Regional ozone in Europe

Would further VOC control measures be effective?

Over the past three years, both the European Commission and the United Nations Economic Commission for Europe (UN-ECE) have developed response strategies to combat concerns over acidification, eutrophication and regional ozone. In each case 'Integrated Assessment Models' (IAM) were used to support policy development. In the case of the European Commission, this resulted in the National Emission Ceilings (NEC) Directive, which is currently under consideration by the European Institutions. In the case of the UN-ECE, this resulted in the multi-pollutant, multi-effects protocol, known as the Gothenburg Protocol, signed in December 1999.

In both cases the IAM was, in part, designed to identify the required reductions in NO_x and VOCs in each country to limit exceedances of an 8-hour average ozone target of 120 µg/m^3 (60 ppb)[1]. CONCAWE fully supports the concept of integrated assessment modelling as an important part of a rational process of environmental policy making. However, in this process, it is important to recognize the influence of uncertainties in the input data and key assumptions on model output. In the case of ozone, one such uncertainty, recognized within the scientific community[2], is the magnitude of biogenic VOC emissions. In this article we explore the implications of these uncertainties on ozone reduction strategies. We shall see that in the 'future 2010 EU', where already agreed measures will have substantially reduced anthropogenic VOCs, further VOC controls offer little potential for improving ozone compliance. This is particularly so if biogenic VOC emissions are higher than currently represented in the EMEP model[3].

RESULTS OF THE NERI (NATIONAL ENVIRONMENTAL RESEARCH INSITITUTE) DANISH EULEREAN MODEL (DEM) FOR THE 1995 BASE CASE EMISSIONS SCENARIO

Number of days with ozone above 120µg/m3 (8-hour values) are shown on the EMEP grid scale of 150 x 150 km

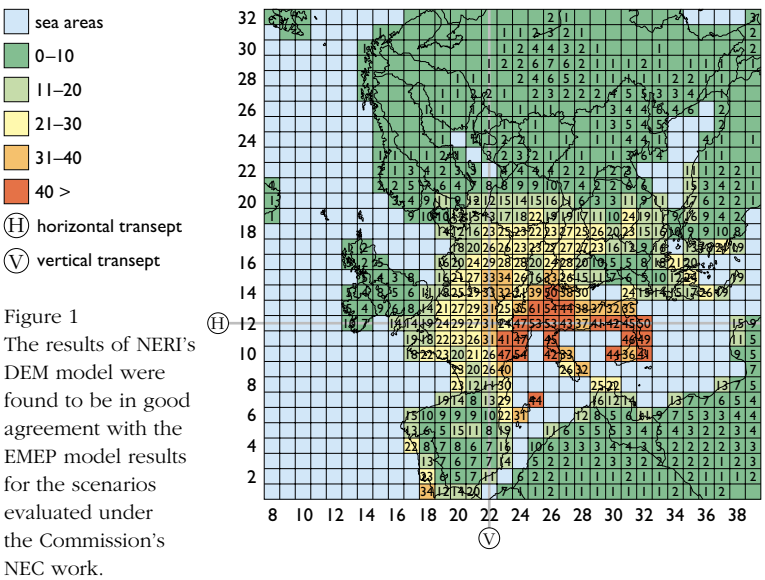

Figure 1
The results of NERI's DEM model were found to be in good agreement with the EMEP model results for the scenarios evaluated under the Commission's NEC work.

CONCAWE engaged the National Environmental Research Institute (NERI) of Denmark to study the potential influence of uncertainties in biogenic VOC emissions on predicted ozone levels in Europe. This institute has its own regional ozone modelling capability, the so-called Danish Eulerian Model (DEM). The results of this model were found to be in good agreement with the EMEP model results for the scenarios evaluated under the Commission's NEC work.

Figure 1 shows the results from the DEM for the 1995 Base Case emissions scenario with biogenic emission correlations consistent with those used in the EMEP model. Exceedance days above 120µg/m^3 (8-hour average) are shown on the EMEP grid scale of 150x150 km.

