

Network of underground cities, linked by rail

TEO XUANWEI AND NEO CHAI CHIN

SINGAPORE — In the not-too-distant future, Singapore could have a network of underground cities, possibly linked by rail.

This was one of the Economic Strategies Committee's (ESC) recommendations — that investment be pumped into the development of underground space over the next decade — as the Government continues to find ways around the problem of space limitations in land-scarce Singapore.

The aim is to add to the Republic's "land bank" as demand for space increases in tandem with economic growth, Senior Minister of State (National Development) Grace Fu said at a press conference yesterday.

"Just as Singapore has reclaimed land in advance to support economic growth in the past, our sub-committee recommends that the government acts early to catalyse the development of underground space," said Ms Fu, who co-chairs the ESC sub-committee tasked to study land productivity.

An underground masterplan should be developed to ensure that space-use above and below ground are "synergised" and "better integrated" with surrounding developments, such as the rail network.

It also recommended the setting up of a national geology office to collate underground information, and setting up a subterranean legal and valuation framework. The recommendation was welcomed by National University of Singapore geography professor David

Higgitt, who described geology as a "neglected discipline" due to the island's limited natural resources.

"However, a national geology office is an important component of plans to develop underground space and a vital complement to structural engineering," he told MediaCorp.

"The geology of Singapore is complex and rock conditions can vary markedly over short distances. Understanding the controls on these variations and their implications for development is a necessary step."

In other recommendations, the committee said that industrial land, which takes up a "significant percentage" of Singapore's land stock, should be used more intensely or recycled. For instance, the Government could incentivise private manufacturing firms to design more efficient plant layouts through grants, said Ms Fu.

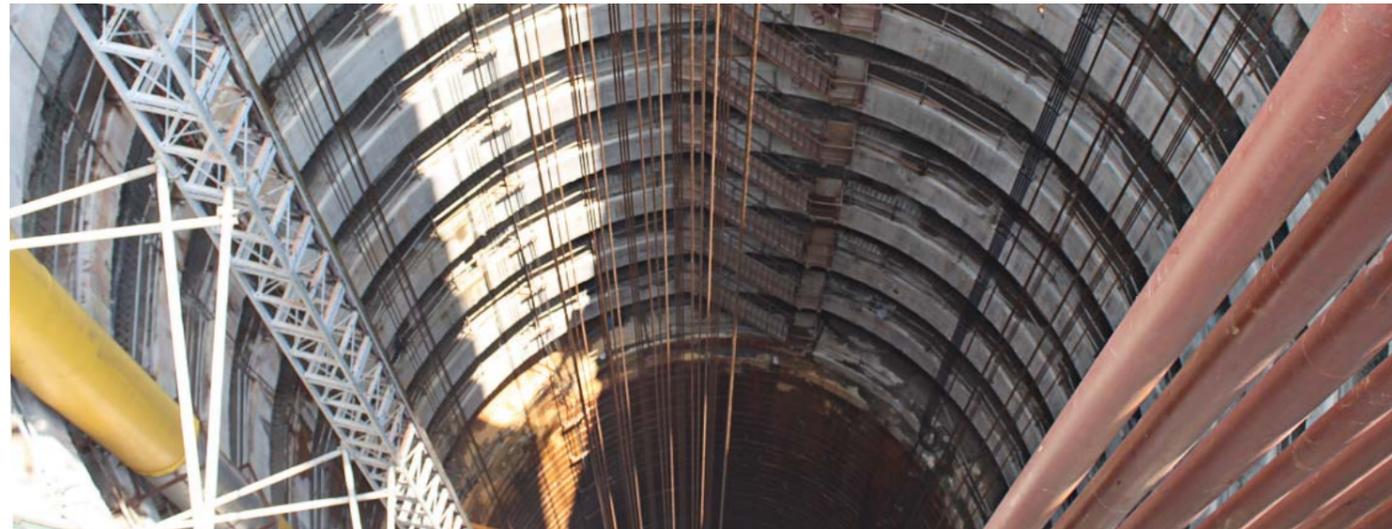
Mature industrial estates should also be diverted for use by "higher value-added activities", similar to how companies such as Hyflux and Caterpillar are based at Kallang and Jalan Tukang now.

