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The Montreal Protocol and the Green Economy

Assessing the contributions and co-benefits of a Multilateral Environmental Agreement

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GREEN economy

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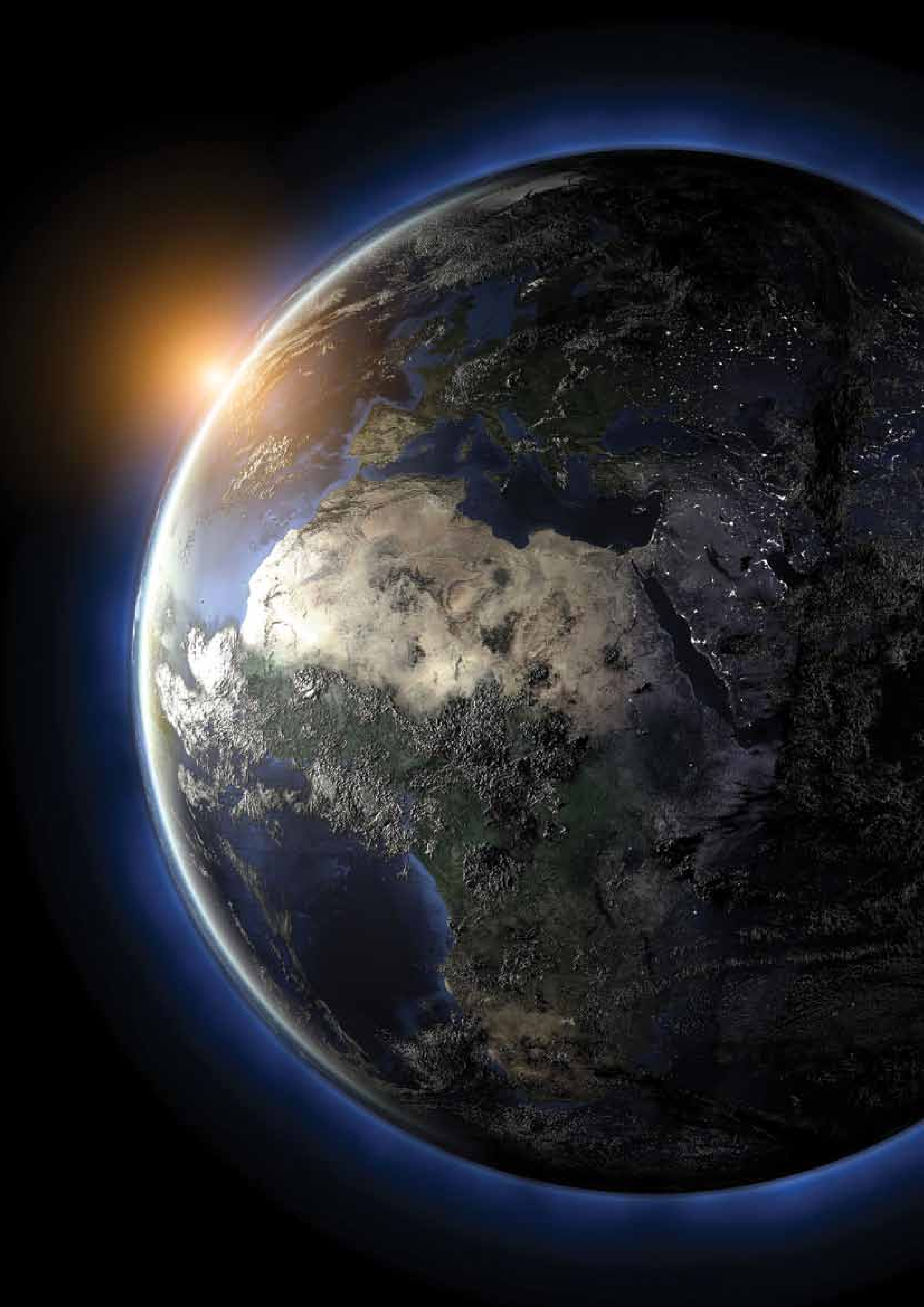

Contents

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The study was authored by:
Anil Markandya
Chair of Economics, University of Bath; Scientific Director, Basque Centre for Climate Change (bc3); President, European Association of Environmental and Resource Economists.
Nick Dale
Environmental Policy Specialist, Metroeconomica.

The study was peer reviewed by:
Stephen O. Andersen
Montreal Protocol expert/former negotiator, Deputy Director of United States Environmental Protection Agency (EPA) Stratospheric Ozone Protection Division, founding and current co-chair of the Montreal Protocol Technology and Economic Assessment Panel (TEAP).
Stephen DeCanio
Professor of Economics, Emeritus, University of California, USA
Shiqiu Zhang
Professor and Deputy Dean of the College of Environmental Sciences and Engineering, Director of the Institute of Environment and Economy (IoEE) at Peking University, Senior Expert member of the TEAP.

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Mars Amanaliev
Head of the Ozone Center of Kyrgyzstan (NOU).
Stephen O. Andersen.
Lucia Antonini
European Commission, DG Climate Action, Unit C2 - Transport and Ozone.
G. Victor Buxton, Montreal Protocol expert/former negotiator, founding TEAP Co-Chair.
Marc Chasserot
Managing Director, Shecco.
Philippe Chemouny
Manager, Montreal Protocol Program, International Affairs Branch, Environment Canada.
Julia Anne Dearing
Information Management Officer, Multilateral Fund Secretariat
Derek Eaton
UNEP Economics and Trade Branch.
Kevin Fay
President, Alcalde & Fay; Executive Director, International Climate Change Partnership.
Jiří Hlaváček
Deputy Director General for International Relations and Director of the Department of Environmental Policy and Multilateral Relations, Ministry of the Environment of the Czech Republic.
Marin Kocov
Ministry of Environment and Physical Planning, Former Yugoslav Republic of Macedonia.
Tom Land
Manager of International Programs, Stratospheric Protection Division, United States Environmental Protection Agency.
Ralph Luken
Montreal Protocol expert, formerly with UNIDO Montreal Protocol Branch.
Maria Nolan
Chief Officer, Multilateral Fund Secretariat.
Roberto Peixoto
Professor at Instituto Mauá de Tecnologia in São Paulo, Co-Chair of the TEAP Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee (RTOC).
Cornelius Rhein
European Commission, DG Climate Action, Unit C2 - Transport and Ozone.
Agustin Sanchez
Montreal Protocol focal point/ negotiator.
Rajendra Shende
Former Head of UNEP DTIE OzonAction Branch.
Tom Werkema
Vice-President, Regulatory Activities, Arkema Inc., USA; Vice President, ASHRAE.
Shiqiu Zhang.

The UNEP team that managed the project:
James S. Curlin
Interim Head, OzonAction Branch
Benjamin Simmons
Head, Trade, Policy and Planning Unit, Economics and Trade Branch.
Ezra Clark
Programme Officer, OzonAction Branch.
Mugure Kibe
Documentation Assistant, OzonAction Branch
Jo Chona
Networking Assistant, OzonAction Branch

Art direction & Design:
Sue Cowell
Atomo design

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ABBREVIATIONS

Article 5 (1)	Developing country Parties to the Montreal Protocol whose annual per capita consumption and production of ODS is less than 0.3 kg. These Parties are referred to in paragraph 1 of Article 5 of the Montreal Protocol.
CBA	Cost Benefit Analysis
CEIT	Countries with Economies in Transition
CFC	Chlorofluorocarbon
CO_2	Carbon Dioxide
CTC	Carbon tetrachloride
EEAP	Environmental Effects Assessment Panel
EU	European Union
F-gases	Fluorinated gases (CFCs, HCFCs, HFCs, PFCs, SF6, etc.)
GDP	Gross Domestic Product
GEF	Global Environment Facility
GEI	Green Economy Initiative
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GWP	Global warming potential
HCFC	Hydrochlorofluorocarbon
HFA	Hydrofluoroalkane
HFC	Hydrofluorocarbon
HPMP	HCFC Phase-out Management Plan
ICOLP	Industry Cooperative for Ozone Layer Protection
IPM	Integrated pest management
kW	Kilowatt
MB	Methyl Bromide
MCF	Methyl Chloroform
MDGs	Millennium Development Goals
MDI	Metered Dose Inhaler
MEA	Multilateral Environmental Agreement
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
NOUs	National Ozone Units
NPP	National Phase-out Plan
ODP	Ozone Depletion Potential
ODS	Ozone Depleting Substance(s)
OECD	Organisation for Economic Co-operation and Development
POP	Persistant Organic Pollutant
R&D	Research and Development
RMP	Refrigeration Management Plan
SAP	Scientific Assessment Panel
SME	Small and Medium Scale Enterprise
TEAP	Technology and Economic Assessment Panel
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nation Industrial Development Organisation
US EPA	United States Environmental Protection Agency
WB	World Bank
WCO	World Customs Organization
WMO	World Meteorological Organization
UV	Ultraviolet

The Montreal Protocol and the Green Economy

Assessing the contributions and co-benefits of a Multilateral Environmental Agreement

Executive Summary

The Montreal Protocol on Substances that Deplete the Ozone Layer was agreed in September 1987 as an international response to the significant threats to the environment and human health posed by continued use of ozone depleting substances (ODS) in the global economy. The treaty protects the ozone layer by establishing controls for the consumption and production of these chemicals, used in a great many industrial, commercial and consumer applications across a range of economic sectors. The agreement included a 50 per cent phase down of CFCs and a freeze on halons, only for developed countries. Subsequent Amendments and Adjustments added new chemicals to the control schedule, a timetabled phase-out, and extended the controls to developing (Article 5) Parties (typically with a "grace period" allowing later phase-out in developing than in developed countries).

The Montreal Protocol has been ratified by 197 countries and is the only such treaty to have achieved universal ratification by all UN Member States. In 1991 the Multilateral Fund for the Implementation of the Montreal Protocol (MLF) was established as a dedicated financial mechanism to assist developing countries to comply with the agreed control measures.

The Montreal Protocol is widely heralded as a success story both in terms of achieving its direct aims in ODS phase-out targets and the resultant curbs in ozone depletion, and consequent environmental and health benefits. The successful meeting of phase-out targets has meant that since the adoption of the treaty there has been an aggregate fall in consumption and production of ODS up to 2010 of about 98 per cent from baseline levels. Developed countries (non- Article 5) achieved over 99 per cent phase-out from baseline ODS consumption by 2005 while the corresponding figure for developing countries (Article 5) was about 80 per cent phase-out for all ODS with consumption baselines. Annual global production of controlled ODS reduced from over 1.8 million tonnes in 1987 to 83,000 tonnes in 2005. The consequence has been a measurable reduction in key ODSs in the troposphere (WMO, 2010), with projections that continued implementation of the Protocol's provisions will result in the ozone layer returning to 1980 levels by between 2060 and 2075.

In addition to the direct benefits of achieving the phase-out of ODS the Montreal Protocol has created enabling conditions that have stimulated a transition to a Green Economy. UNEP defines such an economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011a). This definition combines economic goals of income growth with social goals of poverty reduction and employment creation as well as environmental goals including reducing greenhouse gas emissions and pollution, and preserving biodiversity and ecosystems services. This concept challenges the notions that: (i) there is an inevitable trade off between environmental sustainability and economic progress and (ii) a green economy would restrain growth and perpetuate poverty in the developing world.

The contributions of the Montreal Protocol to the Green Economy are evaluated first in terms of economic impacts of ODS phase-out at the sector level and at the macro-economic level. The report then considers social and environmental co-benefits and the important contribution of the institutional arrangements of the Montreal Protocol. Under the economic impact heading the first point to note is that instead of imposing a cost to the economies of the countries that participated, the Protocol ended up actually strengthening them and moving them closer to the ideals of a Green Economy described above. From a number of studies we find that:

a) While significant investments were made in measures to protect the ozone layer, this investment resulted in technological advances and design innovations that reduced costs, produced cleaner and more reliable products and created a better working environment.

b) For some developing countries the transfer of know-how and technology (a crucial part of the Protocol) meant they could compete better in international markets and thus it helped expand production on a significant scale, especially in emerging economies such as China. The new technologies were not only better for the environment, but they were more energy efficient and safer in the workplace.

c) The new products did not often result in higher prices for consumers; in fact the prices of some of them declined as the new technologies were more efficient and some of the gains in efficiency were passed on through lower prices.

d) The phase-out contributed to maintaining Gross Domestic Product growth, including by avoiding loss in agricultural and fishery yields and by avoiding human health impacts of ozone depletion. There is no doubt that it contributed to a cleaner GDP.

In **social** terms, the transition to non-ODS technologies, products and services did not on balance result in a loss of jobs; rather it resulted in a shift to jobs with a higher level of training and ones that were carried out in a better workplace. There was some phase-out of small and medium-scale enterprises (SMEs), but this was largely compensated by the creation of posts in larger consolidated units.

The ODS replacement process has also had important implications for ensuring the health and safety of workers when operating new equipment and handling alternative chemicals. Safety at work has been addressed in the requirements of MLF projects which include a strong element of training for plant technicians and operators. Other health and safety improvements for workers have resulted from the phase-out of methyl bromide use in agriculture and carbon tetrachloride use as a solvent, both of which are highly toxic.

In terms of health the Protocol is estimated to have generated major benefits. Reductions in cancers and cataracts have been valued at more than 11 times the direct investment costs of phasing out the ODS.

Its contribution to poverty alleviation is indirect but nevertheless important. In particular we note:

a) Employment created by conversion to non-ODS alternatives has often involved training workers in new technologies. This has enhanced the skills base of the participating countries;

b) The significant levels of mortality and morbidity avoided under the Montreal Protocol may benefit some vulnerable groups more than others groups. For example, the cases of melanoma and non-melanoma cancers avoided are likely to particularly benefit vulnerable populations in areas with high agricultural and outdoor worker populations in regions of high surface ultraviolet (UV) radiation levels.

c) The significant valuations for avoided damage to materials from increased UV radiation due to ODS phase-out will benefit a number of sectors including construction and agriculture. These sectors tend to provide livelihoods for poorer sections of society.

The **environmental** contribution of the Protocol is also significant. As well as the key ozone protection achievements mentioned earlier, an important environmental co-benefit is the reduction in Greenhouse Gas (GHG) emissions that the phase-out of ODS represents. It has been estimated that in the twenty years up to 2010, the phase-out of production and consumption of ODS has reduced GHG emissions by a net 135 billion tonnes of CO_2 equivalent or about 11 billion tonnes CO_2 equivalent per year, and this excludes the reductions in GHGs arising from the increased energy efficiency associated with the conversion to non-ODS technologies. The figure of 135 billion tonnes is about five times more than the Kyoto Protocol annual emissions reduction target for the period 2008–2012, and has a total value of around US$3.2 trillion if we value a tonne of CO_2 at US$ 24/tonne CO_2. It should be noted, however, that some CO_2 emissions still arise from the HCFCs permitted under the Protocol and continuing actions for phasing out. HCFCs and addressing HFCs therefore remain an important element in reductions in GHGs.

Other environmental benefits arise from addressing the reduction in terrestrial plant productivity and damages to some aquatic organisms and livestock associated with ozone depletion. This is estimated to have a significant economic benefit for agricultural and fisheries sectors. There is also a considerable environmental benefit in terms of the reduced toxicity from the phase-out of methyl bromide as a pesticide and a shift to more benign methods of pest control.

Finally we note the importance of the institutions and mechanisms of the Montreal Protocol in underpinning the economic, social and environmental contributions. In the study we focus particularly on how arrangements for transfer of clean technology and capacity building at national level and plant level have contributed to the success of ODS phase-out programmes and to raising environmental standards and awareness in developing countries. The approach to and design of institutional arrangements can provide useful lessons in implementing global environmental agreements for the promotion of Green Economies.

The Montreal Protocol offers an excellent example of how international cooperation in solving a major environmental problem can have significant co-benefits that promote green growth. Yet the story is not over; the Protocol has more to contribute to climate mitigation through the phase-out of HCFCs, through addressing the disposal of banks of ODS, and through the development and commercialisation of low and zero GWP energy efficient technologies in areas such as air conditioning, refrigeration and foam.

01 Introduction

The production of this report marks the 25th anniversary of the signing of the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987, nearly 23 years since establishing the Scientific, Environmental Effects, and Technology and Economics Assessment Panels and 20 years since the formation of the Multilateral Fund for the Implementation of the Montreal Protocol. With the recent publication of the UNEP's "Towards a Green Economy" Report as part of the Green Economy Initiative (GEI) the time is right to look at the experience gained in implementing the Montreal Protocol in this context. As well as achieving its direct initial aim to phase out ozone depleting substances (ODS), the Montreal Protocol can be seen as a significant example of how a Multilateral Environmental Agreement (MEA) can provide enabling conditions to stimulate green economies. This study looks at the Protocol's impact on the greening of national economies and the global economy by assessing the nature and extent of its green economy contributions, and its social and environmental co-benefits.

The overall aim of this study is to review the quantitative and qualitative evidence for these contributions to a Green Economy, as well as gain insights from a range of expert consultations on the subject, and to present an overview of our understanding of these contributions. Along the way a large number of documents addressing a broad range of relevant economic impacts have been consulted and the challenge has been to present the key messages gained in a concise and coherent format. The result is a report that we hope makes a useful contribution to the Green Economy debate at a policy maker level as well as to a wider readership and draws out key findings that inform the implementation of other multilateral environmental agreements.

We start with a brief discussion of the meaning of Green Economy and some background on the history and achievements of the Montreal Protocol. This provides the context to the outline of the report aims and structure.

DEFINITION OF GREEN ECONOMY

The UNEP "Towards a Green Economy" Report defines a green economy as "one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities" (UNEP, 2011a). This definition combines economic goals of income growth with social goals of poverty reduction and employment creation as well as environmental goals including reducing carbon emissions and pollution, and preserving biodiversity and ecosystems services. Moreover, it understands these economic, social and environmental goals as interlinked and mutually supporting whereby a low carbon, resource efficient economy will rebuild natural capital, promote environmental sustainability and support social inclusion. This concept therefore challenges the notions that: (i) there is an inevitable trade off between environmental sustainability and economic progress and (ii) a green economy would restrain growth and perpetuate poverty in the developing world.

In the wider context a green economy can be seen as an engine for achieving sustainable development and supporting progress towards the Millennium Development Goals (MDGs). The MDGs are derived from the agreement by world leaders at the United Nations Millennium Summit in September 2000 for a set of time-bound and measurable goals and targets for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women.

The UN Green Economy Initiative sees the transition to a green economy as being driven by public and private investments, policy reforms and improvements in regulation.

