The change is in the air.

Fresh air and ventilation are critical in underground mining, but many mines still rely on outmoded, inefficient systems that consume excessive amounts of energy. It's time for a change.

The lives of underground miners depend on a constant supply of air to survive and work. Not only do they need oxygen to breathe, contaminated air, such as the fumes generated by blasting and exhaust emissions from mining equipment, must be evacuated from their workplaces. Ideally, all mines should, therefore, be equipped with the best ventilation systems money can buy. Unfortunately, that is not always the case. Modern, energy-efficient ventilation systems are still few and far between in a global perspective.

Research shows that although many ventilation systems can claim to meet local health and safety standards, they are also the biggest economic "villains" of the industry, generating enormous levels of inefficiency and waste, culminating in ever-increasing energy costs.

Compared to other industrial applications, designing, and constructing a ventilation system for an underground mine is undoubtedly a complex and challenging task. The nature and structure of the workings; the type and number of mobile machines in use, such as drill rigs, LHDs and haulers; the number and deployment of mine personnel; the energy source; and the cost of powering the system are just a few of the parameters that need to be taken into consideration.

A typical ventilation system consists of fresh-air raises and raises for evacuating contaminated air, which go all the way up to the surface, in one or several steps, to the primary fan station. Added to this are secondary fans that drive the fresh air from the fresh-air shaft via ventilation ducts into the production areas as shown in Figure 1, as well as fans in the production area itself, which distribute the fresh air and dilute exhaust gases.

Individual systems always vary in size and quality and in the way they are set up, but in general they all have one thing in common; they are inefficient and often impossible to adapt to the changing needs of the underground mining environment. While drilling normally requires 30–40% ventilation capacity, low-level haulage will require significantly more. The guidelines for ventilation needs vary from one situation to the next and are set according to installed diesel effect.

In many cases, however, the only way to ensure that a mine has sufficient air throughout the working day is to overventilate. As a result, many of these systems are typically run at 100% of their capacity most of the time, constantly driving fresh air into mining areas where often no mining is taking place and extracting air from

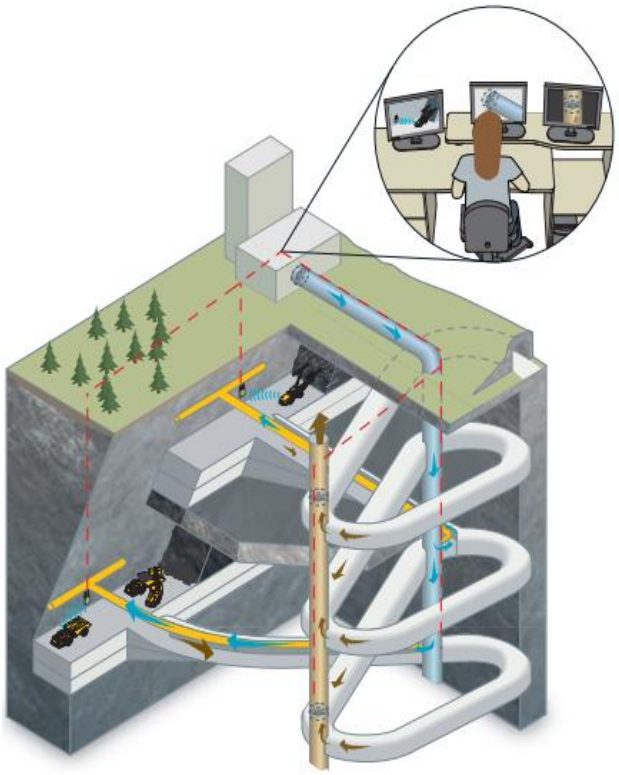

Figure 1. Using a variable-frequency system such as SwedVent, ventilation output can be adapted to each activity, giving energy savings of 30–50%.

areas where there are no fumes to extract. Furthermore, they normally leak substantial amounts of air along the way, which reduces pressure and further increases both energy consumption and running costs.

Ventilation on demand

Today's state-of-the-art ventilation systems solve most, if not all of these issues. To begin with, their individual components – fans, tubing and ducting – are, or should be, constructed from robust, top-class materials, designed to withstand the rigors of the mining environment with a minimum risk of leakage. Not only that, but they also usually come with some form of control facility, which enables the right amount of fresh air to be directed to the right place at the right time, and fumes to be extracted quickly and efficiently at any given time.

