S.11 Charge Cycle Optimization and Energy Management for Battery Electric Vehicles

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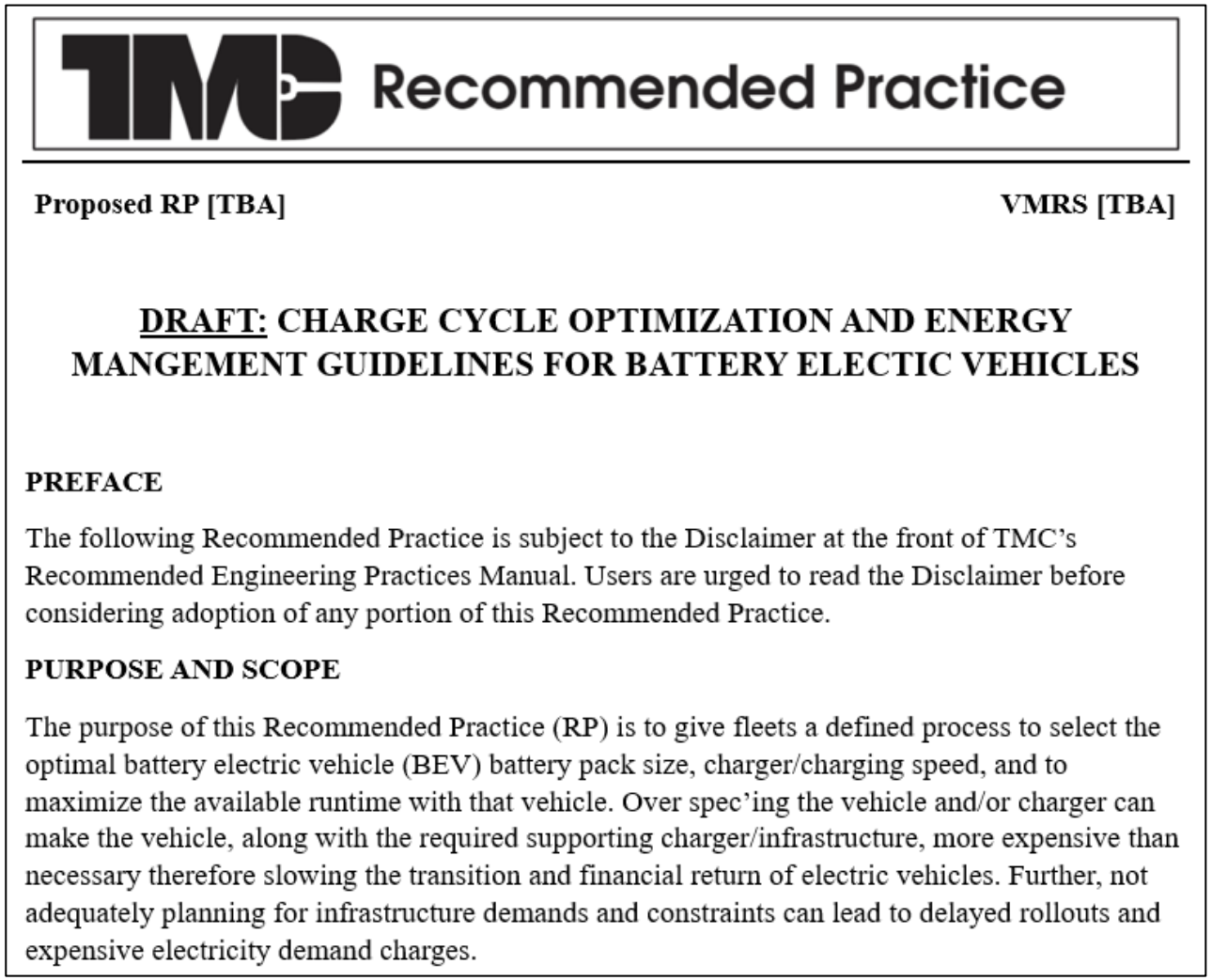
Agenda

1. Antitrust Review
2. Review RP Draft
3. Q&A
4. Volunteer Sign-up
5. Next Steps



TMC Recommended Practice

Proposed RP [TBA] **VMRS [TBA]**

DRAFT: CHARGE CYCLE OPTIMIZATION AND ENERGY MANGEMENT GUIDELINES FOR BATTERY ELECTIC VEHICLES

PREFACE

The following Recommended Practice is subject to the Disclaimer at the front of TMC's Recommended Engineering Practices Manual. Users are urged to read the Disclaimer before considering adoption of any portion of this Recommended Practice.

