

'This book is the story of why we can all be optimistic about the future if we are willing to be brave and dedicated world citizens.' Mario Molina, Nobel Prize in Chemistry

TECHNOLOGY TRANSFER FOR THE OZONE LAYER

Lessons for Climate Change

Stephen O. Andersen, K. Madhava Sarma
and Kristen N. Taddonio



Advance praise for *Technology Transfer for the Ozone Layer*

‘Imagine the pride of earning the Nobel Prize for warning that CFCs were destroying the ozone layer. Then imagine that citizens, policymakers, and business executives heeded the warning and transformed markets to protect the earth. This book is the story of why we can all be optimistic about the future if we are willing to be brave and dedicated world citizens.’

MARIO MOLINA, Nobel Laureate in Chemistry and Professor, University of California

‘In 2002 I characterized Andersen and Sarma’s *Protecting the Ozone Layer* as one of the most impressive environmental books ever written. Now, with Taddonio, they have produced a timely encore that should become one of the most important books for addressing climate change. This authoritative and meticulously researched treatise cuts to the heart of the problem: the crucial issues of technology research, development and diffusion that have been largely lost in the hot air of climate rhetoric. The authors rightfully put them centre-stage, and draw on the highly relevant success of the Montreal Protocol to provide detailed prescriptions for achieving an indispensable global energy technology revolution.’

AMBASSADOR RICHARD BENEDICK, US chief negotiator of the Montreal Protocol and author of *Ozone Diplomacy*

‘A major global achievement in the field of scientific understanding and effective policy has been the set of initiatives taken to save the ozone layer, which provides inspiration and a useful model for action in the field of climate change. This book is extremely valuable reading for policymakers and scholars alike particularly in the context of the challenge of climate change being faced globally.’

R. K. PACHAURI, Chairman, Intergovernmental Panel on Climate Change (IPCC) and Director General, The Energy and Resources Institute (TERI)

‘2007 is the 20th Anniversary year of the signing of the Montreal Protocol and there is cause for great celebration for the leadership of both developing and developed countries that led to the proper implementation of the Protocol. This book gives an authoritative account of how impossible challenges to the transfer of ozone-friendly technologies were overcome for the good of human society and ecosystems.’

MOSTAFA K. TOLBA, Under-Secretary-General, United Nations, and Executive Director, United Nations Environment Programme, 1976–1992

‘The lessons documented in this book show that solutions to climate change are attainable and in the global economic interest – if we accept the challenge and make the commitment to deal with it.’

ALAN MILLER, International Finance Corporation (IFC)

‘This book provides a forward-looking, substantive account of how technology transfer, at its best, collaboratively and cost-effectively enables countries to tackle the ozone layer issue – it demonstrates the relevance of lessons learned from the Montreal Protocol to environmental issues faced today.’

MARIA NOLAN, Chief Officer of the Multilateral Fund Secretariat

‘The success of the Montreal Protocol has been supported by unprecedented technology development and transfer under the international collaboration. Japanese chemists and engineers are very proud of their voluntary participation in protecting the ozone layer for future generations. We believe the lessons learned during these twenty years help the technological challenge for the climate change. Lift your spirits up by reading how technology transfer can save the Blue Planet again.’

MASAAKI YAMABE, National Institute of Advanced Industrial Science and Technology, and Asahi Glass Company, Japan

‘The authors have dedicated their entire personal capacity and lives to the fight for a better environment for all. Without their intelligence and dedication, the Montreal Protocol’s unique success would not be there. In this book they extend their wisdom and experience to guide actions on our most serious environmental challenge: climate change. Having negotiated intensively in both of the environment regimes for more than a decade, I can assure you that this guidance is badly needed. I urge everyone to study carefully the valuable lessons from these eminent writers and implement them expeditiously.’

JUKKA UOSUKAINEN, Acting Director General, International Affairs Unit, Ministry of Environment, Finland

‘Stephen Andersen and Kristen Taddonio of the EPA and Madhava Sarma of the Ozone Secretariat (retired) do an excellent job showing the many ways that voluntary partnerships speed global environmental protection. Programmes like the Energy Star label on efficient products and initiatives under the Montreal Protocol have produced dramatic results. Imagine what we can accomplish as we continue to transfer technology to protect the climate.’

KATHLEEN HOGAN, Director, EPA Climate Protection Partnerships Division

‘A highly informative, well researched compendium of technology transfers effected under the Montreal Protocol, written by authors who have traversed the length and breadth of this successful environment treaty. Stakeholders of current and future global environment treaties will be vastly benefited when they study the whole process of technology transfers effected under the Montreal Protocol to phase out ozone depleting substances.’

