Trends in the long term HFC use in the automotive sector

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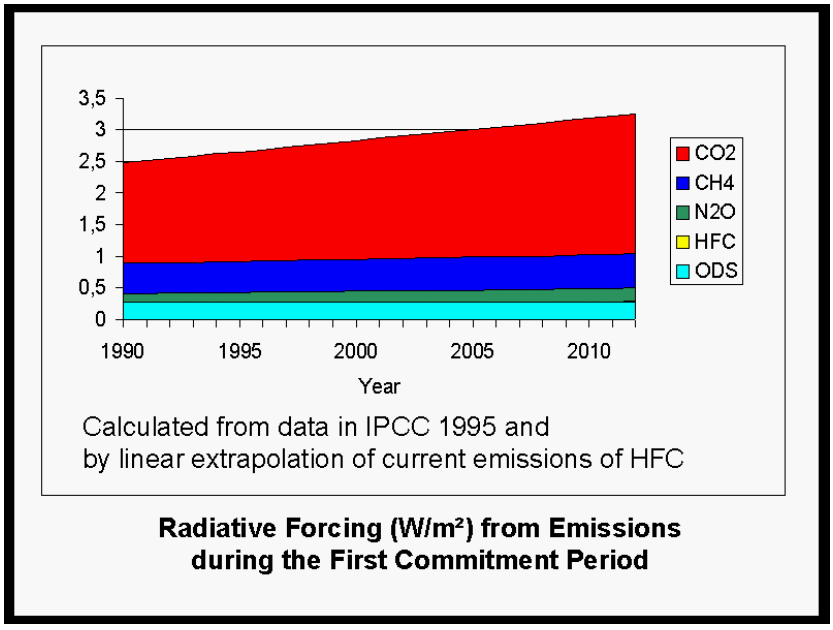
Introduction

Some of the publicity at present from NGO (Non Governmental Organisations) and others would suggest that the elimination of HFC would solve the global warming problem or allow a country to meet or substantially meet its commitments under the Kyoto Protocol. Both of these assertions are not correct at all and lead to confusion about the important issues in the climate change debate.

This paper provides an overview about forecasted HFC emissions from MAC systems and puts these into context with the total Global Warming issue. Improvements in HFC 134a systems and servicing as well as the effect of recovery & recycling on requirements for virgin HFC 134a is also taken into account. The figures indicate that elimination of HFC will essentially have no environmental impact during the First Commitment Period of the Kyoto Protocol.

Radiative forcing from emissions during the First Commitment Period

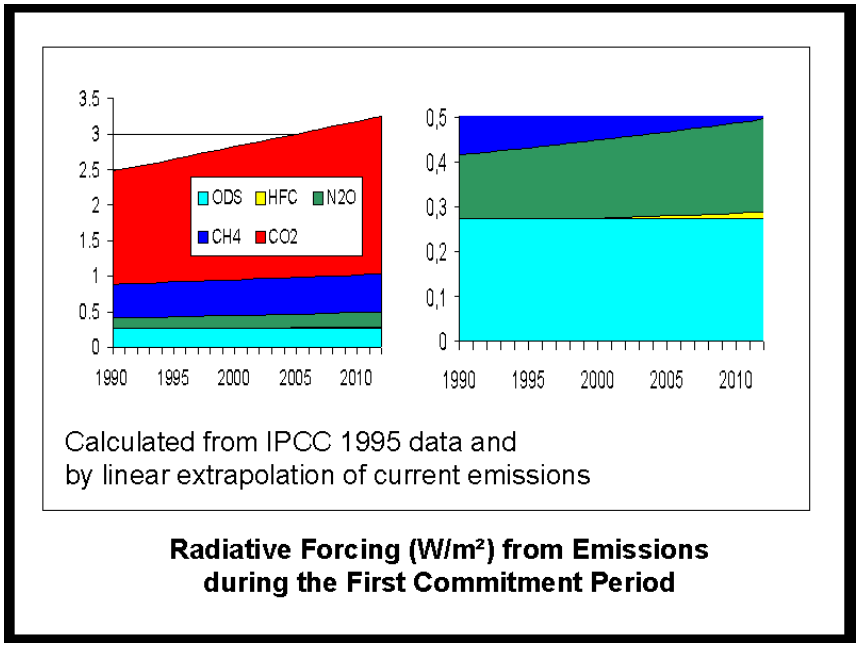
The forecasted contributions of various substances to the global warming are shown in the next figure. Various versions of this chart have been used over the years. What this shows is that by far the biggest contribution results from CO2 itself resulting from energy generation from fossile fuels (red). Other major contributors are Methane (CH4, blue) emitted from wetlands like rice fields. Nitrous oxides (green) are also making a significant contribution. ODS are Ozone Depleting Substances like CFC (pale blue).



