DeCIPHER: The Saga of CFCs, Ozone Depletion, and Climate Change

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Bass Connections in Energy & Environment

Key Actors: Research, Government, Industry, Advocacy, News Media

Decisions on Complex Interdisciplinary Problems of Health and Environmental Risk

This year's DeCIPHER team examined the history of CFC decision-making through the lens of 5 key acts or 'decision nodes' — crucial moments in the narrative arc of risk and refrigerants that allowed project members to study competing interests of influential stakeholders or actors through background research, expert interviews, a role-playing decision theater and retrospective analysis.

DeCIPHER Roles: Background Research, Retrospective, Expert Interviews

Act I: Birth of CFCs
1920s to 1950s

1930: CHAPMAN MECHANISM
Chapman develops theory to explain presence of ozone layer

1957: INT'L GEOPHYSICAL YEAR
Worldwide network of ozone stations created

1928: CFC SYNTHESIS
Midgley, Henne, & McNary invent CFCs

1930: CFC BOOM
CFCs enter refrigerators, air-conditioners & aerosols

Act II: Ozone Depletion
1960s to 1970s

1960s: OZONE DESTRUCTION
Scientists search for destructive trace gases to explain low ozone levels

1978: U.S. CFC BAN
U.S. bans non-essential CFC aerosol products

1973: CFC ACCUMULATION
Lovelock detects CFC build-up in atmosphere

1970: 1ST EARTH DAY
Advocates gather and teach

1971: UV RADIATION
McDonald links ozone depletion and skin cancer in presentation to Congress

1974: OZONE DEPLETION THEORY
Rowland & Molina publish theory of CFC-led ozone depletion

Act III: A Global Problem
1980s

1987: "SMOKING GUN"
The Airborne Antarctic Ozone Experiment confirms chlorine as ozone hole culprit

1984: OZONE HOLE
British Antarctic Survey detects ozone hole

1985: VIENNA CONVENTION
First legal framework to protect global atmosphere

1987: MONTREAL PROTOCOL
Int'l treaty phases down CFC production

Act IV: A Treaty Evolves
1990s

1992: EARTH SUMMIT
Framework Convention on Climate Change signed

1999: HALON-1011
Another gas added to regulated ODS list via MP Beijing Amendment

1991: GLOBAL OZONE REDUCTION
Scientific Assessment of Ozone Depletion finds worldwide ozone depletion

1990: MULTILATERAL FUND
MP London Amendment establishes MLF to provide financial support to developing countries

1992: HCFCs & METHYL BROMIDE
MP Copenhagen Amendment adds new regulated ODS

Act V: A Climate Problem
2000s to 2010s

2000: OZONE HOLE PEAKED
The Antarctic ozone hole peaks at 28.4 million km^2

2016: HFC PHASE-DOWN
MP Kigali Amendment adopts HFC freeze and phase-out to mitigate global warming

2007: HCFC PHASE-OUT
MP Adjustment speeds up HCFC phase-out due to its GWP & ODP

2013: HFCs & GLOBAL WARMING
Fifth IPCC Report highlights GWP of HFCs

New Coolants

Early Chemical Refrigerants: Inefficient, Toxic

CFCs: Efficient, Nontoxic, Nonflammable

HCFCs: Lower ODP*

HFCs: Low ODP, High GWP*

HFOs: Low GWP, Toxic, Flammable

Emerging Risks

Exposure to Toxic Gas, Gas Poisoning

Ozone Depletion; Increasing UV Radiation; Skin Cancer, Crop Damage

Continued Ozone Depletion; Skin Cancer, Crop Damage

Climate Change; Mass Extinction, Less Fresh Water, More Extreme Weather

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Plot

- Chemical refrigerants critical to food safety, but several people die in bed from toxic refrigerant leaks
- DuPont introduces Freon, a nonflammable, nontoxic CFC

- Landmark theory of ozone depletion: CFCs released into atmosphere will deplete stratospheric ozone for next century
- NRDC pushes US government to ban CFCs, while DuPont claims the science doesn't warrant action

- International scientific consensus on CFCs reached with NASA/WMO Blue Book
- MP requires 46 signatories to come into effect
- DuPont commits to CFC substitutes

- MP amended to regulate additional ODSs
- Developing countries demand delayed timelines and permanent establishment of MLF to make technological advancement feasible

- MP amended to include controls for high GWP alternatives to ODSs
- Chemical companies align with environmental groups for faster global rollout of alternatives

Backstage Pass

"Do you change your technology, your behavior, or your values when faced with risk and reward?"

Philip Dray, co-author of *Between Earth and Sky: How CFCs Changed Our World* (2003)

"DuPont was spending millions of dollars to find CFC alternatives… there was still some uncertainty around CFCs and ozone depletion, but they were still willing to invest in it."

Dr. Mark Shiflett, DuPont chemical engineer during transition to CFC alternatives, Foundation Distinguished Professor, University of Kansas

"Everyone thinks solving the ozone hole was easy—it wasn't easy. And because it wasn't, the insights are more relevant for other global environmental challenges than is widely recognized."

Dr. Edward Parson, author of *Protecting the Ozone Layer: Science and Strategy* (2003), Professor of Environmental Law, University of California, Los Angeles

"Science doesn't fix our problems, but you need a solid scientific foundation to realize your policy goals."

Durwood Zaelke, Founder & President of the Institute for Governance and Sustainable Development and key architect of the Kigali Amendment

Dr. A. R. Ravishankara
University Distinguished Professor, Colorado State University and key contributor to atmospheric ozone science

"Trusted relationships between people can be more persuasive in changing policy than risk analysis alone."

Dr. Stephen O. Andersen, Director of Research at Institute for Governance and Sustainable Development, Former Senior Expert Member of the MP Technology and Economic Assessment Panel

Jennifer Haverkamp, J.D.. Former US Ambassador and Kigali HFC Amendment negotiator

Insights

- Society relied on businesses' own research of their chemical products
- Chemicals seen as immediate health risks, not as part of a complex, environmental system

- If CFC theories of ozone depletion had been disproven and costly regulation proved premature, it could have needlessly harmed the economy and the credibility of future regulation

- Scientific certainty is not a prerequisite for action; imperfect information is inherent in decision-making
- CFC regulation may look easy, but it was difficult and far from inevitable

- Sound science enables complex policymaking but does not drive it
- The MP fostered an awareness that slow-but-steady cooperation can tackle global, environmental problems

- Risk analysis alone does not convince policymakers; it's leveraging relationships, narratives, and compromises.
- Consensus is the goal, but agreement may require overcoming some opponents

Key to Abbreviations: MP: Montreal Protocol; MLF: Multilateral Fund; ODS: Ozone-Depleting Substance; ODP: Ozone Depletion Potential; GWP: Global Warming Potential; CFC: Chlorofluorocarbon; HCFC: Hydrochlorofluorocarbon; HFC: Hydrofluorocarbon; HFO: Hydrofluroolefin

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Images courtesy of: Agricultural Research Center (aerosol can), Global Warming Political Union (UV/ozone layer diagram), NASA (2006 ozone hole maximum), Global Warming Art Project (map of temperature increases)