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Incorporating Electrical Trucks and Automated Container Stacking System in the ports for sustainable and efficient operations

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Abstract

In our research we discuss the sustainability and efficiency advantages that come from switching from diesel to electrical trucks and the use of the automated container stacking system in the context of a port operation as an integral part of the economy that contributes to the progress of any city. The main objective is to explore the methods that can be applied to ensure the success of these initiatives, cost barriers, pre-requisites and challenges that go with this decision.

In this research our findings demonstrate that switching to electrical trucks instead of diesel significantly reduces the level of emissions, lowers pollution levels, reduces long term operation costs. The switch to electrical trucks is feasible as there are companies that are producing heavy duty electrical trucks such as the Volvo. Those trucks will be sold mass produced by 2022. Moreover, we find that the total cost of operation for an electrical truck becomes less when compared to a regular truck, when the truck is autonomous, and the energy used to generate those trucks is used from the company (DP World). DP World already has 3 major solar projects in place. Moreover, the incentives to make the switch into electrical trucks is also due to the increased regulation from the IMO (International Maritime Organization) that is pushing industries towards using cleaner fuels. On that note, cleaner fuels will be facing major shortages in compliant fuels (Stinson, 2019). Therefore, it makes more sense for maritime industries and DP World to consider making the switch to electrical vehicles, as not only does it protect the environment but also reduces the safety risks associated with driving trucks in the port. A study conducted by Jakarta port demonstrated that traffic accidents in the port make up around 37% of all accidents in the port, almost 50 accidents out of 117 accidents are all truck related. Switching to autonomous electrical vehicle eliminates the human error in such accidents especially if the truck follows a preguided route. The ACSS will increase the efficiency the port by transforming the traditional methods of container handling to an automated safer option, where instead of reshuffling all the containers to reach a specific one, the ACSS concept is basically like a vending machine for the containers. Moreover, the idea of Automated Containers Stacking System (ACSS) this idea involves stacking multiple levels of containers (up to 11 as against conventional yard of 4 to 6) in metal framework that greatly reduces the area of land needed (especially where land is at a premium) and since this is a crane operated cube, eliminates the limitations of traditional reach-stackers that are limited to handling a maximum of 4 to 5 boxes high stacks. The ACSS concept is materializing in BOX BAY, this demo is being built in Jebal Ali terminal 4 and if it proves to be successful can be patented to DP World. The structure of Box Bay is installed with solar panels that can generate solar energy to be used in port operations. Therefore, by applying such initiatives such switching from diesel to electrical, using clean energy to meet the energy requirements of those electrical vehicles and incorporating the ACSS will have a massive influence on the operations of the ports. By applying technology in useful and innovative ways it can truly add value to the port while also protecting the environment due to the reduced emissions levels, using cleaner energy sources and creating efficient operational processes. These ideas if applied can be a major steppingstone for the port to transform itself into a smart and efficient hub.

1. Statement of the Problem

Adopt, Adapt and Innovate – an integrated approach to energy efficiency in Port Industry using renewable energy and technology in trucking and container stacking.

Sea trade was the main sources of income within the region before finding oil during the 1970s in UAE, unique location and inexpensive oil have led to a massive spurt in growth and ports have played key role in this development. Globally ports aim to be efficient in handling goods with the minimum cost and use of resources while maintaining a high standard services and efficient operations. Our research shines a light on innovative solutions that can enhance the current operations.

Port industry accounts for **3% of the global greenhouse emissions**, this traditional industry engages trucks on a large scale to handle, lift and move and transport containers resulting in a lot of emissions and pollution to the ecosystem. Also, conventional methods of manual stacking is inefficient and requires additional expensive specialized equipment, energy consumption, delays, accidents and additional costs.

Within the port yard, there is an intense use of vehicles such as IVTs, Cranes, Reach Stackers and other heavy equipment to handle the millions of containers that are pass though the ports. These equipment not only consume huge amounts of fossil fuels, but also contribute to environmental pollution.

Our research involves studying the opportunities and the possibilities of **switching to electrical trucking and applying the automated container stacking system (ACSS) as a means to lower the impact on environment.**

While nothing really prevents the use of conventional methods, this approach is part of collective social responsibility while considering the financial cost effectiveness. and operational efficiencies.

The main problem is the emissions and the pollution produced by the diesel trucks and the lack of long-term durability of the trucks during its life cycle, safety issues related to diesel trucks demonstrating the benefits of switching to electrical trucks. Moreover, we research the possibility of replacing the traditional stacking method with an innovative method of stacking using the ACSS which will improve the stacking method to stack higher there by creating more capacity in smaller area and a very efficient method of arranging containers.

Successful implementation can pave the way for wider applications especially within the logistics sector that is intricately woven together within the port industry.

2. Background of the Problem

While studying city sciences sustainability course, the idea for this project was formulated for our final project and it involved addressing an existing problem with a solution that can add value to our work.

We are employed in DP World which is a leading global port operator and trade enabler, while one of us works in Investor Relations and the other in Projects Planning and Management. Both these offers plenty of opportunity to play with innovative ideas with a goal of building a strong bond with investors, shipping lines and a large network of ports all around the world.

This encouraged us to apply what we learned in our field and challenged us to find an area of improvement as port is a crucial part of the economy, thus if a port can be transformed into a smart port, it inspires the other sectors in the city to follow in the same steps.

The ideas we propose are based on the Dubai Ports current operations and these initiatives aim to improve the current efficiencies and the sustainability measures.

The current fleet used in the port are regular diesel trucks and port has been considering and testing out the potential of adding hybrid trucks. Therefore, the possibility of switching to electrical vehicles could be around the corner. This switch can lead to significant strides in terms of reducing our emissions.

For many decades' transportation methods have been growing cleaner and more efficient, while the freight trucks barely moved the needle on sustainability and efficiency.

Diesel trucks are considered to be the workhorses in the manufacturing and delivery industries, they play a huge role, therefore it is essential that they become part of the solution especially that we reached to a day and age where the world has the available technology and the means for investment.

The concept of ACSS is inspired from an idea that has been introduced within the technological industry, the automated car parking system. The concept is basically the car that is stored is easily accessed and is stacked vertically to save space. Similarly, the idea of the ACSS was conceptualized.

3. Project Definition and Goals

Switching from the traditional diesel trucks to electrical will reduce the environmental impact caused by emissions from the trucking. DP World operates more than **65 marine terminals** across six continents, if this can be successfully applied it can **create a domino effect** where the other ports follow similarly. The project is aimed at creating sustainable and efficient solutions for current problems at the port. The electrical trucks use clean energy that is generated from renewable sources at the port will majorly benefit the port and the environment.

The key barrier for such implementation is the already existing vast fleet of diesel trucks. The idea is not to move the trucks from within the yard to outside, but rather, retire them from active service and use alternatives in their place.

Making the switch needs to make commercial as well as operational sense to the ports and to owners of the trucks that run in the port, such as the shipping lines. <u>In this paper we consider incentives that can motivate and influence the shipping lines and the customers to make the shift to electrical trucks.</u>

In addition, the ACSS is a smart solution to store, track and manage containers stacked in the yard of the port in a more efficient, environmental way. An integrated ACSS together with energy efficient vehicles would result in less machines and in the long run, profitable.

The usage of the ACSS will include **less dependency on the manpower** in the site, with ACSS only a truck driver will be needed to locate the container in a specific area and managed through computer applications by an employee at a location **away from the yard**.