MONTREAL PROTOCOL

History and mechanisms

The Montreal Protocol on Substances that Deplete the Ozone Layer was agreed in 1987 as an international response to the significant threats to the environment and human health posed by continued use of nearly 100 anthropogenic ozone depleting substances (ODS) in the global economy. The treaty protects the ozone layer by establishing phase-out schedules for the consumption and production of these chemicals which are used in a great many industrial, commercial and consumer applications across a range of economic sectors (Andersen & Sarma, 2002). It has been ratified by 197 countries and is the only such treaty to have achieved universal ratification by all UN States. In 1991 the Multilateral Fund for the Implementation of the Montreal Protocol (MLF) was established as a dedicated financial mechanism to assist developing countries to comply with the agreed control measures (see Box 1). The Multilateral Fund has been instrumental in convincing governments in the developing world to sign up to the Montreal Protocol and has played an important role in ensuring compliance with Protocol commitments. Furthermore, since 1991 the Global Environment Fund (GEF) has aided ODS phase-out activities in countries with economies in transition (CEITs), which are not eligible for funding under the MLF, to implement ODS phase-out activities to meet obligations under the Montreal Protocol (UNIDO, 2011).

The key commitment by the governments that have signed or acceded to the treaty (the "Parties") is to achieve the phase-out of the different ODS within given timeframes. The policy responses for achieving these commitments were enacted both at international level (including the crucial step of setting up the Multilateral Fund and trade measures such as harmonizing international customs codes for ODS), regional level in the case of the EU regulations and several regional economic groupings in developing countries, and most significantly through individual governments transposing those commitments into national laws and policies.

Since the Protocol does not stipulate specific policy measures that each country should implement to achieve the agreed ODS phase-out, the detail of policy responses vary by country and an overview of the range of policy measures used is given in Table 1. These included supply side measures (such as through regulation and prohibition of ODS use) and demand side management (for example, taxes and levies) as well as measures to raise awareness about the ozone issue and encourage good practices (such as recovery and recycling). Moreover, both supply and demand side measures encouraged demand for alternatives to ODS. In the case of the US, for example, the Clean Air Act was amended to provide a framework for implementing the Montreal Protocol. This provided mechanisms that included taxes on many ODS, labelling of ODS-containing products and supporting the identification of alternatives through the Significant New Alternatives Policy program. In the case of the EU, the implementation of the Montreal Protocol was based on a two -tier system with overarching EU Regulation complemented by national policies and measures (Oberthur *et al.* 2000; Andersen & Sarma, 2002).

BOX 1 MULTILATERAL FUND OF THE PARTIES OF THE MONTREAL PROTOCOL

The Multilateral Fund for the Implementation of the Montreal Protocol was established in 1991 to assist developing countries meet their Montreal Protocol commitments. It is managed by an Executive Committee with equal membership from developed and developing countries. The Fund Secretariat in Montreal assists the Committee in this task. Since 1991, the Fund has approved activities including industrial conversion, technical assistance, training and capacity building worth over US $2.8 billion, supporting over 6,500* projects and activities in 145 countries.

The Multilateral Fund was established by a decision of the Second Meeting of the Parties to the Montreal Protocol (London, June 1990) and began its operation in 1991. The main objective of the Multilateral Fund is to assist developing country Parties to the Montreal Protocol whose annual per capita consumption and production of ozone depleting substances (ODS) is less than 0.3 kg to comply with the control measures of the Protocol. Currently, 148 of the 197 Parties to the Montreal Protocol meet these criteria. They are referred to as Article 5 countries.

Contributions to the Multilateral Fund from the industrialized countries (or non-Article 5 countries) are assessed according to the UN scale of assessment. As at November 2011 the contributions made to the Multilateral Fund by some 45 countries (including Countries with Economies in Transition or CEIT countries) totalled over US$ 2.9 billion.

Projects and activities supported by the Fund are implemented by four international implementing agencies (UNEP, UNDP, UNIDO and The World Bank) and by bilateral agencies. To facilitate the phase-out by Article 5 countries, the Executive Committee has approved 143 country programmes, and has funded the establishment and the operating costs of ozone offices in 143 countries.

Source Multilateral Fund for the Implementation of the Montreal Protocol
** Excluding closed and transferred projects*

Table 1 Overview of Types of Policy Responses to the Montreal Protocol

	TYPES OF POLICY	EXAMPLE	IMPLEMENTING PARTY/ LEVEL
Voluntary agreements	Agreements with business on phase-out and recovery	Voluntary agreements with aerosol and foam industry. E.g. Finland	Industry, and government
Regulation	Prohibition of use of ODS	• Prohibition of CFC emitting aerosols in cosmetic and convenience products in U.S • HCFC use bans in EU, Canada, U.S	Government, international agency
	Production and import quotas	• Import-export licensing systems, e.g. in EU for all ODS • Import quotas, e.g. HCFCs in EU	
	Sales bans for products containing ODS	Ban on products containing HCFCs in EU and US	
	Trade controls	• Mandatory reporting of HCFC trade in most non Article 5 countries and increasingly in Article 5 countries • Permits for transit to address illegal trade, e.g. HCFCs in some Eastern Europe and Central Asia countries	
	Record keeping and labelling requirements	Labelling requirements vary by country. e.g. being introduced for ODS containers in EU	
	Other ODS control measures	Mandatory emission control measures in Canada and EU	
Economic Instruments	• Taxes and levies on ODS • Tax breaks for non ODS	• Fee on use of CFCs and Halons e.g. in Denmark • Ozone depleter tax in US	Government
Other incentives/ support	Support for development of alternatives/ information	Bilateral and MLF assistance, e.g. for capacity building such as customs training and awareness raising	Industry, Government, MLF implementing agencies, NGOs

Achievements

The Montreal Protocol is widely heralded as a success story in terms of progress made to date in achieving its direct aims in ODS phase-out targets with near complete compliance by both developed and developing countries. As a result of this treaty, ozone depletion has reduced and the world has achieved significant environmental and health benefits. On top of this, the achievement of Protocol objectives has occurred without any significant 'wrong turnings' in terms of technological development and without compromising health, safety and security in production of products crucial to society (Andersen *et al.*, 2007).

The successful meeting of phase-out targets has meant that since the adoption of the treaty there has been an aggregate fall in consumption and production of ODS of about 98 per cent from baseline levels. Developed countries (non- Article 5) achieved over 99 per cent phase-out from baseline ODS consumption by 2005 while the corresponding figure for developing countries (Article 5) was about 80 per cent phase-out for all ODS with consumption baselines. Annual global production of controlled ODS reduced from over 1.8 million tonnes in 1987 to 83,000 tonnes in 2005. The consequence has been a reduction in ODS in the troposphere, with projections that continued implementation of the Protocol's provisions will result in the ozone layer returning to pre-1980

IMPROVED HUMAN WELL-BEING AND SOCIAL EQUITY, WHILE SIGNIFICANTLY REDUCING ENVIRONMENTAL RISKS AND ECOLOGICAL SCARCITIES levels by between 2050 and 2075. Studies therefore conclude that the implementation of the Montreal Protocol is resulting in considerable avoided impacts for the ozone layer and climate change with their associated and profound biological, meteorological, economic and social consequences (WMO, 2010).

Furthermore, the Protocol has demonstrated the benefits of global environmental responsibility being taken via a legally binding international multilateral environmental agreement. It has shown that real success in addressing global environmental issues can be achieved through a participatory process with cooperation between international organisations, governments, scientists, industry and civil society (UNDP, 2007)[1]. As noted in the recent Millennium Development Goals Report (UN, 2011) the Parties to the Protocol have accomplished unprecedented success in such an international environmental agreement which provides an example of what international cooperation can achieve.

Aims of Study

This study addresses the different ways and the extent to which the Montreal Protocol has contributed towards the greening of the global economy. While some reports have highlighted facets of this contribution (See for example UNEP 2010c, UNIDO, 2009 and US EPA, 2007) there are currently no overarching studies available that address the Montreal Protocol's contribution to the Green Economy in a comprehensive way in order to illuminate how MEAs can aid progress towards a Green Economy.

The approach taken is to focus first on the Green Economy contributions of ODS phase-out at the sector level and at the macro-economic level. The report then considers the social and environmental co-benefits and the important contributions of the institutional arrangements of the Montreal Protocol. Available analysis, evidence and examples are presented in each of these dimensions. The aim is to assess the nature and extent of this contribution, to point to where further evidence may be needed for a fuller understanding of the contribution and to draw lessons from the experience of the Montreal Protocol that may be applicable to a greater or lesser degree to the success of policies promoting a green economy, including under other international environmental treaties. The study also aims to demonstrate the link between the Montreal Protocol and Green Economy by providing examples where ODS phase-out activities have contributed to key sectors which are the focus of the Green Economy Initiative (GEI), such as clean industrial technology, sustainable building and construction, and sustainable agriculture.

The structure of this study is outlined in Table 2. Chapter 2 covers economic contributions at the micro level, including investment in manufacturing of non-ODS chemicals and equipment/technologies and stimulation of more efficient production processes and at the macro level, such as the impacts on consumers and trade. Chapter 3 discusses social contributions especially through public health benefits. Chapter 4 outlines environment contributions through ozone layer protection, ecosystem benefits and climate change mitigation. Institutional and financing arrangements of the Montreal Protocol that have underpinned the other contributions are covered in Chapter 5. The conclusions given in Chapter 6 summarise key findings in terms of contributions of the Montreal Protocol to key sectors of the Green Economy. It also considers lessons from the experience of the Montreal Protocol for the promotion of the Green Economy and the future contribution of the Protocol in this context.

Annex 1 gives background information on reporting requirements under the Montreal Protocol and discusses availability of data on co-benefits of the Protocol. In particular, it should be noted that the Montreal Protocol official reporting required by Parties was originally very specifically focused on achieving phase-out of ODS consumption and production and not specifically aimed at promoting a green economy or sustainable development. This means that data on the Protocol's wider economic impacts was not part of this official reporting and evaluation from the start and, while there has been a steady expansion in reporting of the wider impacts, the focus of this reporting remains quite limited.

Annex 2 presents more detail on cost benefit studies on the Montreal Protocol that are quoted in the main report. Finally, Annex 3 explains the consultation process for this study.

[1] Further discussion of the importance of state cooperation in MEAs and the example of the Montreal Protocol can be found in Barrett (2003).

Table 2 Overview of Montreal Protocol's Contribution to Green Economy

GREEN ECONOMY ISSUE	LINK TO GEI AND MDGs[2]	CONTRIBUTION BY MONTREAL PROTOCOL
Sustainable economic growth		
Competitiveness	GEI: Improved human well-being and social equity, MDG: 1B and 7	Investment in manufacturing of non ODS chemical and equipment/technologies
		Stimulation of more efficient production processes (including energy efficiency and labour productivity)
		Driving innovation: Redesign of products and equipment
		Industrial rationalisation and achieving economies of scale
		Creation or stimulation of new sectors
Macro economy		Consumer impacts
		Trade in ODS and non ODS chemical and equipment/ technologies
		Contribution to GDP
Social		
Employment	GEI: Creation of "decent employment" MDG: 1B and 3A	Contribution to employment creation and training
Health	GEI: Human well-being and social equity, MDG: 6	Reducing risks associated with UV radiation (skin, eyes, immune system)
		Public health benefits through reduced local pollution (e.g. methyl bromide)
Poverty Alleviation	GEI: Human well-being and social equity. MDG: 1A	Support for conversion to non ODS technologies in relevant sectors in developing countries. Link to health and employment impacts
Environmental		
Ozone layer protection	GEI: Reducing environmental risks MDG: 7	Direct contribution through ODS phase out
Ecosystem benefits	GEI: Reducing environmental risks MDG: 7	Reduced damage to agricultural, livestock and fisheries yields. Damage to materials (linked to economic contribution)
Climate change	GEI: Reducing environmental risks MDG: 7	Direct contribution through ODS phase-out. Indirect contribution through greater energy efficiency of replacement products/processes
Cross cutting/institutional		
Financing mechanisms	MDG: 8	Activities of MLF and GEF in technology transfer and financing of adoption of new technologies
Capacity Building	MDG: 8	Capacity building activities of MLF and GEF have catalysed the Green Economy

[2] **MDG 1:** Eradicate extreme poverty and hunger MDG 1a: Reduce by half the proportion of people living on less than a dollar a day
MDG 1b: Achieve full and productive employment and decent work for all, including women and young people
MDG 1c: Reduce by half the proportion of people who suffer from hunger
MDG 3: Promote gender equality and empower women
MDG 6: Combat HIV/AIDS, malaria and other diseases
MDG 7: Ensure environmental sustainability
MDG 8: A global partnership for development

02 Green Economy Contributions

The original size of the ODS market and its importance to the functioning of equipment across a great variety of sectors was significant at the time of negotiations for the Montreal Protocol in the late 1980s. For example, it is estimated that in the United States, where CFC consumption represented about a third of worldwide CFC use, "CFCs played a role in delivering some US$ 28 billion in goods and services and were essential to the functioning of some US$ 130 billion worth of installed equipment such as refrigeration units and air conditioners" (Cook, 1996).

Following the signing of the Protocol and the establishment of its financial mechanism, a dramatic decline in production and consumption of ODS was achieved by the Parties so that by 2004 only about 7 per cent of the baseline figures for all controlled substances remained, and this was mostly accounted for by the slower phase-out schedules in Article 5 countries (UNEP 2005). Clearly such a shift away from ODS production and use, as well as the shift to ODS with lower ODP, was achieved through profound changes in the operations of the economic sectors involved. This Chapter aims to outline the nature of these changes and to highlight how they have contributed to a Green Economy. The contributions we focus on include those at business level, such as the stimulation of more energy efficient production processes and driving innovation in more environmentally friendly technologies, and macro-economic impacts such as those on trade, consumers and GDP.

As background to the discussion in this Chapter, Table 3 gives details of the main applications of key ODS and their replacement substances.

Table 3: Overview of key ODS applications and alternatives.

APPLICATIONS	ODS[3]	ALTERNATIVES[4]	NOTE
Aerosol Products	CFC 12, 14, 114	Non-medical aerosols: hydrocarbons, dimethylether, CO_2 or nitrogen, HFC-134a Medical aerosols: HFC-134a, dry powder inhalers	Conversion more difficult for medical aerosol product, metered dose inhalers (MDIs) and the Parties have approved some authorizations for the use of CFCS
Flexible and rigid foams	CFC 11, 12, 113 (113 used as foaming agent)	First generation: HCFC 22, 141b, 142b Second generation carbon dioxide, HFCs, Hydrocarbons, CO_2	
Refrigeration and air conditioning	CFC 11, 12, 113, 114, 115	First generation: HCFC 22, 123, 124 Second generation: HFCs, hydrocarbons, ammonia, Natural refrigerants	
Solvents	CFC 113, MCF[5] CTC	First generation: HCFC 141b Second generation: Maintenance-free or dry processes, no-clean flux, aqueous and semi-aqueous systems, Hydrocarbons, Hydrofluoroethers (HFEs), Volatile flammable solvents (e.g. methyl alcohol)	Rapid pre Montreal Protocol growth in electronics applications
Sterilants	CFC-12	Many options	Sterilant gas used by hospitals and commerce
Fire Fighting	Halon 1211, 1301 and 2402 CTC methyl bromide	Halon 1211 replaced with CO_2 or dry chemical alternatives Water, CO_2, inert gases, foam, HFCs	Pre Montreal Protocol consumption of halons was rising due to increasing demand for Halon 1301 and 1211 in protection of electronic equipment Halon 2402 was only a small part of global market, mainly in Soviet Union, Asia and Eastern Europe
Pest control/soil fumigation	methyl bromide	Integrated pest management systems, Artificial substrates, Crop rotation, Phosphine, Chloropicrin, 1,3-dichloropropene, Heat, Cold, CO_2, Steam treatments Combined/Controlled atmospheres	

[3] Carbon Tetrachloride (mainly used as a feedstock for CFCs) is also listed as a controlled substance, under the Montreal Protocol.

[4] Note that the list of alternatives include hydrochlorofluorocarbons (HCFCs) that were adopted as transitional substances to replace CFCs in the refrigeration, foam, solvent, aerosol and fire fighting sectors (first generation). At the 19th Meeting of the Parties it was agreed to accelerate the phase-out of HCFCs, which are also controlled substances under the Montreal Protocol. Alternatives to HCFCs are listed as 'second generation' alternatives in the table above.

[5] Methyl Chloroform (MCF was used as a solvent in a variety of applications including vapour degassing, cold cleaning, aerosols, adhesives and electronics).

THE BENEFITS TO SOCIETY OF ODS PHASE-OUT FAR OUTWEIGH THE COSTS

INVESTMENT BROUGHT ABOUT BY ODS PHASE-OUT

In this section we review the available information on the amount of investment in ODS phase-out activities engendered by the Montreal Protocol as background to an overall assessment of the contribution to a Green Economy. The extent of these investments are outlined by source, application and region. It is important to remember that the significant levels of investment brought about by the Montreal Protocol should be seen in the context of the subsequent returns to these investments. As discussed later in this report available studies have concluded that the benefits to society of ODS phase-out far outweigh the costs. Furthermore, after initial concerns about the costs of ODS phase-out, industry as a whole supported the phase-out process due to the rich commercial opportunities for returns on investments.

The types of investment and costs we are interested in are those that are unlikely to have occurred without the Montreal Protocol, such as research and development for alternatives to ODS, capital investment in changed processes and new facilities, as well as the costs of non ODS alternative substances. We cannot know the level of such investment in an alternative scenario where there was no Montreal Protocol implementation. However, available studies suggest that business would have continued as usual with production using cheap CFCs and there was little indication that industry would develop ODS alternatives in the absence of a regulated phase-out (Vanner, 2006). Therefore, it is reasonable to assume that without the Protocol some investments and their consequent contributions to a Green Economy would not have occurred at all and that other changes, such as improvements in energy efficiency, may not have occurred until much later, whether prompted by climate change initiatives or by market competition bringing about more cost efficient processes.

Availability of investment data

In our review of literature and in expert consultations about these Protocol related investments there is a mixed picture in terms of availability of global level data. On one hand there is detailed reporting on Multilateral Fund and GEF investments and many case study examples of investment across sectors and regions. On the other hand, there are limited global studies on the level of total investment, in particular, information on the significant investments in phase-out activities made by business is only partial. This may be inevitable, given the vast range of investments and businesses involved and issues of commercial confidentiality (see discussion in Annex 1).

Availability of global estimates of incremental costs of the Montreal Protocol (including R&D investment, capital investment in changed processes and new facilities and additional material, energy and labour costs) is rather limited but some indicative results are given, for example, in the ACR (1997) cost and benefit study. This study estimated total incremental costs of the Montreal Protocol for developed and Article 5 countries relative to the scenario of continued use of ODS using projected growth in their consumption to 2060. The total costs of the measures taken to protect the ozone layer were calculated to be US$ 235 billion (1997 prices) compared with an estimated global benefit of US$ 459 billion. While the study methodology necessarily relied on rather general assumptions, the results gave an early indication that global benefits of ODS phase-out far outweigh global costs, particularly since it did not include health benefits which are the significant part of any valuation of benefits of the Protocol. Annex 2 discusses further the methodology and results of available cost benefit studies.

