Appraising the Environmental Advantages of Underground Storage Facilities in Athens, Greece

Athanassios Mavrikos¹, Dimitris Kaliampakos¹

¹ School of Mining and Metallurgical Engineering, National Technical University of Athens, Greece.

ABSTRACT

The promotion of urban underground development confronts many obstacles. Among them, the absence of the environmental impact assessment from the evaluation process is one of the most important. Decisions solely based on the grounds of construction cost comparison and not including neither the operational cost nor the environmental impacts tend to penalize underground structures. The paper addresses the appraisal of the environmental benefits of underground structures. A comparative analysis of an underground and an aboveground storage facility in the urban area of Athens, Greece, is presented. For the appraisal of the environmental benefits, the Benefit Transfer Method is implemented. The results of the analysis prove that the environmental benefits of the underground storage facilities have a considerable economic value. Generally, the incorporation of the monetary benefits that stem from the environmental compatibility of underground works, in the evaluation and decision-making process can lead to sound decisions improving the environmental conditions and enhancing the quality of life in urban areas.

1. INTRODUCTION

Urbanization has been one of the most distinguishable characteristic of the last decades, documented and studied both in developed and developing countries on a global scale. The unparalleled urban sprawl has resulted in megacities as well as accumulated urban problems. In a constantly growing and changing urban area the pressure is on urban planners to strive to alleviate the negative consequences of urbanization. In this context the prospect of utilizing the urban subsurface stood out as a feasible alternative offering multiple advantages with regards to the city’s structure. Underground metropolitan railways, road and railway tunnels, underground parking facilities, underground utility networks and underground sewage treatment plants are typical examples of urban underground development. However, the implementation of these prospects is still under consideration as traditional techniques employed in the decision-making process tend to penalize underground solutions. Usually comparisons between surface and underground alternatives are made on the grounds of construction cost, where the higher initial construction cost of underground structures render them as second-best options. The situation is sometimes reversed when decision-makers include operating and maintenance cost in the analysis or use a Life-Cycle Assessment approach (Sellberg, 1996). Nevertheless, a vital parameter that is missing from this process is the assessment of the environmental impact of each alternative. Granted that environmental awareness is rapidly raising worldwide, the need to include this field, when examining possible solutions, is becoming pressing.

Until recently, researchers stressed the necessity of appraising the environmental advantages of underground development, especially in cases involving large urban areas, but at the same time they identified the lack in proper tools for expressing the advantages in monetary terms and relied on descriptive or qualitative approaches (Godard and Sterling, 1995). However, the continuous development in Environmental Economics and its relevant tools for appraising environmental goods
and services and non-market valuation in general have enhanced the decision-making process and resulted in environmental efficient solutions.

The present paper utilizes the Benefit Transfer Method (BTM) to appraise the environmental advantages of both aboveground and underground storage facilities in the urban area of Athens, the capital of Greece. The BTM is used to estimate economic values for ecosystem services by transferring available information from primary studies already completed in another location and/or context. The site of the original research is usually called “study site”, while the site to which the benefit estimate is transferred is called “policy site” (Rosenberg and Loomis, 2001). Thus, the basic function of BTM is taking the results from one or more primary economic studies with estimated values for similar impacts, and modifying and transferring them to the project being evaluated. This process is a cost-effective way to evaluate the environmental effects of projects when original research is not possible (Kula, 1994). In any case, primary research is the “first-best” strategy, especially in cases where a high degree of precision is critical.

2. UNDERGROUND DEVELOPMENT AND THE ENVIRONMENT

Underground works are generally identified as a means to minimize environmental impacts. When environmental criteria are taken into account, underground works are usually preferred to aboveground alternatives (ITA, 1998). The way the public values the drawbacks of aboveground structures affects the assessment of underground structures. Unfortunately, most of the numerous advantages of underground structures, especially those concerning the protection of the environment, cannot be assessed easily in terms of monetary value. On these grounds, it is clear that the commonly used cost-benefit approach is probably flawed and should be revised. Decisions involving cost comparisons should not only refer to the well-defined life-cycle costs, but must take into account the various advantages offered by the underground alternative, particularly the environmental benefits (Sterling and Godard, 2001). Although the benefits of urban underground space use are obvious, especially in terms of urban revival, time savings, environmental protection etc., the difficulty in providing decision-makers and urban planners with quantitative information is penalizing underground alternatives (Sterling, 2005).