The main goals of the ACSS is to reduce the costs by needing less manpower and reduce the use of the machines, such as cranes to remove and install the containers and as the self-addressing system of the boxes is very precise, the time needed is minimal with virtually no clerical errors in identifying a required box.

Using ACSS will also **free up precious yard space** that can be used for other facilities or even handle a bigger capacity of business. It will also provide us with quality reporting and operational data feedbacks that will gain the trust of current and possible customers.

4. Literature Review

According to the chairman of the Chennai port Atulya Misra (2017), port industry is responsible for 3% of the global greenhouse emissions. Other ports that have initiated the switch to electrical vehicles: Morley (2019) announced that the port of New York and New Jersey have already received a **five million dollar grant** to start using electrical tractors at the yard, these ports have stated that among their main priorities is to reduce pollution while implementing low energy operations in their processes.

The importance of using clean energy to power the electrical trucks:

Medium (2018) conducted a study that showcased that trucks alone are accountable for 41% of the total greenhouse gas emissions. Other advantages as deduced by Hanley (2017), electric trucks means less noise pollution.

Hanley (2017), quotes the vice president of Volvo Edward Jobson who vouches for the use of electrical trucks, Jobson advocates for the regenerative braking efficiency that is in electrical trucks. Jobson suggests that altering the brake energy recuperation and applying more efficient auxiliary drives will lead electrical trucks used for trash collection to increase its efficiency rates up to 80%, as opposed to diesel trucks that reach an average efficiency of 20%. Hanley (2017) discusses the potential for electrical trucks to be energy storage units, as suggested by the CEO of a high technology business Zap&Go Stephan Voller suggests that if a fleet of a hundred electricals trucks, each tuck can hold 1 Megawatt of energy, that is 100 Megawatt of stored energy that would be available.

The types of renewable energy that can be used:

Solar and tidal energy can be used due to the standard sunny weather in Dubai and tidal energy can be used due to the proximity of the sea at the ports.

Research has also been done by Port Technology (2011) to show how solar energy can be used at the ports. Port technology (2017) emphasize the importance of generating renewable energy on the site can significantly reduce pollution and the terminals energy expenses. Port Technology (2017), also mentions the ideas of where the **solar panels** can be installed such as on top of equipment, cranes and warehouses.

Offshore Energy (2015) considered the integration of tidal energy and wave energy to be collected and used efficiently to fulfil the energy requirements at the port. Developers at Offshore Energy (2015) have showcased constructing an energy platform that merges various production sources such as **solar, wind, wave and currents**.

Offshore Energy (2015) showcases the progress at the port of Brest, France which completed assembling a tidal turbine. According Simec Atalntis Energy company (2020), tidal turbines are consistent form of kinetic energy and is easily installed in 45 minutes. This company is already working towards breaking the record to build the world's largest and strongest axis turbine. Simec Atalntis energy has already invested five million pounds in the development of this turbine and is expecting to be selling the turbines to ports.

DP World Melbourne (2020) is already reducing emissions through its port machinery where the machines used to handle the containers such as the straddles is powered by bio-fuel. Incorporations of stricter regulations can be achieved through phases similar to the implementation by Port of Los Angeles (2008).

Where California Environmental Protection Agency (2008) applied the clean air regulation in the port by two phases. The regulation was initiated in 2009, the first phase is that by 2009 all the trucks in the port are required to be equipped by an engine certified to California federal emissions standards with engine models from 1994 to 2007.

The second phase that started in 2013, where all trucks are required to be equipped with models that exceed the 2007 engine model. The next step is comprehending the sources of port emissions. The diesel forum (2020) articulates the different forms of emissions that are created in ports, where the majority of the ports worldwide have a large assortment of diesel-powered equipment not necessarily just trucks. The equipment is primarily used to move freight and offer key services to the port.

A study conducted by the International Energy Agency (IEA), demonstrates the carbon emission from heavy duty vehicle from the year 2000 to 2030. The study tracks data from the G20 countries, which is an international forum that includes 20 countries. The data shows that in 2000 the CO_2 emissions where at 677mt and by 2030 it is expected to reach 1281mt. This means that CO_2 emissions increased by 2.6% yearly due to heavy duty vehicles (Iea, 2020).

Worldwide countries in the G20 are starting to develop stricter policies to apply on heavy duty vehicles to ensure less carbon emissions (Iea, 2020). For instance, Argentina, Brazil. Mexico and South Korea are all going through new stages to apply stricter heavy-duty vehicle standards in place by 2022 (Iea,2020). While in March of 2019, Japan already apprised its fuel efficiency standards for trucks and buses, with a new target to reduce emissions in trucks in japan by 13.4% (Iea,2020).

A word on the nature of emissions being dealt with:

Sources of Port emissions and characteristics of the emissions are important aspects to comprehend when making the transformation to electrical vehicles in the port. Among the main substances encompassed in exhaust emissions are **Carbon Dioxide (CO_2), nitrogen oxide (NO_x) and particulate matter (PM),** these three are attracting severe attention.

CO_2 is considered to be carbonic acid gas that is colorless and odorless. The more the increase of CO_2 in the air the more the risks of global warming. CO_2 is increasing due to the combustion of fossil fuels, while PM is a common term that refers to numerous types of particulate matter emitted by diesel and other engines. Typically, PM consist of soot, fuel particles and sulfates. When PM levels increase it has direct impact on human health, inhaling large amounts of PM can cause respiratory issues and chronic lung disease (Isuzu, 2020).

The difference between regular diesel **and clean diesel** is that the latter is highly refined to enhance combustion efficiency and diminish emissions. The main difference between the two is present in the level of Sulphur in the fuel (AutoBytel,2020).

Using clean diesel can significantly reduce the emissions, it basically refers to a system that includes a modern engine design to reduce the emissions produced by the engine, such equipment requires funding, for example, In the United States the funding from 2008-2015 was around $158 million for the port related emission reduction endeavors (Diesel Technology Forum, 2020). Research conducted by Diesel technology forum verifies that repowering old engines signifies one of the most cost-effective strategies that can be applied to achieve clean air and reduce emissions in the port communities.

The ACSS concept inspired by automated parking system

This was introduced in Paris for the first time in the year 1905 as mentioned by Gautam (2018). The idea was invented in a garage called “Garage Rue de” to avoid the traffic areas and enhance the movements of people and cars. After the introduction of this new idea, many countries got inspired and started to apply it in different parts that required the same facility to be provided. Gautam (2018), also says that this technology soon was facing various setbacks due to the misuse of it where people ended up waiting for long time to get their cars back, and the system was not as flexible or helpful in return.

Moreover, in the 90's the idea was brought back and started trending again with Japan leading on since it was the country that mostly adopted and applied it with an approximate number of 40,000 parking bays and about 1.6 million automated parking, Gautam (2018). Japan understood that it is a necessity to accommodate all the vehicles with a smart solution, so when other countries gave up on the idea Japan kept on developing it in a way to minimize the problems by offering smart solutions.

They started understanding that the reason why other countries stopped this system is due to the time spent for customers to get their vehicle. Japan then started building other systems that replaced the human aspect of the process, when they previously needed a man to assist the movement of the cars in and out of the parking which was not time efficient. They came up with a fully automated process where they linked the automated parking with a system that is linked and instilled in their computers.