INVESTMENT BY SOURCE:

Public Sector

Breaking down ODS phase-out investments by source we have well reported funding data from the Multilateral Fund (see Box 1) and GEF projects. As at July 2011, the Multilateral Fund had approved over US$ 2.7 billion in funding for incremental costs for Article 5 countries to meet their obligations for ODS control measures (see Table 4).

Additionally, the GEF provides financial support to CEITs to support ODS phase-out targets and deadlines. These investments include technology development and transfer, outreach and training, institution building and programs to phase-out ODS. Approximately US$ 210 million, has been allocated by GEF with another US$ 250 million leveraged in co-financing (28 ODS phase-out projects in 18 CEITs) (Dixon, 2011, UNIDO, 2011).

Another source of investment funding has been from national Governments including bilateral assistance to Article 5 countries and co-funding of projects by home Governments. A key example here is the ten donor countries that committed US$ 19 million to assist in the closure of the Russian Federation's production facilities for CFCs and halons by 2000, supplementing funding of US$ 10 million from the GEF. An example of home government funding is the HCFC Phase-out Management Plan (HPMP) in the Maldives which received counterpart funding from the government of about US$ 300,000 additional to the US$ 1,100,000 MLF contribution (excluding support costs for implementing agencies). The EU has also invested in ODS phase-out through, for example, the European Commission supported "JumpStart" project (2009-2010) to encourage developing countries compliance with HCFC phase-out obligations.

Table 4 Total Approved Funds for Multilateral Fund projects by type of project (as at end of July 2011 excluding closed and transferred projects)

TYPE	NUMBER OF PROJECTS APPROVED	TOTAL FUNDS APPROVED INCLUDING SUPPORT COSTS (US $)	APPROVED PHASE-OUT (CONSUMPTION) (ODP TONNES)	APPROVED PHASE-OUT (PRODUCTION) (ODP TONNES)
Country Programme	164	7,905,748	0.0	0.0
Demonstration	104	56,964,279	576.0	0.0
Institutional Strengthening	789	91,683,655	693.2	0.0
Investment	2,553	2,205,279,677	256,353.4	185,462.0
Preparation	1,472	82,722,865	0.0	0.0
Technical Assistance	1,104	266,396,347	13,547.2	0.0
Training	322	28,423,543	1,236.2	0.0
Total	**6,508**	**2,739,376,114**	**272,406.0**	**185,462.0**

Source Multilateral Fund Secretariat

Private Sector

It is important to note that substantial investments have been made by both domestic companies and multinational corporations in ODS-consuming industries in developing alternative technologies and in other ODS phase-out activities (OECD, 2005). This is particularly the case in developed countries, while in Article 5 countries the scope for private sector investment has been less, although MLF and GEF funded projects have stimulated co-financing in some cases. For example, MLF financed chiller conversion projects in Mexico, Thailand and Turkey were co-funded through use of a revolving fund with contributions typically amounting to about 40 per cent of total project costs (UNEP, 2009d).

After initial resistance to change in some sectors, many industries came fully on board with the Montreal Protocol and instigated their own ODS phase-out initiatives and programmes , e.g. the private sector voluntary initiative in India announced in 2002 by four large manufacturers of CFCs aimed at accelerating the phase-out of ODS in the country (OECD, 2005). The reasons for this increasing private sector investment in ODS phase-out activities are examined in the analysis by Bayramoglu (2009). This looks at how the design of international environmental agreements affects the incentives for investment by the private sector in environmentally-friendly technology. The study concludes that an agreement based on a uniform standard with transfer payments (such as the Montreal Protocol) may be preferable as it creates greater incentives for firms to invest in abatement technology.

Some of these private sector investments are difficult to define and quantify (for instance, in some cases it may not be clear to what extent there are other reasons for investments in new technology besides ODS phase-out requirements) and are not systematically reported (due to commercial confidentiality among other reasons), but case studies indicate that they can account for a far greater proportion of ODS phase-out related investments than other sources of funding. For example, the funding for closure of ODS production and investment in alternatives in the Czech Republic included contributions of about US$ 2.3m by the GEF and US$ 1.9m by the national Government (1994-1996) as well as financing via the State Environmental Fund which disbursed about US$ 12m million to support phase-out activities up to 2009. However, the investment from the private sector was estimated at about US$ 150m (See Box 2 for Czech Republic Case Study).

While acknowledging the significance of private sector investments, a number of articles and studies point out that original estimates of phase-out costs of ODS proved to be overestimates. Andersen & Sarma (2002) found that one reason for this was that the cost savings of substitutes such as lower operating and maintenance costs, and higher product reliability were not taken into account in these ex-anti estimates. In the case of refrigeration and air conditioning equipment there were savings in fuel and maintenance costs. For electronic equipment ODS phase-out (where it was employed as a solvent) increased reliability and performance while for some aerosol applications alternative propellants were cheaper allowing recovery of costs of investment. Another suggested reason for these overestimates is the greater level of international cooperation and technology transfer (promoted through the TEAP and other agencies) than envisaged, which acted to reduce anticipated costs (ACR 1997). It should also be noted here that a trend over time of declining unit costs per ODP-tonne of ODS abated (for all ODS including methyl bromide) has been confirmed by statistical analysis (DeCanio & Norman, 2005).

Further evidence of overestimates of the costs of phase-out is given in a study by Vanner (2006). This reviewed a range of ex ante phase-out cost estimates from the late 1980s/early 1990s and ex post estimates from after this period. It found examples ranging from an ex ante/ex post cost ratio of 1.6 in the case of total CFC phase-out in the US to a ratio of 40 in the case of foam blowing plants interim use of HCFC-22. It concluded that "Analysis of the details of ex-ante cost estimates shows they simultaneously under estimated the extent and the feasible rate of phasing out the use of ODS, whilst over estimated the unit cost".

BOX 2: EXPERIENCE OF THE CZECH REPUBLIC IN ODS PHASE OUT

The case of the Czech Republic illustrates the experience of a transition economy country in ODS phase out. The developed heavy industry, mining and chemical sectors in the period up to the 1990s in the former Czechoslovakia left a significant negative environmental legacy. This included the production of about 7,400 tonnes of ODS and the consumption of over 10,700 tonnes of ODS, of which 90 per cent were produced and 80 per cent consumed in the territory of what became the Czech Republic in 1993. However, by the end of the 1990s ODS phase out obligations under the Montreal Protocol had been achieved in tandem with a restructuring of industry and introduction of new clean technologies.

The country program for ODS phase out in the fromer Czechoslovakia was started in 1992, with support from the GEF, which set up the regulatory framework. This included a system of charges for ODS production and imports operated by the State Environmental Fund since 1993, with collected funds being used to support the introduction of non ODS technology and recovery and disposal of ODS. Total expenditures by the fund up to 2009 had reached about US$ 12m. A technical support and investment project (1994-6) for phase out of the production and use of CFCs was supported via a GEF grant of US$ 2.3m and national Government funding of US$ 1.9m. Subsequently, a licensing system for imports and exports of ODS was introduced in 1996 in advance of the 1997 Amendment to the Montreal Protocol.

Vital to the success of ODS phase out was investment in new technology by the private sector of the newly formed Czech Republic, which understood the benefits of cleaner production and the global opportunities this presented. Encouraged by the state regulatory framework the private sector invested an estimated $ 150m (2bn Czech Koruna) in the switch from ODS. Restructuring of the chemical sector, in particular, introduced new non-ODS technologies and at same time increased energy efficiency and reduced material intensity.

Implementation of Montreal Protocol commitments was also aided by private sector associations. The "Association of refrigeration and air-conditioning technology" with a membership of around 900 companies (private and public) having total turnover of about US$ 700m has been responsible for the exchange of information and experience on ODS phase out and capacity building through training.

Finally, protection of the ozone layer is one of the priorities of the Czech Development Assistance Programme which started in 1997. The country is now a leading player in capacity building for countries in the region (and beyond) and has been able to pass on experience in technology for ODS extraction (removal from equipment and products) and recovery in countries such as Lithuania, Ukraine, Macedonia and India. It has also given assistance in framing of legislation and on setting up State Environmental Funds.

Sources Pers. Comm. Mr. Jiří Hlaváček (Ministry of the Environment of the Czech Republic), Čermáková, Hlaváček & Jelinek (2006) and Hlaváček & Dobiásovsky (2007).

INVESTMENT BY APPLICATION:

Table 3 gives an indication of the great variety in types of investments in ODS phase-out activities between different applications, ranging from investments in replacement substances to new technologies or management regimes (e.g. Integrated Pest Management in case of methyl bromide phase-out). It is interesting to note that the majority of ODS phase-out was achieved by not-in kind replacements, i.e. by items not functionally identical to or with the same specifications as the items being replaced (Andersen *et al.* (2007, p.52) states that "only 20 per cent of the ODSs that would have been used if the question of ozone depletion had not arisen, have been replaced using in-kind chemical substitutes"). As well as investment in conversion, ODS phase-out has also stimulated investment in environmental services for recovery and recycling, for example manufacturing of recovery and recycling equipment for refrigerants in the refrigeration and air conditioning sectors.

Table 5 gives a breakdown of Multilateral funded projects in developing countries according to sector and illustrates the relative significance of investment in phase-out of ODS in refrigeration and foam applications in developing countries (for a case study of phase-out of CFCs in the refrigeration industry in China see Box 3). As noted above these MLF payments do not include counterpart funding by private sector or other agencies. In total the Fund approved US$ 2.7 billion for phase-out projects (as of July 2011).

Table 5 Total Approved Funds for Multilateral Fund projects by sector (As at end of July 2011 excluding closed and transferred projects)

SECTOR	NUMBER OF PROJECTS APPROVED	TOTAL FUNDS APPROVED INCLUDING SUPPORT COSTS (US$)	APPROVED PHASE-OUT (CONSUMPTION) (ODP TONNES)	APPROVED PHASE-OUT (PRODUCTION) (ODP TONNES)
Aerosol	202	94,060,299	27,807.5	0.0
Destruction	22	3,724,580	45.3	0.0
Foam	1,260	439,129,143	68,868.0	0.0
Fumigant	357	131,547,815	7,700.4	0.0
Halon	150	92,009,144	39,440.6	30,381.0
Multi-Sector	8	2,816,251	670.0	0.0
Other	11	17,381,709	1,530.0	0.0
Process Agent	39	130,303,211	19,572.5	51,935.0
Phase-out Plan	1,012	482,841,969	45,091.5	11,206.0
Production	65	348,163,802	0.0	91,940.0
Refrigeration	1,585	598,975,019	53,559.8	0.0
Several	1,576	288,592,688	752.9	0.0
Solvent	217	108,626,015	7,312.5	0.0
Sterilant	4	1,204,469	55.0	0.0
Total	**6,508**	**2,739,376,114**	**272,406.0**	**185,462.0**

Source Multilateral Fund Secretariat

The cost per kilogram of ODS phased out varies greatly between sectors and applications depending on availability and costs of substitutes and the investment needed in new technologies and capital equipment. To give an indication of this Table 6 shows threshold values by sector used as guidelines for acceptable costs per kilogram for phase-out of ODS in different uses for Article 5 countries. These were developed to inform decisions of investment projects submitted to MLF and GEF. The table shows significant variation in threshold per kilogram costs between applications. The most cost effective phase-out is shown in the halons and aerosols sectors. Much higher threshold values were necessary for the foam, refrigeration and solvents sectors.

Table 6 Cost effectiveness thresholds of MLF investment projects

SECTOR/SUB-SECTOR	COST EFFECTIVENESS THRESHOLDS (US $/KG ODP)
Aerosol	
Hydrocarbon	4.40
Foam	
General	9.53
Flexible polyurethane	6.23
Integral skin	16.86
Polystyrene/polyethylene	8.22
Rigid polyurethane	7.83
Halon	
General	1.48
Refrigeration	
Commercial	15.21
Domestic	13.76
Solvent	
CFC-113	19.73
TCA	38.50

Source UNEP (1995)

Note that these indicative costs per kilogram values would be different for developed countries. In the case of aerosols *initial* use of hydrocarbons to replace CFCs in developed countries reduced material costs of propellant by up to 80 per cent (although conversion was more difficult for metered dose inhalers (MDIs) which lowered average cost reductions).

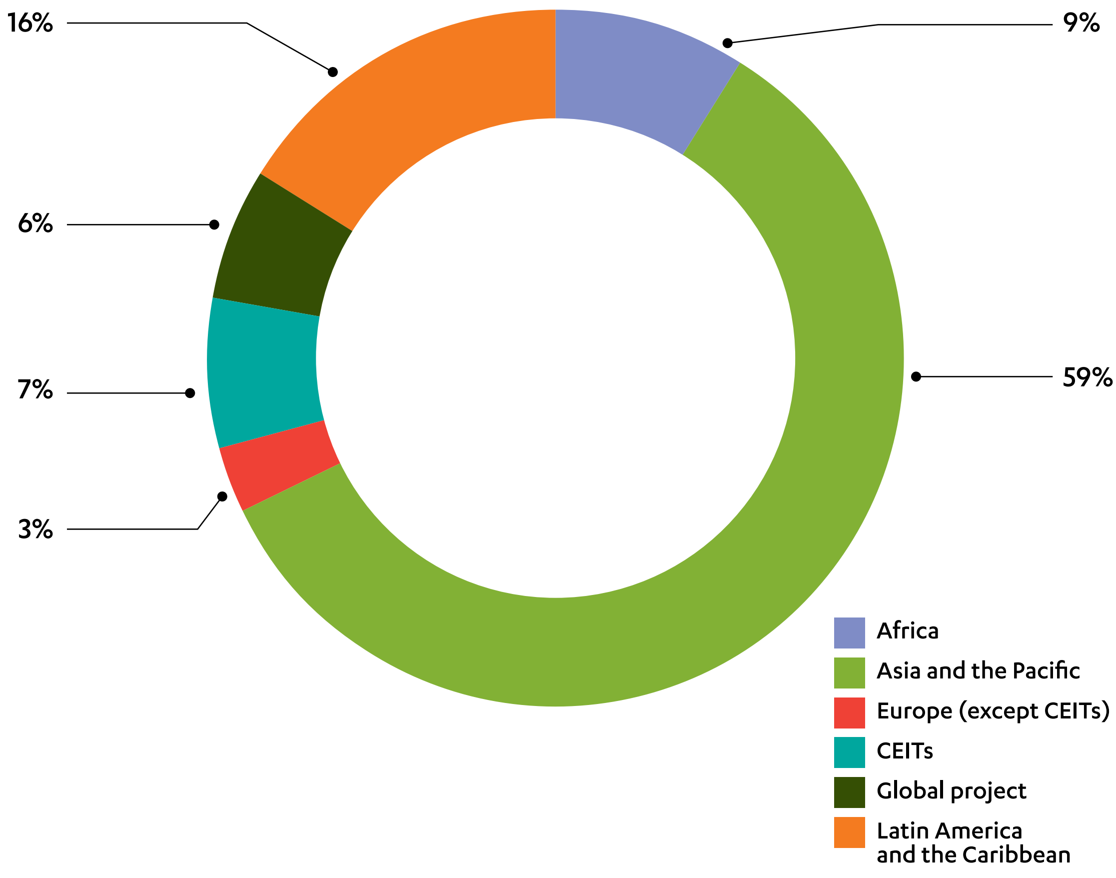
In the case of solvent applications for ODS, among other responses to the phase-out was a great increase in recycling and conservation by user sectors. Several large electronic companies reported costs savings resulting from elimination of CFC-113. The use of 'no-clean solder fluxes' is a key example of costs savings in this sector eliminating solvents and saving on manufacturing costs.

There is some evidence of cost differentials according to timing of investment in substitutes. The Vanner (2006) study gives the example of a division in the CFC producer market in the mid 1980s between companies leading the development of substitutes in anticipation of regulation and some remaining companies resisting change, which by the end of the 1980's were themselves trying to compete in the substitutes market. Delays in innovation thus led to lost market opportunities. In fact, a different technological route was followed by early adapters with Du Pont investing in HCFC technology as a CFC substitute and mainly European competing companies taking a longer period to develop HFCs as CFC substitutes.

INVESTMENT DIFFERENCES BY REGION:

It is difficult to compare total investments in ODS phase-out related activities between regions due to the incomplete availability of estimates for the private sector. Most such investments will have been in developed countries while in many developing countries, especially countries with a small industrial base the availability of such private sector funds is very limited (only about 40 of the 146 countries supported by MLF have any significant industrial activity). Regional comparisons of MLF approved funds to eligible developing countries and GEF-approved funds to CEIT countries. (Figure 1) show a high proportion of investment in Asia and Pacific countries reflecting ODS conversion in the rapidly expanding manufacturing industry in emerging economies such as China and India.

Figure 1 Total approved funding from the Multilateral Fund and GEF Approved by Region (as at end July 2011)[6]



Source Multilateral Fund Secretariat and UNIDO (2011)

It is also important to note that differences in economic circumstances between developed, CEIT and Article 5 countries impact on the type and level of ODS phase-out costs between regions. In general the per kilogram replacement costs were higher in Article 5 countries than developed countries, with a marked difference in, for example, the cases of foams and aerosols. This is due to a variety of differences in circumstances, for example conversion for foams was more expensive due to greater difficulties with access to hydrocarbons and the smaller scale nature of businesses in some Article 5 countries. For some applications such as CFC-113 and methyl chloroform in solvents there were often many Small and Medium Enterprise (SME) users in Article 5 and transition countries which faced higher replacement costs than developed countries due to lack of technical and financial resources. This underlines the importance of improved conservation and technology transfer practices (See Chapter 5).

[6] Except for GEF funds quoted in UNIDO (2011).

BOX 3: PHASE OUT OF CFCS IN THE REFRIGERATION INDUSTRY IN CHINA

CFC use as a refrigerant (CFC-12) and as a blowing agent for rigid foam insulation (mainly CFC-11) was widespread in the manufacture of domestic and commercial refrigerators and freezers in China. The successful phase out of these CFCs has proved the opportunity for technological upgrading and industrial rationalisation which has contributed to the rapid expansion of the refrigeration equipment sector over recent years.

