

# Off-road Transportation Electrification

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# Outline

- Study summary
- Methodology
- General changes from 2015 study
- In progress results for categories
  - Inputs
  - Specific changes from 2015
  - Electricity plots

# CEC Study Purpose

- Estimate total electricity demand for off-road vehicles and applications from 2019 – 2030
- Include new categories to the 7 old categories
- Produce Low, Medium, and High scenarios for electricity usage for each category for years 2019-2030

# 2015 Study Off-Road Categories

- Truck Stop Electrification (TSE)
- Trailer Refrigeration Units (TRUs)
- Industrial Forklifts
- Port Cargo Handling Equipment (CHE)
- Airport Ground Support Equipment (GSE)
- Utility Work Trucks
- Shore Power

# New Study Categories

- Locomotives (Class 1)
- Construction, Mining, Industrial
- Commercial Harbor Craft
- Motorcycles (?)
- Likely complete a subset of the above

# Methodology Inputs

- Present fleet stock (# vehicles/applications)
  - Separate category for each vehicle type (e.g. airport baggage tug, airport belt loader, forklift classes)
  - Data from ARB Orion database in most cases
- Estimate population growth through 2030
- Estimate vehicle/application activity (VMT or hours) and fuel economy (mi/kWh, kWh/hour)
  - Data from Orion Database in most cases
- Estimate % of electrified vehicles/applications in fleet
  - Generally assume linear increase through 2030
  - Data from current reports, recent activity, and regulations
  - Discussions with stakeholders

# Methodology Calculations

- Vehicles
  - Electricity usage =  $\# \text{ veh}_e * \text{VMT} / (\text{mi/kWh})$
- Applications (Truck stops, shore power, etc.)
  - Electricity usage =  $\# \text{ equipment} * \text{hours usage (elec)} * (\text{kWh/hr})$
- Some cases data includes total energy usage (e.g. airport GSE)
- Variation of inputs by year
  - Population increases
  - % electrified increases (dominates)
  - Fuel economy/usage, activity held constant

# Scenarios: Low, Medium, High (Range of Estimates)

- Electrification demand mostly determined by % adoption of electrification (dominates range)
- Project Low, Medium, and High scenarios stock growth
  - data from U.S. Bureau of Economic Analysis; Moody's Analytics (CA counties) for projected economic growth from 2019 – 2030
- Low
  - Close to lower bound, extrapolate from 2019 with present regulation
- Medium
  - Best estimate and roughly in middle of Low and High
- High
  - Aggressive assumptions



