



## **Deep City: toward combined uses of the urban underground resources**

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The urban underground may be considered as the reservoir of four resources: groundwater, space, geothermal energy and geomaterials. The use of those local resources is beneficial to the sustainable development of our cities through reduction of resources importation (energy, water, materials) and surface area recovery (infrastructures placed in the underground may offer new opportunities in the surface for uses with higher social or environmental value). However, the urban underground is also particularly vulnerable; groundwater and soils are subjected to qualitative and quantitative impacts.

Nowadays, the urban underground resources are mainly exploited on a project basis when a need appears. This is explained by the fact that the urban underground remains poorly known. The information is diffused in various offices and mainly not accessible or not understandable to non-specialists. Therefore, the full resource potential of a city is not assessed. On the other hand, the interactions between the resources uses are poorly taken into account and conflicts of uses are often observed. The Deep city project consists in the development of a methodology dedicated to urban planners and managers in order to benefit from the potential of the urban underground, to avoid conflict and to exploit synergetic uses. With this aim, tools are developed to evaluate the resource potential of the urban underground and research is performed to better express, understand and predict interactions between the various uses of those resources.

The exploitation from the underground resources is related to various conditions such

as geological environment, legal framework, urban constraints, etc. . . The information about those conditions is complex, heterogeneous and most of the time only partially known on the entire territory; so that a purely deterministic approach is not possible. Moreover, the dimensions involved in the evaluation of the resource potential are not always commensurable and the evaluation of an overall potentiality will reflect stated preferences (for example to decide if a volume with a good geology and poor legal condition is suitable for a given use). In order to take account of this complexity, we developed a multicriteria evaluation system. For each potential use, the conditions are evaluated through literature review and expert interview, a matrix is obtained. An aggregation of the various criteria is then performed. The system is implemented in a GIS, the result being cartography of the potential uses of the urban underground.

This first evaluation is performed on a sectorial basis, the use are evaluated one by one but not the combination of the uses. To evaluate this combination, we should consider the interactions between the various resources. The urban underground is a dynamic system, with fluxes from water, heat and materials (e.g. pollutants). Classical analytic models are efficient to perform quantitative analysis, but they are limited a priori to certain factors and physical relationships. To take account of the various factors, we propose using a systemic approach. The interactions are translated into causal relationship with the use of diagrams, these diagrams are tools to support the analysis of the system, evaluate the potential impacts and reveal the action levers and the critical factors.