

# STORAGE DURING TRANSITION

**Danny Constantinis, EM&I Group, Malta,** explains why robotic and digital technologies will play an important role in supporting storage facilities for cryogenic products.

**E**nergy is critical to all economies – particularly emerging economies, as they cannot develop without adequate and reliable power supplies. The transition to cleaner energy will inevitably require new technology for storing energy, be it oil, LNG, carbon dioxide (CO<sub>2</sub>) or hydrogen.

Supply chains have been stretched to the limit during the pandemic, and this has highlighted the problem with the current 'just in time' philosophy which cannot cope with unexpected disruptions.



Inevitably, more (and different types) of storage will be required in the future to overcome these problems, and storage facilities – such as tanks – will need remain ‘fit for purpose’ throughout their operational life.

Inspection and maintenance will need to be carried out as safely, quickly and efficiently as possible to maintain the availability of tanks. Shortages of oil, gas and other specialist chemicals have all been experienced during the COVID-19 pandemic, so strategic reserves need to be established for most industrialised countries to cope with future disruptions. This in turn means more available storage capacity.

Keeping tanks safely in service can be made more efficient and a lower risk to workers by using robotic

methods of inspection, starting with designing or modifying assets to enable remote systems. Preferably, access ports to allow for robots to be inserted into tanks will need to be part of the basic design rather than introduced retrospectively.

Safety incidents in confined spaces have spiked in recent years. As such, risk assessments should be based on an acceptable level of safety set by the directors of the companies concerned, due to the huge financial, reputational and legal implications concerned (e.g. corporate manslaughter) if they knowingly allow more dangerous methods to be used when safer methods are available.

Robotic inspection will also play a greater part in inspecting storage facilities for cryogenic products, as robots can operate at much lower temperatures than is practical for manned entry and this saves out-of-service time when warming up and cooling down tanks.

EM&I has developed a number of robotic and digital technologies as a result of its leadership of joint industry projects (JIPs) for the oil, gas and floating offshore wind industries. These have been particularly successful in improving safety and efficiency whilst reducing manpower and costs.

Although there has been a lot of publicity surrounding renewables such as floating wind, solar and wave energy, there is no doubt that oil and gas will be a prominent feature of the energy mix for many years.

## The oil and gas industry

The oil and gas industry produces US\$1 trillion of tax every year and employs approximately 6 million highly-skilled people worldwide, whereas renewables often require subsidies. It will take decades to gradually wind down this industry, particularly because of the rapidly increasing demand for petrochemicals, which require crude oil as the basic feedstock. Storage of oil products is a well-established process that will still benefit from improved inspection and maintenance methods.

Storage on floating storage regasification units (FSRUs) is a useful capability and enables hydrocarbon ‘atoms-to-electrons’ technology to quickly deliver power to areas where there is no effective grid structure. Again, the inspection of storage facilities will benefit from advanced methods.

## Hydrogen in all its forms

Hydrogen will play an increasing role in clean energy usage, which can help to cope with the ‘intermittency’ of renewable energy. However, the methods of hydrogen production have different degrees of environmental impact, and the challenges of transportation and storage are yet to be resolved.

Green hydrogen is the most environmentally friendly as it is generated by using renewably-sourced electrical power, such as solar or wind,

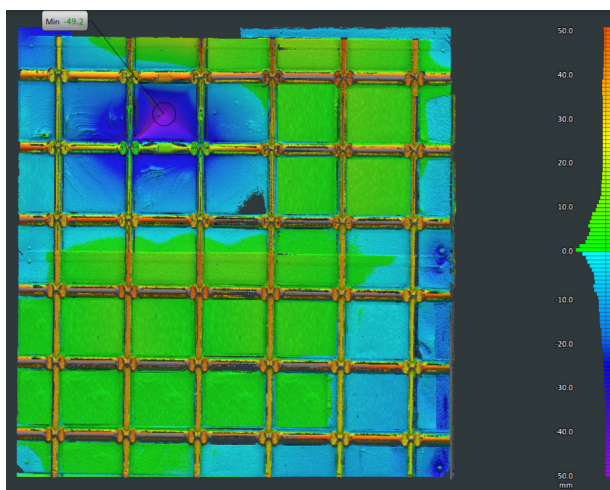


**Figure 1.** A NoMan optical camera.



**Figure 2.** A floating storage regasification unit (FSRU).





**Figure 3.** A NoMan laser scan of LNG membrane test piece.

to electrolyse water. In some ways, the hydrogen produced can be considered as a ‘battery’ that enables electrical power that would be wasted or difficult to distribute by grids to be ‘stored’ in the hydrogen gas.

