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THE UNDERGROUND SEWAGE TREATMENT PLANT
AT BRUNICO IN MEDIA PUSTERIA

LA STATION D'ÉPURATION SOUTERRAINE DE BRUNICO

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Résumé
La station est située dans le Trentino Alto Adige, région principalement montagneuse avec 20% de la surface utilisable pour l'habitat ou la production et d'une grande qualité environnementale.
Le choix du site résulte de l'analyse de différents types de stations d'épuration en surface et en souterrain et de l'examen de plusieurs localisations. Finalement, la station souterraine présente l'impact environnemental le plus faible, condition essentielle pour maintenir les équilibres écologiques dans la région. De plus, une analyse comparée des coûts à moyen terme montre que les coûts industriels de la station souterraine sont inférieurs à ceux d'une station en surface. Cette analyse ne tient pas compte des coûts environnementaux et sociaux (population voisine) liés à la présence d'une station d'épuration en surface.
La station a été conçue de manière à respecter des normes de dépollution très sévères selon les standards de l'EIA (évaluation d'impact environnemental) ; elle a une capacité hydraulique de 95 000 équivalents habitants, ce qui correspond à une capacité biologique de 130 000 eq. hab. Le déblai d'environ 200 000 m^3 de sol est envisagé, sur des sections variant de 50 à 250 m^2. La station devrait entrer en service à la fin 1995.
Objectifs de la conception :
- localisation fonctionnelle des éléments permettant une extension future ;
- insertion dans le site naturel et aménagement "naturel" des espaces libres ;
- prise en considération du fait que les bâtiments sont visibles.
La comparaison entre les conceptions en surface et souterrain repose sur les facteurs suivants :
- facteurs environnementaux, sociaux, paysagers ;
- facteurs liés à la construction ;
- facteurs liés au fonctionnement.
L'analyse économique compare les coûts de construction et de fonctionnement pour des stations de même capacité dans trois cas : station en surface, semi-enterrée et souterraine.

Abstract
The plant is located in the Trentino Alto Adige. This region is mainly mountainous with 20% of the land usable for residential and production purposes. It is of great environmental value.
The choice of location was made after considering various types of plant on the surface and underground and various locations. Finally it was decided that an underground plant would have the least environmental impact, an essential condition for maintaining natural environmental equilibriums in the region. Furthermore, a comparative cost analysis over the medium term showed that the industrial costs of the plant underground were lower than those of a surface plant. This analysis did not quantify environmental and normal social costs (to nearby communities) arising from the presence of a surface plant.
The plant was designed to very high purification standards in accordance with EIA (environmental impact assessement) standards; it has a production capacity of 95,000 equivalent hydraulic inhabitants corresponding to 130,000 equivalent biological inhabitants.
The excavation of approximately 200,000 cubic metres of rock is envisaged with cross sections varying from 50 to 250 sq m.
The plant is planned to go into service at the end of 1995.

Design objectives:
- functional location of the various parts allowing for subsequent expansion;
- natural insertion into the area, where possible, and natural organization of free space;
- consideration given in the design to the fact that buildings are visible from above.

The comparison between designs for surface and underground plants considered the following factors:
- environmental, social, landscape and urban factors;
- construction factors;
- operational factors.

The cost analysis compared the costs for the construction and operation of wastewater treatment facility with the same production capacity but with different locations: in the open, earth-sheltered and underground.

Keywords: umerground construction; wastewater treatment facility; environment.

1. INTRODUCTION

During the last few years there has been a tendency in Italy, as in other countries, to pay greater attention to underground space as a resource for the location of various types of infrastructures. It safeguards the environment and also brings with it other advantages as will be seen below.

It should first be considered that many civil engineering works have already been sited underground. Some of the most important have been listed below:

METROPOLITAN MAINLINE RAILWAYS	Stations Workshops Rail yards Power lines
ROADS	Urban networks Regional networks
TRANSPORT NETWORKS	Oil pipelines Gas pipelines Power lines Electrical distribution Data networks Heat
INFRASTRUCTURES	Parking complexes Ice stadiums Sports complexes Markets Concert halls Cinemas Museums Hotels State archives Libraries
WAREHOUSES AND STORAGE FACILITIES	Water Cereals Compressed air

	Fuels Heat Perishable materials Goods Refrigerated storage
WASTE DUMPS	Urban Industrial Hospital Radioactive waste Chemical waste
CIVIL INSTALLATIONS	Hydroelectric stations Thermo-electric stations Electrical substations Refuse treatment Waterworks Data processing plants Transformer stations
NUCLEAR INSTALLATIONS	
MILITARY INSTALLATIONS	Nuclear shelters Military headquarters Military depots Airports Missile ramps

The reasons for the success of the decision to design and construct underground are to be found in the following considerations:

- The scarcity of available surface areas that are suitable and still usable, especially in urban areas;
- Ecological and landscape motives;
- Technical requirements;
- Strategic and security requirements;
- Less costly when both initial investment and long term operational costs (see energy savings and maintenance) are taken together.

