Rewarding Zero-Emissions Container Movements

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May 25^{th}, 2022
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San Pedro Bay Ports

- Ports of Los Angeles and Long Beach (POLA/LB)
  - 30%+ of total imported goods to the U.S.
  - 60% of freight tonnage imported/exported in the West Coast
- Located in the South Coast air basin
  - Chronic air quality issues
- Since 2012 conducting zero emission drayage demonstration projects
  - Millions in funding

Clean Air Action Plan (CAAP) 2017

- All vehicles accessing the port to be zero-emission by 2035
  - Near-zero emission heavy duty trucks (NZEHDT)
  - Zero-emission heavy duty trucks (ZEHDT)
- **Clean Truck Fund Rate (CTFR)**
  - Charged to beneficial cargo owners (BCOs)
  - Every container moved in non-ZEHDTs
  - Harbor Commission approved a CTFR of $10 per TEU

Los Angeles Times

CLIMATE & ENVIRONMENT

L.A.-Long Beach ports approve truck fee too low to clean smog, groups charge

LOS ANGELES BUSINESS JOURNAL

Wednesday, May 19, 2021

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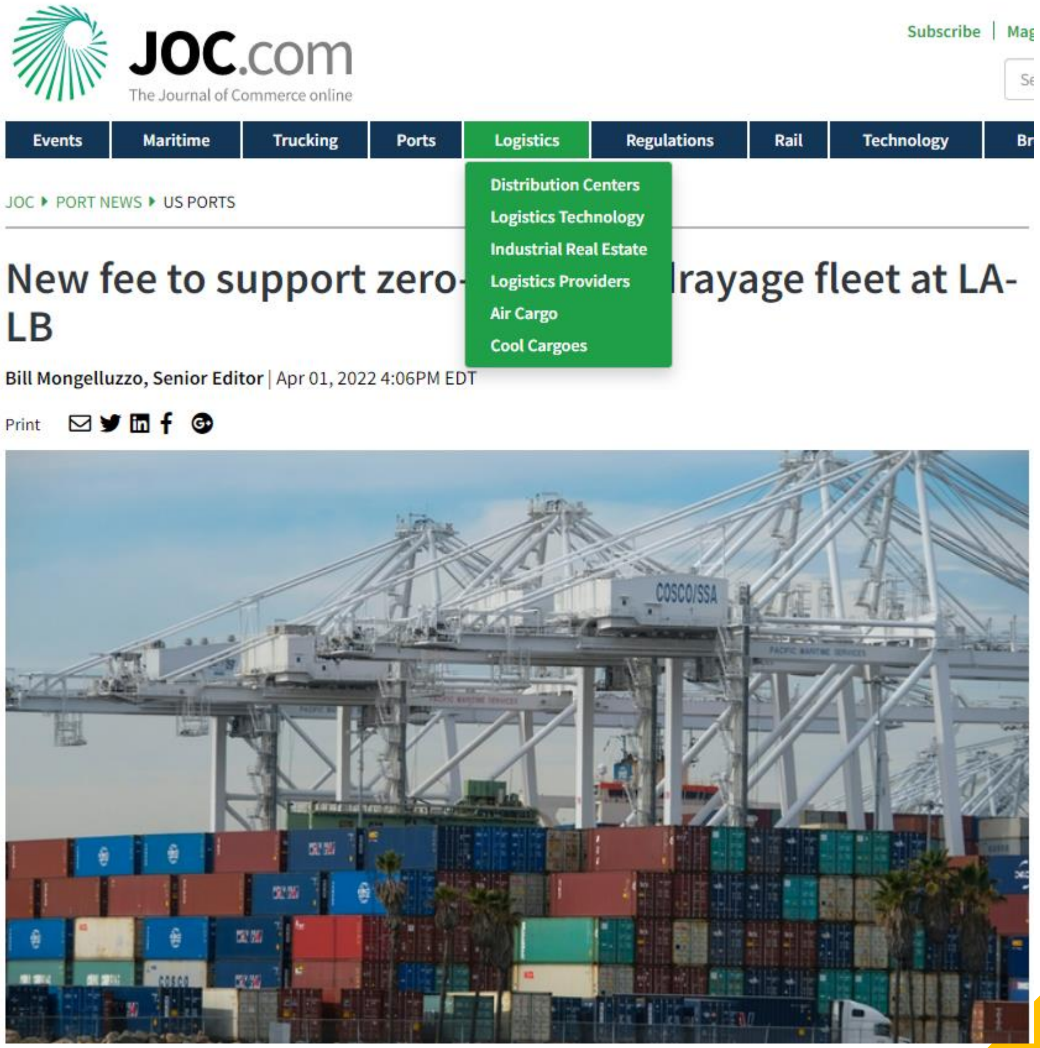
LA, LB Ports Postpone Plan for Clean Truck Fund

