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Sub-marine groundwater for the supply of drinking water. A review of the hydro-geological potential and its technical and economical feasibility.

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Sub-marine groundwater is water stored in aquifers under the sea-bed and is expected to be present in large quantities on the continental shelf. The proposed utilization of sub-marine groundwater as a new source of drinking water supply is a radical and new idea that has never been fully explored or tested anywhere in the world. In regions where access to raw water of acceptable quality is very limited and desalination of sea water is the only realistic alternative to increase the supply of potable water, utilization of sub-marine groundwater might play a role.

A technical concept deemed suitable to the hydrological and geological characteristics of sub-marine water is proposed based on well-proven technology from the off-shore oil & gas sector. A course economic assessment of this concept is conducted based on judgmental cost estimates from experts in the hydro-geological and oil & gas domain.

The technical concept uses a jackup or a barge with a modular rig during drilling, while a steel jacket with a modular rig or a sub-sea installation is assumed to be feasible technical solutions during production. The selection of technology will vary from case to case depending on factors such as the local off-shore conditions (wave/wind exposure, drilling depth, distance from shore, etc.), required reliability of supply, access to/availability of technology and financial considerations. A standard reverse osmosis plant is proposed as treatment solution, given the assumed need to desalinate moderately saline water. The costs of each treatment step, as a function of raw water salinity are providing input to the subsequent economical estimates. The proposed treatment solution is assumed being a conservative choice of technology.

The costs of producing drinking water from sub-marine groundwater are compared with desalination of sea water, given that this is the only realistic alternative. Based on a systematic risk assessment using the same comparative financial structure and assumptions as Zhou and Tol (2005), it is found that utilisation of sub-marine groundwater can be economically competitive. The calculation gives an expected unit cost of 1,23 US $\$/m^3$. Performed Monte Carlo-simulations give 5 % and 95 % percentiles equal to the unit cost levels 1,07 and 1,39 US $\$/m^3$, respectively. This is not far from the proposed feasibility benchmark of 1,14 US $\$/m^3$ by Zhou and Tol (2005), or the average costs of 1,46 US $\$/m^3$ derived from their large database of built desalination plants (based on reverse osmosis-technology). The dominating cost driver is considered being the salinity of the sub-marine groundwater, affecting the need for water treatment and consequently energy consumption.

Hence it is concluded that a premise for the proposed technical concept is that the sub-marine groundwater holds sufficiently better quality (lower salinity) than the ambient sea water to justify the additional costs related to exploration and exploitation of the sub-marine water resource (i.e. the *additional* off-shore oil & gas technologies). A review of publications mainly from the US, supported by a limited number of publications originating from European research groups, were all positive in their conclusions that fresh and brackish water can be found on the continental shelf. These indications may therefore suggest that sub-marine groundwater may be a realistic alternative to desalination of sea water, seen from an economic point of view. Lower energy consumption related to treatment of less saline sub-marine groundwater moreover implies that environmental benefits, assuming the use of fossil fuels as energy source to water desalination, may be achieved.