 DOI: 10.3217/978-3-85125-883-7-03

Tunnel Ventilation and UN 2030 Sustainability Development Goals – we have a story to tell

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ABSTRACT

The 2030 Agenda for Sustainable Development, adopted by all United Nations Member States, provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. Politically tunnel projects must be seen and actually be responsive to the United Nations climate change agenda. This means we, as tunnel ventilation experts, must articulate the benefits and efficiencies of the ventilation systems we design, operate, and refurbish using this modern narrative. From energy consumption minimisation to control systems that will respond to deceased emissions – our emphasis must be on explaining our approaches focused on the principles of sustainability. If we do not focus on these messages, we risk catastrophic rejection of our projects on sustainability grounds. The biggest threat to tunnelling and tunnelling projects is our industries lack of focus on adequately promoting underground infrastructure contribution to achieving the UNs sustainability objectives of 2030 and transformational opportunities, in the face of climate change. This paper proposes a framework for articulating tunnel ventilation opportunities that embraces the United Nations 2030 agenda for sustainable development.

Keywords: Sustainability, ventilation, underground, infrastructure, climate change

1. INTRODUCTION

On 28 February 2022 the Intergovernmental Panel on Climate Change (IPCC) [1] being the United Nations (UN) body for assessing the science of climate change established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO), published a, '*... dire warning about the consequences of inaction ...*' advising that, '*... climate change is a grave and mounting threat to our wellbeing and a healthy planet. Our actions today will shape how people adapt and nature responds to the increasing climate risks.*'

The 195 member governments of the UN IPCC have collectively warned of acute food and water insecurity, loss of life, and loss of infrastructure. The report urges immediate adaptive action be taken including more resilient life critical services such as clean water, critical infrastructure such as energy and transportation systems, storm drought and flooding controls, and sustainable transport systems.

The United Nations (UN) Department of Economic and Social Affairs revised its 2030 Sustainability Development Goals (SDGs) [2] in recognition of the declaration on 12 December 2020 by the United Nations Secretary General of a climate emergency [3] and consistent with the findings of COP26 [4].

Underground infrastructure, tunnels, are a proven method for robustly addressing adaptive and transitional climate change issues. Tunnels are a proven method for improving the human condition and are well suited to responding to the world's most pressing climate change and sustainability issues.

However, tunnels are carbon heavy during construction and consume energy over very long periods of time.

Tunnel ventilation is one of the big consumers of energy during the lifetime of a tunnel and we as tunnel ventilation practitioners must be mindful of that energy burden and adjust our approach to tunnel ventilation and how we describe the systems we design, operate and refurbish, with the declared climate emergency and sustainability development goals in mind.

There is a common and popularist view that all governments must exercise their decision making powers on behalf of their people to mitigate climate change by the most appropriate spending of limited public funds.

This means that most decisions relating to underground infrastructure in all countries include a requirement to demonstrate how the project will benefit the environment more than other projects competing for the same limited resources. Even during competitive bidding for tunnel projects – sustainability issues are often weighted and can be decisive for successful bidding.

Modern history demonstrates that there is a close relationship between underground infrastructure and underground development and positive environmental and social outcomes. From the provision of clean water and sewerage to highly efficient underground transportation systems, to the efficient and effective delivery of energy and other resource, the association between underground infrastructure and social and environmental benefits is clear. However, collectively as a global industry, we have failed to keep pace with the narrative, language, and metrics used to measure and communicate the collective benefits (and disbenefits) of the use and development of underground space.

This failure was recently highlighted in Germany by a legal challenge to a metro project on the basis of its adverse environmental impact due to its high construction carbon footprint.

There will be more such challenges as communities and their governments critically review their investment strategies through the new lenses of a perceived climate emergency and the urgency of taking action. Internationally this is now being evidenced in project procurement documentation which assesses the merits of projects using criteria designed to measure likely adverse impact on climate and the environment generally. As a professional industry we must rise to this challenge and better and more transparently articulate the implications of underground works projects and there long term operational implications for humanity and the planet.

2. Tunnel Ventilation

There are a range of metrics associated with tunnel ventilation which can inform and assist decision makers assess the merits of underground projects generally and competing design and operational regimes specifically. For transportation tunnels it is possible to calculate the impact on carbon emissions due to increased vehicle efficiency and reduced journey times [5]. For utility tunnels such as water, sewerage and power, calculations can be undertaken to demonstrate the overall reduced carbon footprint of the underground option and offset that from the ventilation energy carbon footprint.

2.1. Ventilation - Energy Consumption

The practice has been to describe energy consumption of competing ventilation design options primarily based on cost. By adopting a sustainability development goal (SDG) criteria various design options can be assessed in an SDG framework that better informs the decision making process.

The source of energy for tunnel ventilation should be a factor in assessing the impact of energy consumption on achieving sustainability performance. A naturally ventilated tunnel will likely have minimal mechanical ventilation, a tunnel powered by renewable energy sources has a smaller footprint than the equivalent tunnel powered by fossil fuel electricity generators. An example of the difference of the source of electricity can have on the environmental footprint of a tunnel was examined in the context of tunnel air cleaning technologies comparing a nuclear powered option with a coal powered option [6]. The analysis found that it was better not to clean tunnel air if the power source was from a coal powered electricity generator.

2.2. Using United Nations Sustainability Goals

The United Nations Department of Social and Economic Affairs has created a set of 17 goals which can be used as a method to link ventilation engineering to positive sustainability outcomes. In doing so ventilation practitioners can assist decision makers positively assess ventilation proposals.

