HARNESSING THE WASTE HEAT

W. T. Cutts, American Tank & Vessel Inc., USA, outlines the next steps for existing liquid storage terminals in their transition to clean energy by utilising waste heat.

For the future of the liquid terminal industry, nothing is more important than engagement in a solution for the energy trilemma (affordability, security, and sustainability). Engagement here must be defined as building a profitable terminal business around the energy trilemma. Some investors are starting to distance themselves from the hydrocarbon industry, and publicly traded companies are faced with the challenge of satisfying a broad range of investors on the path forward. Therefore, the terminal industry needs a plan to support positive economic results, capitalising on an energy transition solution.

The good news is, there are opportunities to reformulate existing terminals to leverage the clean energy future. The solutions involve emission reductions, storage of products generated through renewable efforts, optimisation, and new technologies, which take advantage of existing terminal infrastructure, systems, and locations. A number of leading technologies that support terminals are listed in Figure 1. One of the new exploitable technologies for liquid terminals is the CRCES™ (carbon reduction clean energy storage) system. This process works well in bulk storage terminals. CRCES works with an industrial heat pump to accumulate energy from waste heat, then stores the energy in tanks. Another technology for waste heat storage is the use of thermal energy with liquid or aggregate in tanks. Both systems can be profitable in the short-term for terminals with the right criteria.

The most viable solutions must harness current terminal assets, store energy, and at the same time secure a renewable means of power generation. The combination of these efforts paints a picture of transition accepted by the most aggressive investors. As a reference point for terminal competition, one need look no further than lithium-ion

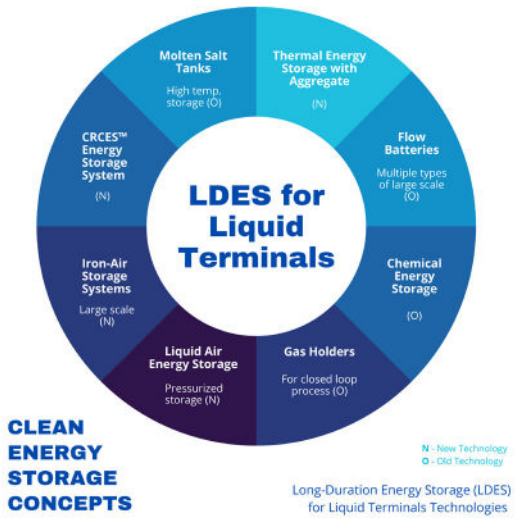

Figure 1. Chart of long duration energy storage (LDES) for liquid terminal technologies.

Figure 2. Clean energy process piping.

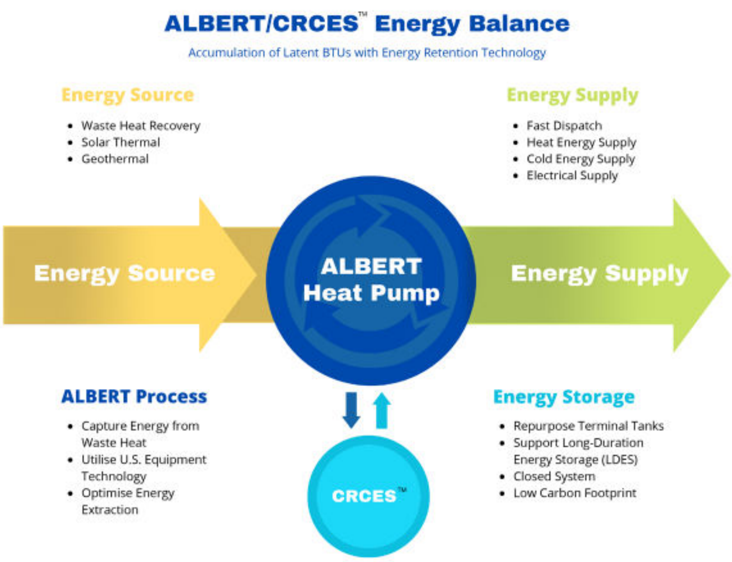

Figure 3. Flow chart of the CRCES™ process.

batteries for electrical energy storage (EES). When it comes to power generation, solar and wind are the systems to beat. The liquid terminal industry can outperform photovoltaic (PV) solar with batteries by supporting long-duration energy storage (LDES), lower EES cost, and a lower carbon footprint among other things.

When embracing new technology, from an investor perspective, there are plenty of selling points, but the big challenge is favourable economics. The solutions lie in old concepts and technologies formulated to fit the liquid terminal industry. Taking advantage of the location of many terminals, specifically their proximity to industrial facilities and power grids, is a key element for success.

Thermal energy storage systems and CRCES technology are simply types of waste heat recovery and clean bulk energy storage that compete with solar, wind, and batteries. Compared to clean power generation paired with batteries, these systems offer unlimited life cycles, no cost of future battery replacement, a smaller area requirement for energy storage, and efficient LDES. These systems also have faster project timelines, provide more local jobs compared to deploying batteries, and offer a lifespan of over 20 years.

