The Impact of KVA on Port Electrification

for Trucks, Top Loaders, and RTG's

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California Energy Commission (CEC) together with the Ports in California and the Port tenants and operators are working together to electrify the trucks, Top Loaders and RTGs (Rubber Tired Gantry crane) operating in the port terminals. All ports in one form or another have established goals to achieve zero-emissions through processes including electrification of their equipment. Utility companies are also involved in this effort, and will support the goals to be accomplished in a cost effective and timely manner.

At P2S Inc., staff and management have been brainstorming what opportunities are available to achieve the goal, and what method to follow, to assure successful results. We looked back at gantry cranes when they first came into operation and how they grew to what they are today at the ports as well as the reefer installations, and more recently with the “cold ironing” of ships in the ports. Electrification of gantry cranes, reefers and ships have similarities when compared to electrification of trucks, top picks and RTGs. Hence, it is worth giving a moment to think about the requirements for electrification of trucks, top picks and RTGs and apply lessons learned from the electrification of gantry cranes, reefers and ships to avoid pitfalls of the past.

In this article, an attempt is made to quantify the electrical requirements during electrification of port terminals, and provide recommendations to accomplish this goal, in a cost effective manner.

CRITICAL DECISIONS FOR MANAGERS IN ELECTRIFICATION

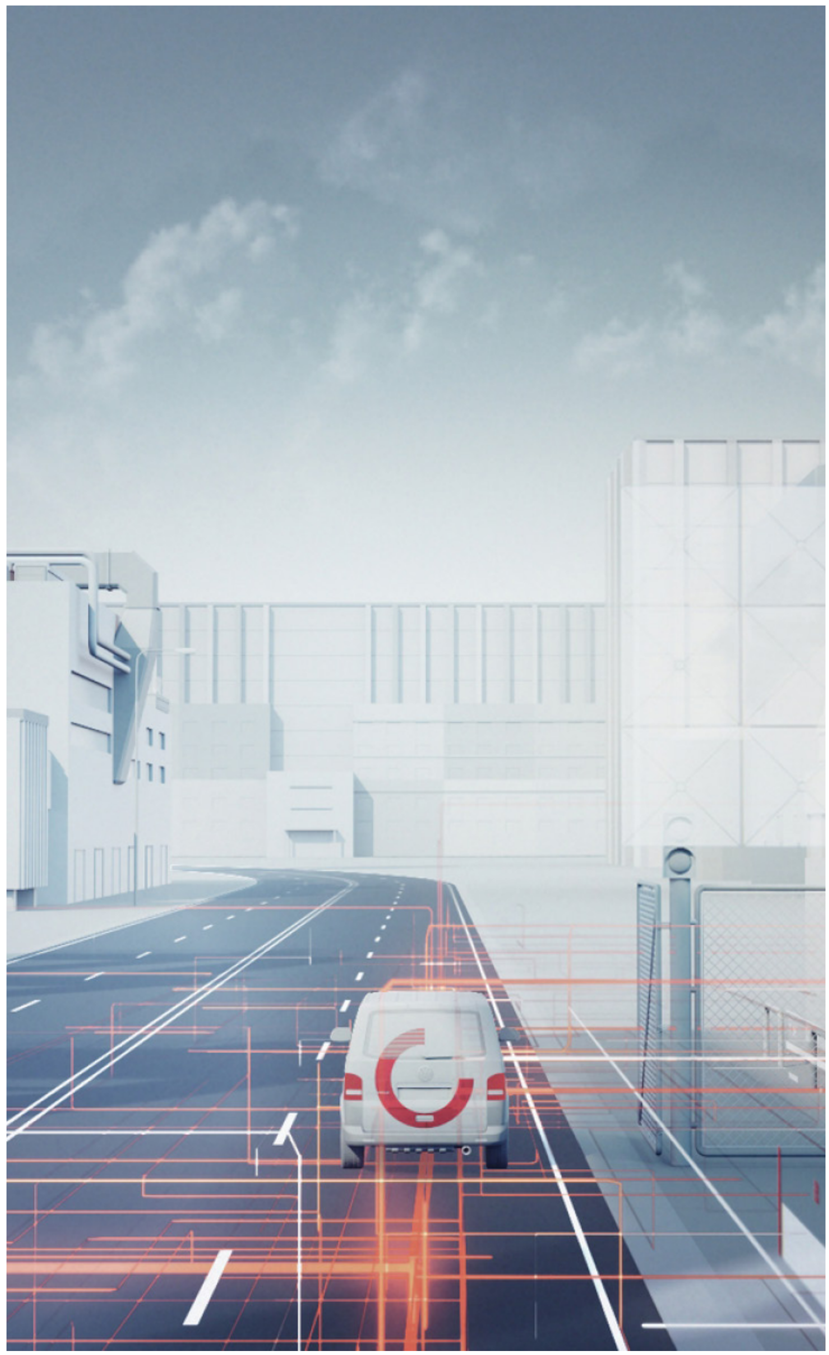
After a decision is reached to electrify trucks, top loaders or RTGs, the next step is to decide the quantity of these vehicles required for the project. Although this quantification is not an easy process for managers, once this quantity is determined, the second challenge is to determine what the kilo-volt ampere (KVA) requirement is for the truck, top loader or the RTG. Without a determination what this KVA rating is, it would be impossible to proceed with the design necessary for any electrification project.

