Sustaining Sustainability in Marine Terminals: A Strategic Framework

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Sustainability initiatives in maritime industry, despite their global need and relevance, are often riddled with strategic and implementation issues. Here we examine "green" initiatives of top-five global marine terminal operators. We classify their initiatives as technology-centric, process-centric and relationship-centric, *and develop a core-competency-driven framework for these initiatives. Our findings indicate that technological initiatives are easy to adopt and yield quicker impact in reducing emissions and increasing ROI. On the other hand, process-centric and relationship-centric initiatives are more difficult to deploy, take longer to yield benefits, but are difficult to imitate. We argue that terminal operators should recognize the value of long-term initiatives that are difficult to replicate, to build competency.*

INTRODUCTION

Over the last 20 years, maritime transportation and port terminals have seen a significant increase in container volumes. Despite recent economic uncertainties and trade fluctuations, world container traffic has more than tripled in volume between 1995 and 2009 (Bureau of Transportation Statistics 2011). This massive and continuous growth in global trade has increased environmental concerns of transportation. Since almost all movement of goods requires burning of high-carbon-fossil fuels, it results in an increased concentration of gases like carbon-dioxide, methane, nitrous oxide, and hydro-fluorocarbons. These atmospheric-polluting gases prevent heat from escaping, somewhat like the glass panels of a greenhouse, and result in significant climatic changes/ abnormality (Environmental Education Outreach Program 2007).

According to the International Transport Forum (2010), the transport-sector alone accounts for nearly one-quarter (24%) of all greenhouse gas (GHG) emissions in the world. International standards (European Commission 2014) mandate emissions to be cut by at least half of the 1990 levels by 2050. In 1990, maritime transportation accounted for 7% of the world's transport-related CO_2 emissions; in 2000, the industry was responsible for nearly one billion tons of emissions each year, translating to 15% of the overall transport emissions (Michaelowa and Krause 2000). Contrary to the target, numbers are likely to more than double by 2050, if no immediate and sustained action is taken (Michaelowa and Krause 2000). Indeed, this is the primary motivating factor for this paper and we focus singularly on providing rigorous strategies for long-term sustenance of sustainability in the maritime industry.

SUSTAINING SUSTAINABILITY STRATEGICALLY

Sustaining sustainability or long-term survival of a sustainability system, by definition, requires a strategic viewpoint and analysis. Areas where quantitative data are readily available and analytical models have been *proven* to yield results in strategic decision-making, quantitative methodology may yield the best solution. However, situations where (largely) non-numerical, context-driven data, called qualitative data, are available and the situation is complex/multi-layered, are better suited for deploying qualitative tools. A qualitative strategic framework can often adeptly handle complex issues and help decipher patterns, resulting in insights that can be easily understood and used by decision makers.

In our past work (Boile et al. 2008), we proposed a strategic system of Inland-Depots-for-Empty-Containers (IDEC) to support sustainable regional repositioning of empty containers. This work utilized mathematical models for a holistic framework that incorporated environmental, economic, and societal objectives yielding sustainable solutions. The idea was to utilize restored/cleaned land originally contaminated due to industrial use, called Brownfield sites, for proposed inland depots that are closer to customer clusters in the region. Deterministic (Boile et al. 2008), stochastic (Mittal et al. 2012), and multi-criteria decision models (Mittal et al. 2013) were developed and tested with case-study data from the New York/New Jersey port region.

In this paper, for the context of *green initiatives* where qualitative data are more readily available, we consider the traditional, qualitative strategic management concept of core competency. The focus is on sustainability practices undertaken by terminal operators, inside their facilities. Instead of considering regional initiatives, attention is provided to individual "green" initiatives adopted by terminal operators. A framework to develop competitive advantage, through the proper adoption of sustainability initiatives, is provided. Keeping in mind the triple bottom line approach (profit, people, and planet) (Slaper and Hall 2011), energy and emission reduction practices are analyzed and then structured into a broader strategic framework. We expect practicing managers at marine terminals, maritime stakeholders, and companies involved in strategizing sustainability initiatives to gain insights from this qualitative framework. Before we delve into the framework, we discuss some of the past relevant work.

LITERATURE REVIEW

According to Climate KIC (Climate KIC 2014), most of the emissions in ports are generated at container terminals. Due to the cranes' fluctuating demand and supply for energy, abnormalities or faults (i.e., temporary or momentary abnormalities or faults that quickly disappear when power is disconnected and restored in a short duration of time) are common, which makes its power management difficult and complex. Due to smog produced from crane operation, diesel exhaust emissions from ships, railroads, trucks, and other cargo handling equipment at the terminal, an increased level of air pollutants are found in and around the ports.

In the last decade, considerable attention has been given to the issue of climate change and global warming. There is an increasing pressure in the transportation industry to devise and implement environment-friendly strategies for global freight movement. A myriad of approaches have been developed through research-driven studies, technological advances, and innovative activities to limit energy consumption and carbon emission in maritime transportation.

Environmental impact of freight shipping on our lives as well as our planet is studied by Bailey and Solomon (2004). Their study on mitigation strategies suggested a range from low cost methods (such as, restriction on truck idling) to systems requiring more significant investments (such as, cold ironing and alternative fuels). Cold ironing is another name for providing shore-side electrical power to ships. This requires installation of an expensive electrical grid/sub-station at the terminal and cable-laying. The advantage of cold ironing is that it reduces the consumption of fuel for vessels while in port, and eliminates the associated air and noise pollution. In a similar effort, Eyring (2010) assessed the contribution of gaseous and particulate emissions from oceangoing ships to anthropogenic emissions (i.e., emissions resulting from human activities, which includes burning of fossil fuels for energy, deforestation, and land-use changes that result in net increase in emissions) and air quality.