PURPOSE AND SCOPE

The purpose of this Recommended Practice (RP) is to give fleets a defined process to select the optimal battery electric vehicle (BEV) battery pack size, charger/charging speed, and to maximize the available runtime with that vehicle. Over spec'ing the vehicle and/or charger can make the vehicle, along with the required supporting charger/infrastructure, more expensive than necessary therefore slowing the transition and financial return of electric vehicles. Further, not adequately planning for infrastructure demands and constraints can lead to delayed rollouts and expensive electricity demand charges.

- Technology & Maintenance Council

. . . Turning Experience Into Practice

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- Audio or video recordings are not permitted at this session. However, photography is permissible.
- The opinions expressed in this meeting are those of the individual and not necessarily the opinion of his/her company nor of TMC unless stated otherwise.

ANTITRUST/PATENT DISCLOSURE

- To minimize the possibility of antitrust problems, the guidelines detailed in your registration packet should be followed at all TMC meetings, task force and study group sessions.
- All participants in any group involved in the development of standards or recommended practices shall disclose, as stated in the antitrust/patent disclosure guidelines in your registration packet, all patents or patent applications that are owned, controlled or licensed by the Participant or Participant's employer when the Participant reasonably believes such patent or patent application may become material to the standard or RP development process.

Constructive Comments Are Always Appreciated!

TMC welcomes your comments, but please make certain that they are constructive and appropriate before you turn in your evaluation sheet!

Thank You for Your Cooperation!

S.11 Charge Cycle Optimization and Energy Management for Battery Electric Vehicles

Purpose of Charge Cycle Optimization and Energy Management for Battery Electric Vehicles RP

To give fleets a defined process to select the optimal battery electric vehicle (BEV) battery pack size, charger/charging speed, and to coordinate and maximize the available runtime and benefits of that vehicle.

RP Draft – Structure

Purpose and Scope

1. Vehicle Acquisition Plan
2. Battery Pack Options
3. Estimating Efficiency and Energy Consumption
4. Duty Cycle/Available Charge Time
5. Charging Requirements
6. Site Electricity Rates
7. Site Electrical Capacity
8. Discuss, Document, and Prioritize Goals
9. Evaluate Scenarios and Leverage Data for Decision-Making

RP Draft – Scope

In Scope

- Yard tractors
- Straight trucks
- Over-the-road tractors (day cabs – depot charging only)
- Buses/transit vehicles
- Other vehicles that are domiciled at a single site
- Charging includes on-site/depot charging

Out of Scope

- Transport Refrigeration Units (TRUs) - DISCUSS
- On-road and public charging
- On-site electricity storage strategies, microgrids, and vehicle-to-grid setups

1. Vehicle Acquisition/Deployment Plan

Dates considering purchase decision process, grant award timing, delivery lead times, infrastructure availability, etc.

	Desired Acquisition Timing						
	< 3 months	3-6 months	6-12 months	12-18 months	18-24 months	24-30 months	24-36 months
Yard Truck							
Straight Truck							
OTR Truck							
Other							

Figure 1: Vehicle Acquisition Planning Table

2. Battery Pack Options

Battery capacity and cost

	Battery Pack Options				Cost Difference
	Small		Large		Large Pack - Small Pack ($)
	Size (kWh)	Cost ($)	Size (kWh)	Cost ($)	
Yard Truck					
Straight Truck					
OTR Truck					
Other					