Sustainable Development Goal 7 is to ensure access to affordable, reliable, sustainable and modern energy for all. The UN is promoting accelerated action on modern renewable energy especially in the heating and transport sectors. When designing a tunnel passive ventilation (such as regular openings and innovative use of the piston effect) could be explored (if appropriate) and their benefits weighted to reflect the emerging importance of lower energy consumption in underground transportation assets. This is often difficult because until very recently the environmental effects of emissions from many road tunnels were driven by the prudent management of emissions from fossil fuel engines. That situation is changing rapidly, and tunnel ventilation designers can now embrace improved fossil fuel vehicle emissions and thereby engage in an SDG discussion from a tunnel ventilation perspective. In doing so tunnel ventilation engineers assist projects navigate increasingly rigorous sustainability based assessments of projects.

2.3. Efficiency of Tunnel Ventilation

There are many opportunities to improve the efficiency of tunnel ventilation systems.

The configuration and exact location of fans (of whatever type) impact the efficiency of the ventilation system. Detailed consideration of fan location and orientation, overall cross section, niche design, duct size and detailed geometry to energy consumption and therefore the SDGs is a powerful tool for project advocacy. For example providing a greater distance between a tunnel lining and jet fan can greatly increase the efficiency of the jet fan because the plume of the jet fan is not impinged by the tunnel wall and the energy of the jet fan can be transferred more efficiently into momentum.

By describing the advantages of alternative tunnel geometries in terms of impact on energy efficiency of the ventilation system in an SDG context decision making can better balance construction costs with the overall SDG outcomes or the design life of the infrastructure. It is best to translate the energy consumption and efficiency performance into a SDG context to help inform the decision makers.

2.4. Duct Work – Detailed Design

The aerodynamic efficiency of tunnel ventilation has been a consistent theme was the hallmark of renowned scientists at the Technical University of Graz such as the generation of Karl Pucher, Alex Härter and Ferro whom carefully explored energy efficient designs, proposing guiding vanes and curved ducts wherever possible. In recent years a focus on construction costs has driven cheaper and less efficient designs – the SDGs provide a narrative that values efficiency – for the collective good of our people and shared planet.

In 2022 there are opportunities to deliver energy savings in project ventilation through detailed design of ducts. Such detailed design work can rightly inform SDGs and become part of the advocacy for tunnel projects. Describing these efficiencies in the context of modern SDGs allows decision makers to better consider the merits of tunnel projects and alternative tunnel ventilation solutions.

2.5. Fan Efficiencies

There are a range of techniques and technologies that improve the efficiency of fans either through refinement of their physical design or the control systems that regulate their use.

2.5.1. Design

Various fan manufacturers claim efficiencies in their fan design. As part of the narrative to assist the decision making process these efficiencies should be described in terms of achieving the UN SDGs. It is not enough to merely talk about the improved efficiency because decision makers need information in a form and usable language that helps them meet requirements in policy and contractual documents of evidence of improved energy efficiency in major infrastructure.

2.5.2. Control

The ability to better control ventilation systems is also an opportunity to reduce energy consumption and usually reduce peak energy consumption by a range of techniques and technologies that reduce start up peak energy demand and optimise energy usage for a given ventilation outcome.

By framing the narrative that describes these energy consumption changes in terms of reduced peak energy demand and decreased overall energy usage provides a basis for making evidence based claims about how a control system contributes to achieving United Nations Sustainability Development Goals. This in turn helps decision makers make informed decisions about how best to spend their limited resources.

3. Lateral Thinking

It is not common for technical practitioners to embrace translating their technical engineering data and evidence into a narrative that informs broader public policy and decision making. However, the UN has declared a climate emergency and popular opinion is demanding that limited financial and technical resources be mobilised to address the emergency.

A reduction in peek energy consumption of underground infrastructure makes more energy available to the community because the reduction in peak demand allows more users of the same overall amount of energy with no reduction in the level of service. In making more energy available, such a strategy meets the requirements of SDGs 7, 8, 9, 11, 12, and 13.

The energy reduction meets SDG 7 as it increases access for others to the existing available energy, SDG 8 as it promotes more sustained use of underground infrastructure, SDG 9 as it promotes resilient infrastructure, makes the infrastructure more sustainable and is an innovation, SDG 11 as it makes the network it forms part of more resilient and sustainable, SDG 12 by making energy consumption more sustainable, and SDG 13 as it is an example of urgent action to reduce energy consumption and thereby combat climate change.

Figure1: SDG Icons 7 to 9 and 11 to 13

By embracing more energy efficient underground designs and including either in new build or refurbishment higher efficiency and better control of tunnel ventilation a project is directly contributing to the stated United Nations objectives. In linking our tunnel ventilation outcome to these United Nations goals our outputs become more persuasive to decisions makers and the general public demonstrating we are taking urgent action to combat climate change by reducing energy consumption and better articulating the benefits of tunnels and underground space.

More action is required to better quantify and capture the benefits of improved approaches to tunnel ventilation specifically and underground infrastructure generally. The ITA is embarking on a program to help formalise a process of capturing the tremendous benefits and innovations in the use and development of underground space for the benefit of humanity and the planet.

4. CONCLUSION

We, as tunnel ventilation practitioners, can do our part in ensuring that the positive contribution we make to humanity and the planet is captured and recognised by decision makers and the public. The most fundamental step in achieving that outcome is embracing the language and concepts of sustainability and climate change in the narratives we generate. Furthermore, by describing the innovations in tunnel ventilation using the SDGs it makes it easier for allied professionals to perform carbon footprint offset calculations to address the considerable carbon cost of building underground infrastructure and places.

Describing our advances in tunnel ventilation, the great innovations and improvements we are making in reducing energy consumption, and describing the energy tunnels consume in terms of the offset of emissions generated by above ground activity without the tunnels is increasingly critical to ensuring the true environmental value of underground solutions is not overlooked by decision makers focused on addressing the climate emergency and the competing projects seeking to transition and adjust our human activities.

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