Michaelowa and Krause (2000) studied trends in international maritime transport and provided policies/measures to reduce emissions in a cost-efficient way. Psaraftis and Kontovas (2010) illustrated three ways to reduce maritime greenhouse-gas (GHG) emissions: (a) technical methods such as adoption of efficient ship hulls, energy-saving engines, more efficient propulsion, alternative fuels, cold ironing in ports, and sails to reduce power requirements; (b) market-based instruments such as emissions trading and carbon levy schemes; and (c) operational strategies like speed optimization, optimized routing, improved fleet planning, and other logistics-based measures. Morais and Lord (2006), in their review of programs and strategies at North American ports, found that automation technologies, extended gate hours, and reservation appointment systems can be effective in reducing the overall truck idling time at terminals and limiting GHG emissions associated with terminal drayage activities. However, contrary to this study, another study (Giuliano and O'Brien 2007) that evaluated the outcomes of the legislation permitting terminals to adopt either gate appointments or off-peak operating hours as a means of reducing truck queues at gates, found no evidence of reduced queuing or transaction times.

A Canadian study emphasized implementing Internet-based cargo information systems (advanced freight scheduling appointment and container tracking) to improve terminal productivity and reduce congestion/pollution inside the terminals (Transport Canada 2006). A study by Lun (2011) found that container terminal operators can improve their throughput and profitability and have an efficient and cost-effective operation if they adopt green management practices (GMP). It suggested that GMP consists of: (1) cooperation with supply chain partners, (2) environmentally friendly operations, and (3) internal management support. Sisson (2012) described the concept of "zero emission" terminals and gave three basic rules for reducing gas emissions: 1) do everything possible with electric power, 2) generate as much renewable power on site as possible, and 3) make the terminal as efficient as possible.

The study by Rijsenbrij and Wieschemann (2011) emphasized the fact that the future will bring increasing demand for sustainable designs in port handling facilities. Terminal operators looking for cost reductions may look into the design of terminal (stack) handling systems. It presented a design approach and directives for stacking systems and connected transportation systems in container terminals. Leonardi and Browne (2010) calculated the carbon footprint of more than 25 international maritime supply chains and identified main shipping characteristics. They found that by changing vessel type and its routing, a 20% reduction in energy use can be achieved. Network analysis models to explore tradeoffs among alternative route selection across different modal combinations and to identify optimal routes for minimizing carbon emissions are presented (Winebrake et al. 2008). In an interesting study, the high service speed of ships was found as a significant reason behind increased air pollution (Kontovas and Psaraftis 2011). To further reduce energy use and maritime emissions, a study recommended constructing compact terminals to transfer stacks directly at the quayside and replacing diesel-powered terminal equipment by a hybrid or all-electric energy source (Geerlings and Duin 2011).

In summary, various studies have examined the impact of maritime shipping on society and the environment and have proposed different ways for mitigating its negative environmental effects - whether it is by ship re-routing or redesigning, modification of terminal layouts, improvement in vessels' operational characteristics, or assessment of terminal-equipment's emission reduction strategies.

At the local/government level, zoning is one of the widely used methods to control the physical development of land. Countries such as the United States and Canada have requested the International Maritime Organization (IMO) to designate their coastal regions as areas where oceangoing ships would face strict controls on emissions of sulfur, particulate matter like soot, and other pollutants that endanger human health. According to the new rules in California, roughly 2,000 oceangoing vessels that enter California ports each year must switch to fuel with lower sulfur content before coming within 24 nautical miles of the state's coast (Los Angeles Times 2009). Similarly, European Union legislation established a set of rules that target reducing sulphur oxide emissions from maritime transport (Miola et al. 2011).

On the private initiatives and innovations stance for greener maritime transportation, there has been tremendous growth. Companies around the world are developing new ways to lower fuel consumption and air pollution. In one example, SkySails, a German company, has put large towing kites on oceangoing vessels to take advantage of ocean winds thereby reducing the fuel requirement and its associated pollution. Experiments show that towing kites can help reduce emissions by up to 35% annually (Environmental Leader 2010). Figure 1(A) shows the system components of SkySails, which primarily consists of a large Flexifoil kite, an electronic control system, and an automatic system for the kite's retraction.

From wind to harnessing solar power, a Japan-based company, Eco Marine Power, is developing a way to use both solar and wind energy for powering tankers, cargo ships, and other seafaring vessels (Eco Marine Power 2014). It uses solar panels as rigid sails [shown in Figure 1(B)] that harness the energy from renewable sources to propel the ship. This innovation has been shown to reduce the amount of fuel consumption and emission of harmful gases. Use of solar power for powering boats is also under development and enhancement by a German company named PlanetSolar (PlanetSolar.org). In May 2012, PlanetSolar became the first ever solar electric vehicle to circumnavigate the globe. Figure 1(C) shows the solar-powered boat, which is covered by 537square miles of solar panels that connect to one of the two electric motors in each hull. In a separate effort, solar power to transport large volumes of liquid has been developed by Australian company, Solarsailor, in its vessel called "Aquatanker" (SolarSailor.com). Figure 1(D) shows the Aquatanker with its 30-meter long sails, decked in photovoltaic panels, controlled automatically by a computer to angle the sails for maximum wind and solar efficiency. They are found to catch enough wind to reduce fuel costs by as much as 20% to 40% (SolarSailor.com).

