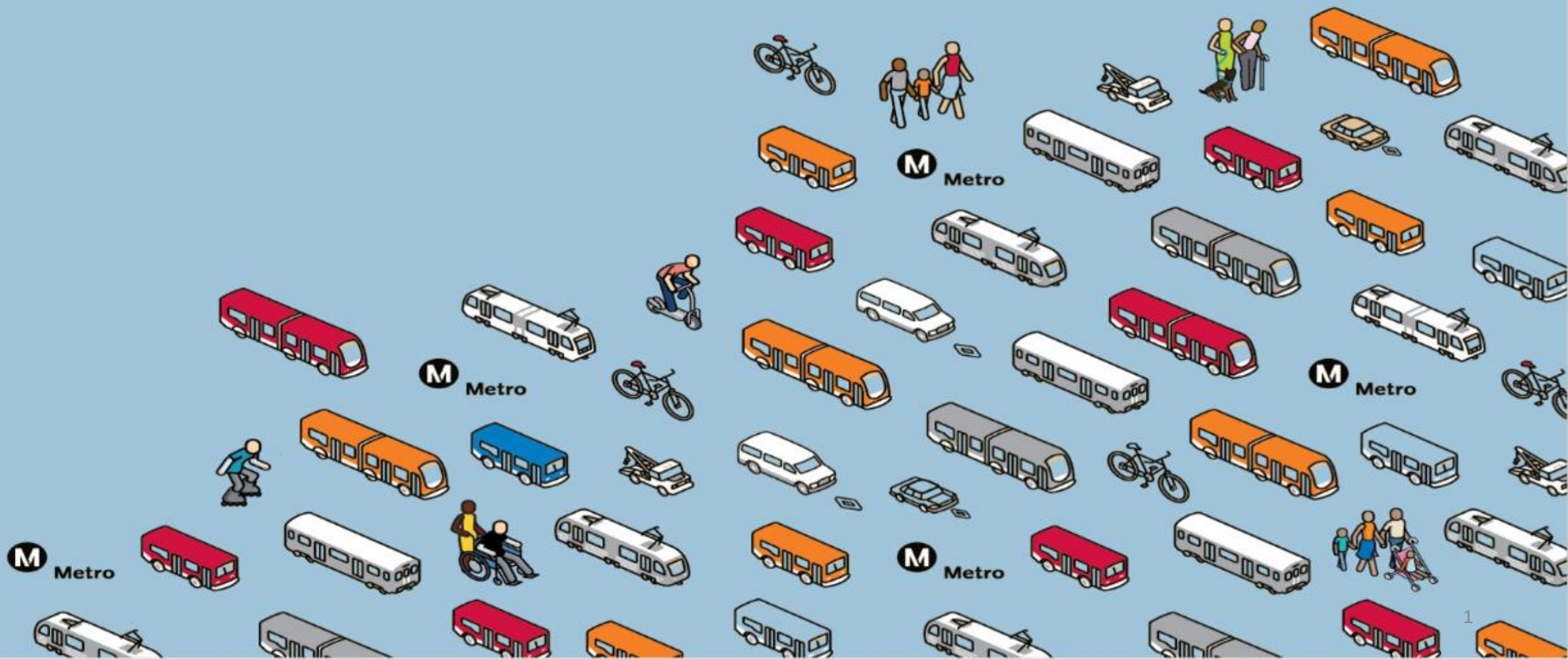
Zero Emission Bus (ZEB) Program Update

Operations, Safety, and Customer Experience Committee
July 18, 2019



Presentation Overview

- Transition to ZEB Operations - Guiding Principles
- Bus Fleet Requirements & Availability
- Current Background & Timeline
- Strategic Plan for ZEB Implementation
- Phase I | Update on Near-Term Activities
  - Silver and Orange Line Electrification
  - ZEB Master Plan
    - Challenges
    - Utility Grid Modeling
    - Conversion of Operating Divisions

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Transition to ZEB Operations – 2017 Guiding Principles

- Continue to replace aging bus fleet (~200 Buses per Year)
  - Status: 465 buses ordered in 2017.
    - ~350 buses to be delivered in 2019.
- Upgrade current CNG buses to "Near-Zero" Low NOx engines
  - Status: 196 buses upgraded at Mid-life (On-Target)
- Maintain existing bus fleet in a "State of Good Repair"
  - Status: Fleet age is increasing.
    - Extend Life (re-tank & recycle into "mid-life") or replace additional 369+/- buses by 2022
    - Assumes 1:1 replacement of CNG to Electric
- Improve Service Quality and Reliability
  - Status: New CNG Buses placed into service in 2019.
- Transition Metro Orange Line (MOL) to Zero-Emission by 2020
  - Status: On Target for Completion
- Transition Metro Silver Line (MSL) to Zero-Emission by ~2021
  - Status: On Target for Completion
- Goal of 100% Zero -Emission Bus Fleet by 2030
  - Status: Master Plan addresses implementation roadmap.