ARUN BHARAT RAM, Chairman and Managing Director, SRF Limited (a leading Indian chemical company)

Technology Transfer for the Ozone Layer

Technology Transfer for the Ozone Layer

Lessons for Climate Change

Stephen O. Andersen, K. Madhava Sarma
and Kristen N. Taddonio



EARTHSCAN

London • Sterling, VA

First published by Earthscan in the UK and USA in 2007

Copyright © K. Madhava Sarma, 2007

This book has not been subjected to publication review by the U.S. Environmental Protection Agency (EPA). The views of the authors presented here do not necessarily represent the views or policy of the United States Government, the EPA, or the Global Environment Facility (GEF); no official endorsement should be inferred. The views expressed by individual authors are their own. The authors and EPA do not make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or utility; nor do they assume any liability of any kind whatsoever resulting from the use or reliance upon any information, material, or procedure contained therein. Mention of tradenames, products, or services does not convey official EPA or author approval, endorsement, or recommendation.

All rights reserved

ISBN: 978-1-84407-473-0

Typeset by MapSet Ltd, Gateshead, UK

Printed and bound in the UK by Antony Rowe, Chippenham

Cover design by Nick Shah

For a full list of publications please contact:

Earthscan

8–12 Camden High Street

London, NW1 0JH, UK

Tel: +44 (0)20 7387 8558

Fax: +44 (0)20 7387 8998

Email: earthinfo@earthscan.co.uk

Web: www.earthscan.co.uk

22883 Quicksilver Drive, Sterling, VA 20166-2012, USA

Earthscan publishes in association with the International Institute
for Environment and Development

A catalogue record for this book is available from the British Library

Library of Congress Cataloging-in-Publication Data

Andersen, Stephen O.

Technology transfer for the ozone layer : lessons for climate change / Stephen O. Andersen,
K. Madhava Sarma, and Kristen Taddonio.

p. cm.

“Sequel and complement to *Protecting the Ozone Layer: The United Nations History*.”

Includes bibliographical references and index.

ISBN-13: 978-1-84407-473-0 (hardback)

ISBN-10: 1-84407-473-0 (hardback)

1. Ozone-depleting substances. 2. Ozone layer depletion—Prevention—History—20th century. 3. Technology transfer. I. Sarma, K. Madhava, 1938- II. Taddonio, Kristen. III. Andersen, Stephen O. the United Nations history. *Protecting the ozone layer* : IV. Title.

TD887.O95A63 2007

363.73875526—dc22

2007021491

The paper used for this book is FSC-certified and totally chlorine-free. FSC (the Forest Stewardship Council) is an international network to promote responsible management of the world's forests.

Contents

<i>List of figures, tables and boxes</i>	<i>xii</i>
<i>About the authors</i>	<i>xvi</i>
<i>Foreword</i> by Monique Barbut	<i>xix</i>
<i>Preface</i> by Achim Steiner	<i>xxi</i>
<i>Acknowledgements</i>	<i>xxiv</i>
<i>Introduction</i> by Marco Gonzalez	<i>xxvii</i>
1 Prologue	1
2 Contours of technology transfer	5
Introduction	5
Technology transfer as a positive measure	5
What is technology transfer?	5
Early lessons in technology transfer	7
Pathways and stakeholders	11
Facilitating technology transfer for environmental protection:	
Theory and observations	17
Conclusion	21
3 Background of the ozone and climate agreements	23
The science of ozone depletion	23
The increasing use of ozone-depleting substances	27
Governments and UNEP respond to the scientific findings on ODSs	28
The Montreal Protocol on Substances that Deplete the Ozone Layer, 1987	29
The role of the Multilateral Fund	31
The role of the Global Environment Facility	33
Results of Protocol implementation	34
Status of the ozone layer today	34
The science of climate change	35
The United Nations Framework Convention on Climate Change of 1992	38
The Kyoto Protocol	39
Climate protection from the ODS phaseout	41
4 Technology change in developed countries	45
Introduction	45
Cooperation in industrialized countries set the stage for worldwide technology cooperation under the Montreal Protocol	45