Japan did not stop with automated parking for cars, but also involved a smart automated system to park their bicycles where the customer himself can initiate the process with technical object attached to the bicycle wheels which then moves it to the parking area. Japan also took a step further by having underground automated parking's to preserve the maximum space of land for other projects, as we found in article published in Web Japan (2017).

Other benefits to the ACSS:

From the research we noticed that most countries with high density are gravitated to this system for the outcome it gives and serves the social, economic and environmental needs. It increases the quality of living by easing a huge part of the daily routine by the help of other smart technologies like sensors that help you detect the availability of parking spaces beforehand to plan your way accordingly.

Other innovations that are revolutionizing how port operations are handled mainly come from China.

Yangshan, the robotic port:

The Yangshan Deep-Water Port which is an extension referred to as the fourth phase the biggest automated cargo wharf and falls under the category of a deep-water port. It stretched along the coastline by 2,350 meters with an area of 2.23 million square meters. It is the World's Biggest Automated Container Terminal without the need of attendance for 24 hours as mentioned by Hermesauto, 2017. It ranked the first worldwide in handling 40 million TEUs annually with 26 overhead cranes, 130 driverless automatic guided vehicle (AGV) and 120 rail-mounted gantry cranes as mentioned in The Straits Times News (2010).

It relies greatly on AI system to onload and offload which is fully automated intelligent system that collects and sorts all operational instructions from the computer inputs and turns them to the operational equipment needed with the domestic automated management system at the main port to support overall operations. Hermesauto (2017) also added that it is also called the robotic port with all equipment being manufactured in China that involves five 50,000 DWT berths and two 700,000 DWT berths. The port was able to handle 4 million standard containers (TEUs) that expanded to 6.3 million dues to the technology's advancement.

Qingdao Port automated operations

Port Qingdao Port is another example in China that is located in Qingdao city and is the first fully-automated port which set a record in operation efficiency by being able to handle 30 containers per hour by each single crane which made it the fastest unloading ships in the world when it comes to speed.

One of the technologies is uses is the **5G remote operation system** as stated by B.R.Desk (2019) to handle containers with no human in the terminal and broke the world record by itself in using the technological breakthroughs that resulted in unbeatable port turnouts times where it handles an average of 39.74 in a single crane per hour and nearly 1800 containers in one hour.

Ningbo-Zhoushan Port – backed by advanced communications backbone

Last example to mention is Ningbo-Zhoushan Port and it is the busiest port in China and amongst the top three worldwide. It is the World's first to exceed the volume of 1 million times cargo throughput since 2017 and reached an annual container record throughput of 26 million standard containers the year 2018 as stated by Seatrade Maritime (2019.

It uses 5G for crane remotely control all the port operations. It is also advanced in having reliable communication services by 5G due to the high-bandwidth and low-latency which results in reliable communication, high resolution and send information faster through the system. Looking at those three most innovative ports in China we can pinpoint the main factors of operation efficiency which is using technological data, tools and materials to thrive with smooth and accurate operations that required the least effort with minim risks of damage or errors.

To translate the following statement in the port we will avoid financial costs, low quality of services, delay of the operational process, damage of the environment and surroundings, misuse of the available space, death or accidents possibilities and low satisfaction of parties or clients.

We realized that for our ACSS to function with a higher capacity and to reach to the quality we need, it should be linked to a system that is linked to the computer with the codes of each container. This will improve our reporting system efficiently and a lesson learned from the failure of the automated parking in the 60's.

5. Methodology Used

The feasibility of the maritime sector switching to electrical trucks requires actual manufactures that produce such trucks that are built for port usage. The available electrical trucks are mainly for individual usage and not necessarily specialized.

The plan is to research manufacturers who are willing or planning to build such trucks of the likes of Tesla, GM and Ford, as those manufactures have initiated interest in the field of electrical vehicles. In term of quantitative benefits, the plan is to make an estimate of how much the usual expenses of diesel trucks used in the ports and what would be the long-term savings if the switch is made to electrical trucks.

Obtaining and preparing the data, before the analysis could begin, the data has to be organized in a functional format. Most of the data preparation was conducted by online research <u>and meeting with operations faculty in the port.</u>

We also generated data from the Port operations manager who gave us the average cost it takes in operating a diesel truck in the port and compared it to the average cost of operating an electric truck, both the data was given from the port operation manager in DP World Shaheen Najeeb. The cost demonstrated that initially obtaining an electric truck is expensive, however when the truck is autonomous and the energy is generated from the port, then **in this case the average cost of an electric truck becomes less than that of a diesel truck. Therefore, it proves that making the switch is cost-effective in the long run.** Moreover, the data in terms of measuring the extent of truck accidents in the port was collected from a case study in Jakarta Port, where the data was collected over a five-year period, this data is discussed further in the anaylsis. **The data from the Jakarta Port demonstrates how trucking accidents in the port make a huge part of the total accidents in port. Therefore, switching to electric autonomous trucks will reduce the human errors in driving trucks at the port.**

The next step in preparing the data was to research the manufactures for electrical trucks. The type of trucks currently used by ports worldwide according to Camex Transport Services (2020). It is essential to understand the different type of trucks and how long will it take to transition those trucks to electrical vehicles.

In accordance with Camex Transport services (2020), a renowned freight company in Sydney which specializes in transporting bulk supplies such as steel, oversized building sections and general freight transport. Camex transport (2019) analyzes the different types of trucks typically used in the port.

Generally, a freight truck is classified into two main types. A fixed trailer truck and a separated trailer truck, however the carrying capacity and the design of the truck is divided into six different types of trucks that are:

- Semi- trailer truck
- Straight truck
- Jumbo truck
- Tail- lift truck
- Detachable trailer truck.
- Flat-bed truck

After analyzing the details of port machinery in the port operations, The port operations manager shared a detailed analysis conducted by the port of Melbourne DP World (2020) elaborates on how the ports can incorporate the usage of machinery such as straddle carriers and reach stackers are both unregistered vehicles that is considered to be a type machinery that can on a smaller scale be used replace the function of a truck in the port. The straddle machinery at DP World's port at Swanson Dock West is already running on biofuel to decrease the carbon emissions.

According to Diesel Forum (2020), the largest contribution of emissions comes mainly from the ocean-going vessels (OGV), such as the ships, tankers, bulk carriers, the roll on and roll off vessels that carry vehicles. Then the other sources of emissions such as the trucks, rail and the material handling equipment. The data generated in terms of emissions in port equipment is conducted through the National Port Strategy assessment (2016). Where the amount of reduced emissions is calculated in each process of the port operations.

As objectives for this capstone project included analyzing how the project can be implemented efficiently within port operations, it was essential to understand how the two projects play a huge role in sustainability, efficiently and reliability.

Interview internal sources in the organization:

As for the ACSS project by interviewing people from different departments like Operation Department to get detailed knowledge of process on site and have more operational background, Health and Safety Department to shed the light on the best practices and safe materials to be used in order to maximize the effectiveness of the initiative, Sustainability Department to have an idea about the newest products and services available and areas to consider while working on the project, engineers to give us more detailed ideas on the technical parts of the system, IT department to help us understand the needed system or application to be installed to better track containers while being in the office.

Input from Other regions

We also use our network with other regions within the company to gain more guidance and new perspectives with the information we will provide. We also include other companies within the same industry, making sure to understand the effect of our project on both short and long term to the business operation, performance and reputation.

