Report

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Swiftly Green Best-Practice Case: Infrastructure spatial planning and environmental effects

Version Control

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2 Introduction

The SWIFTLY (SWeden-Italy Freight Transport and Logistics) Green Corridor project is a European project, which run from March 2013 until December 2015. In this project 13 partners from Austria, Belgium, Denmark, Germany, Italy and Sweden develop a toolbox for green corridors in the TEN-T core network. The lead partner is CLOSER (Lindholmen Science Park AB, Sweden).

The objectives for this toolbox are to implement green efficient, integrated and multimodal solutions along the TEN-T Scandinavian-Mediterranean core network corridor. The developed toolbox from Swiftly Green consists out of guidelines, tools and recommendations for green logistic and transport. These measures are based on applicable research and development, transferable results of earlier projects or best-practices cases.

Tunnels are becoming an increasingly important factor in infrastructure improvement and enhancement. The growing number of tunnel projects, along with the renovation and maintenance of existing tunnel systems, represent a considerable proportion of construction projects in the infrastructure sector. This infrastructure sector has considerable potential with regard to ecological improvements.

Best-practice case – Infrastructure spatial planning and environmental effects

The Brenner Base Tunnel is the heart of the Scandinavia-Mediterranean TEN Corridor from Helsinki to La Valetta, Malta. The European Union is promoting the expansion of this transnational multimodal corridor and considers this work to be high-priority. The BBT is meant primarily for freight transport, allowing a modal shift of traffic from road to rail. Passenger trains can also travel through the tunnel. Thanks to the almost horizontal tunnel train traffic will no longer have to contend with the steep up- and downhill slopes on the 20km longer Brenner railway line.

Figure 1: Brenner Base Tunnel (BBT) in the Scandinavia-Mediterranean TEN Corridor
Contributing to this toolbox, this document summarizes the best-practice case – Infrastructure spatial planning and environmental effects – from the Brenner Base Tunnel (BBT). This infrastructure project delivers for the toolbox best-practice cases for an environmentally friendly infrastructure planning and construction. Beside the wide variety of environmentally aspects at the BBT spatial planning the output of best-practice cases in this document is concentrated on a limited number of greening measures for the toolbox. These measures are chosen by selection criteria to define solid, effective and transferable measures.

2.1 Scope and objectives

The implementation of the SWIFLY Green Toolbox depends highly on its measures. By including best-practices cases and selecting their measures with highest greening potential, a wide variety of innovative measures will be included in the first version of the SWIFLY Green Toolbox. The measures of this best-practice guide comprise examples of green innovations implemented at the infrastructure planning of the BBT. They are chosen carefully to receive solid and effective measures and to guarantee a sufficient transferability.

Due to the complex dependencies of some measures, evaluations by life cycle assessments (LCA’s) are realised to confirm and estimate their greening effects. These life cycle assessments give detailed insight about dependencies and environmental impact of infrastructure constructions on the one hand and quantify the reduction of the environmental pollution on the other hand.

The aim of this report is to support a green and efficient TEN-T core network through the growth and population of the SWIFLY Green Toolbox database by solid and effective measures of the best-practice cases Brenner Base Tunnel.

Figure 2: Construction of BBT, Ahrental Austria
2.2 Instruction to readers

This report consists of six main tunnelling relating topics. For each topic a general description with a conclusion/outlook is given. This is followed by the fact sheet and some optional specific information of technical examples from the BBT. Following topics and related measures are covered in the chapters:

Chapter 3: Recycling of tunnel spoil for filler, drainage gravel, solid and loss foundation layers and as aggregate for concrete.

Chapter 4: Reduced low-level CO2 concrete and shotcrete with recycled aggregates

Chapter 5: Tunnel 3D surface mapping for optimizing geometry and construction cycles to obtain material savings (excavation material, shotcrete, concrete, explosives)

Chapter 6: Unreinforced tunnel inner linings

Chapter 7: Recycled aggregate concrete usage for material savings (aggregates, reduction of demolition material)

Chapter 8: Potential geothermal energy exploitation in the BBT tunnel system (Italian side).
2. Thermal use of drainage water

Description: The thermal use of drainage water from tunnel works is a technique already implemented in many Alpine tunnels, such as the Loetschberg Tunnel and the Gotthard Tunnel. The exploitable power depends mainly on water temperature ranges and steady-state inflows.

In normal gradient conditions, the temperature of the drainage water is not sufficient to directly provide heat to buildings, so that a heat pump system should be installed in order to rise up the temperature.

In the case of BBT tunnel, the thermal power is also conditioned by the temperature threshold of the Isarco river, where the drainage water is discharged according to environmental regulations. The admissible temperature change of the river is about 1 °C.

The Aica service tunnel is already excavated and the drainage water rate varies between 50 and 70 l/s; the values of stationary drainage water rate of the entire BBT Italian tunnel system were calculated by estimations realised during the preliminary design phase and then updated with the Aica service tunnel present values;

The drainage water rate values are:

- Aica service tunnel: 50 - 70 l/s (measured).
- BBT tunnel system, between the national Italian border and the Aica access portal: 250 - 350 l/s (estimated).

The 3D Temperature Mountain Mapping model (see factsheet n°1) indicates the following range of temperature values:

- Aica service tunnel: 20 - 24 °C.
- BBT tunnel system, between the national Italian border and the junction with the Aica service tunnel: 24 - 28 °C.

