The impact of this new type of jet fan on the three pillars of sustainable development can be seen in the table below.

TABLE 9. IMPACT OF NEW JET FAN ON THE THREE PILLARS OF SUSTAINABLE DEVELOPMENT

Pillar	Positive aspects	Negative aspects
Economic	Reduction of operating costs (energy and maintenance)* Lower initial investment (less jet fans) Higher availability of the tunnel for traffic	Cost of new jet fans
Social	(No significant impact)	
Environmental	Reduction of energy consumption (reduction of CO2 emission and preservation of resources)'	

*Depending on the solution retained

4.4.5. Air cleaning

We must remember that a road tunnel used by any given vehicle does not lead to more pollution than a journey by the same vehicle in the open air. However, this pollution is concentrated at certain points (each end of the tunnel and/or vitiated air extraction systems). This is why studies of a tunnel's extracted vitiated air are always very detailed, especially when a tunnel is located in a highly urbanized area.

In some countries, vitiated air treatment systems have been put in place, (a non-exhaustive list of examples follows).

In Spain: Since the M30 motorway to Madrid runs through a highly dense urban pattern, efforts have been made in order to avoid air pollutants that could eventually reach the population. Thus, several filtering stations are deployed at ventilation shafts along the tunnels. There are two different types of filters; on the one hand electrostatic particle precipitator filters, and on the other hand NO2 active carbon filters.

In Japan, some long tunnels in urban areas have been equipped with noise suppressors, electrostatic precipitators and low-concentration nitrogen dioxide (NO2) removal systems in order to minimize the influence on the surrounding environment.

In Italy, In Sottopasso di Monza (2.000m long twin-tube tunnel) that runs between Milano and Monza on a highly dense urban road, in Cesena (central Italy) and in Pozzano (south Italy) tunnel electrostatic precipitators have been installed on the exhaust air extraction system in order to minimize the polluted air impact on the urban environment.

In France, the French portal of the Mont-Blanc tunnel is equipped with electrostatic precipitators for particles in the exhaust air.

In Norway, there are a total of 8 tunnels with electrostatic precipitators:

- The environmental requirements for particle cleaning, both inside and outside Norwegian road tunnels, have to a high degree been politically motivated.
- With the exception of two tunnels (Strømsås and Lærdal) the precipitators initially used were first generation and were in operation over the period 1989 - 2012. The precipitators were ceiling mounted, by-pass mounted and one of them shaft-mounted.

- From a practical, environmental and economic point of view the Norwegian investigations and measurements of the first generation filter plants indicated that the electrostatic precipitators' efficiency (under certain conditions) is questionable.
- The last precipitator was closed down in 2013, due to low efficiency and high operational costs.
- As for the use of high-efficiency cleaning plants, one prior assumption ought to be that the benefits are reasonably proportionate to the total investment and operating costs of the plant. However such benefits have not been experienced.
- The precipitators are energy-consuming with high operating costs and have all been closed down due to these main factors.

Illustration 7 - Picture of electrostatic filters of an Air Cleaning System

As a conclusion, regarding air cleaning, the results are different from one country to another.

An overall balance has to be established between actual efficiency and investment costs, then energy and maintenance costs. The use of air cleaning in road tunnels is relatively new and the number of these installations is very limited. The decision to use such systems therefore has to be carefully analyzed, taking into account several criteria (investment costs, efficiency, maintenance, etc.).

Case study: Evaluation of an NO and NO_2 suppression system

The M5 East, (Sydney, Australia) completed in December 2001, is a 10-kilometre freeway carrying an average of 100,000 vehicles per day.

In 2007, the construction of a filtration plant was launched in order to test the efficiency of filters over an 18-month period in the west-bound tunnel of the M5 East.

The results of the experiment showed that the system tested was neither very efficient, nor cost-effective, but a more efficient system could potentially be developed. In 2014, the filtration plant was closed down.

This experiment is particularly interesting in that its aim was to improve the air quality in the tunnel and consequently the health of users (social pillar and environmental pillar).

The impact of this type of the filtration plant on the three pillars of sustainable development can be seen in the table below.

TABLE 10. IMPACT OF FILTRATION PLANT ON THE THREE PILLARS OF SUSTAINABLE DEVELOPMENT

Pillar	Positive aspects	Negative aspects
Economic		Investment, maintenance and operation costs
Social	Human health (limited impact)	
Environmental	Good for the environment but no real NO_2 removal efficiency	

4.4.6. Effluent treatment

The effluents that are produced by a highway tunnel are either from the underground water table, collected by the tunnel drainage system, or tunnel road surface liquids (cleaning water, rainwater or thawing snow inflowing from tunnel portals or from vehicle tyres, transported liquid goods leakages, or fuel leakages) which are collected by the waste water collection system of the tunnel.

Usually underground water from the tunnel drainage system can be used without any treatment for fire-fighting purposes, for cleaning and for irrigation, or can be channelled directly to the final receiver.

Effluents from tunnel road surface liquids coming into the waste water collection system contain chemical pollutants of different and various levels of toxicity, and flammability i.e. components in a solid or dissolved state, including organic matter as well as minerals, metals, hydrocarbons, solvents, polymers, oil, grease and de-icing salt. The disposal of these liquids must not violate environmental regulations. Depending on the country and regulatory framework in force, these effluents undergo more or less complete treatment before being dumped into the waste water or sewage collection system, outside the tunnel.

For the tunnel road surface liquids collection system it is very important to avoid fire in case of spillage, by installing appropriate devices like firetraps. In order to facilitate the use of clear underground water and to avoid treatment of needless quantities of wastewater (mixture of clear water and road surface liquids), generally the system for drainage of underground water from surrounding rock mass is completely separate and independent from the system for the collection and disposal of road surface liquids.

4.4.7. Recycling

Certain parts or components from equipment used in underground construction works have to be regularly replaced. Consequently, during normal operation a tunnel produces waste (lighting elements, batteries from Uninterruptible Power Supply (UPS) units, filters from pollution collection systems, asphalt from pavements, etc.). When recycling that waste, the objective is to completely or partially re-use the different elements when manufacturing new products.

Therefore, recycling is an important topic in environmental policy insofar as it contributes to conserving natural resources, since recycled materials will be used instead of materials that would otherwise have been taken from nature.