In a completely new and innovative way of propelling ships, a Japanese sailor and environmentalist developed and sailed a wave-powered catamaran. His journey to date is the longest known voyage by a manned wave-powered boat (WavePropulsion.com). Figure 1(E) shows the system components of a wave-powered catamaran. Its propulsion is generated by two horizontal fins mounted beneath the bow of the ship. Incoming waves cause these fins to move up and down, producing dolphin-like kicks of thrust, which drives the ship forward.

Ireland-based B9 Shipping Company is working toward designing the world's first 100% fossil fuel-free cargo sailing ships. Figure 1(F) shows the futuristic wind powered cargo ship that employs a Dyna-rig sail propulsion system combined with an off-the-shelf Rolls-Royce engine powered by liquid bio-methane derived from municipal waste (B9 Shipping 2012). While these approaches are yet to be tested for actual freight transportation, yet they do indicate promising, sustainability-driven future trends in the maritime industry.

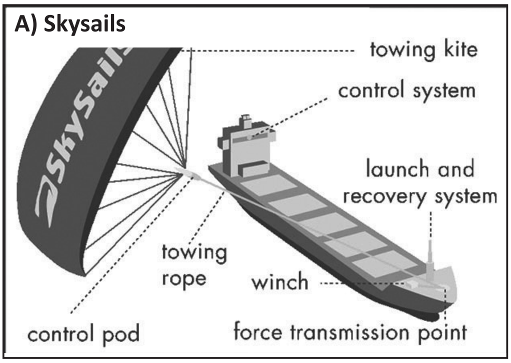
In many study initiatives and innovations described above, green initiatives are largely looked at in light of compliance and their accompanying tactical benefits. Sustainability is seldom seen as a competitive differentiator and is built as part of terminal operator's business strategy. In this paper, using established core competency framework, we provide a mechanism for coalescing sustainability initiatives of terminal operators in both short-term gains and long-term advantage. Past academic work has researched different techniques to reduce emissions but none has looked at it from a strategic viewpoint for building competency. To the best of the authors' knowledge, no other study or model has been proposed that builds a long-term competency for terminal operators by utilizing a combination of green/sustainable initiatives.

Core competency is defined next.

CORE COMPETENCY

C. K. Prahalad and Gary Hamel (Prahalad and Hamel 1990) defined core competency as a central practice of combining a company's resources and skills to distinguish them from others in the market. It is said that even though a core competency can take various forms, it must fulfill three key criteria: (1) be difficult for competitors to imitate, (2) can be adopted across functional units/markets, and (3) provide value to the customer.

Figure 1: Green Innovations in Maritime



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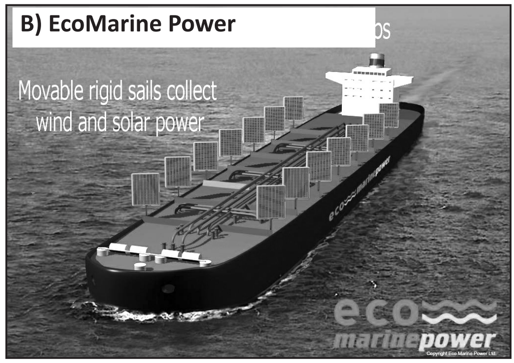

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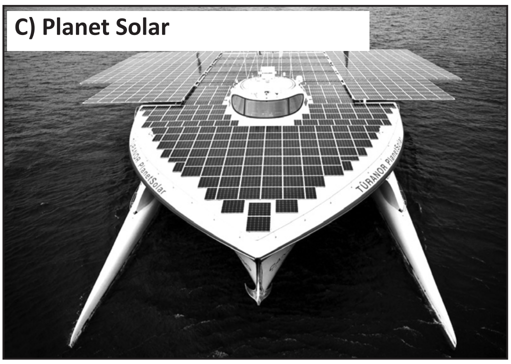

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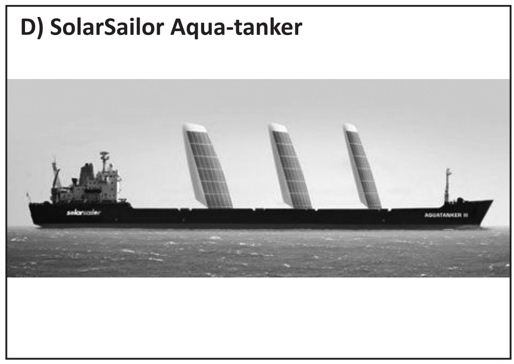
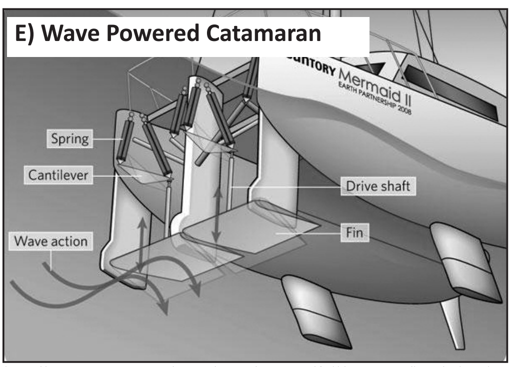


http://www.treehugger.com/solar-technology/solar-sailor-sun-sails-to-be-fitted-to-chinese-cargo-ships.html



http://www.nature.com/news/2008/080820/full/454924a/box/3.html

http://www.cleanechnica.com/2012/06/22/b9-cargo-ship-uses-no-fossil-fuel-only-sails/

Past research has shown that competencies can typically be grouped under three basic types: technological know-how, reliable processes, and close relationships with external parties (Mascarenhas et al. 1998). Technological know-how represents using machines, equipment, software/tools and materials for gaining competency. Reliable processes indicate constructing a practice that may remain with the company for a long time. It is a methodology that is dependable, consistent, and time-tested. Lastly, strategies that are relationship focused and may build strong and trustworthy relationships between different industry stakeholders can develop a strategic competency.

