– PRELIMINARY OUTLINE –

Charge Cycle Optimization and Energy Management for Battery EVs:
Selecting the optimal size battery pack and charger speed to work within infrastructure constraints and maximize the value of Electric Vehicles.

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

In Scope:

- Yard Tractors, Straight Trucks, Over-the-Road Tractors
- On-site/depot charging
- Opportunity + Overnight Charging

Out of Scope:

- Trailers/TRUs
- On-road/public charging
- On-site electricity storage strategies and Vehicle-to-Grid (include comments on this, but don't go into depth on it – acknowledge that it could be helpful – peak shaving, reduce demand charges, etc) Complementary other things – note what some of these could be. Microgrids, solar (on-site power generation), other thought-starters.

1. **VEHICLES - Identify the vehicles to be acquired**
    a. Document each type of vehicle- Quantity and desired timing – <6 months, 12 months, 24 months

2. **CHARGING REQUIREMENTS - Charging options and required charger specs**
    a. Vehicle voltage
    b. Charging connector options
    c. Document the typical and maximum recommended kW charge rate for each vehicle/OEM (to consider risk to battery health and life and demand charges). What does battery supplier say (if info not provided by OEM)? .5C? 1C? (explain these concepts). Cost to replace batteries if you've charged or discharged too fast. Will the truck derate to protect the batteries? Provide a grid as an example framework.
    d. What is the recommended minimum SOC? How is this protected? E.g. Limp mode. Where is the sweet spot on the high and low end? SOC window – how high and how low?
    e. What are the charge speeds and infrastructure capacity implications for available/compatible chargers?
    f. Potential Deliverable: Worksheet template to capture/calculate this information

– PRELIMINARY OUTLINE –

3. **ESTIMATING EFFICIENCY/CONSUMPTION – Determining and Optimizing Battery Run Time**
    a. Estimate kW consumption per vehicle per hour/per mile
        i. Consult with OEM by requesting data from their existing deployments with similar use cases – note this can vary significantly by OEM
        ii. Measure consumption from a multi-day test run on site or on routes
        iii. Adjust estimate for cold/hot weather
            1. Cab heat estimated energy consumption
            2. Battery heaters consumption rate at expected winter temperatures
            3. A/C consumption rate
            4. OEM experience with similar weather conditions
    b. Actions that impact energy consumption
        i. How often moving
        ii. How fast
        iii. How far
        iv. How heavy
        v. Grade
        vi. Temperature
        vii. Tire rolling resistance
        viii. Driver behavior – acceleration, cab heat, A/C usage – (see RP 1114A - Driver's Effect on Fuel Economy)
    c. Potential Deliverable: Worksheet template to capture/calculate this information

4. **BATTERY PACK OPTIONS - Selecting the Right Size Battery (Connect into new EV Spec'ing Task Force)**
    a. What pack size options are available from each truck type/OEM?
    b. What is the cost difference?

5. **DUTY CYCLE - Determine the duty cycle for the vehicles to be charged**
    a. Truck usage schedule, departure and return times – typical and peak season
    b. Miles/hours - typical schedule and peak season
    c. Driver shift schedule and break schedule – typical and peak season. Can driver breaks be staggered to allow for shared chargers for opportunity charging or must all drivers take breaks at same time?
    d. How does this vary by vehicle type? Opportunity charging works for yard trucks, but not for delivery vehicles. Delivery does 1 route then has plenty of charge time after. Compare to some delivery vehicles that might have multiple drivers/shifts so have less available time.
    e. Potential Deliverable: Worksheet template to capture this information. Daily and weekly calendar-type worksheet. Add version for peak season. Populate an example.

6. **AVAILABLE CHARGING TIME**
    a. When are the vehicles on site? Is this consistent? Note times.
    b. Where can the trucks be parked?
    c. Document break times, dwell times, and other time available for charging
        i. Calculate breaks between shifts
        ii. Calculate overnight unused vehicle time
        iii. Can charging take place during working hours during driver breaks or between shifts?
    d. Where is the optimal location for each truck type to be parked/charged to maximize convenience, opportunity charging, and ease/cost of electrical infrastructure installation? How does it vary for each type of truck and how it's used?
    e. Do available and necessary charge times overlap? If opportunity charging is part of strategy, will a charger always be available or will shared chargers limit opportunity charging? – do you need to prioritize which vehicles can get the charge time? Some might sit on chargers longer but need to give other vehicles (e.g. yard truck) priority to get its opportunity charge. Consider demand charging rates.
    f. Is it feasible or risky to share chargers among different vehicles? Consider recommendation to keep all vehicles plugged in overnight especially during cold temperatures so they're all ready to go in the morning.
    g. Potential Deliverable: Worksheet template to capture/calculate this information

7. **CHARGE SPEED - Determine Required Charge Speed**
    a. Calculate total amount of kWh per shift and per day to be replenished through charging, compared to times available for charging
    b. Do this math as it can vary dramatically depending on available time for charging

8. **SITE ELECTRICAL CAPACITY - Determine available electrical capacity of building - (Jon M/Matt S working on Charging Infrastructure RP)**
    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?
    f. Is on-site storage necessary or helpful? (out of scope for this RP)
    g. Potential for new capacity. Talk about this as an option and then it may reference other RP. New electric service - Timing, cost.
    h. Reminder: Capacity usage based on maximum potential draw of installed chargers +20%, not what is actually needed or used. Be cautious about unused capacity. Utility company may have feedback so you don't "reserve" more than you'll actually be using. Would a "current limiter" be an option so you're not tying up more than you're using?

9. SITE ELECTRIC RATES – How much will the electricity cost?

a. Document electricity rate schedule including Time of Use (TOU) rates - peak rates, seasonal rates, etc.
b. Demand charge rates and when they take effect
c. Potential Deliverable: Worksheet template to capture this information and note potential demand charge rates

10. PRIORITIZE GOALS – Rate efficiency vs. truck availability and battery pack size efficiency

a. Maximize truck usage
b. Minimize electrical costs
c. Costs of various battery pack sizes available for each vehicle
d. Costs of chargers and ratios of trucks to chargers

11. EVALUATE SCENARIOS - Evaluate scenarios to optimize charging cycle and minimize other costs.

a. Evaluate expected and exception scenarios for electrical usage, capacity required, and costs
b. Is the optimal scenario available today? (Available vehicle, charger, infrastructure capacity, etc.)
c. Is there a solution that can be implemented today to gain learning and make progress while longer term optimizations develop?
d. What level/average of electricity cost is acceptable to achieve the minimum required ROI
e. Potential Deliverable: Provide example that leverages data from previous spreadsheets for other sections' data.