Radiative Forcing (W/m²) from Emissions during the First Commitment Period

The contribution of the use of HFC to cumulative global warming by 2012, the end of the first commitment period under the Kyoto Protocol is virtually zero. The corresponding yellow area is almost invisible using this scale. Elimination of HFC will essentially have no environmental impact during the First Commitment Period of the Kyoto Protocol.

It is easier to see the magnitude of the HFC contribution on the next figure where the scale has been expanded.



Radiative Forcing (W/m²) from Emissions during the First Commitment Period

The left graph is in the same scale than the previous slide. The right graph provides the same figures in an enlarged scale. The contribution of HFC -again indicated by yellow colour- is less than 0.1% of man made global warming by 2012. Eliminating HFC will have essentially no environmental impact during this period. Even by 2050, using HFC responsibly the contribution to global warming would be of the order of 2%.

Industry Initiatives

However because HFC have a global warming potential industry has been working since their introduction to reduce emissions, to contain them in systems, and to recover and recycle them. The pace of progress is actually quite rapid and projections of emissions made only a few years ago are now out of date, as they generally do not take into account the improvements that have been made or are planned.

The MAC industry recognises that air conditioning systems must be improved. Besides company specific projects there are a number of broader industry initiatives that are addressing global warming contribution from MAC systems. One example is the is the MACS Voluntary Partnership between SAE and EPA in USA. Objectives of this initiative are:

- to promote cost-effective designs and improved service procedures to minimise emissions from HFC-134a systems.

- to co-operate on development and testing of next-generation mobile air conditioning systems that satisfy customer requirements and environmental, safety, cost, and reliability concerns; and
- to communicate technical progress to policy makers and the public.

These initiatives are very different from the replacement of CFC 12 by HFC 134a at the start of the 1990s. At that time it was very clear that replacing CFC 12 would 100% eliminate a refrigerant with a potential to deplete the ozone layer. Now, in assessing HFC systems industry needs to be certain that the approaches it takes are a net benefit in reducing global warming emissions.

This is not a straightforward question because it depends on the HFC baseline selected, the geographical – and hence climatic location, the driving cycle, existing servicing and recovery practices, and the selection of the most appropriate cost effective measures. There are no clear answers today, except that improvements in HFC 134a MAC systems will definitely have a benefit.

Improvements for HFC 134a MAC systems.

Improvements can be in system energy consumption, through reduced thermal loads and improved efficiency. With low HFC 134a emissions, comparisons of energy consumption for different technical options is very important. The choice of test conditions can then affect the outcome. Various sources have suggested that energy efficiency improvements in the range 10 to 30% may be possible.

This presentation concentrates on the impact of improvements in HFC 134a containment on HFC emission projections and refrigerant requirements. It assumes that HFC 134a continues to be the universal choice of the car industry so that the impact of system improvements can be clearly demonstrated. There is significant potential to reduce refrigerant emissions by reducing system charge, by improved components for containment, by better service practice including recycling, and by end-of-life recovery.

