Design of Electrical Infrastructure at Container Terminal and 'Net Metering'

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Abstract - Net metering is generally a consumer-based incentive for renewable sources such as wind or solar power systems also referred to as 'cogeneration'. It is still a grey area for container terminals with large electric machines, such as quay cranes, automatic stacking cranes, that can operate in the regenerative mode and export electric energy to the grid. With actual measured electrical data presented for discussion, this paper provides information for the readers to provide a better understanding of their access to net metering, ultilizing their electrical equipment capabilities and be informed for their next negotiation with the power supply company

1. Introduction

"Net metering" with Net used in the sense of meaning "what remains after deductions", in this case, the deduction of any energy outflows from metered energy inflows. Under the net metering scheme, consumers who have facilities, that are capable of exporting generated electricity back into the grid, receive credit for such generated electricity.

Currently, there are net metering laws or regulations in most of the developed countries. However, net metering under these laws is generally a consumer-based incentive for renewable sources such as wind or solar power systems also referred to as 'cogeneration'.

It is still a grey area for container terminals with large electric machines, such as quay cranes, automatic stacking cranes, that can operate in the regenerative mode and export electric energy to the grid. Most of the terminal operators are not aware of the magnitude of such regenerative energy and they just assume that such energy would be consumed within the terminal.

This paper studies the regenerative energy generated by the quay cranes, then discusses the effect of net metering on the designing of electrical infrastructure at container terminals.

Fig. 1. Container Terminal in Australia

Fig. 2. Container is loading on to ship

2. Measure data for study

The measurement was carried out at a substation that supplies five quay cranes and 448 refrigerated container (reefer) outlets, at a container terminal in Australia.

Schneider circuit monitor CM3250 is used at the high voltage supply end of each quay crane to capture the electrical data, these CM3250s have on board memory to log data every second.

The reefers are supplied via two 2MVA transformers, Schneider power meter PM650 is used at the low voltage end of each transformer to capture electrical data every minute. Fig. 3 shows the actual supply arrangement.

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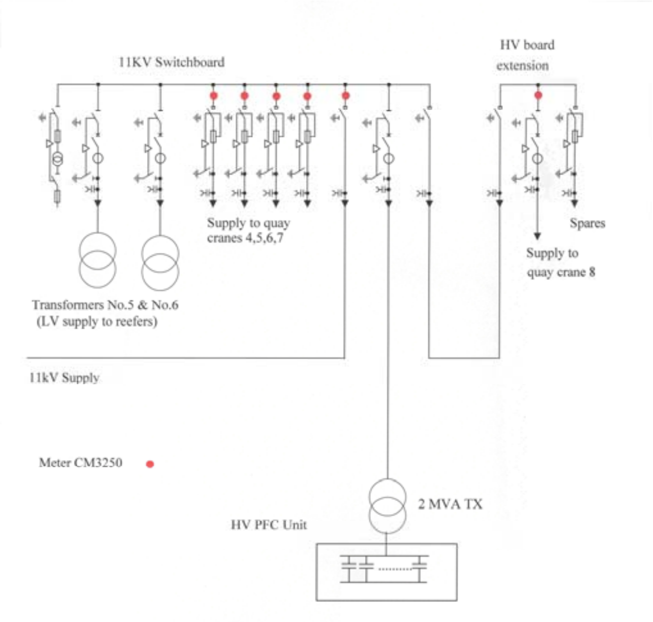

Fig. 3. Supply arrangement of substation

All circuit monitor CM3250s are set to measure energy in "signed mode" that is the CM3250 considers the power flow direction as per extract from its user manual shown in Fig. 4.