Industry and military motivations for leadership on ozone protection	49
Commercialization of alternatives	50
Cost of the ODS phaseout was less than predicted	71
Conclusion	71
5 Military and space agency leadership to protect the ozone layer	73
The history of the use of ODSs by military and space agencies	73
Military motivation for leadership	78
Early military leadership	79
Military technical leadership	83
Military contribution to the phaseout of ozone-depleting electronics and aerospace solvents	89
Application of aerospace technology to solve ODS elimination challenges – A ten-year quest	92
Military leadership in the phaseout of ozone-depleting refrigerants	96
Vintaging	97
Essential use exemptions	99
Halon banks	99
The role of government agencies as customers and market leaders	100
The challenge for governments	101
Workshops by NATO	102
Useful phaseout strategies adopted	103
Conclusion	104
6 Technology transfer to phase out ODSs in foams	105
Introduction	105
A brief history of ODS foam	105
Technical description of foam design, manufacturing and use	106
Early voluntary phaseout of polystyrene rigid foam	107
Factors that influenced choice of technologies	107
Sustainability, suitability and the environmental properties of alternative technologies	115
Technologies selected in developing countries	117
Technologies selected in countries with economies in transition	120
Specific experiences with alternative technologies	121
Conclusion	129
7 Technology transfer to phase out ODSs in refrigeration and air-conditioning	131
Difficult decisions: The history of refrigerant choice	131
Refrigeration and air-conditioning: Technical options and choices for the CFC phaseout	138
Current status of each refrigeration sector	140
What technologies did CEIT and developing country enterprises select, and why?	146
Conclusion	152

8	Technology transfer to phase out ODSs in aerosol products	155
	Background and introduction	155
	Not-in-kind alternatives to aerosol products	156
	Examples of aerosol products that contained CFC propellants and alternatives for each application	159
	The Technology and Economic Assessment Panel and its Technical Options Committees	165
	Aerosol products technology transfer by the MLF	165
	Aerosol products technology choices by CEITs in GEF projects	169
	Sterilants and miscellaneous CFC uses	172
	Lessons learned from MLF technology transfer activities	173
	Conclusion	174
9	Technology transfer to phase out ODSs in fire protection	175
	History of halons as fire extinguishing agents	175
	Types of halon alternatives for total flooding and local application systems	177
	Types of halon alternatives for portable extinguishers	178
	Evaluation by the MLF of the halon phaseout in developing countries	179
	Halon banking, recovery and recycling	182
	Halon phaseout and management in CEITs	184
	Conclusion	187
10	Technology transfer to phase out ODSs in solvents	189
	Introduction and history of the use of ODSs as solvents	189
	Technical options for phasing out ozone-depleting solvents	191
	Solvent technology choices made in CEITs and developing countries	202
	Examples of specific technologies implemented in CEITs and developing countries	205
	Solvent technology cooperation outside the funding mechanism	213
	Conclusion	213
11	Technology transfer to phase out ODSs in pest control	215
	<i>Melanie Miller and Marta Pizano</i>	
	Introduction	215
	Montreal Protocol controls	215
	Major uses of methyl bromide	217
	Identification of alternative technologies and major challenges	219
	Types of technologies adopted	220
	Technology transfer and change in developed countries	225
	Technology transfer and change in CEITs and developing countries	238
	Additional activities that affected technology transfer and change	244
	Experiences and barriers in technology transfer projects	247
	Remaining challenges	250
	Factors that assisted adoption of alternative technologies	251
	Conclusion	252

12	Barriers to technology transfer faced by CEITs and developing countries	255
	Introduction	255
	Technology transfer priorities: Outcomes of the 1992 Earth Summit and the 2002 World Summit on Sustainable Development	255
	Technology transfer problems that arose during the implementation of the Montreal Protocol	257
	What experience shows about actual barriers to technology transfer	266
	Conclusion	268
13	Awareness and capacity-building	269
	<i>Rajendra Shende and Tilman Hertz</i>	
	Introduction	269
	Technology transfer and capacity-building	269
	Awareness raising	275
	Information exchange	276
	Training and networking	277
	Institutional strengthening	278
	Strategic reorientation of OzonAction to facilitate the technology transfer: CAP (Compliance Assistance Programme)	279
	Case studies of technology transfer enabling tools in action	282
	Lessons learned	284
	OzonAction pointers for other multilateral environmental agreements	285
	Case study: Greenpeace's pioneering advocacy of natural refrigerants	286
	Conclusion	292
14	Lessons	293
	Introduction	293
	Lesson 1: Act now	297
	Lesson 2: Develop visionary technology assessment	300
	Lesson 3: Encourage leadership by multinational and domestic enterprises	303
	Lesson 4: Identify and involve all stakeholders, and develop local and international partnerships	304
	Lesson 5: Raise awareness	306
	Lesson 6: Require country programmes from each developing country, with specific voluntary goals towards green growth	307
	Lesson 7: Empower the financial mechanism to be a proactive instrument for technology transfer	310
	Lesson 8: Create focal points and networks	313
	Lesson 9: Develop and implement training programmes	314
	Lesson 10: Use regulations and policies to promote technology transfer	315
	Lesson 11: Remove legal and institutional barriers and improve systems of governance	318