In 1995 a report prepared by ITA’s Working Group 13 was published (Tareau, 1995). Attempting to address the direct and indirect advantages of underground structures, the paper focused on a pressing problem of urban areas: parking space. Several direct advantages of underground parking facilities are identified, such as the preservation of the surface space and the increased protection against environmental conditions. At the same time factors such as the limited nuisance and the minimization of the visual impact, in spite of their importance, are described with qualitative terms in the absence of proper appraisal techniques.

Large urban areas face many problems in their efforts to comply with the principles of sustainable development. One typical aspect is energy consumption. Underground structures are far more efficient solutions in this particular field as the stable environmental conditions in the underground space with the limited variations in ambient temperature ensure the minimization in energy consumption (Carmody and Sterling, 1993).

Recently, environmental economics techniques have been employed in order to appraise services or goods related to underground development. In 2000 a study, involving four cities in Japan, estimated the value of an intrinsic parameter of underground development: the preservation of the surface area (Nishi et al, 2000). The study used a questionnaire based survey that examined the residents’ willingness to pay (WTP) both for renovating the view or scenery in underground spaces and to preserve the view around residential areas. The results of the study, regarding the latter, show that, on average, the WTP is US$77.5/year/person (in 2000 price levels), in support of the opinion that the use of urban underground space has many important environmental advantages that need to be valued.
3. APPLICATION OF THE BENEFIT TRANSFER METHOD IN THE CASE OF UNDERGROUND STORAGE FACILITIES IN ATHENS

The appraisal of the environmental benefits of an underground structure is applied in the case of underground storage facilities in Athens, Greece. The analysis compares the environmental impact between an underground and an aboveground storage facility. Equivalence between the two options is based on the total storage capacity, which is equal in both cases and therefore the operational parameters are the same. The decision to apply the appraisal to the sector of storage facilities and 3rd Party Logistics (3PL) in general was based on the following facts:

- 3PL is a thriving sector which has displayed an average total turnover growth of 24.5% on an annual basis in the last 8 years (Mavrikos, 2006).
- The demand for storage volume is expected to stay in high levels in the future.
- The two main problems that the sector faces, namely the high land cost and the limited surface space can be effectively addressed with the construction of underground storage facilities (Kaliampakos et al., 2002; Zevgolis et al., 2004).

3.1 Identification of the environmental factors

The analysis concerns a hypothetical scenario of either constructing a typical storage facility on the surface or constructing an underground storage facility in Koropi, an eastern suburb of Athens, near the new Athens international airport. According to market research, the area is expected to attract many storage facilities in the near future as it has significant advantages in terms of infrastructure and the demand for storage facilities is high. The two alternatives have an equal storage capacity, which amounts to 15,600 EuroPallets (Mavrikos, 2006). The environmental factors that were examined and the expected impacts are presented in the following table (Table 1):

<table>
<thead>
<tr>
<th>Factor</th>
<th>Impact</th>
</tr>
</thead>
</table>
| Landscape alteration | Land/Residence value  
 | Recreation services  
 | Nuisance |
| Flora        | Land/Residence value (especially regarding forests)  
 | Recreation services  
 | Health (indirectly)  
 | Nuisance (reduction in biodiversity) |
| Fauna        | Recreation services  
 | Nuisance (reduction in biodiversity) |
| Air pollution | Land/Residence value  
 | Recreation services  
 | Health  
 | Forests  
 | Crops  
 | Shallow aquifers  
 | Nuisance |
| Noise        | Land/Residence value  
 | Recreation services  
 | Health  
 | Nuisance |

The impact to flora and fauna was regarded as impact on the ecosystem in general. In the case of the underground storage facility, some of the environmental factors do not apply or apply only during the
construction period (ITA, 1998). Nevertheless, they were included in the appraisal process by calculating their proportional contribution for that period, on the assumption of a 20-year operation duration.