TABLE 1
ENERGY READINGS
Copy of Table 4-3 from Schneider CM3250 User Manual

Accumulated Energy, Incremental	
Real (In)	0 to 999,999,999,999 Wh
Real (Out)	0 to 999,999,999,999 Wh
Reactive (In)	0 to 999,999,999,999 VARh
Reactive (Out)	0 to 999,999,999,999 VARh
Apparent	0 to 999,999,999,999 VAh
Reactive Energy	
Quadrant 1 [1]	0 to 999,999,999,999 VARh
Quadrant 2 [1]	0 to 999,999,999,999 VARh
Quadrant 3 [1]	0 to 999,999,999,999 VARh
Quadrant 4 [1]	0 to 999,999,999,999 VARh

[1] Values can be displayed on the screen by creating custom quantities and custom displays

The circuit monitor can accumulate the energy values shown in Table 4–3 in one of two modes: signed or unsigned (absolute). In signed mode, the circuit monitor considers the direction of power flow, allowing the magnitude of accumulated energy to increase and decrease. In unsigned mode, the circuit monitor accumulates energy as a positive value, regardless of the direction of power flow. In other words, the energy value increases, even during reverse power flow. The default accumulation mode is unsigned.

Fig. 4 Extract from the circuit monitor CM3250 user manual

3. Results

Electrical data was captured during actual working conditions: loading containers to container ship. At the same time, loading sequence and container weight are also recorded. Fig. 5 shows graph of Real Power (kW), Reactive Power (kVAr) and Apparent Power (kVA) of one quay crane working on the same ship hold, ie. minimum usage of gantry motion.

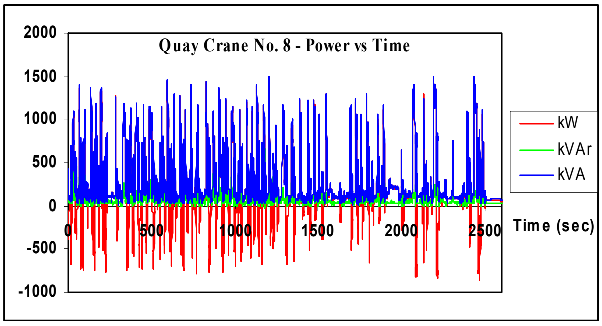

Fig. 5. Quay crane No.8 – Captured 1 second data – Graph of powers vs time.

Calculation shows that in average the regenerative energy produced when the quay crane lowering the load is 28% of the energy draw from the grid. The results are summarized in Table 2.

TABLE 2
QUAY CRANE NO.8 – RECORDED FOR I HOUR

Measured Data	Value
Loads (including Hatch lids – 20T)	29
Load Weights	b/w 7T & 48.4T
kWHr Import from grid	157.10
kWHr Export to grid	43.60
Net used energy (kWHr)	113.50
kWHr Export / kWHr Import (%)	28

The same calculation is performed on a typical quay crane loading cycle. Fig. 6 shows the power curves of the same quay crane when loading 26T container and the results are shown in Table 3. In this case, the regenerative energy is 30% of the energy drawn from the grid.

TABLE 3
QUAY CRANE NO. 8 – LOADING 26T

Measured Data	Value
kWHr Import from grid	5.55
kWHr Export to grid	1.65
Net used energy (kWHr)	3.90
kWHr Export / kWHr Import (%)	30

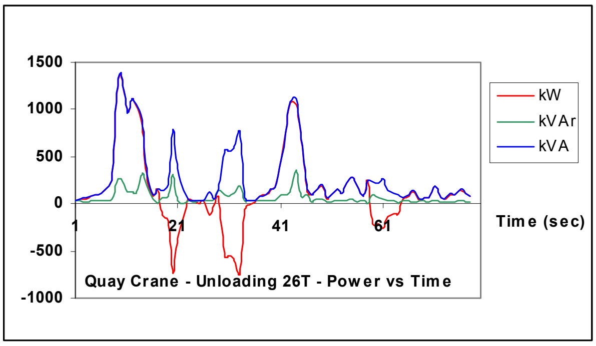

Fig. 6. Quay crane No. 8 – Captured 1 second data – Graph of powers vs time for one loading cycle: Lock container - Hoist – Hoist & Cross travel – Lower – Unlock container – Hoist – Hoist & Cross Travel – Lower & land on top of next container.

For container terminals, net metering program is still a grey area. When the matter is raised, normal responses from the Utilities are:

a. the customer is not licensed to sell electricity
b. the quality of regenerated energy is not at an acceptable level
c. the amount of export energy is too small
d. the exported energy is not metered and it will cost customers to implement a metering system.
e. it is not a legal requirement to provide net metering for container terminal customers.

