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Industrial Solutions

Renewable Underground Pumped Hydro Energy Storage

Closed Underground Mines

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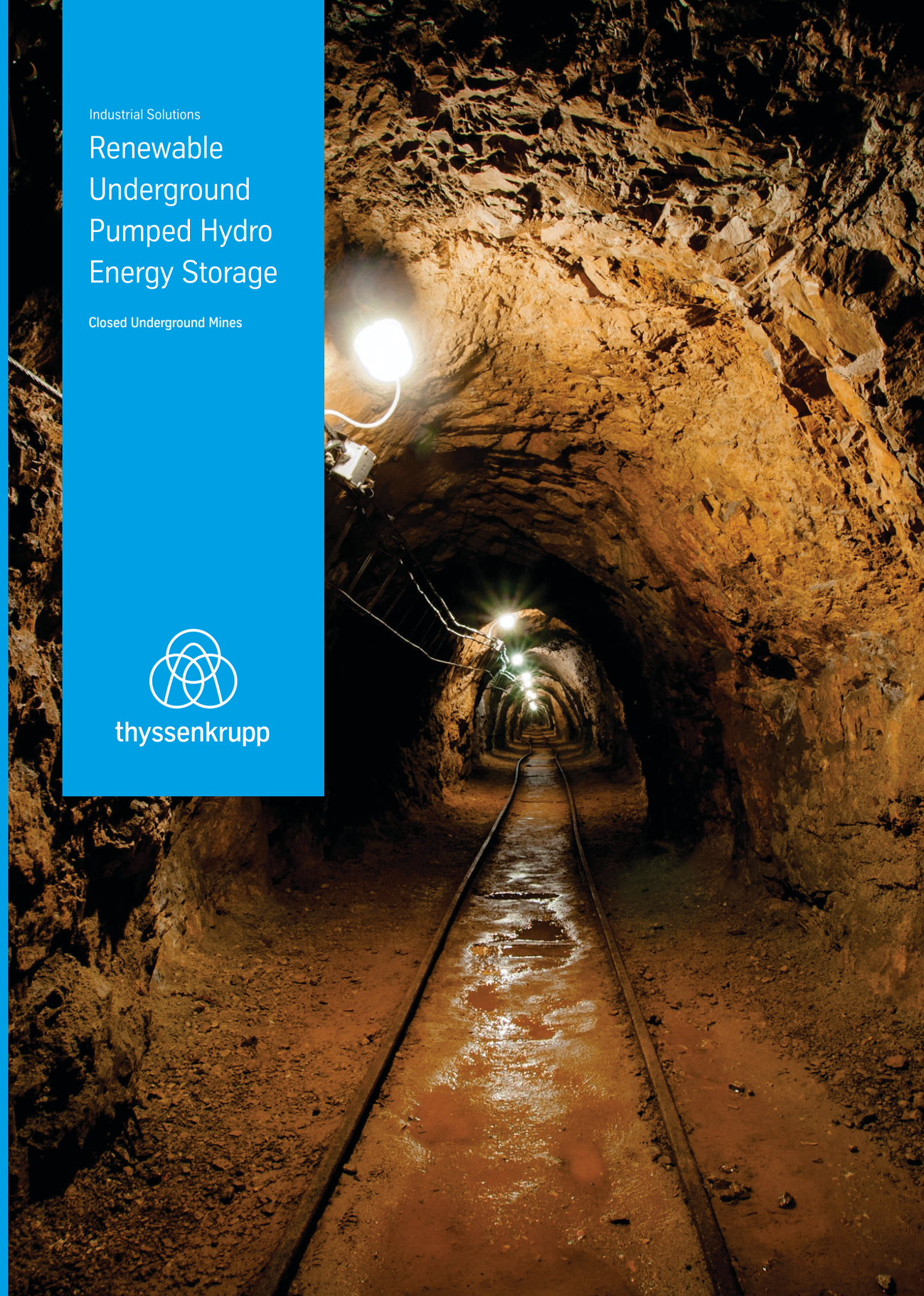
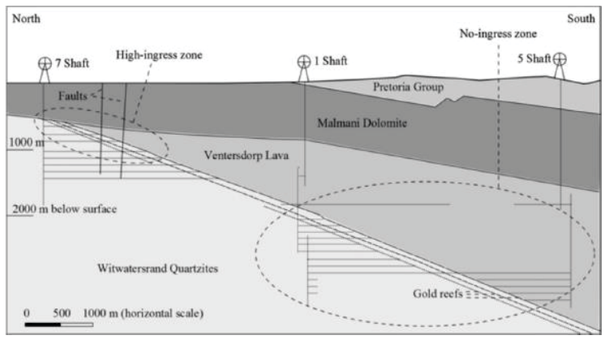


Core concept

Gold mines in South Africa are the deepest mines on Earth with shaft systems extending up to 4 km below surface. After more than a century of gold extraction, many mines are now closed or approaching closure. Instead of allowing more of the extensive underground mine void systems to be irreversibly flooded with acidic mine water threatening natural and built environments these projects aim at using abandoned deep level mine shafts to store and generate energy. First estimates suggest that the potentially available generating capacity of only one or two shafts could significantly improve South Africa's ability to meet peak demand and overcome currently experienced shortages as well as ensure future grid stability under conditions of rising contributions of fluctuating wind and solar energy.