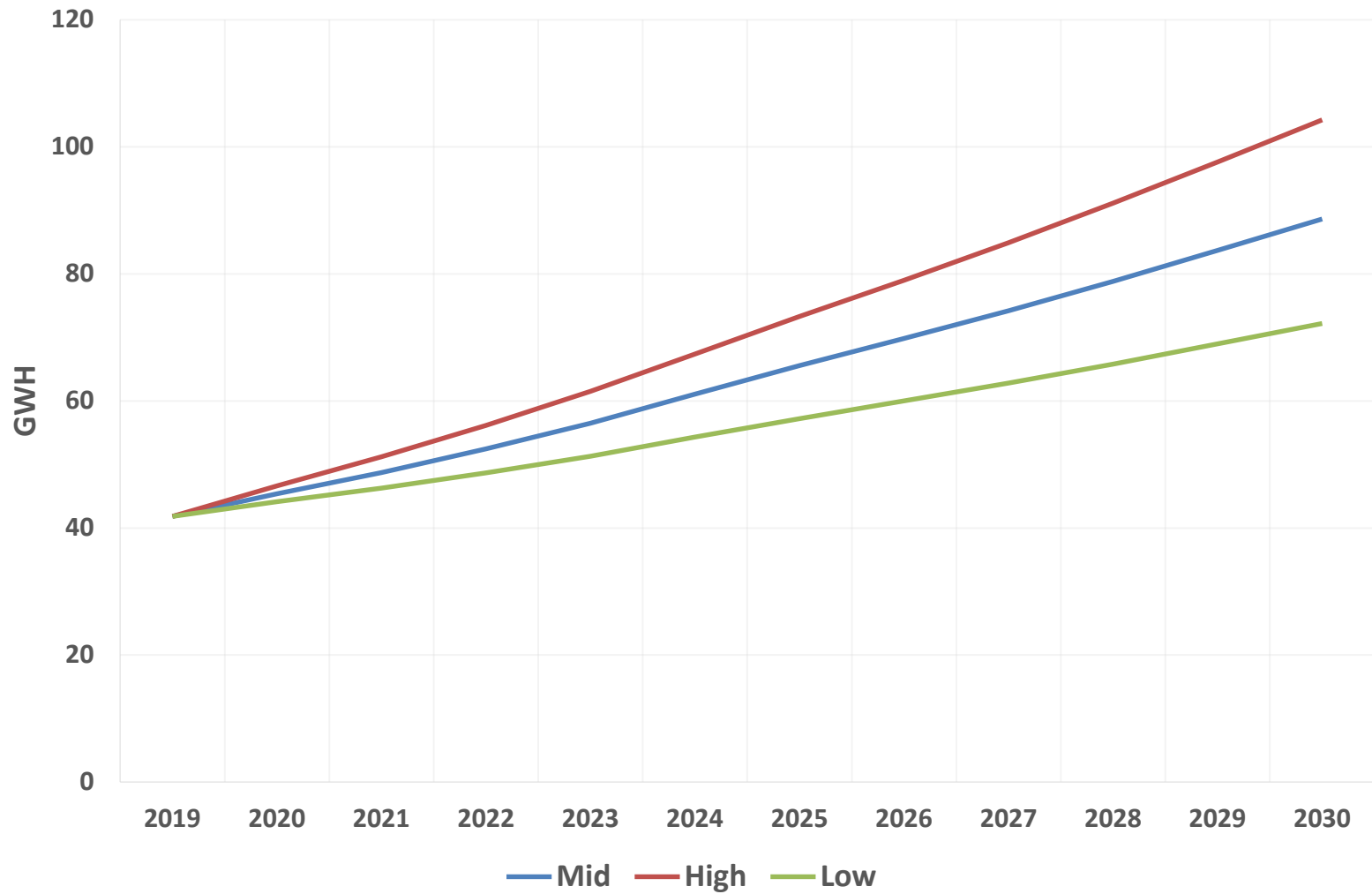
# General Changes from 2015

- Orion database
  - Reporting of all vehicles/equipment with emissions
  - No electric vehicles/equipment
  - Assume large difference in accuracy
- ARB regulations
  - 2015 vague planning stage
  - 2019 specific targets

# Airport GSE

- LAX study 2013 – economically beneficial
- Airports and airlines push to electrify
- 2019 high percentage of equipment already electrified
- 2019 percentages higher than 2015 projections, overall projections much higher
- Mid-range of projected electrification
  - A/C wide body tug: 30%
  - Baggage tug, belt loader: 80%