April 1, 2022 CTF Started

$10 per TEU

Expects to collect $90 million in the first year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New fee to support zero- [...] drayage fleet at LA-LB

Bill Mongelluzzo, Senior Editor | Apr 01, 2022 4:06PM EDT

Print

Transitioning to ZEHDTs and NZEHDTs

Incentives are Needed

Key Factors Affecting the Use and Efficiency of ZEHDTs for Drayage

Operational:

- Shift duration and travelled distance
- Average loads
- Trips vs. tour composition
- Dual transactions
- Truck turn times

- Fleets and vehicles:
  - Nature of business and fleet size
  - Truck price
  - Vehicle characteristics and fueling/charging characteristics

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Incentives

- Most in the form of purchase vouchers
- Example:
  - Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)
  - Up to $150,000 for Class 8 Battery Electric Trucks
  - There are ~15,000 – 18,000 drayage trucks serving the POLA/LB
    - ~$2.3 – $4.5 billion on incentives

- Challenges:
  - Lack of capacity to internalize risk
  - Vouchers for drayage would require billions of dollars
  - Existing funding level is not commensurate with needs
  - Incentives may favor large carriers

Rewards Program: Leveraging the CTFR

- Innovative coupling of the CTFR with a rewards program attached to zero-emission transport at the ports
  - Reward carrier for every container movement made by ZEHDT
  - Reward level to bridge the gap between diesel and ZEHDT costs
- Evaluate the program as potential solution to accelerate the transformation to cleaner technologies
- Opportunities:
  - Improve efficiency
  - Consistent with other programs that reward use
  - Mitigates the burden on carriers

Methodology

Method

1. Gather data from secondary sources;
2. Characterize and synthesize drayage operations;
3. Forecast improvements in operations, vehicle characteristics, and port activity;
4. Mathematical optimization: estimate CTFR and Reward levels
5. Generate and simulate different scenarios
6. Impact assessment

Container Forecast and Technology Penetration

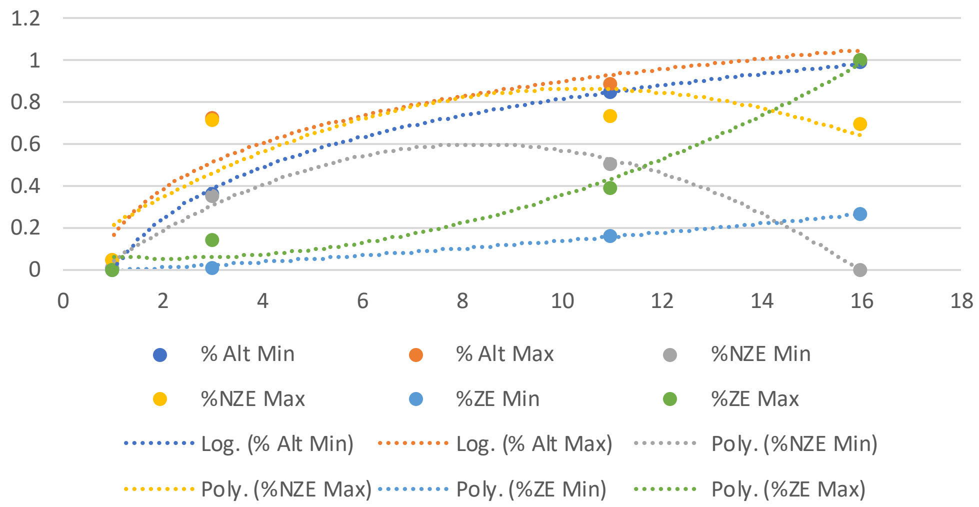
Scenarios:

