special meteorological conditions in polar regions, can rapidly destroy ozone. Chlorine from CFCs is also blamed for ozone depletion over the rest of the world. Proof is less definite, but the measured decreases are consistent with the theoretical modelling.

From the time of their invention 50 years ago up until the mid-1970s, CFCs were the ideal chemical for many industrial and consumer applications. They are inert, non-toxic and cheap and they have become almost indispensable for refrigeration, foam blowing, aerosol propellants, fire extinguishers and as solvents.

In 1974, a problem was recognised. These CFC molecules are so inert that they can drift up unchanged to the stratosphere, where they are decomposed by the strong ultraviolet light, releasing free chlorine atoms. The common 2-atom oxygen molecules are broken up by ultraviolet to form 3-atom ozone. Later this reaction may reverse, setting up the natural cycle and balance of creation and destruction of ozone. A single chlorine atom from a CFC can break in to initiate an ozone-destroying reaction sequence and while remaining unchanged itself, it catalyses the destruction. The single chlorine atom can take part in this reaction sequence perhaps 100,000 times before it is finally removed by something else. So a mere 100 grams of CFC, the amount in a single spray can, will eventually destroy over three tonnes of ozone (although some will recover through the natural creation processes).

World usage of CFCs reached a peak in the mid-1970s and declined for a few years after that, due to bans on aerosol cans with CFCs in USA and some other countries. However, new uses, especially in the foam plastic industry, have led to new production records and we now produce about one million tonnes of CFCs annually. This increases the amount of CFC in the atmosphere by about 5 percent annually, and we must bear in mind that most of this will not drift sufficiently high in the stratosphere to begin its decomposition for several decades or a century.

Montreal Protocol

New Zealand has signed and ratified the Vienna Convention on the Protection of the Ozone Layer (1985) which is a United Nations treaty in which nations agree not to destroy the ozone layer. Unfortunately this convention has no teeth, so during 1987 the United Nations Environment Program (UNEP) convened a series of meetings to determine an enforceable international agreement to reduce the use of CFCs. The result was the Montreal Protocol on Substances which Deplete the Ozone Layer. This specifies a phased 50 percent cutback on CFC use by 1999. The Protocol will come into force when nations representing 66 percent of world consumption have ratified. This is expected to be during 1989, when both USA and the European Community have ratified. New Zealand ratified the Protocol in June 1988.

The Protocol is the compromise necessary to have any type of agreement between demands such as a 90 percent cutback by 1996 (USA) and a mere freeze of production capacity (which would allow increases for maybe a decade) (Europe). The achievement of a Protocol which included these nations as well as Japan and USSR was a major triumph for UNEP and sets a precedent for other global environmental issues. Nevertheless it is clear that the Protocol itself is not strong enough to protect the ozone layer. As it stands, instead of accumulating an extra 5 percent of CFCs each year, we will accumulate only about an extra 2 percent. Even an immediate 85 percent cut back would still maintain the chlorine at present levels.

However, there is hope. The prospect of a 50 percent drop in production during the next ten years is devastating for large industries and their investors. The Protocol gives such a strong signal to industry that work towards alternative technologies and voluntary cutbacks is already going ahead and it seems likely that major industries will have abandoned the dying technology well before 1999. There are also likely to be calls for a stronger Protocol at the first review of the conditions in 1990, mainly because of the new scientific evidence of the CFC-ozone link that has been established since the signing in 1987.

New Zealand consumes about one quarter of a percent of the world's CFCs. The Protocol calculates the amounts of the different CFCs by their "ozone depleting potential", a figure derived from their chemistry. Allowing for this, usage in New Zealand in 1986 was approximately 31 percent aerosols; 27 percent plastic foams; 20 percent refrigerants; 20 percent fire extinguishers; 3 percent solvents.