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Bus Fleet Requirements & Availability

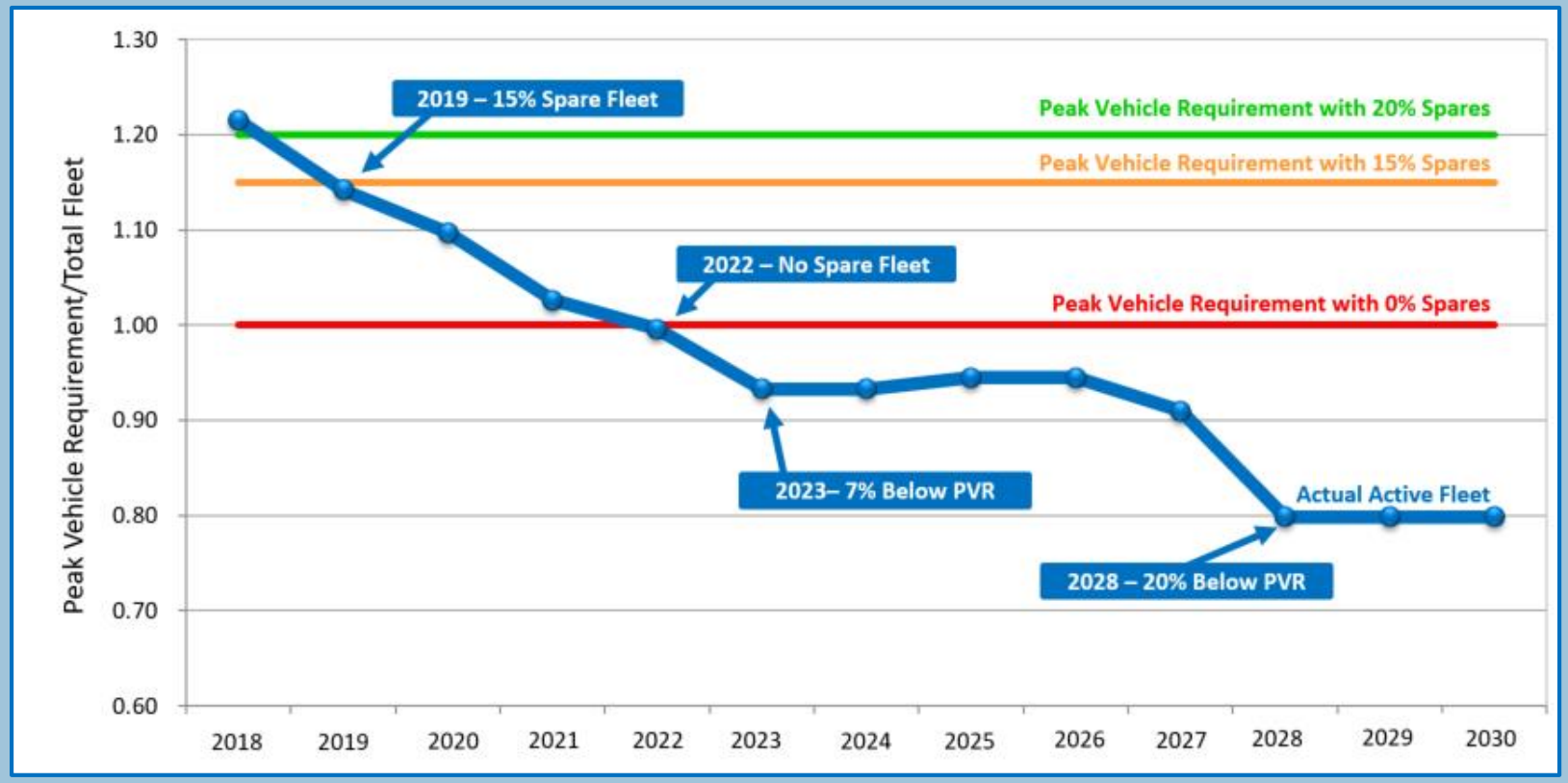
Fleet Planning Parameters

Peak Vehicle Requirement
- 2,300+ buses (scheduled service + spares)
- 1,900+ buses (scheduled service only)

Spare Ratio
- 20% > (FTA requirement)
- 15% - 20% (Metro policy)

