

The Urban Underground in the Deep City Project: for Construction but not only

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ABSTRACT

What is the potential of city's geological underground for its sustainable development?

The project "Underground resources and sustainable development in urban areas" (called also "Deep City Project") is motivated by the critical congestion of many cities around the world leading to environmental and public health problems. Consequently, it is obvious that major changes are needed in order to reach new conditions, which are more compatible with sustainable development.

The theses of the project are:

- *A more comprehensive use of the urban underground is one key-solution for getting more space and more healthy living conditions at the surface of the city.*
- *However this increasing use of underground cannot be achieved without a long term 3D planning.*
- *This planning must consider the resource of space for underground construction, but also other underground resources such as geomaterials, groundwater and geothermics.*
- *The management of the urban underground must not be sectorial (e.g. transportation or building or water supply or geothermal extraction) but must integrate the potential of all these resources. The project is defining the rules for multi-uses of the resources according to the various geological formations present below the city and their properties.*
- *As underground conditions are very variable from a city to another and even variable at the scale of a city, geological knowledge and 3D modelling is the first step of investment in order to define the long term multi-uses potential.*
- *Shifting some activities toward the underground implicates a significant improvement of the human acceptability for this space. Research in sociology and architecture are done in this direction.*

Up to now, the project has studied experiences of some large cities like Paris and Mexico. It is presently defining the new methodological concepts, the principles of which are described in this paper. The fundamentals of a real 3D - land planning is presented, which will be introduced in a new federal law.

This article is a derivate of the presentation made recently at the ACUUS meeting of Cape Sounion in summer 2007.

1. PRESENT SITUATION OF BIG CITIES AROUND THE WORLD

The critical congestion of many cities around the world generates heavy environmental and public health problems. The scale of cities cannot infinitely grow at the surface for many reasons:

- Length and complexity of infrastructures (transportation, services, natural resources),
- Land planning and ecological equilibrium (respect of a minimum of non-urbanised regions of the territory).

Therefore, the third dimension of the cities is often their last possibility of development. The upwards axis is intensively used by the high buildings recently constructed all around the world. The downwards axis is also used but essentially for transport infrastructures and for car parks facilities. The experience of this underground "colonisation" reveals that in many cases it has led to important problems on its integrity and by the way on the long-term management of the city (Parriaux et al.,

2006). Consequently, it is obvious that major changes are needed in order to reach new conditions, which are more compatible with sustainable development.

2. AIMS OF THE DEEP CITY PROJECT

The project “Underground resources and sustainable development in urban areas” (latter called “Deep City Project”) have been selected in the framework of a large research operation about the sustainable development of the built environment in Switzerland (Project NRP 54 of the Swiss National Fund). Its aim is to bring sustainable solutions for the use of underground that minimize long-term conflicts and avoids jeopardizing the resources below the city, considering the long term.

3. SPECIFICITY OF A HOLISTIC APPROACH OF UNDERGROUND

Case studies show that urban planners and managers of cities tend to consider their underground with a sectorial approach (Figure A).