To support the ESC's new macro-economic strategies, urban-planning in the next 10 to 20 years will have to factor in making Singapore "the best home for businesses and people", she added.

The former can look forward to integrated locations, which facilitate whole value chain activities. For example, promising SMEs will be housed at suitable "incubator" spaces that support development.

As for workers, the sub-committee suggested distributing economic activities across the island so that jobs are found closer to homes.

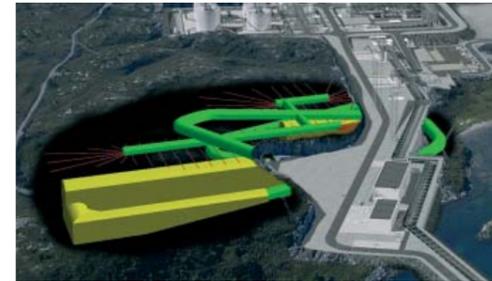
This way, people can enjoy a better quality of life, said Ms Fu.



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SINTEF - Tritech - Multiconsult Consortium



Jurong Island Hydrocarbon Storage - sub sea rock caverns



Consortium tasks:

- Project management
- Technical advise
- Review services

Project information:

- Construction period 3.5 years
- Total storage volume, stage 1, ~1.5 mill m³
- Size of each cavern ~ 0.15 – 0.33 mill m³
- ~ 100 m below sea level





THE STRAITS TIMES, FEBRUARY 6, 2010

Underground masterplan

In its search for more land to develop, S'pore is increasingly looking at what lies beneath

By TAN HUI YEE

PROPOSAL: Where do you go when you are running out of available land to build on? Underground, according to the sub-committee of the Economic Strategies Committee that looked into raising land productivity.

It suggests that vast quantities of underground space can be carved out for new development once a national geology office is set up to conduct surveys, update geological maps, develop a subterranean land rights system and determine how underground areas can be priced.

Such an office could act as a repository for all information on underground Singapore, and provide expert advice to the public and private sectors.

It could reduce the uncertainty involved for developers looking to build underground. And, by providing better information, developments above and below ground could be synchronised.

The state could supplement its "land bank" via the creation of such spaces alongside new underground infrastructure projects such as MRT stations. This will help create new spaces to locate emerging industries.

In true Singapore fashion, the vision is accompanied by an "underground masterplan", somewhat like what the Government draws up regularly to determine the uses and density permitted for specific plots of land (above ground) over a 10- to 15-year period.

POSSIBILITES: Granite and sedimentary rocks such as sandstone and limestone cover about two-thirds of Singapore, according to the Institution of Engineers Singapore (IES), and it is within these formations that developments can be constructed.

The upside is that technology for such work is established, although experts fear it will take some time before people are willing to accept the idea of living more than six feet underground.

But IES suggests that underground space could be used to house power stations, sports facilities, warehouses, wafer fabrication factories, laboratories, research centres and even incineration

plants. Moving such facilities underground would free up land for housing, parks and open spaces, thereby raising the quality of life.

Furthermore, the legal foundations for the development of subterranean land rights already exist, says Associate Professor Kelvin Low from the Singapore Management University's School of Law. At present, the owner of a plot of land has the right to build both skywards and into the ground via the creation of basements. This existing framework can easily be adapted for underground developments.

In order to allow two projects on each plot of land, the Government could subdivide state-owned land so that the underground portion is treated separately from that above ground. In the same way, a private owner of land can apply for permission to subdivide his or her plot to allow for dual above- and below-ground construction.

PRECEDENTS: Singapore currently uses underground space to accommodate shopping malls, train networks, new highways, civil defence shelters, pedestrian links, and storage for ammunition and oil. Think CityLink underground mall, which links City Hall MRT station to Suntec City, and the 12km-long Kallang-Paya Lebar Expressway, of which 9km runs underground.

And subterranean success stories abound across the world. The Canadian city of Montreal is well-known for its underground city called Reso. Inhabitants can live, work, eat, exercise and be entertained there without setting foot above ground, where temperatures can slip below 10 deg C for six months of the year.

More than 30km of underground tunnels and ground-level interior walkways link the offices, hotels, malls, movie theatres and museums which are part of this network.