Given the above considerations, in Italy too, in the Autonomous Province of Bolzano to be exact, the first underground constructions and some significant studies can be counted. One of these examples is examined to describe the real advantages of such works.

2. THE SEWAGE TREATMENT PLANT AT BRUNICO IN MEDIA PUSTERIA (BOLZANO)

2.1. The installation and the area

The sewage plant, currently under construction, was sited at a place called "TOBEL" near Brunico.

The choice of the type of plant and location was made after examining various alternative proposals on the surface. These were all rejected in turn as undesirable because of environmental impact and general disturbance to the surrounding community and local tourism caused by bad smells.

The plant supplies a wide geographical area as can be seen from the illustration and involves eleven local authorities.

The plant was designed tovery high purification standards in accordance with EEC standards; it has a production capacity of 95,000 equivalent hydraulic inhabitants corresponding to 130,000 equivalent biological inhabitants.

2.2. The plant

The plant consists of an intake tunnel which transports the sewage to a central cavern where preliminary treatment is carried out. The effluent from this treatment passes down two side tunnels and then into a central tunnel for chemical treatment as can be seen from the schematic process sheet (illustrated) after which it is discharged with a degree of purification of 95%.

The residual sludges resulting from the preliminary treatment are subjected to a physical process which consists of disinfection and then anaerobic digestion in special towers (see fig.) with the consequent production of biological gas. The remaining solid waste is further dewatered and stored. Part of it may be used as fertiliser in agriculture and part sent to the waste tip.

The biological gas produced from the sludge digestion fuels a plant producing heat and electricity making the plant autonomous as far as heating is concerning and creating electrical energy savings of 50%.

Finally the air containing bad smelling gases is subjected to a biochemical washing process (see process sheet).

2.3. Civil Engineering

The civil works can be divided into the following three parts:

- Intake tunnel:	a 3.9 m. dia. tunnel, 90 m. in length; it was excavated using a cutter which also had a geological and geotechnical survey function.
- Caverns	one large central cavern approximately 350 m. in length with a cross section varying from 60 to 80 square meters (see drawings and photo). Side tunnels approximately 326 m. in length, with a cross section of from 190 to 240 sq m. and an 80 m. access tunnel with a cross section of 50 sq. m. Connecting tunnels between the central and the side tunnels 40 m. in length with cross section of 50 sq. m. The total volume of the caverns amounts to approximately 200,000 cubic metres.

- Surface installations

The surface installations consist of:

- Service building including:
  - Gasometer
  - Plant for heat and electricity generation and sludge treatment
  - Administration and laboratories
  - Sludge dewatering and storage
  - Biogas digesters consisting of two large cylindrical bodies with a volume of 2,000 cubic metres each.

2.4. General information

The client contracting the work out is the Autonomous Province of Bolzano, which supervises the work through a body named Alta Sorveglianza (High Surveillance).

The contract for the project was awarded to a consortium named the "Consortium of the Constructors of the Province of Bolzano" responsible for construction including land acquisition, design, direction of works and management of the plant for the first 5 - 10 years of operation.

The project is already at an advanced stage of construction. Completion is scheduled for the end of 1995.

The total estimated cost amounts to 125 billion Lire which breaks down as follows:

- Infrastructures	4.00
- Intake tunnels	6.00
- Caverns	35.00
- Civil engineering (surf. and undergrnd)	35.00
- Sewage treatment plant	20.00
- Electrical plant	16.00
- Ventilation plant	6.00
- Special plant	3.00

Total	125.00

3. ECONOMIC COMPARISON (CAVERN V. SURFACE)

A comparison of the two alternatives must take two types of factor into consideration, the first of a general nature and the second of an economic nature.