The refrigerator industry in China expanded annual production from about 188,000 units in 1983 to about 7.5 million units in 1988 (Zhang 1993) and had reached about 14 million units by 2003 due to annual growth rates of around 15 per cent. The value of this industry increased from about 6.5 billion RMB (about US$ 1.7 billion) in 1989 to 40 billion RMB (about US$ 5 billion) in 1998 with a concurrent rise in the number of enterprises in the sector from 217 to about 1000. By 2005 China had become the third largest refrigeration equipment producing country in the world (CES 2007) and by 2008 the value of the domestic refrigerator and freezer manufacturing sector alone in China had reached US$ 26 billion, employing about 150,000 workers (Starmass International, 2008).

This expansion of the refrigerator sector greatly contributed to China's consumption of ODS which grew by about 1_2 per cent per year from the mid-1980s to mid 1990s. By 1997 China was the largest producer and consumer of ODS in the world with a CFC consumption baseline of 58,000 tonnes ODP, and yet the Montreal Protocol commitments for phasing out the principal ODS were successfully achieved by 2010 (OECD, 2007). Assisting in this transformation, the Multilateral Fund approved US$ 865 million to Chinese projects by 2010 making it the largest beneficiary country of the Multilateral Fund.

This process of ODS phase out provided an impetus for the refrigeration sector (among others) to upgrade technology, implement product modifications and rationalise production. This has resulted in many cases of: improved efficiency of appliances, the meeting of international safety and product quality standards, greater adherence to environmental regulations, increased energy efficiency (household refrigerators produced in China improved their weighted-average energy efficiency by about 29 per cent between 1999 and 2005 (UNDP, 2006)) and enhanced skills for technical staff (UNIDO, 2003). This has contributed to increased export opportunities and an increasing share of the international market.

- **Example 1** The Jiaxipera Factory producing compressors for domestic refrigerators converted to use of hydrocarbon alternatives (isobutane refrigerant technology) to CFC-12 with technical advice funded by the MLF. The outcome was the phase out of 200 tonnes of CFCs with an improvement in environmental impact, occupational safety and quality assurance of products, with an annual production increase of 40 per cent from 1994 to 2000.

- **Example 2** A UNIDO project initiated in 1995 supported the phase out of CFC-12 as a refrigerant and CFC-11 as foaming agent at the Huari refrigerator company, converting to isobutene refrigerant and cyclopentane insulation foam blowing. This provided the opportunity to upgrade facilities and rationalize the manufacturing process. The result was that the phase out of 338 tonnes of CFCs also brought about improved working conditions, occupational safety and an increase in labour productivity of 30 per cent (from 352 to 455 units per annum). Furthermore, the improved quality assurance procedures meant that Huari was certified to ISO 9001 standard, laying the foundation for an increase of exports from US$ 50,000 to US$ 2,000,000 (UNIDO, 2003).

- **Example 3** Another MLF funded project supported the Qingdao Aucma Company in converting to cyclopentane insulation foam blowing and HFC-134a refrigerant in their freezer production plant. The ensuing reorganization and rationalisation brought about similar co-benefits of reduced environmental impact and improved working conditions and occupational safety, while production increased by over 50 per cent between 1995 and 2001 to about a million units. Due to strengthened quality assurance procedures the company received ISO certification and, were able to increase exports. In the process there were also increases in direct and indirect employment (UNIDO, 2003).

Despite these success stories China faces substantial future challenges in the phase out of HCFC-22 in industrial and commercial refrigerator production and other sectors. The potential for climate benefits is significant as China was responsible for 69 per cent of total global production of HCFCs in 2006. To address these challenges in July 2011 the MLF has approved in principle US$ 265 million for the first stage of China's HPMP for the period 2011 to 2015, addressing the foam, industrial and commercial refrigeration, refrigeration and air conditioning, and servicing sectors. In total the HPMP aims to eliminate 3,320 tonnes of HCFC consumption in China (UNEP, 2011b, para 171).

STIMULATION OF MORE EFFICIENT PRODUCTION PROCESSES

An important co-benefit of the Montreal Protocol has been the various and considerable improvements in production efficiencies brought about by the need for ODS using industries to adapt processes, redesign equipment and renew components in the phase-out period. These improved efficiencies relate to both energy consumption and resource use. In particular, there have been improvements in the energy efficiency of refrigeration and air conditioning equipment since the start of the Protocol linked to the need to redesign equipment to use replacements for CFCs and HCFCs. Such process efficiency improvements not only directly benefit business competitiveness through lower per unit operating costs, but make a Green Economy contribution through contribution to reductions in greenhouse gases (see Chapter 4), efficient resource use and waste minimisation.

The increasing focus on achieving climate benefits and promoting of low Global Warming Potential (GWP) technologies by Montreal Protocol implementing and bilateral agencies has involved greater reporting on energy efficiency. For example, the TEAP progress report (UNEP, 2010a) provides an assessment of environmentally sound alternatives to HCFCs including examples of their costs and relative energy efficiency of their applications. This demonstrates how the Montreal Protocol has progressed into assessing and stimulating new alternatives using green criteria.

ODS phase-out has also afforded the opportunity for manufacturers in the supply chain to update product specifications and benefit from improved efficiency. For example, when compressor producers in China and Hungary redesigned CFC-12 compressors, used by refrigerator manufacturers, for use with non-ODS alternatives the conversion of processes resulted in improved energy efficiency as well as reductions in noise (Luken & Grof, 2006).

The updating of production process has also provided opportunities to enhance labour productivity. For example, when the Huari Group in China converted production of refrigerators to hydrocarbon alternatives to CFCs, it took the opportunity to upgrade facilities and rationalize the manufacturing processes resulting in an increase in units per worker per annum from 352 to 455 (Luken & Grof, 2006) (see Box 3).

As noted above, we cannot know the extent to which production in ODS using applications may have become more efficient in the absence of ODS phase-out requirements, but it is likely that any such movements have been greatly accelerated by these requirements. Table 7 gives examples of efficiency improvements for a range of applications.

Table 7 Examples of production efficiency improvements during ODS phase-out

SECTOR/ODS	EXAMPLE	SOURCE
Refrigeration/CFC	Peak energy efficiency of centrifugal chillers have improved from around 0.75-0.85 kW/tonne 20 years ago to 0.50 kW/tonne or higher	http://www.facilitiesnet.com/hvac/article/The-Elements-of-Energy-Efficiency--1833
Refrigeration/CFC	Leakage emissions (material efficiency) from chillers improved from 7% per year to less than 1% per year	Trane Inc.
Chemical/ Carbon Tetrachloride	In Mexico phasing out CTC and introduction of new technology resulted in 50% decrease in energy consumption (per unit of production)	Per comm. Agustin Sanchez Montreal Protocol focal point/ negotiator
Chemical	Restructuring of Czech chemical sector introduced non ODS technologies and increased energy efficiency (see Box 2)	Pers. comm. Jiří Hlaváček, Director of the Department of Environmental Policy and Multilateral Relations, Ministry of the Environment, Czech Republic
Electronics	• 'No-clean soldering' eliminated solvent use with savings on manufacturing and maintenance costs • Ford Motor Company estimates that millions of dollars have been saved • Reduced need to clean circuit boards at Texas Instruments saved over US$ 300,000 annually	Andersen *et al.* (2007), OECD (1999)
Fire fighting/Halons	Norwegian Fire Research Laboratory found that water can be as effective as halons for certain uses	OECD (1999)
Agriculture/Methyl bromide	Phase-out of methyl bromide in flower production in Colombia and introduction of IPM strategy saved growers an estimated US$ 1900 per hectare	OECD (1999)

DRIVING INNOVATION: REDESIGN OF PRODUCTS AND EQUIPMENT

In many sectors the requirements of the Montreal Protocol have stimulated innovation in the design of products and equipment as part of a technological shift needed to successfully phase out ODS. In emerging economies in particular such innovation has been driven by the increasing demand for key products, such as chillers. This process has resulted in a number of co-benefits for greening economies in terms of process efficiencies, product performance and reduced environmental impacts.

This is particularly so in the case of refrigeration and air conditioning applications, where the necessity to redesign products has resulted in reduced refrigerant leaks, and maintained or improved energy efficiency, reliability and safety standards[7]. This has also often meant that the new technologies are cheaper to maintain and have higher product quality and reliability than those they replaced (Andersen & Sarma, 2002). For example, an air-cooled chiller unit developed by four Japanese companies using HFC (R407C) gave improved performance in buildings and factories as well as reducing operating costs (OECD, 2005).

Innovation has also been driven through the requirement to replace ODS in foam blowing (in building insulation), fire protection and medical aerosols. For example, the replacement of ODS in thermal insulating foams has improved product performance through delivering a superior foam matrix.

There are also examples of how the Montreal Protocol has stimulated different technological routes to compliance. An example of this is the development of heating and cooling technology based on natural refrigerants to compete with HFC using technology on the basis of costs and environmental performance[8]. It is not in the scope of this study to make a technical assessment of relative merits of competing technologies in terms of ODP, GWP etc. but here we highlight how the Montreal Protocol has stimulated innovation through competition between such technologies (see Box 4). This competition has brought about performance improvements for both natural and chemical alternatives with consequent benefits for the environment.

It is difficult to provide a quantitative indication of the level of innovation driven by the Protocol. However, the study by EPO, UNEP and ICTSD (2010) showed an increase in patenting activity in clean energy technologies coinciding with the adoption of the Kyoto Protocol in 1997 and shows how stimulation of innovations linked to the Montreal Protocol could be further researched. A preliminary search by the World Intellectual Property Organization found that 16 alternative substances or inventions in refrigeration, propellants, foams and solvents had been registered by 1990 (Andersen *et al., 2002*).

We should also note here the stimulation of the development of new ODS replacement substances. For example, the MLF funded a UNDP project to develop and validate the use of methyl formate as a replacement foam blowing agent in Brazil and Mexico. This is intended to encourage low investment options for HCFC phase-out in SMEs. Another example is the development of HFO-1234yf as a new refrigerant approved for use in Japan and Europe for automotive air conditioners to replace currently used HFC (R-134a). This meets The European F-Gas Regulation (2006) due to its much lower GWP.

[7] Replacement of production equipment has provided the opportunity to improve safety in manufacturing processes and products, for example, in the case of hydrocarbon refrigerants.

[8] Compare the ATMOsphere (2010) report on bringing natural refrigerants to the market with the ARAP (2002) report which provides estimates of societal cost savings in the US and worldwide from use of HFC in a number of applications compared to less cost effective alternatives (i.e. comparison of most viable HFC alternative with the most likely HFC option).

BOX 4 COMPETITION BETWEEN NON-ODS REFRIGERANTS

Choices of alternatives to ODS substances and technologies have increasingly needed to take account of the varying environmental impacts of these alternatives. This is illustrated in the case of alternatives for replacing ODS refrigerants. Advocates of the use of non F-gases as CFC replacement refrigerants highlight the climate benefits of these alternatives.

A key example here is the development of Greenfreeze refrigerators, a technology which is the direct result of the Montreal Protocol. In 1993 the first Greenfreeze refrigerators were marketed resulting from collaboration between Greenpeace with the former East German manufacturer, the Foron Company. These used isobutane as a refrigerant which has zero ODP and a very low GWP. A total of 300 million units were sold in Europe, Asia and South America up to 2009 by leading brands in the refrigerator market. There are now developments in the introduction of hydrocarbon and CO_2 technologies in the American market with, for example, the "Refrigerants, Naturally!" initiative with several leading companies (Greenpeace, 2011).

Other natural refrigerants, for example those based on CO_2, are also being developed for use in mobile air conditioning, hot water heat pumps or commercial refrigeration. These alternatives offer climate benefits compared to use of HCFCs and HFCs in applications. At present such refrigerants only represent a small share of the market for these applications (5 to 10 per cent) but the industry suggests that it can compete with chemical alternatives on a cost, energy efficiency and emissions basis given time to develop market awareness and benefit from economies of scale. The uptake can also be driven by the future development of global regulation on F-gases. In the case of developing countries there are possibilities of leapfrogging over the F-gas generation of replacements and moving directly to use of natural refrigerants (ATMOsphere 2010).

However, there remain debates over the relative merits of natural versus chemical refrigerants across economic, safety and environmental performance (see for example the assessment by ARAP, 2002). Such debates illustrate that responses to the Montreal Protocol have long ago expanded from a narrow focus on phase out of ODS to wider considerations of the performance of alternatives in terms of green economy contributions. The value of the Montreal Protocol has been that it has facilitated such analysis of the alternatives to ODS. Furthermore, the competition between alternative solutions brings about performance improvements on both sides with consequent benefits for the environment.

Sources also include pers. comm. with Marc Chasserot (Managing Director, Shecco) and Kevin Fay (President of Alcalde & Fay)

INDUSTRIAL RATIONALISATION AND ECONOMIES OF SCALE

Among the ways that enterprises have adjusted to ODS phase-out to keep competitive in domestic and international markets have been to initiate the reorganization and rationalisation of the production process. This has allowed plants to benefit from economies of scale to achieve productivity increases. Key examples of this process have occurred in some emerging economies, such as China and India, where small scale operations have been consolidated into more competitive production units as part of a more general economic transformation in their manufacturing sectors. In some cases where there were initial difficulties in ODS phase-out it was necessary to rationalize production in order to gain competitiveness.

For instance, in China the phase-out of ODS in packaging and some agricultural exports required the consolidation of SMEs into larger production units before the conversion to use of hydrocarbon technology could be achieved in an economically viable way (Luken & Grof, 2006). Examples of industrial rationalisation include:

- In China, UNIDO umbrella projects for the conversion from CFC-12 to butane technology in the manufacture of extruded polyethylene foams resulted in combinations and relocations of plants and production lines. The final structure involved 52 small enterprises with 171 production lines being converted to 20 enterprises with 84 production lines (and the phase-out of 3390 tonnes of ODP). This consolidation provided for long term competitive survival (Luken & Grof, 2006).

- Hauri, the Chinese refrigerator manufacturer, achieved the conversion to cyclopentane insulation foam blowing and isobutane refrigerant by building new production facilities and rationalizing processes. The result was that the phase-out of use of 338 tonnes of CFCs was attained with an annual production increase of 5 per cent (UNIDO, 2002).

- In the refrigeration sector a project to convert the Aucma freezer production plant in China to non CFC technologies resulted in an increase in annual production from 650,000 units in 1995 to over a million in 2001 without the installation of new production capacities (Luken & Grof, 2006).

Due to the capital investment needed, the consolidation of production has been easier to attain for larger companies rather than SMEs. However, rationalisation and economies of scale have not only resulted from consolidation into larger production units but also from cooperation between SMEs. For example:

- In a UNDP assisted project started in Malaysia in 2000, 11 SMEs were required to phase-out CFCs in the production of over 34,000 commercial refrigeration units. In doing this they benefitted from economies of scale in the bulk-buying of standard replacement technology, and in the harmonization of production lines instead of each enterprise buying separate customized equipment. This resulted not only in greater cost-effectiveness of project funding but also in production costs savings to achieve a more competitive market position (UNDP, 2007).

- The India Foam Sector Umbrella Project initiated by UNDP and the Ministry of Environment and Forests for 80 SMEs was started in 1997 and this developed low-cost, low-output, non-ODS foaming equipment in collaboration with suppliers. Economies were achieved through standardization and bulk procurement for achieving economies of scale. Extensive technical assistance and training enhanced the capacity of the SMEs to operate these systems (UNEP, 2007).

CONSUMER IMPACTS

The available evidence on the impact of the phase-out of the use of ODS is that there has been no great *cost* disadvantage experienced by consumers. The review of literature by Vanner (2006) notes that by the mid 1990s "virtually all of the global reductions in CFC use had come at little or no cost to consumers". In the case of refrigerator manufacture, for example, while at first hydrocarbon based substitutes were less energy efficient and more costly, by the end of the 1990s this replacement technology was as energy efficient as the available alternatives and any cost differential was in favour of hydrocarbon Greenfreeze technology (see Box 4). Similarly, there was no negative impact on consumers of ODS phase-out in household aerosol products which became less costly to manufacture. For example, one estimate calculates that the switch to hydrocarbon aerosol propellants saved US consumers US$ 165 million per year (quoted in OECD, 1999).

Cost savings to end users have also resulted from ODS phase-out giving the opportunity for more efficient practices to be introduced. For example, in the Costa Rica fishery sector (which accounted for more than 50 per cent of national CFC consumption) inefficient and commonly leaking CFC based refrigeration systems resulted in high costs for fishing vessel owners. Conversion of fishing vessels (in the UNDP supported end-user incentive programme as part of the Refrigerant Management Plan) resulted in co-benefits to owners from lower operating costs which repaid the investment in new cooling systems in under a year. Moreover, the raised awareness generated by the project led to reduced CFC consumption by some vessel owners not in the original programme and benefited the refrigeration servicing industry (UNDP, 2007).

Further consumer benefits have come through improved product *reliability*. For example, the use of 'no-clean soldering' processes instead of cleaning with CFC-113 in electronics manufacturing has resulted in much lower error rate and longer life products (Andersen *et al.*, 2007). Another important case is the phase out of CFCs in MDIs[9]. The change from CFCs to Hydrofluoroalkanes (HFAs) in MDIs presented substantial technical challenges but this has given the opportunity to improve significantly the performance of the product in drug delivery to asthma sufferers (Leach, 2005).

[9] Import of products containing most CFCs and halons (Annex A substances) banned from 1992.

A VITAL ISSUE FOR THE SUCCESS OF THE MONTREAL PROTOCOL HAS BEEN THE PHASE-OUT OF TRADE IN ODS AND ODS CONTAINING PRODUCTS

The phase-out process has also brought about greater consumer information through the development of eco-labelling and energy classification on products (see UNIDO 2009). This allows greater public awareness that products do not contain ODS and that this change has not come at the expense of energy efficiency. In fact, the consequence of the improved energy efficiencies of products has been that consumers benefitted through lower electricity bills due to reduced energy consumption. Energy consumption of new domestic refrigerators in the US, for example, has reduced by about 60 per cent over the last 20 years (AHAM, 2010).

There have also been great opportunities for consumer cost saving resulting from the need to address climate change. The necessity to minimise the climate impact of the use of HFC-134a as a CFC replacement refrigerant in vehicle air conditioning has encouraged on site recycling of HFC 134a such that about 90 per cent of the original refrigerant cost can be recouped through recycling and reuse during service (Andersen *et al., 2007*).

TRADE IMPACTS OF ODS PHASE-OUT

A vital issue for the success of the Montreal Protocol has been the phase-out of trade in ODS and ODS containing products and the converse rise in trade of non-ODS replacement substances and equipment/technologies. The main trade restrictions introduced under the Montreal Protocol were: (i) control of trade in ODS with non-Parties[10], (ii) control of trade in products containing ODS with non-Parties[11] and (iii) the import-export licensing systems to regulate trade in ODS between Parties. In addition to direct trade stipulations under the Protocol, national governments party to the Protocol also introduced a range of trade measures, such as import quotas and bans, as part of their strategies to meet consumption and production phase-out targets.