The Japanese city of Osaka also has an integrated underground city centre and no fewer than six underground malls, all of which are connected by rail. The walkways, and office and department store basements form a labyrinth like subterranean network, adorned with artificial rivers, sunken gardens and glass facades to direct natural light to the basement level.

PRACTICAL PROBLEMS: Despite technological advances, building underground is inherently difficult. Extensive geotechnical studies and mapping are required, plus feasibility studies to ensure projects are viable.

Cost is another big factor, as depending on soil conditions, such developments can end up costing up to three times more than comparable surface structures.

Property consultant Knight Frank's managing director Danny Yeo feels cost considerations will restrict large underground developments to areas where land costs are high, like Orchard Road.

How to protect existing surface-level property could also prove to be another stumbling block.

According to SMU's Pmf Low, owners of properties next to underground sites are protected by law, given that subterranean developers are deemed liable for any damage to their buildings resulting from construction, even if it is not due to carelessness.

Such liability, he notes, is stricter than that found in some other common law countries like Canada and New Zealand, which require proof that the developer was negligent before he can be made liable.

While Singapore's stricter regime safeguards the interests of those with terrestrial property, it could render subterranean development more expensive here if neighbouring buildings were shoddily built and hence more easily damaged, he notes.

First underground cavern for Singapore's oil & chemical industries

The Singapore Government has decided to spend S\$700 million to design and construct Phase 1 of the Jurong Rock Cavern. Built at subterranean depths beneath the seabed of Banyan Basin in Jurong Island, Phase 1 will be commissioned in 2011 and will offer 1.47 million cubic metres of storage space for liquid hydrocarbons such as crude oil, condensate, naphtha and gasoil.

The Jurong Rock Cavern is able to save an equivalent of at least 60 hectares of surface land. Such land savings can now be allocated for higher value manufacturing activities.

I am told that both existing and new manufacturers on Jurong Island have expressed keen interest to utilise the Jurong Rock Cavern. JTC expects Phase 1 to be completely taken up prior to its completion and is already exploring a second phase that could add an additional 1.3 million cubic metres of underground storage.

For both phases, the primary objective of the Jurong Rock Cavern will be to support the operations of Jurong Island manufacturers. This is no different from the existing business models on Jurong Island whereby manufacturers optimise plant operations and investments by outsourcing non-core activities such as logistics and utilities, to third party service providers.

Turning Jurong Rock Cavern into reality took years of hard work, imagination and perseverance by many parties both within and outside the Government. But it is this spirit of constant innovation and breaking new ground that will ensure that Singapore retains her ability to compete in this fast changing and dynamic competitive environment.

Conclusion

The future of Singapore's chemicals cluster is bright. The Government will work together with the industry, to capture this continued growth. Let us also continue to push ahead on new frontiers such as the Jurong Rock Cavern, which are crucial to our future competitiveness.

On this note, I would like to take this opportunity to wish the JTC project team and its contractors every success for the smooth execution of the Jurong Rock Cavern project.



Mr Lim Hng Kiang, Minister for trade and industry, Singapore

Work on Jurong Rock Cavern to start in Nov

By RONNIE LIM

CONSTRUCTION of the estimated \$700 million phase 1 of the Jurong Rock Cavern (JRC) will start in November, with the first two of five underground oil caverns expected to be operational by December 2010.

This is the 'tight schedule' set out by JTC Corporation in a prequalifying tender just called for JRC's main design and construction.

Reflecting the 'fast-track' of the JRC project - which JTC recently said has drawn strong user interest - next up will be JTC's request for proposals, expected later this month, for an operator to run the underground Jurong Island storage.

Phase 1, according to the tender document, involves the construction of five separate caverns with a total storage capacity of 1.485 million cubic metres for crude oil, naphtha, condensate and gas oil (diesel).

Four of the unlined rock caverns - which will basically use the 'principle of hydrodynamic confinement' to contain the oil - will store 330,000 cu m each, and the fifth 165,000 cu m. All are designed to be interchangeably used for the various oil products and will be linked to the future Phase 2 of JRC (adding another 1.3 million cu m of storage).

In all, Phase 1 work involves 'about seven km of galleries and tunnels for an excavated volume of about 2.5 million cu m beneath Banyan Basin,' JTC said.

