conversion cost = [incremental capital cost (ICC) = net present value (NPV) of the carrying cost of premature replacement] + [NPV of IOC over project life], at				
Phase out in year 5: Minimum compliance cost (MCC)				
Discount rate	Project life	Annual change in IOC	MCC, in \$ of year of phaseout	MCC, in today's \$
10% p.a.	10 years	-10% p.a.	\$35.0	\$21.7
20%	10	-20%	16.4	6.6
25%	10	-30%	10.6	3.5
Phaseout today: Cost of accelerated phaseout (IOC calculated only for 4 years)				
Discount rate	Project life	Annual change in IOC	Incentive required for accelerated phaseout (today's \$)	
10% p.a.	10 years	-10% p.a.	\$31.3	
20%	10	-20%	\$25.9	
25%	10	-30%	23.2	

remaining economic life of existing equipment to be four years and the project life to be 10 years, keeping in mind that neither are observable and could change. If the firm's discount rate is 10% p.a. and it expects the annual IOC to decline at the rate of 10% p.a., it would perceive its MCC – the net present value of the incremental capital cost plus the incremental operating cost, calculated for the year in which the phaseout would occur – to be \$35/kg ODP four years from now, or \$21.7/kg ODP in today's dollars. With a discount rate of 25% p.a. and expectation of IOC declining at 30% p.a. – a pattern consistent with the example given in Table 2

discussing the revealed willingness to accept for a hypothetical average of recent domestic refrigeration projects – it would perceive its MCC to be \$10.6/kg ODP (four years from now) and \$3.5/kg ODP (in today's dollars). In the latter case, if the firm were given the choice of accepting the grant today and converting four years hence, it should be satisfied with \$3.5/kg ODP. Of course, it would accept any higher amount if offered; if it had to compete, however, and risk losing the grant to its competitor, it would wish to offer its phaseout for an amount close to \$3.5/kg ODP.

Let us suppose the firm weighs the choice of converting today versus four years hence when it has to. Such premature ODS phaseout would increase the firm's economic capital and operating costs of adjustment. First, the capital costs would increase because equipment is replaced even though it has a significant remaining economic life. The economic costs of early replacement are given by the carrying costs of the new equipment, calculated for the number of years of premature replacement. Second, the operating costs also increase because the firm begins to incur the differential operating cost before it has to, and because the differential operating cost is lower in the later years as a result of (assumed) expected decline in price differentials<sup>13</sup>.

Given the assumption that the firm would switch to the non-ODS technology when it replaces its existing equipment (in year 5), from the firm's perspective today, if it were to convert today in return for a grant, it would compare the cost of phaseout today to that in year 5, and not to that of continued use of ODS technology permissible in the absence of the Protocol. This is calculated in the lower portion of Table 3 as the carrying cost of premature replacement and the IOC over four years.

It is clear that any incentives for premature replacement have the potential for adding significantly to the costs of adjustment so long as the firm expects the IOC to remain positive and any collateral benefits of adjustment to be negligible. On the other hand, as the discussion for Table 2 observed, the "revealed willingness to accept" in projects thus far imply that at least some of the firms that have accepted the grants thus far have a combination of higher discount rates, shorter project evaluation horizons, and an expectation of faster decline in IOCs<sup>14</sup>. Parameters for the particular hypothetical firm modelled in Table 3 are not known in advance (nor can they be). In a bid auction, however, many other firms with varying circumstances would participate. Some other firm with different parameters would have different costs — not externally knowable — and different "willingness to accept", which its phaseout bid would reveal; for instance, if the

latter firm's remaining economic life were nearly zero<sup>15</sup>, its bid would be lower. The firm modeled in Table 3 may choose between not bidding in an auction today and take its chance next time, or participate if it believes its bid to be lower than what it perceives its competitor's bid is likely to be. If it fears a loss of competitive advantage, it might even lower its own bid below its own estimate of incremental cost because in doing so, it only hopes to gain a benefit (competitive advantage).

### Savings via competitive bidding

Any estimate of the potential savings of the Fund's resources under the phaseout bid approach requires a specification of the firms' bids as well as grant levels under current rules. Clearly, this is a difficult task, since the behavior of each firm would depend upon its own circumstances, as well as its perceptions about the behavior of other firms. An auctioneer can never precisely know what bids would be offered; rather, s/he can only guess the offers based on market research and then devise the rules of auction accordingly<sup>16</sup>.

To demonstrate savings, one would have to select arbitrary assumptions and behavioral rules for each firm. For instance, one could specify that the firm would choose to accept 50% of its MCC calculated at 10% discount rate and expected change in IOC of 10% p.a., and thus derive savings of 22% as compared to \$14/kg ODP. Or one could specify that the firm would only accept 100% of its MCC at 25% discount rate and expected change in IOC of 30% p.a., and show savings of 75%. (In each case, the firm's MCC is expressed in today's dollars for a conversion in year 5). But the firm's discount rate and expectations, as also its perception of remaining economic life, its market strategy and risk aversion, or its collateral benefits of conversion, may not be known or determined administratively<sup>17</sup>. An actual bid would only show the price and quantities demanded, not what percentage it may be of the firm's (unknown and unknowable) MCC. To maximize the chances of winning, the firm can also be expected to seek to lower its costs as much as possible — e.g., identify an ODS substitute at a lower price<sup>18</sup> — and to choose

its technology option in such a way as to maximize its savings and collateral benefits.

Competitive pressures are likely to ensure that the firm would bid as close to its "willingness to accept" as possible or risk losing the grant to other firms<sup>19</sup>. Once the firm makes an offer, it represents its "willingness to accept" and thus at least 100% of its "agreed incremental cost".

### Implementation of bid auctions

Bid auctions of varying complexity can be designed to meet the needs of specific situations. The simplest from the Fund's perspective would be periodic (say, annual or biennial) sealed-bid auctions, where each bidder offers different quantities and prices, similar to many other conventional systems of bulk procurement. Bidders would self-select the year in which they bid. Each bid would follow a standard contract proposal format, which would consist of a technical proposal to confirm its phaseout approach and a separate cost proposal constituting its "offer price" or grant request without revealing its "true" (and unknowable) costs<sup>20</sup>.

Table 4 provides a general outline of the main issues and options that arise in the design of bid auctions. For simplicity, it is assumed that a government agency is the auctioneer and sets the rules; this function may well be performed by an independent contractor. The relative importance of issues, and the relative merits of options, are specific to particular situations; the listing here is meant to be illustrative, though it does address a larger set of alternatives than the illustrative example above.

For instance, a variety of alternatives may be considered by the MFEC to determine the country-level aggregate sum; the simplest would be setting a minimum target for the aggregate phaseout offers – in tons per million dollars, say (or, conversely, a maximum aggregate average price). Pre-allocation of the aggregate sum may be necessary to help establish confidence among bidders and provide the national ozone units a stable

framework in which to design and conduct an auction. Firms enter an auction with their assessment of relative likelihood of success, but are likely to avoid them altogether if they cannot sufficiently rely on there being some successes. In order to avoid the so-called "disbursement problem" that arises when the budget is fixed upwards as well as downwards (i.e., a fixed sum has to be disbursed in a particular period), the country should not be required to spend the entire sum in a given auction, but rather permitted to carry over amounts not committed to subsequent rounds<sup>21</sup>. Also, when bid auctions are applied in multiple countries, a country should not be penalized in a subsequent round of pre-allocations simply because it was able to obtain significantly cheaper reductions in a previous round. In other words, because one auction's results are not necessarily good indicators for the future, subsequent aggregate pre-allocation at the country level should not penalize good performance in an earlier round.

In the absence of prior information indicating that a particular class of participating firms may share certain characteristics which justify breaking the auction across different groups, the simplest option is to have a single auction across all firms, with a maximum acceptable bid price announced in advance and the right to reject any or all bids.