Project outline

Tried and tested for over 100 years pumped hydro energy storage is a proven tool for covering peak load demand. Within minutes, several hundreds of Megawatts - as much as the output of a large conventional power station – can be provided compared to hours or days required by the latter. Moreover, in view of the growing share of renewable energy, buffering associated input fluctuations is of increasing importance for ensuring future grid stability. Applying the concept to water-rich underground mines minimises socially contested impacts on pristine environments such as mountains while averting essentially indefinite costs for pumping and treating polluted water emanating from closed and flooded mines.



Why South Africa?

While the concept is currently explored in several countries including Germany, Finland, Poland and Australia, we believe conditions in South Africa are particularly favourable for achieving economic viability and rapid implementation due to a range of aspects:

Favourable geotechnical conditions:

- Ultra deep shafts allow high energy yields at low water volumes
- Hard-rock geology provides stable geotechnical conditions with low risk
- Extensive and well-documented mine voids offer a large underground storage capacity without costly excavations
- Water-rich karst aquifers frequently overlying underground mines provide sufficient feed flow even during extended dry periods
- Pumping shafts equipped with adequate capacity and grid connection exist and are still operational
- Combining RUPHES with local solar and wind power as well as geothermal energy further increases energy yields and economic viability

RUPHES benefits for operating mines:

- Eliminate costly power interruptions adversely impacting on productivity and life of mines
- Buffer future electricity tariff hikes
- Produce clean drinking water as a possible second revenue stream
- Avert post-closure costs for long-term pump-and-treat of AMD from flooded mines already amounting to billions of Rand per year
- Being a sustainable, ecological and innovative concept RUPHES is likely to improve the environmental image of mines and associated share value

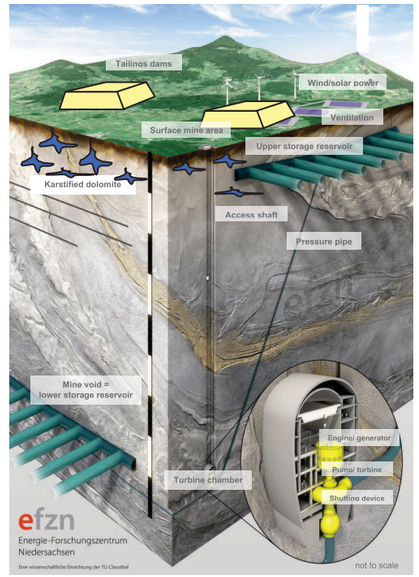
Geological cross section of a typical deep level gold mine in the far west rand operating below water-rich dolomite (WINDE ET AL. 2017)

RUPHES benefits for energy and water security:

- Assists in meeting peak-load demand reducing need for load-shedding
- Adds to grid stability by providing regulating power and frequency stabilisation as well as additional black start capacity
- Reduces transmission losses of imports from remote coal-fired power stations to local mines as large consumers
- Protects large karst aquifers from AMD-related contamination

RUPHES benefits for post-closure development of mining communities:

- Assists in ensuring post-mining availability of clean water and energy as the two most serious limiting factors for economic growth in South Africa
- Supports sustainable and affordable post-mining development in former mining areas



Schematic structure of a RUPHES utilising abandoned deep level gold mines. (Figure courtesy of EFZN)

Project phases

- Phase I: Conducting a feasibility study covering technical, legal and economic aspects followed by site-specific investigations to identify and select mines and shafts best suited for implementation of the project.
- Phase II: Implementation of a reference project based on proven technical feasibility and financial viability.

Feasibility study

Preliminary studies of the South African energy provider Eskom dating from the late 1990s and in-depth research by scientists (Winde et al. 2017) suggest that the concept is technically feasible and financially viable. However, this needs to be confirmed for a concrete site covering all geotechnical and engineering work as well as environmental, legal and economic aspects.

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Thyssenkrupp Industrial Solutions South Africa has signed a Memorandum of Understanding with Wismut, to collaborate on Underground Pumped Hydroelectric Energy Storage projects in South Africa. Wismut is a federal government-owned company operating in Saxony and Thuringia. Its principal business is decommissioning, cleanup and rehabilitation of uranium mining and processing sites. Thyssenkrupp Industrial Solutions South Africa and its affiliated companies are an organization engaged in amongst other things, engineering, project development, project construction, procurement and project management.

WISMUT