Container demand – low, mid, high

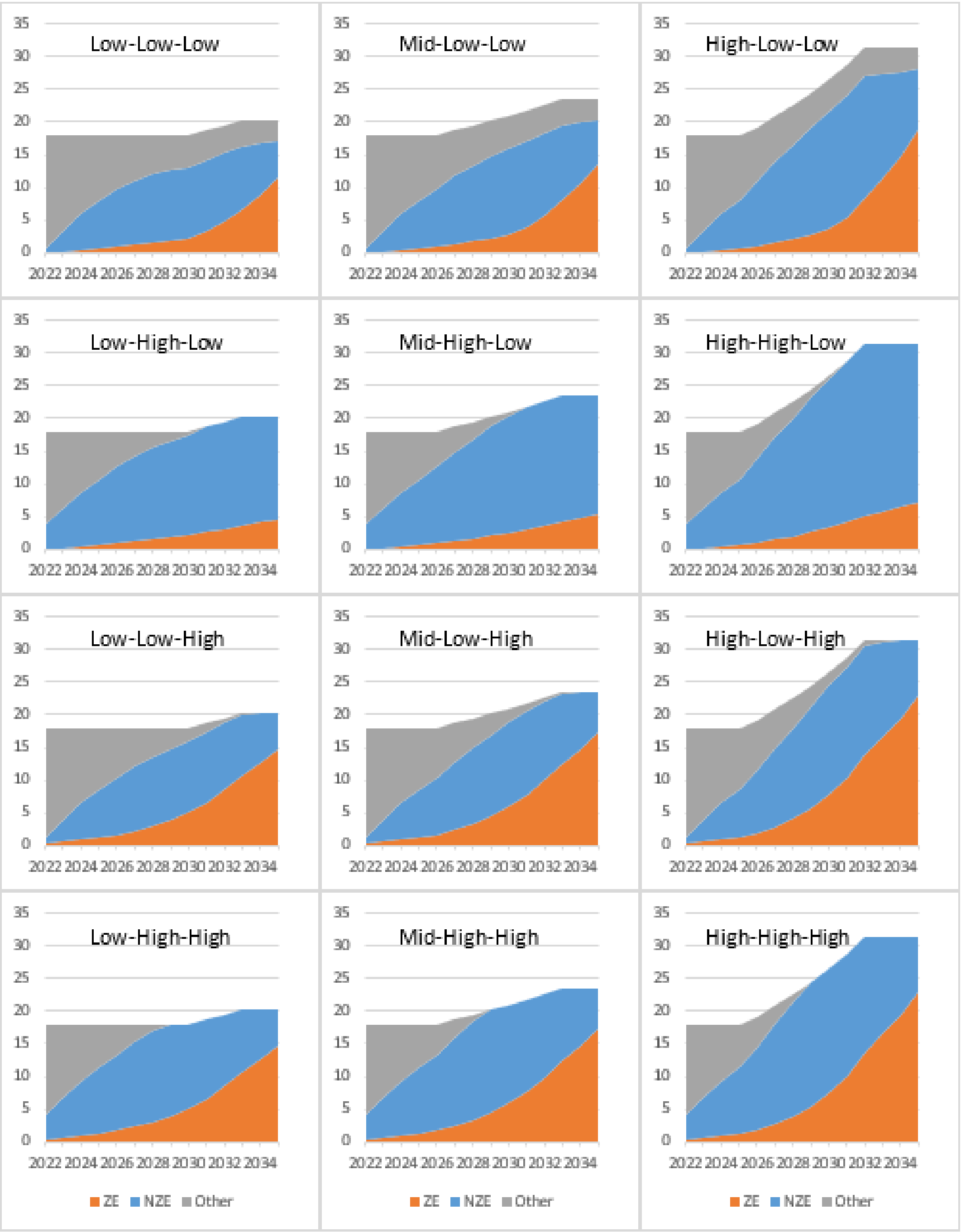
ZEHDT penetration – low, high

NZEHDT penetration – low, high

Container-ZEHDT-NZEHDT



Container-ZEHDT-NZEHDT



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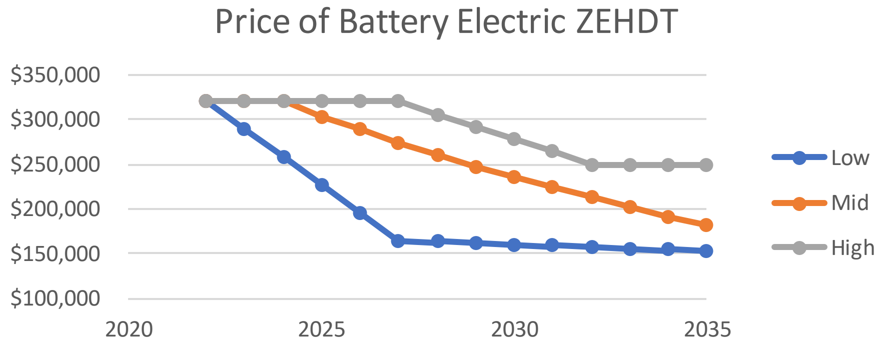
Optimal CTFR & Reward Level

Bridge the gap between ZEHDT and Diesel



Minimum level of reward needed

$$Min\ Z_{(CTFR_t, IRR_t)} = CTFIRR_{t=T} + \sum_{t} {}^{MY}S^{\tau=t} \cdot AZE_t$$

Subject to:

Fleet penetration and active fleet balance

$$ZEA_t = ZE_t - ZE_{t-1}, \forall t$$

$$NZEA_t = NZE_t - NZE_{t-1}, \forall t$$

$$AZE_t = MIN\left(\frac{D_t}{313 \cdot teu \cdot t_t^{ZE}}, {ZEA_t}/{2} \right), \forall t$$

$$ANZE_t = MIN\left(\frac{D_t - 313 \cdot teu \cdot t_t^{ZE} \cdot AZE_t}{313 \cdot teu \cdot t_t^{Non-ZE}}, {NZEA_t}/{2} \right), \forall t$$

$$ANE_t = \left(\frac{D_t - 313 \cdot teu \cdot \left(t_t^{ZE} \cdot AZE_t + t_t^{Non-ZE} \cdot ANZE_t \right)}{313 \cdot teu \cdot t_t^{Non-ZE}} \right), \forall t$$

CTFR collection and Reward Disbursement

$$CTF\_Collection_t = \begin{cases} 313 \cdot teu \cdot t_t^{Non-ZE} \cdot lteu \cdot CTFR_t \cdot ANE_t & , \forall t < 9 \text{ (year 2030)} \\ 313 \cdot teu \cdot t_t^{Non-ZE} \cdot lteu \cdot CTFR_t \cdot \left(ANE_t + ANZE_t \right) & , \forall t \geq 9 \end{cases}$$

$$IRR\_Disbursement_t = 313 \cdot teu \cdot t_t^{Non-ZE} \cdot ANE_t \cdot CTFR_t, \forall t$$