We now examine and discuss some of the best known initiatives for energy and emission reduction in marine terminals worldwide. Consistent with core-competency literature, these practices are later classified as` technology-centric, process-centric and relationship-centric.

Transforming Green Initiatives to Strategic Competencies in Sustainability

Utilizing a recent report by Drewry Shipping Consultants (Drewry Research and Advisory Organization 2012), the top-five global terminal operators are identified (Table 1). The five terminal operators - Port of Singapore Authority (PSA), Hutchison Port Holdings (HPH), A.P. Moller (APM), Dubai Ports World (DPW) and China Ocean Shipping Company (COSCO) account for 29% of the world's throughput (by equity). Attention is given to only the top five operators, in the expectation they will provide a spectrum of initiatives, ranging from small to large/complex ideas. Smaller operators often tend to involve only a subset of possible initiatives.

Table 1: Top Ten Global/International Terminal Operators' Equity Based Throughput, 2012

Ranking	Operator	Million TEU	% share of world throughput
1	PSA International	50.9	8.2%
2	Hutchison Port Holdings	44.8	7.2%
3	APM Terminals	33.7	5.4%
4	DP World	33.4	5.4%
5	COSCO Group	17.0	2.7%
6	Terminal Investment Limited (TIL)	13.5	2.2%
7	China Shipping Terminal Development	8.6	1.4%
8	Hanjin	7.8	1.3%
9	Evergreen	7.5	1.2%
10	Eurogate	6.5	1.0%

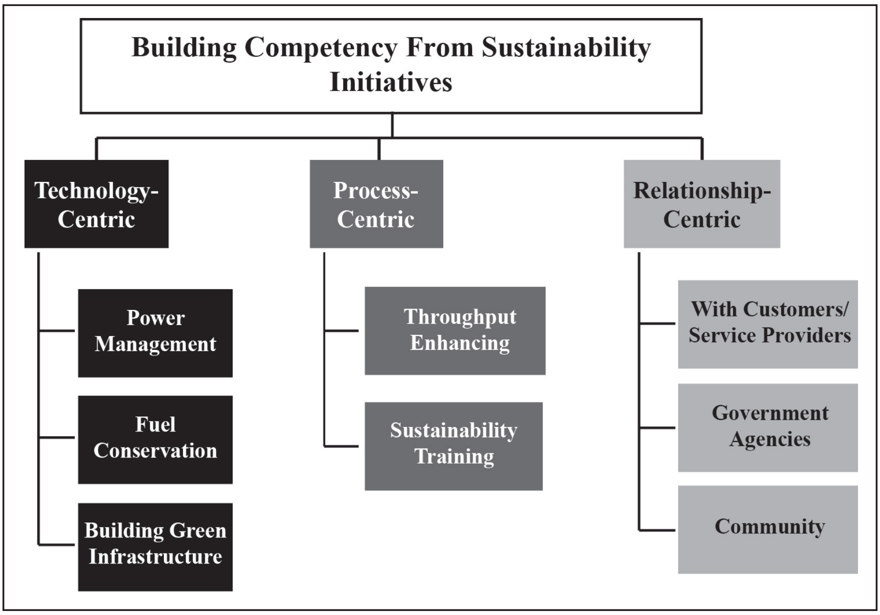
Source: Drewry Maritime Research, http://www.drewry.co.uk/news.php?id=232

To perform the study, the following approach is adopted:

- Using existing literature, trade reports, news articles and terminal operator's website, prepare an exhaustive list of green initiatives undertaken globally by top terminal operators. We believe that global initiatives can provide a useful benchmark and encourage adoption/testing of these initiatives in other locations where they are not currently being used. We caution the reader that an absence of a terminal operator's name or example from a specific country vis-à-vis a particular initiative, does not necessarily imply they are not pursuing it; it merely shows that we could not confirm it through publicly available sources. To keep track of initiatives by operator(s), a three-letter code is appended (i.e., PSA, HPH, APM, DPW, and COSCO). Our compiled list with its references is available at: https://sites.google.com/site/ukierinexgift/project-definition/paper-submissions (Mittal et al. 2014).
- Consistent with the core competency literature, classify all green initiatives into three broad categories: technology-centric, process-centric, and relationship-centric.
- Within each broad category, aggregate the initiatives (iteratively) into logical *strategic competency* groupings. In doing so, care is taken to ensure that these competencies *have potential* to (a) be deployed across location/markets, (b) add value to customer, and (c) not be easily imitated by competitors. Figure 2 presents the complete categorization.

We next explain these categories of green initiatives adopted by global terminal operators.

Figure 2: Categorizing Sustainability Initiatives



Technology-Centric Competencies (TCs)

Initiatives adopting novel and smart technologies fall into this category. It includes installation of state-of-the-art machines, embracing cutting-edge tools/techniques, and using alternate sources of energy to prevent or reduce carbon emissions. TCs are relatively easy and quick to implement. They deliver faster visible returns. However, their ease and quickness in deployment make them easily replicable by competitors. Later, we will discuss mitigating factors that can help elevate TCs to be core competencies. The three TCs uncovered here were:

Power Management Technologies. Initiatives that focus on deploying technologies to reduce/moderate the energy consumption in a terminal. They result in lowering of electricity bills, which leads to reduction in operator's operational costs. Customers accrue benefit from increased efficiency and cost savings due to the deployment of these technologies. While it's possible that these savings may not be directly passed onto the customer in monetary terms, reduced emissions and greener operations provide an improved customer service experience. Indeed, today's shippers and freight-forwarding companies increasingly aim to reduce their freight supply chain carbon footprint (U.S. EPA Webpage). They need to improve environmental performance and reduce carbon emissions throughout their supply chains. Given that marine terminals are one of shippers' key supply-chain links, reduction in carbon emissions at terminals becomes an imperative customer service priority for terminal operators. Additionally, port personnel and neighboring communities experience an increase in wellness and quality-of-life through adoption of such initiatives.