Figure 2: Battery Pack Options Planning Table

3. Estimating Efficiency and Energy Consumption

Capturing estimates and considering drivers of variability

			Estimated Cold Weather Adjustments			Estimated Hot Weather Adjustment
	OEM-Projected Consumption (kWh/hr)	Site-Test Consumption (kWh/hr)	at 32°F (+ x kWh/hr)	at 0°F (+ x kWh/hr)	at -20°F (+ x kWh/hr)	(+ x kWh/hr)
Yard Truck		Test 1 data				
		Test 2 data				
Straight Truck		Test 1 data				
		Test 2 data				
OTR Truck		Test 1 data				
		Test 2 data				
Other						

Figure 3: Efficiency and Energy Consumption Planning Table

4. Duty Cycle and Available Charge Time

A. Calculate total on-site charging time available
B. Truck usage schedule, departure and return times
C. Miles/hours needed
D. Driver shift schedule and break schedule
E. How does this vary by vehicle type?
F. When are the vehicles on site?
G. Where can the trucks be parked?
H. Document break times, dwell times, and other down time available for charging
I. Where is the optimal location for each truck type to be parked/charged?
J. Do available and necessary charge times overlap?
K. Is it feasible or risky to share chargers among different vehicles?

4. Duty Cycle and Available Charge Time (table)

						Duty Cycle: Truck is Working = W; Truck is on-site and can be Charging = C; Truck is Off = O, neither working or charging. Complete for full 24 hours ==>																																															
Vehicle ID	Vehicle Type	Work Profile	Battery Pack Size (kWh)	Energy Use Rate (kWh/hr)	Typical Annual Miles or Hours	8:00 AM	8:30 AM	9:00 AM	9:30 AM	10:00 AM	10:30 AM	11:00 AM	11:30 AM	12:00 PM	12:30 PM	1:00 PM	1:30 PM	2:00 PM	2:30 PM	3:00 PM	3:30 PM	4:00 PM	4:30 PM	5:00 PM	5:30 PM	6:00 PM	6:30 PM	7:00 PM	7:30 PM	8:00 PM	8:30 PM	9:00 PM	9:30 PM	10:00 PM	10:30 PM	11:00 PM	11:30 PM	12:00 AM	12:30 AM	1:00 AM	1:30 AM	2:00 AM	2:30 AM	3:00 AM	3:30 AM	4:00 AM	4:30 AM	5:00 AM	5:30 AM	6:00 AM	6:30 AM	7:00 AM	7:30 AM
Truck 1	Yard Truck	Typical, Mon-Fri																																																			
Truck 2	Straight Truck	Typical, Mon-Fri																																																			
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Other																																																					

Figure 4: Duty Cycle/Available Charge Time Planning Table

5. Charging Requirements

A. Charger compatibility: what chargers work with each truck?
B. Charging connector options
C. Vehicle voltage and fit within charger's range
D. What is important to know about the truck's batteries?
E. Typical and maximum recommended kW charge
F. What is the recommended minimum SOC?
G. What are the charge speeds and infrastructure capacity implications for available/compatible chargers?

5. Charging Requirements (table)

		Charger and Connector Considerations			Recommended Charge Rate (kW)	Recommended State of Charge (SOC) %			
	Vehicle Voltage	Charging Connector Options	Charge Speed	Infrastructure Capacity Implications	Max	Min	"Sweet Spot" High End?	Cost to Replace Batteries ($)	Will Truck Derate to Protect Batteries?
Yard Truck		Option 1							
		Option 2							
Straight Truck		Option 1							
		Option 2							
OTR Truck		Option 1							
		Option 2							
Other									

Figure 5: Charging Requirements Planning Table

6. Site Electricity Rates

Document the full electricity rate schedule for each utility

A. Time of Use (TOU) rates, peak rates, seasonal rates, etc.

B. Demand charge details

Rate Period Definitions					Electricity Rates				
Period		Months Period Applies (e.g., June-Sept)	Days of Week Period Applies (e.g., M-Fri)	Hours Period Applies (e.g., 11:01pm-3am)	Fixed-Fee Base Charge ($)	Consumption Charge ($/kWh)	Demand Charge ($/kW)	Transmission Charge ($/kWh)	Delivery Charge ($/kWh)
Non-seasonal									
Summer	Economy								
	Off-Peak								
	On-Peak								
Winter	Economy								
	Off-Peak								
	On-Peak								

Figure 6: Site and Electricity Rates Planning Table

7. Site Electrical Capacity

Determine the available electrical capacity of the building. The following variables, at a minimum, should be considered:

A. How much total available capacity exists today?
B. What portion of available capacity can be dedicated to EV deployments?
C. What is the timeline and cost to increase available capacity?
D. How can you maximize the current available capacity?
E. Where in the building is it located?