$$CTF\_Cum\_Collection_t = CTF\_Collection_t + CTF\_Collection_{t-1}, \forall t$$

$$IRR\_Cum\_Disbursement_t = IRR\_Disbursement_t + IRR\_Disbursement_{t-1}, \forall t$$

$$CTFIRR_t = CTF\_Cum\_Collection_t - IRR\_Cum\_Disbursement_t, \forall t$$

$$CTFIRR_t \geq 0, \forall t$$

$$CTFR_t \geq CTFR_{t-1}, \forall t$$

$$IRR_t \leq IRR_{t-1}, \forall t$$

Minimum reward

$$IRR_t^R = \begin{cases} Min\_IRR\_TEU_{t=1} & , \forall t \leq 5 \\ Min\_IRR\_TEU_t & , \forall t > 5 \end{cases}$$

$$IRR_t^B = IRR_t - IRR_t^R, \forall t$$

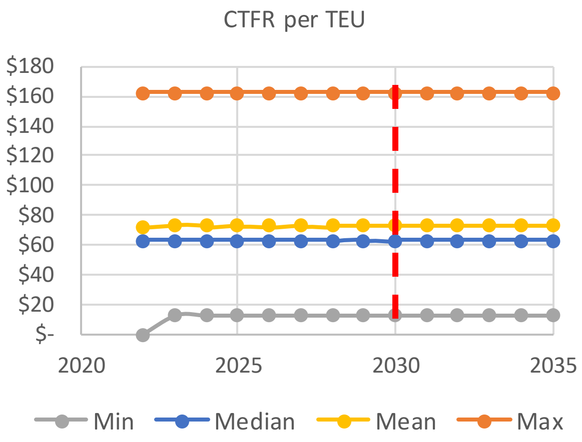
$$IRR_t \geq IRR_t^R, \forall t$$

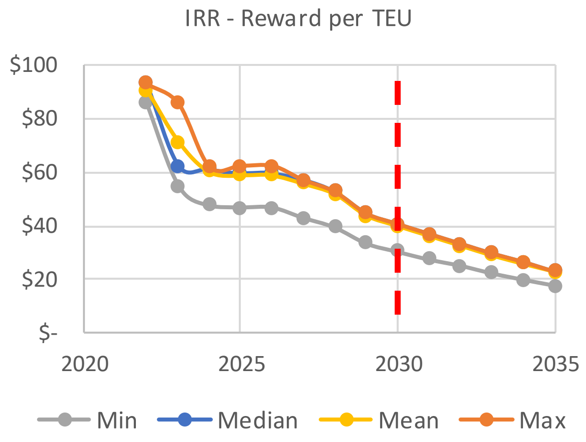
$${}^{MY}S^{\tau} = \sum_t IRR_t^B \cdot 313 \cdot teu \cdot t_t^{ZE}, \forall \tau \Rightarrow t$$