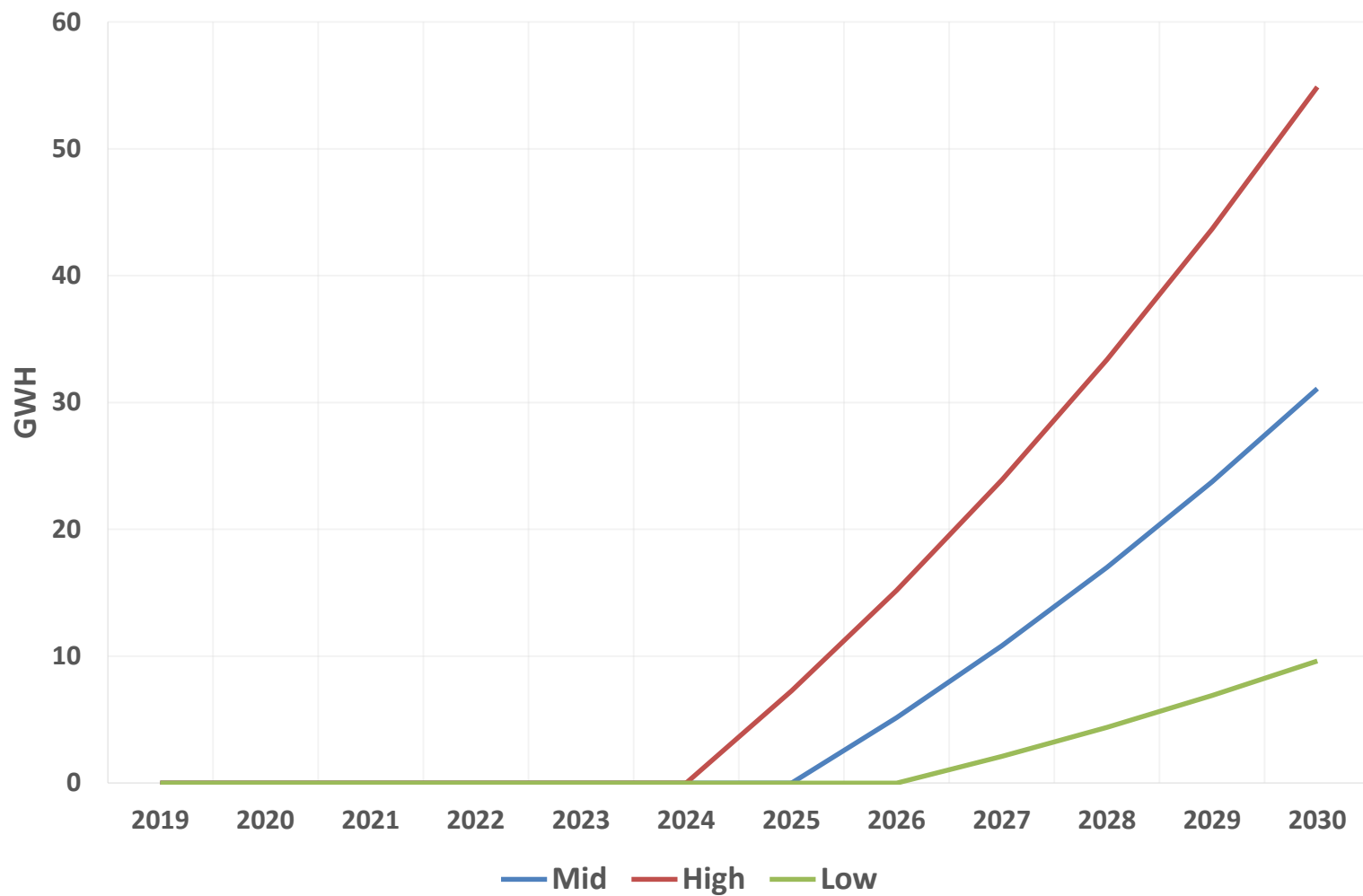
## AIRPORT GSE ELECTRICITY DEMAND FORECAST



# Port CHE

- Lower population from Orion
- ARB might start requirements in 2026
  - Low scenario start 2026
  - Mid scenario start 2025
  - High scenario start 2024
- Electrification slower than 2015 projections
  - 2015: 10-20% in 2026 (mid scenario)
  - 2019: 1-3% in 2026 (mid scenario)
- Lower electricity demand than 2015 projections