Lesson 12: Use public procurement to promote alternatives	319
Conclusion	319
<i>Appendix 1 Control measures of the Montreal Protocol</i>	
<i>Appendix 2 Indicative list of categories of incremental costs</i>	323
<i>Appendix 3 List of project completion reports studied</i>	327
<i>Appendix 4 A technology transfer agreement</i>	329
<i>Appendix 5 List of military ODS management and phaseout initiatives in the US</i>	335
<i>Appendix 6 Useful websites for information on military phaseout</i>	340
<i>Appendix 7 Ozone and climate protection awards won by military organizations</i>	343
<i>Notes</i>	
<i>List of acronyms and abbreviations</i>	351
<i>Glossary</i>	379
<i>About the contributors</i>	385
<i>Index</i>	393
	403

List of Figures, Tables and Boxes

FIGURES

2.1	Factors that lead enterprises to adopt or reject new technologies	15
3.1	Effect of each Montreal Protocol control measure	42
3.2	Effective stratospheric chlorine	42
3.3	Radiative forcing of ODSs and CO ₂	43
3.4	Emissions of ODSs and CO ₂	43
4.1	European Community HCFC consumption	60
5.1	Comparison of the ozone depletion potential (ODP) of halons and CFC-12	75
5.2	NASA's reusable solid rocket motor ODS elimination programme overview	92
5.3	Total solid rocket motor TCA usage/reduction history	93
6.1	Foam technology innovation	111
6.2	Ozone depletion potential tonnes phased out by alternative foam-blowing technologies	118
6.3	Evolution of foam technology choice in developing countries	119
6.4	Technology selection and project size	119
7.1	Refrigerant choice in MLF projects	146
10.1	Consumption reduction approved and number of enterprises using ozone-depleting solvents	204
11.1	Example of equipment used for applying alternative pesticide products via modified drip irrigation systems in Italy	221
11.2	Production of carnation flowers in bags filled with local substrate materials in Kenya	222
11.3	National methyl bromide consumption in the US, the EC, Japan and Israel, 1991–2007	225
11.4	EC consumption of methyl bromide, indicating limits established by the Montreal Protocol and EC regulations, 1991–2005	235
11.5	Nominated and authorized methyl bromide consumption for CUEs in the EC, 2005–2007	236
11.6	An example of public information materials	243
13.1	Regional breakdown of country programmes prepared with assistance from UNEP	274
13.2	Regional networking map	278

TABLES

2.1	Similarities and differences between environmental technology and other technologies	10
2.2	Stakeholders	16
3.1	Ozone-depleting substances and sectors where used	27
4.1	Industry motivation to speed protection of the ozone layer	50
6.1	Uses of ODSs in foams	107
6.2	MLF cost-effectiveness thresholds	112
7.1	Flammable and toxic refrigerants in use before CFCs	132
7.2	Refrigerant choices to replace CFCs, 1990–2005	139
7.3	Environmental impacts and atmospheric lifetimes of selected refrigerants	140
8.1	Some examples of substitutes for ODS aerosol products	157
8.2	Costs of transfer of patented MDI technologies	163
10.1	Advantages and disadvantages of alternatives to CTC, CFC-113 and TCA	192
10.2	Solvents selected to replace CFC-113, TCA and CTC in China	203
11.1	Main uses of methyl bromide pesticide products (fumigant)	218
14.1	Comparison of the technical assessment bodies for the Montreal Protocol and the UNFCCC	302

BOXES

2.1	Technology transfer in the Montreal Protocol, UN Framework Convention on Climate Change and Kyoto Protocol	6
2.2	Definitions of technology transfer	7
2.3	From technology transfer to technological learning and capabilities	8
2.4	Stages of technology transfer	11
3.1	The dual benefit of the Montreal Protocol: Ozone and climate protection	42
4.1	Development of HCFC-225	47
4.2	Crisis and opportunity for Daikin	49
4.3	Creativity and challenge: The Seiko Epson saga for protection of the ozone layer	51
4.4	Japanese support for phaseout of ODSs in small and medium-sized enterprises	56
4.5	European Union leadership on HCFCs	58
4.6	Governmental support for ODS phaseout in Japan	61
4.7	The first voluntary national sector phaseout	62
4.8	Technology transfer for household refrigerators in Thailand	63
4.9	Industrial cooperation on phasing out ODSs in Japan	67
4.10	Japanese support the total ODS phaseout by CEITs and developing countries	68
4.11	Japanese leadership in training CEITs and developing country experts	69