Bus Retirement Age
- 12 years (FTA requirement)
- 15-18 years (Metro Policy)

Metro Bus Fleet Decommissioning Forecasts



- 834 additional buses needed by FY2022 to meet current service levels with exceeding FTA spare ratio and age requirements
- 465 buses on order (~350 buses to be delivered in 2019)

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Current Background & Timeline

- **January 2019**
  - Provided Preliminary update to Board Staff to indicate need for procurement actions

- **July 2019**
  - Provide Metro Board with a ZEB Master Plan update
  - Evaluate opportunities to expedite transition
    - Bundle division conversions to single procurements
    - Acquire or lease additional operating space

- **September 2019**
  - Refine cost estimates, infrastructure phasing schedule, and procurement strategies
  - Procurement Decision (using contract Options)

- **Spring 2020**
  - Provide Metro Board with a ZEB Master Plan update
  - New Bus Procurement Decision – Fleet Mix (TBD)
    - Delivery in 2023 and later.

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Strategic Plan for ZEB Implementation

- Phase 1: Near-Term Activities (2020 – 2021)
  - Orange Line Electrification – Charging Infrastructure & Vehicles
  - Silver Line Electrification – Charging Infrastructure & Vehicles
  - Upgrade Near-Zero CNG Engines to RCNG at mid-life
  - Refine & Develop Master Plan Details

- Phases 2/3: Long-Term Activities (2022 – 2030, and beyond)
  - Conversion of Divisions from CNG Fueling to Battery Charging
  - Procurement of Vehicles

- Key Milestones 2019:
  - ZEB Technology Assessment/ZEB Master Plan
  - Dimensions of Phases 2 and 3

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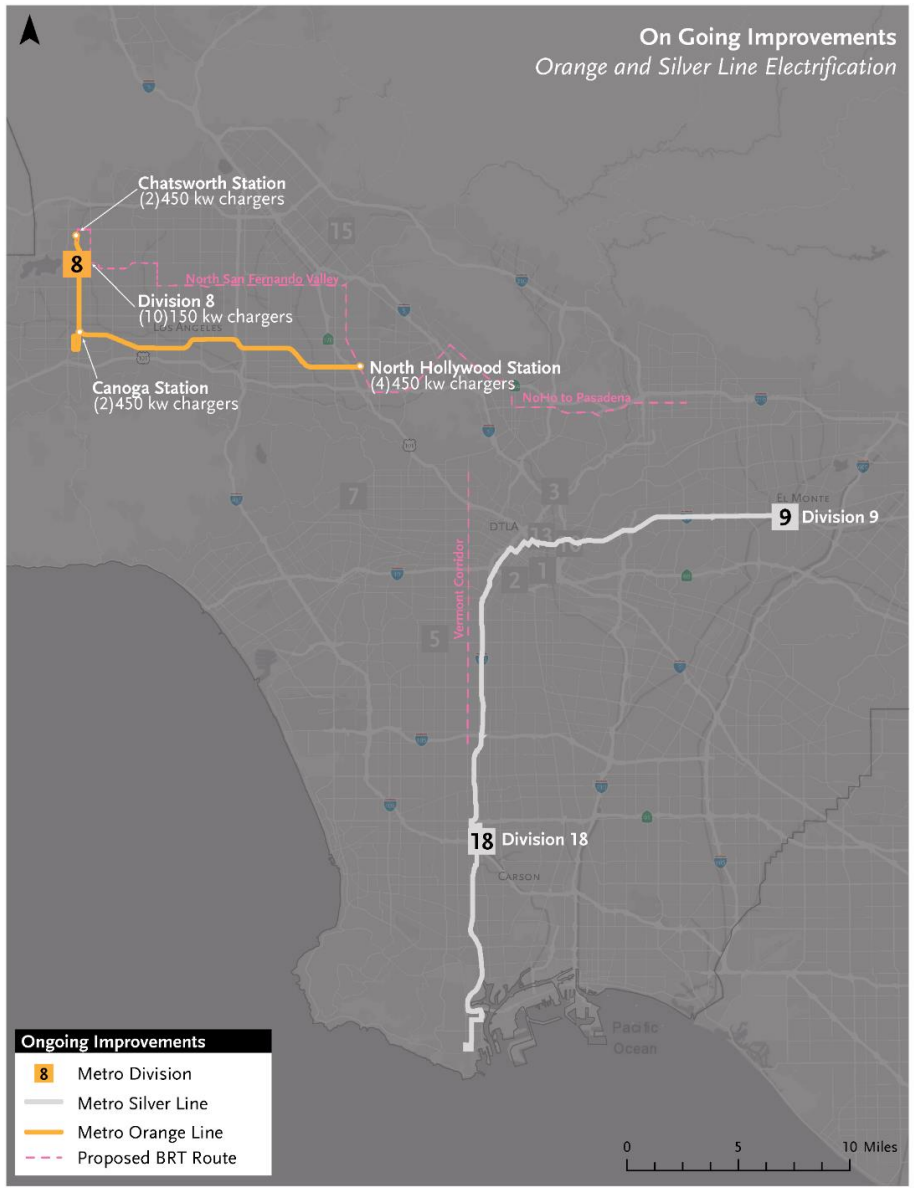
Silver and Orange Line Electrification