The study on international trade impacts of the Protocol by Brack (1996) concludes that the trade provisions contributed considerably to attracting signatories and reducing the world market for ODS and ODS using products overall. The stipulations that Parties should not engage in ODS related trade with non-Parties, in particular, sent a message to countries not complying with the Protocol that their industries based on export of ODS did not face a viable future and provided an added incentive to join the Protocol. As more countries became party to the Protocol this incentive grew and the world market for ODS and ODS using products for industries in non-participating countries shrank (OECD, 1999).

The mandating of ODS import/export licensing systems was adopted in 1997 in response to the emerging issue of illegal trade in ODS, particularly in CFCs, partly caused by the differing phase-out schedules between developed and Article 5 countries, which resulted in a two-speed phase-out process. Such illegal trade has been evident since the mid 1990s and, although it has since declined in developing countries, is still common in the developing world and has been estimated to represent around 10 to 20 per cent of legitimate trade (Brack et al, 2006). This is an important issue to address because it undermines the phase-out process and reduces incentives for industry to invest in non ODS substitutes and technologies.

In order to improve the monitoring and control of trade in ODS it was also necessary to create new customs codes relating to substances controlled under the Montreal Protocol in the Harmonized Commodity Description and Coding System (HS) codes (Andersen & Sarma, 2002)[12]. Capacity building and awareness raising initiatives in customs authorities, for example through the UNEP Training Manual for Custom Officers (UNEP 2008), have also been part of a process of greening of customs institutions across the world.

Impact of phase-out

Trend data on trade in ODS reflects the significant global declines in their consumption and production since 1987. Earlier studies on the impact on trade in ODS of the Montreal Protocol (Markandya & Milborrow, 1997) picked up early trends in the reduction of trade in controlled substances (as well as the growing problem of illegal trade in some CEIT countries) and this decline has accelerated with the success of the treaty. Figure 2 shows the significant reductions in global imports of ODS since 1997 and illustrates one side of the picture on the greening of trade.

The other side of this picture is the increase in trade of ODS replacement substances and technologies. Figure 2 shows

[10] In response to requests from the Parties of the Montreal Protocol the World Customs Organisation Council created separate international customs codes for Annex A (group I) substances (CFCs), halons, Annex B (group I) substances (other fully halogenated CFCs), methyl chloroform, and carbon tetrachloride. As of 2012 a subsequent revision of customs codes will be introduced for ODS which inter alia will provide separate codes for some HCFCs, and amalgamate codes for CFCs.

[11] Import of products containing most CFCs and halons (Annex A substances) banned from 1992.

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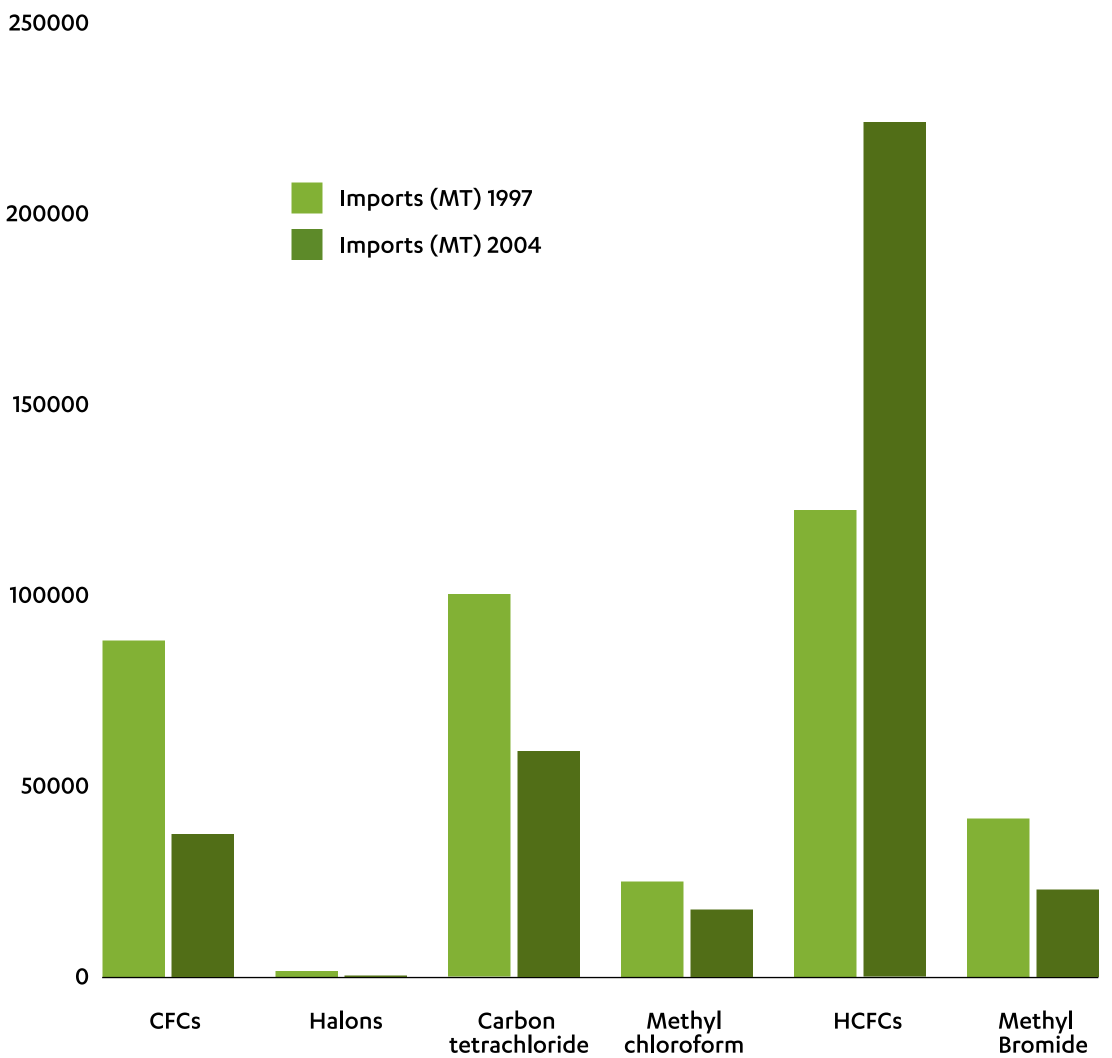
trade in HCFCs almost doubling in the period 1997 to 2004, although it is difficult to give an overall estimate of the increase in value and volume of trade in ODS replacement substances due to the great variety of replacements across different applications. It is important to remember that while this increase in non ODS trade represents a greening of trade as far as ozone protection is concerned, the GWP of some replacements such as HCFC and HFCs means that future progress in phasing out/phasing down these chemicals is very important to ensure further greening of trade.

The significance of trade in products which contain non ODS or lower ODS alternatives is illustrated in the example of air conditioning and refrigeration equipment. The value of exports of air conditioning equipment from China (the world's largest exporter) grew from US$ 2.7 billion in 1997 to about US$ 10 billion in 2010[13]. Similarly, the value of Chinese exports of refrigerators and freezers grew from US$ 1.6 billion to US$ 5.7 billion in the same period.[14]

Figure 2 Trends in global trade in ODS (Million Tonnes)



Source Adapted from data in Brack *et al.* (2006)

[13] Trade statistics from UN Comtrade database for HS code "Air conditioning equipment and machinery"(84.15).

[14] Trade statistics from UN Comtrade database for HS code "Refrigerators, freezers and heat pumps nes" (84.18).

The Montreal Protocol has therefore created considerable international trade in chemical products that replace ODS, non-ODS containing equipment and related services such as training in new technologies and processes. In particular, the rapid expansion in recent years of manufacturing exports from emerging economies such as China has coincided with, and to some extent been stimulated by, the opportunities provided by ODS phase-out. Furthermore, a broad range of developing and CEIT countries have been able to seize the export opportunities having been aided by MLF and GEF funded projects for transfer of technology and capacity building.

CONTRIBUTION TO GDP

The economic benefits of ODS phase-out through industrial development, technological innovation, and rationalisation described in this chapter have all contributed to national macroeconomic growth in developed and developing countries as measured by GDP. To the extent that such GDP growth has been made more environmentally friendly through reducing ODS and the linked GHG emissions, and has had other resulting co-benefits such as on human health, it can be seen as a contribution to greening of the macro economy. Given the data available, however, it is not possible to precisely quantify the extent to which national and global economic wealth measured by GDP has grown as a result of the Montreal Protocol compared to a business as usual scenario.

We should note here the strong growth in GDP in key emerging economies over the last two decades, in particular China and India and highlight the role in this growth played by the industrial conversion in key sectors of those countries brought about as a result of, inter alia, the Montreal Protocol. The opportunities provided by the Protocol to increase competitiveness through improved production efficiencies, introduction of new technology and industrial rationalisation set the stage for expansion of production and exports in manufacturing sectors such as refrigeration and air conditioning. For example, the value of the refrigerator and freezer manufacturing sector in China reached US$ 26 billion in 2008 (Starmass International, 2008). In India, the refrigerator market which has been growing at a rate of about 15% per year and is estimated to be about 3.5 to 4 million units per year, valued at Rs. 50 billion (about US$ 1.1 billion) [15].

[15] http://www.iupindia.in/503/EE_Refrigerator_Industry_in_India_36.html

03 Social Co-Benefits

This chapter addresses the co-benefits of the Montreal Protocol in terms of the social equity element of our definition of Green Economy. In particular, it discusses how the phase-out of ODS in the world economy impacts on employment, human health and poverty alleviation.

EMPLOYMENT

In the context of Green Economy and Millennium Development Goal 1B ("Achieve decent employment for women, men, and young people") we are interested in the impacts of the Montreal Protocol on employment numbers as well as on wages and provision of decent working conditions. While project specific data and case studies on employment are available (see Table 8), particularly for MLF and GEF financed projects, there are no global studies of the order of magnitude of the impact of the phase-out of ODS on employment. This may be partly due to the difficulty in some cases (especially those that are not funded through MLF) of isolating ODS phase-out as the key reason for changes in employment resulting from business re-structuring or modernising processes and technologies.

The message gained from expert consultation for this project is that there has been no net loss of employment resulting from the Montreal Protocol as had been feared in some quarters at the start of the phase-out process. Furthermore, much of the employment in the relevant sectors has been in roles requiring greater training in technical skills reflecting an improvement in the overall quality of jobs on offer. In fact, a prerequisite for the economic success of transformations in production stimulated by the Montreal Protocol has been the acquisition by managers and technicians of the necessary technical skills and information to adapt to new processes and technologies. Training programmes to enhance those skills are therefore an important component of MLF and GEF funded projects (see Chapter 5). Funding of training has been especially important in the servicing sector in developing countries where the servicing of equipment using ODS largely took place in small workshops. Training contributed to the formalization of service industries and the greater empowerment of workers via training certificates. Latest data reported to the MLF indicates that a total of 77,502 refrigeration servicing technicians have been trained, 60,375 have been certified, and 3,627 refrigeration technician trainers have been trained (UNEP, 2011c).

Employment opportunities have been created in activities directly relevant to a Green Economy such as recycling, containment, retrofitting to improve energy efficiency and reduce leakages and introduction of other best practices. New jobs have also been created due to expansion in sectors that are developing and manufacturing non-ODS chemicals and equipment/technology. These include jobs created in training programs for technicians working with these non-ODS technologies.

Table 8 Examples of employment impacts connected to ODS phase-out

SECTOR/COUNTRY	EXAMPLE	SOURCE
Refrigeration (US)	General Electric investments in cyclopentane in phase-out of HFC-134a or HFC-245fa create 25 new jobs and helps retain more than 1,000 jobs in Decatur manufacturing facility	GE press release (2011)
Foam (Brazil)	Conversion from CFC to castor oil-based polyurethane by a Poly-Urethane Industria E Comercio Ltda established a local demand for castor oil (mamona) supporting farming in the northern part of Minas Gerais state and maintaining employment for about 4,500 farming households	UNDP (2007)
Refrigeration (CEIT)	Refrigerator companies e.g. NORD (Ukraine), Snaige (Lithuania) expanded production with resulting employment increases prior to the 2007-2009 economic crisis	GEF (2009)
Refrigeration (China)	Household refrigerator and home freezer manufacturing industry in China employed 154,293 employees in 2008	Starmass International (2008)
Agriculture (Mexico)	As a result of replacing methyl bromide with grafting in crops e.g. watermelon and tomatoes. Production and female employment has increased	Pers. Comm Agustin Sanchez

The review by Luken and Grof (2005) of MLF investment projects implemented by UNIDO found that most projects had contributed to sustaining long-term employment. Some conversion projects had increased employment numbers due to the demand for increased production while others had enabled job continuation by supporting local manufacturers to remain competitive. There were other examples of where job losses in production had been partly offset by new employment for safety requirements (e.g. expanded polyethylene foam packaging enterprises in China). Cases were also found of secondary employment generation such as in training services connected to ODS phase-out, for example in the maintenance of refrigeration and air-conditioning equipment under Refrigerant Management Plans (RMPs) in Romania (UNIDO, 2002).

In the agricultural sector there are also examples of increased employment impacts related to the replacement of methyl bromide as a soil fumigant by non-chemical and chemical alternatives. In Mexico the introduction of grafting in crops (e.g. watermelon and tomatoes) to replace methyl bromide has increased production and female employment (pers comm. Agustin Sanchez, Montreal Protocol focal point/ negotiator, Mexico).

There are, however, cases of inevitable job losses resulting from the ODS phase-out process. For example, a number of enterprises in the aerosol sector closed or reduced production due to difficulties with managing the process of converting away from ODS use. In some Article 5 countries rationalisation of production and the advantages of economies of scale meant a shift away from a prevalence of SMEs towards larger scale centralised units in some sectors such as refrigeration. In China, this process brought about a 50 per cent decrease in employment in SMEs in some specific sectors (Luken and Grof, 2005). However, this was balanced by new opportunities at the larger enterprises where wages and conditions were improved.

The ODS replacement process has also had important implications for ensuring the health and safety of workers when operating new equipment and handling alternative chemicals[16]. This is particularly important for the safe use of flammable hydrocarbons as substitute aerosol propellant and the use of chlorinated toxic solvents as replacement for CFCs. Safety at work is therefore addressed in the requirements of MLF projects, for example, in the requirements to prepare safety plans by suppliers of foaming and refrigeration equipment, recipient companies and safety authorities, which include a strong element of training for plant technicians and operators (UNIDO, 2002).

[16] For a full assessment of health risks associated with use of substitutes for ODS see UNEP 2010b, Appendix 2-1.

Other health and safety improvements for workers have resulted from the phase-out of methyl bromide use in agriculture which is highly toxic (see health section below) and the introduction of much safer not-in-kind alternatives, like Integrated Pest Management. Furthermore, it should be noted that the avoidance of health impacts of overexposure to UV radiation outlined below may have a disproportionate benefit for agricultural workers in areas where avoided UV irradiance is higher.

HEALTH

A major motivating factor in the original Montreal Protocol negotiations was the predicted severe health impacts of ozone layer depletion. Overexposure to UV radiation has a range of serious health effects, including skin cancers (contributing to an increase in melanoma), eye damage (including cataracts) and immune system suppression[17]. A number of estimates have been made for the health impacts avoided by measures to protect the ozone layer under the Montreal Protocol and these clearly demonstrate the significance of these global benefits.

The study by Slaper et al. (1996) estimated that with no restrictions on ODS, incidence of skin cancer would quadruple by 2100 while under the Copenhagen Amendments to the Montreal Protocol increases in incidence would peak at about 10 per cent around the year 2060. The recent report on cataracts incidence by the US EPA (2010) estimated the impacts of the Montreal Protocol Amendments of 1997, which phase out HCFCs in developing countries and methyl bromide in developed countries (2005) and developing countries (2015). The results of modelling showed over 22 million cataract cases would be avoided in the United States up to the year 2100.

A key study measuring global health benefits of the Montreal Protocol was undertaken by Environment Canada (ARC, 1997). Health benefits were quantified over the period 1987 to 2060 using dose response functions from the literature but were not valued in economic terms (only cases avoided). The study by Velders et al. (2001) uses the ARC (1997) health benefit estimates and US EPA (1999) study valuations for US health benefits as a basis for estimating the monetary value of global health benefits. The summary results are given in Table 9. The study estimated that taking into account these health benefit valuations the overall benefit/cost ratio of the Montreal Protocol was boosted to about 11:1 compared with about 2:1 for the estimate without health benefit valuations being taken into account (See Annex 2 for discussion of CBA studies of the Montreal Protocol).

We should also note that there may be local health benefits from the phase-out of ODS. The key example here is the public health benefits from phase-out of methyl bromide under the Montreal Protocol Amendments of 1997. Methyl bromide use in agriculture posed a health risk to workers and neighbouring communities due to its toxicity and is associated with acute lung injury and neurological effects.

Table 9 Estimates of health benefits of the Montreal Protocol (1987-2060)

HUMAN HEALTH BENEFITS	REDUCED CASES (MILLION)	VALUATION (US $ BILLION 1997)
Non-Melanoma Cancer	19.1	573
Melanoma Cancer	1.5	45
Cataracts	129.1	93
Skin Cancer	0.3	1109

Source Adapted from ARC (1997) and Velders *et al.* (2001)

17 See full discussion of the human health effects of ozone depletion and interactions with climate change see Chapter 2 of the Environmental Effects Assessment Panel Report (UNEP 2010b).

POVERTY ALLEVIATION

The link between poverty alleviation and environmental sustainability is clearly embedded in the concept of Green Economy and in the Millennium Development Goals. Indeed, the continuing contribution of the Montreal Protocol towards achieving MDG-7 (Ensure Environmental Sustainability) is cited in MDG reports between 2003 and 2010. The report of the Secretary-General of the United Nations has used the example of the Montreal Protocol for how global solutions are successfully working to achieve the MDGs:

"We already have one encouraging example showing how global solutions [to ensure environmental sustainability] can be found. Thanks to the Montreal Protocol on Substances that Deplete the Ozone Layer, the risk of harmful radiation appears to be receding — a clear demonstration of how global environmental problems can be managed when all countries make determined efforts to implement internationally agreed frameworks". (UN, 2005, paragraph 57)

While the main reporting on Montreal Protocol is focused on ODS phase-out, the impact on poverty alleviation is a relatively unreported area and comes indirectly via economic development, employment, health and environmental benefits arising from that phase-out. Poverty alleviation is therefore a cross cutting issue and the main contributions of the Montreal Protocol include the following:

- **Support for economic development in Article 5 and CEIT countries** via projects supported by the MLF and GEF. Support for technology transfer and related training have helped these countries to develop sectors such as refrigeration and air conditioning manufacturing and compete on a more even footing in the global market. This global competitiveness has been achieved in part by the possibility afforded from technology transfer to leapfrog over earlier generations of technology to the latest developments. In China and India, for example, growth of such industries has increased their contribution to national economic wealth (as outlined above). Employment created by conversion to non-ODS alternatives has often involved training workers in new technologies. This has enhanced the skills base among the populations of these in recipient countries (see discussion on capacity building in Chapter 5).