8. Discuss, Document, and Prioritize Goals

A. Maximize Savings vs. Speed of Learnings
B. High-use sites vs. High-visibility sites
C. Maximize truck usage
D. Minimize electrical costs
E. Costs of chargers and ratios of trucks to chargers
F. Future roll-out and expansion plans
G. Other considerations

9. Evaluate Scenarios and Leverage Data for Decision-Making

A. Assess if the optimal scenario available today
B. Fastest path to learning
C. Define what level or average of electricity cost is acceptable to achieve the minimum required ROI
D. Calculate minimum requirements for success and costs to go above minimum ROI
E. Determine ideal battery pack size
F. Determine ideal charging plan – including ratio, mix, and location
G. Guide operations team(s) on how to manage the trucks and charging schedules
H. Assess improved data for Total Cost of Ownership (TCO) calculations and scenarios
I. Define recommended rollout sequence/timing/phases to fit within budget and capacity

Q&A

Volunteers & Next Steps

- 2-3 meetings over next few months to enhance and refine
- Post updated version to TMC Connect in advance of Fall meeting
- Final chance for input at Fall meeting then go to ballot for approval

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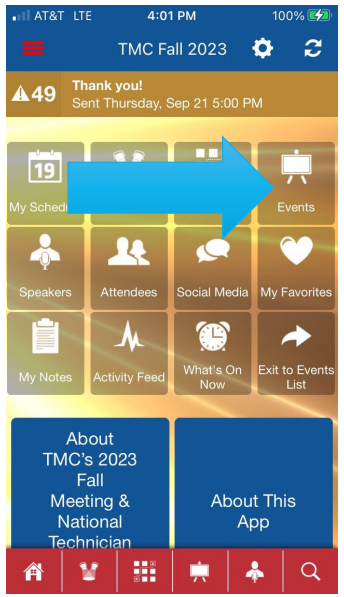

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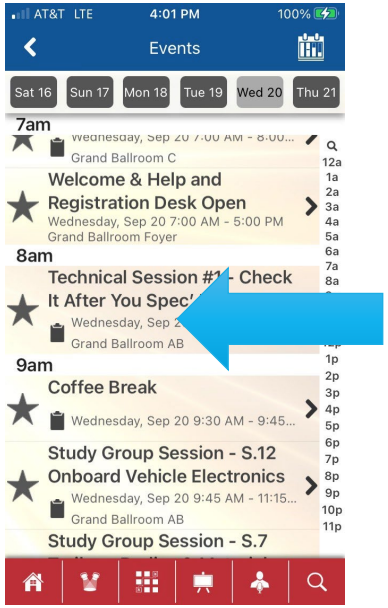

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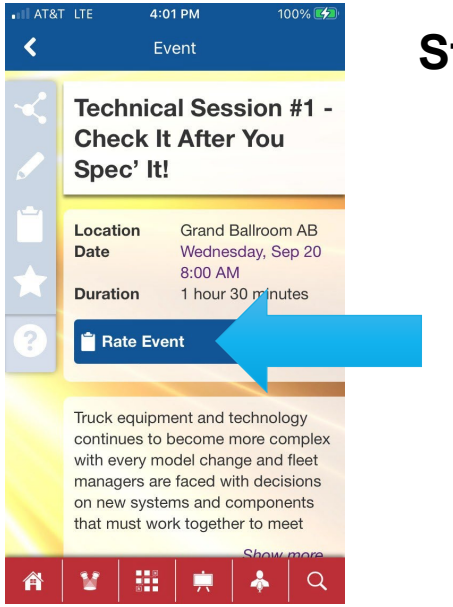

Step 4