Reconciling Nonroad Equipment Activity
(It has always been Load Factors)

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Emission Inventory Conference

September 27, 2023

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NONROAD Model Background

- NONROAD model (25th year, but now buried in MOVES)
- Emissions modeling method largely unchanged since the original 1991 report using much the same 'rudimentary' methods and input estimates as California offroad modeling.
  - Diesel ('distillate') consumption **overestimated by 2.3x**: Kean, Sawyer, and Harley (2000)
- Load factor (LF) errors explain nearly all the fuel consumption overestimate
  - Fuel Consumed = Population x Power x **Load Factor** x Time x Engine Efficiency (BSFC)
  - EPA Ports Emissions Inventory Guidance (2022) and MOVES report high load factors
  - Default LF values shown to be inaccurate at the facility level where population, power, hours, and fuel consumption are known such as with intermodal equipment
- Load factor determination methods
  1. Engine computers (since the advent of electronically controlled engines)
  2. Fuel consumption rates (gal/hr) for specific operations

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Engine Computer Logs (Sample hostler/terminal-yard trucks)

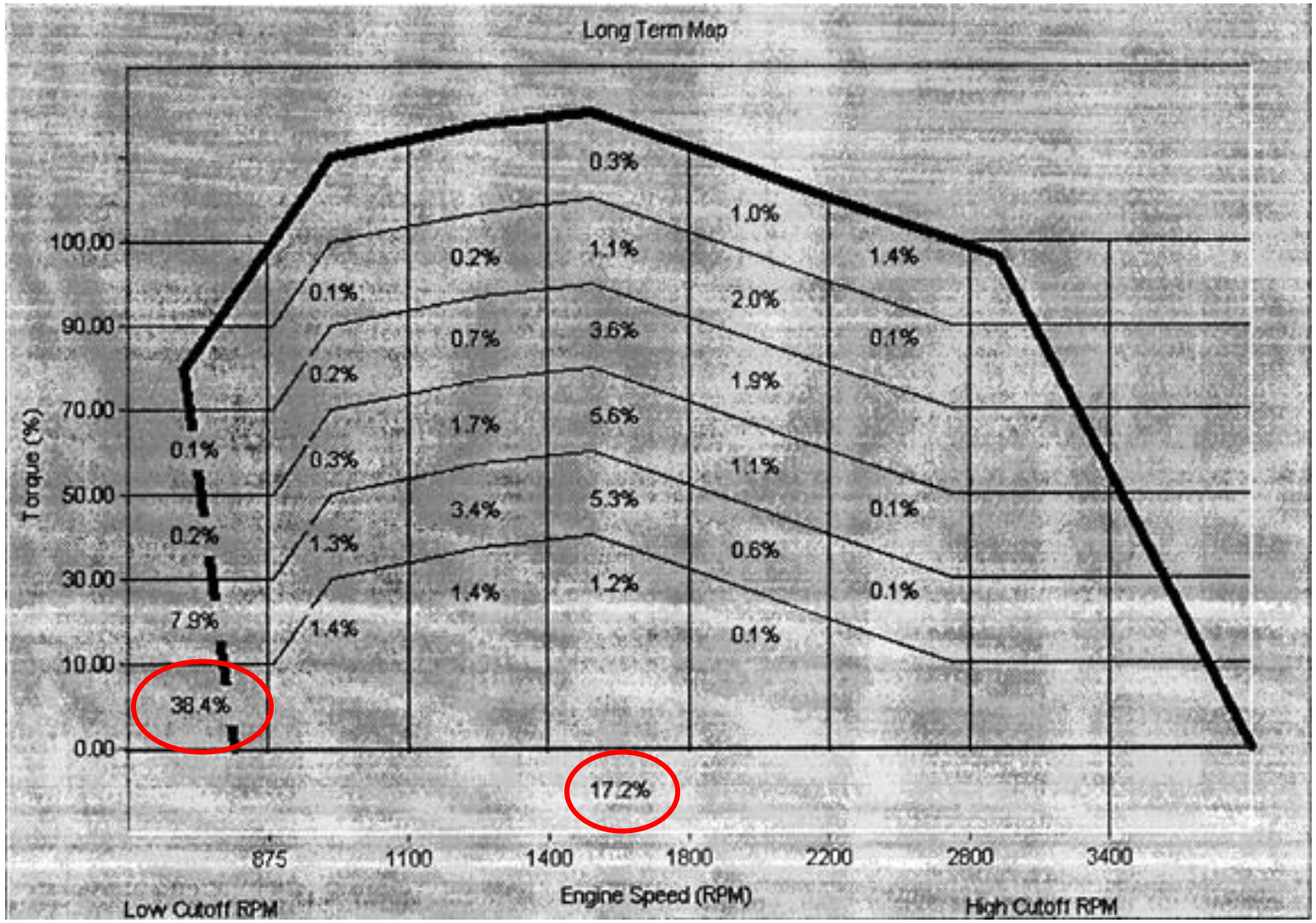

Photo courtesy of Tracy Fidell, Port of Oakland

- Relative Time in mode
- Relative Mode Torque by engine speed ('engine map')
  - From engine maker
- Power = Speed x Torque
- Low power modes
  - >55% of activity
  - Low-speed Idle
  - Higher speed Idle
  - Braking/Coasting

Fuel Consumption to Load Factor

- Survey logs of refueling events (Like nerds do with their cars)
  - Over weeks and several equipment pieces provides a robust sample of activity.
  - Engine hours and fuel dispensed (gallons) recorded at each refilling event
- Rated power, equipment type and/or vocation for each