In addition, we research more about the materials that should be used to hold on the capacity of the containers and make sure this applies with the ports security policies. The system that will be linked to the computer should be also within our policies as it will hold private information that should not be accessed.

In the future there will be room for improvements where employees in control rooms can get a more detailed data on containers that are stored in the yard. For example, the code of each container, type of the container and summary description of the categories will be organized efficiently.

Applying the present situation of DP World when it comes to the operational efficiency in the port and concentrating in the UAE Region based terminal which is the soul and heart of the company it is currently a leading business and logistics hub in the Middle East. It is investing greatly in smart and innovative technologies within the trade industry to encourage global connectivity.

The terminal has increased 5% in its customer base year-on-year for 2018/2019 in the automotive sector with a recorded business worth AED 38.8 billion in total trade value. DP World, UAE Region portfolio includes Jebel Ali Port, Mina Rashid Cruise Terminal and Coastal Berth, P&O Marinas, Mina Al Hamriya in Dubai and three Zones: Jebel Ali Free Zone “Jafza”, National Industries Park “NIP” Dubai Auto Zone “DAZ”, Dubai Trade & World Security (DP World, 2020).

Focusing more on a narrower location and the potential areas to implement our two innovative ideas we are talking about Jebel Ali Port which has currently total of four phases. Unlike China, where they implemented most of their automated terminals in the fourth phase, we started with the third phase to have a fully automated terminal since 2018 in JAFZA. DP World since then was a leader in technological investment and smart solutions which includes the most popular project “hyperloop” launched recently and was a huge success.

While planning the idea of ACSS since we started collecting data the company started creating a demo simulation called BOXBAY and we were involved in the process of building the best plan strategy with all the resources and researches we can use as a support.

While researching about other ports in China and Japan mentioned in the report, we have concluded that none of them had a process similar to ACSS although those ports are global leaders in the industry. Therefore, ACSS with its new and innovative concept drives progress and adds substantial value to the container handling systems on a global standard.

Moreover, the fact that ACSS is planned to stack up to 11 containers rather than the typical 4 containers, proves the added value and space this brings to the yard operations. Also, the fact that it eliminates any container handling accidents since the concept is fully automated, eliminates the risk of the containers falling and causing accidents.

6. Sources of Data

The project will be studied and generated from different resources to ensure that all points and angles are well covered, studied and comprehended. We will start by talking to employees with an operations background at the port since they will know what points we must focus on and ensure the success of the. Due to the pandemic the planned interviews were replaced by exchanging e-mails and data instead. That also included many sources online especially collected data of other projects and studies. One of our main sources of operational data is Harvey Bostock a Project Manager and an engineer who in charge of Terminals three and four in Jebal Ali Port. In addition, Alex Civira who worked in many different projects worldwide under DP World and an expert of smart innovation business developments within the ports industry.

In order to make the switch to electrical trucks and add a new automated storage with a huge capacity, technical information from individuals who are experts in the field will add pragmatic value to the concept. Information from reports conducted by DP World Ports worldwide was shared by port operations manager from DP World Melbourne.

The information we will seek includes best locations to apply the idea, quality materials that would mostly be environment friendly yet capable of delivering the purpose, expected costs in order to achieve the goal and timeline for the project to be built and completed. We will get most of the core information from data provided by individuals who work directly in ports trade, for an added value of the data. An expert in the ACSS field from DP World, Abdullah Al Haidan who is currently working in the simulation of BoxBay project that is considered to be the first prototype of the ACSS concept. Abdullah provided major input on our analysis process.

After collecting the information from the company, we will definitely have points to check and add from online research and sources. This will include any other possibilities that might rise and will add quality to our project. We will also have to find ways to connect the accessibility of the project via technology and application systems that can link the entire process to a computer screen and be activated by simple yet studied clicks. That will require some extra consultation with the IT department and sites that will surely
provide us with variety applications and systems to choose from and include in our final presented project outcome.

7. Analysis

At the beginning of researching the two concepts of electrical vehicles and the automated container stacking system, the first thing is to comprehend how the current operations take place.

We have considered first the current process in the container terminals. The process is usually basic and uniform worldwide, the difference occurs in the tools, methods and systems to increase the efficiency and convenience.

To explain how we started analysing the process to detect challenging areas that can be changed and result in overall improvement. We will mention the entire standard process of loading and unloading container terminals. A simplified diagram of the process is demonstrated in Figure 1.

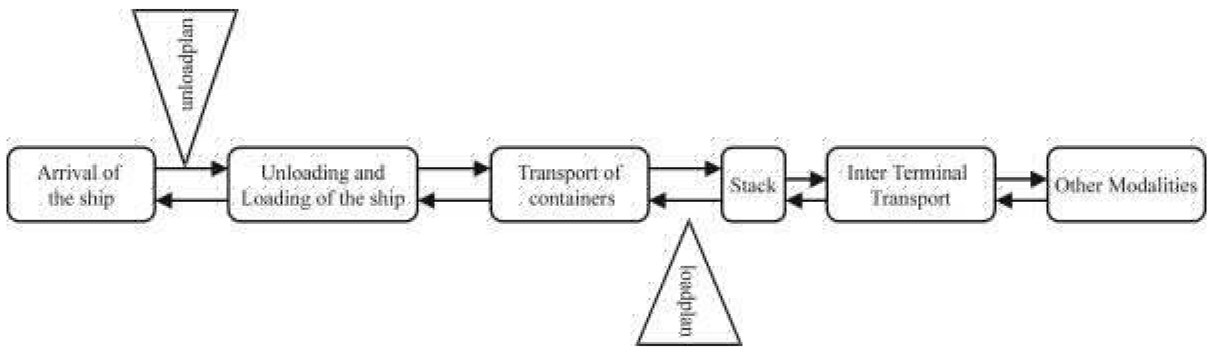


Figure 1: Process at container terminal

The process starts with the arrival of the ship carrying all the containers to be offloaded to the port, using QCs (Quay cranes) then the containers are moved from the ship parked in the deck. The QCs loads the containers to the trucks to be moved to the planned designated area in the port yard. Afterwards, depending on the yard space of the port the container will be driven through many lanes of stacked containers using normal trucks until it gets to the targeted location to carefully store until the other process takes place. By other process we mean either the container gets transferred into the city or wait for another ship or railway to be transferred to the client/end user.

Understanding this process gave us a wide understanding of the core business in ports and daily operations and we understood that we would require more details to get the ultimate desired value. We started with what was already available in our container terminal and the machine, tools and systems used. We understood that each terminal in Jebal Ali Port includes a total of four terminal, where each terminal has its separate and unique process which gave us a broad understanding of why each one has different turnover results. Adding electrical vehicles and the ACSS will significantly contribute to the efficiency and the quality of the operations.

Jebel Ali container handling capacity increased from 18 million TEU (twenty-foot equivalent units) to 22.4 million. (5) The container storage area exceeds the initial outdoor yard stacking space and includes a space of 9,665 squares meters of a cold storage space to cater the containers requiring special storage conditions like pharmaceutical products, cosmetics and chocolates and many more. (DP World, 2020)

In addition, it includes a cool storage facility with three rooms which handles the capacity of 3,240 square meters with temperature that ranges between 10°C to 20°C and a cold storage with the temperature rage of -29°C to +13°C that includes a pallet storage capacity of 8,183 square meters. It covers yard space of over than 1.4 million square meters and 27 berths. The 15 meters deep of quayside gives Jebal Ali the advantage of allowing special and huge cargo vessels to berth into the terminals.