Power management initiatives are, for the most part, easy, quick and inexpensive to implement. They are generally deployable across locations/facilities and not difficult for the competitors to imitate. Examples include:

- Installation of voltage optimization units to systematically control the equipment's voltage input. For example, DPW terminals installed PowerSines ComEC voltage optimisation system in its units that supplied power to its refrigerated and frozen containers to extend equipment's life, reduce energy consumption and waste, and lower emissions [DPW].

- Use of lower-watt flood lights on lighting towers and switching-off terminal lights during operations downtime to help save energy and costs [HPH].
- Replacement of fluorescent lamps with LEDs, use of motion-sensor lights, and employing precision cut lenses (Prismalence) to help reduce lighting energy consumption while maintaining illumination/visibility [PSA, DPW].

Fuel Conservation Technologies. These are initiatives that focus on deploying technologies to improve fuel economy, increase power, lower emissions, and reduce maintenance downtime for the terminal operator. Ensuing benefits translate to increased customer value via improved speed, reliability, and reduced cost. Fuel conservation technologies are easy and quick but can sometimes be expensive to implement. They can be imitated especially if competitor is willing and able to commit resources. Some examples are:

- Installation of electrified Rubber Tired Gantry (RTG) cranes or eco-RTG cranes to reduce the amount of diesel fuel needed, resulting in lower emissions. These cranes require shorter maintenance intervals and fewer stoppages for refueling, resulting in shorter downtime and cost reduction [PSA, APM, DPW, HPH].
- Vehicles used in ports or yards that move and stack freight containers are called drive straddle carriers. Replacement of these mechanical drive straddle carriers with hybrid diesel-electric drive machines that consume approximately 20% less fuel and emit carbon up to 90% less than the conventional mechanical drive, diesel-only machines [APM, DPW, HPH].
- Installation of variable speed drives (that provide soft-start capabilities and decrease electrical stress and line voltage sags associated with full voltage motor start-ups) in RTG and quay cranes to regulate speed and torque of equipment, resulting in reduced fuel consumption and pollution and lowered operating costs [PSA, HPH, APM, COSCO].

Green Infrastructure Technologies. Technology-driven initiatives that aim to build green infrastructure such as eco-friendly buildings, electrical sub-stations, and windmills in the port terminal. Their objective is to reduce air emissions and help the company build its positive image among its employees, customers, government agencies, the broader community, and society at large. These technologies, while ubiquitous, can be costly to implement. Nevertheless they offer long-term, sustained benefits due to cost savings from reduced energy consumption, lower maintenance costs, tax credits from the government, and increased health of the employees. If proven reliable and financially viable, they can be adopted across facilities/locations of the organization. The chief barrier to imitation for these is the capital investment required. Some examples of green infrastructure technology are:

- Enabling shore-side powering (cold ironing) for berthed vessels. Terminal operators adopt the technology because of its long-term benefits on human health, marine wildlife, and the eco-system around the port facility. Regulatory requirements, pressure from environmentalists, and community groups play a significant role in the adoption of cold ironing. On June 21, 2004, the Port of Los Angeles and China Shipping Container Line announced the grand opening of the West Basin Container Terminal, the first container terminal in the world to use Alternative Maritime Power. Beginning Jan. 1, 2014, California mandated that at least half of all container ships run on shore-side electricity at berth (Port of Long Beach Website).
- Constructing buildings that allow use of natural day lighting. For example, PSA Singapore uses the Sola-tube day lighting system, which captures daylight by redirecting low-angle sunlight and rejecting overpowering midday sunlight for consistent lighting throughout the day [PSA].
- Constructing windmill farms at the terminal to power terminal activities. For example, APM terminal operates a €12.5 million power distribution network at the Rotterdam container terminal with electricity generated solely by wind power [APM].

- Deploying automated guided vehicles (AGV) for transporting containers between the harbor quay and the storage area. AGVs require laying sensors, wires, and tapes on the floor to control unmanned machines in the terminal area. The AGVs help increase efficiency and reduce material handling costs. The first automated terminal in the U.S., an APM Terminal in Portsmouth, Virginia, is still the most automated facility in this country [APM, PSA].
- Installing solar panels on roofs of terminal buildings to power water heaters, and traffic lights and charging RTG crane batteries to reduce energy consumption and emissions [PSA, HPH, APM, DPW, COSCO].
- Using ultra-low sulfur diesel (ULSD, which is 97% cleaner than the standard diesel fuel) for all cargo carrying equipment in the terminals [PSA, HPH].