- The significant levels of **mortality and morbidity avoided** under the Montreal Protocol and outlined in this report are likely to benefit all, including the poor. Indeed in some cases vulnerable groups may benefit more than others. For example, the cases of melanoma and non melanoma avoided are likely to particularly benefit areas with high agricultural and outdoor worker populations in regions of high surface UV radiation levels. We should also note that the Montreal Protocol will have contributed to health benefits and poverty alleviation to the extent that the transfer of refrigeration technology has allowed for improved food preservation and vaccine storage in developing countries.

- The significant valuations for **avoided damage to materials** from increased UV radiation due to ODS phase-out (see Chapter 4) will benefit a number of sectors including construction and agriculture. These sectors tend to provide livelihoods for poorer sections of society.

THANKS TO THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER, THE RISK OF HARMFUL RADIATION APPEARS TO BE RECEDING

04 Environmental contribution

In this chapter we highlight the significant contribution of the Montreal Protocol not only towards achieving its primary aim, ozone layer protection, but also in terms of the co-benefits of protection of ecosystems due to avoided UV radiation resulting from ODS phase-out and climate change mitigation due to avoided GHG emissions.

OZONE LAYER PROTECTION

The near complete compliance with ODS phase-out targets agreed under the Montreal Protocol by developed and developing countries has resulted in dramatic falls in ODS consumption and production, as outlined in the introduction to this report. The consequence of this has been a reduction in ODS in the atmosphere with projections that continued implementation of the Protocol's provisions will result in the ozone layer returning to pre-1980 levels by between 2050 and 2075.

Under business as usual scenarios it has been estimated that by 2050 ozone depletion would have increased to at least 50 per cent in the mid latitudes of the northern hemisphere and 70 per cent in the mid latitudes of the southern hemisphere, which is around 10 times current levels. Studies conclude that the implementation of the Montreal Protocol has resulted in considerable avoided impacts for the ozone layer with associated environmental, social and economic co-benefits (WMO, 2010).

ECOSYSTEM BENEFITS

An important impact of increased UV radiation at the earth's surface resulting from ozone depletion is biodiversity loss through damage to terrestrial and aquatic ecosystems[18]. The recent study by the Environmental Effects Assessment Panel (EEAP) notes that in areas of substantial ozone depletion the evidence indicates a reduction in terrestrial plant productivity of around 6 per cent due to increased UV-B radiation (UNEP 2010b). There is also evidence that increased solar UV-B radiation damages some aquatic organisms and in combination with increased global temperatures this may negatively impact species of ecological importance.

[18] For a discussion on the link between the Montreal Protocol and biodiversity loss see the article "Ozone Layer Protection and Biodiversity: the Struggle to Save Life on Earth" by Ahmed Djoghlaf, Executive Secretary of the Convention on Biological Diversity (in UNEP, 2010c).

These environmental impacts have an economic consequence through the potential for reduction in agricultural and fishery yields and resulting impacts on food prices, food security and livelihoods (of particular concern in developing countries where populations often depend directly on biodiversity for their day-to-day livelihoods). Therefore, by reducing levels of UV radiation the Montreal Protocol is not only delivering environmental benefits but also economic benefits of avoided reductions in agricultural yields.

Overall impacts of increased UV radiation on ecosystems are difficult to assess due to the complex interaction of ozone depletion and climate change factors as outlined in the EEAP study. Estimates of the order of magnitude of benefits to crop harvest in the United States from avoided UV-B radiation increases derived from the study by US EPA (1999)[19] are given in Table 10. This study values this benefit as about US$ 49 billion in the US alone. The table also includes estimates from the Environment Canada study on benefits and costs of the Montreal Protocol (ARC, 1997) which extrapolated from the US EPA estimates to give an indication of the global magnitude of agriculture and fishery damage avoided. These estimates do not include forestry damage.

Increased UV radiation can also cause damage to materials including plastics and wood, and this can be exacerbated by increased ambient temperature resulting from climate change. This has implications for the useful life of materials used in construction, agriculture and elsewhere. Such degradation of material can to some extent be addressed by the use of stabilisation technologies, surface coatings and substituting materials. However, there is an economic cost to such damage and estimates of these costs in the case of polymers from the US EPA and ARC studies are also given in Table 10. The headline figure here is an estimated saving of US$ 459 billion dollars for the period from 1987 to 2060 from avoided damages to agriculture, fisheries and materials alone.

Table 10 Estimates of benefits from UV radiation increases avoided

EFFECT OF UV RADIATION	SOURCE OF ESTIMATE	VALUATION OF AVOIDED DAMAGE (US$)
Global agricultural damage	Reduced damage globally for period 1987 -2060 (ACR, 1997)	191 billion
Global fisheries damage	Reduced damage globally for period 1987 -2060 (ACR, 1997)	238 billion
Global materials damage	Reduced damage globally for period 1987 -2060 (ACR, 1997)	30 billion
Reduced crop harvests in US	Avoided 7.5 per cent decrease from UV-b radiation in US by 2075 (US EPA, 1999)	49 billion
Damage to Polymers in US	Avoided damage to materials from UV-b radiation in US by 2075 (based on estimated costs of addition of stabilizers). (US EPA, 1999)	6 billion

19 See Stratospheric Ozone Assessment (Appendix G) if the CBA of the US Clean Air Act (US EPA, 1999).

BY REDUCING LEVELS OF UV RADIATION THE MONTREAL PROTOCOL IS NOT ONLY DELIVERING ENVIRONMENTAL BENEFITS BUT ALSO ECONOMIC BENEFITS OF AVOIDED REDUCTIONS IN AGRICULTURAL YIELDS

CLIMATE CHANGE

The importance of ODS phase-out to the international efforts to tackle climate change under the UNFCCC has become increasingly apparent in the period since the instigation of the Montreal Protocol almost 25 years ago. Most ODS are also powerful GHGs and the successful implementation of the Montreal Protocol has played a significant role in these efforts to reduce GHG emissions. ODS contribute to climate change directly through emissions of the gases to the atmosphere, and indirectly through the GHG emissions resulting from the energy consumption of equipment containing the ODS. In fact, the phase-out of CFCs has contributed to date far more to reducing radiative forcing than GHG reducing measures undertaken in the Kyoto Protocol (Velders *et al.*, 2007; UNEP, 2010b), as illustrated in Figure 3.

The study by Molina et al. (2009) reports that in the twenty years up to 2010, the phase-out of production and consumption of ODSs has reduced GHG emissions by a net 135 billion tonnes of CO_2 equivalent or about 11 billion tonnes CO_2 equivalent per year. This is about five times more than the Kyoto Protocol annual emissions reduction target for the period 2008–2012 (WMO, 2010). The monetary value to be attached to this reduction is uncertain as studies of the social costs of carbon, which measure the damages caused by the release of one tonne of carbon at a given point in time, are subject to significant uncertainties. Nevertheless, some values are available and the European Commission and the UK government have recently suggested that those working in this field use a figure of €17.2/tonne CO_2[20]. At current exchange rates this amounts to US$ 24.2/tonne CO_2. The value attached to the cumulative reduction in GHG emissions from the Montreal Protocol would then be estimated at US$ 3,262 billion over a period of 20 years. This amounts to about 6 per cent of the world's current GDP or put another way, the average annual reduction over the period is valued at 0.3 per cent of current GDP.

It should, however, be recalled that some ODS replacement substances are themselves contributors to GHG emissions. HFCs currently account for about 0.4 billion tonnes of CO_2-equivalent per year (and under "no control" scenarios it is estimated that by 2050 GWP–weighted emissions from HFCs might be comparable to those of CFCs at their highpoint in the 1980s), while HCFCs account for about a further 0.7 billion tonnes per year (Velders et al., 2009). Therefore, continuing actions for phasing out HCFCs and addressing HFCs[21] remain important elements in reductions in GHGs. In the future, it is estimated that the accelerated phase-out of HCFCs under the Montreal Protocol agreed by Parties in 2007 will result in a reduction of up to 16 billion tonnes of CO_2- equivalent by 2040. Also, the emission of 5 billion tonnes of CO_2 equivalent can be avoided up to 2015 by recovering and destroying HFCs.

UNEP's Green Economy Report (2011a) highlights the contribution that the Montreal Protocol can also make to climate change mitigation in the waste sector through the successful collection and destruction of ODS held in banks. The TEAP has estimated that in 2002 global ODS banks amounted to about 3.78 million ODP-weighted tonnes representing potential emissions of 20 billion tonnes CO_2 equivalent. However, addressing ODS banks remains a key challenge for the future of the Protocol.

In addition to these direct reductions in GHG emissions from ODS there are also reductions in GHG emissions resulting from greater energy efficiency in industry brought about by the Montreal Protocol (as discussed in Chapter 2). The consequence of all these reductions in GHG emissions is that the Montreal Protocol is recognised internationally as a mechanism for greatly reducing risks of abrupt climate change from anthropogenic causes.

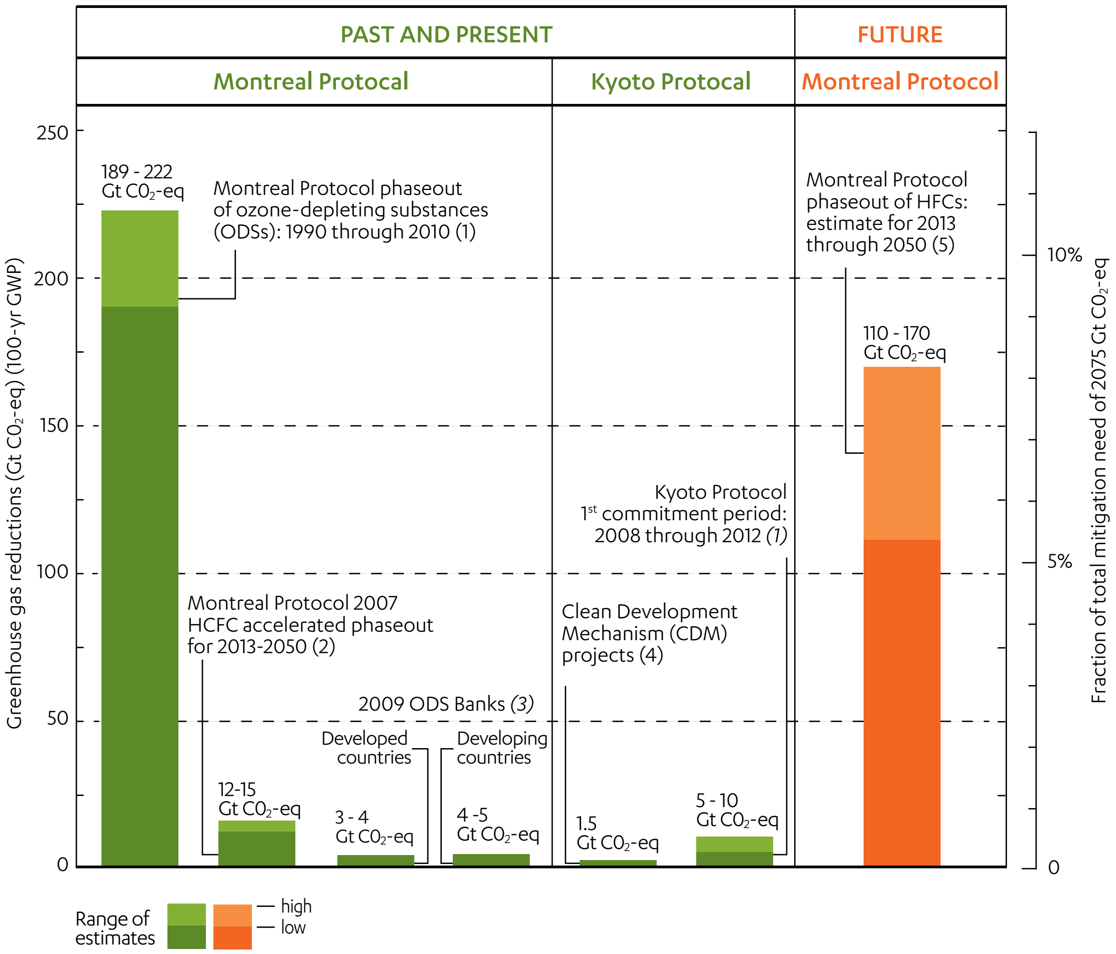
[20] European Commission (2008). Commission Staff Working Document - Impact Assessment - accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020. SEC(2008) 85/3. (Page 7): http://ec.europa.eu/clima/documentation/docs/sec_2008_85_ia_en.pdf and Department for Energy and Climate Change – DEEC (2009). Carbon Valuation in UK Policy Appraisal: A Revised Approach. (Table 6.3, page 44) http://www.decc.gov.uk/assets/decc/what%20we%20do/a%20low%20carbon%20uk/carbon%20valuation/1_20090715105804_e_@@_carbonvaluationinukpolicyappraisal.pdf.

[21] For further discussions about the need to reduce the climate impact of HFCs, see the recent UNEP synthesis report (UNEP, 2011).

The phase-out of ODS use across economic sectors globally should therefore be seen as a major element in the introduction of cleaner technology alongside initiatives under the Kyoto Protocol to green industry, such as the Clean Development Mechanism. There is an argument that, even taking this climate change mitigation contribution alone, the Montreal Protocol is one of the important foundations for progress towards a global Green Economy in that it is currently responsible for a significant share of the multiple economic, social and environmental benefits of addressing climate change.

Consultations for this study highlighted that climate change mitigation issues are becoming increasingly important in the future development of the Montreal Protocol[22]. There is a current focus by the TEAP on low GWP technologies and energy efficiency in the phase-out of HCFC across sectors (UNEP, 2010a) and the remit is expanding to also address the regulation of F-gases. In this context it is necessary to ensure a harmonised approach between the Montreal and Kyoto Protocols, in particular for the successful phase-out of HCFCs and addressing HFCs[23].

Figure 3 Climate protection from the Montreal Protocol and Kyoto Protocol



Source Velders et al. (2007)

[22] For example, the Executive Committee of the Multilateral Fund agreed in 2010 to provide up to a maximum of 25 per cent project funding above the cost effectiveness threshold for HCFC phase-out projects when required for the introduction of low GWP alternatives (Decision 60/44).

[23] Contributions to the methodology of how to jointly account for the ozone and climate protection impacts of investment projects include the study by Norman et al. (2008).

OTHER ENVIRONMENTAL BENEFITS

We should also note that the process and technological transformations arising from the requirements of the Protocol have resulted in a range of other contributions to "reducing environmental risks and ecological scarcities" in our definition of Green Economy. These include:

- *Improved waste management practices*. For example, a large-scale methyl bromide elimination project in Argentina not only contributed to complete conversion to non-chemical alternatives in a number of provinces but this process also provided the opportunity to promote the recycling of agricultural solid plastic waste[24] . (UNDP, 2007).
- *Reduced toxicity* (e.g. methyl bromide phase-out and replacement with Integrated Pest Management)
- *Noise reduction*. For example, the redesign of CFC-12 compressors to handle ODS-free (isobutene) refrigerants has reduced noise and vibrations as well as improving energy efficiency (UNIDO, 2002).

There are also examples of competition between alternative non-ODS replacements stimulating performance improvements and consequent benefits for the environment. This is illustrated by the example of natural and flourinated refrigerants given in Box 4 (page 36).

[24] This training and extension programme was implemented by Instituto Nacional de Tecnologia Agropecuaria (INTA) of Argentina, in partnership with the National Ozone Office and UNDP and targeted thousands of mainly small and medium-sized farms. A pilot project (Punto Limpio) was initiated to encourage farmers to return used agricultural materials (polystyrene trays and tarps) which were recycled into building materials and used in community housing construction.

THE CONSEQUENCE OF ALL THESE REDUCTIONS IN GHG EMISSIONS IS THAT THE MONTREAL PROTOCOL IS RECOGNISED INTERNATIONALLY AS A MECHANISM FOR GREATLY REDUCING RISKS OF ABRUPT CLIMATE CHANGE FROM ANTHROPOGENIC CAUSES

05 Institutional Contribution

While the direct contribution of the Montreal Protocol to a Green Economy and associated environmental and employment impacts are more quantifiable, we should not underestimate the importance of the institutions and mechanisms of the Protocol in underpinning these contributions. The institutional arrangements can provide useful lessons in implementing global environmental agreements for the promotion of Green Economies. In this section we focus particularly on how arrangements for technology transfer and capacity building at the plant level and national level have both contributed to the success of ODS phase-out programmes.