[1] *In the case of the Commission's NEC Directive, this means limiting exceedances to 20 days a year, averaged over three successive years.*

[2] *Norwegian Meteorological Institute (NMI), Norway,* Biogenic VOC Emissions in Europe, *Parts I and II*

[3] *EMEP is the UN-ECE's European Monitoring and Evaluation Programme for Long-Range Transboundary Air Pollution. The EMEP MSC-W Ozone model is a Lagrangian trajectory model and was used to support both the Gothenburg Protocol and NEC Directives.*

The exceedance days data for each EMEP grid along the horizontal (H) and vertical (V) transepts, for each biogenic VOC emission scenario, form the basis for the following discussion of the results from the NERI work.

IN A '2010 EU' THERE ARE VIRTUALLY NO 'VOC-CONTROLLED' AREAS

Figures 2 and 3 (horizontal and vertical transept respectively) show the exceedance days in 1995 and the predicted exceedance days in 2010 resulting from 'already-agreed measures' for NO_x and VOC control. The overlaid lines show the 2010 levels if only NO_x (blue) and only VOC (red) measures were implemented. These data clearly show the areas of Europe that are so-called VOC controlled (e.g. UK) and NO_x controlled (southern Europe).

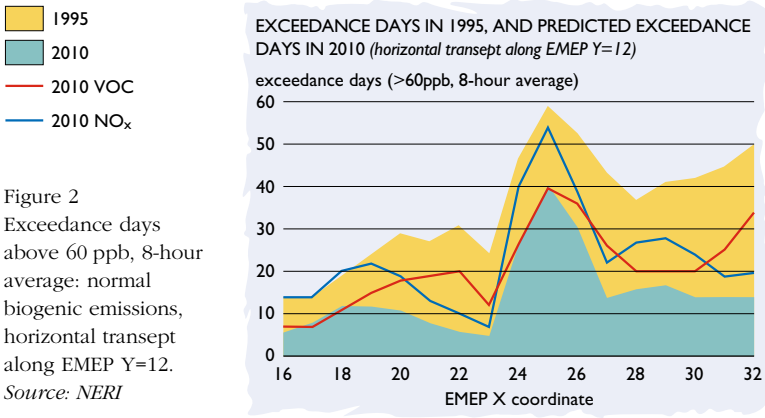

Figure 2
Exceedance days above 60 ppb, 8-hour average: normal biogenic emissions, horizontal transept along EMEP Y=12.
Source: NERI

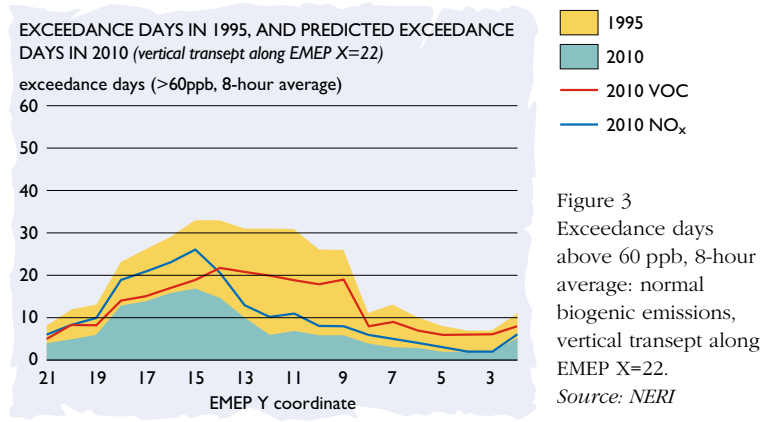

Figure 3
Exceedance days above 60 ppb, 8-hour average: normal biogenic emissions, vertical transept along EMEP X=22.
Source: NERI

In Figures 4 and 5, similar plots are given for emission reductions beyond already agreed measures (down to the so-called IIASA[4] 'Maximum Feasible Reductions' (MFR)). Here the picture changes rather dramatically with further NO_x measures offering a much more significant reduction potential than further VOC measures. This characteristic shift is evident for the whole EU area.