Process-centric Competencies (PCs)

Initiatives that improve existing or develop new innovative practices fall in this category. It includes modifying, upgrading, and schooling procedures and methodologies for lowering emissions in the terminal. Due to inherent difficulty in changing and modifying processes, PCs are more difficult to implement than TCs. Implementation of PCs across units/locations is generally more complex as they need to be adapted to the idiosyncratic environment of a unit/location. Due to these complexities, PCs are difficult to imitate by the competitors. The PCs uncovered by our analysis are:

Throughput Enhancing Processes. Refer to improving practices that increase terminal productivity. These initiatives include developing coordination among activities, managing traffic, optimizing routing, improving layout, and allocating appropriate resources to increase terminal's throughput and reduce its waste, costs, and emissions. Through these initiatives, customers experience dual benefits of improved service and reduced costs. Throughput enhancing initiatives require time, commitment, and diligence. Once successfully implemented, they can be adopted across the operator's different facilities. Imitation by competitors is not straightforward since it requires time, effort, and dedication to develop and implement these practices. Some examples are:

- Coordinating and streamlining berthing, ship planning, yard planning, resource allocation and gate operations at the terminal to improve productivity, efficiency, and overall serviceability. For example, PSA terminal operator in Singapore adopted a Computer Integrated Terminal Operations System (CITOS) to manage their equipment and people seamlessly, flexibly, and in real time [PSA].
- Continuously monitoring the number and movement of trucks in the terminal to help relieve congestion and minimize truck turnaround time. For example, terminal operators deploy advance booking systems such as Truck Appointment Management System (TAMS) to help avoid unnecessary/delayed visits [PSA, APM]. DPW implemented Optical Character Recognition (OCR) technique to enable faster gate-ins for the truckers [DPW]. They install truck positioning systems under the Gantry cranes to reduce container transfer time between the crane and the truck when being off-loaded from the ships [DPW].
- Creating dedicated storage areas for empty containers or modifying yard layout to maximize terminal's space utilization [PSA, APM].
- Determining optimal routes and dispatches for transporters, such as straddle carriers and terminal tractors, to help lower labor, fuel, and maintenance costs and emissions at the terminal and thereby increase terminal's productivity [DPW].
- Employing Automated Guided Vehicles for material handling that utilizes lasers to transport containers between the quay and container yard efficiently and reliably, without any human driver [PSA].
- Utilizing non-road intermodal transportation at the terminal for speedy transfer of containers from the facility. Launching barge-rail links between the port terminals and neighboring cities

helps reduce truck traffic, increases speed of container transfer, and lowers emissions [PSA, APM, DPW].

Sustainability Training Processes. These initiatives created a workforce that is well trained in eco-friendly practices. It involves educating, motivating, and training employees in methods of maintaining/enhancing the quality of air, land, and water environment at the workplace**.** These initiatives require planning, effort, and commitment. Transition pains and lack of reliability during the pilot phase can pose further challenges to terminal operators. Once pilot successes have been firmly established, these initiatives can be deployed across the operator's different functions, facilities and locations. Imitation by competitors is difficult as it requires a shift in mind-set coupled with determination and dedication. Some examples are:

- Training crane operators to operate machines/equipment in a way that reduces waste and improves operational efficiency of the equipment [DPW, PSA, HPH].
- Training employees by various operations-based, technical, IT, and managerial courses to enhance and deepen their knowledge of the equipment and operations [PSA].
- Training support staff by organizing programs such as Basic Education for Skills Training (BEST), Worker Improvement through Secondary Education (WISE), and Critical Enabling Skills Training (CREST) to increase their productivity [PSA].
- Educating staff by providing company's sustainability report and environment-related information via portal website and WLAN to make them aware of best practices, policies, guidelines, and company's performance on carbon reduction strategies [COSCO].
- Institutionalizing and incentivizing policies and measures to develop a sustainable environment in the facility. Some terminal operators establish practices that promote eco-friendly mindset among employees, encouraging them to recycle and conserve resources to help create a greener environment [PSA, HPH].

Relationship-centric Competencies (RCs)

These initiatives involve forging relationships that may help port terminal operators function more effectively and efficiently. RCs tend to be the most complex, requiring significant deployment time and effort. Returns are rarely immediate. However, once an organization builds a reputation and capability to forge such relationships, these can be leveraged across locations. Due to the above mentioned reasons, RCs are difficult for competitors to imitate. Based on our research, the following RCs were found:

With Customers/Service Providers. This involves initiatives that develop and deepen partnerships between the terminal operator and its customers, such as railroad companies, shipping lines, and container freight service providers. A strong relationship helps in streamlining the activities, prevent delays, minimize points of conflict, and increase work productivity while keeping the environment green. These partnership initiatives take time to develop and yield returns. Some examples are:

- DPW and Etihad rail collaborated to develop an intermodal rail terminal in Jebel Ali Port to enable a highly efficient and eco-friendly way to transfer containerized freight arriving at the port. This brought substantial benefits to the involved stakeholders, and the UAE economy as a whole [DPW].
- PSA Antwerp and Naviland Cargo collaborated to increase the terminal's hinterland rail connectivity, which resulted in improved quality of operations and increased satisfaction among customers [PSA].
- APM Terminal in Gothenburg developed a rail system called "Railport Scandinavia" to collaborate with inland dry-harbors to help customers drop off and collect their containers

locally. This helped streamline operations, aggregate in-and-out-bound shipping, use greener mode of transportation, and improve throughput and reliability [APM].

With Government Agencies. These initiatives built relationships between the governing agencies/port authority and the terminal operator. A strong relationship with these agencies builds public image, improves success of future ventures, and transforms a (traditionally) adversarial relationship to one of trust and cooperation. Such initiatives take time to develop and are forged by an attitude of focusing on shared benefits. Some examples include:

- Incheon Port Authority (IPA) and PSA International (PSA) shared information and ideas in the area of port operations, technology, and best practices, gaining better understanding and unveiling opportunities for port development in the Incheon area [PSA].
- APM Terminal in Jamaica built a unique collaboration with U.S. Customs to help expedite the cargo inspection process, which benefited Jamaican exporters by increasing their sales, serviceability, and revenues [APM].