- Orange Line (60-foot BEBs)
  - 45 Buses (40 New Flyer, 5 BYD)
    - NF Pilot bus due Summer 2019
    - NF and BYD Production Complete Fall 2020
  - Depot Charging (Division 8)
    - Charger Commissioning: July 2019
  - En Route Charging
    - Expected Completion: Fall 2020
- Silver Line (40-foot BEBs)
  - 60 Buses (BYD)
    - Pilot: TBD
    - Production Completed by Winter 2021
  - Depot Charging (Division 9)
    - Design considers full-scale deployment and upgrading capacity to 18 MW. (Current Limit of 5 MW)
    - Applied for SCE Charge-Ready Transport
  - En Route Charging
    - Design On-going for El-Monte & Harbor Gateway



ZEB Master Plan - Challenges

1. Bus-Related Challenges:
   - Performance Standard: 65mph top speed; sustain 10% grade; 250+ mile range
     - Currently, up to 120 mile range with Full HVAC, Passenger Loading
   - Curb Axle Weight : Current limit is 24,000 lbs.
     - In 2022 limit drops to 22,000 lbs.
     - Limits ability to add batteries to increase range
   - Technology reliability risks – not service proven
2. Division Charging Infrastructure Challenges:
   - Limited grid capacity at divisions
     - Limits number of BEBs that can be assigned
   - Long lead times for utilities to implement necessary grid upgrades
     - Need to increase capacity from ~5 MW to ~15 MW
     - 3 to 5 year cycle from planning to deployment
   - Limited space at divisions
     - Conversion must be done sequentially, adding time to schedule