4.12	The Montreal Protocol Partnership Strategy is alive and well in climate protection	70
5.1	Specific applications for some halons	76
5.2	Halon use in aircraft, ships and other vehicles	76
5.3	Military use of ozone-depleting solvents	77
5.4	The challenge of finding replacements	78
5.5	Perspective on the need for early action to phase out halons and ODSs	79
5.6	Decisive action by the US DoD	80
5.7	Dedication to fire protection and ozone protection	81
5.8	US military transfer of halon recovery and recycling technology	84
5.9	Halon usage and management in India's aviation sector	87
5.10	NASA leadership to eliminate ozone-depleting solvents	91
5.11	Eliminating ODSs in solid rocket motors	95
5.12	Eliminating ODSs from the processes used to manufacture Space Shuttle solid rocket motors	96
5.13	The CFC phaseout leads to superior technology	97
5.14	The US Department of Defense ODS Reserve	100
5.15	US Navy clearinghouse helps to coordinate ODS phaseout	102
5.16	Ozone and climate protection conferences	103
6.1	The US EPA Energy STAR™ and High GWP Partnerships grew out of Montreal Protocol cooperation	108
6.2	The EU green leadership	109
6.3	Technology change in the Japanese foam industry	109
6.4	Technology change in the domestic refrigerator and freezer industry	111
6.5	The TEAP Foams TOC	116
6.6	Quotes from the project completion reports of the GEF and MLF illustrating the reactions to LCD foam technology	125
6.7	Quotes from the project completion reports of the MLF illustrating the reactions to water foam technology	126
7.1	Coca-Cola's impact in India	135
7.2	The first Japanese manufacturer of HFC-134a automotive air-conditioners	136
7.3	History of the birth of non-CFC refrigerators in Japan	137
7.4	Case study of Matsushita supported by Greenpeace Japan	138
7.5	The birth of ozone- and climate-friendly refrigerators in Japan	141
7.6	Using life-cycle climate performance to assess and minimize climate impacts of ODS substitutes and alternatives	144
7.7	Reasons why enterprises were unlikely to revert to ODSs after switching to HFC-134a: Explanations offered in MLF project completion reports	148
8.1	Phaseout of CFC-MDIs in Japan	161
8.2	Conversion in India	170
8.3	Case study: Phasing out CFCs in the aerosol sector in Russia	171
9.1	Study of halon recovery and regeneration in Hungary	185
10.1	Japanese development of HFE (hydrofluoroether)	196
10.2	Industry leadership in Japan for phasing out TCA	197

10.3	Ozone-safe technical preferences for metal cleaning	198
10.4	Overcoming technical difficulties at Tsvetotron Brest, Belarus	207
10.5	Japan/India bilateral CTC phaseout project	212
11.1	Rapid adoption of not-in-kind technology: Example of tobacco seedlings	223
11.2	Technical leadership by post-harvest fumigation enterprises	226
11.3	Technical leadership by soil fumigation enterprises	227
11.4	Information dissemination in Italy	228
11.5	Technology transfer activities and levies in Australia	230
11.6	Technology transfer and regulatory activities in Japan	231
11.7	Impact of agricultural production standards in Almería, Spain	232
11.8	Early phaseout of methyl bromide in soil sector in The Netherlands	233
11.9	Early action for ozone protection in Denmark	234
11.10	Policy driving change: Fumigation of homes in California	234
11.11	Policy-led technology change in the European Community	235
11.12	Technology transfer in Argentina and Brazil	241
11.13	National plans and policy development in CEITs	242
11.14	Technology transfer activities in Jordan	245
11.15	Technology transfer in China's strawberry sector	246
12.1	Intellectual property and access to technology	256
12.2	Quotes from project completion reports indicating intellectual property rights-related problems	263
12.3	South Korea intellectual property rights case study	264
12.4	Lessons learned by implementing agencies	267
13.1	The 1992 Rio Declaration on Environment and Development	270
13.2	Partnership changing the world through well-defined technology transfer mechanisms: The Asia–Pacific experience	271
13.3	UNEP's instrumental role in raising awareness about the importance of ozone layer protection	275
13.4	Websites for ozone protection partnerships and programmes	276
13.5	Examples of enabling tools for the aerosol sector	280
14.1	The lessons	320

About the Authors

Stephen O. Andersen

Director of Strategic Climate Projects, Climate Protection Partnerships Division, US Environmental Protection Agency



