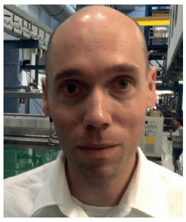

PERFORMANCE IMPROVEMENT IN YARD LIGHTING

A NEW APPROACH

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Seaports – the nexus of trade, logistics, and production – are hugely important in facilitating both national and international trade. Recent decades have witnessed a spectacular increase in freight transport worldwide, 90% of which crosses the sea after loading in seaports. Container transport in particular has been influenced by this increase in global sea transport. For example, the maximum capacity of containerships used to be 10,000 TEU, but this increased over a 10-year period to 22,000 TEU. There are, of course, knock-on effects from these developments that must be addressed by the seaports that have to accommodate incoming, outgoing and transiting trade.

Productivity is the keystone of effective container terminals, and increases in productivity are constantly in demand to keep ahead of developments and remain competitive. In addition to labour productivity, equipment purchases can be a factor in meeting this challenge, as energy consumption constitutes a large share of operating costs. Bigger – and therefore presumably better – generator units, then, are often seen as the solution; but in fact it may make more sense to use smaller generator units. For instance, increasing ship-to-shore (STS) productivity is not an efficient option if the incoming freight cannot be handled at the same speed dockside.

On the outside looking in, however, it is very difficult to guesstimate an individual container terminal's energy consumption, as terminals are understandably cagey about disclosing such information in an industry that is notoriously competitive.

Our team recently completed a work on the EU-facilitated Green Efforts research project, which can be found in a 2017 paper by Duin et al referenced below. That project, which commenced in 2012 and ended mid-2014, was a collaborative research project that had the objective of reducing energy consumption at terminals. From the findings of that project, a terminal's energy consumption profile can be ascertained

Terminal	Length (m)	Width (m)	Height (m)	Light (cd)	Estimated number of masts	Real number	Deviation (%)
DELTA (ECT+APM)	2700	1000	40	300000	75	70	7
APM	1500	500	40	300000	25	27	7.5
Antwerp	1100	400	25	250000	27	28	3.6
Hamburg	500	235	20	200000	16	18	11
Los Angeles	1800	750	40	300000	50	50	0

Table 1: Yard lighting validation results

and consequently improvements can be suggested. In this case, we specifically address yard lighting.

Round-the-clock operations are a feature of many terminals, and consequently yard lighting is typically required for safe and efficient container operations in the hours of darkness.

As already stated, energy consumption constitutes a large share of operating costs, and yard lighting is a significant element of this. For instance, about 15% of yearly energy consumption at the Noatum Container Terminal Valencia (NCTV) was accounted for by yard lighting (2,881,060 kWh electricity) in 2012.

As with many other mechanical operations, specific design and layout standards have been set for lighting in terminals. The whole stacking yard area should have a luminance of more than 20 Lux throughout to ensure staff safety and the safe handling of containers. Furthermore, the average required luminance for different areas of the port is also specified.

The Illuminating Engineering Society (IES) designer's handbook is the source for the port and terminal lighting illumination requirements set out below:

Large open areas	5–20 Lux
Entrances	100 Lux
Buildings/Containers	5–20 Lux
Gatehouses	30 Lux
Perimeter fence	5 Lux

In earlier research, we developed a model of the processes involved in container transhipment at terminals, in terms of terminals' energy consumption and characteristics, in particular in relation to lighting.

Five terminals worldwide were studied to ascertain the validity of the outcomes of our lighting model.

The results in Table 1 show a variation in the deviation of errors between 0 and 11%. Our research revealed that the model is more applicable to larger terminal spaces: the higher the number of lighting poles, the smaller the effect of small deviations. The average difference – 5.82% – is quite low; it is therefore concluded that the models fits rectangular-shaped terminals best.

The energy consumption and the related carbon footprint can also be computed. For the ECT Delta and the APM Rotterdam terminals, the model calculation revealed that, with 40 metres high, 300000 candela (cd) intensity:

48 (75-270 lighting poles are needed for ECT Delta terminal, giving an electricity consumption of:
48(NL)×16(Nb)×2kW(Pb)×365x12h(TL) = 6.7 million kWh

27 lighting poles are needed for one APM Terminal in Rotterdam, giving an electricity consumption of:
27(NL)×16(Nb)×2kW(Pb)×365x12h(TL) = 3.7 million kWh

On the basis of the Netherlands' geographical location, it is assumed that 12-hour lighting operations are necessary because of the 24-hour working day. In the ECT Delta and APMT Rotterdam examples above, given that Dutch CO_2 emissions per kWh generated are 370g, their respective annual carbon footprint for yard lighting energy consumption is:

6700000 kWh*0.37 kg/kWh= 2479000 kg=2479 tons CO_2

3700000 kWh*0.37 kg/kWh= 1369000 kg=1369 tons CO_2

High Pressure Sodium (HPS) lamps are currently used at the ECT Delta terminal, but the terminal could instead use the more energy-efficient Light Emitting Diode (LED) lamps. The higher investment cost involved in purchasing the latter, however, prevents prospective users from immediately recognizing the financial benefits of increased efficiency of LED lamps. Nevertheless, the lifetime of LEDs is significantly longer than that of HPS lamps, and LEDs warm up more quickly. If the ECT Delta terminal (number of masts = 48) implemented the recommendation to change to LED lamps, it could realize annual savings of €350,124, principally because of reduced energy consumption, thereby achieving a significant CO_2 footprint reduction of 1,058 ton CO_2 per year. The benefit of implementing a change from HPS lamps to LEDs has not only economic but also environmental/societal benefits, in that the light from LED lamps is not thrown as far as light from HPS lamps, and consequently residents living near a terminal are less subject to light pollution.

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ABOUT THE ORGANIZATION

Delft University of Technology, also known as TU Delft, is 175 years old in 2017. It is the largest and oldest Dutch public technological university, located in Delft, the Netherlands. It counts as one of the best universities for engineering and technology worldwide, typically seen within the top 20.

Founded in 1913, Erasmus University Rotterdam is a highly-ranked, international, research university within the Netherlands with a student population of 23,000 and a research community of circa 1,400 scholars.

Jacobs University is a private, English-language campus university with the highest standards of research and teaching. Young people from around the globe become citizens of the world with leadership qualities at Jacobs University in Bremen.

The Rotterdam University of Applied Sciences, also known as Hogeschool Rotterdam, is a vocational university located in the city of Rotterdam, Netherlands. It was created in 1988 by a large-scale merger of 19 higher education schools followed by a merger with the Hogeschool voor Economische Studies. It teaches at ten campuses in Rotterdam and one in the nearby city of Dordrecht.

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