WHAT IS KVA AND KW?

The number that measures how large an electrical installation is, can be defined by a unit called the kilo-volt-ampere, commonly referred to as KVA. The larger the KVA number required for an electrical equipment, means larger equipment. KVA is a unit similar to kilo-watt (KW). One KVA is equal to 1000 volt-ampere (VA). Similarly, 1 KW is equal to 1000 Watt (W).

Electrically speaking, KW of power is needed for an equipment if that equipment was 100% efficient. However, due to inefficiencies, the electrical power delivered to that same equipment would be measured by KVA, which the utility company would have to produce, deliver, and charge accordingly to the end user.

For this paper, we will assume KVA and KW are the same and will refer to KVA unit, as the electrical power needed for the trucks, top picks and RTGs, as we compare the effect and the burden these machines contribute in the electrification of a typical port terminal and operation. To reference how much electrical power is in KVA, a typical wharf gantry crane is rated at 1500 KVA. A reefer container is rated at 15 KVA.



WHO DECIDES THE KVA RATING?

Anyone involved in an electrification project can determine what the KVA rating should be for a truck. A port commissioner certainly has the authority to decide, as well as the executive director of the port, and the program manager. There are many individuals involved in a project who have the authority to determine what KVA rating should be used for a truck. Present rules, procedures, and codes allow this freedom of decision.

WHAT IS THE COST IMPACT OF THE KVA RATING?

The cost impact of KVA ratings in an electrification project is substantial. If the KVA rating assigned is lower than a minimum number required for the proper operation of a truck, then the project would result in a failed installation, and will not serve the purpose. An attempt to salvage the installation would be expensive to maintain and be potentially abandonded. If the KVA is higher than necessary, the installation cost would be more expensive, and the maintenance and utility charges will be excessive.

ARE THERE OTHER CONSIDERATIONS BESIDES KVA?

Yes, there are many other considerations to make sure costs of electrification of trucks remain checked, however KVA rating tops the list. Other important considerations are what electrical demand to use, or how fast the trucks will charge their batteries. In this short article, we will only discuss briefly the impact that KVA decision has on an electrification project.

KVA USE CASE - THE RIGHT KVA RATING

Let's use an example of installation for electrification of trucks only where the quantity involved is 100. To enable the electrical design, the KVA rating of the truck needs to be determined. Some projects may determine that 300 KVA per truck is adequate. Yet there are some, who claim 1000 KVA is needed for the truck. Some end users, who want to reduce the charging time for their trucks, request a designer to use of 1500 KVA. What is the correct KVA in this example? At one extreme, using 300 KVA per truck, for 100 trucks, is like adding 20 cranes in a terminal. At the other extreme, using 1500 KVA per truck for 100 trucks, is like adding 100 cranes in a terminal. In this example, one can easily see the impact and the importance of the KVA assigned for each truck.

