Terminal Equipment Electrification

Impact to Operations

Presentation by Bart Vermeer





Zero Emissions Drivers

Regulation

Decarbonization objectives own organization

Customer demand

Community demand





Electrification

Equipment is the Starting Point

- > Innovation
- > Technology
- > Reliability







Electric Terminal Tractors (UTR)

The Workhorse for Horizontal Transport

- > Battery powered equipment has limited range
- > It takes time to recharge
- > It increases the peak power demand
- > Battery capacity reduces over time
- Active battery management and systems are required to optimize charging / driving cycle
- > It impacts the terminal layout
- > Plugging / unplugging requires manpower



UTR Charging Strategy

An Example

Parameters	Un	its	Inpu	ts	Ouputs
Battery capacity	kWh		22	20	
Battery power use per hour	kW		18	.0	
SOC	%		20	%	
Charger (average output)	kWh		12	20	
Operating hours	Hours			10	
Charging	Hours		2.0	00	
Connect/Disconnect/Change	Ηοι	ırs	0.1	10	
Degradation remaining capacity	%		85	%	
Degraded battery size	kWh				187
UTR - Base Line					150
Peak Power demand Base line			MW		17.8
UTR (Non Staggered)	150	\$	250,000	\$	37,500,000
Chargers (Non Staggered)	135	\$	110,000	\$	14,850,000
Total UTR + Chargers Non staggered				\$	52,350,000
Peak power demand staggered charging			MW		4.4
UTR	180	\$	250,000	\$	45,000,000
Chargers (Staggered)	33	\$	110,000	\$	3,630,000
Total UTR + Chargers staggered				\$	48,630,000

Operate / Charge Cycle



- Fast charging creates higher peak demand and impact battery health
- > In vehicle charging in breaks means, all equipment charges at same time and create high peak demand
- Staggered charging means swapping vehicles, and cost operational time
- Battery swap requires more batteries and smart exchange station

Battery Capacity Degrades Over Time

Battery Energy Percentage of Initial Battery Capacity (1-5 Years) No Battery Degradation



> Take into account battery degradation over time

Battery Energy Percentage of Initial Battery Capacity (After 5 Years) Includes Battery Degradation



Electrical Demand

Micro Grid

- > Micro grids can alleviate peak demand:
 - > Local power generation (Solar / Wind)
 - > Battery Energy Storage System
 - > Reduced draw from the utility grid (peak shaving)
- > Challenges:
 - > Space for solar/ wind
 - > Cost for batteries (grants and subsidies can help)
 - > Production of sufficient green local power









Impact on Terminal Layout



Staffing Impacts

- > Needs to drive to charging station
 - Innovations with dynamic charging are in development
- Operator needs to switch equipment in case of staggered in vehicle charging
 - > Is there an opportunity to find optimized slots and combine with breaks.
- > The UTR needs to be connected / disconnected to the charger
 - > Who will perform this task?
 - > Is wireless charging the answer?
- > Battery Management
 - Recharging requires monitoring of fleet / battery status, active management of charging stations.



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Electric Top Picks

Workhorse for Container Stacking (in US)

- Machine consumes twice as much as UTR and requires larger battery pack.
- > Type of challenges are similar, however the challenges itself are much bigger.
- > Still a lot of work to do.



Electric RTG

Workhorse for Container Stacking

- > Requires an electrical grid
- > It limits flexibility to switch between blocks
- Combination of Top Pick Operations / RTG operations in same blocks is difficult
- Crossing roads between blocks requires special solutions



Electrification using Various Methods

Bus-bar eRTG



Full Battery eRTG



Cable Reel eRTG



Pros & Cons

eRTG Bus-bar

Pros

- > Flexibility
- Drive-in bus-bar system allows RTGs option of precise location and auto steer
- Drive-in system may be driver-operated or automated

Cons

- > Above-grade electrical infrastructure
 - > Substations, bus-bar system and supports
- > Subject to corrosion, physical damage
- In future layout, top-picks are not present in RTG areas, lessening the likelihood of accidental damage



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Pros & Cons

eRTG Cable & Reel System

Pros

- > Minimum above-grade infrastructure
 - > Substations, cable anchors, and connection points
- > Data Communication
 - Direct fiber-optic cable connectivity to TOS provides potential for remote operation and / or automation

Cons

- > Unassisted aisle crossing requires cable slot and panzerbelt cover
 - Not recommended where top-picks may be present
 - RTG area in future layout does not require toppick access, so cable slot and cover may be reconsidered

Pros & Cons

eRTG Full Battery Powered System

Pros

- > Operational Flexibility:
 - > RTG's reposition freely from block to block
- > Less above-grade infrastructure
 - Substations, chargers and connection points (same as bus-bar and reel)

Cons

- > Limited range and many unknows at this point
- > It still need an electrical grid in the entire yard





Decarbonization

- \rightarrow It is not if, but when
- Electrification is currently the most common path to net zero emissions
- > It requires a holistic approach:
 - > Equipment
 - > Power demand and grid
 - > Space and Layout impact
 - > Labor impact

Thank you

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