Moving over to the chosen terminal and why did we focus on one certain terminal since we have four in Jebal Ali. This goes back to the distinctiveness of each terminal and the available facilities in each due to the technological advancement of the port. The constant innovative approach of the port is reflected in the companies plan to extend the port capacity and improve efficiency.

The introduction of automation in systems in Jebal Ali Ports

The turning point for Jebal Ali Port is in the commencement of terminal 3, which signifies the beginning of innovation through the implementation of semi-automated operations that was introduced in the concept of the containers being offloaded from the ship to the QCs by remote controller system and sensors managed from indoor control rooms. This added value by controlling errors, swift damage control and minimizing safety risks during this process. After Terminal 3 successful operations, terminal 4 was introduced as the new fully automated terminal referred to as phase 4. The focus was to have a fully automated operations process with the replace of machines, tools and systems to reduce the man-power needed and introduce innovative solutions that are best for the environment, production, safety, quality, space usage, cost, level of satisfaction and efficiency. Therefore, we focused on terminal four to find any gap to improve and add smart solutions from our courses that we learnt in city sciences to accomplish the capstone project. (DP World, 2020)

Constraints: Among the constraints that are discovered in this research for the electrical vehicles is the cost aspect of it, it will be costly for customers to initially purchase an electrical vehicle but in the long term it is cost effective as demonstrated later in the report in a table that compares both the price of an electrical vehicle and a diesel truck.

However, the increased clean air regulations are being adopted worldwide which signifies the push towards making the switch to either electrical vehicle trucks or clean fuel trucks. Currently, the California Air Resources Board approved the Advanced Clean Truck regulation, which means that by 2045 every new truck sold in California will be zero-emission.

The transition does not have to be extreme or done all at once, for instance in California ports, the newer acquired trucks that use fossil fuels will be modified to include an effective exhaust control technology that limits the carbon emissions from the trucks.

The California air resource board will be regulating the requirements for the diesel truck fleets to transition to electric trucks year on year. The transition can also be done on a smaller scale, where the port unregistered vehicles such as the straddle carriers. The straddle carriers is a type of vehicle that is used to move containers within a terminal. The straddlers can load and unload trucks, they are operated by a driver who sits in a glass cabin at the top of the machinery.

The drivers uses a computer to know which container to pick up. Straddles normally can stack up to 3 containers high. In DP worlds terminal at Swanson Australia the straddlers are powered by bio-fuel to decrease emissions. Thus, it shows the port is motivated to make the change to reduce its overall emissions.

Sources of Port emissions:

According to the National Port Strategy Assessment (2016), the data generated in terms of emissions in port equipment is as follows:

- Particulate matter in ports is mostly generated from the vessels 52%, followed by harbor craft of 27%, trucks make up 15% of the PM emissions, 5% from the equipment and 1% from the rail.
- While the Nitrogen Oxide emissions are generated by mostly the harbor craft of 47%, then by the vessels which produce 33% of the emissions, then trucks produce 10% of the emissions, followed by the equipment which produce 7% of the NOx emissions and 3% is generated by rail. Harbor craft refers to smaller vessels such as the tugboats (Diesel technology forum, 2020). Port machinery does not have to be all electrically powered for instance, substituting the machinery with the latest clean diesel models can make a significant difference. The amount of reduction of the NOx and PM as analyzed by the National Port Strategy assessment (2016):

- Rubber tired gantry cranes when powered with clean energy can reduce both NoX by 3.7 tons and PM by 0.2 tons.
- Reach stacker powered by bio-fuels can reduce both NOx by 2.4 tons and PM by 0.139 tons.
- Tug Boat with a clean diesel model can reduce both NOx by 48 tons and PM by 1.3 tons.

- Trucks in the yard if transitioned to cleaner diesel engines can reduce both NOx by 0.6 tons and PM by 0.1 tons.

To better understand the impact 1 ton of NOx is the equivalent of a car driving 13 million miles to produce 1 ton of nitrogen oxide emissions.

The DP world port in Swanson Australia which is using powering its reach stackers by biofuels is annually reducing their nitrogen oxide emissions by 2.4 tons just from the reach stackers equipment.

If not electrical vehicles, ports can switch to clean diesel instead:

In south California, the port authority made changes to the port machinery and the trucks to be updated to the latest clean diesel engines, this change led to PM falling by 85% which accounts for 745 tons annually, and the NOx levels also reduced by 51% which accounts to 8,325 tons annually. These remarkable figures where achieved through introducing clean diesel technology in the port.

The cost of clean Diesel is increasing and is becoming limited

The cost of clean diesel fuel is expected to increase by 2020. Experts from the US energy information administration is expecting the price of diesel to increase by 20 cents more per gallon. This increase has driven the International Maritime Organization (IMO) to set a deadline for the maritime industry to make the switch from bunker fuel to cleaner burning diesel fuel.

In regard to trucking, the main issue is not in pricing but in availability of the fuel. The council of Economic advisors released a statement that verifies the possible lack of availability is in that the global bunker fuel embodies 5% of total oil demand therefore, fuel switching by ships in 2020 will create major disruptions in markets (Stinson, 2019). There will be a shortage of supply between 200,000- 600,000 compliant fuel barrels, which will likely lead to higher prices (Stinson, 2019). For the trucking industry in the long run it will make more economical cost to switch to electrical vehicles. Due to the fact that the price of the clean compliant fuel is increasing due its lack of availability.

Frost and Sullivan, a research firm is estimating that the outlook of the global logistics industry is estimated to be around 10.6 million euros by 2020. The logistics industry is renowned to be slow in terms of adapting to change. Among the manufacturers of the electrical vehicles trucks to be used in port operations include Tesla.

Speaking to a DP World Port Operation officer Shaheen Najeeb, based on his experience the average life of a truck is ten years, the value of the truck depreciates as the vehicle become older. The total fixed cost of a conventional diesel truck is $77,842 compared to the fixed cost of an electrical vehicle is $370,906.

The initial price of an electrical truck is almost 5 times more than a regular diesel truck. However, the variable costs for the diesel truck amounts to $408,332 and the electrical vehicle variable cost amounts to $514,992.