Stephen O. Andersen began work on climate and ozone layer protection in 1974 as a member of the Climatic Impact Assessment Project on the effects of supersonic aircraft. With K. Madhava Sarma, he is author of *Protecting the Ozone Layer: The United Nations History* and, with Durwood Zaelke, *Industry Genius: Inventions and People Protecting the Climate and Fragile Ozone Layer*. Prior to joining the US Environmental Protection Agency (EPA), he worked for environmental and consumer non-governmental organizations (NGOs) and was a professor of environmental economics. In 1986, he joined the fledgling EPA Stratospheric Protection team, working his way up to Deputy Director. Since 1988, he has been Co-chair of the Technology and Economic Assessment Panel and has also chaired the Solvents Technical Options Committee, the Methyl Bromide Interim Technology and Economic Assessment and the Task Force on the Implications to the Montreal Protocol of the Inclusion of HFCs and PFCs in the Kyoto Protocol. He was co-editor of the IPCC/TEAP Special Report 'Safeguarding the Stratospheric Ozone Layer and the Global Climate: Issues Relating to Hydrofluorocarbons and Perfluorocarbons'. He pioneered voluntary programmes to phase out CFC food packaging, recycle CFCs from vehicle air conditioning, halt testing and training with halon, and accelerate CFC solvent phaseout in electronics and aerospace. He created the EPA ozone and climate protection awards and helped found the Industry Cooperative for Ozone Layer Protection and the Halons Alternative Research Corporation. He helped negotiate the phaseout of CFC refrigerator manufacturing in Thailand and the corporate pledge to help Vietnam avoid dependence on ozone-depleting substances (ODSs). He served on the team that commercialized no-clean soldering and the team phasing out ODSs from solid rocket motors. He is the recipient of numerous awards, including the 1990 EPA Gold Medal, the 1995 Fitzhugh Green Award, the 1995 UNEP Global Stratospheric Ozone Protection Award, the 1996 Sao Paulo Brazil State Ozone Award, the 1998 US

EPA Stratospheric Ozone Protection Award, the 1998 UNEP Global 500 Roll of Honour, the 1998 Nikkan Kogyo Shimbun Stratospheric Protection Award, the 1999 Vietnam Ozone Protection Award, the 2000 Mobile Air Conditioning Society Twentieth Century Award for Environmental Leadership, the 2001 US DoD Award for Excellence and the 2007 US EPA Best-of-the-Best Stratospheric Ozone Protection Award. He has a PhD from the University of California, Berkeley.

K. Madhava Sarma

formerly Executive Secretary, Secretariat for the Vienna Convention and the Montreal Protocol, United Nations Environment Programme



K. Madhava Sarma is currently a consultant on ozone issues and integration of the common aspects of global environmental treaties for greater synergy. With Stephen O. Andersen, he authored *Protecting the Ozone Layer: The United Nations History* (Earthscan, co-published by UNEP, 2002). He was the Executive Secretary of the Secretariat for the Vienna Convention and the Montreal Protocol from 1991 to 2000. During his tenure as Executive Secretary, he served the Parties to the Protocol through the turbulent Meetings of the Parties in Copenhagen, Vienna,

Montreal, and Beijing – including three replenishments of the Multilateral Fund for the Implementation of the Montreal Protocol. He streamlined the administration of the institutions of the Protocol, the reporting requirements and other administrative obligations so that Parties could devote their full attention to resolving challenging political issues. Prior to being recruited to head the Secretariat, Madhava Sarma was a senior member of the Indian diplomatic team involved in the Montreal Protocol negotiations between the first and second Meetings of the Parties (1989–1991). During this time, he was often an effective spokesman for the developing country perspective and cosponsored many of the provisions of the London Amendment that satisfied developing countries while creating enforceable obligations to protect the ozone layer. He made other significant contributions as the senior Indian official looking after environmental policy, law, institutions and international cooperation, including responsibility for all global environmental issues. Prior to joining the national Government of India, he served (as a member of the Indian Administrative Service) as Head of District Administration, State Water Supply Board, and as Secretary to the Government, Irrigation and Power. During this state tenure, he was responsible for planning and implementation of many water supply, irrigation and energy projects. He earned the 1996 US EPA Stratospheric Ozone Protection Award and a 1995 award from UNEP ‘For Extraordinary Contributions to Ozone Layer Protection’, and the 2007 US EPA Best-of-the-Best Stratospheric Ozone Protection Award.

Kristen N. Taddonio**Project Director, Climate Protection Partnerships Division,
US Environmental Protection Agency**

Kristen N. Taddonio is Manager of Strategic Climate Projects at the US Environmental Protection Agency (US EPA) Climate Protection Partnerships Division. She organizes public–private partnerships for environmental innovation, harmonizes international standards to speed technology market penetration, and directly promotes technology transfer with information, leadership pledges and conferences. In the Climate Protection Partnerships Division she brought together a team of international experts from industry, government, military, and standards

organizations who are removing global barriers to climate-friendly refrigerants. The success of her team will allow vehicle manufacturers to market environmentally superior technology worldwide with confidence and safety. Her partners are from Australia, Austria, Belgium, France, Germany, India, Italy, Japan, Netherlands and the United States. At the EPA, she manages an annual budget of more than US\$600,000 and organizes the annual Climate Protection Awards, which were established in 1998 to recognize exceptional leadership, outstanding innovation, personal dedication and technical achievements in climate protection. Prior to her latest promotion, she was a technical writer and a marketing associate for the Energy Star programme for new homes. She earned a Masters Degree in International Science and Technology Policy and a Bachelors Degree in International Environmental Resources from the George Washington University's Elliot School of International Affairs, where she graduated *summa cum laude*. She has also earned degrees in Scientific and Technical Communication and Liberal Arts. Her papers have been featured in plenary sessions of conferences and workshops in Austria, France, India, Italy, Japan and the US. She is Co-chair of the United Nations Task Force on the Legacy of the Technology and Economic Assessment Panel (TEAP) of the Montreal Protocol (Report published April 2007, United Nations Environment Programme, and Nairobi, Kenya). In 2007, the Mobile Air Conditioning Society–Worldwide presented Kristen Taddonio with the Government Partner of the Year Award.