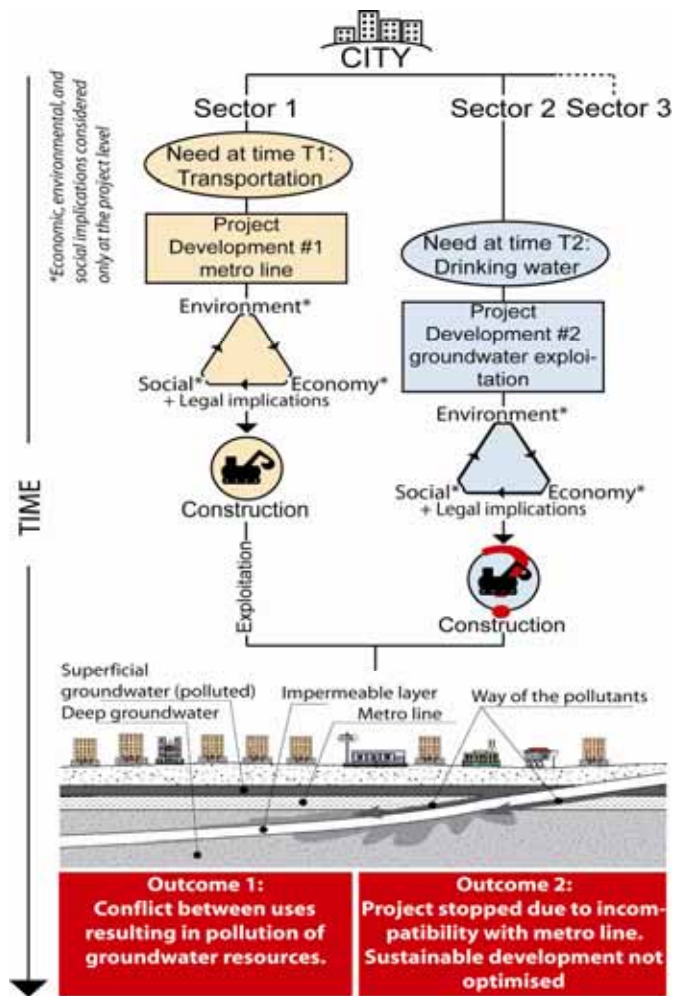


Figure A : Example of the sectorial approach. At a time t_1 , the transportation office needs to construct a subway; it designs and builds it, taking into account mainly technical and financial criteria. At a time t_2 , another office is looking for new drinking water supplies; the study of a groundwater pumping plant reveals that it is no more possible because the subway was built inside the aquifer that contains the groundwater resource. (After Parriaux et al., 2006)

Some cases like Mexico-City (Birkle et al., 1998, González-Morán et al., 1999, Tortajada, 2006) and Paris (Prunier-Leparmentier, 1991, Duffaut and Méglin, 1995, Deveughele et al., 1983) confirm heavy interactions between groundwater and subways. There are several reasons that explain this sectorial development:

- Necessity to build rapidly an infrastructure at the lowest cost,
- Absence of long term planning of the geological volumes below the soil surface,
- Lack of knowledge on the nature and the structure of underground,
- The professionals of administrative services have sometimes few contacts together,
- Their understanding of the other domains concerned by underground is often very poor.

At the opposite of such sectorial approach, the Deep City project treats underground with a holistic approach. Underground of cities is considered as a space rich in resources. This means that this volume contains goods that can be used by the society. This potential can be divided into four main resources (Figure B):

- Resources in space (place for building and infrastructure construction)
- Resources in geomaterials (mainly issued from underground excavations)
- Resources in groundwater, for drinking or industrial purposes (aquifers at different depth)
- Resources in geothermy (shallow and deep geothermal systems)