Even if the auctioneer is permitted to carry over amounts from one period to next, he may be concerned that not enough firms would participate. The issue is not what their offer prices would be, just that they would not reveal the offer prices. Some firms may well appear to be "not convinced"; perhaps their existing equipment is younger, perhaps they expect CFCs to get cheaper as demand for them falls, perhaps they do not derive any collateral benefits of conversion. An auctioneer may well make participation mandatory, especially for a certain class of firms (by ODS, use sector, or size group). Additional pressure may be exercised by adopting a "use it or lose it" rule – for example, if the firm does not submit a winning bid (i.e., in competition with other firms) for three successive rounds, and continues to be using ODS five years ahead,

its ODS entitlement (the quantity it is permitted to offer for phaseout) would be reduced by, say, 50%. Arguably this stretches the meaning of "agreed incremental costs"; the idea is simply that an auctioneer, once determined to obtain a certain amount of phaseout, can use a variety of tools at his disposal. Another, less drastic, practical solution to get around the problem of "non-participation" is to set a minimum guaranteed price (perhaps even different price bands for different end-use sectors)<sup>22</sup>.

If a likely reason for the firms' reluctance to participate in bid auctions is their perceived difficulties in obtaining the technical and economic information required to prepare the bids, the Fund should expand the technical assistance activities at the national level. As compared to the project-by-project approach, a bid auction approach shifts the burden of evaluating technical and economic options from the Implementing Agencies and their consultants to the firms. On the other hand, the project-by-project approach limits the transmission of information to one firm (or a group of firms) at a time. If the national-level technical assistance activities are expanded, not only do all firms share equally in the information and expert advice available (which may encourage them to participate in the auction), but the unit costs (per ODP phased out) of providing such services will also be lower. Another advantage (as compared to firm-level technical assistance) would be that the government would obtain greater information and understanding of the ODS markets, enabling it to create more effective policy frameworks and design more efficient auctions (e.g., by creating due diligence criteria to minimize the risks of non-performance).

Similarly, although heterogeneity among ODS uses and users may well ensure competition, the auctioneer may be concerned, based on market intelligence, about the possibility of collusion among bidders. He could set a "maximum acceptable price" which somewhat protects against collusion. If some of the bidders find the maximum acceptable price too low, the first

round of auction may "fail" in that there would be some money left to be carried over to the next round, whose rules may have to be set differently. A similar problem may rise at the level of a *class* of firms. Let us suppose, for example, that a certain class of firms may have inherently much lower WTA than another such class, and individual firms in both classes are aware of this. Firms in the former group may be able to bid uniformly higher prices up to what each of them perceives to be the likely lowest bid from the latter group. If the auctioneer also knows of such a possibility, he may choose to set "divided auctions" with different maximum acceptable bid price for different classes of bidders. Such "divided auctions" should be run concurrently, without setting a sector-specific budget limit.

In short, even as competitive bidding practices are very much rooted in the national legal and organizational (business and government procurement) cultures, auctions can be custom-tailored to meet the efficiency challenges in specific situations<sup>23</sup>. As compared to the project-by-project approach, one can gather a large number of competitive bids in one sweep; indeed, if the Fund can commit itself to multi-year allocations in advance, a national auctioneer may well permit the firms a wider latitude in choice of phaseout timing and have multi-period bids in a single auction. That is, firms offering phaseout four years hence now at a \$/kg price to be paid *then* may compete with firms offering phaseout a year hence at a \$/kg price to be paid now. (To the extent that premature replacement costs and the price differentials between ODS and substitutes decline over time, phaseout offers can be expected to be lower in the future.)

Unlike other routine bulk procurement processes, it is impossible in the case of ODS phaseout to observe another actual procurement and get a sense of prevailing market price or different firms' bids. In large countries, they would at least reduce the administrative costs of project-by-project need assessment and may reduce the monitoring and verification costs as well. On the

**TABLE 4: LIKELY ISSUES AND OPTIONS IN DESIGN OF BID AUCTIONS**

<p>1. Determination of country-level total grant (assuming a given aggregate sum at the Fund level):</p> <ul style="list-style-type: none"> <li>a. <i>Pro rata</i> according to the countries' per capita ODP baseline consumption.</li> <li>b. <i>Pro rata</i> according to the countries' per capita ODP "consumption" phaseout commitment in excess of Protocol requirement.</li> <li>c. International comparison: The Fund sets an aggregate maximum average price based on prior experience and market analysis, including sectoral composition of ODS use and indications of sectoral variations in cost components.</li> <li>d. Competitive inter-Party (not cross-national inter-firm) bidding: The Fund permits Party bids, combined with pre-set price ranges and/or ODP quantities.</li> </ul>
<p>2. Terms of aggregate (country-level) grant:</p> <ul style="list-style-type: none"> <li>a. Disbursement: (i) Up-front; (ii) Upon bid selection and award; (iii) linked to disbursement to firms; (iv) combination.</li> <li>b. Duration: (i) fixed period (e.g., annual); (ii) roll-over permitted.</li> <li>c. Grants for implementation and enforcement costs: lump-sum or prorated according to phaseout success or other criteria (e.g., regulatory measures, stricter limits than those imposed by the Protocol).</li> <li>d. Implementing Agencies' role: <i>national</i> "portfolios" (rather than project portfolios or sectoral portfolios; one manager responsible for an entire country); review and approval of bidding rules and bid selection; implementation monitoring and reporting.</li> </ul>
<p>3. Determination of firm-level ODS use (phaseout offer) entitlement:</p> <ul style="list-style-type: none"> <li>a. Period: Target year only, or interim annual, or cumulative over a period.</li> <li>b. Quantity: (i) based on historical amount ("grandfathering") and reduced according to the Protocol's schedule for the entire country; (ii) based on initial auction of "use permits".</li> </ul>
<p>4. Auction rules:</p> <ul style="list-style-type: none"> <li>a. Participation: voluntary or mandatory ("use it or lose it"); general or specific to substance (e.g. halons), use-sector (e.g. domestic refrigeration), or size groups; user firms only or third party (agent/broker) bids.</li> <li>b. Aggregate quantity targets: (i) none; (ii) minimum total from acceptable offers; (iii) maximum total from acceptable offers.</li> <li>c. Performance schedule: (i) at a fixed time (e.g. 2 years from date of bid award); (ii) at any time up to a pre-set schedule (e.g. any time by 2004).</li> <li>d. Acceptable bid price ranges: (i) none; (ii) maximum acceptable price; (iii) minimum guaranteed bid price.</li> <li>e. Selection criteria: (i) award bid price, subject to applicable maximum; (ii) award a market clearing price.</li> <li>f. Bid rejection criteria: (i) unacceptable price; (ii) unacceptable verification procedure.</li> <li>g. Rebidding within the same auction: (i) not permitted; (ii) permitted.</li> <li>h. Government participation: May choose to "withhold" a certain quantity of entitlements as permitted under the Protocol, or create and hold entitlements to "reclaimed" ODS, in order to make up for any shortfalls in an auction.</li> </ul>
<p>5. Terms of grants to firms:</p> <ul style="list-style-type: none"> <li>a. Disbursement: (i) up-front cash; (ii) up-front promissory notes or vouchers, encashed upon verification; (iii) combination.</li> <li>b. Verification: (i) by government agencies according to detailed pre-set rules; (ii) left to firms and industry groups to develop standards, and demonstrate acceptable compliance to broad, general rules; (iii) combination.</li> </ul>
<p>Notes:</p> <p>1. More options are suggested here than discussed in the example in the main text; some of these options may impose different firm-level control requirements than those imposed at the Party level by the Protocol.</p>

other hand, if a large number of user firms are encouraged to compete, the rate of conversions may be expedited, with ratcheting effects on market composition (ODS vs. their substitutes, and products containing them)<sup>24</sup>. The only way to know the prevailing market price or the scale effects of conversion is via conducting an actual, pilot auction.

It bears emphasizing that bid auctions as proposed here be applied only at the national level, not at the inter-country level (whether between countries or between firms from different countries, as is implicitly permitted in the Fund's use of CETVs). Inter-country bid auctions are likely to be impractical, inequitable, and may even be inefficient. This is because governments have no way of estimating the optimal conversion costs of individual firms, and firms in different countries operate face different markets and policy environments. The potential for firms' forecasting and estimation errors is far greater (than when they are competing for grants against other firms in the same country), with the likely result that the bid prices

would be much higher than they need be.