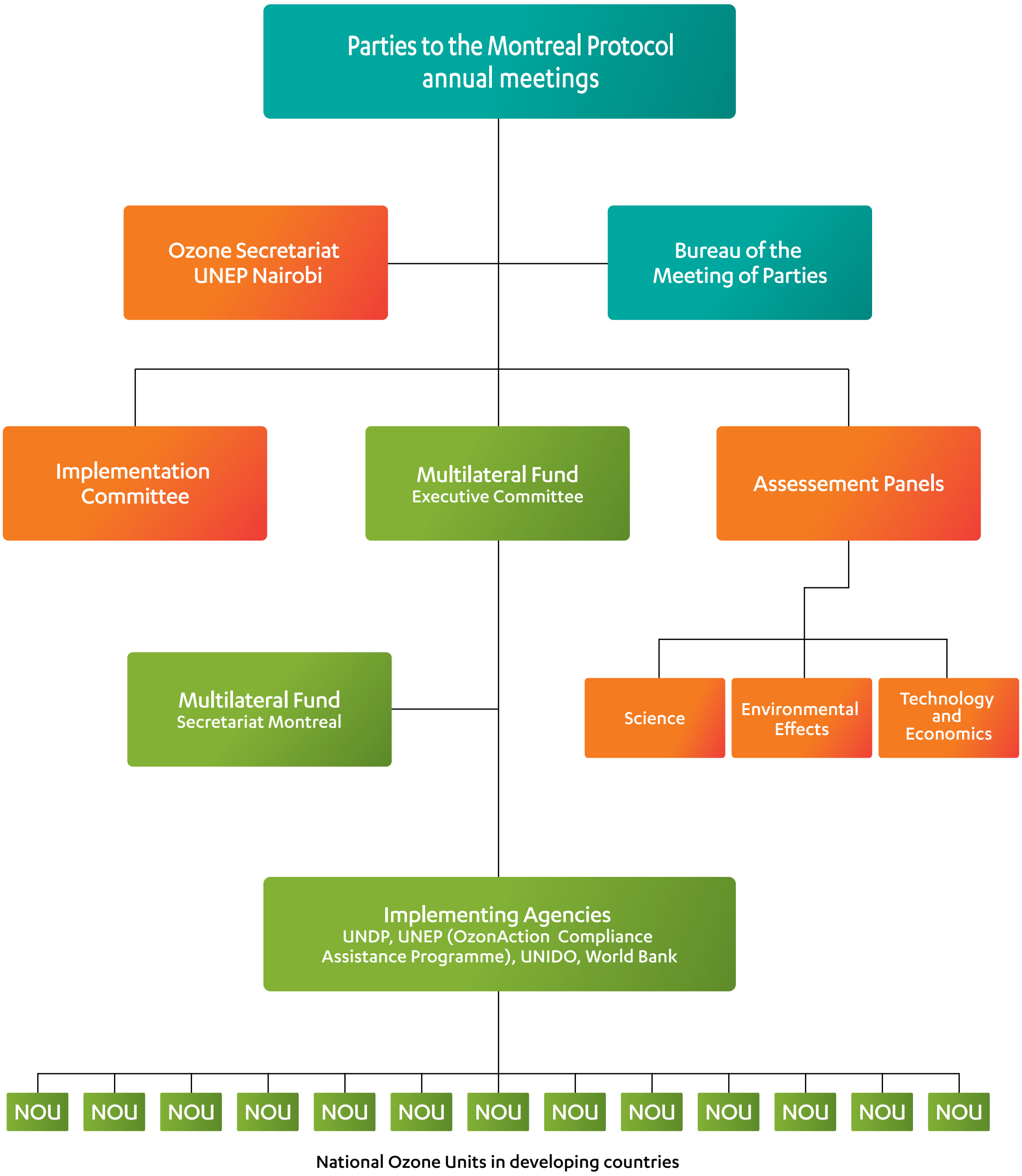
TECHNOLOGY TRANSFER

The Montreal Protocol Articles and national commitments provided the framework for long-term technological conversion, but key to the successful outcomes of the Protocol in terms of ODS phase -out and associated co-benefits has been the institutional arrangements for effective management of the phase-out and technology transfer to facilitate global access to best available ozone-friendly technologies. Such technologies may also embody other environmentally friendly attributes such as energy efficiency and safety features that contribute further to a Green Economy (Andersen et al., 2007).

Figure 4 outlines the institutional linkages of the Parties to the Montreal Protocol. Key to technology transfer arrangements are the expert assessment panels, the Multilateral Fund (See Box 1) implementing and bilateral agencies, National Ozone Units and the UNEP Regional Networks of Ozone Officers. The three assessment panels carry out independent assessments on the scientific issues and environmental effects of ozone depletion, and the status of alternative substances and technologies and their economic implications.

Figure 4

THE OZONE PROTECTION LANDSCAPE



Source Ozone Secretariat, Fund Secretariat, OzonAction 2007

A number of the main features of the technology transfer arrangements that contributed to their success emerged in the expert consultation for this study and are summarised below:

- The setting out and effective **communication of technological options** for how to replace existing ODS by parties to the Montreal Protocol, rather than focusing on regulating the prohibition of ODS.

- Use of **performance standards** for assessing non-ODS options (taking into account environmental and safety issues) rather than prescription of approved technological options stimulated development of new technology by industry.

- **The collaborative nature of work by different independent parties** to develop, validate and provide information on the best available technological alternatives for the phase out of ODS including:

  (i) The Assessment Panels. Structure and culture of the assessment panels has made them a powerful means for gaining trust in technical assessments. There has been a development of a "spirit of the Montreal Protocol" through wide collaboration among participants [25]

  (ii) National Ozone Units and UNEP's Regional Networks of Ozone Officers facilitating the diffusion and exchange of experience of best technological options.

  (iii) National government agencies working with industry to disseminate information.

  (iv) UNEP's Compliance Assistance Programme (CAP) which maintains close and continuous interactions with various stakeholder groups within recipient countries to understand their information and technical adaptation needs. The location of staff in the regions aids delivery of advice to countries and networks so that appropriate interventions can be made to resolve issues in a timely manner and help countries expedite their responses to emerging challenges.

  (v) The private sector whose contribution has been particularly vital in developing and diffusing alternative technologies to open up new global markets. As well as research and development by individual companies, industry associations have engaged in performance testing and providing information on alternatives, some of which were expressly formed to aid ODS phase out[25].

- **Multilateral Fund support** for technology transfer to developing countries. Key features contributing to successful outcomes are:

  (i) Implementation of projects through partnerships of the country's government and stakeholders with multilateral and bilateral implementing agencies.

  (ii) Support for National Ozone Units which has assisted developing countries in taking ownership of their ozone protection programme.

  (iii) Multilateral Fund policies and guidelines, applied through project review by the Fund Secretariat and deliberations of projects by the Executive Committee, promote the adoption of the most cost-effective ODS replacement technologies.

  (iv) Country driven compliance approach - Encouraging developing countries to develop multi-year phase-out plans (e.g. CFC national phase-out plans (NPPs) and HPMPs) that include technology transfer, technical assistance, capacity building and awareness-raising activities. Each plan is governed by an agreement which specifies the total funding, performance targets, their verification, and provisions for penalties if targets are not met.

  (v) Financing by the MLF of incremental costs of ODS phase out for eligible Article 5 country projects is a cost effective approach to disbursement of available funds.

25 For further discussion of this issue see the study of the global ozone protection community by Canan & Reichman (2002).

CAPACITY BUILDING ACTIVITIES

From its inception the Executive Committee of the MLF recognised the importance of institutional strengthening in government agencies to enhance capacities for delivery of ODS phase-out objectives. *National level* capacity building activities include those that assist public sector institutions to develop and deliver effective national policies, country programmes and national phase-out management plans to meet ODS phase-out targets. The initial key to these efforts was setting up and supporting National Ozone Units responsible for design of country phase-out programmes and selecting projects to be assisted by the MLF.

Necessary support also included training for government officers responsible for implementation of national plans and policies. An example of such capacity building is the China Online Training System (China State Environmental Protection Administration and UNEP). Since launching in 2005 about 2000 local officials from 12 provinces and cities have been trained in ODS phase-out information as a complement to face-to-face training. Training is also essential for customs and enforcement officials who implement regulation of the trade in ODS. Data for Article 5 countries submitted to the Multilateral Fund Secretariat indicates a total of 15,997 customs officers have been trained[26] (UNEP, 2011c). The MLF has supported the training of customs officers in developing countries as part of the Green Customs Initiative (a partnership of five convention secretariats and six international organisations). This has built national capacity to monitor trade in commodities of environmental concern including but not limited to ODS (UNEP, 2007).

Support for national level capacity building has also been given through bilateral assistance. An example here is the work of GIZ Proklima (Germany) and Agence Française de Développement (France) in Africa. Since 1998, GIZ Proklima has assisted 17 African countries in their national refrigerant management plans (RMPs) for phase-out of use of CFCs in the refrigeration and air conditioning sectors. Subsequently, Germany and France came together to fund and implement several projects together. After creating an institutional framework for regulating ODS in the countries, the projects undertook capacity-building within the customs service. A further component has been the training of service technicians in training centres who then provide training in best practice to technicians throughout their countries (UNEP, 2007). A similar effort was undertaken in Japan through annual month-long training programs for ozone officers from developing countries who studied technical solutions, regulatory and voluntary approaches, and the metrics of measuring project success.

There can also be support from private sector and NGO institutions that help industry meet national targets, such as Research and Development institutions, for example in Romania the RMP was supported by an independent refrigeration training centre (Luken & Grof, 2006).

At *plant level* capacity building is aimed to support industry managers and technical staff and takes the form of technical assistance, training, information dissemination and demonstration projects for introducing ozone-friendly alternatives to ODS. Specific areas for plant level capacity building are in project design, production engineering and equipment maintenance (Luken & Grof, 2006). Capacity building has been promoted in Article 5 countries through MLF funded projects in over 120 countries (OECD 2005). For example, the India Foam Sector Umbrella Project (initiated by UNDP and the Ministry of Environment and Forests) provided extensive technical assistance and training to enhance the capacity of the SMEs involved to operate new non-ODS foaming equipment (UNEP, 2007).

We should also recognise wider capacity building impacts. The MLF funded UNEP DTIE outreach programme has provided targeted awareness publications on the ozone issue which have been translated into many languages. Education for schoolchildren is aimed to impact also on adult awareness and purchasing power (e.g. of energy efficient products).

After more than two decades of experience, considerable expertise has been built up in the developing country ozone community, particularly ozone officers, customs officers, and refrigeration and air conditioning servicing technicians, through capacity building measures and 'on the job' experience. This expertise in National Ozone Units, regional networks and elsewhere within the public and private sectors can have a positive impact on raising the level of performance across all relevant national implementing agencies.

[26] It is noted in the MLF report that it is unclear whether this total is annual or cumulative data (UNEP, 2011c).

AFTER MORE THAN TWO DECADES OF EXPERIENCE, CONSIDERABLE EXPERTISE HAS BEEN BUILT UP IN THE DEVELOPING COUNTRY OZONE COMMUNITY

06 Conclusion

In this report we have outlined the many different ways in which the Montreal Protocol has provided and continues to provide direct and indirect contributions to the greening of the world economy. These contributions were not in many cases envisaged as part of the very specific original aims of the Protocol to phase out production and consumption of ODS, but are nevertheless part of the bigger picture when the co-benefits of the Protocol over the last 25 years are examined. The study started by assessing the direct impacts of ODS phase-out at the sector and at the macro-economic levels, before considering the social and environmental co-benefits, although it should be recognised that issues such as energy efficiency link across these different aspects. The study also highlighted the importance of the institutional arrangements of the Montreal Protocol for achieving Green Economy contributions. In each chapter we have aimed to illuminate how the co-benefits of the Protocol connect to the main facets of a Green Economy as defined in UNEP's Green Economy Initiative. An overview of contributions of the Montreal Protocol and their links to the key objectives of the Green Economy Initiative and MDGs is given in Table 2 of the introduction.

Chapter 2 focused on the Green Economy contributions of the Montreal Protocol outlining the various ways in which ODS phase-out schedules and the process of converting to non-ODS alternative chemicals and equipment/technologies provided the opportunity for business to improve competitiveness and expand into new markets. In particular, this process has stimulated investment in more efficient production processes including energy efficiency, and driven technological innovation and industrial rationalisation. These effects have also had benefits for the consumer in terms of product cost and performance and are reflected at the macroeconomic level through impacts on trade and economic growth.

The wider social impacts on human health, employment and poverty alleviation of the Protocol were examined in Chapter 3. The considerable quantified public health benefits of reductions in UV radiation are of particular significance in demonstrating the success of the Protocol and the contribution to MDGs. Chapter 4 discussed the important environmental co-benefits of the Protocol through its significant contribution to climate change mitigation and reduced damage to agriculture and fisheries ecosystems (with resulting economic benefits to crop and fishery yields). Finally, chapter 5 emphasized the importance of the institutional and financing arrangements of the Montreal Protocol in underpinning the achievements in phasing out ODS and the co-benefits to the Green Economy covered in the report. This includes the vital role of the Multilateral Fund in facilitating technology transfer and capacity building activities.

Taken together, the achievements of the Montreal Protocol covered in this report provide a compelling case for its success not only in ozone protection but also in terms of wider benefits for the Green Economy. Investment made in the switch away from ODS use has been returned many times due to the range of benefits that have contributed to general human wellbeing and environmental sustainability. Available cost benefit studies on the impacts of the Montreal Protocol have concluded that the benefits of ODS phase-out will far outweigh the costs with one study estimating a benefit/costs ratio of about 11:1 (See Annex 2).Furthermore, these assessments have mainly focused on valuing the benefits to health and agricultural/fishery yields and have not included the significant contribution of the

Montreal Protocol to reducing GHG emissions, nor the range of economic co-benefits described in Chapter 2 or other non- quantifiable institutional contributions.

To demonstrate the range of linkages between the achievements of the Montreal Protocol and the Green Economy, Table 11 provides examples of co-benefits of the Protocol according to the key sectors which are the focus for the Green Energy Initiative. Many ODS containing products were used (and continue to be used) in a great variety of industrial and domestic contexts, for example, the ubiquitous use of refrigeration and air conditioning equipment containing CFCs and HCFCs and range of the fire fighting applications using halons. Therefore, the co-benefits of their phase-out have been felt across a breadth of economic sectors as is shown in the table.

Table 11 Examples of Green Economy contributions by sector

KEY SECTORS FOR GREEN ECONOMY INITIATIVE	ODS PHASE-OUT	EXAMPLES OF CO-BENEFITS FOR GREEN ECONOMY
Agriculture	Methyl bromide phase-out from use as fumigant	Health benefits to agricultural workers
	All ODS	Yield benefits of avoidance of UV radiation
Building and Construction	CFC/HCFC phase-out in building insulation foam	Energy efficiency improvements from superior foam matrix
	All ODS	Avoided damage to materials by UV radiation
Fisheries	All ODS phase-out	Yield benefits of avoidance of UV radiation
Industry	Electronics: (CFC-113 and MCF)	Montreal Protocol encouraged a great increase in recycling and conservation by user sectors. Several large electronic companies reported costs savings resulting from elimination of CFC-113. The case of 'no-clean solder fluxes' is a key example of costs savings in this sector (savings of about US$ 1.50 per kg were reported)
	Refrigeration: (CFC)	Energy efficiency improvements from conversion to non CFC refrigerants
	Pharmaceutical: Improved drug delivery of MDIs due to redesign of product from CFCs to HFA use	Health benefits to Asthma and Chronic Obstructive Pulmonary Disease (COPD) sufferers. Associated economic benefits
	Chemical: Solvents	Cost saving by use of no-clean technologies
Transport	Vehicle air conditioning	Reduction in use of ODS and replacement *by* HFC 134A in automotive sector resulted in increased energy efficiency
Waste	Recycling and conservation of ODS Setting up of ODS banks	Greening the waste sector. For example, TEAP estimated that worldwide ODS banks are available at approximately 3.78 million ODP-weighted tonnes in 2002 and have potential to release over 20 billion tCO_2-eq of GHGs (UNEP 2011a)
Energy	Refrigeration and air conditioning	Examples of energy conservation. See Table 7

KEY LESSONS FROM THE MONTREAL PROTOCOL EXPERIENCE FOR PROMOTION OF A GREEN ECONOMY

It is true that the Montreal Protocol benefited from specific circumstances that aided its success to date. For example, it deals with a specific set of substances for which viable alternatives are or can be developed, the costs of implementation are relatively modest and the benefits from complying are considerable (See Annex 2). Nevertheless, the Montreal Protocol experience provides a principal example of how success in global environmental governance can be achieved and it can offer valuable lessons in gaining economic co-benefits from multilateral environmental agreements[27].

First and foremost, it showed that global environmental protection can be a win-win process; that serious global environmental challenges can be successfully addressed and it is possible to succeed in implementing MEAs without serious negative economic impacts. In particular, it challenges fears about greening economies that: (i) there is an inevitable trade off between environmental sustainability and economic progress and (ii) a Green Economy would restrain growth and perpetuate poverty in the developing world (UNEP, 2011a). Furthermore, it has increased awareness of the need for investment decisions to consider the environment as part of long term viability and intergenerational equity.

Based on recurring themes in our expert consultation and review of literature, key conclusions on the approach and design of the Montreal Protocol and how these achieved ODS phase-out as well as creating enabling conditions for a transition to a Green Economy are as follows:

- **A new type of MEA**. The Montreal Protocol can be credited with helping to introduce new approaches to global environmental governance. It is based on a sense of equity, transparency and common but differentiated responsibilities. It is solution-focused with time bound, measurable targets. The MLF created results-based management and accountability frameworks. It also stimulated the use of concepts such as the "waste hierarchy" and "cradle to grave" approaches to the management of chemicals.

- **Incremental approach**. The evolution of the Protocol showed the effectiveness of a step by step approach in terms of: (i) ODS reduction targets agreed by the developed world and Article 5 countries and (ii) the listing of controlled substances. Thus, the greening process is a continual process not a "one off" decision.

- **Technology transfer institutions**. Key to the successful outcomes of the Protocol has been the institutional arrangements for technology transfer to facilitate global access to best available ozone/ environment friendly technologies. This includes the expert assessment panels, the Multilateral Fund and its implementing agencies, National Ozone Units and the UNEP Regional Networks of Ozone Officers, as well as technology transfer carried out by multinational corporations. In particular, the technology panels were able to effectively demonstrate technical and economic feasibility of alternatives as well as energy and resource efficiency advantages. Technology transfer has given the opportunity for recipient economies to be on the cutting edge of technology and benefit from more resource efficient processes. It therefore helped to level the playing field giving incentive for developing countries to compete with developed countries, especially in the case of the emerging Asian economies.

- **Financing mechanism**. The Multilateral Fund provided an example of how global collaboration can be based on the principle that countries have a common but differentiated responsibility to protect and manage the global commons. Its governance has equal representation from donors and recipients, i.e. there are seven representatives each from developed and developing countries on the MLF Executive Committee. Financing by the MLF and GEF of only incremental costs of ODS phase-out for eligible Article 5 country projects is a cost effective approach to the utilization of available funds. In addition, performance-based funding promotes government commitment to compliance supported by long-term funding agreements. Moreover, there is evidence that the MLF is providing a useful model elsewhere since the current ideas for design of the Green Climate Fund are based on some elements of the MLF.

27 For comparison of Montreal Protocol and climate change negotiation see for example: http://www.acus.org/new_atlanticist/copenhagen-failure-vs-montreal-success

- **Capacity building**. The work towards strengthening institutional and human capacity in developing countries (supported by MLF) and CEIT countries (supported by GEF) is an important part of the success of the Montreal Protocol and, while difficult to quantify, the lessons learned are useful for other MEAs promoting Green Economy.

- **Trade measures**. Trade provisions of the Protocol, in particular the stipulations that Parties should not engage in ODS related trade with non-Parties, contributed considerably to attracting signatories and reducing ODS overall. Further, the enforcement mechanism for these stipulations was novel and gave real incentive for compliance.

- **Technical innovation and cooperation from the private sector:** While the Protocol was and continues to be driven by governments and international institutions, its success has been dependent on the active participation of industry. The Protocol sent signals to industry, such as via legally binding phase-out schedules, but allowed industries to manage how they addressed ODS phase-out, rather than using a top down approach. Although many private companies were initially resistant to ODS phase-out, the demonstrable commercial advantages of conversion meant that the private sector as a whole soon supported the switch and remains integral to R&D into cost-effective replacements for ozone depleting chemicals and technologies.