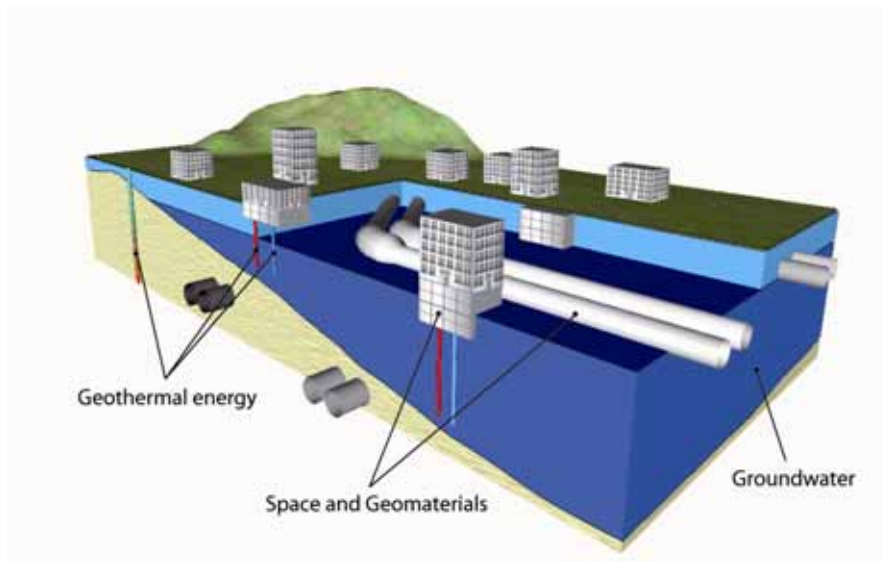


Figure B : The four main resources of the city's underground (After Blunier et al., 2006)

Beside these scientific and technical aspects, the Deep city project is also dealing with human sciences issues:

- Economical feasibility and sustainability of underground construction, compared with surface works,
- Human acceptability of the displacement of some activities into underground, including sociological and political impacts.

4. CONCEPT OF MULTI-USES

The fundamental thesis of the Deep City project is the following:

- A geologic volume in the urban underground should be used as most as possible for combined uses without creating long-term conflicts ("multi-uses" concept),
- Rules defining the conditions of multi-use must be established (possible synergies, exclusions, limits etc.),

- 3D land planning has to be undertaken as the classical 2D land planning, in order to take into account the development of the volume below the city and integrate it in a complete urban management, which makes the connection between surface and underground constraints,
- As geological conditions are the roots of underground structures and properties, a 3D geological model must be constituted using all the available data collected in past works. Existing civil engineering structures have to be included in this model.

This holistic approach needs to consider the underground as a system, with many complex interrelations between parameters. This work is in progress (see Blunier et al., 2007 presented in this conference).

5. TOWARDS A 3D-LAND PLANNING

It is obvious that much of the interactions between the various resources of the urban underground cannot be managed at the scale of the parcels. The optimization of a multi-uses of these resources is a task of the community for the whole city. In the spirit, it is a land planning operation but not limited to the two dimensions commonly uses for territorial representation. It relates to the precursory work presented by E. Hénard (Henard, 1903-1906), E. Utudjian (Utudjian, 1952a, Utudjian, 1952b) and their followers (See for example Godard and Sterling, 1995, Rönka et al., 1998, ITA Working group 4, 2000, Edelenbos et al., 1998, Barles, 1995), but proposes to integrate the four resources in the planning strategy.

In fact, the multi-uses approach leading to this 3D land planning needs a step by step procedure (Figure C):