Optimal CTFR & Reward Level

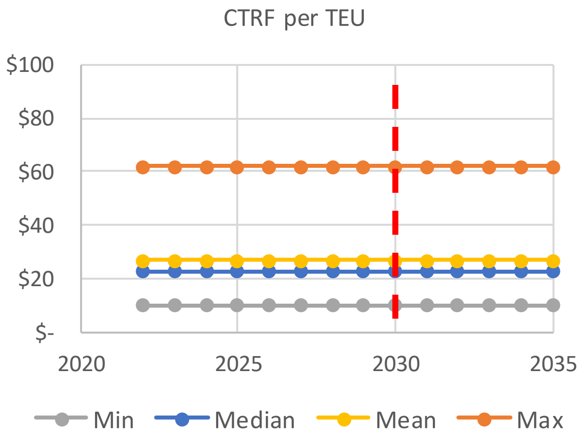
Continuous reward

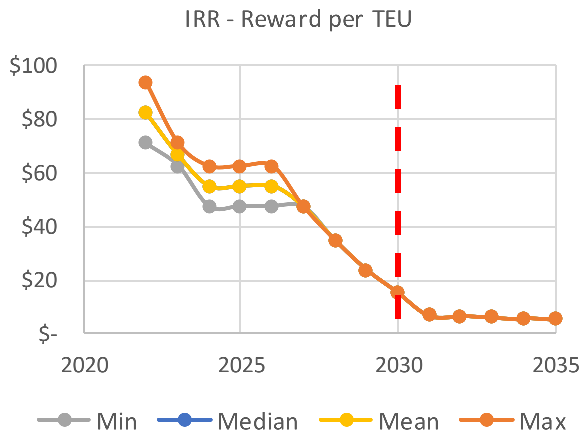
Mid-Price Scenario





Low-Price Scenario





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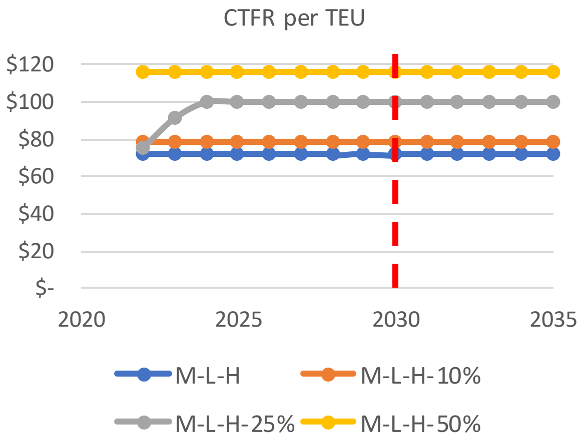
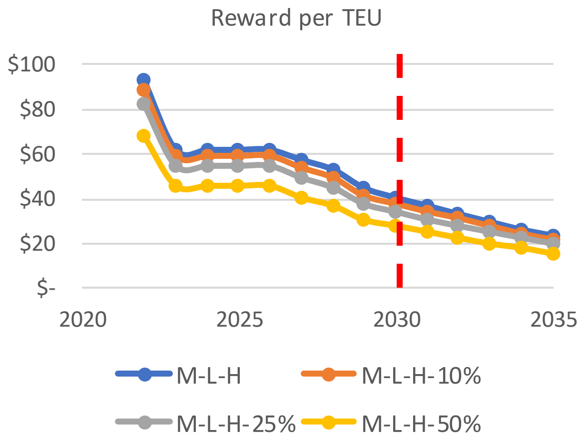
Optimal CTFR & Reward Level