- **Voluntary Agreements:** An important element to ODS phase-out has been voluntary agreements including: (i) Industry-government partnerships such as ICOLP, (ii) voluntary national agreements such as the US foam food packaging phase-out agreement and the recycling agreement for vehicle air conditioning refrigerants, and (iii) voluntary international agreement such as the Thailand-Japan refrigerator sector partnership, the Vietnam Pledge, and the agreement of developed country leading companies to phase out ODS in overseas operations within one year of phase out in the home country (Andersen et al., 2007).

FUTURE OF THE MONTREAL PROTOCOL

During consultations with experts a number of themes emerged regarding the future of the Montreal Protocol and its continuing contribution to developing a global Green Economy. These are particularly focused on the inter-linkages of ODS phase-out with climate change.

- **Phase-out of the high-GWP first generation ODS replacements**. A significant challenge is the phase-out of HCFCs (by 2020 for developed and 2030 for developing countries) and avoiding or reducing high-GWP HFCs [28], with resulting climate benefits (UNEP 2011). The Multilateral Fund is integral to aiding phase-out in developing countries through funding transfer of technology and HPMPs (see MFS, 2010).

- **Addressing banks of ODS:** It is also important to manage the elimination of banks of CFCs and HCFCs (an estimated 3.5 million ODP-tonnes worldwide) to avoid climate and ozone impacts.

- **Development of low-GWP technologies**. Linked to the schedule for HCFC phase-out (and the concern about HFCs), is the need for continued development of replacement substances and low or zero GWP energy efficient technologies that would "minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations"[29]. For example, use of natural refrigerants like CO_2 is likely to increase in a number of air conditioning and refrigeration applications. TEAP is already focusing on new developments in low GWP technologies and energy efficiency in different sectors (UNEP, 2010a) [30].

- **Synergy between Montreal Protocol and other global treaties**. In the context of HCFC phase out and possible HFC phase down there is a need to develop a consistent approach between the Montreal Protocol and other MEAs, in particular the Kyoto Protocol process but also in other areas, for example the Basel, Rotterdam and Stockholm Conventions [31]. Green Economy can be promoted through harmonized working of ozone depletion and climate change efforts.

28 HFCs are not controlled currently by the Montreal Protocol because they are not ozone depleting substances. Amendments advocating a phase down of HFCs under the Protocol have been presented by a number of Parties and negotiations are currently considering these.

29 Decision XIX/6 of the 19th Meeting of the Parties to the Montreal Protocol.

30 MLF "Funding of up to a maximum of 25 per cent above the cost effectiveness threshold will be provided for projects when needed for the introduction of low global warming potential (GWP) alternatives" decision 60/44 (UNEP/OzL.Pro/ExCom/60/54)

31 Basel Convention on the Transboundary Movements of Hazardous Wastes and their Disposal, Rotterdam Convention on the Prior Informed Consent (PIC) Procedure for Certain Hazardous Chemicals and pesticides in International Trade, Stockholm Convention on Persistent Organic Pollutants (POPs).

- **ODS replacement in developing countries**. Due to later phase-out schedules the extent to which developing countries can skip a generation of technology/ODS substitutes (HCFCs and HFCs) and move to, for example, natural refrigerants and "not in kind" technology is currently receiving much attention, in the context of the costs and benefits of 'skipping a generation'.

- **Increased awareness of Montreal Protocol's contribution to Green Economy**. There is a great potential for raising understanding and awareness among the policy community and the wider public of the co-benefits of the Montreal Protocol for the Green Economy and sustainable development. The relatively low awareness of these co-benefits may be accounted for to some extent by the very specific original focus of Montreal Protocol official reporting on achieving phase-out of ODS consumption and production.

- **Further research on Green Economy impacts**. Expert consultations and literature searches for this study have indicated that, while there is quantified analysis of global health benefits and reductions in GHG emissions, available information in some other areas, such as private sector investments in more efficient processes and employment impacts, are on a more case study basis which does not provide us with a global and regional overview of the orders of magnitude of these impacts (see discussion in Annex 1). Therefore, research into these areas could be further developed in the future to expand our knowledge of wider economic and social impacts of the Montreal Protocol and provide an example to other MEAs of the full potential for co-benefits in the advancement of a global Green Economy.

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ANNEX 1: DATA REPORTING RELATED TO MONTREAL PROTOCOL AND MULTILATERAL FUND

This Annex briefly outlines the range of official reporting on the Montreal Protocol and discusses availability of information useful for assessing its contribution to a Green Economy. A number of institutions of the Montreal Protocol are responsible for publication of progress on a range of aspects of ODS phase-out. The key sources are as follows:

- Annual Reporting Requirements to the *Ozone Secretariat* by all Parties to the Montreal Protocol on import, export, production of controlled substances, ODS destroyed and trade with non-Parties (Article 7 data). There are also some other reporting requirements such as listing of reclamation facilities and their capacities, summary of activities for R&D, public awareness and information exchange, and some other items of regulation and strategy. The Ozone Secretariat also publishes reports for public outreach (for example, the review of exemplary projects in UNEP, 2007) and reference (for example, the Handbook for the Montreal Protocol (UNEP, 2009c).

- Article 5 Parties report annual data on their country programmes (CPs) to the Multilateral Fund Secretariat including: use by sector, imports, exports, and production of controlled substances; and, other information on progress being made in the implementation of the CP. Based on these data and those submitted to the Ozone Secretariat, the Fund Secretariat prepare an analysis of the status of compliance of Article 5 countries. The Fund Secretariat also produces an analysis of project completion reports (PCRs) containing a section on lessons learned and evaluation studies normally based on a specific sectors.

- *Implementing Agencies of the Multilateral Fund* including UNEP OzonAction produce their own reviews (e.g. UNEP, 2007 and UNIDO, 2010), publicity material (UNDP, 2007) and NOUs produce their own country focused materials.

- The three *Assessment Panels* for Scientific, Environmental, Technology, and Economic Assessments publish periodic assessments, usually every four years. The Technology and Economic Assessment Panel also produces a progress report every year reviewing the status of alternatives and technologies and addressing specific requests by the Parties.

- This report has also drawn on the wide range of academic, industry and other reporting by independent Parties.

The Montreal Protocol was originally very specifically focused on achieving phase-out of ODS consumption and production and not specifically aimed at promoting a Green Economy or sustainable development. This meant that data collection and analysis for the Protocol's wider co-benefits impacts (for example, via improvements in resource and energy efficiency) was not part of official reporting and evaluation from the start and, while there has been a steady expansion in reporting of the wider impacts the focus of this reporting remains quite limited for the purpose of this report.

In the case of the Multilateral Fund, the focus of the Funds Secretariat's review of projects proposals on production, consumption and trade of ODS is now expanding to consider climate and energy impacts in HCFC phase-out and is developing a climate impact indicator. However, other co-benefits are not systematically reported and, as noted in the UNIDO Independent Evaluation Review, it is assumed that project activities also enable the industries to achieve improved economic performance better product quality and reliability, and contribute positively to employment (UNIDO 2010). The UNIDO Evaluation Review addresses this issue and recommends the development of guidelines for the monitoring of Montreal Protocol projects in a broader context, including non-ODS effects. It also notes that the rules and guidelines of the MLF do not allow the use of funds for pursuing non-ODS outcomes "such as productivity, competitiveness, occupational health, or environmental issues additional to ODS phase-out". This stipulation may have inhibited to some extent the reporting of co-benefits of ODS phase-out projects under the MLF.

There has also been some widening in the focus of reporting by the Technology and Economic Assessment Panel (TEAP) over time. The exploration of the practicalities of ODS substitutes for different applications has increasingly considered cost issues having originally not referred to costs in early reports. However, in general it remains the case that some impacts of the Montreal Protocol of relevance to the Green Economy, such as employment, have not been systematically reported and the available evidence in the literature is largely based

36 http://ozone.unep.org/Data_Reporting/

37 http://www.multilateralfund.org/Evaluation/evaluationlibrary/default.aspx

38 Decision 19/6 of 2007 to accelerate HCFC phase out asked the MLF Executive Committee to prioritize alternatives which minimize other environmental impacts, such as global warming. The MLF now give guidance for HCFC management plans in country strategies (e.g. China -70% of HCFCs) and investment decisions now need to consider GWP and CO_2 saved of alternatives.
Report on The Multilateral Fund Climate Impact Indicator (Decisions 59/45, 62/62 AND 63/62) for 64th Meeting Montreal, 11-15 July 2011.

on case studies, which do not necessarily provide an understanding of the national or global order of magnitude of these impacts. Additionally, some such economic evidence is in itself difficult to gather where it concerns commercially confidential information from companies, e.g. levels of investment in innovations. Notwithstanding these challenges, this study draws together the available evidence from sundry sources to present an overview of our current understanding of the subject.

ANNEX 2: COST BENEFIT STUDIES OF MONTREAL PROTOCOL

This section outlines some of the main cost and benefit studies undertaken on the impacts of the Montreal Protocol. The results of these studies are referenced in the main report but here we provide more details and discussion of the methodologies and results.

Environment Canada Study
Although published in 1997 'the Global Costs and Benefits of the Montreal Protocol' study for Environment Canada (ACR, 1997) remains the most comprehensive global assessment of the impacts of the Montreal Protocol of its type currently available. This measured costs and benefits for measures taken internationally to protect the ozone layer, such as replacement of technologies using ozone-depleting substances. Its key conclusions, while based on rather general assumptions, are still valid in that they demonstrate the significance of global benefits compared to costs, and have been a useful contribution to understanding impacts of the Protocol in monetised form. This data has been used as a basis for more recent studies on specific impacts (e.g. the Velders et al. 2001 study). We therefore outline key findings of the study here.

Costs:
Incremental costs of the Montreal Protocol were calculated relative to the scenario of continued use of ODS using projected growth in their consumption. Cost impacts taken into account included R&D for alternatives to ODS, capital investment in changed processes and new facilities, and any additional material, energy or labour costs. Estimates were used in the study for average costs per kilogram of substituting ODS in a range of applications. The calculation of incremental costs also involved estimating the consumption of ODS had the Montreal Protocol not been implemented. Reasonable consumption growth estimates for different ODS were used for the period to 2060 but clearly these alternative "no Protocol" scenarios for consumption are a key area of uncertainty with any such model and such caveats are necessary when quoting there cost estimates. The total costs of the measures taken to protect the ozone layer were estimated to be 235 billion US (1997) dollars.

Benefits:
The benefits measured in the ARC study focused on damages avoided due to protection of the ozone layer provided by the Montreal Protocol. The main effects of no action would have been on human health but impacts on aquatic ecosystems, agricultural production and materials are also included in the study. These benefits are broken down in Table A2.1. Health benefits were quantified using dose response functions from the literature but were not valued in economic terms (only cases avoided). The total global economic benefits (excluding health benefits) were estimated to be US$ 459 billion over the period 1987 to 2060 (compared to the incremental cost of implementation of US$ 235 billion given above) and would have been much greater if health impacts had been given economic values. The study does not break down benefits between developed and Article 5 countries but does note that agricultural and aquatic ecosystem benefits of ozone depletion avoided are potentially very significant in developing countries due to the much greater dependence on agriculture and fisheries for livelihoods.

Table A2.1 Benefits of the Montreal Protocol (1987-2060)

BENEFIT	CASES	VALUATION
Human Health Benefits	**Reduced Cases (million)**	**Valuation from Velders *et al.* (2001) (US$ billion 1997)**
Non-Melanoma Cancer	19.1	573
Melanoma Cancer	1.5	45
Cataracts	129.1	93
Skin Cancer	0.3	1109
Economic Benefits		**Reduced damage from ARC (1997) (US$ billion 1997)**
Fisheries		238
Agricultural		191
Materials		30
Total Economic Benefits		459

Source Adapted from ARC (1997) and Velders et al. (2001)

The study by Velders *et al.* (2001) uses the ARC (1997) estimates for global benefits of the Montreal Protocol as a basis for estimating the monetary value of health benefits. Using relevant VOSL and WTP data this study estimates that taking account health benefit valuations the benefit/costs ratio would be about 11:1 compared about 2:1 for the estimate without health benefit valuations.

Other examples of cost benefit studies and compliance cost assessments for the Montreal Protocol are given in Table A2.2 below.

40 Note that the costs calculated for Article 5 (1) countries are all costs assessed over the period 1989 to 2060 not simply the costs eligible for Multilateral Fund financing.

41 The US EPA, 1999 study calculated valuations for health benefits in the case of the United States.

Table A2.2 Examples of cost benefit studies for Montreal Protocol

STUDY	FOCUS OF STUDY
Velders, *et al.* (2001) *Technical Report on Stratospheric Ozone Depletion*	Updates ARC (1997) global cost benefit study with health impact valuations
Philippe G. Le Prestre, John D. Reid and E. Thomas Morehouse, Jr. (eds) 1998. , *Protecting the Ozone Layer: Lessons, Models and Prospects*	Includes chapter by L. Kuijpers, *et al.*. "Global Benefits and Costs of the Montreal Protocol".
Smith & Vodden (1989). *Global Environmental Policy: The Case of Ozone Depletion*	Quantifies costs (increase in prices of controlled chemicals) and benefits (health) in Canada.
O'Conner (1991). *Policy and Entrepreneurial Responses to The Montreal Protocol: Some Evidence From The Dynamic Asian Economies*	Discussion of costs and benefits of CFC-113 and MCF phase-out for solvent applications in the electronic sectors of five dynamic Asian economies
O'Ryan, *et al.* (2006). *Chilean study of compliance costs*	Quantifies compliance costs of different policy options in Chile and concluded that costs were relatively affordable, varying between US$ 20 million and US$ 1 million under different policy scenarios.
Carpenter *et al.* (2000) *Economic Impact of the Scheduled U.S Phase-out of methyl bromide*	Estimated the costs impact in U.S. of restrictions on replacement substance (1,3-0) use after methyl bromide is phased out in 2005.
USDA (2000) *Economic Implications of methyl bromide Phase-out*	Analysis of economic impacts of using methyl bromide alternatives in terms of yield, cost, and regulatory limitations.
Vogelsberg (1996). *An Industry Perspective, -Lessons Learned and the Cost of CFC Phase-out*	*Ad hoc* industry evidence presented on global costs of ODS phase-out.
DeCanio (2003) *Economic Analysis, Environmental Policy, and Intergenerational Justice in the Reagan Administration: The Case of the Montreal Protocol*	Discussion of the adoption of the principle of *intergenerational neutrality* which had the consequence that the benefits of ozone layer protection far outweighed the costs of regulatory control.

ANNEX 3: CONSULTATION PROCESS

This report has benefited from the insights, opinions and information gathered during consultations with a range of experts from Montreal Protocol agencies, governments, industry and academia (as listed in the Acknowledgements). Experts were selected in consultation with UNEP counterparts and took part in semi-structured interviews while some completed questionnaires instead. Semi-structured interviews are common in qualitative research in a number of social science and policy contexts. They are a method of gathering information and views from individuals or small groups where broad questions are asked, which do not restrict the scope of the interview as much as structured surveys, and allow new questions to arise from the discussion.

The general questions for the semi-structured interviews are given below and were a starting point to help us focus on the interviewees area of experience of the Montreal Protocol and kick off a discussion about its contribution to the Green Economy. A number of respondents completed questionnaires, based on the questions below, instead of taking part in interviews.

1. What are your main areas of experience and knowledge in the contribution of the Montreal Protocol to the Green Economy?

(a) Economic sphere? This might include for example: (i) investment in manufacturing of non ODS chemicals and equipment/technologies, (ii) stimulation of more efficient production processes, (iii) driving innovation, (iv) Industrial rationalisation and economies of scale (v) stimulation of new industry sectors. etc.

(b) Social sphere? This might include: (i) employment, (ii) health.

(c) Environmental sphere? This might include: (i) ecosystem benefits, (ii) Reduced GHG emissions.

(d) Institutional sphere? This might include: (i) activities of MLF in technology transfer, (ii) capacity building activities.

2. For those areas where you have most experience and knowledge, what are the most significant contributions of the Montreal Protocol to the Green economy? (this could be in terms of types of contribution, sectors and locations)

3. What are the key sources of analysis and data for the most significant contributions identified in Q.2 (including official reporting and other studies)?

4. What are the key areas where the Montreal Protocol might contribute to the Green Economy in the future?

5. Any other comments or observations on contribution of the Montreal Protocol to the Green Economy?

About the UNEP Division of Technology, Industry and Economics

The UNEP Division of Technology, Industry and Economics (DTIE) helps governments, local authorities and decision-makers in business and industry to develop and implement policies and practices focusing on sustainable development.

The Division works to promote:

> sustainable consumption and production,
> the efficient use of renewable energy,
> adequate management of chemicals,
> the integration of environmental costs in development policies.

The Office of the Director, located in Paris, coordinates activities through:

> **The International Environmental Technology Centre** - IETC (Osaka, Shiga), which implements integrated waste, water and disater management programmes, focusing in particular on Asia.
> **Production and Consumption** (Paris), which promotes sustainable consumption and production patterns as a contribution to human development through global markets.
> **Chemicals** (Generva), which catalyzes global actions to bring about the sound management of chemicals and the improvement of chemical safety worldwide.
> **Energy** (Paris), which fosters energy and transport policies for sustainable development and encourages investment in renewable energy and energy efficiency.
> **OzonAction** (Paris), which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition to ensure implementation of the Montreal Protocol.
> **Economics and Trade** (Generva), which helps contries to integrate enviromental consideration sinto econimic and trade policies, and works with the finace sector to incorporate sustainable development policies.

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This global study addresses how and to what degree national, regional and international actions taken under the Montreal Protocol have also contributed to the restructuring of national economies and the global one towards a "Green Economy", defined as "one which achieves increasing wealth, provides decent employment, successfully tackles inequities and persistent poverty, and reduces ecological scarcities and climate risks".
More specifically, this study explores how the Montreal Protocol has contributed to the stimulation of more efficient production processes, driving innovation, industrial restructuring, job creation, trade, health and ecosystem benefits, and climate change mitigation.
Jointly developed by the UNEP DTIE OzonAction and Economics and Trade Branches, this report is intended as a case study contribution to UNEP's Green Economy Initiative with its findings informing the question of how different multilateral environmental agreement contribute to a Green Economy.

www.unep.org

United Nations Environment Programme
P.O.Box 30552 Nairobi, Kenya
Tel: ++254-(0)20-62 1234
Fax: ++254-(0)20-62 3927
E-mail: cpiinfo@unep.org

UNEP

For more information, contact:

UNEP DTIE
OzonAction Branch
15, rue de Milan
75441 Paris CEDEX 09
France
Tel: +33 1 4437 1450
Fax: +33 1 4437 1474
E-mail: ozonaction@unep.org
www.unep.org/ozonaction

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