The admissible minimum temperature of the discharge water in the Isarco river is function of the flow rate from the Aica access tunnel and is summarised in Table 1.

| Admissible minimum temperature of the discharge water in the Isarco river (°C) |
|---------------------------------|-------|-------|-------|-------|-------|-------|
| Flow rate (l/s)                |       |       |       |       |       |       |
|                                | Aica service tunnel | BBT Italian tunnel system |
| 50                             | 0,86   | 0,87   | 0,87   | 0,89   | 0,89   | 0,89   |
| 60                             | 1,94   | 1,95   | 1,96   | 1,99   | 1,99   | 1,99   |
| 70                             | 4,29   | 4,31   | 4,32   | 4,38   | 4,38   | 4,38   |
| 250                            | 6,06   | 6,08   | 6,10   | 6,17   | 6,18   | 6,18   |
| 300                            |       |       |       |       |       |       |
| 350                            |       |       |       |       |       |       |

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Table 1: Admissible minimum temperature of the discharge water in the Isarco river according to the local environmental regulation.

The exploitable thermal power is calculated from the flow rate, the water temperature and the admissible discharge temperature in the Isarco river, and is given in Table 2 and 3, respectively for the solely Aica access tunnel and the whole BBT tunnel system (Italian segment).

<table>
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<th>Maximum exploitable power (MW)</th>
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Table 2: Estimation of maximum exploitable power from discharge water of the Aica service tunnel.

Considering the present maximum value of the discharge water flow rate (i.e. 70 l/s) and a water temperature of 24 °C, a maximum exploitable power of about 6.5 MW is expected. Much higher exploitable power will be available once the tunnel system will be completed.

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<td>Flow rate (l/s) Flow rate (l/s) Flow rate (l/s)</td>
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Table 3: Estimation of maximum exploitable power from discharge water of the entire BBT tunnel system (Italian segment).

Data suggest that, although the huge amount of potential thermal power, the temperature is generally low, and a heat pump system is needed.

The city of Bressanone, as well as the nearby villages, such as Varna, is mainly served by a district heating system of biomass central stations, whose working temperature is around 90 °C, with return temperature even up to 70 °C (Source: Sustainable Energy Action Plan of the city of Bressanone). The integration between the low enthalpy discharge water and these existent kinds of district heating systems appears therefore difficult and non-efficient. Even with the aid of high temperature heat pumps, the maximum temperature reachable for the discharge water in order to not have an unacceptable efficiency fall is about 50 - 60 °C.

A possible innovative solution would be to create a new “cold” district heating system, for serving the urban areas not (or partially) connected to the existing grid.

In this case, the concept is different, being the network fed directly by the low enthalpy drainage water, while high temperature heat pumps are placed directly in the urban areas, or even inside the single buildings. The system is balanced by appropriate “cold” storage tanks placed along the network layout. In this way, the heat losses of the network are maintained low, and for each buildings, districts or area, there is the possibility to choose the best heat pump solution, according to internal plants and building eco-efficiency. A scheme of the cold district heating system is presented in Figure 1.
Figure 1: Example of “cold” district heating, fed by ground water and connected to multiple heat pumps in different buildings. (Source: COGEME).

With this solution, it is possible to feed multiple potential areas around the Aica access portal, as shown in Figure 2.

Figure 2: Maximum present exploitable thermal power from the Aica access tunnel and map of potential thermal utilisations in the Aica access area.

The “cold” district heating system solution can be applied also to the closed loop systems, which extract energy from the tunnel linings (see factsheet n°3), if the thermal users are placed far from the tunnel itself.

Derivation: Standard closed loop geothermal design, as reported in the Italian Technical Norm UNI 11466.

Bibliography:

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**Evaluation Results:**

**Utility analysis:**

![Thermal use of drainage water chart]

**Technical:**

- Solution to use drainage water, otherwise simply discharged in the river, as thermoenergy vector.
- Possibility to feed multiple buildings, districts and areas, with different heating needs and working temperatures, located even far from the Aica access tunnel.
- Improvement in balance of geothermal pipelines temperature and flows, through the insertion of storage tanks along the path.
- Possibility of reversing the cycle for cooling purposes thanks to the use of
| Economic: | Practical zero investment costs to extract groundwater and to reinject it in the same aquifer, as traditional open loop systems.  
| Environmental: | Absence of any thermal pollution for the river water, by controlling the discharge temperatures according to the power needed and to the environmental regulations.  
| Social: | Better social acceptance of large infrastructure construction when accompanied by renewable energy projects.  
| Overall evaluation and recommendations: | The thermal use of drainage water is an economically effective way of providing energy to buildings interested by underground infrastructures. It is already a standard technique and it is applied in many Alpine tunnels. The innovation of installing a “cold” district heating network, instead of using directly the heat through heat pumps nearby the tunnel portal, gives the possibility to increase the versatility of the system and to decrease heat losses along the path.  
| | The Aica portal is located in a suitable position for installing a “cold” district heating network and serving many final users and cities, even up to the Bressanone city.  
| | The discharge water, on the contrary, cannot be used in the existent traditional district heating system because of the different temperature levels. This fact can limit the potential diffusion of the new network.  
| Influence on other themes: |
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**Transferability:**

- The thermal use of drainage water is already implemented in many tunnel and underground projects around Europe. The innovation discussed here consists in integrating it to a “cold” district heating network, by increasing its versatility and easy transferability to many other similar projects, since the infrastructure design and construction is influenced only marginally.