Finally, projects involving conversion of ODS production facilities, or reclamation activities, are unlikely to be suitable candidates for national-level bid auctions together with the user firms. This is because in both these types of projects, a firm's expectations are crucially dependent on the aggregate decisions of all the *user* firms who are participating in the auction. If the user firms reveal especially low WTA and the auctioneer is able to buy a great quantity of phaseout with the available budget, the producing companies have a high economic incentive to shift production but the reclamation activities would collapse. The converse also applies. As discussed briefly in the next section, the issue of production sector conversions and reclamation activities needs to be addressed in a comprehensive manner since the markets for controlled virgin ODS, recovered ODS, and their substitutes are essentially worldwide in nature and price of any one should affect the other two.

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- 1/ A number of US electric utilities have sought additional capacity via competitive bidding including from demand reduction. For a broad overview of US bidding programs, rules and results, see Swezey (1993) and Kliman (1994). A number of developing countries have also used competitive bidding programs for privatizing existing electric utility assets and/or acquiring new generating assets.
  - 2/ For example, the end-use markets (refrigeration, foams, aerosols), remaining economic life of existing equipment, discount rate (in turn based on cost of equity and borrowing), marketing strategy, market power vis-a-vis its suppliers and competitors, and benefits of conversion.
  - 3/ Valuation of existing assets affected by deregulation of the electricity industry in the US - i.e., of the so-called "stranded assets" - has certain similarities to the problem here of determining the firm-level economic costs of regulatory change. See Baxter (1995) for a discussion of alternative approaches, including "market-based", to this problem. At least one US electric utility has proposed competitive bidding as a means to determine such values.
  - 4/ A firm knows only its own costs but not that of its competitor, and the auctioneer knows neither except as actually revealed in their offer price. Sequential auctions have the advantage that the auctioneer gains knowledge from the first auction that he can use in the next round, as can all the firms whose bids are rejected.
  - 5/ In terms of economic theory, this is a "lump-sum" subsidy that has no distortionary effects because it does not affect the prices and costs faced by the firm at the margin.
  - 6/ Note that "excess demand for grants", which in turn has required changing the rules of the game, is a practi-

cal problem for the Fund and the implementing agencies only under the project-by-project approach. Strictly speaking, an auction would also have a residual, unmet "excess demand"; the distinction is that the uncertainty and the costs of preparing the bid are borne by the enterprise, who is therefore likely to adopt a strategy which would maximize its probability of winning (i.e., all other things being equal, come as close to its own perceived value of the phaseout grant).

- 7/ In order to derive a "representative" sample, a significant number of projects had to be eliminated for certain reasons: the projects included compressor manufacturing conversion, or had partial foreign ownership (which limits Fund's grants), or did not contain data on prices for ODS and their substitutes, or showed unit grant or cost levels which appeared to be considerably outside the range represented by others.
- 8/ A firm may well choose to replace existing equipment with the same technology instead of converting if it deems the potential cost of premature replacement in response to the Protocol requirements outweighs the avoided incremental operating cost in the interim.
- 9/ For example, assuming that the government imposes the same phaseout schedule on user firms as that on production and imports. This assumption is needed to avoid a separate analysis of the options to stockpile virgin ODS or create/purchase reclaimed ODS.
- 10/ While licensing, testing and training costs for a new technology may be significant, they are assumed to be at least offset by productivity gains or other collateral benefits.
- 11/ At least to the extent that the net present value, if negative, of incremental operating costs does not more than offset the initial capital cost, rendering the conversion project as an economic one which would be undertaken by the firm *without the Fund's support*. Projects with such "net savings" may not *need* the Fund's support but, under the Fund's current procedures, are eligible for grants.
- 12/ International price data and projections are not available except for the expected prices for selected firms (from the Fund's project documents), which show tremendous variations. Although Brazil produces ODS substitutes already, the reported HFC-134a price in Annex Table A.4.3 is significantly higher than the generic values used by OORG (1994) or ICF *et al.* (1994). If HFC-134a prices can be lowered to \$4-6/kg, as observed for some other countries, the project cost estimates shown here would be substantially lower.
- 13/ Note that the proposition "the later the cheaper" is valid only when the present value of net incremental costs (capital plus operating), as calculated from the firm's perspective, is positive.
- 14/ For ease of modeling, this expectation has been defined in terms of the change in the price differential between ODS and its substitute. It can also serve as a proxy for expected collateral benefits or remaining economic life.
- 15/ In which case its choice would be between bidding now and converting to non-ODS technology with the amount it can win and replacing existing equipment with the same (ODS-using) technology and bidding later. The Fund's current rules do not allow it the latter option, but it may still find it in its economic interest to continue using ODS until some later date (up until it is legally banned from doing so) even if it does not obtain any conversion grant.
- 16/ For example, maximum acceptable bid and/or minimum guaranteed bids (for small users, say), by sector or across sectors. It is beyond the scope of this paper to discuss alternative auction types and corresponding bidding strategies. For an introductory review, see Milgrom (1989).
- 17/ And, to the extent that the Fund may have some prior information about some of these variables, under current rules it would have to engage in detailed project review and negotiation; note, however, that at the very least only the total sum need be negotiated.
- 18/ Note that the reported price differential at this time between CFC-12 and HFC-134a in Brazil is much higher than observed elsewhere or as perceived to be "normal" by the OORG.
- 19/ Although the illustration provided above is for the domestic refrigeration sector, the auction is assumed to be



available to firms in all sectors. The auctioneer may choose to announce in advance a "maximum acceptable price" for each sector, but competition across sectors must be permitted.

- 20/ This assumes a sealed-bid discriminatory auction, where each bidder gets just the price in his/her bid. Other types of auctions and rules - open auctions, or permitting re-bids - can be envisioned as well, but require more research for specific situations. In principle at least, because the Protocol allows a significant interval until developing country firms are obligated to phaseout, an auction may issue "entitlement certificates" valid for a certain number of years, and these can themselves be traded among firms in turn. Similarly, an open auction permitting rebids may use "kg ODP per \$" rule and allow firms to bid partial quantities at different prices. There are many *theoretical possibilities*; *practicality* beyond the simple concept presented here depends on specific situations.
- 21/ For example, because not enough "acceptable" offers are received which would permit the country to meet the terms of its aggregate grant from the Fund. More specific rules would need to be developed; e.g., a "use it or lose it" (partially or fully) rule for firms in a specific sector may reduce the likelihood of such an outcome.
- 22/ The "sectoral approach" now under consideration for China addresses precisely this "non-participation" issue. On the other hand, administrative assessments of sectoral incremental costs may also be prone to error; some firms from a sector believed to have higher offer prices may in fact *underbid* some firms from the sector believed to have a lower offer price, if cross-sectoral competitive bidding were allowed.
- 23/ Some parallels are found in the electricity industry. In the early days of promoting non-utility generation in California, utilities were required to contract with cogenerators and independent power producers at the *projected* avoided cost. For projects below a certain size, utilities were required to use the "standard offer" - akin to "fixed price" - contract. For larger projects, contracts were individually negotiated, but with the avoided cost calculations as the benchmark. Later, as the avoided cost declined, as did the prices offered. State agencies and utilities still had an interest in buying renewable sources of energy, so they devised a "renewables only" competitive bidding. In the UK, the government did not wish all renewable technologies to compete against each other, so they employed technology-specific indicative "price bands", leaving actual negotiating details to the project developer and the distribution company.
- 24/ As the use of ODS substitutes and products containing them expands, domestic market forces may become the "drivers" behind expanding their market share even more.

# 5 Other Market-Based Instruments

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Conceptually, competitive bid auctions represent a market-based instrument that requires neither the price nor the quantity of ODS phaseout to be pre-determined; it is a means of allocating the grant budget<sup>1</sup>. Two other broad categories of MBIs are also possible:

Tradeable permits for ODS "consumption" or use: Once the national government has elected to implement the Protocol at the level of domestic firms by granting them permits to produce, import, or use ODS as described in Section 2, it may further allow them to trade these permits among themselves upon mutually acceptable terms. That is, the government determines the aggregate allowable quantity, and the market determines the prices as well as who gets to produce, import or use how much of the ODS. Additionally, the government's initial allocation of permits may itself be market-based, e.g., when they are auctioned off rather than conferred to firms on the basis of historical record.