This control capability, which is often referred to as "ventilation-on-demand" is the most effective and cost-efficient way of dealing with ventilation in underground workings, optimizing the input of fresh air and optimizing the output, or extraction of "bad" air via the ventilation shafts. Not least, they provide the flexibility mine managers need to plan ventilation in parallel with mining operations on a shift-to-shift, or day-to-day basis.

At the very least, an on-demand ventilation system will give:

- Air flow tailored to the needs of equipment or activity
- Local adaptability
- Reduced energy costs
- Minimised energy waste

In designing the most appropriate underground system, three criteria should be taken into account. Firstly, a well-ventilated environment must be provided wherever miners will be at work in order to supply oxygen, not only for humans to breathe but also for efficient engine combustion, to control temperature, to dilute and remove toxic gases and, in a few cases, to ventilate areas where there may be levels of radon. It may also be important to cool the air underground.

Secondly, as today's mines are in a permanent state of evolution, the system should be developed in such a way that it can be easily scaled up to meet needs for expansion or going deeper at some point in its future. In these cases, having additional cooling systems connected to the same grid is a must. And last, but not least, it should be as cost effective as possible in order to minimize energy costs and safeguard the mine's financial resources.

Optimised air flow

One system that offers all these advantages and more is the SwedVent system. As well as high quality materials, flexible ducting, low noise and control, SwedVent also believes that a successful solution depends largely on the combination of components and, therefore, offers a wide range of different solutions for underground use.

This includes high pressure fan stations that can deliver air along extensive lengths of ducting in different diameters, with a capacity of 2.5–175 m3 /sec. Even more important is that the system also offers impeller blades with variable angles that can be set up in series. The possibility to simply adjust the pitch of the blade angle makes it simple and quick to adapt the fans to suit different motor dimensions and pressure requirements.

Together, these features enable a multitude of solutions to be constructed for different requirements and the air flow to be optimized for each application.

One interesting development that is likely to advance this technology further is a cooperation agreement between equipment supplier Atlas Copco and the automation and power company ABB, whose control technology gives the possibility to regulate the ventilation fans in all parts of the mine and can be coupled with Atlas Copco's SwedVent fans.

Such systems have already proved their worth at a number of mines in Sweden and Canada. At the Kristineberg Mine in Sweden, for instance, automation has reduced the cost of ventilation for the owner, Boliden, by at least 30%. Here, the fans, of which about 30% are frequency-controlled, are programmed to only operate in the rooms where activities are in progress – a solution that has enabled Boliden to postpone an expensive project to sink a new ventilation shaft.

Another Boliden-owned mine, Garpenberg, has a similar system in place for a part of a new major mineral deposit at Lappberget, which will substantially extend the mine's operating area. In this case, the energy consumed by the fans fell by approximately 500 A or 200 kW, signifying a potential cost reduction of around 40%. In fact, the savings achieved at Garpenberg are expected to be so substantial that Boliden expects the investment to be recovered within just three years.

Identification sensors

To design demand-driven ventilation systems based on the estimation, regulation and presence of vehicles is a difficult challenge. Mobile equipment in underground mines consume a significant amount of energy, typically 100 GWh/year, which can be as a much as 50% of the total energy consumption for underground activities. In addition, these vehicles are entering and leaving production areas all the time, meaning that the air demand for the airways to the production areas constantly changes. Fresh air must also be distributed to the areas where mine personnel are located, and the incoming air may also need to be heated or cooled.

The solution for this is to mount WiFi transmitters on all mobile equipment and receivers on the fans in the various drifts. This enables the presence of vehicles, their type and work activity to be identified by the central ventilation control system, which then allocates the required air flow accordingly. In this way, fans are not activated unnecessarily in areas where mining operations are not in progress.

This also enables the ventilation system to be fully synchronized with daily and weekly production plans from the mine planners' office.

Multivariable models describe how changes in the speed of fans affect both the airflow and the pressure over fans. The overall objective is, therefore, to optimize the system in such a way so that the desired airflow in various airways is maintained at the same time as the power required to run the fans is minimized.

Since the cost of ventilation is a major item for all mines – often accounting for 35–45% of the total energy consumption – it is an area that is ripe for improvement with huge potential gains, both for the mine's balance sheet and the people who work underground.