Consumers' role

There is very little opportunity for a domestic consumer to reduce CFC use by wise buying. About 70 percent of aerosol cans are now propelled by hydrocarbons (and the can is labelled with the propellant). In May 1988 the Aerosol Association, representing the spray can industry in New Zealand, announced its intention to completely phase out the use of CFCs by the end of 1989, well ahead of any requirement in terms of the Protocol. Some of the uses of foam plastics are trivial packaging uses and could be avoided, but the difficulty is identifying CFC-containing products which usually look much the same as plastic foams blown with hydrocarbons or other inoffensive gases. Domestic fire extinguishers, for example the 1 kg BCF type, are extremely efficient and convenient, but this compound has a very high ozone depleting potential and will eventually all escape into the atmosphere. Can we go back to dry powder extinguishers? Alternatives to the use of BCF (or halons) in commercial size fire systems do not seem to be available. However huge cutbacks in use can be made by rationalising maintenance and testing procedures.

The real pressure must come on the Government, preferably with the support of responsible industry groups, to keep up the momentum of the Montreal Protocc! internationally. This can be done by New Zealand establishing a policy stronger than the Protocol. The present policy established for the Protocol negotiations is about equal in strength to the present protocol. To propose a complete phase out earlier than about 1995 would probably be too tough on our industry which must depend on the new technologies gradually coming in from overseas, but a policy aiming for a phase out about 1995 would be in line with what is probably going to be demanded from the governments of United States, Sweden, Norway, Finland and Canada.

A reduction in the atmospheric concentration of CFCs will have another benefit through reducing the greenhouse effect. CFCs are particularly efficient greenhouse gases, and three of our 100 gram spray cans have an effect equal to one tonne of carbon dioxide! And that's another story.

Tom Clarkson is an atmospheric chemist for the New Zealand Meteorological Service. He was head of New Zealand delegations at international negotiations leading up to the Montreal Protocol in 1987.

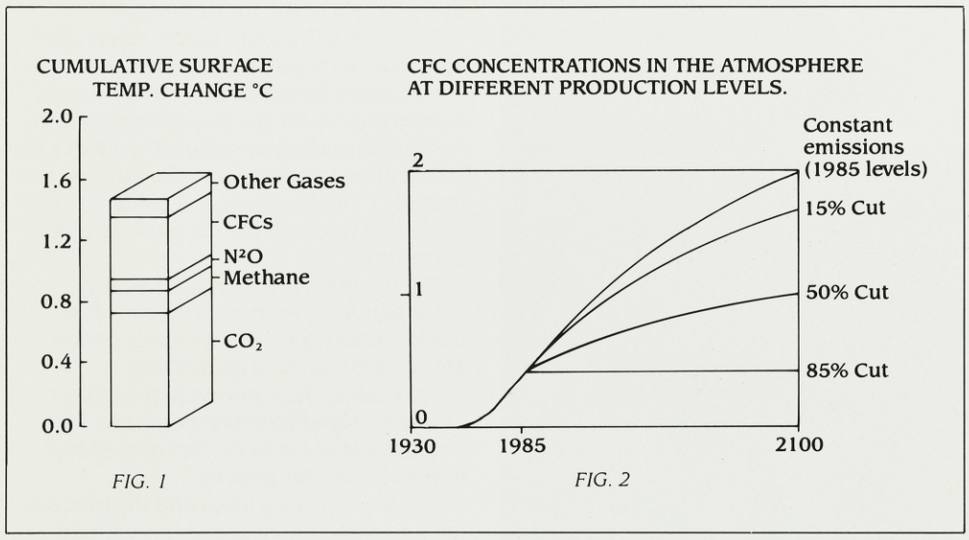

Figure 1: Projected contribution of "greenhouse gases" to global climatic warming by the year 2030. Note the substantial role of CFCs. Figure 2: Even a CFC cutback as high as 85 percent, which was agreed to by the Montreal Protocol, will not be enough to stop ozone destruction. The graph shows that such a cut would have a stabilising effect – but in fact by keeping CFC omissions at today's levels, ozone continues to be destroyed faster than it is created.

** Nevertheless, as our stand on the nuclear issue has shown, we can espouse a strong moral message for the rest of the world to note–Editor.*