Foreword



Throughout the world, the Montreal Protocol is viewed as a great success and a tribute to institutions, countries, and individuals that made it happen. We at the Global Environment Facility (GEF) are proud of our role in supporting countries with economies in transition (CEITs) in their efforts to implement the Montreal Protocol. We are encouraged by these countries' successes and welcome the opportunity to show how technology transfer and financing can solve the many daunting challenges of global environmental protection.

The GEF – the largest funder of environmental protection in developing countries and economies in transition – was created in 1991, at a time when it was clear that Russia and the Newly Independent States and the other countries of Central and Eastern Europe would need the global community's support to meet their obligations to phase out ozone-depleting substances under the Montreal Protocol.

Responding to the appeal of the Parties to the Protocol, the GEF provided financial assistance to them at a crucial juncture and enabled them to implement the Protocol. In 15 years, from 1991 to 2006, these countries have decreased their consumption of ozone-depleting substances from about 296,000 tonnes to 350 tonnes – a reduction of over 99 percent.

Global environmental problems cannot be treated in isolation. At the GEF, we increasingly work with countries to intervene across domains to address climate change, biodiversity conservation, sustainable land management and chemicals management, including pollution of international waters from persistent organic pollutants (POPs).

The GEF strategies for climate change, POPs and ozone layer-depletion are indicative of the flexibility that we exercise. Within each domain of intervention, project developers are encouraged to seek synergies and co-benefits with the other areas: for example, between ozone and POPs, or between climate change and ozone. This ability to work across global environmental issues is one of the greatest strengths of the GEF.

There are two potential ways in which the phaseout of ozone-depleting substances might increase the risk of climate change: using substitutes that have a high global warming potential; and introducing less energy-efficient technologies. Therefore, the focus of GEF's work has been to help the countries transfer from ozone-depleting substances to both ozone-safe and climate-safe options. The GEF funds the conversion to technologies that have the least impact on

global warming while being technically feasible, environmentally sound and economically acceptable.

The book also points out another important dimension of GEF's work: bridging the environment and development for sustainable development. It shows that technology conversions in many enterprises were instrumental in helping a number of sectors to modernize and adapt to a market economy.

I am pleased that the authors are recording this vital technology transfer story. A performance study of GEF has praised the Montreal Protocol process for its emphasis on clear goals and for creating an enabling environment for alternatives. The authors of this book have succeeded in bringing out the best from this process. I hope that the stakeholders of climate and other treaties will examine these lessons and adopt those that are suitable for their circumstances.

Monique Barbut

CEO and Chairperson

Global Environment Facility

Washington DC

June 2007

Preface



This is the first authoritative account of how technology was transferred worldwide under the Montreal Protocol. It tells the remarkable story of how governments, industry, consumers and the concerned public can, when faced with an environmental change crisis that threatens the health of the planet, work quickly and creatively to transform markets. As such it holds lessons on how to deal with other mutual and common challenges facing the environment, livelihoods, economic stability and human health across a wide range of spheres.

The story of the Montreal Protocol is worth repeating in all its detail. The Montreal Protocol of 1987 was the first convention based on the precautionary approach and the concept of a ‘common but differentiated responsibility’. The preamble of the Protocol says the Parties to the Protocol are:

Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations and bearing in mind the developmental needs of developing countries,

Acknowledging that special provision is required to meet the needs of developing countries, including the provision of additional financial resources and access to relevant technologies, bearing in mind that the magnitude of funds necessary is predictable, and the funds can be expected to make a substantial difference in the world's ability to address the scientifically established problem of ozone depletion and its harmful effects,

These strategies were later made explicit in the 1992 Earth Summit in Rio de Janeiro as Principles 7 and 15 of the Rio Declaration and have been followed by virtually every environmental Convention since.