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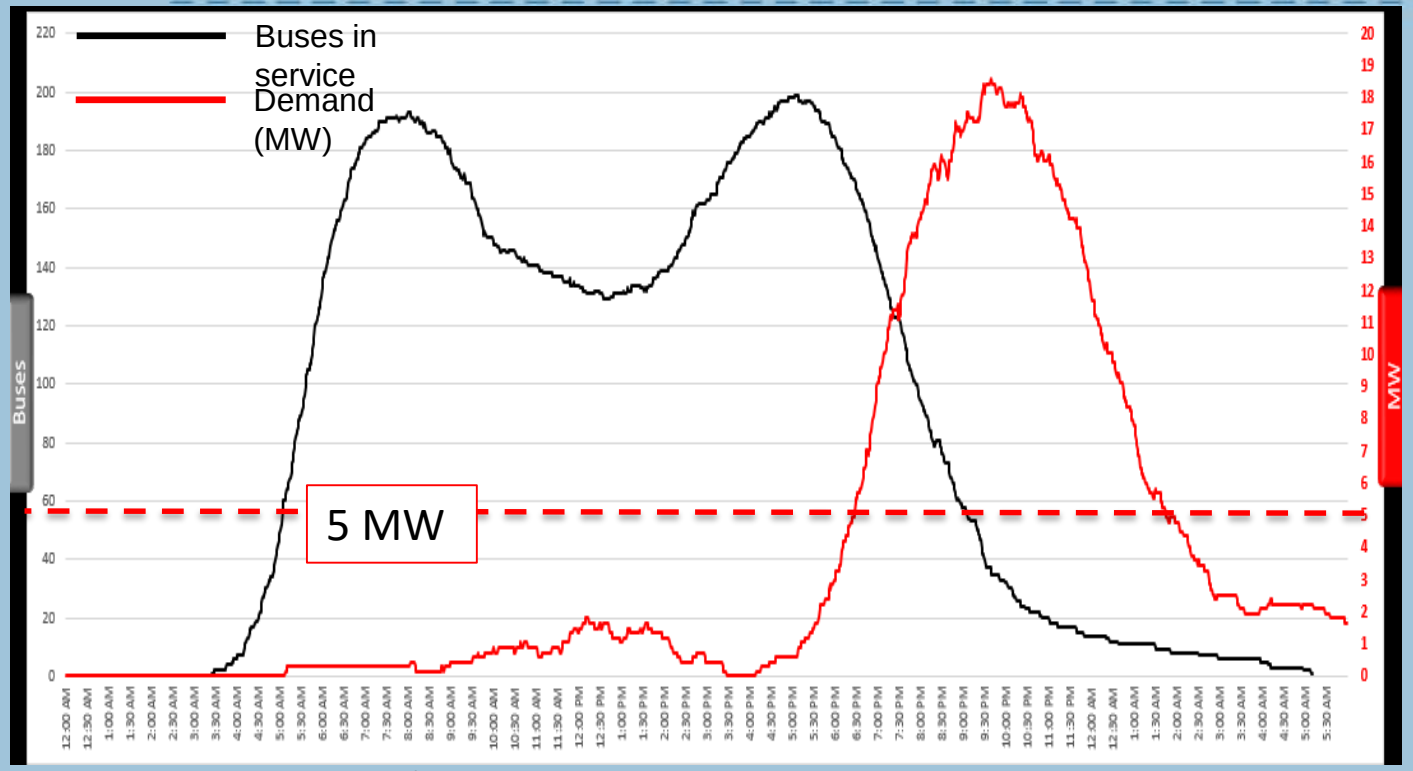
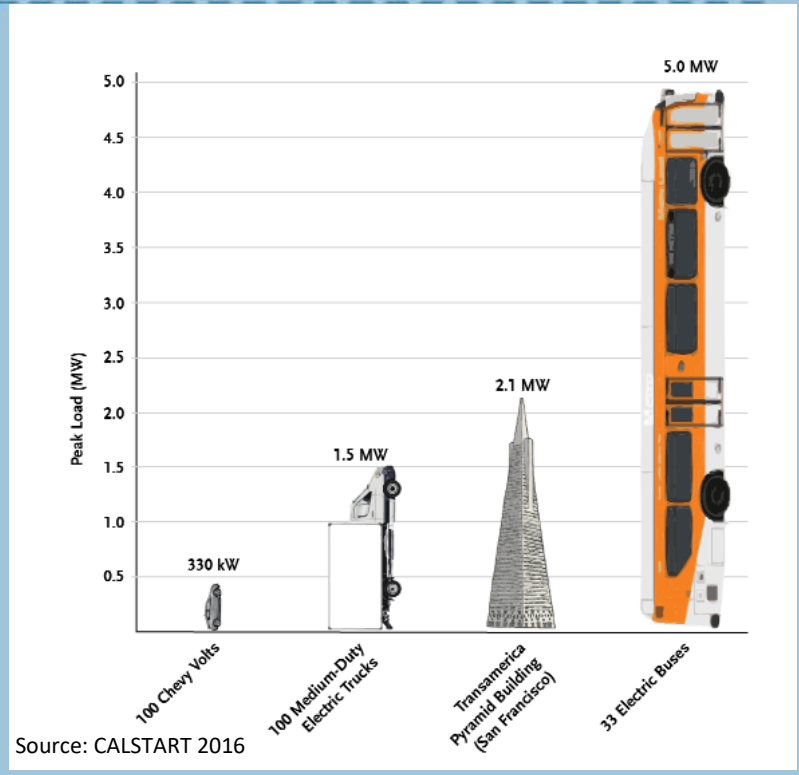
ZEB Master Plan - Challenges

3. Funding Challenges:
   - Additional capital funding required for 100% ZEB program
   - Preliminary Capital Cost Estimates
     - ~$700 Million to ~$1 Billion in Infrastructure costs
     - ~$400 Million in additional vehicle costs.
   - Operational:
     - Utility Rates and resulting costs are under revision.
     - Operating Costs are not fully known at this time.

Need to optimize depot and en route charging strategies; vehicle performance; service block ranges; and costs.

ZEB Master Plan – Utility Grid Modeling (Division 9 Example)





Source: CALSTART 2016

- Modeling is Basic Input to Utility Planning
- ~18 MW needed at Division 9 with no En Route Charging
  - Transamerica Pyramid Building requires 2.1 MW
  - Only 5 MW is capacity currently available