Community Alliances. This involved initiatives that connected the terminal operator with its surrounding community to develop a sustainable and thriving environment. By nature, these alliances require mutual trust and time to develop. However, through its actions, once a company develops a reputation of being community-oriented, this competency can be deployed more easily at other locations; other communities then become likely to trust a time-tested organization with a strong culture of developing community alliances. These initiatives are difficult for a competitor to imitate since it requires well-documented historical results. Some examples are:

- Creation of natural environment by planting trees in the terminal area. For example, one of HPH ports planted 34,000 mangroves to offset the construction of a terminal expansion. In another instance, APM Terminals in Virginia, USA, set aside over 150 acres of undeveloped forest and wetlands. They recreated 27 acres of wetlands by planting nearly 200,000 wetland plants.
- Building relationships with the local community. PSA in Singapore set up a $16 million endowment fund to award bond-free scholarships to Singapore citizens. These scholarships aim to provide the lower-income families with financial assistance to attain formal qualifications and/or technical skills [PSA].
- Deploying high-efficiency air and diesel filters in port equipment to clean up emissions from older, dirtier diesel engines, which may demonstrate their commitment to clean air for the community [HPH, APM].
- Organizing community outreach through environmental protection activities such as Earth hour, recycling programs, painting competitions, scholarships, and green essay competitions [HPH].

Key Insights from the Core Competency Qualitative Framework

From the above list of initiatives, we can infer that terminal operators participate in sustainability through a range of initiatives. Beginning with tree plantation within their terminals, to applying the latest fuel-saving technologies in equipment, lighting, and buildings, improving traffic flow within the terminal, educating staff, and organizing green awareness programs are undertaken. Strategic benefits of these green initiatives for terminal operators are improved energy use, reduced air emissions and pollution, better human health, reduction in functional and operational costs, and an ability to promote the company's image as green by becoming environment-friendly. Sustainability initiatives can provide companies/facility-operators a competitive advantage (over competitors) with lowered operational costs, increased productivity, and better pricing/service for its customers.

The issue is that terminal operators often look at green initiatives as only initiatives without positioning them strategically. They venture into sustainability initiatives in an *ad hoc* fashion.

These initiatives are often undertaken with an ROI mindset and rarely looked at in a strategic way as a source of competitive advantage. Indeed, tremendous opportunity is lost by attending to narrow and short-term goals. Terminal operators are better served by not having a unidimensional focus on Return-on-Investment (ROI), as it can cloud their ability to look at strategic benefits of an investment. Indeed, initial cost of investment should not be viewed as a deterrent in situations where it positions the organization to gain long-term competitive advantage that can yield rich dividends in new market entry, brand recognition, relationship with government agencies, and capturing market share.

Through our analysis, we find that it is important for terminal operators to view similar initiatives cumulatively. Aggregation of (a group of) similar initiatives into (a small number of) competencies enables operators to gain clarity on prioritizing investments and measuring strategic benefits. We recommend this as an important step for all terminal operators.

Historically, sustainability initiatives across industries have been driven by technological advances. Due to this, a technology-biased mindset for sustainability is often developed. Not surprisingly, terminal operators, too, seem to reflect this prevalent technology-driven sustainability paradigm. However, by utilizing the existing literature on core competencies, we show that a portfolio of sustainability competencies that encompass technology, processes, and relationships are better positioned to offer long-term strategic competitive advantage than simply focusing on technology-centric competencies alone.

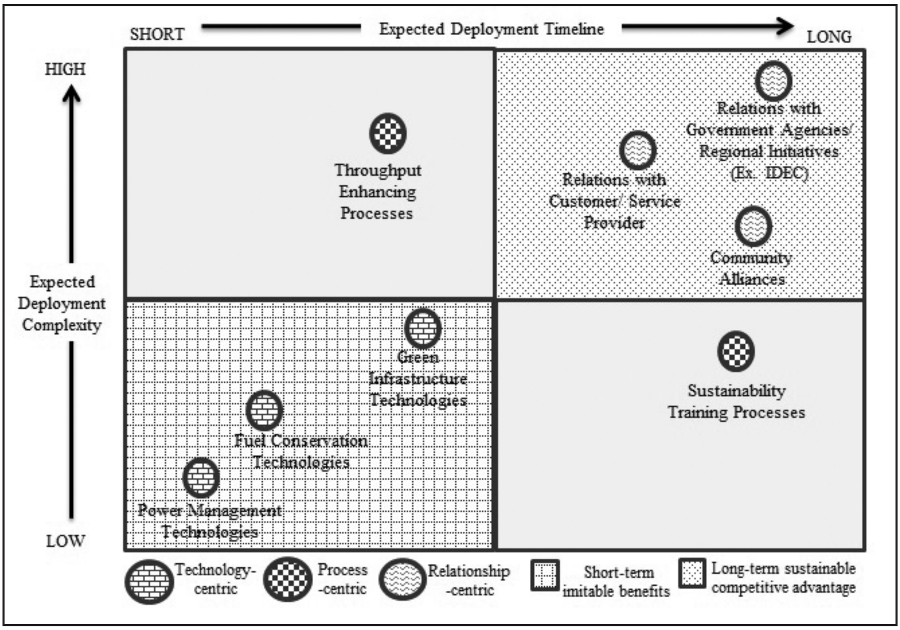
Technology-centric competencies (power, fuel, and green) are relatively less difficult to deploy and helps organizations receive positive reinforcement by yielding quick returns. Due to this ease in deployment, they can often be imitated by competitors. Process-centric competencies require more time/commitment. Bringing change in existing practices requires time, willingness, planning, training, communication, and coordination, as well as local cultural awareness. Altering policies and implementing new processes is a complex, delicate, and challenging task, making these more difficult to imitate by competitors. Relationship-centric competencies are the most complex and time consuming to develop. Long-term strategic partnerships with customers, government agencies, and communities build on a history of mutual trust, shared goals, and successes. Typically, competitors have a difficult time imitating such relationships, especially if they lack historical strength in the area of forging partnerships.

