IMPACT ASSESSMENT OF POLLUTANT EMISSIONS IN THE ATMOSPHERE FROM A POWER PLANT OVER A COMPLEX TERRAIN

Grazia Ghermandi, Sara Fabbi, Barbara Arvani, Giorgio Veratti, Alessandro Bigi and Sergio Teggi

Department of Engineering “Enzo Ferrari”, University of Modena and Reggio Emilia, Modena, ITALY

Contact: grazia.ghermandi@unimore.it

ABSTRACT

The development of a natural gas-fired tri-generation power plant (520 MW Combined Cycle Gas Turbines (CCGT) + 58 MW) in the Republic of San Marino (RSM), a small independent country in Northern Italy, is under assessment. The power plant has the aim to meet completely the energy requirements of RSM and export part of its production to Italy. The present work investigates the impact assessment of pollutants emitted in the atmosphere from the power plant stacks, subjected to the regulatory limits defined by the Italian law (DL 153/2006 and DL 46/2014, implementation of 2020/59/EU). The impact assessment was performed via lagrangian simulation of the atmospheric dispersion of the emitted plume by the means of the Aria Industry package (Aria Technologies, France, and Arianeet, Italy). The dispersion was simulated for NOx and CO pollutants. The simulated concentrations were compared with the air quality limits of the Italian law (DL 153/2010 implementation of 169/2008/EC). Since the simulated concentration of CO were widely lower than the regulatory limits, the simulation focused only on NOx.

DOMAINS AND METHODS

Spatial domain

40 x 40 km², 200 m square cells, 20 layers on vertical grid, 3500 m top level → diagnostic wind, temperature and concentration fields

20 x 20 km², 100 m square cells → only concentration fields

Simulation periods

10-days periods representative of low, moderate and large atmospheric dispersion conditions of 2014:

- March 11th and 20th (worst-case meteorological condition)
- June 6th to 15th
- June 19th to 28th
- November 8th to 17th.

RESULT

The simulation results for the most critical period, from March 11th to 20th, is shown at right as maps (a) and (b) of average hourly NOx concentrations from the plume emitted by the power plant, in the first atmospheric layer (10 m) of the spatial domain (20 x 20 km² (a), and 40 x 40 km² (b)).

The simulated plume appears stretched approximately from West to East. The average hourly NOx concentration maximum value in the investigated period is 65 µg/m³, at about 5 km West from the power plant, close to the Mount Titan relief, that represents a physical barrier to the plume dispersion. The plume concentration at ground over the domain is lower than 2 µg/m³.

On the larger domain (b) isolated concentration peaks with maximum values of about 90 µg/m³ occur against natural obstacles (as hills), about 25 km South - East of the plant.

The maximum average hourly NOx ground concentration for March 11th (representative day for local sea-breeze effect evaluation), was 150 µg/m³ and occurred close to the Mount Titan, due to the local sea-breeze combination with the prevailing atmospheric circulation at mesoscale.

The average plume value for the domain is equal to 2.2 µg/m³.

In the other analyzed periods the average hourly NOx concentration maxima result 77 µg/m³ (a) June 6th to 15th, 30 µg/m³ (b) June 19th to 28th and 390 µg/m³ (c) November 8th to 17th respectively (maps below).

COGENERATION PLANT

The cogeneration plant is the Mitsubishi MHPS GT Model M90F5 and H-25(42) Combined Cycle Gas Turbines (CCGT, 520MW and 58MW thermal power) powered by methane gas. For the plant, whose efficiency η = 64% (as assured by the Manufacturer), the NOx emission limit results in 52 mg/Nm³ and 300 mg/Nm³ for CO in dry exhaust gas (DL 46/2014). The emitted NOx concentration was set to 50 mg/Nm³, as provided by the Manufacturers, and slightly below the emission limit of 52 mg/Nm³.

CONCLUSIONS

In spite of the very high pollutant emission rate from the plant stacks, the simulation showed a limited environmental impact: average hourly concentration at ground level were very low, with only isolated peaks where the emitted plume hits the mountain reliefs.

The investigation shows that the regulatory limit for average hourly NOx concentration is already exceeded more than 18 times during the investigated periods, but limited to a wide, steep slope area along the cliff of Mount Titan. Due to its location respect to the source, this area may be considered the most exposed to a local accumulation of pollutants emitted from the power plant.

Single peaks in scattered domain cells) mainly occur in different areas of the domain for each simulated period, without the evidence of recurring accumulation points. CO ground concentrations resulted always largely lower than the regulatory limits.

The paper highlighted the SPRAY ability in reliably simulating the dispersion of a pollution plume through a complex terrain and under unsteady wind conditions.

REFERENCES