However, if the power of the electrical vehicle can be generated through the solar installation in the port, and the vehicles are autonomous then this will decrease the variable cost in terms of the driver cost and the electrical cost which will bring down the total cost of operation of electrical trucks to $404, 467. Thus, the operation cost of electrical trucks will be less than diesel trucks. The following table data was retrieved from the port operation manager in DP world and it demonstrates the fixed, variable and total costs of operations for both diesel trucks and electrical trucks.

in US dollars	Conventional Truck	Electric Truck (Tesla)
Net price	47,465	158,669
Cost of capital	4,339	14,646
Tax	13,019	13,019
Insurance	13,019	13,019
Battery cost	0	176,229
Total Fixed cost	77,842	375,582
Variable cost		
Tyres	22,376	22,376
Maint and repair	13,019	6,509
Fuel	257,803	0
cost of electrcity	0	84,487
Urea tank	9,086	0
Engine oil	1,220	0
TM oil	813	0
coolant	135	0
cost of driver	26,038	26,038
Total Variable Cost	330,490	139,410
Total Cost of Operation	408,332	514,992

TCO scenario for electrical vechiles	eliminate
Autonomus vechile (driver cost)	-26,038
Power generated through (renewable energy at the port)	-84,487
Total cost of Operations if vechile is powered through renewable energy generated through the port and eliminate driver	404,467

Added benefits of introducing electrical vehicles:

Among the added benefits of introducing electrical vehicles is the reliable navigation when an electric truck is autonomous. Therefore, the route for the trucks is specifically guided, hence it can reduce the chances of yard accidents. These options adds reliable navigation, reduces the risk of collision to zero and increases safety. Kalamar is a company that DP World is considering for making the switch towards smarter yard equipment. The benefits of introducing electrical trucks to port operations are the following:

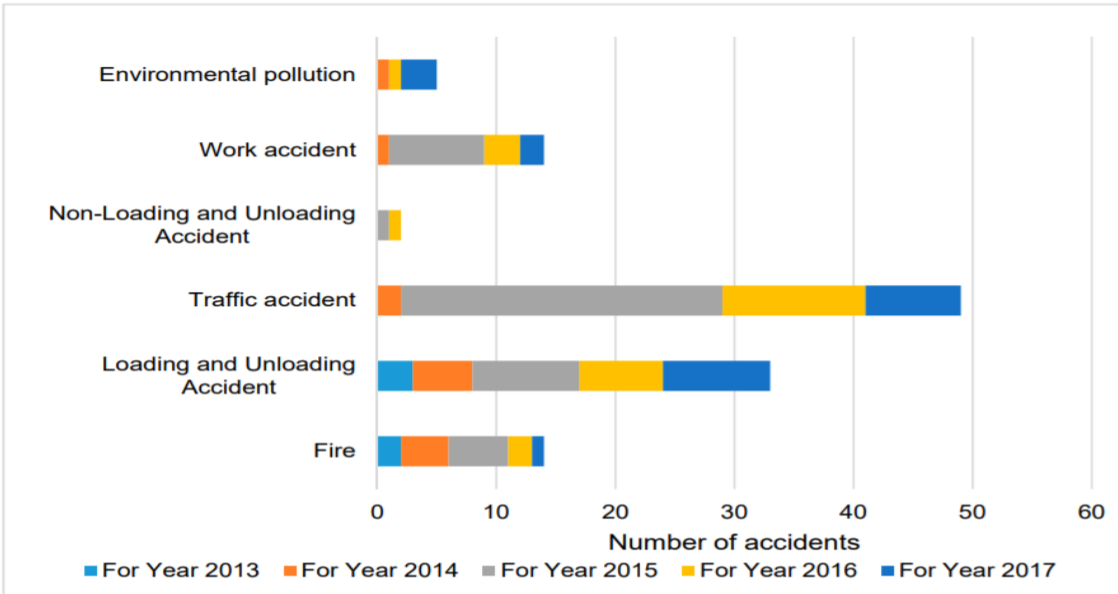
1. **Collision avoidance.**
2. **Extra safety** as the process is automated, no room for mistakes.
3. The electrical vehicle is smarter than a regular diesel truck due to the sensing equipment which can provide incremental status updates.
4. Onboard autonomy present in electrical vehicle.
5. **Information management and connectivity,** electrical trucks are connected through a network, that can communicate with the other trucks in the yard.

A study conducted by the marine science and engineering demonstrate that the human factor when operating vehicles in the yard are among the prevalent causes of accidents in the container terminal (Budiyanto & Fernanda, 2020). The study found that 41.8% of container yard terminals are caused by traffic accidents within the trucking in the port.

The function of a truck in the port includes many processes such as stevedoring which refers to loading and unloading the ship, delivering, receiving all those aspects involve high risk. According to the Hong Kong Maritime department, in 2016 there was 76 accidents related to loading and unloading containers on the truck.

Based on a case study analyzing the risk assessment, which was conducted by the marine and engineering journal, the study shows that accidents occurring over five years in the port of Tanjung Priok in Jakarta, Indonesia. The study collected data across two terminals in Jakarta's port and it showed that over the past 5 years from the year 2013 to 2017, there was 117 accidents occurring in a container terminal (Budiyanto & Fernanda, 2020). A graph of the study is demonstrated in Figure AB.

Figure AB: accident data in the container terminal during five years case study by marine and engineering journal



The bar chart demonstrates that traffic accidents is among the highest contributor to accidents in the port yard. The chart shows that the traffic accidents make up almost 50 accidents of the all the 117 accidents in this case study (Budiyanto & Fernanda, 2020). Therefore, switching to electrical trucks will significantly reduce the number of accidents in the port. To further visualize the extent of the accidents, the common causes of the accidents is presented in table 1 which further categorizes the common cause of each accident and the percentage of their contribution.

Major	Risk Factor	A	B	C	D	E	F	Sum	Percentage %	
Human	Pilotage Error	0	5.4	0	30.4	3.9	0	39.7	36.42%	52.75%
	Poor Supervision	0	1	0	0.2	0	0	1.2	1.10%	
	Negligence when Working	3	0	0.5	0	5.1	0	8.6	7.89%	
	Poor Tool Maintenance	0	6	0.5	0	0	0	6.5	5.96%	
	Navigation Error	0	1.5	0	0	0	0	1.5	1.38%	
Machinery	Equipment Damage	4.75	11.05	0	7	4.5	0	27.3	25.05%	29.63%
	Engine Damage	3	0.5	0	0	0	0	3.5	3.21%	
	Electrical Error	0	1.5	0	0	0	0	1.5	1.38%	
Environment	Flood	0	0.5	0	0	0	0	0.5	0.46%	14.86%
	No Warning Signs	0	0	0	5.8	0	0	5.8	5.32%	
	Limited Lighting	0	0	0	1	0	0	1	0.92%	
	Damaged roads	0	0	0	2.4	0	0	2.4	2.20%	
	Fuel Spills	0	0	0	0	0	2	2	1.83%	
	Load Spills	0	0	0	0	0	3	3	2.75%	
	Slippery footing	0	0	0	0	0.5	0	0.5	0.46%	
	Equipment Exposed to Water	0	0	1	0	0	0	1	0.92%	
Nature	Hot weather	2	0	0	0	0	0	2	1.83%	2.75%
	Rain	0	0.5	0	0.5	0	0	1	0.92%	

Table 1 causes of accidents and the percentage of contribution.

The table confirms that the human factor is the dominant cause of accidents in the yard by almost 53%, especial the negligence accidents in driving, which is referred to as pilotage error is the highest at 36.42% of the total accidents (Budiyanto & Fernanda, 2020). Therefore, it is worthy for ports to consider electrical trucks especially due to the autonomous factor as well as reduces pilotage and navigational errors.

Volvo Vera the heavy-duty electric truck.