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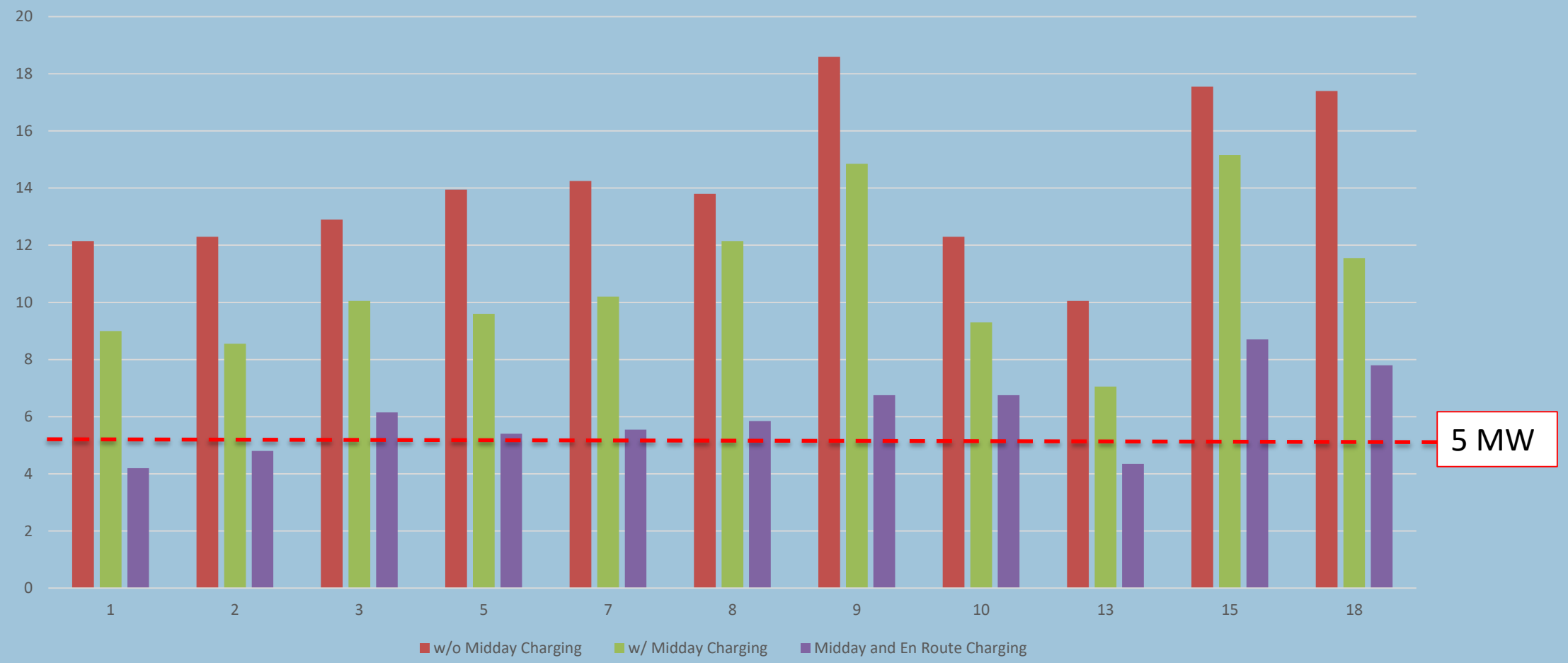
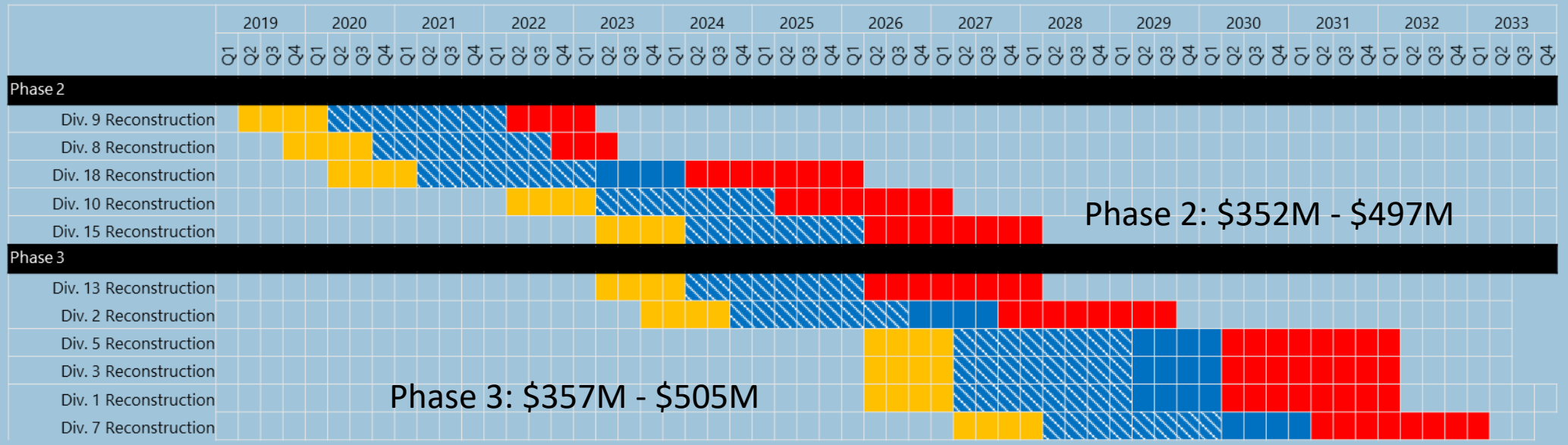
ZEB Master Plan – Utility Grid Modeling (All Divisions)