Piloted by UNEP, the Montreal Protocol allowed developing countries more time than developed countries to implement the control measures so that alternative technology would be mature and affordable. Developing countries had the advantage of ‘leapfrogging’ over alternatives that entered the market early but were soon made obsolete by technical progress. In 1990, on the urging of developing countries, developed countries agreed to finance the incremental costs of the phaseout in developing countries with its own financial mechanism

called the Multilateral Fund. In 1991, the Global Environment Facility (GEF) was created by the Governments to deal with a wide range of global environmental issues, including ozone depletion. The GEF financed the incremental costs of those eligible countries not qualifying for financing under the MLF, including the countries of Eastern Europe and central Asia with economies in transition. The original control measures of the 1987 Protocol were repeatedly strengthened by the Parties to the Protocol on the basis of periodic scientific and technological assessments to provide for the phaseout of nearly a hundred ozone depleting chemicals on a specified time schedule.

The success of the Protocol is now acknowledged by all, even though the phaseout of the ozone-depleting chemicals is by no means complete. 190 governments have ratified the Protocol and are actively committed to phasing out ozone-depleting chemicals. The Fund to date has granted more than US\$2.1 billion to the developing countries to switch to ozone-friendly solutions. The GEF has assisted the CEIT to the tune of US\$200 million. Technological cooperation over the last 20 years has led to outstanding reductions of over 95 per cent in the consumption of ozone-depleting chemicals. Continuing scientific observations through satellites, balloons and ground-based observation have confirmed this reduction, as elaborated in the periodic reports of the Scientific Assessment Panel.

Protection of the ozone layer involved a large number of stakeholders. Many United Nations organizations did their part, including: the United Nations Development Programme (UNDP); United Nations Environment Programme (UNEP); United Nations Industrial Development Organization (UNIDO); World Health Organization (WHO); World Meteorological Organization (WMO); Food and Agriculture Organization (FAO); and Regional Economic and Social Commissions. International financial institutions, such as the World Bank and the Global Environment Facility, and national financial institutions also played an invaluable part in implementation. Industry and industrial organizations eschewed their usual competitive spirit and shared technologies and techniques to phase out ozone-depleting chemicals. Non-governmental organizations not only kept an alert eye on the issue and sounded the alarm when necessary, but also developed ozone-safe technologies and spread awareness about such technologies. National governments employed many regulatory, economic and policy instruments to achieve the phaseout as planned.

Does the success of the Montreal Protocol process suggest any advice for other global environmental treaties? While the treaties differ from one another, there are many common strands among them. Most, if not all, treaties aim at replacing some of the current environment-unfriendly technologies with environmentally sound technologies. The challenges posed to the Earth's environment by some issues (like climate change) are so serious that the world community has to adopt the new technologies as soon as possible in all the countries.

This is precisely the challenge met by the Montreal Protocol process. It would be sensible for the world community to study the process and adopt its useful features so that time is not lost by reinventing the wheel with every

convention. This study will also be relevant to UNEP's Bali Strategic Plan for Technology Support and Capacity-building.

I am grateful to Stephen O. Andersen, who has been a co-chair of the Montreal Protocol's Technology and Economic Assessment Panel (TEAP) since its inception 18 years ago; Madhava Sarma, who served as the Executive Secretary of the Secretariat for the Vienna Convention and the Montreal Protocol for more than nine years; and to Kristen Taddonio, for agreeing to put together this book. It was a labour of love for them. They obtained contributions to this study from many of the people who made it a triumph. It is a timely contribution on the occasion of the twentieth anniversary of the Montreal Protocol.

I hope this history and analysis will please all those who contributed to the success of the ozone agreements, serve as an authentic record of one of the world's great achievements and assist other Conventions in their way forward.

Achim Steiner

Executive Director

United Nations Environment Programme

Under Secretary-General, United Nations

- [download online Diamond \(Hetty Feather\) for free](#)
- [read Scepticism \(The Selected Works of Arne Naess, Volume 2\)](#)
- [read The Tailgating Cookbook: Recipes for the Big Game for free](#)
- [download online Adbusters, Issue 61: Art Fart online](#)
- [click Hard Bop: Jazz and Black Music 1955-1965](#)
- [read online Mayo Clinic on Arthritis: How to Manage Pain and Live an Active Life](#)

- <http://thewun.org/?library/Sherlock-Holmes-and-Philosophy--The-Footprints-of-a-Gigantic-Mind--Popular-Culture-and-Philosophy-.pdf>
- <http://drmurphreesnewsletters.com/library/Food-Gift-Love--More-than-100-Recipes-to-Make--Wrap--and-Share.pdf>
- <http://tuscalaural.com/library/How-to-Kill-a-Dragon--Aspects-of-Indo-European-Poetics.pdf>
- <http://tuscalaural.com/library/Adbusters--Issue-61--Art-Fart.pdf>
- <http://hasanetmekci.com/ebooks/Collage-in-Twentieth-Century-Art--Literature--and-Culture--Joseph-Cornell--William-Burroughs--Frank-O-Hara--and->
- <http://drmurphreesnewsletters.com/library/Er-ist-wieder-da.pdf>