All these responses are just excuses to avoid and/or delay the introduction of net metering program.

It is also very hard to find out how the billed energy consumption (kWHr) is determined. It could be (i) the total energy drawn from the grid (kWHr Import from grid), (ii) the net used energy or (iii) the sum of import and export energies (unsigned mode for Schneider CM3250).

The amount of regenerative energy is dependant on the skill of the quay crane drivers, the container weight and the final positions of the handled containers. Data obtained in this study shows that in average, the energy required to handle one container:

Drawn from grid 5.5 kWHr
Regenerative 1.6 kWHr

For an average container terminal that handles around 100,000 containers per month or 1,200,000 containers per year, then when net metering is introduced, the electricity saving would be 160,000 kWHr per month or 1,920,000 kWHr per year.

Another way of viewing the situation is that if net metering is not available, that is the Utility does not recognize the regenerative energy, then the container terminal would lose 160,000 kWHr per month or 1,920,000 kWHr per year as in above example.

If the regenerative energy can be consumed within the container terminal (by reefers, office, work shop…) then net metering would not have a big impact on the electricity cost.

The container terminal in Australia, at which this study was carried out, has been electrically designed with the view of internal use of regenerative energy. As can be seen from Fig. 3, a based load of 448 reefer outlets are on the same bus bar as the high voltage supply to the quay cranes.

Snap shots of power usage within the substation were recorded every second for 9 minutes. The number and size of the reefers are also recorded. Fig. 7 shows the power usage of each equipment and total load on the high voltage switchboard.

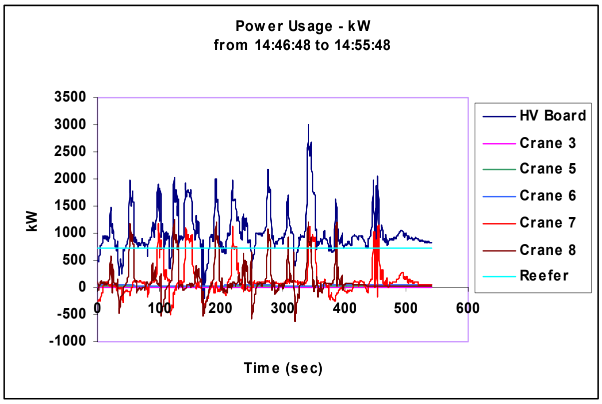

Fig. 7. Power curves – snap shot of power usage of the substation

It can be seen from the graph that:

a. Cranes No. 3, No. 5 and No. 6 are not working
b. Reefers load (194 off 20' + 51 off 40') is around 750kW
c. Regenerative energies from cranes No. 7 and No. 8 are used by the reefers
d. When both cranes No. 7 and No. 8 were lowering the load, more than 750kW was regenerated

The energy usages are summarized in Table 4.

TABLE 4
POWER CONSUMPTION – SNAP SHOT

	kWHr	kWHr Import	kWHr Export
HV Board	151.7	151.8	0.1
Crane 3 (DC)	0.0	0.0	0.0
Crane 5 (DC)	3.1	3.1	0.0
Crane 6 (DC)	5.7	5.7	0.0
Crane 7 (AC)	18.1	22.4	4.3
Crane 8 (AC)	16.0	20.4	4.4
Reefers	108.8	0.0	0.0

During this monitoring period, cranes No. 7 and No. 8 regenerated 20.3% of energy that they have drawn from the grid. Unused regenerative energy is 0.1 kWHr. The unused regenerative energy would be higher if all quay cranes are working.

Without net metering, container terminals that do not have large base load such as the reefers, should consider using a "peak lopping" or 'energy storage" device for storing the regenerative energy. Negotiation with the power supply company is still the best option.

4. Conclusions

With actual measured electrical data presented for discussion, this paper provides information for the readers to gain a better understanding of their access to net metering, ultilizing their electrical equipment capabilities and be informed for their next negotiation with the power supply company.

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