MEASURES TO REDUCE PARTICULATE MATTERS AT AN AIRPORT: THE CASE OF COPENHAGEN AIRPORT

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Copenhagen Airport is the main airport in Denmark and the largest airport in Scandinavia, with 26.6 million passengers, 254,838 flights and 372,748 tons of freight handled in 2015. Copenhagen Airport is operated by Copenhagen Airports A/S (CPH). CPH owns and operates Copenhagen Airport and Roskilde Airport.

Copenhagen Airport has a very central location, with only 15 minutes by metro to Copenhagen City Centre. The airport is located by the sea, and with the main part of all flights taking place over water this location is beneficial in terms of environmental impacts on the surroundings.

CPH plans to develop Copenhagen Airport to be able to handle at least 40 million passengers yearly. The main principles for the development are to maintain a compact, efficient one roof airport and to implement new technology in order to support the most seamless travel possible.

Local Air Quality – the health and safety perspective

Like many other airports, CPH has been working with air quality management for a number of years. Focusing on the airport's possible impact on the neighboring communities, CPH has monitored the air quality at the fence since 2000. The monitoring program has been focusing on particles (PM2.5), NO and NO2. Results have always been well below regulatory limit values.
Based on the air quality monitoring program, CPH was convinced that we were doing quite well in terms of air quality. However, following measurements of polycyclic aromatic hydrocarbons (PAH) at the apron at the Leonardo Da Vinci Airport in Rome (Cavallo et al., 2006), the air quality in terms of working environment at the apron area gained more focus among staff as well as management in both CPH and among our partners at the airport. With the aim of taking a fact-based approach to this challenge, a thorough survey of air pollution related to the working environment of Copenhagen Airport was conducted from 2009 to 2011 by Danish Centre for Environment and Energy, Aarhus University (DCE) for CPH. The findings are published as a scientific report: Assessment of the air quality on the apron of Copenhagen Airport Kastrup in relation to working environment (Ellermann et al. 2011).

The aim of the survey was to map the air pollution at the apron and to determine the sources of air pollution. Giving the focus on working environment, the emphasis was on determination of air pollution in those areas of the apron where staff are working. **Figure 1** shows the locations of the airport's air quality monitoring stations.

The study led to the main conclusion that for the majority of the investigated air pollutants (nitrogen oxides, $PM_{2.5}$, PAH, VOC, particulate organic and elemental carbon) the concentrations

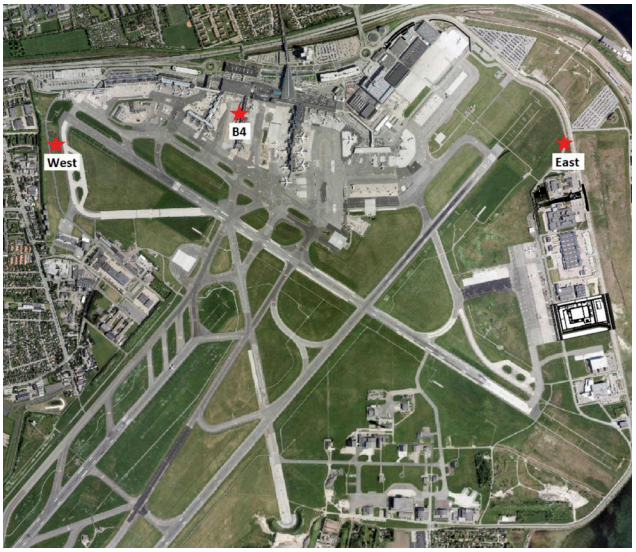

Figure 1. Overview of Copenhagen Airport. The red stars illustrate the locations of the airport's air quality monitoring stations: Station West (NO, NO_2, $PM_{2.5}$ and UFP), Station East (NO, NO_2, $PM_{2.5}$) and the apron station, Station B4 (NO, NO_2 and UFP).

at the apron are below the comparable levels measured at H.C. Andersens Boulevard (HCAB), one of the busiest streets in Copenhagen (approximately 60,000 vehicles per day). Also, all measured pollutants were below air quality limits for the pollutants, where such exist.