WHO IS THE BEST AUTHORITY TO DETERMINE KVA RATING FOR TRUCKS?

Under the present circumstances where projects are evaluated and authorized to proceed to design, such procedures do not allocate the time required to consider the determination of KVA ratings. In order to proceed with the electrical design, the designer must have this KVA rating. With no other option available to an electrical designer, and no guidance from management, the electrical designer alone determines a KVA rating. Taking what the designer feels may be the safest approach, this rating is usually ranked on the higher end. This approach results in an installation and maintenance that is much more expensive for the end user with no real benefit.

In the present environment, the best authority to determine the KVA rating for trucks, would be the highest ranking executive in an organization, who has a direct interest in making sure costs remain checked. Port commissioners, port executives and terminal operators are in position to influence reaching the proper KVA determination by inquiring:

1. Why 1500 KVA and not 300 KVA per truck?
2. What demand factor is being used in design? Why this demand factor and not higher or lower?
3. Demonstrate how the electrification installation would change, because batteries can be charged in 15 minutes, instead of 4 hours?
4. For the project, who determined what the KVA rating is for the truck? Is this an industry standard? Where is the standard?

Understanding the impact of such questions by an authority will influence and control the cost of the electrification project. Otherwise, the result will be either unsatisfactory or more costly than it has to be.

KVA IMPLICATION ON COST

Properly applied KVA rating for a truck, top loader or an RTG, would reduce installation cost by 50% to 75% compared to an installation without such considerations. In some cases, maintenance cost will be eliminated altogether, due to elimination of unnecessary equipment and installation.

ELECTRICAL CAPACITIES OF PORT TERMINALS IN PAST YEARS

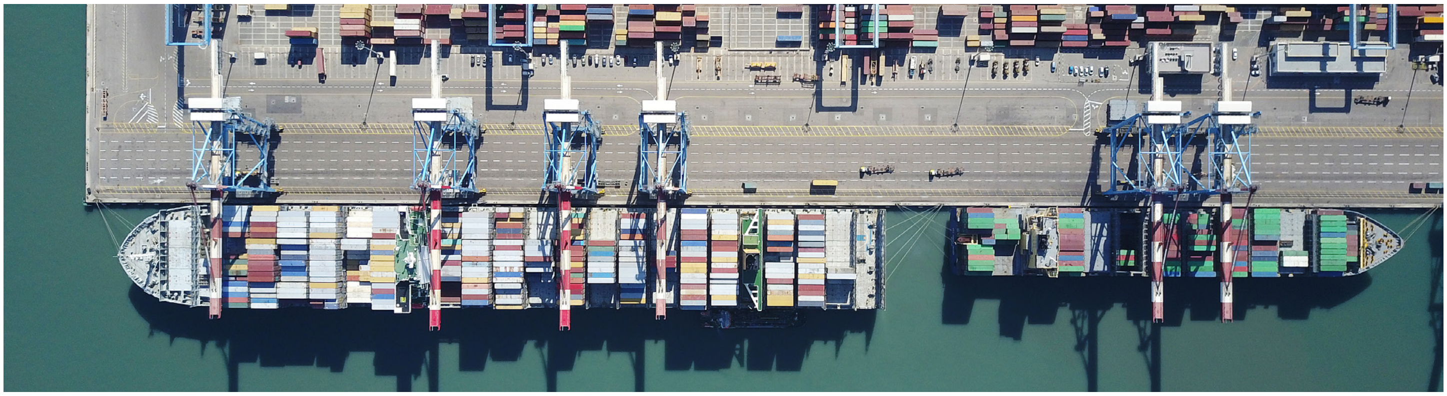
During a recent brainstorming session at P2S regarding the topic, today's gantry cranes in comparison to earlier models, are significantly heavier, therefore the electrical requirements for current gantry cranes have experienced similar increases. For instance, the early cranes were rated around 300 KVA, whereas today it is not uncommon to see cranes that are rated 1800 KVA. Dual hoist cranes, which host two lifts on a single structure, are rated at 3000 KVA each.