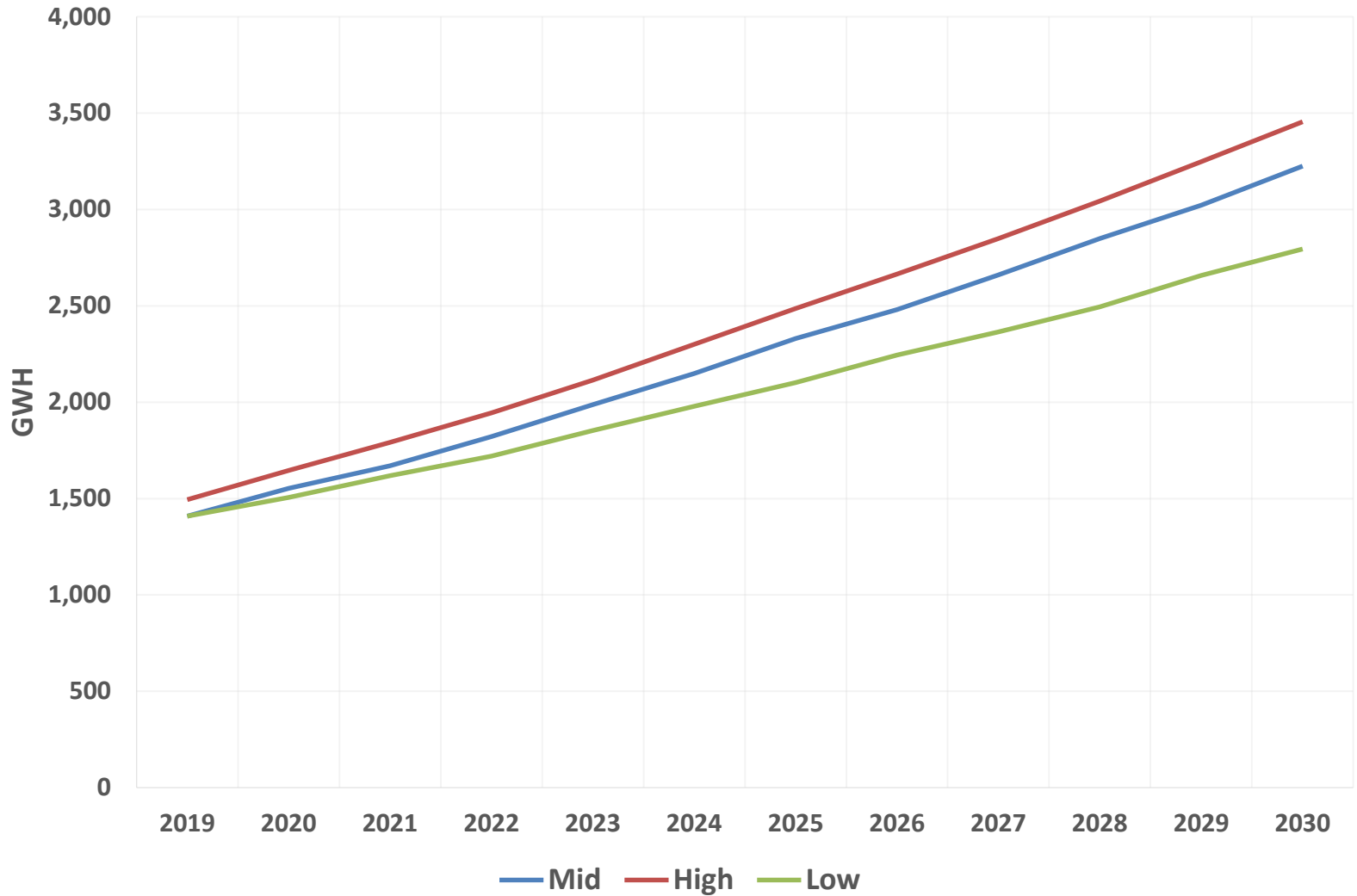
## PORT CHE ELECTRICITY DEMAND FORECAST



# Industrial Forklifts

- Largest electricity demand category
- Class 1-3 electric (~55% of population)
- Class 4-5 fossil fuel (~45% of population)
- ARB may require all < 8000 lb class 4-5 forklifts to be electric by 2035
- Percent electrification class 4-5 (43 – 65% in 2030)
- Higher electricity demand due to ARB regs