Volvo is introducing a complete range of heavy-duty electrical trucks in Europe by 2021 (Volvo Trucks, 2020). This move is a massive leap towards electrification of heavy-duty vehicles. Currently Volvo is running tests on its heavy-duty trucks, the trucks will weigh up to 44 tonnes (Volvo Turck,2002). The truck battery will serve a range up to 300km. The volume production for the Volvo heavy duty electric truck will commence in 2022 (Volvo Trucks,2020)

The truck doesn't have a driver cabin like a conventional truck, the Volva Vera is fully autonomous which means it doesn't require a driver. This truck can be connected to a cloud service and the truck can be supervised online through a command center (Volvo Trucks, 2020). The truck provides several indications throughout its journey via the command center such as the live location, the weight of the load it's carrying and the time that is required to reach its destination. This truck will be zero-emissions. The Volvo Vera is a concept that is a part of an innovative solution created for the port terminal in Gothenburg, Sweden. The Volvo Vera is a result of a collaboration between Volvo and the Danish international shipping and logistics (Volvo Trucks, 2020).

The electrical truck will travel on a pre-outlined route at a maximum speed of 40km per hour (AB Volvo, 2019). The predefined route will be installed in the system, and the truck will automatically follow the route. Thus, decreasing the pilotage errors to zero%. The main aim behind the Volvo Vera is to provide a seamless transport in logistics and introduce a new adoption of the autonomous transport solution for heavy-duty trucks in the logistics industry (Ab Volvo, 2019).

The fully electric heavy-duty trucks such as the Volvo Vera are already will not only reduce emissions, but also the noise pollution (Volvo Trucks, 2020). The noise factor is important to consider especially when ports are in a close proximity to urban areas.

Creating renewable energy through the port

Dubai Ports world is undertaking a journey to invest in creating renewable energy. One of the projects includes covering the DP World Head office parkings with solar panels as part of the DP World Solar Program.

Phase one was completed in 2017, the solar panels on the parking are providing 40% of the total energy consumption required in Jebal Ali. The project includes 4482 solar panels, the plant size is 1142.9kWp and total energy produced per year is at 1,874,802 KwH/ year (Amana buildings, 2018). Moreover, it reduces Co2 levels by 22,000 tons which is the equivalent to taking 4500 cars of the road (Amana buildings, 2018).

Due to the success of this solar rooftop plan, DP World invested in another project for solar panel installations on top of the staff accommodations buildings in Jebal Ali. The solar panels on the staff accommodation buildings will cover 110 buildings and include 17,500 solar panels and will generate more than 10.72GW of annual energy production (Roy, 2020).

These projects demonstrate that ports have the potential to become a "renewable energy hub". A study conducted by Eurelectic accosictaion, forecasts that by the year 2050, the total renewable energy generated by ports will account for 70% of the total electricty generated in the port. (SITE)

Project Planning

In order to start an innovative project that is unique with no formal reference to copy from and includes smart construction and transportation technology. For that we have prepared a timeframe and a list of data needed to gather and focus on.

It is important to state that the project prepared is a testing concept which will only be taking a certain space in the yard and trial of approximately one year and a half would be needed to acknowledge any possible needs against the resulted outcome to determine the continuality of the project and expansion possibility. Starting with planning and driven by many ideas of automation and technological advancement the challenge was to find a company that is expert within the technological field to match the quality of DP Worlds quality of services being a leading company for international trade worldwide.

SMS was chosen to be the best **qualified partner** due to its advanced knowledge and practice in electrical and automation system with the support of its experience in digitalization, technical services, manufacturing, design and sustainability. We had many other choices in mind but due to the relevance of their vision and quality to DP World the other companies like Universal Robots, UBTECH and NVIDIA did not stand a chance of winning. The second step for us was to build a list of main data to gather which are listed below with a brief of the collected outcome:

- **Consultants:**

Simulation consultant is needed to combine the vision of both parties and puts it into a live 5D diagram, where all areas are covered to test the model's effectiveness and possibility to be functional and entuned with the main goal and objective. We had many choices in the market to consider like HSC Chemistry, Solid Edge, iGrafx but we chose SimScale for the clear quality and reasonable price against it. It gives a product that is customized according to the industry which is exactly what we needed with such an innovative idea.

Legal consultant was required due to the joint venture planned and to secure the idea under a patent name which we refer to in our case by (ASCC and Truck) and for such service we chose Astrea Legal Associates LLP which is a firm that has the best lawyers and legal team and we are aware of their strong portfolio from previous dealings, and most importantly we need to make sure that our partners are also involved in the tendering process. Once a mutual agreement is formed to go ahead with paperwork and consultancy charges

Construction Concept Design consultant is the most important part that determine the likelihood of the functionality of the process and the required materials, space and resources needed to start with the constant reflection of the 5D simulation provided and communication with the simulation consultant for the best outcome for the implementation of the project.

- **Materials:**

The materials needed for the project would be from available since all materials required for the system are used on site. It is also worth to mention that the crane and metal used in the ASCC would be provided by the partner company (SMS) which is the best reflection of joint venture. In addition, the land is already owned by the company and this keeps all required resources for the project to be inhouse and minimum costs to be required.

- **Manpower:**

The needed manpower for the project in 18 months of testing/pilot stage would include four skilled IT professionals in the control room provided by SMS, one general supervisor, one truck driver and shuttle carrier driver whom are already from DP World staff. After the pilot period we have gathered more data from interviews and the change would be mainly of the partners inclusion in the port where the automation system will be controlled by two DP World employees from their offices in terminal two due to their close location to the automated area in terminal 4. Moreover, the truck drivers on site would be doubled excluding the trucks entering from outside the company by clients. The calculated manpower needed using ASCC compared to the traditional port process would result decrease by approximately 52%.

- **Space:**

Taking into consideration the use of eleven containers accessed smoothly and separately with ASCC against traditional stacking of six and sometimes four during high wind seasons to ensure safety and steadiness of the containers at the yard. Space is one of the main threats ports faces worldwide and it is a great point looked at as a representation of the organization system of the port as a shipment company/investor. The added potential is majorly increased due to its relation to yard space capacity. The implementation of ASCC is calculated to require 1/3 of the space used in traditional port stacking systems which is a great motivation to install this smart technology throughout smart ports in the future.

- **Environmental:**

The environmental value added by the ACSS system will be direct and instant as all diesel fuelled machinery and tools involved in the traditional system would be changed to electrical power which is friendly to the atmosphere and environment. In addition, due to the heavy metals used building the ASCC system the roof of it can easily carry and handle solar panels which was discussed while making the analysis of construction design, this means that even electrical power usage would be charged from natural resources that would add to the quality of the environment around compared to any industrial zone endangered of toxic and polluted air and atmosphere.

- **Safety:**

DP World has one of the main and constant objectives is to have zero fatality and accident rate and perceives manpower as a huge asset no matter of the dependency on electrical and technological advancement. The community of the company is treated as a family member that pushes the flow of the company to thrive and that is a value implanted in employees and staff of the company internationally and one of the main reasons of the employees loyalty to the company. With the ASCC we ensure that the rout and directions are stated clearly with a simple single stop of truck driver to easily unload and offload the container. This decreases the risk of needed manpower on site in the area surrounding the truck and ensures minimum effort of truckdriver with simple and safe access. Also, the design included a fenced ASCC area with no site operations, limiting of movements needed due to automation dependency and in case of maintenance requirement the entire system stops functioning with the alarm to attend the needed action and for clearance of the area if required.

- **Innovation:**

Innovation is a major focus point worldwide and we have been encouraged during our studies to widen our horizon to look at things from many different perspectives. This supported us to look at challenges we encountered while planning and analysing with specialists and experts differently. ASCC would be a major lead for the thrive of ports industry if implemented and that is guaranteed according to the analysis we have done and available data. It encourages smart and innovative solutions, increase the turnover rate, build a stronger brand name, encourage environmentally friendly solutions, attract major and more clients and investors, increase the satisfaction level of all involved parties and ensured a more effective, efficient and quicker profit returns to the port industry of the country or city. All of these innovative and positive focused attention leads to a stronger community, healthier environment, connectivity and active flow of country trade and relations.