However, the number of particles (as shown in **Figure 2**) did not match this picture. The levels measured at the apron showed that the particle number (6 – 700 nm) was about two to three times higher at the apron than at HCAB and 85-90% of the particle number consisted of particles with a diameter between 6 and 40 nm. This particle fraction accounted for the difference between

the particle number at the apron and HCAB. The ultrafine particles (particles with a diameter less than 100 nm) originated from the combustion of jet fuel and diesel at the apron. At the outskirts of the airport, the particle number was about 20 – 40 % lower than at HCAB. It is important to note that there is no air quality limit value in Denmark for particle number.

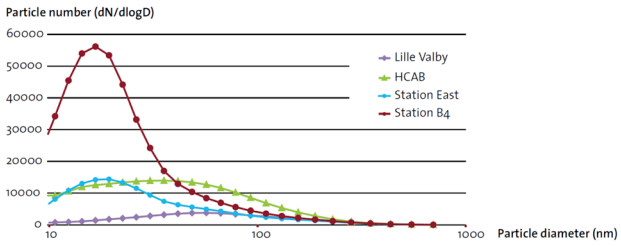

Figure 2. Particle number measurement results at Copenhagen Airport. Measurements for an urban busy street (HCAB) and rural background (Lille Valby) are shown for comparison.

The Copenhagen Airport Air Quality Program

The DCE study made it clear that the most prevalent air pollutant at the apron area was ultrafine particles On this basis, CPH established the Copenhagen Air Quality Program in its current form. The program is organized across the airport companies with personnel on the apron, with the common goal of minimizing the exposure of ultrafine particles to employees.

The Copenhagen Airport Air Quality Program is managed by CPH, but the strength of the program is the cross organizational set-up and the fact that representatives in the program include both employees, management at various levels, union representatives from handling companies, main carriers, ANSPs and authority representatives. The work is voluntary and based on collaboration and an open dialogue between the partners and the success of the program is highly dependent on this partnership.

The program is organized in four work streams:

- Behavior
- Ground support equipment
- Stand technology and operations
- Research and analysis

In each work stream a number of various projects and initiatives have been and are being conducted. The scale of these projects varies from time limited awareness campaigns to scientific studies.

CPH has, on a voluntarily basis, established continuous monitoring stations for ultrafine particles at two locations: At the central apron (B4) and at the western boundary close to residential areas. Measurements started in August 2010 and are done 24/7. This means that CPH has been measuring continuously for 6 years and will continue measurements in order to collect data for documentation of effects from the various remediation initiatives. The stationary measurements are supplemented by ad hoc measurements with handheld devices (the measurement of ultrafine particles with a handheld device is shown in **Figure 6**).

Environmental and Operational Results Go Hand In Hand

Looking at the global perspective, operations at airports only account for a small part of the environmental impact of air travel. However, seen in a local perspective, this fraction is very important for the local communities in and around airports, and in the case of ultrafine particles in Copenhagen Airport, especially for the working environment for staff. And of course the global and local aspects of environmental impact are connected. CPH is welcoming the focus ICAO has set on particle emissions from aircraft engines, and expect the new nvPM standard to have a positive effect on the local as well as the global air quality – even if it is in the long term perspective. Also, our work within the Air Quality Program goes hand in hand with our Airport Carbon Accreditation at level 3, optimization: A reduction in emission of ultrafine particles involves a reduction of CO_2-emissions.

Locally, the projects conducted within the frames of the Copenhagen Airport Air Quality Program have resulted in a reduction in ½-year mean levels at the central apron area of about 50% (see **Figure 3**).

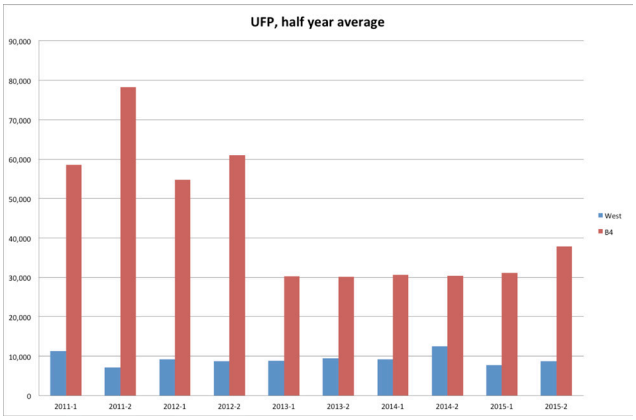

Figure 3. ½ year mean levels of UFP measured at the central apron and the western boundary. Since 2011, the level at the central apron has been reduced with about 50%.