Pricing (tax/subsidy) policies: Via pricing policies, the government influences the prices of ODS and/or their substitutes, and the market determines the firm-level prices and quantities of chemicals as well as the aggregate quantities of chemicals. Main examples are a tax on ODS and/or a subsidy on substitutes; more generally, a differential taxation scheme according to the ODP of individual substances. The rates of tax and/or subsidy may also be varied over time.

Other market-based policy instruments are also available to governments: for example, use of fiscal policies such as accelerated depreciation allowance or investment

tax credits, or concessional financing, targeted at conversion projects; or, differential tax treatment of goods containing ODS vs. those containing the substitutes. Some general features of these MBIs are:

1. Flow of funds: Because permit auctions and ODS taxes involve flow of funds away from the firms to the government, their political acceptability may be low. On the other hand, governments may elect to either recycle the revenues in the form of tax credits to firms which undertake conversion or subsidies on ODS substitutes. Another alternative is to dedicate the revenues to a trust fund (perhaps with control shared among industry representatives and the government) to finance industry-wide activities such as information-sharing, technology and market intelligence, training, and research and development. (The Fund itself may choose to participate in such national trust funds as a means of meeting incremental costs which are not specific to individual conversion projects.)<sup>2</sup>

2. Financial vs. Economic Calculus: Generally speaking, both permit auctions and taxes or subsidies affect firm-level financial calculus without affecting national economic costs of compliance, except to the extent that they reduce uncertainty, motivate search for lower-cost solutions, and increase the flow of information (if the bids in permit auctions are made public). On the other hand, they both do influence the "agreed incremental costs" in the market for ODS phaseout, i.e., the transactions between the Fund and the firms which are willing to convert. That is, a firm which has to purchase a permit from the government (in the initial auction) or from

another firm would weigh its decision against the choice to convert, offering its phaseout service to the Fund. Similarly, a tax on ODS and/or a subsidy on the substitute affects the firm's valuation of the incremental operating cost associated with conversion. Two implications follow: (i) these other MBIs can be powerful complements to the Fund's grant assistance to firms; and, (ii) to the extent that government's use of domestic transfer mechanisms reduces the Fund's grants to firms but not necessarily the national economic costs, the Fund should provide preferential treatment to governments willing to so collaborate (e.g., via direct grants to governments or domestic revenue-recycling mechanisms such as suggested above).

3. Timing of policies: Because developing countries are not bound by any aggregate limits on ODS consumption until 1999, and because the effect of developed countries' production phaseout (with a limited exemption for production to export to developing countries) on ODS markets and use patterns are yet to be determined, some latitude is available for the design and implementation of a tradeable permits regime (in production, imports, or use) or a pricing regime. Proper design of pricing policies or of "rules of the game" in a tradeable permit regime would require harmonization between different types of permits (production, imports, and use) and perhaps international policy harmonization as well (so as to have an international regime in production permits, for example, or so as to avoid undesirable impacts on the domestic firms' competitiveness in world trade). In the case of ODS tax policies, for example, developing country governments may well wait to use them if and when the risk of "under-phaseout" becomes imminent – at any time between 1999 and 2004, say – and then apply taxes to the level of severity required.

This paper deals primarily with improving the efficiency of the Fund's grant allocation process (with the flows of funds to firms) and actions the Fund is authorized to take, while these other MBIs are subject to national governments' jurisdiction. In due course, developing countries may well wish to take advantage of these MBIs which can be

powerful complements to the Fund's grant allocation process and may well lower the governments' costs of monitoring and enforcement. Some comments on the issues involved in their design and use are offered below for further analysis and research.

### Tradeable permits

A tradeable permit regime is suitable for situations where only the aggregate environmental damage from multiple sources is sought to be contained, and the cost of containment varies among individual sources. Compliance with the Protocol is certainly an aggregate obligation, and from the phaseout projects undertaken thus far it appears that the cost of conversion to ODS substitutes does vary significantly across firms. A tradeable permits regime would appear to be applicable to such a situation.

In fact, Section 3's characterization of transactions between the Fund and the user firms as a "market in ODS phaseout" is only a special sub-market in a tradeable permits regime. It is easy to see how this is so. The firms may be seen as holding a certain property right, a permit – to use ODS, that is – and they may choose to enjoy that right themselves, or sell it to another firm, or "sell" it to the Fund which "extinguishes" this property right. The sole distinction is that if another firm bought the permit, it would likely "exercise" the permit – i.e., use ODS during the period permitted – while the Fund buys it off to permanently "retire" it. The situation is similar in the case of permits for ODS production. A particular advantage is that the observed prices in inter-firm trade provide information to the Fund about how different firms value ODS use, and conversely the observed prices in the Fund's competitive auction of grants provide similar information to firms. If a firm can offer its permit to another firm at a higher price than the value it has to exercise that permit for its own benefit, it is rational for it to switch to ODS substitute; in turn, if it can obtain a higher price for the permit from another firm than from the Fund, it is rational for it to offer it to the former. In either transaction, the offeror has competition; indeed, under a tradeable permit regime, the Fund also has competition

from other buyers. In practice, of course, all these transactions are not likely to be struck at a single point in time with identical information available to all participants; therefore, there will be divergences between the prices in inter-firm transactions and those in the Fund's bid auction.

Permit regimes of varying complexity can be created. For example, firms may be allowed to trade permits for one ODS for another within a Protocol grouping (e.g., CFC-11 for CFC-12) for their own use or for trading to another firm. Firms may also trade permits for any future period. Transactions between firms may be permitted to be bilateral and private, with only the record of transaction to be submitted to the government, or may be made in a central exchange, with all transactions made public.

National tradeable permit regimes may also be linked so as to create international tradeable permit regimes. Indeed, the Protocol explicitly permits inter-Party transfer of production and/or net imports<sup>3</sup>. The US and the European Union have adopted the permissibility of such transfers in their respective legislation or regulations<sup>4</sup>. Beyond 1995, the allowable production in developed countries for export to the developing countries to meet the latter's "basic domestic needs"<sup>5</sup> is also transferrable. Inasmuch as the markets in ODS and their substitutes are indeed global, and that country-level competition in converting ODS production may be limited (see below), an international tradeable permits regime for ODS production may also facilitate an international auction for production sector conversion.

On the other hand, even though tradeable permits regime offer many opportunities for policy innovation and can theoretically offer significant cost reductions in country compliance with the Protocol, the actual savings achieved depend on the volume and frequency of trading<sup>6</sup>, which to a certain extent depend on the design of the scheme, which can sometimes be a politically thorny issue. Several features of ODS markets and the Protocol indicate that the volume of trading may really be quite small, and that the costs of implementing and enforcing an

ODS tradeable permits regime may be quite high, as compared to, say, the celebrated sulfur dioxide (SO<sub>2</sub>) emission allowance scheme in the US (under the so-called "acid rain program"). Indeed, it appears that even though the US and the European Union permitted trading of ODS production and "consumption" allowances among firms, the actual volume of inter-company, inter-substance and inter-national trades thus far is reportedly extremely small. The likely reasons, and the implied differences from the US acid rain program, may be summarized as below.

(i) In many countries, the use of certain ODS is scattered among a large number of small firms. In such situations, the government's costs of tracking ODS permit exchanges would be very high, as would the firms' transaction costs. The risks of "non-performance" - i.e., firms exceeding their permitted use or continuing the use after the permits have been transferred to another firm - may also be very high. This is different from the SO<sub>2</sub> emissions situation, where a small number of large emitters have to be monitored, and the costs of monitoring systems are minuscule as compared to the overall budgets of emitters. ODS markets also differ in that ODS can be stocked and that reclaimed ODS may be used in unrestricted quantities; this suggests that firms may more wish to take advantage of flexibility afforded internally rather than trade with other firms.