Following assumptions regarding specific improvement are regarded to be realistic:

- The Mobile Air Conditioning Climate Protection Partnership paper of March 2000, comments an estimate that average annual vehicle leakage could be reduced from 0.07 kg/year to 0.04 kg/year.
- Charge sizes are also being reduced. The average charge size will depend to some extent on the proportion of small vehicles with air-conditioning. A reduction of 1% per year on average is not unrealistic.
- Higher quality systems are reducing the number of vehicles requiring service according to data from the USA, which will lead to reduced service losses.
- In addition improved connectors are now available with much reduced leakage at operating conditions and also when the vehicle is not being used. This will reduce leakage and reduce the need for service to top up refrigerant. Only one planned service during vehicle life is believed to be feasible. Developments suggest that further improvements are possible.

Improvements in HFC 134a MAC service & recovery

Service practice in terms of mandatory or voluntary requirements is variable across the EU, although servicing is beginning to be addressed by an increasing number of Member States. Germany and the Netherlands are two countries with well established systems that are leading to better service practice and reduced refrigerant requirements.

End-of -life recovery is required in the EU through the end-of-life vehicle directive (by 2007) and is already existing practice in some Member States such as Germany and the Netherlands. Additionally it can be assumed that 70% of remaining charge will be recovered according to the target set in Japan. End-of-life recovery will make a major impact on refrigerant emissions in terms of reductions. We will illustrate this in one of the following figures.

The underlying assumptions used for the following projections are in line with the improvements that are contained in the Mobile Air Conditioning Climate Protection Partnership paper of March 2000, and take account of future end-of life recovery targets. It is not assumed that hermetic HFC 134a systems are used for example, but that improvements in technology and practices are made progressively.

Emission Projections

The scenarios illustrated on the following figures are based on specific data for the respective countries. For each year and country the new car market, the A/C penetration for the relevant year, the recovery rates and the average charge size for the new car fleet have been taken into account.

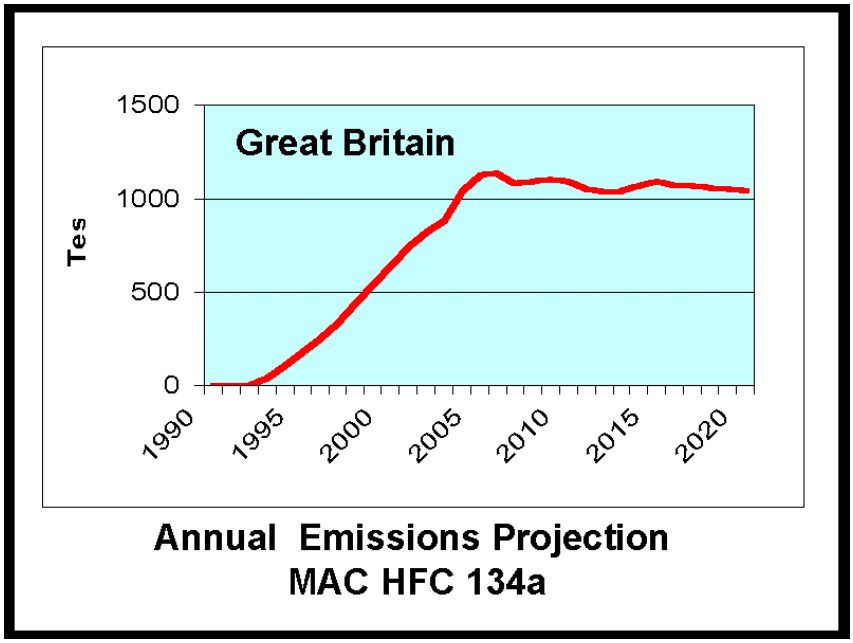
For the European picture average values derived from the regional data have been used. These values are indicated in the following table.

	2000	**2010**	**2020**
AC penetration	61%	84%	84%
Vehicle leakage in use	85g	50g	45g
Average charge size	730g	680g	620g
End-of-life recovery	25%	70%	70%