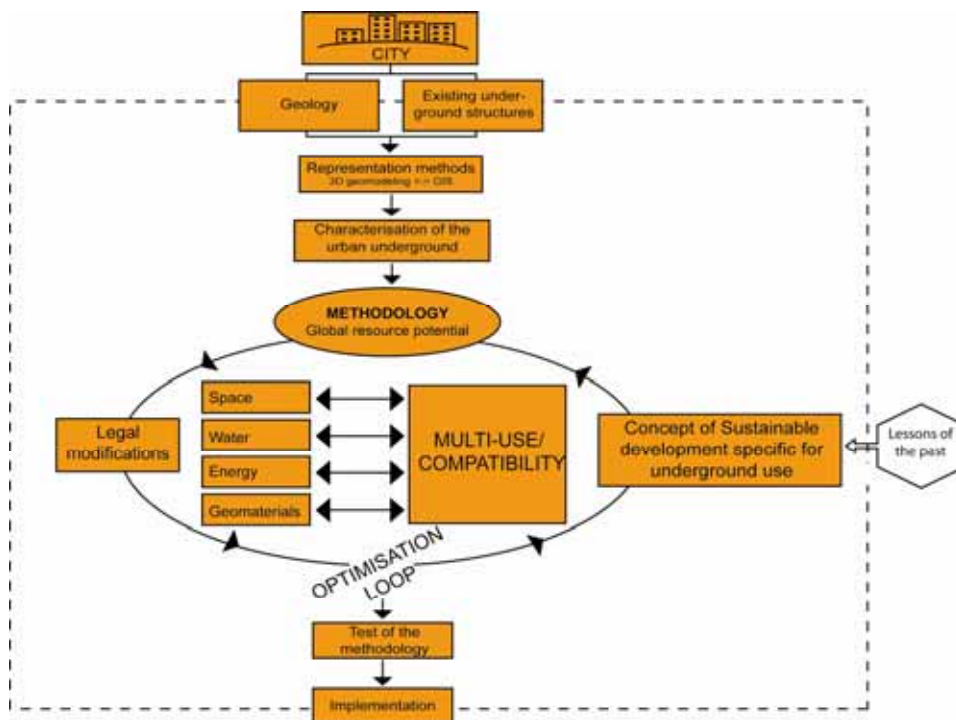


Figure C: The different steps of the multi-uses approach of the resources of urban underground.

- Step 1 : 3D-geological model of the city

On the basis of geological maps, the collection of boreholes and data issued from underground structures, a 3D-geological model is dressed in order to define the entire space below the city as precise as possible. This model identifies volumes corresponding to the main geological formations. Behind this geometry, the model contains a data set on the properties of these geological units that will

allow characterizing the resource potential of each formation. The accuracy of this model will depend of the density of factual observations collected in the geological data set. The best way to optimize this operation is the introduction of a systematic collection procedure of boreholes profiles, in collaboration with private consulting companies. That is what Canton de Vaud is doing after an accident during the construction of the M2-subway of Lausanne; this accident was mainly due to the loss of an ancient geological information at this spot that could have probably prevented the event. At the beginning rather underdetermined, the model will progressively become more precise and more usable for the knowledge of the urban underground. The geological model is the special basis for many specific models related to resources, for example groundwater flow finite element models, thermal diffusion, soil and rock mechanical models etc...

- Step 2 : present engineering structures

The geological model must be completed by the introduction of the present state of underground built environment, in order to make a register of the anthropogenic occupation of this space. This operation is presently tested on some districts of Geneva, city selected for the testing of the Deep City project. In this case too, the geometrical knowledge of the basement of each building is very partial. But the deepest ingressions are often rather recent and can be introduced in the model.

- Step 3 : study of the multi-use resource management concept

The definition of the potential of urban underground in the mind of a resource sustainable development is the major step. It starts by choosing the most probable developing scenarios for the city. For each of them, the thesis of multi-uses as the one developed in the Deep City project should be applied. The result is the reservation of some geological formation for some specific uses (e.g. groundwater), the allocation of some else for other purposes (e.g. space and geothermy), combined uses with restrictive rules in others (e.g. groundwater and geothermy).

- Step 4 : integration in the long term land planning procedure

The allocations affected to the various volumes of the underground must be introduced in a 3D land planning. The connection of this new dimension to the existing surface management is very important as the function of each underground structure is related to an activity or a work at the surface. The general laws presently controlling land planning can be applied in the same mind. The regulation concerning the property of underground is variable according to the countries; it may need some adaptation in order to allow the development of the main underground infrastructures of the community.

- Step 5 : adaptation of existing structure to the new land planning concept

The land planning concept does not only fix the boundary conditions of new structures but identifies constructions that are not compatible with the long term policy. Some of them that are completely in contradiction will have to be suppressed and the space secured. Some else can be adapted to the new conditions. These transformations are progressively made according to the opportunities of urban changes.

6. CONCLUSION

Up to now, urban underground is mainly considered as a space for construction. The philosophy of the Deep City project is a new way to treat this space in a more holistic manner as a multi-resources medium. It gives to the underground the statute of a part of the territory. Underground contains resources like the surface of the ground. The fact that it is not well known is not a reason to ignore it in the main planning operations of the city. It brings important chances to the city to make its future more compatible with sustainable development and to improve the quality of life of the inhabitants. It is now urgent to invest in its knowledge in order to correct some errors of the past and to plan it in a large optimization of its resources. Underground construction will increase, but not by ignoring the other potential uses of this geological space.

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