(ii) Electric utilities have a high degree of flexibility to vary their SO<sub>2</sub> emissions; firms producing or using ODS may have extremely limited flexibility, if at all. Their choice in most cases is likely to be of a "yes"/"no" type - i.e., continue or convert (via any among multiple options). If they expect some fluctuations in operations, they are more likely to increase or deplete their ODS stock rather than purchase above-quota permits from other firms. On the other hand, firms that for their own economic reasons (other than the market value of permits, that is) produce or use less ODS than they are entitled to (or close operations) would earn a windfall profit. (Note that national aggregate limits on production and imports apply every single year, and inter-period transfers are not permitted under the Protocol).

(iii) Some observers of the US acid rain program suggest that firms are usually more inclined to enter the permit trade market if they have obtained permits by paying for them (e.g., via an auction or on a sliding-scale fee basis) rather than just receiving them. On the other hand, conferring permits on the basis of historical production or use is likely to be far more politically acceptable than requiring fees or auctioning the permits. Because ODS production and most of the uses are tied to long-lived capital stock, these permits would not be traded often, if at all. Even if import permits are auctioned, they are likely to be of short duration (e.g., a year or two), and the permit holders may have no desire to trade in the interim.

(iv) The Protocol's control schedules apply to a large number of ODS, different groupings of which have different reduction and phaseout schedules<sup>7</sup>. Unless inter-substance and inter-temporal trade were permitted, firms may just not have enough information – or, collecting such information may be very costly – to make reasonable valuations of the permits.

With the use of innovative designs of permits and "rules of the game", these and other difficulties are not insurmountable. For example, tradeability may be limited to a certain group of ODS and activities or firms. Some other ODS or uses may be subjected to a "sectoral ban", if the costs of a forced switch are judged to be minor. Or the government may "withhold" certain quantity from the initial allocation, if by auction, and use its own holdings to influence market behavior and prices at a later point in time.

In the near term, however, developing countries may wish to try using annual or biennial auctions for tradeable permits for ODS imports<sup>8</sup>, and use the experience gained to create a broader, longer-term tradeable permit regime for ODS production and/or use. As tradeable import permits regimes are established in a greater number of large enough countries, firms may well find it in their advantage to enter in long-term contracts with exporting firms in the developed

or developing countries, in turn partly reducing the uncertainty about availability and costs of ODS over a longer term (say, five years or more). If the experience is heartening, and if several large countries join in developing national and international tradeable permits schemes, the volume of trade may grow and indeed deliver the savings such schemes promise in principle<sup>9</sup>.

#### Taxes and subsidies

Taxes on ODS and subsidies on substitutes – or, in broad terms, pricing policies which may also include price stabilization schemes (floors for ODS and ceilings for substitutes) – may be somewhat easier to use than a tradeable permit scheme. The key issues in using these instruments are administrative efficacy and accuracy of the tax/subsidy levels selected. Because compliance with the Protocol means honoring aggregate quantity limits according to a particular schedule, pricing policies alone risk being insufficient or overshooting the target.

Any new tax is likely to meet with resistance from those who have to pay it (though a subsidy would be welcome by those who benefit from it). Also, imposition of a new tax may well require legislative authority and collection and enforcement activities would require involvement of a number of government agencies. More importantly, it is difficult to determine, *a priori*, the appropriate tax/subsidy rate without a reasonable estimate of price elasticities of demand, especially over time (and, inasmuch as the Protocol constraints both certain ODS as well as their substitutes, albeit with different control schedules, the cross-price elasticities of demand)<sup>10</sup>. Prohibitive tax levels of the type used in the US are simply not necessary until the national phaseout limits are approached<sup>11</sup> in developing countries.

A tax/subsidy scheme would also require harmonization with other domestic policies and, if the country's exports of goods containing ODS or substitutes are significant, with the tax/subsidy policies in major trade partners as well. For example, if the country

has implemented a scheme to auction ODS import permits, the bids in such an auction would provide some indicators of the scarcity value of ODS to the user firms. For "imports only" countries, it may be argued that no additional taxation is justified. For countries with domestic production, import permit auctions may lead to certain windfall gains for domestic producers. It may be difficult to estimate the extent of such gains in advance, because as the ODS phaseout of recent years begins to show its impacts, ODS markets may well swing one year to the next. Frequent changes in income tax rates on domestic producers or excise taxes on domestic production are neither easy nor desirable. In some situations, the government may have to use lump-sum taxes or fees, or non-price measures to induce conversion by domestic producers (e.g., voluntary agreements).

Assuming that the administrative difficulties of policy harmonization and coordination among government agencies are overcome, the determination of appropriate tax/subsidy rates would remain more a matter of trial and error, which in turn may lead to some problems. For example, if tax revenues are supposed to be dedicated to a specific phaseout assistance scheme, the risk exists that the revenues from users that continue use (and thus pay taxes) fall short of the expenditures for those who convert. One answer to such a contingency would be to accumulate tax revenues in a "reserve pool" or a fund to expedite phaseout at a later date if necessary.

Despite such doubts and difficulties, the powerful role of pricing policies in effecting compliance cannot be denied; it is precisely because of such power that their use has to be cautioned against, otherwise the country may end up incurring excessive cost for compliance with the Protocol. For example, a prohibitive tax of the type used in the US may force a pre-mature retirement of end-use equipment (such as domestic or mobile air-conditioners) without compensation. At this point and for a few years still, the main task for the developing countries is to curtail the growth of use and consumption of virgin ODS, which can be effectively met

with the "permit and prohibition" regime described in Section 2. At the same time, their governments may wish to (a) initiate the legislative action required for imposition and collection of taxes (and the ability to adjust tax rates as deemed necessary) at a later date, and (b) use the registry and permit systems discussed in Section 2 to study potential collection and enforcement costs and revenues under alternative tax regimes. The latter would also help determine the merits of government- or Fund-financed centralized ODS reclamation and banking schemes, and associated regulations to control the ODS requirements to service the existing stock of cooling equipment. Again, as in the case of instituting a tradeable permits regime, national governments may need to be provided direct incentives (grants) from the Fund to undertake the steps which lower the firm-level financial costs of use phaseout (i.e., via lowering the WTA in a bid auction) but not necessarily the country economic costs.

#### **Note: Special Role of the CFC Production and Reclamation Activities**

It was pointed out at the end of Section 4 that projects involving conversion of ODS production facilities, or reclamation activities, may not be suitable candidates for bid auctions for user firms. There are other reasons to suggest that the nature of competition in the ODS production activities may be fundamentally different from that in the ODS use sectors.

First, unlike the use sectors, production of specific ODS in a country is likely to be concentrated in a very small number of firms<sup>12</sup>. Both ODS and their substitutes are generally bulk chemicals. Their production appears to be characterized by sizeable economies of scale and significant learning effects, and sometimes patent monopolies. If the existing ODS producers are operating at sub-optimal size, and further if financing their conversion is likely to lead to sub-optimal size in substitute production, that is clearly not in the country's economic interests.

Second, in the absence of import

restrictions, the markets in ODS and their substitutes are indeed global in nature, and the Protocol's control measures clearly provide for substitution of domestic production for imports (and vice versa) during the phasedown period. If importing ODS – from other developing countries or from the developed countries, under the exemption granted for meeting the “basic domestic needs” of developing countries – is cheaper than maintaining domestic production, the latter should retrench. Similarly, if importing the substitutes is cheaper than converting the domestic production capacity, the country should import rather than convert.

The calculus is further complicated by (a) the permissibility of ODS stock increase during the grace period, (b) the availability of destruction credits to increase permissible production<sup>13</sup>, and (c) the exclusion of reclaimed ODS from the control limits. This is because, even as ODS use is phased out, the aggregate demand may not fall *pari passu* because of possible stockpiling: (a) by firms who wish to service, i.e., re-charge, the stock of existing cooling equipment, and (b) by user firms who do not yet convert, even if it is assumed that they do not increase their annual ODS use *rate* (if only because such an increase is barred by the conditions of their permit). Of course, stockpiling only shifts the time pattern of demand; ultimately the demand would have to fall. Similarly, the aggregate supplies may also not fall, if the producers (or importers) choose to maintain their production (or imports) up to the permissible quota and add to their own stocks for possible sales in later periods.