'The storage caverns and associated tunnels will be constructed by drill and blast method in sedimentary rocks. Two 130 m deep vertical access shafts are currently under construction to allow access from the ground surface for the construction and operational access of the storage caverns.'

A JTC spokeswoman told BT that the latest design and construction tender will be carried out in two stages. The prequalifying stage will close on May 11, after which JTC will shortlist the contractors for the actual contract.

JTC, which in February awarded a \$19 million contract to the Geostock-Jurong Consultants consortium to carry out the basic engineering design and to manage the JRC's construction, said in the latest tender document that it has also appointed Sintef Tritech-Multiconsult as the project manager.

Several companies, including tankfarm operators like Royal Vopak and Dubai-owned Emirates National Oil Company, had earlier said they were interested in operating the JRC.

The JRC will have two jetties, and will be able to take oil flows from VLCC jetties which will allow very large crude carriers to discharge their cargoes.

BT earlier reported that this could draw some Gulf countries which currently have strategic crude oil stocks on board floating VLCCs to use the JRC.

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Minister Lim Hng Kiang at the Ground-breaking Ceremony of the Jurong Rock Cavern

Published Date: 08/02/2007

SPEECH BY MR LIM HNG KIANG, MINISTER FOR TRADE AND INDUSTRY, AT THE GROUND-BREAKING CEREMONY OF THE JURONG ROCK CAVERN, BANYAN BASIN, JURONG ISLAND, ON THURSDAY, 8 FEBRUARY 2007 AT 10.05 AM

Distinguished guests,
Ladies and gentlemen,
Good morning.

It gives me great pleasure to officiate at the groundbreaking ceremony of the Jurong Rock Cavern – the first underground rock cavern for the oil and chemicals industry in Singapore and South-east Asia.

Over the last two decades, Singapore has truly blossomed into a global chemicals hub. In the mid 1990s, the innovative vision and bold decision to proceed with the reclamation and amalgamation of seven islands to create a 3,200-hectare Jurong Island had laid the foundation for the growth of a highly competitive and robust industry cluster.

This cluster extends from oil to petrochemicals to specialty chemicals. Collectively, the chemicals cluster has had a compounded annual growth rate of more than 14% over the past 10 years. Last year, the output from the chemicals cluster grew by over 10% to exceed S\$74 billion. In so doing, the size of the industry is now on par with the output from the electronics cluster, which has long held the position of being Singapore's largest industry sector in manufacturing.

Growth & Expansion of Singapore's Chemicals Cluster

2006 has indeed been an exciting year for Singapore's chemicals cluster, with more than S\$2.6 billion in fixed asset investments committed.

The year was marked by several milestone events such as the ground-breaking of Shell's new ethylene cracker and downstream MEG plant, and Concord Energy's decision to establish Singapore's first greenfield refinery in the past 30 years. 2006 was also a year when several new plants on Jurong Island commenced operations, including Sumitomo Chemical's second Methyl Methacrylate

Monomer (MMA) Plant, and Petrochemical Corporation of Singapore's Metathesis Plant.

These developments which I have highlighted reflects Singapore's competitive position in this industry, which has allowed us to ride the current industry upturn to capture a series of projects and take Singapore's chemicals cluster to the next higher level. As Asia's demand remains robust, the Economic Development Board is expecting to announce more projects this year. More importantly, this wave of projects will bring about a significant transformation of the industry over the next 3 to 5 years. Singapore's chemicals cluster would have acquired a critical mass and its highly integrated nature will mean that we have high value-added downstream activities.

The Singapore Government is committed to the long-term growth of the chemicals cluster. With the current strong investment climate, we are mindful that competition for resources and infrastructure will be intense. If not well managed, costs could spiral out of control and as a result, projects may be delayed or even completely cancelled. As such, we will do our best in adopting a holistic and multi-faceted approach that will give current and future investors in Singapore the confidence that their projects can be seamlessly and expeditiously implemented in the coming years.

Several initiatives are being developed to support Jurong Island's and the chemicals cluster's rapid expansion. I would like to take this opportunity to highlight two of them.

