Distributed power generation may be better for air quality

A recent study has compared the impact of future power generated from large, central stations with power generated from smaller distributed generators (DG) in California on air quality. It concluded that although DG produces more emissions, its impact on air quality is likely to be smaller than central power stations due to complex interactions between air chemistry and transport.

One of the proposals to meet the future demand for electricity is to develop distributed generation (DG) of power. DG produces electricity from many small power generators located close to the area of demand, contrasting with traditional, central power stations that are typically in remote areas. However, DG could lead to increased levels of pollutant emissions, which could potentially worsen air quality in urban air basins.

This study investigated the impacts on air quality of different DG and central power station developments of similar capacities in the South Coast Air Basin of California, USA, for the year 2010. In particular, for each scenario, the researchers assessed the consequences for air quality resulting from the movement and chemical reactions of emissions in the atmosphere.

Two DG scenarios were developed that represented a different mix of technologies used to produce electricity, including gas turbines, natural gas combustion engines, micro-turbine generators, fuel cells, photovoltaic systems and hybrid gas turbine and fuel cells.

In addition, two central power plant scenarios were designed for a state-of-the-art natural gas combined cycle power plant. One scenario assumed continuous, normal operation of the plant over 24 hours; the other scenario assumed a ‘worst-day’ situation where plant operation is discontinuous, which increases pollutant emissions. Three different locations for the central power plant were chosen to represent a range of impacts on air quality in the region.

Even though the study found there would be more emissions from DG installations than emissions from central generation, the impacts from central generation will potentially be greater because the emissions occur within a smaller area. Depending on the location of the central power plants and the weather conditions, the emissions would also interact with pollutants from local sources. Emissions from DG, on the other hand, would be dispersed over a wider area.

Under normal operation, a central power plant would release less pollutant emissions than DG except for nitrogen oxides and ammonia. Ozone is a secondary pollutant formed in the presence of nitrogen oxides and sunlight. However, due to the complex chemistry of ozone formation, increased levels of nitrogen oxides actually reduce ozone formation.

But increased nitrogen oxide emissions contribute to the secondary formation of fine particulate matter (PM$_{2.5}$). Therefore, in addition to direct emissions of PM$_{2.5}$ from central generation, higher concentrations of wind-driven nitrogen oxides reacting with local pollutants would also increase PM$_{2.5}$ levels.

The impact of air quality on the health of local populations was assessed from exposure to ozone levels and PM$_{2.5}$ concentrations. It was found that total pollutant exposure was not strictly related to direct emissions. This highlights the importance of not only considering direct emissions but also the spread of emissions and the complex chemical reactions that occur during transport of emissions in the atmosphere.

Contact: ddabdub@uci.edu
Theme(s): Air pollution, Climate change and energy