- Mid-day and en route charging can optimize:
  - Power limitations
  - Range and weight
- Sub-optimal for fleet size, operating costs, and bus parking

ZEB Master Plan - Conversion of Divisions (Phasing Schedule)



- Procurement (12 Months)
- Design and Utility Agreements/Approvals (24 Months)
- Division Staging and Construction (24 – 36 Months) with existing power
- Utility Upgrades and Construction (24 Months) with optimal power

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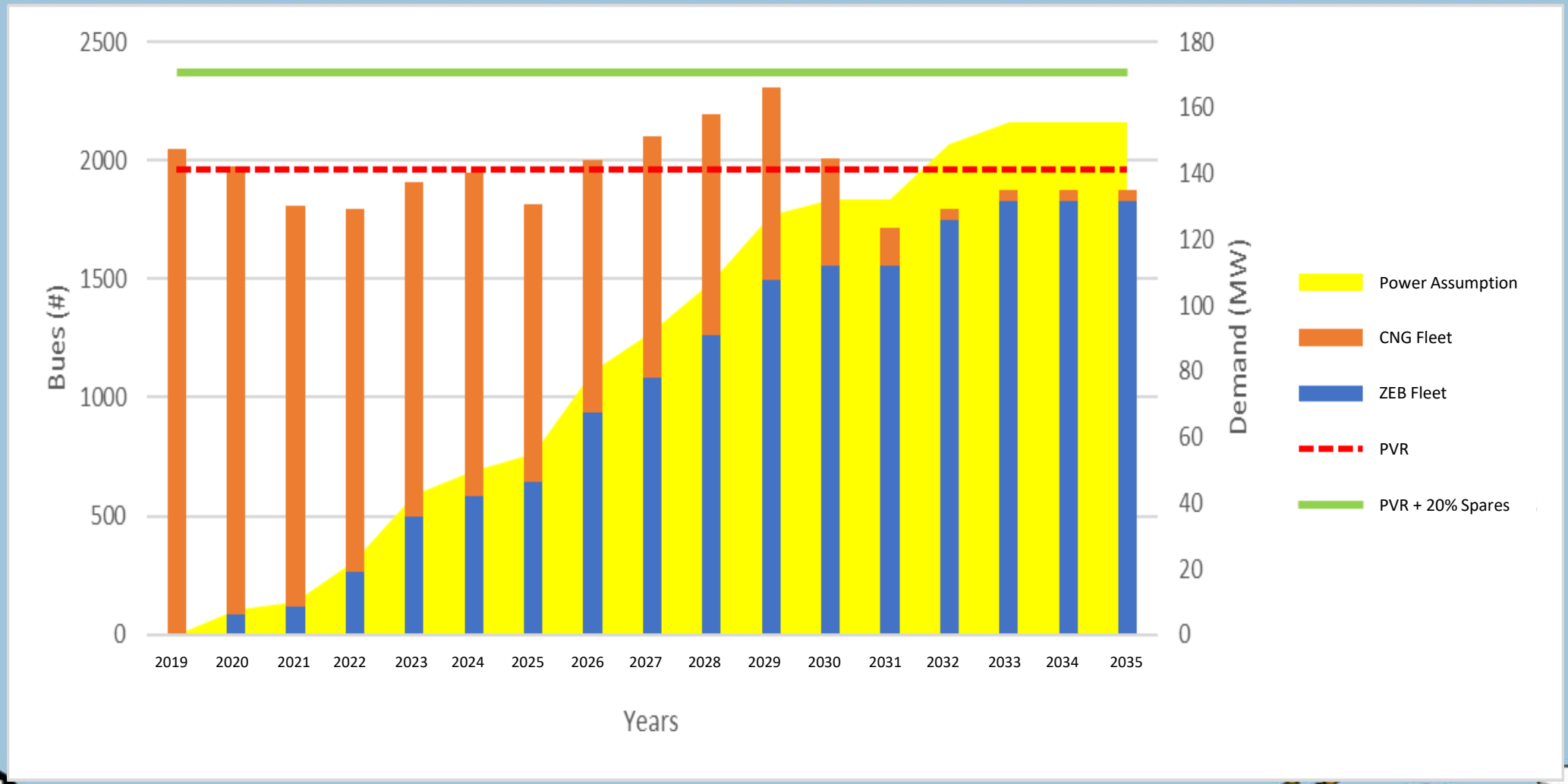
ZEB Master Plan – Conversion of Divisions (Phasing Schedule)