# INDUSTRIAL FORKLIFTS ELECTRICITY DEMAND FORECAST

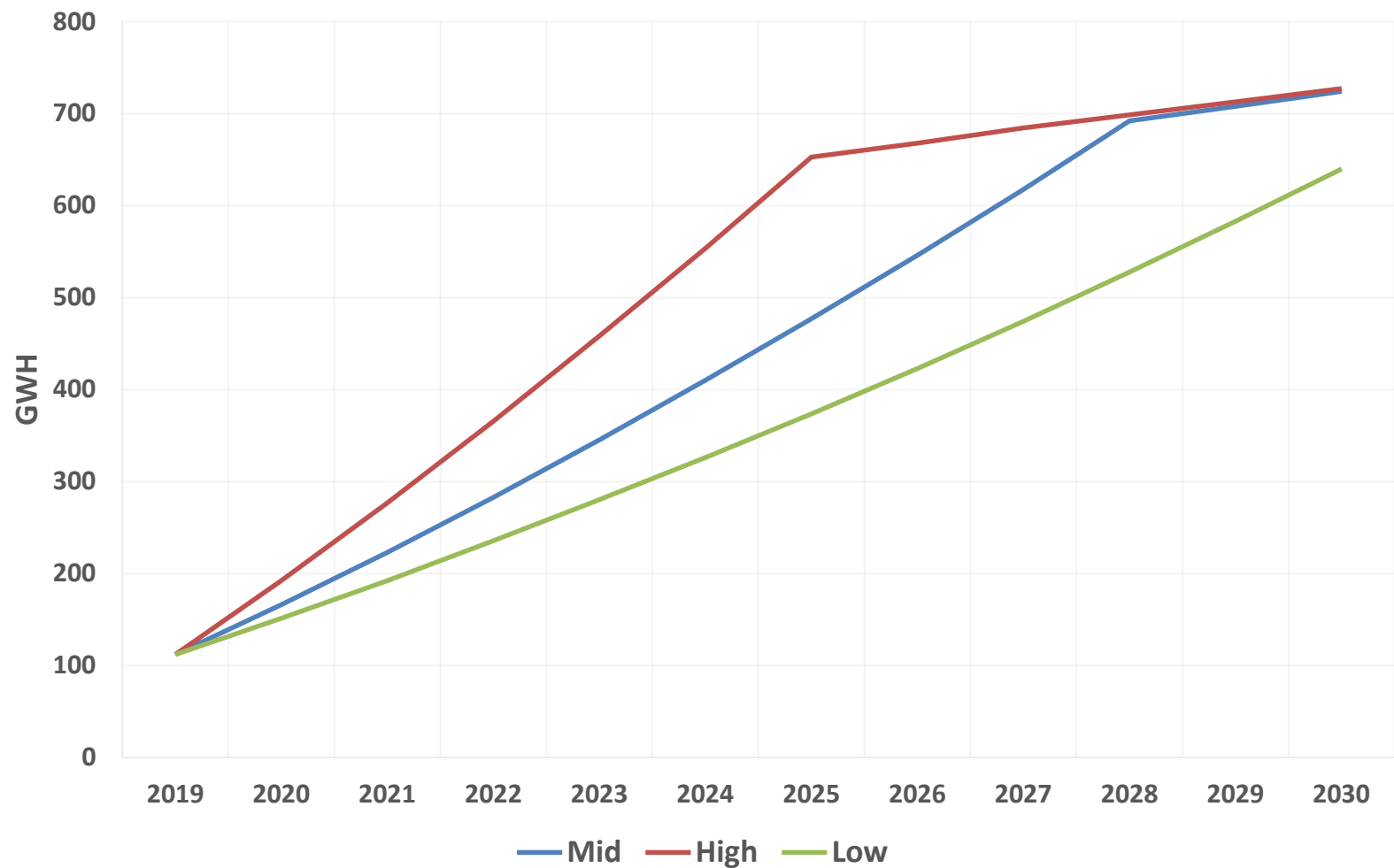


# Transport Refrigeration Units (TRUs)

- ARB strong regulations
  - 100% electrification of > 25 hp TRUs by 2025 including out-of-state
  - Potential issue: infrastructure
  - 100% electrification of < 25 hp TRUs by 2031
- 2015 high scenario ~ 50-60% electrification in 2026 (20% out-of-state)
- Much higher electricity demand

