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Synergic and conflicting issues in planning underground use to produce energy in densely populated countries, as Italy
Geological storage of CO_2, natural gas, geothermics and nuclear waste disposal

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HIGHLIGHTS

- ▶ In densely populated countries, the public need a synergic approach to produce low-carbon energy.
- ▶ The paper is mapping coexistent and different underground technologies to produce low-GHG energy.
- ▶ The paper calculate Energy Density Potential in Land – EDPL in terms of [GW h/ha/year].
- ▶ Draw-plate technologies platforms (EU-ZEP, etc.) should merge using underground together.
- ▶ Synergies among the different uses of deep underground (up to 5000 m) jointing the energy lobbies.

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ABSTRACT

In densely populated countries there is a growing and compelling need to use underground for different and possibly coexisting technologies to produce "low carbon" energy. These technologies include (i) clean coal combustion merged with CO_2 Capture and Storage (CCS); (ii) last-generation nuclear power or, in any case, safe nuclear wastes disposal, both "temporary" and "geological" somewhere in Europe (at least in one site): Nuclear wastes are not necessarily associated to nuclear power plants; (iii) safe natural gas (CH_4) reserves to allow consumption also when the foreign pipelines are less available or not available for geopolitical reasons and (iv) "low-space-consuming" renewables in terms of Energy Density Potential in Land (EDPL measured in [GW h/ha/year]) as geothermics. When geothermics is exploited as low enthalpy technology, the heat/cool production could be associated, where possible, to increased measures of "building efficiency", low seismic risks building reworking and low-enthalpy heat managing. This is undispensable to build up "smart cities". In any case the underground geological knowledge is prerequisite.

All these technologies have been already proposed and defined by the International Energy Agency (IEA) Road Map 2009 as priorities for worldwide security: all need to use underground in a rational and safe manner. The underground is not renewable in most of case histories [10,11]. IEA recently matched and compared different technologies in a unique "Clean Energy Economy" improved document (Paris, November 16–17, 2011), by the contribution of this vision too (see reference).

In concert with "energy efficiency" improvement both for plants and buildings, in the frame of the "smart cities" scenarios, and the upstanding use of "energy savings", the energetic planning on regional scale where these cities are located, are strategic for the year 2050: this planning is strongly depending by the underground availability and typology. Therefore, if both literature and European Policy are going fast to improve the concept of "smart cities" this paper stresses the concept of "smart regions", more strategic than "smart cities", passing throughout a discussion on the synergic and conflicting use of underground to produce energy for the "smart regions" as a whole.

The paper highlights the research lines which are urgent to plan the soundest energy mix for each region by considering the underground performances case by case: a worldwide mapping, by GIS tools of this kind of information could be strategic for all the "world energy management" authorities, up to ONU, with its Intergovernmental Panel on Climate Change (IPCC), the G20, the Carbon Sequestration

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Leadership Forum (CSLF) and the European Platforms such as the "Zero Emissions Fossil Fuel Power Plants" (EU-ZEP Platform), the Steel Platform, the Biomass Platform too. All of these organizations agree on the need for synergistic and coexistent uses of underground for geological storage of CO_2, CH_4, nuclear waste and geothermic exploitation.

The paper is therefore a discussion of the tools, methods and approaches to these underground affecting technologies, after a gross view of the different uses of underground to produce energy for each use, with their main critical issues (i.e. public acceptance in different cases).

The paper gives some gross evaluation for the Lazio Region and some hints from the Campania Region, located in Central Italy. Energy Density Potential in Land (EDPL), is calculated for each renewable energy technology (solar, wind, geothermal) highlighting the potentiality of the last.

Why the Italian case history among the densely populated countries? on the Italian territory is hard to find suitable areas (mostly if greenfields) to use the own underground, with respect to other European countries, due to the presence of seismotectonic activity and many faulted areas characterized by Diffuse Degassing Structures (DDSs, which are rich in CO_2 and CH_4). In this cases, public acceptance must be facilitated by the concerted efforts of researchers, universities, NGOs and policy-makers.