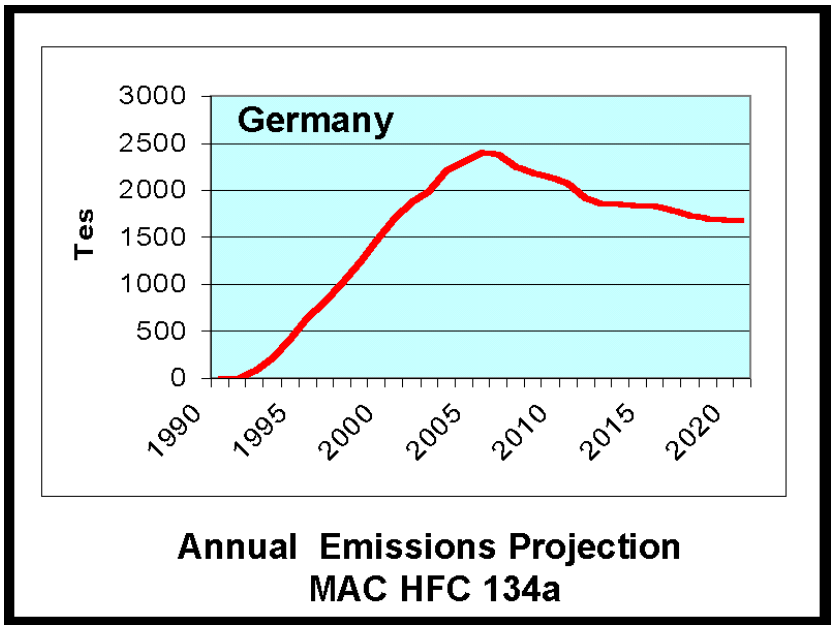
The basic assumptions for Europe are that

- A/C penetration will grow until 2010 and will flat out afterwards.
- Leakage rates will be reduced.
- Charge sizes will be reduced and
- Recovery & recycling will increase.

As said before the market for air-conditioning can be different within Europe. Using the underlying assumptions some specific emission projections can be estimated for the different states. The following figures provide an overview about the expected HFC emissions resulting from MAC systems in Great Britain, Germany and Italy. A figure for Europe is also provided.



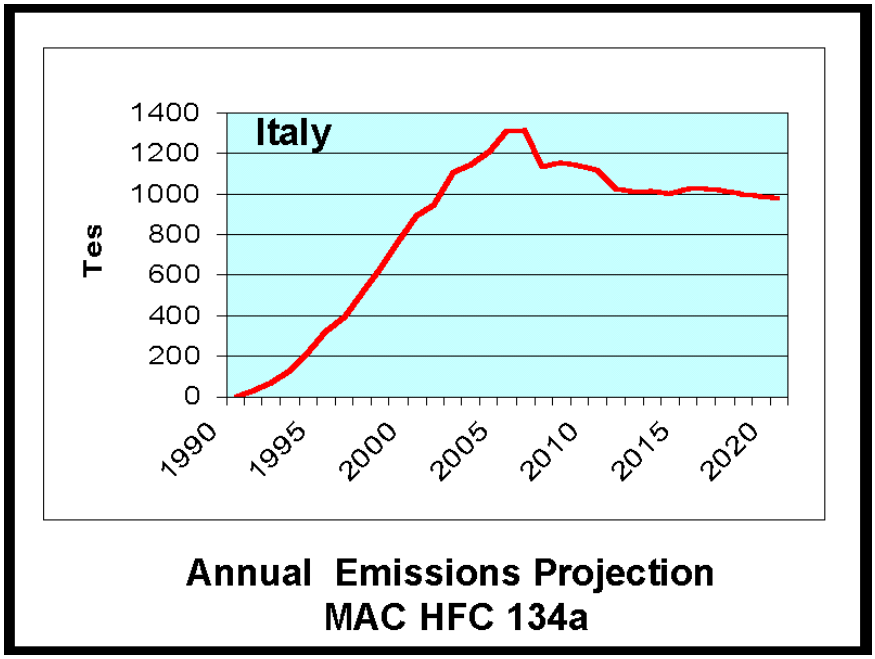
This is a projection for the UK where AC penetration has being growing very rapidly in past couple of years. Some emission studies have expressed the concern that emissions may be rising beyond the first commitment period under the Kyoto Protocol . Clearly based on this projection the emissions will plateau even without any major technology improvements beyond 2007.