- **Costs:**

Items	Given by experts (AED)	
Consultancy ● Simulation ● Legal ● Concept Design	 150,000.00 100,000.00 300,000.00	
Materials ● DP World Available Resources ● Shuttle Carrier	 2,000,000.00 2,000,000.00	
Electrical ● Electrical cost (without the solar power) ● Electrical Cost (with the solar power)	 35% less than traditional port system N/A	
IT ● Automation control system	 Confidential	
Solar ● Panels and Installation	 free of cost through BoT model	

Outcomes:

Further in the research, discovered that trucks are not the sole culprit of emissions in a port, that the other machinery also contributes to significant amounts of emissions, where it was relatively close in percentages 10% and 7% where the annual emission rate of nitrogen oxide for trucks and the port machinery respectively (Diesel Technology Forum). That solar energy is the ideal energy to generate renewable energy through the port. The experts in the port discussed that tidal energy is not sufficient and will not generate enough energy, therefore the ports in Dubai are focusing on solar energy rather than tidal or wind energy.

Estimated Results

The first ASCC would be placed in Terminal 4 in Jebel Ali Port which is considered the first in the ports industry and a demo was illustrated with the partnership with a well-known industrial engineering German family-owned company. The reason for choosing the following company is because pf their experience in dealing with coil and metal that can handle high weight. The ASCC will easily give an easy access to all containers with the same amount of effort and simple clicks rather than worrying about the positioning of the container in the yard which will lead to 100% utilization.

The container will be stacked in separated rack compartments with eleven racks compared to the usual five containers stacking which will reflect an increase of the capacity handled of the same space by 200% and three times more. Moreover, the time will be reduced 30% compared to the traditional loading and unloading. The ASCC will increase the safety of the port, boost energy efficiency, and reduce the cost greatly. (3) Cost on the other hand is reflecting a saving of approximately 20% of the usual cost mainly because we will just need to pay one-third of the lease cost of the smaller used area against the number of containers stacked in the terminals yard. (4) The ASCC will be able to handle two huge container vessels at the same time with footprint over 32 ha and berth length of 800m. (4) During our investigation on the areas of trade where the efficiency will be easily detected and due to the expensive process of almost half-full containers shipped to Africa and Latin America. (4)

Results

One of the findings throughout the research of port operations machinery that the port can incorporate smaller protypes of electrical vehicles to run in the port, such as the straddle carriers that are operating in DP World Swanson Dock, and the reach stackers can also be fueled by clean energy that can be generated at the port through using the solar projects that are taking place at the port.

The fact that DP World initiated another solar panel installation project in 2020 on the staff accommodation roofs demonstrates the efficiency created in the 2017 project with the solar panel rooftop installations on the staff parking. If the power generated through the renewable energy is used to power the electrical trucks, then the total cost of operation of running an electrical truck is less than the cost of running a diesel truck.

Also, by making the switch to electrical trucks and having them operate autonomously this can significantly reduce the truck accidents that make up the majority of the port accidents which compose of 36.42% of the total accidents typically occurring at the port (Budiyanto & Fernanda, 2020).

Moreover, the increased regulation from the International Maritime Organization which mandates that the industry makes the switch to clean fuel, leads to a major scarcity in clean fuel. On an environmental outlook diesel trucks contribute to 15% emissions of particulate matter and 10% emissions of Nitrogen oxide from the total emissions that occur in a port. Thus, switching to electrical vehicles is a logical, cost-efficient in the long run, environmentally friendly and sustainable.

Project Implementation is currently the BoxBay prototype project that is mainly targeting to start functioning during Expo 2021. After implementing this prototype and it is proven to be successful, DP World is planning to slowly spread these smart and innovative technologies throughout its regions around the globe. This also was a main point for us to rely on while approaching experts for information and add our own input from our studies. This is seen a new concept with a high value that is more than what we estimated in our report as we shared ours with experts.

We gained many insights of the prototype while preparing the report, but most information given were confidential and that is the main reason the shared data in this report were either from what was shared online or an estimation from the experts. This is seen as the future of ports industry and during the research we have found that there are major developed citied that have high ranks under “bigger”, “top” or “busiest” with semi of fully automated systems but missed this small details that are based on our analysis more advanced than what is in the industry.

8. Results

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9. Conclusions/Future Work

The global trade moves billions of goods for global trade, where the goods are processed and moved in the ports by a fleet of diesel-powered trucks and equipment. Substituting the old diesel trucks and equipment will be costly but it can significantly reduce the emissions of nitrogen oxide and PM by more than 80%. Therefore, the environmental benefits by eliminating diesel trucks are worth considering. Moreover, the added safety in making the switch to electrical autonomous vehicles will reduce the accident rate at the port, especially that the majority of the accidents in the yard are caused by trucking accidents, as discovered over a five-year study conducted in Indonesia. By making the switch to electrical vehicles that are driverless it completely eliminates the human error that is makes up 53% of all the errors that occur in the port (Budiyanto & Fernanda, 2020).

The fact that DP world is looking into creating renewable energy in the port further supports its sustainable and long-term growth plans. Therefore, considering electrical vehicles that can be powered from renewable energy generated in the port is a practical solution in the long run especially considering the cost viewpoint. The overall cost of purchasing an electrical vehicle is cost effective when it is autonomous, and the energy is generated from the port is used to fuel the truck. Since, DP world has already created three projects that are based on generating solar energy, these projects can support the concept of powering the trucks from the energy created. Thus, the idea of electrical vehicles in the port is sustainable, feasible and efficient. The aim behind making the switch to electrical trucks it to decrease the effect of transport in the maritime and logistics industry. Therefore, by making a swift transition from regular fossil fuels to rely on electricity that can be generated through renewable energy. However, making this shift depends on the pace of transition which will differ across each region. Many factors affect making the decision to create the switch such as the financial ability of companies, access to charging infrastructure and the overall added value to the company.

The concept of ACSS will considerably shift the way ports operate, due to the many benefits it provides, from safety, efficiency and reliability. The fact that this concept is an innovative application to the conventional stacking methods will aid in finding the required box instead of reshuffling and provide the ability to stack up to 11 containers high compared to the conventional method of stacking 4-6 containers. The ACSS will save space in the yard, where the space can be used for other purposes. Moreover, the world is shifting quickly into automation and the mindset of industries is becoming more accepting and flexible with new ideas. ACSS and Electrical trucks started as minor ideas but resulted in impressive calculated impact that can make a difference in port operations, a simple idea can materialize from a concept to reality especially if the concept is feasible, adds value and create a positive impact and all these categories apply for the ACSS and the EV trucks in the port industry. Many realizations took place while reading, collecting and analyzing the data provided and one of them is that there will always be room for improvements and innovative methods to deal with challenges. Within the port industry and with all the advancement of available technologies and resources, one can always find a process or part of process that can be improved, which then can lead to a major positive outcome. The effects of innovation play a significant role where innovating in one area can create a domino effect in other areas such as the environment, smart solutions, digitalization, improved business relations, partnerships and many more.

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