- Load Factor = Fuel (gal/hr) x Density (lb/gal) / BSFC (lb/hp-hr) / Rated Power (hp)
  - BSFC from NONROAD modeling defaults (<10% uncertainty and cycle dependent)
  - Density (uncertainty ~1%) and values are easily found

Fuel Consumption vs. Engine Data Methods (Yard trucks in the same fleet)

Photo courtesy of Tracy Fidell, Port of Oakland

Engine Computer Method			
Power (hp)	n	Mean LF	CI (90%)
155	12	0.191	0.006
215	4	0.122	0.004
Fuel Consumption Method (Avg. LF)			
155	4	0.229	0.004
215	16	0.123	0.004

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Results Diesel Yard Truck and Container Handling Equipment
(Vocation Specific: Full vs. Empty Container Handling)

Yard Trucks		Fuel Method		Default
Power (hp)	n	Avg. LF	CI (90%)	EPA (ARB)
215	31	0.137	0.011	0.39 (0.39)
200	70	0.146	0.010	
155	20	0.210	0.010	
Container Handling				
375	15	0.180	0.041	0.43 (0.59)
210	3	0.460	0.001	
205	4	0.168	0.002	
173	4	0.260	0.015	

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Why are Load Factors still too High?

- EPA is (practically) prevented from surveying equipment, so help them out and voluntarily submit data
- Opportunity with GHG inventory or Permit preparation
  - Doesn't everybody collect fuel consumption data?
  - Are fuel consumption rates trustworthy and useful? (yes, and easy to collect!)
  - Alas, most clients do not want the data published
  - Vocation issues (e.g. industrial/mining/landfills vs. general or road construction) including idling and equipment sizing for the work
- OFFROAD/NONROAD Load Factors have been adjusted downward over the years
  - Diesel Tractors/Loaders/Backhoes LF = 0.21 (prior to NONROAD, the LF was 0.55)
  - Port intermodal yard trucks LF reduced from 0.59 to 0.39 (not low enough)
  - RTG Cranes from 0.43 to 0.20 (ARB OFFROAD changed these because engine power was shown to be too low for passively regenerated diesel particulate filters)
  - MOVES LPG/Gasoline Forklifts LF = 0.30 while diesel forklifts LF = 0.59; what gives?