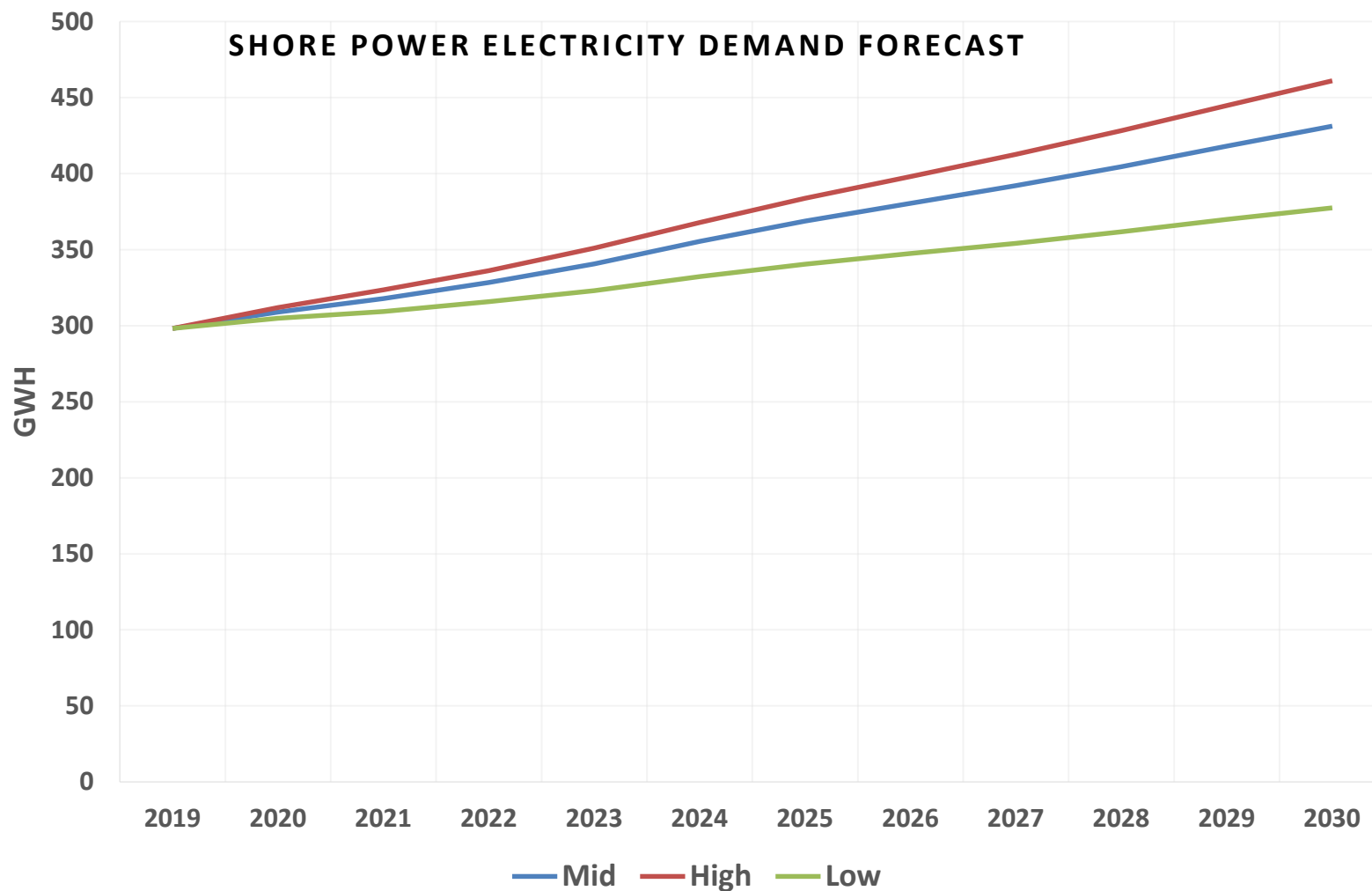


# TRU ELECTRICITY DEMAND FORECAST



# Shorepower

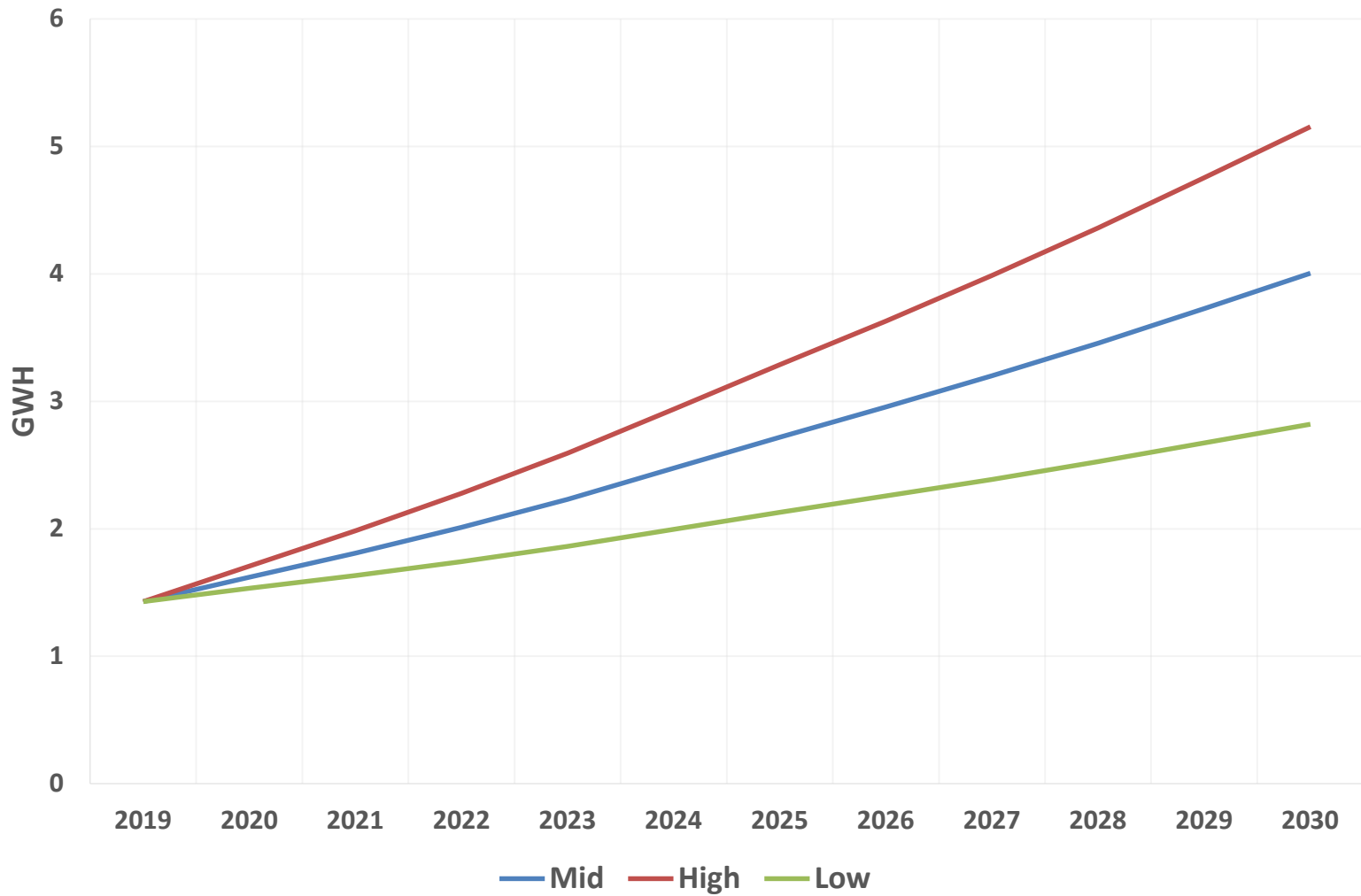
- ARB Inventory for Ocean-Going Vessels
  - Incredibly detailed data (berthings, hours, kW)
- Added 4 vessel types
  - Old: container, reefer, cruise, tanker
  - New: auto, bulk, Ro-Ro, general
- Percent electrification similar 2015 to 2019
- Slightly lower electricity demand due to lower population of some vessel types



# Work Trucks

- Battery provides power at work site through PTO
- Edison Electric Institute study
  - Electricity demand
- California utilities
  - Bucket truck populations
  - Percent electrification
- 2015 and 2019 results similar