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ZEB Master Plan - Conversion of Divisions (Phasing Schedule)

- Division overhead charging
  - Gantry is lower-cost design
  - Gantry optimizes space
  - Gantry with platform:
    - Saves space
    - Provides for equipment, solar and battery storage
    - More expensive

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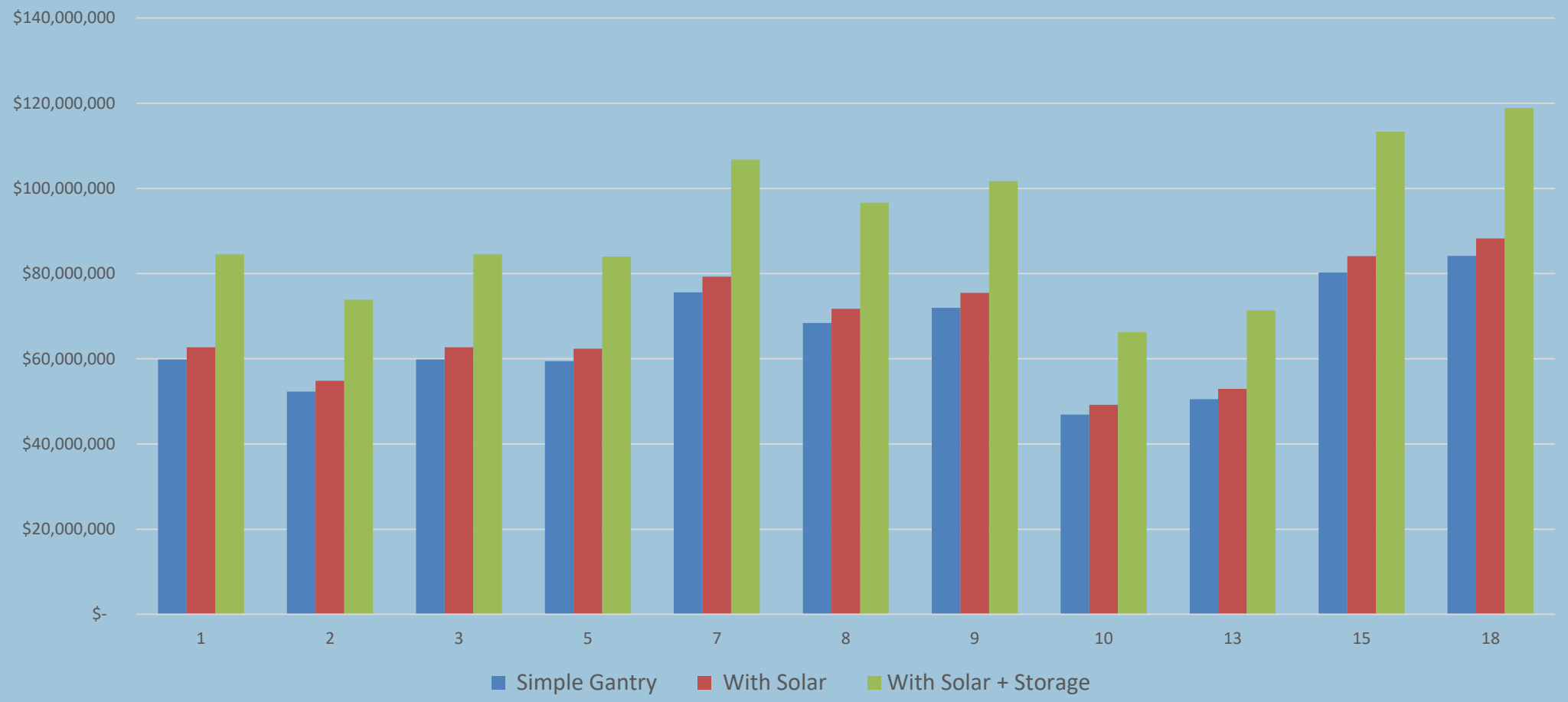
ZEB Master Plan - Conversion of Divisions (Cost)



- Simple Gantry Arrangement
  - ~$50M - $80M per Division
- Sophisticated with Solar and Battery Storage
  - ~$70M - $120M per Division



Thank you