The essential issue is relative costs of supplies for virgin and reclaimed ODS from different sources, domestic as well as imports, especially for CFCs. These price differentials are crucial to the economics of conversion (of use or production), of reclamation, and to the design of pricing policies which seek to influence the price differentials. Unfortunately, data on historic or projected trends in availability and price of ODS and substitutes are extremely sparse. As shown in Annex Table A.6, the production rate of virgin CFCs permitted by the Protocol far exceeds the

current consumption rate in the developing countries; similarly, the cumulative permissible production far exceeds the likely cumulative consumption.

One may expect an increase in the production rate for 1995-97 period, if only because of the motivation provided by the Protocol to establish a higher baseline; even then, aggregate capacity constraints are not likely to occur<sup>14</sup>. In the presence of such excess production capacity, reclamation may well be commercially unattractive. However, the question to ask is not whether it is cheaper to produce a ton of ODS than to reclaim it from existing stocks, but whether it is cheaper to convert to substitutes than to reclaim. Essentially, ODS phaseout (for non-halons) is likely to become more of a “stock management” problem as the “emissive uses” (such as in aerosols, solvents and foam-making) are curtailed<sup>15</sup>. In developed countries such as the US, heavy taxation of sales of virgin ODS (whether from current production, as was the case until the beginning from this year, or from stockpile) combined with tax exemption for the reclaimed ODS, seems to have helped limit the stockpiling of virgin ODS and provided incentives for commercial ODS destruction and recycling activity, though perhaps not at as high a level as might have been anticipated.

While it is not self-evident that similar measures are yet useful for the developing countries, reclamation may be economically as well as environmentally more attractive: the former since it yields a useful product, and extends the remaining economic life of existing ODS-using equipment (either in the firms which use ODS to manufacture other products or in the firms and individual who use ODS to service existing stock of ODS-containing goods), and the latter since it at least postpones emissions and may avoid them altogether if ODS can be continuously recycled. The Ozone Operations Resource Group (OORG) has thus recommended it as “a first priority” (OORG, 1994, p. 27).

Yet, only a few recovery and recycling projects have been undertaken thus far in the developing countries, most of them at pilot or

demonstration scale. One reason appears to be the greater difficulties of preparing and implementing a project with numerous, small-scale firms in the so-called "service sector". More importantly, there may be no commercial incentive until the Protocol limits on virgin ODS become binding and/or their prices increase. Even then, optimal investments in recycling would remain subject to uncertainties about the size — an unexpectedly rapid retirement of ODS-using freezers and chillers, for example, may lead to under-utilization of recovery, recycling and reclamation investments — and distribution of the end-use stock<sup>16</sup> and prices for virgin and reclaimed ODS. The problem of establishing a one-to-one relation between the Fund's accelerated phaseout program and a country's compliance obligations may be more serious for the production sector conversion (than for the use sector): if the Fund finances production conversion but the country's imports make up for it up to the amount permitted by the Protocol, not only is accelerated phaseout negated, but the CFC prices may not rise to the level that may justify reclamation<sup>17</sup>.

While the excess capacity in production may have kept prices low and discouraged reclamation and banking (stockpiling)

activities for the CFCs — the situation seems to be different for the halons — it is noteworthy that the price differentials between CFCs and their substitutes reported in recent project submissions (reported as a composite in Annex Table A. 3) appear to be much greater than those in the developed countries (ICF et al. estimates as shown in Annex Table A.5). As the pace of conversion accelerates in the developing countries, the prices of ODS substitutes may be expected to fall, and the Fund's assistance to production sector conversions may help in this regard. Previous discussion on the nature of competition on the supply side, and on the importance of reclamation activities, suggests that all sources of supply be viewed in an integrated framework, which is currently restricted by lack of relevant price data and cost indicators.

So far, the Fund has not provided grants for production sector conversions (except for some shutdown) and has financed only demonstration projects on recycling and reclamation. Because assistance in production sector conversions and recycling and reclamation activities may both lower the economic costs of compliance and reduce the uncertainties associated with optimal timing of phaseout, greater priority ought to be given to such projects.

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<sup>1</sup>/ Although the Protocol permits concessional lending approach for the financial mechanism, it has not been used thus far. Especially for those end-use sectors where technology assessments and market research suggest that ODS substitution project may be economical from the firm's perspective - i.e., the so-called "net savings" projects where the operating savings more than outweigh initial gross capital expenditures - concessional lending, loan guarantees or equipment leasing may be more appropriate than grants. In principle, market-based instruments can also be devised for concessional lending, though they are not addressed in this paper.

<sup>2</sup>/ Vincent (1996) discusses many such funds and associated issues.

<sup>3</sup>/ Protocol Article 2, paragraph 5 for production for London Amendment signatories and for consumption (i.e., production and net imports) for Copenhagen Amendment signatories. Governments, for example in the US and the European Union, have in turn allocated their allowable national consumption to domestic firms and permitted inter-firm trades. The Protocol mentions "transfer" rather than "trade" (and so do the US and European Union legislation as well), probably because the Parties as such may not claim an ownership interest in ODS. Governments thus recognize the inter-firm "trade" by the means of an inter-Party "transfer".

<sup>4</sup>/ For the US, see 40 CFR (*Code of Federal Regulations*) § 82.12 and a detailed discussion in the *Federal Register*, 60:90, 10 May 1995, p. 24970-25009. Also, see Lee (1996). With the introduction of "destruction credits" for CFCs



whose ODP value can be applied to expand a firm's allowance for HCFCs, the US has in effect expanded the scope of inter-substance exchange. For the European Union, see European Communities (1994).

5/ Protocol Article 2. The Protocol language is unclear whether the "basic domestic needs" criterion applies to one developing country at a time, or to *all* developing countries as a group. Inasmuch as inter-Party transfers of *consumption* (which include imports) are permitted for the developing countries, the latter interpretation would appear to hold valid at least for the Copenhagen Amendment signatories among them.

6/ See Hahn and May (1994) and US GAO (1994) for analyses of factors limiting SO<sub>2</sub> trading; the latter's critique of SO<sub>2</sub> allowance auction by the US Environmental Protection Agency is also illuminating for comparable situations. Also see Hays (1995) for a critique of the US SO<sub>2</sub> allowance trading program.

7/ In addition, the Parties have yet to determine developing countries' control schedules for CFC substitutes which also have ozone depleting potential and whose use will grow over time. Unless the limits were set in aggregate ODP-equivalent terms, national quantitative restrictions for each substance individually may create unnecessary disruption in industrial activity and distort firms' current choice of substitute technology.

8/ For imports-only countries, such schemes may be relatively easy to implement, as has been the case in Singapore and New Zealand, non-Article 5 countries. See Chapter 4 in UNEP (1995a) and SEI (1995). For a review of auction theory and application to replacing import quotas, see Takacs (1994). Countries which both produce and import may find it significantly harder. (Mexico also planned to have tradeable production and import permits, but implementation appears to have stalled.)

9/ Kerr (1995) argues for a transition from an international funding mechanism such as the MFIMP toward an inter-national tradeable permit regime, if the transaction costs are not too high.

10/ See Barthold (1994) and UNEP (1995a), Chapter 4.

11/ See Annex Table A.4.2 for US list price and tax rate information, US Internal Revenue Code 26 § 4681-2 for enabling legislation, and 26 CFR Part 52 for implementing regulations. Fay (1995) reports an estimate that the US has collected more than \$6 billion in ODS taxes, and proposes that a part of the revenues be used for financing ODS phaseout in the developing countries, e.g., via the Fund. Also see Hoerner (1996.)

12/ Also, unlike the user firms, ODS phaseout (i.e., substitute production) is in the main line of business for the producing firms.

13/ The Protocol assumes that all production of virgin ODS ever will eventually result in atmospheric emissions. On the other hand, if any quantity of virgin ODS or ODS in the user stock (e.g., in the refrigeration and cooling equipment such as refrigerators, air-conditioners, and chillers) is physically or chemically destroyed (i.e., converted to substances which cannot escape in the atmosphere), a corresponding credit (in ODP terms) is granted to the country so that an ODP-equivalent virgin ODS is permitted to be produced, in exemption of the overall prohibition. The US has incorporated this provision in its national regulations.