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1. Rationale

The worldwide demand for energy has grown so much that there is the need to develop a strategic mixed-energy plan. Such a plan should follow the IEA Road Map 2009 (see www.iea.org and its improvements as the IEA Workshop "Monitoring Clean Energy Economy", 16–17 November, 2011, Paris, www.iea.org, which follow the first International School in Erice about a synergic approach to a multi-face sound energy mix, using underground too [1]). This multi-component approach to the energetic use of underground (0–5000 m depth) is fundamental to solve the problem of "low carbon" energy production, namely to reduce the increased CO_2 emissions. The main sources of anthropogenic CO_2 are from industrial processes, transportation and residential and commercial buildings. The most urgent reduction need is that of CO_2 emissions from the coal-power generation industry. A study published in 2006 by the European Commission [2] shows that if existing trends continue, CO_2 emissions will be unsustainably high by 2050 – that is, CO_2 concentrations will be 900–1000 ppm by volume. This affects abruptly the climate changes. Also the recent climatic and weather episodes such as the "big cold" during the first days of February, 2012 are considered as a consequence of North Pole climatic effects (www.NOAA.gov). At present, literature is full of papers before and after this mentioned report, highlighting the urgency to find remediation to the energetic–climatic crisis. Now is time to "do".

Recent studies are dealing with power management systems planning under uncertainty and management of composite electric power systems [3] considering the complex multiple electric power generation patterns, considering and the security-failure risk assessment, which unfortunately does not include the geological ones [1].

A variety of complexities are associated with power management systems together with multiple forms of uncertainties: literature up to date does not consider enough those associated with underground resources, reserves, capacity and intrinsic risks. Moreover, when the renewable energy is considered, very often the geothermics are not mentioned (as in [3]). The importance of geothermal energy is growing worldwide and it is not possible to take off from the evaluations (www.egec.org, www.geothermalcommunities.eu).

It is very difficult for decision-makers to single out optimal decision alternatives for cost-effective power generation and therefore it is desired to develop affective tools to support the planning of power management systems [3]. However in densely populated countries, as Italy, where the NIMBY (Not In My BackYard) and NUMBY (Not Under My BackYard) syndromes are predominant, the problem are not the technology-costs, but the planning pass through the more difficult obstacle of public acceptance. It is a paradox but it is more difficult to find the best heuristic approach [21] (Quattrocchi and Boschi, 2011, www.terrascienza.it) [48] to a public communications of the risk with respect to schedule algorithms for identifying potential decision alternatives of power generation companies within a liberalized market.

The actual literature does not considered enough uncertainties existing in the real-world power generating activities i.e., the geological ones, such as reserves, supply, storage capacity, technology development, M&V limitations. The emphasis in literature is too much focused on "costs", but the real obstacles are linked to sociological and political aspects: how much the citizens trust in good science and technology.

Geological variables, as number of possible earthquakes generated by fluid overpressures due to geogas storage activities or the area possibly affected by CO_2 or methane leakage at surface and indoor could not be canalized together with other concepts as possible stochastic linear optimization programming into the management of power generation (see references in [3]).

For geological choices to select the final use of a portion of deep underground or adjacent deep geological structures, there are more than difficulties in analysing economic consequences due to the violation of relevant policies in irreversible resources, with enormous implication in environmental liability and management, including the role of colossal private assurance companies.

If we consider the underground-linked power generation technologies (reserves, storage space, faults, etc.) the time-patterns for decisions are too much longer and completely different with respect to other power generation technologies: years instead of months, as order of magnitude of time scale to take final decisions. In cases when the underground is not involved, routinely, according to the social and geographic features of a specific region, multiple electric energy resources are considered to satisfy the electric power demand and guarantee the safety in power supply: literature very rarely considers the case histories where the deep underground is involved. Very often the bar-chart and scheduling of interactive relationships among subfactors within a power generation management system do not consider the interactive relationships among peculiar subsystems, such as underground availability, where also the geological part of the problem is involved within a power management system itself. It has routinely complex interactions – with the external subsystems (including residential living, economy, policy and environment, mass balance energy resources, mass balance for plants capacity) and balance between power fuels supply and demand. Any change in one subsystem, with its time-dependent processes (i.e., permits and allowances for the underground use) will cause the variations of others subsystems (time-dependent by the longer process, as the

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