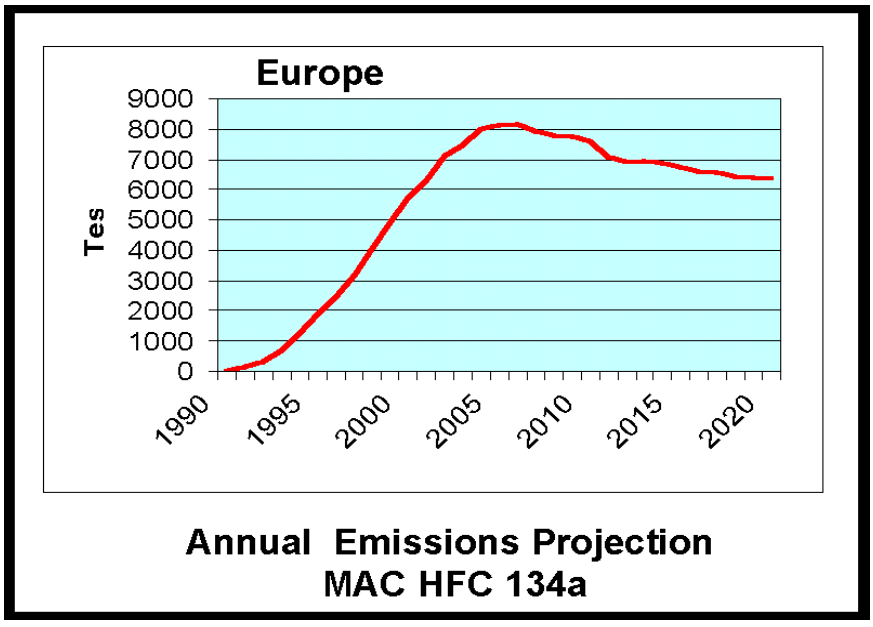
Using the same underlying assumptions for Germany and taking into account some of the characteristics of the German market, we obtain an emission projection that peaks in 2007 at about 2500 tes HFC 134a, and then begins to decline. This projection has a lower and earlier peak than that estimated by Dr. W. Schwarz and Dr A. Leisewitz in a study provided 1999 for the German Federal Environmental Agency, UBA. The key difference is the assumption that operating emission rates will be lower than 10%, which was assumed by Schwarz and Leisewitz.

The important feature of this projection is not the absolute value of the emissions - there will no doubt be disagreements about the projection - but that there is a clear peak and that emissions reduce beyond 2010, in the second Kyoto commitment period, as a result of improvements in containment technology and service practice.

The emission projection for Italy is similar showing a peak in about 2007, when the impact of the end-of-life vehicle directive should have reduce end-of-life emissions.



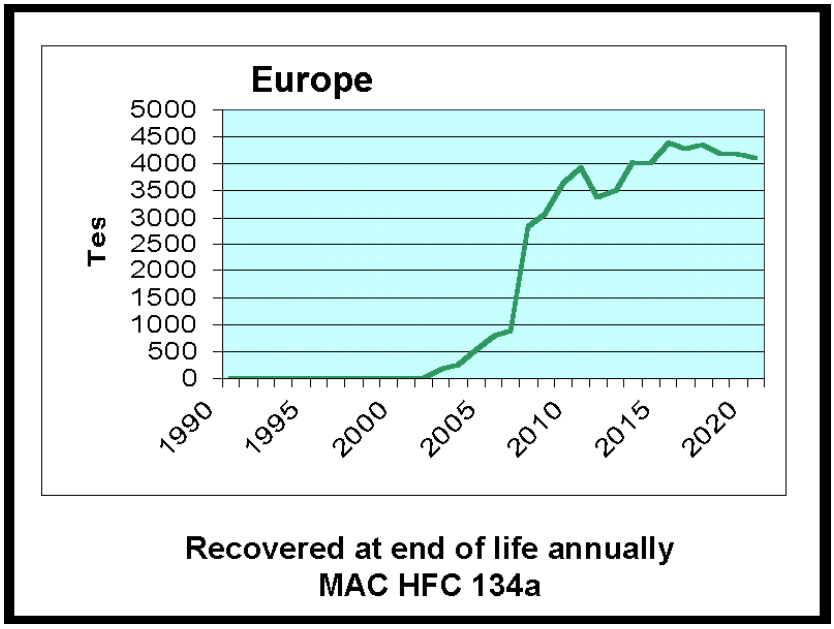
Applying these assumptions to the whole European Union results in a maximum emissions projection which is similar to that estimated by March Consulting in their report for the European Commission in 1998. However higher penetration rates are assumed in the projection shown here, but this is offset by improvements in containment which were not anticipated several years ago.