Hydrogen needs to be stored and transported at very cold temperatures, which is itself a challenge. One solution is to use a carrier gas such as ammonia, which has a high storage density and is easier to liquefy ( $-33^{\circ}\text{C}$ ). There will be an important market in future for hydrogen electrolysis plants and facilities for storage before transportation to regions where the energy is required.

The facilities themselves – the storage and the transportation methods, primarily ships – will also need regular inspection and monitoring, which in turn means additional drivers for developing robotic and digitised methods to carry out this work with minimal out-of-service time.

For many other liquids and chemicals that are not ‘temperature sensitive’, multi-purpose tanks and terminals may be desirable in the future. The geographical position of tanks and terminals should ideally be convenient for port facilities so that alternative sources of supply can be used if pipelines are not practical or reliable.

In many cases, the ability to receive and store fuels in liquid form for regasification to a nearby thermal power station is served by FSRUs. These are being used increasingly, particularly in remote locations with little infrastructure or islands with peak seasonal demands, as they can be made available quickly and economically compared with onshore facilities, and can be supplied from anywhere in the world. Some are also equipped with power generation so that they can become offshore power plants as well.

## New robotic inspection technologies

It is clear that future storage will involve low temperature facilities both on and offshore. New cleaning, inspection and maintenance technology is required. The old methods need to be challenged and the regulatory framework undoubtedly reviewed in order to make the operation of floating LNG (FLNG) and hydrogen assets as safe and

efficient as possible. The FloGas JIP is currently focusing on LNG and is looking at issues such as the frequency and execution of tank inspections, and whether putting people into these areas can be avoided in the future.

The traditional approach is the following: prior to entering the dockyards, LNG trading vessels are warmed up, gas freed and opened up for a visual inspection. The classification society surveyor will focus on areas such as the pump and pump tower, and the tank bottom sides, to look for deformations or bonding issues and to establish leakage rates.

For the FLNG units, where the systems remain ‘live’ either by virtue of production or by send out, the time taken to remove one tank from service and bring it to a temperature for inspectors to safely enter, can be onerous. Likewise, returning the tank to service can be risky, especially if the thermal gradient exceeds the design parameters of the containment system. The FloGas JIP will explore whether this thermal cycling should be avoided or minimised.

As a result of the success of the Hull Inspection Techniques and Strategy (HITS) JIP, EM&I commissioned a study to see how laser technology can be used to ‘map’ the tank structure and to identify any anomalies in the membrane containment system.

The purpose of the first phase was to trial laser scanning on the various types of membrane containment using optical and laser systems such as the NoMan technology.

Typical anomalies principally included sloshing damage and leaks through the membrane. Trials were carried out in both China and Europe on representative, full-scale test pieces, and a number of challenges became apparent.

One challenge was the highly-reflective nature of the membranes, which had the effect of ‘blinding’ the laser scanner so that certain parts of the lining were not sending the laser signals back to the transmitter. This was overcome by scanning from multiple locations and selecting suitable targeting procedures so that areas that had been reflective in one position were now able to send back data for processing.

## Looking ahead

Now that the NoMan technology has been successfully trialled on full-scale containment system test pieces in China and the UK, the FloGas Working Group is looking at the requirements to enable the system to work in LNG containment without person entry.

As the basic physics have been proven, the next phase is to consider how these inspection robots can be introduced into the LNG storage space through the limited access available at the pump tower bend, or potentially through the vapour dome.

While still at the proof-of-concept stage, engineers working on this challenge feel confident that solutions are available, and work is underway to try out these systems on live assets towards the end of 2022. When compared with traditional methods, the system is expected to be safer, faster and greener. 