In general terms the following positive factors can be listed in favour of the cavern alternative (see Table):

- Environmental and social aspects that make it difficult to imagine the construction of a large sewage treatment plant without running into bureaucratic problems caused by the enormous impact it would have on the area with damaging consequences for tourism.
- The loss of cultivable land for agriculture and of green landscape. It is sufficient to consider that only 20% of the land in Alto Adige is usable for agricultural, residential and industrial purposes. Conservation of usable land is of the maximum importance.
- Construction times: construction times are much shorter as they are not affected by the weather. This means a lower investment of capital and continuous work on the part of personnel involved in construction.
- Energy savings on the operation of the plant because the ambient temperature of the caverns is almost constant and does not require external heat input to ensure maximum performance at the optimum operating temperature. Savings in extraordinary maintenance costs because the construction is protected from atmospheric agents.
- Finally the possibility of trapping bad smelling air inside the cavern and then subjecting it to biological washing treatment thus avoiding distress to the surrounding community.

In economic terms the problem was analysed in depth as can be seen from the **two tables**. A comparison of the plant with two alternative surface designs was made, one an outdoor plant, the other indoor. Initial investment costs (construction, plant, filling and land) in terms of the expected life of the plant according to full depreciation periods were compared. The sum of these provided the construction cost for one year of the life of the plant.

Annual operating costs were also calculated (pumping, ventilation, illumination, heating, ordinary and extraordinary maintenance) and added to the costs in the previous table.

Examination of the figures shows that the underground plant is less costly than surface plants without even considering all the other advantages of a general nature already described.

IMPIANTO DEPURAZIONE MEDIA PUSTERIA -ARA
ABITANTI EQUIV.IDR. 195.000
ABITANTI EQUIV. BIOL. 130.000

CONSTRUCTION COSTS

TIPO IMPIANTO	OPERE CIVILI			OPERE ELETTROM.			COPERTURA			TERRENI			TOTALI		
	anni ammortiz.	imp. totale milioni	imp./anno milioni	anni ammortiz.	imp. totale milioni	imp./anno milioni	anni ammortiz.	imp. totale milioni	imp./anno milioni	anni ammortiz.	imp. totale milioni	imp./anno milioni	costo costruzione milioni	per abitante equivalente milioni	costo costr/anno milioni
ALL'APERTO	30,00	43.000.000	1.433,33	15,00	34.000.000	2.226,67	30.00	2.000.000	66,67	30,00	3.000.000	100,00	82.000,00	0.63	3.866,67
COPERTO	30..00	45.000.000	1.500,00	20.00	39.000.000	1.950,00	30,00	10.000,00	333,33	30,00	2.00.000	66,67	96.000.000	0,74	3.850,00
IN CAVERNA	50,00	50..000.000	1.000,00	20,00	42.000.000	2.100,00	60,00	30.000,00	500,00	30,00	500.000	16,67	122.500.000	0,94	3.616,67

OPERATION COSTS

TIPO IMPIANTO	ENERGIA ELETTRICA DI ESERICIZIO da acquis.		POMPAGGIO		VENTILAZIONE E TRATTAMENTO ARIA		ILLUMINAZIONE		RISCALDAMENTO FABBRICATI		MANUTENZIONE ORDINARIA		MANUTENZIONE STRAORDINARIA		TOTALE GENERALE COSTRUZ+GESTIONE
	kwh	milioni/anno	kwh	milioni/anno	kwh	milioni/anno	kwh	milioni/anno	kwh	milioni/anno	h/uomo	milioni/anno	% app.elet	milioni/anno	milioni /anno
ALL'APERTO	1.500.000	375,00	600.000	150,00	200.000	50.00	120.000	30,00	200.000	50.00	3.600	180,00	1.50	510.00	5.211.670
COPERTO	1.580.000	395,00	600.000	150.00	600.000	150.00	160.000	40,00	400.000	100,00	3.000	150,00	1.5	585.00	5.420.000
IN CAVERNA	1.540.000	385,00	0	0.00	1.000.000	250,00	240.000	60,00	160.000	40,00	3.200	160	1.5	630,00	5.141.670

GENERAL CONSIDERATIONS

TIPO IMPIANTO	IMPATTO AMBIENTALE ED URBANISTICO	PERDITA DI TERRENI	DISTURBI AL BENESSERE FISICO ABITANTI	PERDITE ENERGIA TERMICA UTILIZZABILE	AFFIDABILITA' IMPIANTI PER METEOR.	PUNTEGGIO
ALL'APERTO	*	*	*	*	*	5.00
COPERTO	**	**	**	**	**	11.00
IN CAVERNA	***	***	***	***	***	15.00

* = MINIMO   ** = MEDIO   *** = MASSIMO