The first is in growing our Process Construction and Maintenance industry, sometimes also called the supporting process industry. Construction of new plants requires a substantial pool of manpower, even though we recognize that this requirement is normally for a temporary period of 2 to 3 years. As such, the Singapore Government will work towards ensuring that the supporting process industry has access to sufficient manpower resources to cope with the anticipated spike in chemical construction projects over the next few years. Through this phase of growth, we will also work to upgrade the supporting process industry so that they will be able to provide ongoing support to the chemicals cluster, post construction. By building up a strong track record in Singapore, these companies in the supporting process industry can venture into the region and beyond.

The second is infrastructure enhancements on Jurong Island, to facilitate the increased throughput of construction workers, equipment and materials to and from mainland. JTC will be upgrading the capacity of Jurong Island's checkpoint to accommodate more people during peak hour.

While we prepare ourselves to maximise opportunities for growth, we must also be on the lookout for new, bold and innovative ideas to maximise available resources, optimise existing infrastructure and enhance Jurong Island's competitive advantage. The Jurong Rock Cavern is a shining example of this spirit and mindset.

Jurong Rock Cavern ready by 2013

Work on underground oil storage facility to start by year's end; phase 1 to cost \$890m

By JESSICA CHEAM

PHASE I of Jurong Rock Cavern, the first underground oil storage facility to be built in South-east Asia, will finally begin construction by year's end and cost about \$890 million. The first storage caverns will be ready by the first half of 2013, said JTC Corporation during a briefing yesterday. JTC has awarded the building contract to South Korea's Hyundai Engineering and Construction - over the only other bidder, fellow South Korean firm SK Engineering and Construction.

The tender was called in late 2007 but the complexity and design of the project led to delays, said a JTC spokesman. Its cost has also risen, above the \$700 million expected earlier. Japanese firm Sato-Kogyo has already built two access shafts and start-up galleries in the initial phase for the storage caverns, work that has cost about \$50 million.

The media yesterday visited part of the rock cavern under the seabed of the Banyan Basin via an access shaft that went as deep as 132m below ground level. Workers will use a technique that drills and blasts sedimentary rock to build the cavern, which will be used to store liquid hydrocarbons such as crude oil, condensate, naphtha and gas oil.

The first phase consists of 8 km of tunnels and five caverns. Together, they will contain nine storage galleries, each about nine storeys high and big enough to accommodate the water from more than 64 Olympic-sized swimming pools.

The Jurong Rock Cavern will free up about 60ha of usable land above ground, which is highly sought after by investors on Jurong Island. This land can now be used for higher value-added manufacturing activities, said JTC's spokesman.

The Government is also considering building offshore sites to cater to Jurong Island's storage needs.

"The cavern will provide strategic storage for better fuel security and it also gives Singapore a competitive advantage to attract more investors," said the spokesman.

Hyundai Engineering won the contract due to its experience in building similar projects in South Korea and Taiwan, said JTC. The contractor is also working on other projects here, such as phases 3 and 4 of the Pasir Panjang Terminal and the One Shenton Way residential development.

THE STRAITS TIMES, FEBRUARY 2 2010

Need more space? Let's go underground

By Jessica Cheam

ONE innovative solution to meeting the nation's expected shortage of land is to go underground and carve out spaces. These subterranean land banks would be located mainly near transport hubs, according to the Economic Strategies Committee (ESC) report yesterday.

As Singapore plans ahead for a city 'remains extremely liveable even as we grow, we have to make more efficient use of our land (and)... this will call for bold and imaginative urban planning and redevelopment', said the report.

Senior Minister of State for National Development Grace Fu expanded on the idea yesterday, saying that the Government has to identify new industrial estates to serve new industries.

It could create basement spaces with new underground infrastructure, and land banks around our rail network, said Ms Fu, who co-chairs the ESC sub-committee on land.

She said the Government has found 'tremendous potential for us to create infrastructure underground already' during the process of developing the rail system.

'This means that there's land that can be created underground. We may not need to tap (it) any time soon but if we're to do it, as we are developing the infrastructure underground, it's getting the land ready for us,' she said.

The Government also wants to develop a masterplan to ensure that underground and ground spaces are developed in sync with each other to ensure that the maximum potential is realized. It is setting up the National Geology Office to collate information on underground development.

The Government will also develop a subterranean legal and valuation framework that will benefit private and public sector efforts in developing underground spaces, added Ms Fu.