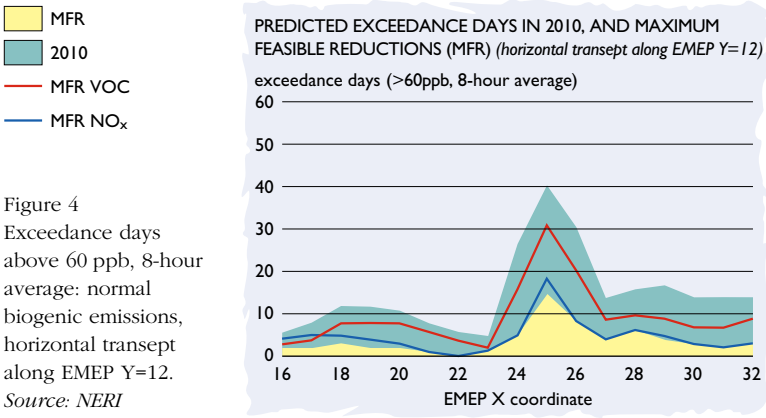

Figure 4
Exceedance days above 60 ppb, 8-hour average: normal biogenic emissions, horizontal transept along EMEP Y=12.
Source: NERI

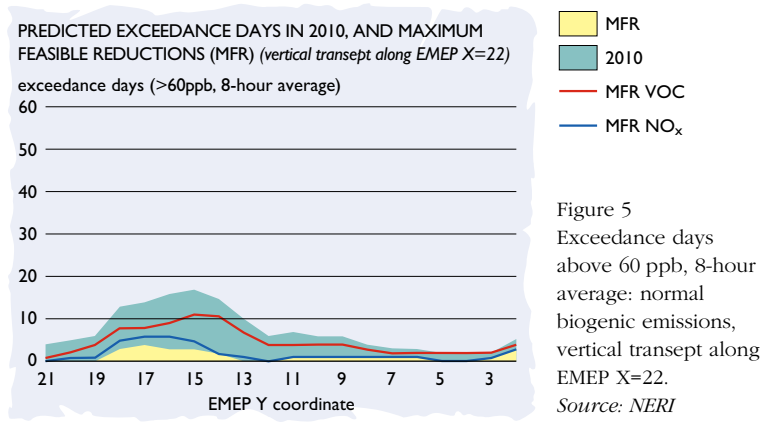

Figure 5
Exceedance days above 60 ppb, 8-hour average: normal biogenic emissions, vertical transept along EMEP X=22.
Source: NERI

The very large reductions in VOC emissions that are anticipated to occur as a consequence of already agreed measures means that in a '2010 EU' a much higher proportion of residual VOC will be from biogenic sources. It is therefore not surprising to see a move away from the VOC and NO_x-controlled areas that characterized the 'mid-90's EU' to one that is largely NO_x-controlled in 2010. We shall now examine the impact of higher biogenic emissions on such a shift.

[4] *International Institute of Applied Systems Analysis, Luxembourg, Austria: this institute developed and maintains the Integrated Assessment Model 'RAINS' which underpins the Gothenburg Protocol and the NEC Directive.*

WITH HIGH BIOGENIC VOC EMISSIONS, OZONE ABATEMENT POLICIES SHOULD FOCUS ON NO_x CONTROL

The DEM model was used to evaluate the impact of a threefold increase in biogenic VOC emissions, well within the range of reported uncertainties. The results are given in Figures 6 through 9 below.

Figure 6 and 7 indicate that if biogenic VOC emissions are three times higher than currently represented in the EMEP model, then even the design of 'already agreed measures' may have over emphasized VOC control measures. The figures also clearly show that already agreed NO_x measures alone achieve essentially the same improvement as the combined effect of NO_x and VOC measures. This points to the potential for significant regret investments should the case for high biogenic emissions be confirmed.