Ships that are currently subject to "cold-ironing", are considered to be electrically large equipment with large loads in an installation. Container ships require anywhere from 1500 KVA to 3500 KVA when they are at berth at a port. Cruise ships on the other hand, will require 10,000 KVA to 15,000 KVA electrical power.

Reefer containers are considered to be smaller in regards to electrical rating, compared to gantry cranes and ships. However reefer container quantity in a typical port terminal contributes greatly on the electrical facilities required to serve a port terminal. When they were first introduced, reefer containers required about 10 KVA each, however, only 30 of these reefers were equivalent to a gantry crane in the past — Some previous designs rated each of these reefers at 25 KVA. The quantity of reefers in a typical port terminal has also increased considerably with 1000 to 2000 reefers in a new port development. Even at 1000 reefers, if 25 KVA rating is applied, it will burden the terminal's electrical installation by 25,000 KVA (1000 x 25). Such an installation, compared to a ship that requires 3500 KVA power, would mean the reefer load is equivalent to having approximately seven ships "cold-ironing" at a port terminal.

ELECTRICAL CAPACITIES OF PORT TERMINALS IN NEAR FUTURE

Leaders within the port industry are considering electrification of trucks, top loaders and RTGs. What impact will this have on the electrical facilities in a port terminal? Answering this question brings the industry closer to its common goal of a zero-emission standard. At P2S we have been following these developments and are brainstorming the options available to minimize installation and maintenance of these facilities, as well as contribute to a cost effective installation.



COMPARISON OF TRUCKS WITH "COLD IRONING"

Based on past experience with gantry cranes, ships and reefers, it's worthwhile to determine the KVA requirements for the trucks, top loaders and the RTGs. This is not intended to give a detailed explanation of all technical parameters necessary to determine how the KVA rating of these machines are calculated, but rather highlight the important considerations of these machines and their impact on the KVA rating.

From the port terminal operator's perspective, since time saved has enormous value in serving their ships at berth, any operation must be performed quickly. If a truck is operating electrically, this means the vehicle must have stored energy. Stored electrical energy in the batteries placed on the truck are used to move throughout the terminal and haul goods. After hours of operation, the truck will deplete the stored electrical energy from the batteries, which are required to be recharged.

The battery capacity will limit the amount of hours available for trucking service. Port of Long Beach (POLB) and Port of Los Angeles (POLA) conducted a study where it was agreed to standardize the truck capacities at 207 KVA each. Some manufacturers are already providing 300 KW (or KVA) batteries. However, over time the KVA required by each truck will increase, as did the reefers and the gantry cranes. For the sake of this article, 300 KVA will be used for the truck to facilitate analysis.

The number of trucks in a typical port terminal is anywhere from 35 trucks to as many as 170. Once again, for this analysis, let's assume there are 100 trucks in the terminal. Given each container ship requires anywhere from 1500 KVA to 3500 KVA, we will use 2500 KVA, and compare this figure with the requirements of a truck. A truck will require 300 KVA each, which means for 100 trucks in a terminal, the electrical power required for the truck batteries will be 30,000 KVA. In other words, truck electrification will require 12 times more electrical power than one ship in a typical port terminal.

TRUCK CYCLE OF OPERATION

The operational cycle of electrified trucks in a typical port terminal, beginning with fully charged batteries, will have the following four steps:

STEP 1

Truck batteries are charged and wait to go into service to haul containers.

STEP 2

Truck batteries charged and haul containers around the terminal.

STEP 3

Truck depletes the electrical energy from the batteries and needs to recharge.

STEP 4

Truck is taken out of terminal service to re-charge its battery supply.

There are a number of considerations from the operational cycle that are worth analyzing for their impact on port terminal electrification plans. The discussion in this paper is limited to Step 4 only — the truck is "taken out of service for recharging its batteries". There is a desire to keep this out-of-service period as short as possible. Some port terminal operators prefer a 15 minute period, instead of waiting 2-4 hours.