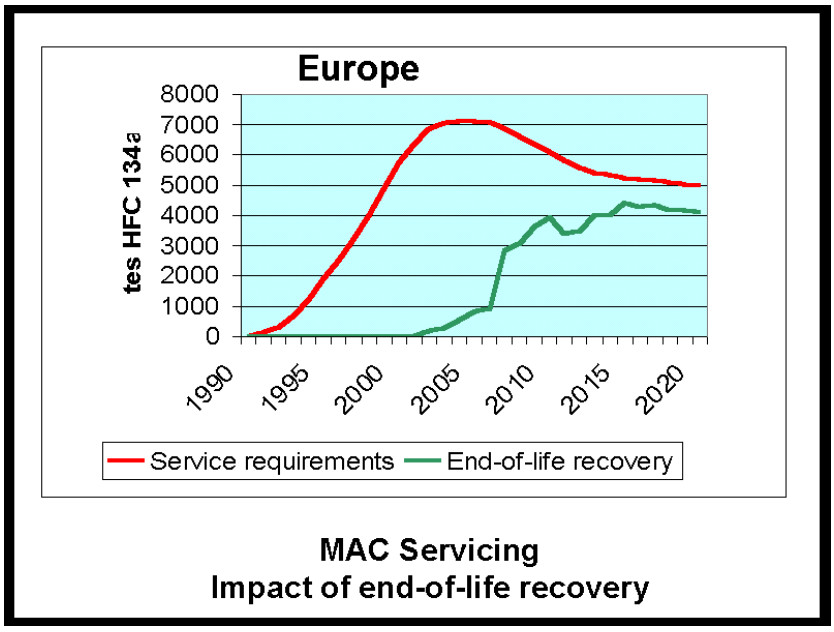
These emissions are less than 0.3% of total greenhouse gas emissions projected for Europe for 2020. It is also worth pointing out that the transport sector is undertaking a range of initiatives to reduce total tailpipe greenhouse gas emissions from vehicles, and efforts to improve air-conditioning systems could be viewed as part of a wider vehicle initiative.

Impact of recovery at end-of-life

The following figures highlight another very interesting point which follows from the assumption that there will be significant end of life recovery, based on the end of life vehicle directive in EU and the target in Japan of 70% recovery rates from old vehicles by 2010. It is expected that there will be a large quantity of HFC 134a available from end-of-life recovery for servicing of MAC systems.



Recovered at end of life annually
MAC HFC 134a



MAC Servicing
Impact of end-of-life recovery

It is shown that end-of-life recovery should actually provide about 80% of the HFC 134a required for servicing of MAC systems. This is a considerable quantity and significantly reduces the requirement for “virgin” HFC 134a for the aftermarket. It is expected that end-of-life recovery should have a substantial impact in other markets globally, including the USA, reducing the requirement for virgin HFC 134a globally

The servicing quantities shown here are assumed to be equivalent to the emissions from operating vehicles.

Conclusions

- Industry has already made major improvements in the containment of refrigerants.
- Further system improvements, service and recycling will further reduce refrigerant emissions.
- The benefits from improved efficiency of HFC systems should not be ignored.
- Refrigerant emissions from the car sector should decrease during the second commitment period even assuming HFC 134a continues to be used for all air-conditioning.
- End-of-life recovery will greatly reduce the need for virgin HFC 134a for the service sector.
- It is important to view HFC MAC systems in the context of overall vehicle emissions as the industry develops strategies to reduce total vehicle emissions

Paper has been presented at European Automotive Air Conditioning Convention 11./12.09.2000, Frankfurt