14/ Under certain scenarios, one may well expect a sharp increase in ODS trade among the developing countries, if imports from the developed countries become more expensive due to the plant closures in the latter.

15/ See Chapter 7 in UNEP (1995a) for an elaboration. Indeed, certain level of demands in the developing or developed countries can be met indefinitely by reclaimed ODS.

16/ Incentive size and structure, and the choice between retrofit and replacement of cooling equipment, depend on the end uses. The distribution of existing ODS stock in the cooling equipment of developing countries may be markedly different from that in the developed countries - for instance, a greater share in domestic refrigeration and air-conditioning equipment, which tends to have smaller leakage rates than in, say, commercial freezers and chillers or vehicular cooling systems.

17/ This problem was pointed out by the TEAP 1991 assessment: "If producers increase their demand for recycled materials in response to rising prices for newly produced ODS materials.. then markets for recycled materi-

als will be stimulated.. However, the recycling market can be weakened by uncertainty about future costs and availability of substitutes and by inadequate policy pressures on the prices of ODS chemicals." (UNEP, 1991, summary para S.21).



# 6 Conclusions and Recommendations

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The years 1995-97 mark a significant stage in the evolving history of the Protocol, as the developed countries' ban on the production and imports of Protocol Annex A ODS has become effective and as the developing countries' baseline levels of production and imports come to be established. How these developments affect the global distribution of ODS and substitute supplies and prices remains to be seen, but it is clear that the focus of ODS phaseout will shift to the developing countries.

In the context of the Fund's grant-financing of conversion of ODS use to substitutes, we have argued that its current procedures have a potential to distort firms' choice of optimal timing and technology, that administrative "need assessment" is inherently constrained in its ability to determine firm-level incremental costs, and that the project-by-project approach does not permit the Fund to make an efficient use of its resources and involves high administrative costs. While these procedures were necessary in the initial phase of the Fund's operations and have yielded invaluable information and understanding, a transition to alternative, market-based approaches is warranted, at least in the case of large developing countries.

We have provided a conceptual argument for an alternative scheme that permits self-selection and competition among firms, and argued that competitive bid auctions for the Fund's grants provide incentives to the firms to minimize their incremental costs and permits the Fund to acquire cheaper phaseout first. It appears to us that such auctions are also administratively simpler and less costly, and may also have greater political acceptability,

than the current approach as well as other types of market-based instruments. We recommend that the MFEC consider bid auctions as an acceptable means of grant transfers for those countries which wish to use them. A pilot scheme may be a simple way to begin, wherein the MFEC commits a fixed maximum sum of money over a particular period for a fixed minimum quantity of phaseout to be obtained via a national auction program for a certain group of end-use sectors. The developing country, in turn, forbids any firm-level project proposal in those sectors to be directly submitted to the MFEC (as is the current procedure) during that period. If the concept is agreed to by a developing country and the MFEC, additional country-level market research would be necessary in order to prepare a detailed auction program proposal<sup>1</sup>.

In addition, we have pointed to the need for developing countries to establish firm-level limits (via permits) on ODS use, production and trade, both in order to monitor compliance with the Protocol and to protect the phaseout achieved from being negated by subsequent growth. The development and implementation of these firm-level controls would also help analyze the relative usefulness of other market-based instruments — a tradeable permits regime and/or pricing policies — that were briefly commented on in this paper. If carefully designed and implemented, these other MBIs hold considerable potential for achieving an orderly compliance with the Protocol, at lower economic costs; promoting optimal levels of ODS reclamation; and, supplementing the Fund's resources. We recommend that the Fund provide incentives to governments to engage in these efforts, perhaps as a

part of a broader policy dialogue between the Fund and the developing country governments via the Implementing Agencies.

Further investigations are warranted on the following topics: (i) global availability and price prospects for virgin Protocol Annex A ODS and their substitutes; (ii) design and implementation alternatives for national and inter-national tradeable permits and pricing regimes for virgin ODS and their substitutes;

(iii) the potential for recovery, recycling, and reclamation activities worldwide to avoid longer-term supply constraints of ODS (for servicing enduse equipment) and to reduce their atmospheric emissions; and (iv) the potential for accelerated conversions in the "production sector".

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<sup>1/</sup> Since the initial draft of this paper, the MFEC has approved an auction plan for Chile (19th Meeting, May 1996)

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## Annex

### Supplemental Tables

- A.1 Fund Budgetary Programming and CETVs
- A.2 Fund Grants for Approved World Bank Investment Sub-projects
- A.3 Approved Costs of Domestic Refrigeration Projects, 13th + 15th + 17th MFEC Meetings
- A.4 US List Prices and Taxes for CFC-11 and CFC-12
- A.5 Comparison of Domestic Refrigeration Materials Prices
- A.6 Prospects for CFC Availability

TABLE A.1: FUND BUDGETARY PROGRAMMING AND CETVs				
Secton	MFEC (8/93) BUDGETARY REQUIREMENTS & TARGETS		MFEC (3/95) COST-EFFECTIVENESS THRESHOLD VALUES (CETVs)	
	Avg. \$/k	Target 1995 ODP (tons)	Max. \$/kg 1995	Available 1995 ODP (tons)
Production				
RAC (Refrigeration/air-conditioning)		2,047		3,705
Domestic	\$34.80		\$13.76	3,470
Commercial	\$6.50		\$15.21	235
Chillers	\$18.89		NA	
MAC (Mobile a/c)	\$11.76		NA	
Halons Substitution Banking	\$4.35 — -	2,478	\$1.48 \$13.91	1,200 NA
Aerosols	\$1.67	3,835	\$4.40	3,913
Foams		5,268		4,992
Unclassified	--		\$9.53	2,590
Flexible pu	\$7.03		\$6.23	424
Rigid	\$5.69		\$7.83	1,372
Integral skin	NA		\$16.86	21
Poly-styrene/urethane	\$8.00		\$8.22	585
Solvents	\$12.00	1,242	NA	153
CFC-113			\$19.73	153
TCA			\$38.50	0
Notes:				
1/ Figures in US\$ of different years.				
2. For comparison of average grants for all projects (including those by other implementing agencies) and across sectors and country groupings, see COWiconsult (1995).				

TABLE A.2: FUND GRANTS FOR APPROVED WORLD BANK INVESTMENT SUB-PROJECTS

SECTOR	NO. OF PROJECTS	TOTAL GRANTS (US\$M) <sup>1/</sup>	TOTAL ODP PHASEOUT <sup>2/</sup> (TONS)	FUND GRANT (US\$/KG)	
				WT. AVERAGE	RANGE
Production					
RAC (Refrigeration/air-conditioning):					
(total)	54	\$70.7	7,105	\$10.0	Not meaningful
Domestic	26	\$32.2	3,338	\$9.6	\$0.8-\$74.4
Commercial	11	\$18.4	1,545	\$11.9	\$6.9-\$33.3
Chillers	1	\$1.1	14	\$78.6	N.A.
MAC (mobile a/c)	8	\$13.3	1,183	\$11.2	\$1.7-47.5
Other	8	\$5.7	1,025	\$5.6	\$3.8-\$16.3
Halon	5	\$3.7	1,655	\$2.3	\$1.8-\$3.2
Aerosol	10	\$9.2	17,711	\$0.5	\$0.3-\$5.0
Foams:	57	\$26.1	6,361	\$4.1	Not meaningful
(total)	24	\$6.8	1,467	\$4.6	\$0.6-\$17.2
Flexible	16	\$10.2	2,172	\$4.7	\$1.3-\$385.0
Rigid	17	\$9.2	2,722	\$3.4	\$0.1-19.6
Other					
Solvent	15	\$8.7	764	\$11.4	\$1.9-\$142.0
Recovery/recycling	-	-	-	-	-
Total (incl. 3 unclassified)	143	\$125.2	34,396	\$3.64	Not meaningful
Total, excluding China	109	\$84.2	12,546	\$6.71	

Source: The World Bank Portfolio of Montreal Protocol Investment Projects, March 1995.

