Sustainable Urban Underground Development

More than half the population of the world now lives in urban areas and the expectation is that this figure will grow rapidly in the next decades – reaching 70% in 2050. Modern cities worldwide need to cope with this rapid urbanization while at the same time protecting these large concentrations of people from natural disasters and the effects of climate change.

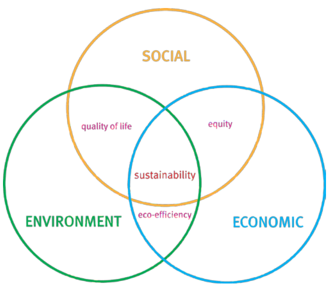
"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Report of the World Commission on Environment and Development (Brundtland 1987)

The creation of sustainable urban areas with the resilience to survive natural disasters and the effects of climate change through urban resilience-building, will be critical for urban planning and engineering in the coming decades. This White Paper will explore these themes and the contribution and impact of underground space use to achieving sustainable urban development and creating resilient cities.

The contribution of underground space

Underground space use is tied to the sustainability of an urban area because the use of underground facilities can positively impact the extent to which human occupancy of a land area affects the surface environment. At the core of concern for a sustainable use of the urban underground is the maintenance of opportunity for urban development by future generations.

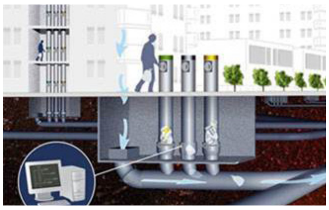


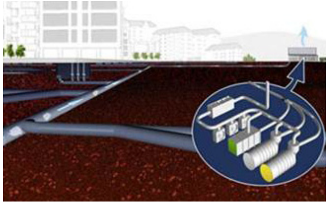
The three pillars of sustainable development.

Underground infrastructure contributes to sustainability of the environment in many ways: saving natural resources, including land, water, and biodiversity; reducing air pollution (mainly in the transport sector, though also for others, such as underground sewage treatment facilities) and unnecessary visual and noise intrusion; creating opportunities for less energy use and waste generation (compact city); creating structures less impacted by earthquakes and other catastrophic events; and enhancing of overall landscape and environmental quality. Facilities placed fully underground (once constructed) do not impact the surface aesthetic and can allow natural ground surfaces and flora that maintain the natural ecological exchanges of thermal radiation, convection and moisture exchange between the ground and the air. Underground infrastructure allows a reduction of land area covered by manmade structures.

Underground structures generally have long expected lives. This due in part to the removal of many environmental exposures, but also due to the heavy structures that may be necessary to support ground pressures. These resilient structures are important for long-term sustainability. Underground structures typically provide excellent resistance to catastrophic events such as earthquakes, hurricanes, tornados, external fires, external blasts, radiation and other terroristic threats.

Coping with urban waste





Urban waste collection through an underground vacuum network. Examples exist in Sweden, the Netherlands, Norway, China, and other countries.

The use of underground facilities can alter the basis for economic growth in an urban area by providing better transportation and utility infrastructure that would be impossible to construct on the surface. In urban areas extensively developed underground infrastructure creates an independent spatial layer of communication and services, including critical facilities that enhance a city's coherence and resilience. Likewise, the use of underground facilities can avoid detrimental impacts to the social structure of an urban area when a major surface or elevated infrastructure project dissects existing neighbourhoods.

Underground infrastructure development can also positively contribute to climate change mitigation by providing energy efficient facilities and enabling higher living standards in compact urban areas. If a certain area of a city is not compact enough to provide different services within walking distance then transportation needs and, usually, automobile usage rises.

In simple terms, underground facilities can be thought of as providing the ultimate "green roof."

The impact of underground space

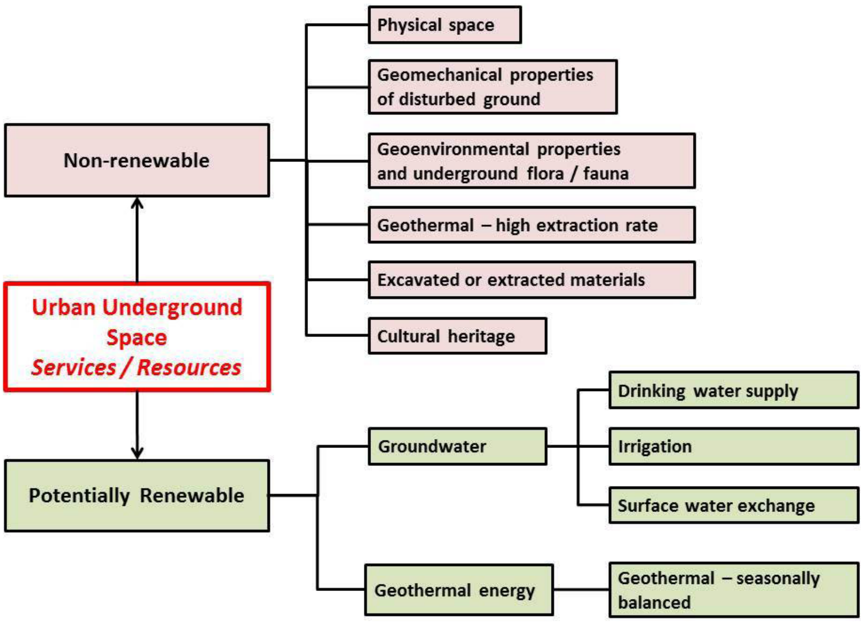
Underground space is an environmental entity and a natural resource in its own right and can be damaged or changed by human activities within the underground. In this respect, it must be stressed that underground facilities, to a much greater extent than surface facilities, represent structures that cannot be returned to their pre-construction condition. Therefore, underground space use must be planned in a sustainable manner also.