Investment will be pumped into research and development and cavern level test bends to gain experience in underground development.

Going underground is not alien to Singapore. The industrial developer and landlord, JTC Corporation, has started work on the first phase of the Jurong Rock Cavern, the first underground oil storage facility to be built in South-east Asia.

Industry observers said yesterday that going underground is challenging from a cost viewpoint.

Mr Ashvinkumar Kantilal, president of the Singapore Institute of Architects, said developers only go into basements when required because of the cost.

'The uses of these underground spaces also have to be very specific,' he said. Perhaps a leap in technology will lower costs to allow Singapore to maximize the potential of such spaces, he added.

Maintaining growth
Singapore's second quarter profit of \$4.6 billion and exports all rebound to maintain its growth momentum in the second half.
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MONEY

THE STRAITS TIMES THURSDAY APRIL 13, 2006

S'pore goes ahead with underground oil caverns

Construction begins this year and will add 8m barrels of storage space on Jurong Island

By Bryan Lee

SINGAPORE will start building a series of vast underground caverns for storing oil in the bowels of Jurong Island later this year, 10 years after the idea was first floated.

The caverns, the first such facility here, will add eight million barrels of oil storage space to the Republic's current capacity of 88 million barrels, with the first cavern expected to be completed in 2009.

The caverns will range in size from 150,000 cubic m to 330,000 cubic m each, with a total capacity of 1.5 million cubic m. To give some idea of just how vast that is, an Olympic-sized swimming pool is just 2,000 cubic m.

An earlier report suggested that the Caverns could be 70m underground.

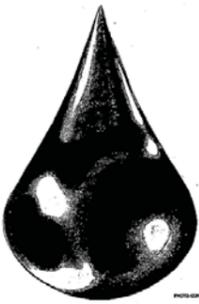
The long-expected move will address a shortage of oil storage space in Singapore which has prompted a rush of plans by private petrochemical logistics firms, such as Hin Leong Trading, to expand their storage facilities here.

The 10 years since the idea first emerged was spent first on refining the concept, then conducting feasibility studies.

Rising oil consumption by Asia's fast-growing economies coupled with expectations of even higher oil prices have led to soaring demand for storage capacity in the Republic, which is a key regional oil trading centre.

The caverns will "help boost Singapore's position as a leading chemicals hub," Minister for Trade & Industry Lim Hng Kiang said yesterday.

Speaking at the opening ceremony of a \$120 million petroleum and chemical storage terminal on Jurong Island owned by



THE STRAITS TIMES, APRIL 13, 2006

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By BRYAN LEE

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Speaking at the opening ceremony of a \$120 million petroleum and chemical storage terminal on Jurong Island owned by

Holland's Royal Vopak, he said the move will "further enhance our chemical logistics infrastructure".

"The caverns have the possibility of integration with above-ground storage and will allow for optimization of the overall storage capacity of Jurong Island," Minister Lim said. "This will result in land savings and offer benefits of enhanced safety and security."

The idea of building an underground oil storage facility here was first reported in The Straits Times in 1996. Inspired by underground complexes in Scandinavia, the caverns were seen as cost-saving solution to Singapore's land scarcity.

They were then seen as housing for a variety of facilities, including sewage treatment, and water storage.

In 2004, the Ministry of Defence opened a subterranean ammunition facility in Mandai.

Specific feasibility studies for oil storage began in 2001 and were completed only last year, spawning much market expectation that the green light would be given soon.

Yesterday, industrial land developer JTC Corp said it will build the caverns at Jurong Island's Banyan Logis-Park, under Vopak's new Banyan terminal. The facility will store crude oil, condensates, naphtha and gasoil, which is used as diesel automotive fuel and jet fuel.

A second phase which will add 1.73 million cubic m of storage space could also get the go-ahead if there is demand, a JTC spokesman said.

