Solar power for marine terminals: generating energy and public acceptance

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Modern marine terminals face increasing demands for electric power. The emerging use of electric terminal tractors can only expand the current requirements for delivering shoreside vessel power and supplying power to operate electric yard cranes. At the same time, terminals face a public relations problem because they are seen as heavy consumers of energy that is drawn from polluting, nonrenewable sources. Although the consumption of electricity produces no emissions locally, it is well known that significant quantities of undesirable pollutants may be emitted at the generating site. Generating renewable power on-site at the port terminals can significantly reduce this off-site pollution, improve public opinion of the ports, and reduce the terminal's energy expenses. Container terminals in sunny climates are particularly good candidates for on-site solar power generation.

Finding space for solar panels

Installing photovoltaic (PV) solar panels on building roofs is already common in sunny climates. Buildings account for a relatively small fraction of a container terminal's area, but even a medium-sized terminal of 150 acres (60.7 ha) offers as much as two acres (0.8 ha) of roof space when maintenance and repair buildings are included. Ports that also manage near-dock warehouses may have even greater potential for rooftop electricity generation, since most existing roofs can support the added weight of PV panels without requiring structural reinforcement.

Employee parking lots offer additional space for solar generation facilities. Canopy structures topped with PV panels not only enhance parking by keeping the cars cooler during sunny days, they also provide a very visible sign of the terminal owner's commitment to sustainable energy practices. PV-topped canopies over 500 parking spaces (each covering 200 square feet, or 19 m^2) would add another 2.3 acres (0.9 ha) of generating capacity.

Larger canopies could be installed over wheeled reefer parking stalls to create additional PV acreage – while reducing power demand by providing shade for the reefers. Covering 300 reefer spots, each consisting of 400 square feet (37.2 m^2), can provide an additional 2.7 acres (1.1 ha) of PV area. Similarly, reefer racks used in straddle carrier terminals could be equipped with PV-topped shade canopies.

Figure 1. Dual-Cantilever Rail-Mounted Gantry (RMG) in Hamburg.

TABLE 1: PV GENERATING CAPACITY ON A MEDIUM-SIZED CONTAINER TERMINAL

Terminal element	number	unit size (sf)	total size (sf)	Peak KW	Mean KW	Annual MWh
Buildings	1	80,000	80,000	616	114	1,000
PV parking canopies	500	200	100,000	770	143	1,250
Reefer canopies	300	400	120,000	924	171	1,500
Dock cranes	10	2,500	25,000	193	36	310
Portal RMGs (CY)	50	3,000	150,000	1,155	214	1,880
Cantilever RMGs (IY)	6	12,000	72,000	554	103	900
Electric tractors	100	120	12,000	92	17	150
Total PV area			**559,000**	**4,304**	**798**	**6,990**

Dock cranes also offer space for PV panels. Electric cranes are already connected to the power grid, and most cranes have the ability to generate power when lowering containers. This power can be fed back into the local grid. Therefore, additional wiring for solar PV generation should be relatively simple to install. Furthermore, rail-mounted gantry (RMG) cranes can be covered with PV-topped canopies. A medium-size terminal may have 50 end-loaded portal RMGs in the container yard (CY), each of which could be equipped with 3,000 square feet (278.7 m^2) of PV canopy. Dual-cantilever RMGs like those typically used to work rail intermodal yards (IY) have a very wide footprint, and therefore represent excellent generating capacity. A single machine similar to the RMG shown in Figure 1 could be equipped with a canopy of 12,000 square feet (1,114.8 m^2). In addition to power generation, canopies on RMGs may provide useful weather protection during crane maintenance.

PV panels can even be installed on smaller equipment. For example, the cabs of electric yard tractors and carts could be covered with canopies. Because these machines are battery operated, a direct infusion of solar energy could extend their daytime operating range between charges.

Solar power payoffs

Table 1 summarises the generating capacity for a medium-sized terminal that makes full use of electric equipment. These calculations assume the production of 7.7 watts per square foot

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(0.7 W/m²) of solar PV panels under peak conditions, and an annual 24-hour mean rate of 1.43 watts per square foot (0.13 W/m²). Over the course of one year, one square foot of solar panels would produce 1.43*365*24 = 12,530 watt-hours or 12.53 kWh of power. Actual output will vary considerably by location, but this is a representative value for reasonably sunny locations.

The table suggests that a medium sized terminal may generate 0.4 to 0.8 MW of power on average depending on the number of terminal elements that can be used. As a point of reference, a vessel plugged into shoreside power typically draws approximately three MW of power so even with very aggressive use of solar panels, terminals will still receive the majority of their power from the local grid. Generally, most or all of the power generated on site by PV panels is used on site, and displaces the need to purchase equivalent power from the grid.

The ability to run reefers and RMGs at some minimal level during daytime even with a loss of grid power may appeal to operators with unreliable grid power. Reefers for example draw approximately 3KW of power, which is similar to the peak output from a reefer shade canopy topped with solar panels.

An additional subtle benefit of on-site solar electric power generation is that solar systems produce the most power during daytime operations, when both terminal electric demand and utility electric rates for grid power are highest.

Most PV panels have a warrantee of 25 years or more, making them a good long-term investment and fit for container terminals, which typically feature leases of 25 years or longer. The relative cost and payback period for solar PV depends on local output, grid power costs, and relevant subsidies. Due to the location-specific nature of the cost analysis, we have not included sample calculations here. However, a payback period of 10–15 years is typical today for most solar PV systems in sunny climates, depending on the tax benefits and incentives that can be applied to the project.

Figure 2. Electric cart equipped with solar PV canopy.

Powerful public relations

The public often views ports as 'necessary evils' that provide jobs and facilitate commerce but are relatively dirty and not likely to devote resources to being 'good neighbours'. The use of a 'green' power-generation technology such as solar panels is a very effective public relations tool for ports and terminals because it is so easy for the public to see and understand. In fact, aggressive use of solar panels may be one of the easiest and most effective ways for container terminals to enhance their public image – as well as their long-term bottom line.

ABOUT THE AUTHORS

Mark Sisson, PE, is an associate vice president in DMJM Harris's marine terminal analysis group, using their computer simulation analysis models to support the terminal planning process. He has worked on marine terminal planning and analysis projects throughout the United States, as well as in Korea, Hong Kong, Rotterdam, and Jamaica.

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ABOUT THE COMPANY

DMJM Harris has provided port planning, design, and construction management services since 1927, and recently enhanced its marine terminal planning and simulation capabilities by acquiring JWD Group. With a staff of over 2,200 professionals, DMJM Harris is the flagship transportation component of AECOM, a global professional services corporation. AECOM has recently been ranked by Engineering News-Record as the USA's #1 design firm in transportation, and #2 in design of marine facilities, and has completed over US$500 million in energy projects.

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