A NEXT GENERATION CONTAINER PORT

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Containerized transportation is an essential part of the intermodal freight transport. Millions of containers pass through container terminals on an annual basis. Managing containers handled by different modalities significantly affects the performance of terminals. Terminal operators are always searching for new technologies to achieve higher efficiency. The proposed next generation high-density container tower system (see Figure 1) is mainly introduced to increase the footprint utilization in order to achieve high throughput within a given land profile. For such systems the use of footprint is much smaller than the footprint required for traditional container ports. Therefore, the saving obtained from the smaller land area might offset high cost of technology. Our proposed next generation container port can increase the storage density significantly. By storing containers in towers of 150 meters, containers can be stored up to 45 levels high, reducing the required land and footprint. Additionally, in a container tower each container is individually accessible as no reshuffling is required.

Supply chain visibility aims to improve supply chain performance by providing reliable data to different nodes in the supply chain including port terminals. In our analysis for the proposed design we answer the following questions:

1. What is the cost of a next generation port compared to traditional ports?
2. Is a next generation port better (in terms of environment) than a traditional system?
3. What is the performance of our proposed next generation port of a given storage capacity?

To investigate the cost feasibility of our proposed system, we compare our proposed next generation container port with the real data obtained from a traditional container terminal. According to our analysis, container storage towers can reduce the required footprint about 66%. Our analysis shows that if the investment in technology and building for the next generation port is up to 1.7 times larger than the traditional port, next generation port still remains cheaper in terms of investment. Based on our results, the investment cost of a next generation port will be increased up to 50%. In addition, use of fully automated container towers results in significant reduction of direct labor cost (due to full automation) and energy costs (fuel and electricity) than the conventional terminals. Although these new container towers might require higher maintenance costs, our results show that in total 16% of operational costs can be reduced by using our proposed container towers instead of conventional container terminals. Thus, our next generation port design will be completely financially feasible compared to current conventional port terminals.

The use of the latest technologies in our next generation port terminal makes it a relatively 'green' terminal. For vertical movements, container storage towers operate with electrically powered lifts, which lead to significantly reduced fossil fuel and energy consumption, and CO_2 emissions compared to traditional straddle carrier crane-based storage systems. For horizontal transport, diesel-electric automated guided vehicles (AGVs) are used which consume 30% less fuel and consequently cause less CO_2 emissions compared to their earlier generations. The average storage and retrieval time of a container can be obtained based on tower dimensions and speed of the lift. By using average storage and retrieval time and engine power, the average energy consumption for each tower can be calculated. In addition, the energy consumption for horizontal movement can be calculated based on the average distance traveled by an AGV and the engine power of an AGV. The total energy consumption can be obtained based on annual throughput of the terminal. CO_2 emissions can be obtained by using life cycle analysis based on energy generated by different types of power plants. The results show that in a next generation container port, although the lifts for vertical movements require powerful engines to hoist heavy containers, the travel distance of AGVs will be decreased significantly in horizontal direction. Hence, the energy saving from AGV movements can offset additional energy consumption by the lifts. Comparing the total energy consumption of our proposed next generation port with real data of the total energy consumption of a container terminal shows that in total 59% reduction in energy consumption and as a consequence CO_2 emissions can be achieved. This reduction is even more significant for CO_2 emissions if electricity is provided by a fossil-fuel power plant.

This research can be extended in various directions. Our computational model and analysis is based on little transparency and visibility within the supply chain (worst case scenario). For instance, we consider a random storage assignment policy as the control policy for the container towers (containers are randomly assigned to storage locations). However, storage assignment of container based on their duration of stay (DOS) can improve the performance of such systems significantly. A two-class-based storage policy can simply be implemented in practice by classifying containers in high turnover and low turnover classes based on their duration of stay. The high-turnover containers are then assigned to locations closer to the pick-up/drop-off point. The results show that such a storage policy can reduce the response time up to 50% compared to a random storage policy.

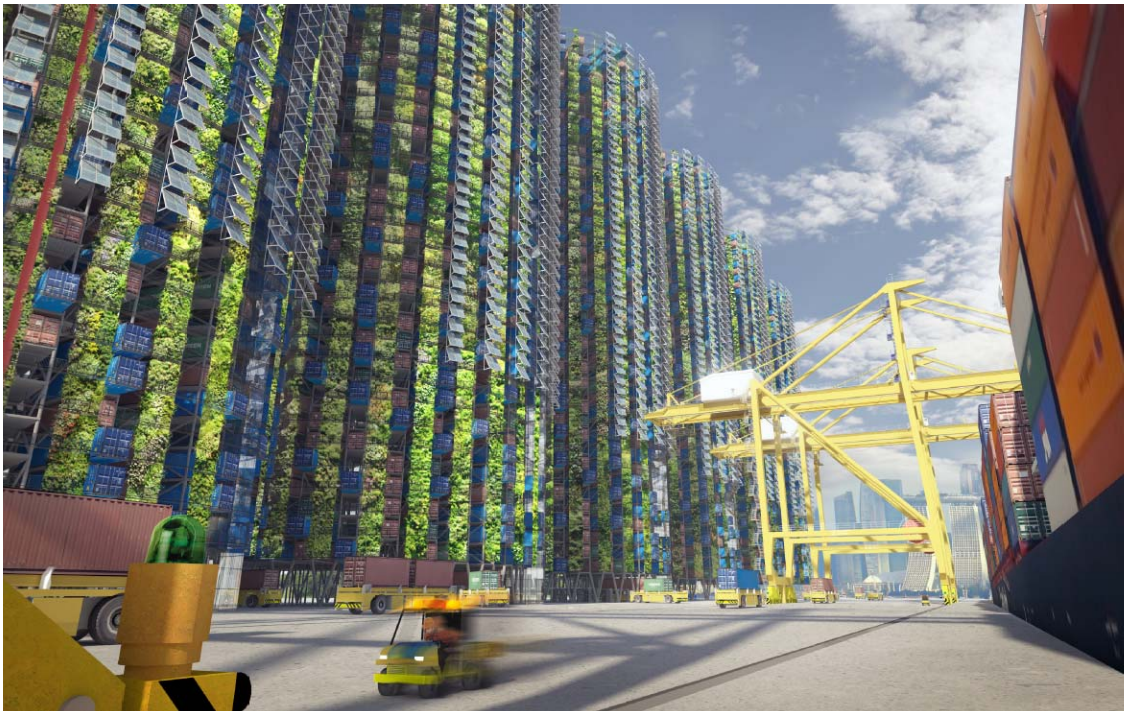

Figure 1. A next generation high-density container tower port (image courtesy of *Casanova+Hernandez*)