To calibrate the imitation difficulty/ease, we plot these competencies on a graph in Figure 3. Y-axis shows the Expected Deployment Complexity and X-axis shows the Expected Deployment Timeline. Expected Deployment Complexity captures the intrinsic difficulty in successfully implementing these competencies.Expected Deployment Timeline refers to the *likely* time it would take for an organization to develop these competencies.

Over time, “softer” competencies improve through organizational learning. For an organization, expertise gained by experience, the “actual deployment time” and “actual deployment complexity,” may reduce vis-à-vis the corresponding expected values. For example, over time, a terminal operator that has spent significant time/resources in training its workforce in the area of sustainability can develop reliable processes in this area.

Synergistic interaction of TCs, PCs, and RCs offer the greatest potential of sustained benefits and competitive advantage to marine terminal operators. It is important that the three categories of competencies should not be looked at in isolation. For example, at a particular marine terminal, fuel-conservation technology (a TC) was installed that automatically switched off crane engines when not in use. Despite the implementation of this technology, in practice, savings were not being realized. Further investigation showed that crane operators, to avoid the inconvenience of switching on engines multiple times, developed a practice of incorporating pseudo moves (such as shaking the joystick) that kept the engine running. Changing this practice required training of crane operators (a PC) to align their behavior with the sustainability mission of the organization. With that training in place, the deployed fuel conservation technology was able to realize its intended goal. Further,

Figure 3: Classification of Green Initiatives on a Core Competency Framework



crane operators started to actively contribute by suggesting new, innovative ideas that advanced the sustainability goals. Similarly, showing a deep commitment to sustainability technology and practices (TCs and PCs), over time builds strong external relationships with customers, government agencies, and community at large (RCs).

A strategic view of sustainability supported with synergistic and diverse types of competencies can enable marine terminal operators to add value to their stakeholders while gaining significant and long-lasting competitive advantage.

CONCLUDING REMARKS

This work utilized available sustainability practices data of various marine terminal operators. With maritime transportation's continued expansion and its consequential environmental impact, immense opportunities exist for improving the sustainability-driven performance of this industry. The key roadblocks to long-term benefits from sustainability initiatives are: (a) short-term thinking, (b) focus on initiatives instead of business strategy, (c) ad hoc adoption of sustainability programs, (d) ignoring multiple stakeholder viewpoints, (e) rigid, irreversible outlook to decision making and (e) lack of judicious use of qualitative and quantitative data. We argue that a rigorous strategic framework can be very useful in addressing the aforementioned shortcomings, thereby improving the longevity and impact of these sustainability programs. This is one of the key contributions of this article.

Another key contribution of this work is in providing a bridge between strategic management and sustainability literatures. We show that core competence is a concept that is closely tied with sustainability because it offers a way for long-term competitive advantage (Javidan 1998). While this work focused on envisioning, developing, deploying, and deepening of sustainability competencies for marine terminal operators, the broad sustainability framework developed can be applied to any industry. Firms involved in developing or strategizing their sustainability practices could benefit from embracing the long-term, competitive-advantage argument formulated in this article.

There are several ways in which this work's contributions and impact can be extended. This work utilized available sustainability practices data of various marine terminal operators. To complement this study, it would be useful to do an in-depth longitudinal study of sustainability practices of leading multinational marine terminal operators. Such a study can help uncover the opportunities and challenges, and help frame structured theories from case studies as suggested in Eisenhardt's seminal research (Eisenhardt 1989).

From the human resource development standpoint, this research offers new areas of investigation in the arena of sustainability. Our work clearly shows that training and development of the workforce, if done strategically, can be a source of competitive advantage for organizations. It would be useful for human resource development scholars to see what practices can yield optimum results under different environmental and cultural factors. Further, it would be valuable to see how practices are transplanted across locations, allowing these competencies to be leveraged across markets.

Organizational behavior scholars may find opportunities to investigate the idea of building trust and relationship among partners around an issue that is truly bigger than them individually. The idea of sustaining the planet can, indeed, allow agencies/organizations to share a common ground where they can forge relationships that look beyond the singular profit-driven focus. Also, given that these relationships can have direct impact on the business strategy of an organization, the importance of this work cannot be overemphasized.

As with leading organizations in any industry, successful terminal operators cannot rely on their past laurels in sustainability to remain leaders in the market. Instead they should innovate, deepen and deploy these competencies in newer communities/geographical locations. The dynamic nature of these competencies needs to be understood and leveraged to ensure continued success (Innovation Excellence 2012). This requires a commitment from top leadership that is supported at all levels of the organization. Further research is needed to envision such a self-sustaining organizational structure that does not view sustainability as a fad or short-term-profit goal but as something that is embedded in the genetic code of the organization.

Finally, this work's greatest impact would be in encouraging organizations, across industries and geographic locations, to diligently and deeply investigate the central thesis of this work – *sustainability as a strategic business driver*. In doing so, deeper and far reaching insights can be gained – now and for generations to come. This promise of synchronizing organizational and societal needs in context of a sustained future on this planet that we inhabit is the sincere hope with which we present this work.

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