TRUCK CHARGING IMPACT

The electrical power necessary to charge the batteries on the truck will be supplied by the terminal operator. The terminal operator will have to install the electrical infrastructure necessary to facilitate truck batteries recharging. The two parameters for truck electrifications are the KVA rating of the truck, and the time required to charge the batteries. For this report, the truck KVA was set at 300 KVA and the time was set for 15 minutes. Keep in mind that increasing the 300 KVA will increase the electrical power necessary for the terminal operator to deliver. Decreasing the time required to charge the batteries, would make it necessary to increase the 300 KVA to a bigger number, meaning bigger electrical service from the utility company and bigger electrical substations.

TOP LOADER AND RTG CHARGING IMPACT

Similar to the truck charging, top loaders and RTGs will have a greater impact on terminal electrification. These machines require more power in KVA, and will require more stringent requirements for charging as well. It is safe to assume that if electrification of a 300 KVA truck has significant impact on terminal electrification, then a 1000 KVA top loader or RTG will have an even greater impact.

WHAT IS ELECTRICAL DEMAND?

Within any facility in a typical port terminal, not all electrically operated equipment is energized at the same time. When electrical equipment is energized, it's not consuming the maximum electricity it's designed for. For example, when a crane is in operation, although its electrical capacity is approximately 1800 KVA, the crane may not be consuming 200 KVA at any given moment. In a given month, the crane may have required a maximum of 400 KVA, yet the terminal is designed to deliver 1800 KVA. In such a scenario, the 400 KVA is referred to as the maximum demand for that crane. Or, if the terminal was designed so that a maximum of 400 KVA is delivered by the terminal infrastructure design, that crane would operate satisfactorily.

Designing with the maximum demand taken into consideration during a port terminal electrical infrastructure design, means the terminal need not ask the local utility, such as SCE, to deliver 1800 KVA for the subject crane, when only 400 KVA is needed and thus avoid electrical surcharges by SCE to the terminal, due to the excess capacity SCE is obliged to make available, that the terminal operator is not using. Similar to the crane example, the condition is also valid for the reefers, lighting and all equipment that operate on electricity.

Overlooking the effect of demand during design of the electrical infrastructure of a typical port terminal adds substantially to the terminal and electrical design and construction cost. Furthermore, it adds unnecessary costs to the maintenance and operation of the system installed. These are avoidable costs, if the authority making decisions on development and operation of a port terminal was made aware of and interest was directed to apply proper electrical demand.

WHO WILL DECIDE WHAT ELECTRICAL DEMAND TO USE?

Electrical demand is not a new phenomenon. It's been known well in port industry but rarely used. In the past, ignoring such phenomenon was not as costly and utility rules were more forgiving. However with electrification of port terminals and the very large loads that are being considered for electrification, overlooking electrical demand will put a terminal operator at a much greater disadvantage than a terminal operator who learns its impact and takes needed action.

The person who is knowledgeable on the impact of the electrical demand on the terminal usually does not have the authority to apply that knowledge into the design. Unfortunately, the person (or persons) who has the authority to direct the design with electrical demand in mind, most likely is not familiar with the next steps necessary to implement. Hence, the existing and present condition, where electrification of port terminals are progressing, but not at a cost effective manner as they can be.

CHALLENGES AND QUESTIONS FOR PORT AUTHORITIES

Port commissioners, executives and terminal operators should gather their design team and ask, among many other questions, if electrical demand was considered and applied into the development of the electrical infrastructure. It should be clearly shown and demonstrated what the effect of properly applied electrical demand is, such as:

1. Area required for electrical switchgear, will be less.
2. Installation cost will be less.
3. Maintenance of some equipment will be non-existent, because some equipment will not be needed for installation and hence none to maintain.
4. Monthly cost of electrical consumption will be less.
5. What is the effect of 100 trucks, each rated at 300 KVA compared to those 600 KVA?
6. What is the effect on the electrical infrastructure in a terminal, when a truck requires to charge its batteries in 4 hours, in 2 hours, or in 15 minutes?

FINAL WORD

Electrification of ports is an expensive proposition by nature. It is our aim to help control and reduce this cost and maintain competitiveness of those who use these principals over those who don't, and achieve the desired goal of Zero Emissions standards.

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