

Referee report ACP Crippa et al, 40 yrs of improvements in European Air Quality

1. The paper has become much clearer now it is limited to the analysis of two alternative historic scenario's for the period 1970-2010 (STAG_TECH and STAG_ENERGY) and results are consistently compared to actual 2010 Reference case.
2. STAG_TECH shows how emissions, life expectancy and crop yields in the world would have developed without the introduction of abatement technologies. The comparison with the actual 1970-2010 development shows the benefits of air pollution policy.
3. STAG_ENERGY shows how emissions, life expectancy and crop yields would have developed without an increase in energy consumption, but with actual air pollution policy and energy policy (in the form of a less carbon intensive fuel mix and more efficient energy conversion). The comparison with the actual 1970-2010 development shows to what extent actual emission increases were caused by consumption growth. My interpretation of STAG_ENERGY differs from the text on P7 L3-4 that highlights the other side of the same coin, namely that this scenario "demonstrates the benefit of industrial developments towards less energy-intensive and less polluting technologies"

We modified the sentence accordingly to the Reviewer's suggestion:

"Compared to the 1970 reference emissions, STAG_ENERGY demonstrates the benefit of all industrial developments towards less energy-intensive and less polluting technologies. It includes not only the technological progress with end-of-pipe measures but also the shifts towards less carbon-intensive fuels (e.g. natural gas instead of coal) and increase of fuel economy and energy efficiency. On the other hand, compared to the REF(2010) data, STAG_ENERGY assess to what extent emission increases by consumption growth."

4. The current description of STAG_ENERGY is not completely clear. It assumes "stagnation in energy consumption since 1970 while... energy efficiency ... [is] assumed as in the reference 2010 data." (P1 L30-31; P3 L31-32). Does this mean that the 2010 primary energy use in this scenario is even lower than in 1970?

Yes, STAG_ENERGY data are lower than the 1970 ones because of the deployment of energy efficiency of 2010.

I am puzzled by figure 4b-right panel, which indicates that all industrial emissions in STAG_ENERGY are higher than in 2010_REF. Does this mean that energy use in industry was lower in 2010 than in 1970? Data on 1970 and 2010 energy use and an equation (eq. 1b?) for this scenario would have been helpful. The text on page 6 L20-36 does not make the method very clear.

The explanation is already provided at page 11 (paragraph 3.2.2):

"As shown in Table S1.2, the ratio of STAG_ENERGY to REF(2010) for the industrial sector is larger than 1 for EU27 due to the presence of heavy industry in European countries in the seventies (the ratio of STAG_ENERGY to REF(2010) for Central Europe is 2.1, while for OECD Europe is 1.6)."

We added to the manuscript 2 equations describing both the STAG_TECH and STAG_ENERGY scenarios to make both scenarios clearer as suggested by the Reviewer:

$$EM_{STAG_TECH,C,i}(2010,x) = \sum_{j,k,f} [AD_{C,i,f}(2010) * TECH_{C,i,j,f}(2010) * EOP_{C,i,j,k,f}(1970) * EF_{C,j,f,i}(1970,x) * (1 - RED_{C,i,j,f,k}(x))]$$

$$EM_{STAG_ENERGY,C,i}(2010,x) = \frac{[\sum_f AD_{C,i,f}(1970)] / EFF_{C,i,f}(1970)}{[\sum_f AD_{C,i,f}(2010)] / EFF_{C,i,f}(2010)} * EM_{REF,C,i}(2010,x)$$

5. It is difficult to relate data in the main text to the data in the Supplementary Material. E.g. according to table S2.1 the increase in SO2 for OECD-Europe in the STAG-TECH scenario compared to 2010_REF would be 172%, P1 L35 mentions 129% for Europe. Is this because “Europe” is defined different here? Does it include Central Europe? Russia?

129% refers to EU27 countries and it has been added for clarity in the text.

Please use a consistent definition of “Europe” throughout the paper. The text on P9 could be made clearer if figures would be related to the same sources. E.g. now L10 refers to SO2-emissions from the power sector, while L13 refers to global SO2-emissions. L16-19 refer to power sector.

In the paper we provide numbers for EU27 countries, but in order to explain different features of Western and Eastern European countries we also use the split of Europe as OECD-EU and Central Europe. This is consistent with our choice of using the 25 image regions also for other analyses in the paper (e.g. discussion of the FASST results). Thus, we need to keep both the EU27 definition and the split of Europe into Central and OECD EU.

Moreover, in order to allow the reader to make consistent evaluations, we added details about regional emissions for the 3 sectors of interest separately in tables S2.