Notes:

1/ In mixed-year, as-committed US\$.

2/ As approved by the MFEC.

TABLE A.3: APPROVED GRANTS FOR DOMESTIC REFRIGERATION PROJECTS 13TH+15TH+17TH MFEC MEETINGS							
Country	Company	ODP abated (t)	Capital grant	Incremental operating cost, Year 1	Composite price differential	Average grant	"Unit Abatement Cost" (assumptions below)
<b>"Representative" projects:</b>							
Indonesia	Topjaya	91	\$14.1	\$2.8	\$12.4	\$14.2	\$5.1
Colombia	Corelsa	22	\$19.7	\$21.0	\$10.8	\$30.2	\$24.2
Colombia	ICASA	72	\$9.8	\$10.7	\$10.8	\$15.2	\$12.3
Colombia	HACEB	69	\$4.2	\$17.5	\$10.8	\$12.9	\$18.2
Colombia	POLARIX	63	\$8.0	\$20.1	\$10.8	\$18.1	\$21.4
Peru	Selva	35	\$7.3	\$9.1	\$8.9	\$11.8	\$10.3
Peru	Coldex	67	\$7.1	\$8.1	\$8.9	\$11.1	\$9.2
India	BPL	165	\$17.5	\$5.8	\$6.5	\$20.9	\$8.7
Jordan	HAMCO	47	\$15.3	\$2.3	\$4.9	\$16.5	\$4.8
Syria	Penguin	82	\$17.1	\$7.6	\$4.8	\$20.9	\$10.4
Syria	El-Hafez	107	\$22.5	\$8.9	\$1.2	\$26.9	\$12.5
Cameroon	FAEM	62	\$28.8	\$5.0	\$1.2	\$31.3	\$9.7
Sum/simple average		882	\$14.3	\$9.9	\$7.7	\$19.2	\$12.2
standard deviation			\$7.0	\$6.1	\$3.7	\$6.7	\$5.8
<b>Not included:</b>							
Combined with compressor:							
Mexico	Mabe (all 3)	427.0	\$6.1	\$7.4	\$6.8	\$9.8	\$8.4
Mexico	Vitro (all 3)	456.0	\$3.5	\$7.9	\$5.4	\$7.5	\$8.5
With foreign ownership							
Indonesia	NABEL	110	\$13.0	\$4.0	\$0.0	\$14.2	\$6.1
Turkey	PEKEL	160	\$3.8	\$1.3	\$0.0	\$4.6	\$1.9
Indonesia	Sharp Yasonta	173	\$9.7	\$4.7	\$0.0	\$12.0	\$6.3
Malaysia	Oyl	22.0	\$26.6	\$3.7	NA	\$28.4	\$8.0
No material price data							
Egypt	Delta	97	\$18.3	\$17.3		\$26.9	\$20.2
Egypt	Electrostar	46	\$29.1	\$5.2		\$31.7	\$9.9
Egypt	Kiriazzi	137	\$8.7	\$6.6		\$12.0	\$8.0

**TABLE A.3: APPROVED GRANTS FOR DOMESTIC REFRIGERATION  
PROJECTS13TH+15TH+17TH MFEC MEETINGS**

Country	Company	ODP abated (t)	Capital grant	Incremental operating cost, Year 1	Composite price differential	Averag grant	"Unit Abatement Cost" (assumptions below)
Not included (continued)							
"Outliers"							
Argentina	NEBA	29	\$24.9	\$12.7	\$14.3	\$25.6	\$16.7
Argentina	Briket	30	\$24.9	\$14.2	\$14.3	\$25.7	\$18.3
Argentina	Piragua	61	\$20.2	\$11.5	\$14.3	\$20.8	\$14.8
Argentina	McLean	74	\$15.1	\$34.9	\$13.0	\$33.0	\$37.3
Argentina	Helametal	62	\$32.9	\$27.7	\$13.0	\$47.7	\$33.1
Argentina	Fribe La Rioja	37	\$31.9	\$32.8	\$11.8	\$49.3	\$38.0
Argentina	Fribe La Rioja	26	\$40.9	\$30.2	\$11.8	\$57.2	\$36.9
Argentina	Autosal	22	\$42.9	\$4.2	\$8.9	\$44.2	\$11.2
Argentina	Aurora	53	\$36.0	\$3.0	\$8.9	\$37.0	\$8.9
Peru	Andina	5	\$39.6	\$9.2	\$8.9	\$44.2	\$15.6
Jordan	NRC	14	\$53.0	\$7.8	\$4.9	\$56.9	\$16.5
Jordan	MEEI	17	\$48.3	\$9.7	\$4.9	\$53.2	\$17.6
Syria	Barada	109	\$6.9	\$4.4	\$2.9	\$9.1	\$5.5
Peru	Lenche	6	\$29.5	\$11.7	\$8.9	\$35.3	\$16.5
Peru	Alfa	7	\$32.6	\$9.0	\$8.9	\$37.2	\$14.4

Source: Authors' calculations based on subproject documents.

Notes:

1. Each project is to use HFC-134a as the CFC-12 substitute for refrigerant; substitutes for foaming agent CFC-11 vary (HCFC-141b or hydrocarbons).
2. "Composite price difference" refers to controlled ODS and the substitute for refrigerant as well as foaming agent use.
3. Average grant and Unit Abatement Cost (UAC) calculated before implementing agency costs.
4. UAC calculated for 10 years project life and 10% discount rate, assuming no change in IOC over time.

TABLE A.4: US LIST PRICES AND TAXES FOR CFC-11 AND CFC-12 (\$/KG)				
YEAR	CFC-11 LIST PRICE	CFC-12 LIST PRICE	CFC-11/12 TAX RATE	
			EXCISE	FLOOR
1988	\$1.75	\$2.29	0	0
1989	2.29	2.75	0	0
1990	2.41	2.89	\$3.01	\$3.01
1991	2.35	2.62	3.01	0.00
1992	2.90	4.16	3.67	0.66
1993	3.75	5.63	7.37	3.70
1994	N.A.	N.A.	9.57	2.20
1995	N.A.	N.A.	11.77	2.20
1996			12.76	N.A.

Sources: List prices obtained from Professor Stephen DeCanio (personal communication, July 1995), in turn based on monthly data from *Chemical Marketing Reporter*. Retail prices are reported to be considerably higher than wholesale list prices. Tax rates from Chapter 7 of UNEP (1995a) and US *Internal Revenue Code*, 20 USC 4681.

TABLE A.5: COMPARISON OF DOMESTIC REFRIGERATION MATERIALS PRICES (\$/KG)				
Source/date/place	CFC-12	HFC-134a	CFC-11	HCFC-141b
ICF, et al. (1994) - Generic	\$2.50	\$7.35	\$2.15	\$4.63
World Bank internal data, August 1995 - Brazil	\$4.32	\$13.17	\$3.53	\$4.78

TABLE A.6 - PROSPECTS FOR CFC AVAILABILITY			
<b>A. Virgin CFC potentially available to developing countries</b>			
Potential production (thousand tons)	Annual	Cumulative (1995-2010)	
Developing countries - 1993 rate	78.3	896.7	
Developing countries - maximum capacity	149.4	1,755.3	
Developed countries - allowed production	151.8	2,277.2	
<b>B. Estimated refrigerant stock and production worldwide, 1994 (thousand tons)</b>			
Substance	End-use	Stock in use	Production
CFC-11	Chillers	61	25
CFC-12	MAC (Mobile a/c)	250	155
	Domestic refrigeration	150	
	Commercial refrigeration	31	
	total	431	
Sources: For (A), UNEP/OzL.Pro/ExCom/15/43 (Limited distribution) Draft. Capacity may be used for CFC-11 or CFC-12 (and other CFCs). Also see Greenpeace (1995). For (B), Chapter 7 in UNEP (1995a). Developing countries' production rate may be constrained by the baseline consumption levels of 1995 to 1997 except to the extent of exports to other developing countries.			





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