All the conducted projects and initiatives play their part in the reduction. However, the one that really made a difference was a project within the "Stand technology and operations" work stream. With this project, the standard push-back procedure was changed and an environmental push-back procedure was implemented, on basis of a test period.

The former standard procedure, involving start-up of aircraft main engines in an area between two piers and with a large apron area is now replaced by the environmental push-back

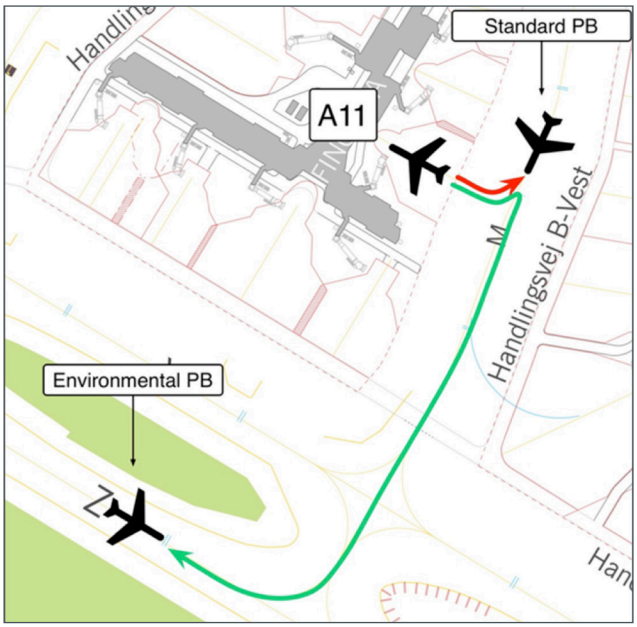

Figure 4. Illustration of the environmental push-back procedure.

procedure involving towing the aircraft to the closest taxiway before start-up of the main engines (see **Figure 4**).

Both the safety aspects and the expected operational consequences of the change of procedure were thoroughly examined and found to be sound before implementation.

As it turned out, the operational effects have been moderate in general and even positive in some traffic situations, especially for arriving aircraft, since the environmental push-back procedure makes more room on taxiway M for arriving traffic.

These results are characteristic for CPH's work towards better air quality at the aprons: the aim is to minimize the amounts of ultrafine particles emitted without compromising the operational efficiency.

What's next?

Figure 5. Employee driving one of CPH's electrical stairs.

Even though the Copenhagen Airport Air Quality Program has been in place for a number of years, there is still work to be done. There are still active and new initiatives in each of the four work streams:

The "behaviour" work is a continuous process, which among others focuses on behavior and awareness at the apron area, such as single-engine taxiing, stop of main engines at gate, limiting use of APUs, limiting time of idling with vehicles etc.

In terms of ground support equipment, CPH has set a standard for "green equipment" with yearly targets for the percentage of green equipment in Copenhagen Airport. Again, the focus is on minimizing the particle emissions from the equipment, meaning that for example electrified equipment and diesel equipment with functional particle filters currently both comply with the standard. **Figure 5** shows one of CPH's electrical stairs.

When it comes to stand technology and operations, the work stream participants are currently analyzing the possibilities to change more push-back procedures.

The research and analysis work stream will be focusing on the results from a scientific cohort study, which are expected in 2016 and the start-up of a new scientific project with the aim of researching the toxicity of ultrafine particles in airports. The results of this project are expected reported in 2019.

If you would like to read more about Copenhagen Airport Air Quality Program: http://dit.cph.dk/wp-content/uploads/2015/07/EN-6-Air-Quality-Air-Quality-Programme.pdf

Figure 6. Senior Project Manager Jesper A. Jacobsen measuring ultrafine particles with a handheld P-trak. Mr. Jacobsen manages Copenhagen Airport Air Quality Program on a daily basis. Photo by Ernst Tobisch.