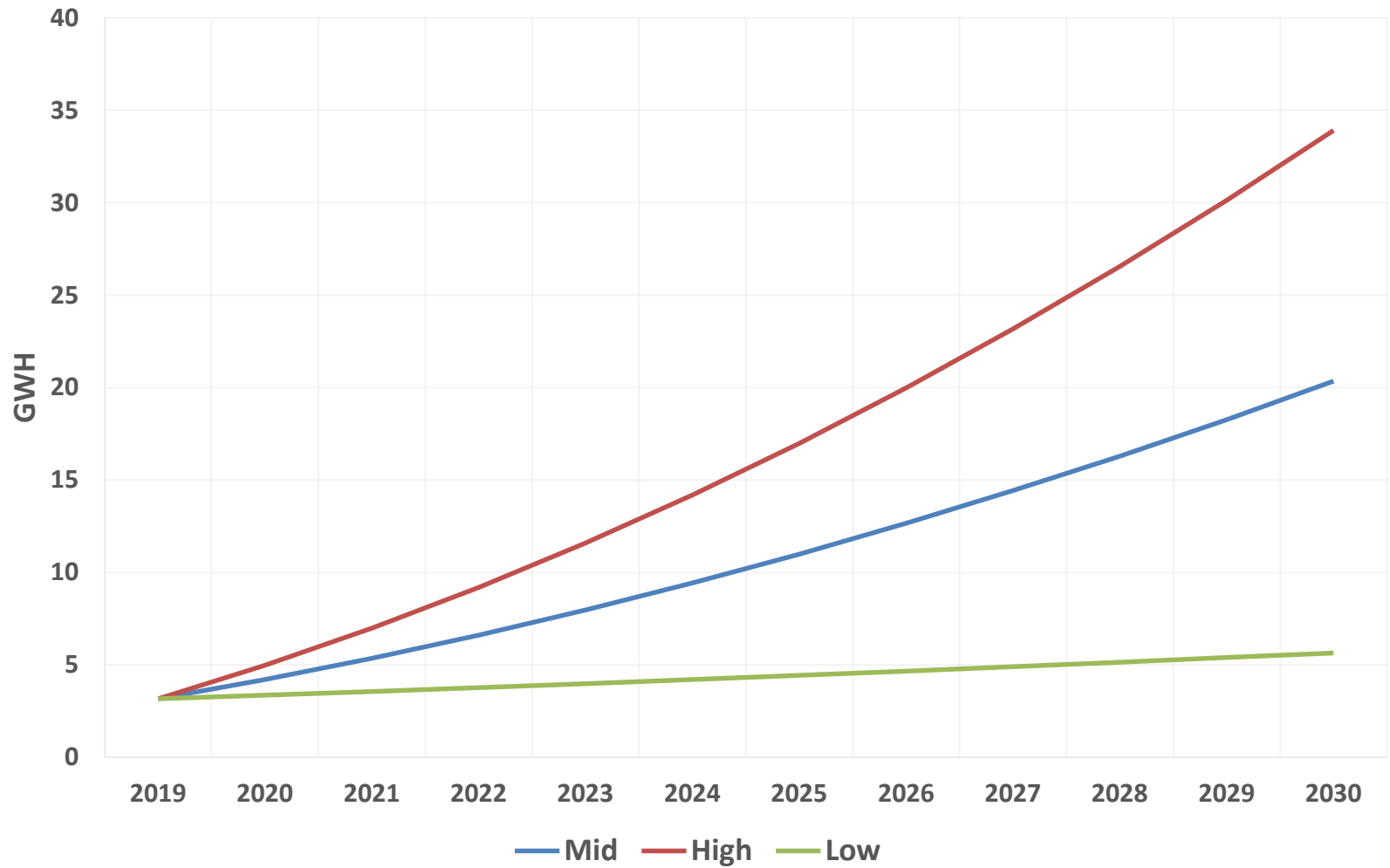
## WORK TRUCKS ELECTRICITY DEMAND FORECAST



# Truck Stop Electrification

- Electrify cabin and connect to grid at truck stop parking space
- Estimate percent of trucks with cabin electrified
- Estimate capacity factor (% time parking space is utilized for electricity)
- 2015 and 2019 results similar

## TRUCK STOPS ELECTRICITY DEMAND FORECAST



# Harbor Craft

- ARB has no present plans to require electrification in regs
- Possible vessel type suitable for ZEV operation is ferries
- Norway has commercial ZEV ferries – fuel cell rather than battery electric
- Some companies want to skip Tier 4 regulation and move to lower emissions



# Construction and Mining

- ARB has no present plans to require electrification in regs
- Demo projects
  - High capacity forklift Port of Stockton
  - Mobile charging for Agricultural tractors
- Possible electrification of rough terrain forklifts
- Australia has fully electric mines
- Mining depends strongly on operations

# Thank You