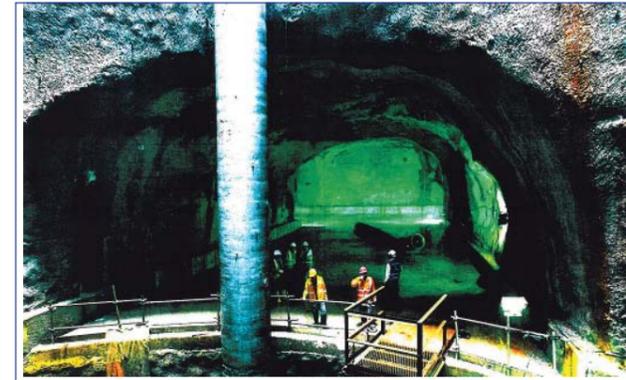
No cost figures were revealed but the project was earlier estimated to cost \$760 million for a four million cubic m facility. No details of the business model were released either.

Vopak chairman John' Breeden said yesterday that his firm has expressed interest in operating the caverns: "We are on top of the caverns."

Vopak's newest terminal, it's fourth in Singapore, can store 340,000 cubic m of oil, on top of 30,000 cubic m of chemicals. The firm is likely to spend another \$500 million to expand it further.

Mr Jimmy Ang, director for Platts Asia oil market reports, said the caverns will offer traders greater flexibility to "move cargo into the region". He dismissed notions of a potential storage tank glut here, saying industry players would have factored in the caverns when planning expansion.

Energy consultant Ong Eng Tong said the caverns are more likely to be used to store crude oil, possibly as a strategic reserve for some Middle East Countries. "Most commercial firms will prefer to store refined products above ground as it is easier to monitor and there's a lower possibility of water contamination."



THE STRAITS TIMES, OCTOBER 29, 2009, ST PHOTO: CHEW SENG KIM

Jurong Rock Cavern to store Petrochemicals ready in 2010

This is what an underground rock cave 132m below the ground looks like, except that this will be used to store Singapore's petrochemicals in future.

JTC Corp yesterday said it had awarded an \$890 million contract to South Korean firm Hyundai Engineering and Construction to begin construction of the first phase of the Jurong Rock Cavern.

The project, which broke ground in early 2007, has completed its initial phase, which consists of two access shafts and start-up galleries for the storage caverns.

When completed, the first phase will have 8km of tunnels and five caverns, and will contain nine storage galleries, each about nine storeys high and big enough to take in water from more than 64 Olympic-sized swimming pools.



TODAY, MAY 14, 2008

An underground reservoir?

Govt tender to study feasibility of more facility in rock caverns

By Ansley Ng

LAND-SCARCE Singapore is already storing some of its military munitions in this way. And work is underways on similar storage facilities for crude oil and oil products.

Now, the Government wants to look at building power stations, warehouses, incineration plants, airport logistics centres and reservoirs all below ground.

Industrial landlord Jurong Town Corporation (JTC) last Friday called a tender for a "underground rock cavern usage feasibility study" to see how subterranean grottos could be used to maximize land use, among other things, the winning consultant will have to study the costs and the use of underground caverns in other countries.

It will also advise JTC on the possible environmental and health issues, such as pollution, radiation and damage to existing buildings and infrastructure.

Last July, TODAY broke the story of how government agencies including the JTC were exploring the feasibility of creating caverns for living.

Professor Zhao Jian, who led early feasibility studies on cavern development in Singapore, had said then that the potential for space underground was "almost limitless" and was "particularly useful for any facilities that are not desirable at surface level, for example, sewage treatment plants".

However, potential sites could be areas with deposits of igneous rock, such as granite, in the central, northern and north-eastern areas of the island.

A 1995 paper by Nanyang Technological University researchers including Prof Zhao, in the Quarterly Journal of Engineering Geology, concluded that the Bukit Timah granite - which forms one-third of the surface area of Singapore - had good potential for underground cavern construction.

The tender closes June 6, and the consultant is expected to work with the Civil Aviation Authority of Singapore and the Energy Market Authority, among others.

OTHER CAVERN PROJECTS:

- In March, the Ministry of Defence opened caverns under the disused Mandai Quarry to store ammunition such as bullets, bombs and missiles. The warehouse caverns - each about the size of six basketball courts - were blasted out of solid granite underneath the quarry, freeing up surface land the size of Pasir Ris town.
- The JTC is constructing the \$2-billion Jurong Rock Cavern beneath Jurong Island, for use by petrochemical companies. The first caverns under Phase 1 should begin operations in 2010.
- A plan in the late 1990s to construct a Science City, a mixed-use commercial project, under Science Park 2 was derailed by cost factors