Reusing inner city docks to bring a waste water treatment plant underground (Dokhaven, Rotterdam, the Netherlands).

The underground environment

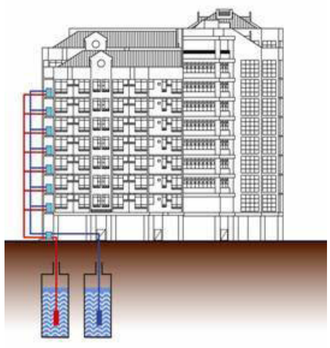
Four basic elements constitute the underground environment as a resource: space, materials, water, and energy. The figure on the next page, illustrates the sustainable implications of the underground resources.

Space in an urban area becomes an increasingly valuable commodity as a city grows. Only the uppermost layers of the underground can be considered as useful for urban space applications. Most utility and pedestrian functions compete for space in the upper 5-10 m below surface. But some transit and deep utilities may extend to the 50-75 m depth range. Important aspects of materials in the underground environment include the soil/rock fabric within which excavation must occur, groundwater is held, and structures are constructed; useful resources/minerals that can be extracted; and hazardous materials (natural or manmade) that need to remain isolated. Groundwater is an important natural resource of the underground that is connected to the local and global hydrological cycle and may be important within an urban area as a water supply resource. Changes in groundwater conditions may also affect surface structures. Energy as an underground resource category includes geothermal resources that can be accessed by active heat exchange with the ground using mechanical systems, as well as the naturally low heat exchange of an underground facility with the surrounding ground.



Renewable and non-renewable underground resources (after Bobylev 2009)

Energy applications

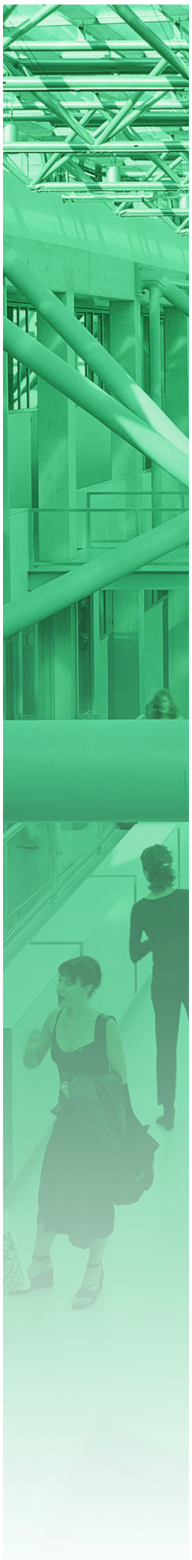


Heat and cold storage schemes are now extensively being used in China. They are a prime example of sustainable development by reducing the carbon footprint through using the inherent qualities of the underground.

Towards sustainable use of underground space

The resource represented by the underground has generally been undervalued by society and the result has led to a lack of effective planning for the increasing uses that develop over time in growing cities.

Efficient and sustainable use of the underground is often significantly hampered by the first-come, first-served nature of prior underground uses. Many uses of the shallow underground develop over time as a city grows. Such uses include building foundations and basements and the extensive network of cables, pipes and tunnels that carry utility and transportation services. While normally treated as individual project choices, the design decisions for these facilities affect the ability to use underground space for future needs.



For example, geothermal heat exchange systems are becoming popular in many northern climates. The sustainability issues associated with such systems include the creation of large volumes of the underground beneath urban areas containing a “forest” of deep vertical boreholes that may constitute an obstacle to other future important uses.

Examples of sustainable practices in using underground space

In Helsinki, Finland a project is underway to use the underground space under the city’s cathedral to locate a data storage centre. As the use of the internet and “cloud” computing grows, the need for storage centres also grows. Locating this centre underground saves in terms of energy needed for cooling and allows the recovered energy to heat 1,000 Helsinki homes during winter.

In Kuala Lumpur, Malaysia a Storm Water Management and Road Tunnel was constructed. What in first instance was meant to be a large storm sewer to prevent the city from flooding during excessive rainfall now includes a road tunnel along part of the alignment which is available to ease traffic congestion except during the major flood events.

Sustainable development of underground space not just calls for using underground space, but using it to combine functions and to create value in doing so for society.

Can you imagine sustainable urban development without the use of underground space?

Developing a city in a sustainable way without including underground space seems unthinkable. Underground space is a worthwhile societal asset and with our understanding of it, the possibilities of use are rapidly increasing. Tunnels which provide energy for surrounding neighbourhoods are not as farfetched as they may sound. Underground space is set to contribute to sustainable cities. Why not start using it today?

About ITACUS

ITACUS sees it as its mission to advance the awareness and thinking on the use of underground space through the creation of a worldwide dialogue. The committee will fulfil its mission in a pro-active manner, furthering the cause of underground space use within the context of societal needs, environmental concerns, sustainable development and climate change

ITA-AITES c/o EPFL
Bât GC, Station 18
CH 1015 Lausanne
Switzerland

T +41 21 6932310
F +41 21 6934153
E itacus@ita-aites.org