Moving forward, the realisation of these benefits requires a commitment to working with the energy industries in the vicinity of the existing terminal. One valuable source of energy is low-quality waste heat. Most industries already utilise waste heat recovery in a variety of manners, but still have low-quality waste heat within their operations. Typical operations consume water, power, chemicals, and land area to expel this low-quality waste heat. Technologies are available to utilise low-quality waste heat, as well as convert existing storage tanks and systems to serve as energy storage containers. A front-end engineering design (FEED) study identifies the resources which can be utilised for energy acquisition, storage, and distribution. Terminal companies who embrace the concept are underwriting their future by:

- Promoting a path to clean energy storage with investors.
- Adding long-term sources of revenue.
- Reducing local industrial consumption of water.
- Expanding relationships with local industries.
- Stabilising the power grid with clean energy.

Utilising existing terminal assets for the storage of clean energy can be accomplished through several applications which support legacy technologies. However, a review of these applications shows that many do not take advantage of a traditional hydrocarbon terminal's assets. For applications to have a good fit, the projects need to utilise current physical assets, support deployment, leverage existing staff and systems, acquire low-cost energy, incorporate good economics, show flexibility for future transitions, and minimise the land required for new equipment.

Most clean energy storage is either burdened with incomplete technology or limited by rare materials. Thermal energy storage and CRCES technology are available for commercialisation and have the benefit of storing energy from low-quality waste heat sources.

These systems can utilise nearly the full storage potential of existing tanks, with minimal modifications. Not only are the assets of a liquid terminal utilised, but the terminal's management systems are appropriate to operate the updated facilities described. Many liquid terminals operate propane facilities or blending, which are of similar complexity to operating the facility supported by CRCES. In addition, most terminals are in areas where it is easy for the terminal to tie itself into the electrical grid, support a substation, generate behind the metre, or work through an electrical broker to sell power.

Utilisation of a terminal's fixed assets will require tanks, a processing unit, thermal piping into the terminal facility, and power grid connectivity. Overall, most facilities have plenty of space for the inbound thermal piping which is used to bring the energy into the terminal. The overall processing facility area is minimal. For example, a 1 GW storage facility would only require a processing area of approximately 100 ft x 200 ft. Tying into the grid is a function of the existing plant, the grid style, and the dispatch rate. This may require additional work with the grid management group, however, the system is very small overall (except for the storage tanks).

Most of the required modifications to existing systems for the implementation of clean energy storage in a terminal occurs in the tanks themselves. There are a variety of applications for storing energy in tanks, from molten salt to chilled water, but there are different requirements for storing heated liquid, heated aggregate, and/or mixed refrigerant liquids. However, the common requirement is a good insulation system. In some situations, the existing tanks can be the primary containment structure for the substance that will store the energy. However, in many applications the existing tank will become the outer tank with a second tank being constructed inside the existing tank and the outer tank acting as an insulation jacket and/or a secondary containment vessel.

Figure 4. AT&V's construction of pressurised storage for hydrocarbon terminals.

Figure 5. Typical atmospheric storage facility featuring 36 tanks built by AT&V.

Tank alterations will take into consideration the stress and thermal performance levels of the existing foundations and steel structures. Older tanks (or tanks that are somewhat corroded) may fully qualify to act as the insulation jacket. All tank modifications, whether dealing with foundations, piping systems, venting and/or overall performance, will comply with required standards, codes, stakeholder requirements, and appropriate certifications. Investigations will need to be performed to ensure minimum risk and liability to investors, terminal employees, the environment, and the public. Some designs may require that the existing tank roof be removed and that the inner tank becomes a primary roof extending over to the old tank's outer shell when reviewing these options with a terminal owner. A variety of options are presented to ensure the solutions are economically viable and perform accurately for the new storage substance, and that thermal requirements are realised.

The power customer is very different from the traditional terminal customer. Power generation facilities can have long contracts with a theoretical customer or customer base that is very stable. The same should be true for clean energy storage in terminals. Ultimately, a power purchase agreement (PPA) or contract with the appropriate grid management firms leads to a long revenue stream that can see inflation and other pricing enhancements included in the terms.

In addition to stable power generation revenue, clean energy incentives should also be realised, and the ability to help stabilise the grid against intermittent power supplies volatility. The systems described here will give terminals LDES capabilities so that arbitrage and opportunities with higher power rates should be realised. In addition, the number one competitor for terminals in clean energy storage is lithium-ion batteries. Competing directly against lithium-ion batteries is an additional financial advantage that terminals have because of the long life of the LDES systems within hydrocarbon terminals vs the short life of lithium-ion batteries and battery replacement issues.

Conclusion

Hydrocarbon terminals are not alone in searching for solutions to the global energy transition. Terminals, however, have an advantage over many industries through the utilisation of current assets, combined with geographic location and the history of being an energy storage provider. By working with industries in relative proximity to the terminal for accumulation of waste heat, modifying existing storage tanks, and utilising their proximity to large electrical grids is a winning trifecta for hydrocarbon terminals. This solution attracts new investors, builds new long-term relationships, and repurposes existing assets with a better return on investment. Such an undertaking is hard work but offers great rewards. T&T