3.2 Application of the Benefit Transfer Method

The EVRI and ENVALUE databases were the primary sources of environmental studies for the application of the BTM. Additionally, several other published studies in international journals and conferences were examined and selected cases were used. The unit values obtained from the selected studies are adjusted in order to offset influences concerning differences of price level and time. As far as the transnational transfer is concerned, it is necessary to take into account the purchasing power and monetary unit between the country of the original study and that of the policy site. The literature shows that a correctly measured Power Purchasing Parity Index (PPPI) is the preferable index for international price comparisons (Damigos and Kaliampakos, 2006). The time difference between the primary study and the policy study is adjusted by means of the Consumer Pricing Index (CP), which reflects the rate of inflation. The following equation is used to convert an estimate from a "study" country (country0) in year of the initial estimate (year0) into an estimate for a "policy" country (country1) and in a different year (year1):

\[
\text{Value (year 1 country 1)} = \text{Value (country 0, year 0)} \times \left( \frac{\text{PPPI country 1 year 0}}{\text{PPPI country 0 year 0}} \right) \times \left( \frac{\text{CPI country 1 year 1}}{\text{CPI country 1 year 0}} \right)
\]

Therefore, all values were adjusted to 2006 price levels. Furthermore, the total annual external cost for each environmental parameter was calculated by multiplying the corresponding values with the number of households in the area.

3.3 Results

The following table (Table 2) summarizes the estimated environmental impact in monetary terms (external cost) for each alternative (Mavrikos, 2006).

<table>
<thead>
<tr>
<th>Environmental factor</th>
<th>Adjusted average value (€/year)</th>
<th>Total external cost (€/year)</th>
<th>Adjusted average value (€/year)</th>
<th>Total external cost (€/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aboveground storage facility</td>
<td></td>
<td></td>
<td>Underground storage facility</td>
<td></td>
</tr>
<tr>
<td>Landscape alteration</td>
<td>31.58</td>
<td>218,370.17</td>
<td>31.58</td>
<td>21,837.02</td>
</tr>
<tr>
<td>Ecosystem</td>
<td>57.84</td>
<td>399,988.50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Air pollution</td>
<td>103.98</td>
<td>719,051.57</td>
<td>103.98</td>
<td>719,051.57</td>
</tr>
<tr>
<td>Noise</td>
<td>20.55</td>
<td>142,083.33</td>
<td>20.55</td>
<td>14,208.33</td>
</tr>
</tbody>
</table>

3.4 The environmental benefits of the underground alternative

The results of the BTM show that, in the case of the underground storage facility, there is a benefit of approximately 724,396.65 € on an annual basis. Assuming that the storage facility will operate for at least 20 years, the accumulated benefits to the households of the area due to the reduction in environmental impact amount to 6.17 M€. If this figure is divided with the total area of the underground storage facility, the produced value of 291.46 €/m² expresses the environmental benefit of the underground structure in monetary terms per square meter. As a yardstick, one should bear in mind that the average land cost in this particular area ranges between 200 and 500 €/m², whereas the construction cost for aboveground storage facilities is around 270 €/m² on average. It is clear that when the environmental benefits of underground structures are expressed in monetary terms, the results can have considerable effects in a decision-making process.
4. CONCLUSIONS

Although many claim that underground structures offer considerable environmental benefits, this parameter is usually missing in the decision-making process. Consequently, the potential of the underground space is not being fully exploited and the public does not enjoy the advantages stemming from its use. Contemporary urban areas are ideal places for a systematic use of the subsurface. The utilization of urban underground space can lead in a more efficient and compact city, thus contributing to the sustainability of urban areas. The continuous progress in the field of Environmental Economics has supplied researchers, urban planners and decision-makers not only with the necessary tools to appraise the environmental benefits related to underground structures, but also with an abundance of studies that one can use.

The results of the analysis presented above show that when the environmental benefits of underground alternatives are appraised, it can lead to better decisions that could favor underground structures despite their larger initial construction cost. In the case examined here, it is proved that the operation of an underground storage facility in the area of Athens is environmentally more efficient and the benefit expressed in monetary terms is considerable. Furthermore, it should be stressed that, especially in the case of the environment, the advantages and benefits of underground alternatives are enjoyed by the residents living in the surrounding area as they are the ones that enjoy an enhanced environment and a better quality of life. Therefore, it is of paramount importance that, in the near future, policy and urban planners as well as decision makers incorporate the appraisal of the environmental impacts when comparing different alternatives.

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