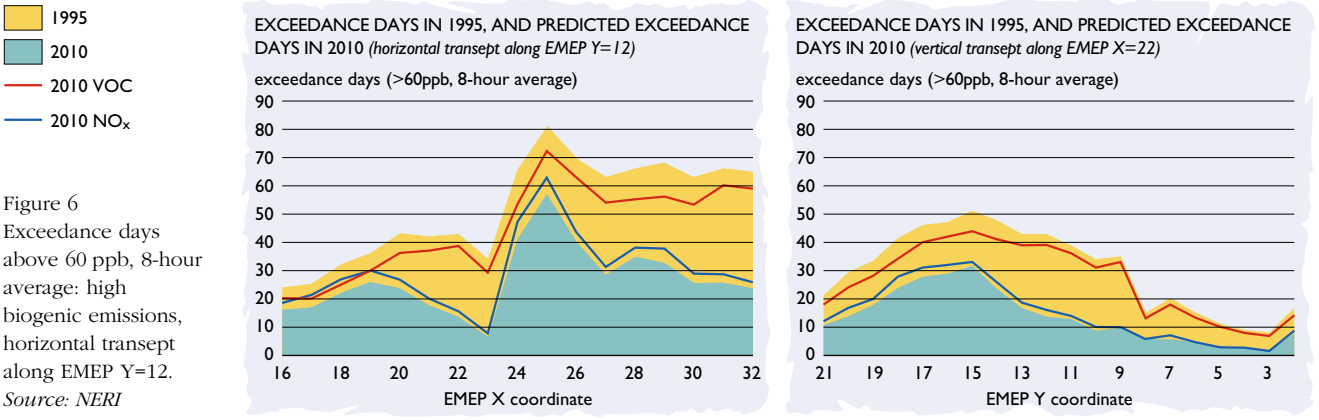

Figure 6
Exceedance days above 60 ppb, 8-hour average: high biogenic emissions, horizontal transept along EMEP Y=12.
Source: NERI

Figure 7
Exceedance days above 60 ppb, 8-hour average: high biogenic emissions, vertical transept along EMEP X=22.
Source: NERI

Figures 8 and 9 clearly show that further measures aimed at further reducing ozone exceedances should be focussed on NO_x and that further VOC controls offer essentially no significant improvement.

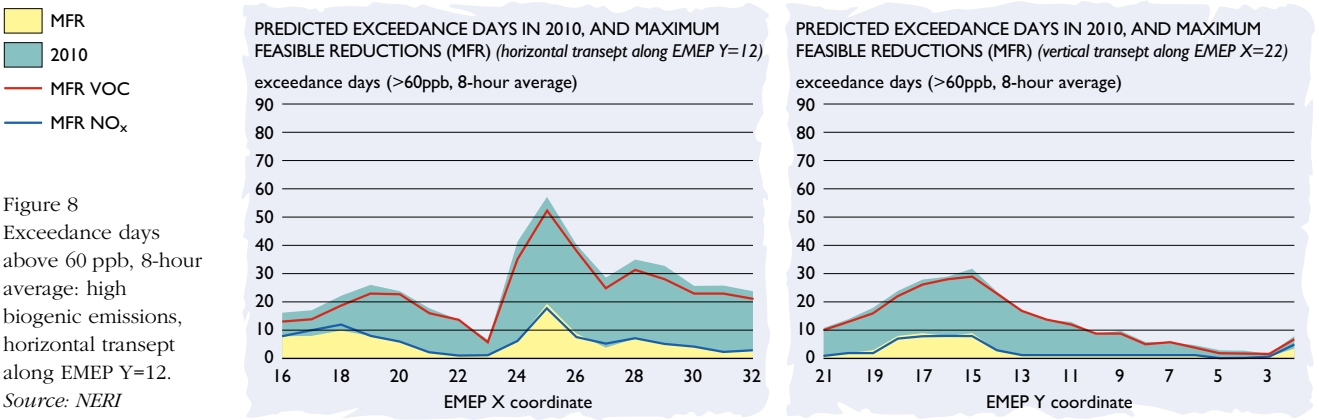

Figure 8
Exceedance days above 60 ppb, 8-hour average: high biogenic emissions, horizontal transept along EMEP Y=12.
Source: NERI

Figure 9
Exceedance days above 60 ppb, 8-hour average: high biogenic emissions, vertical transept along EMEP X=22.
Source: NERI

These findings should be taken into account for setting future priorities within programmes like the Commission's soon-to-be launched CAFE initiative. They also bring a cautionary message to those involved in the finalization of the NEC Directive.