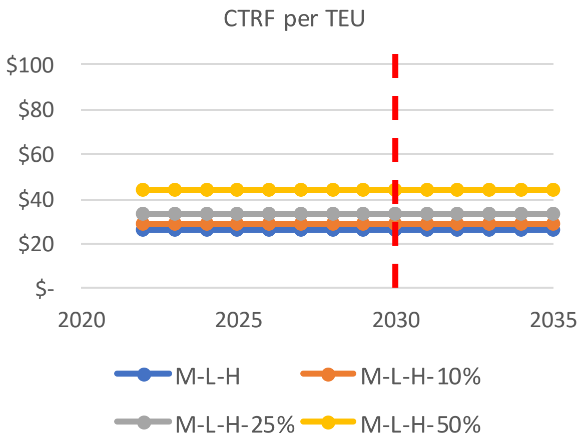
Impact of Turn Time Improvements

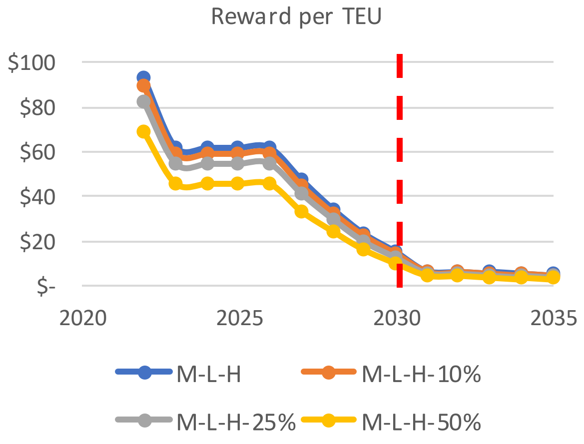
Mid-Price Scenario





Low-Price Scenario





M-L-H: Mid Container Demand, Low NZEHDT, High ZEHDT penetration

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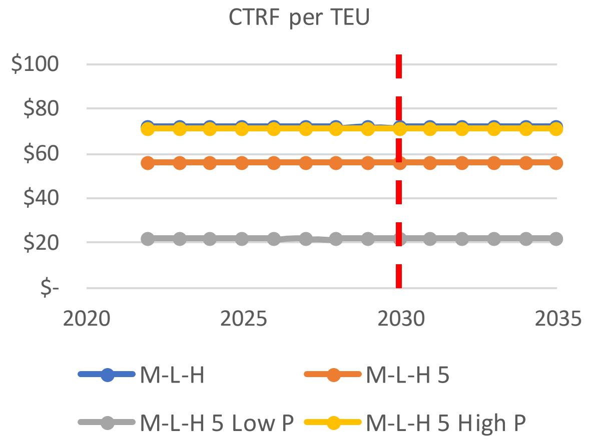
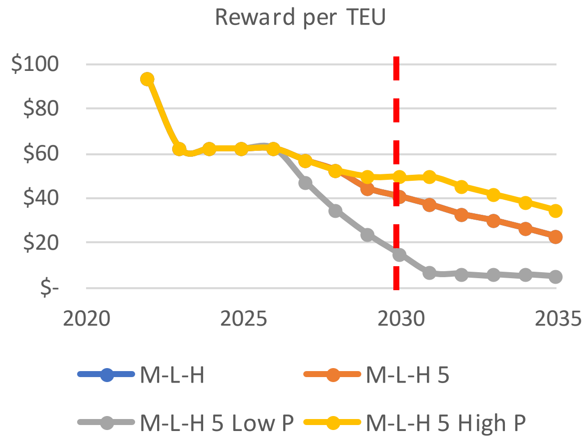
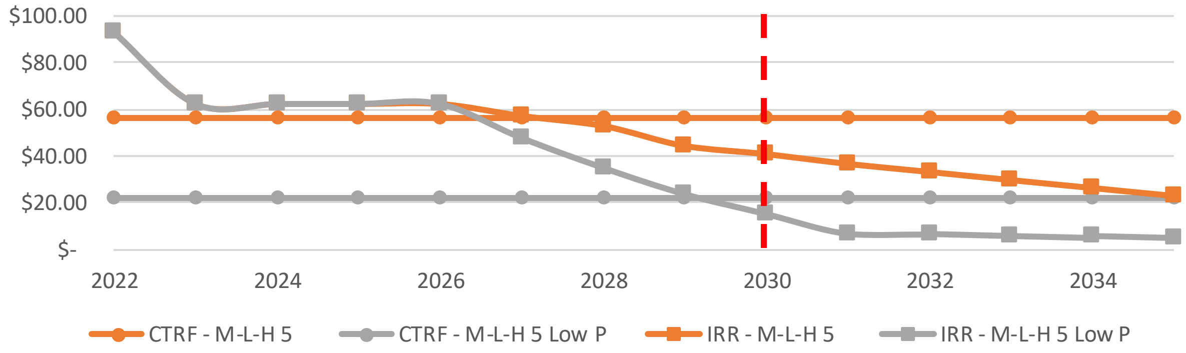
Optimal CTFR & Reward Level

Covering 5-year lease

- CTFR: $22-$56 per TEU
- Reward:
  - 2022: ~$90
  - 2035: ~$5-$23







M-L-H: Mid Container Demand, Low NZEHDT, High ZEHDT penetration

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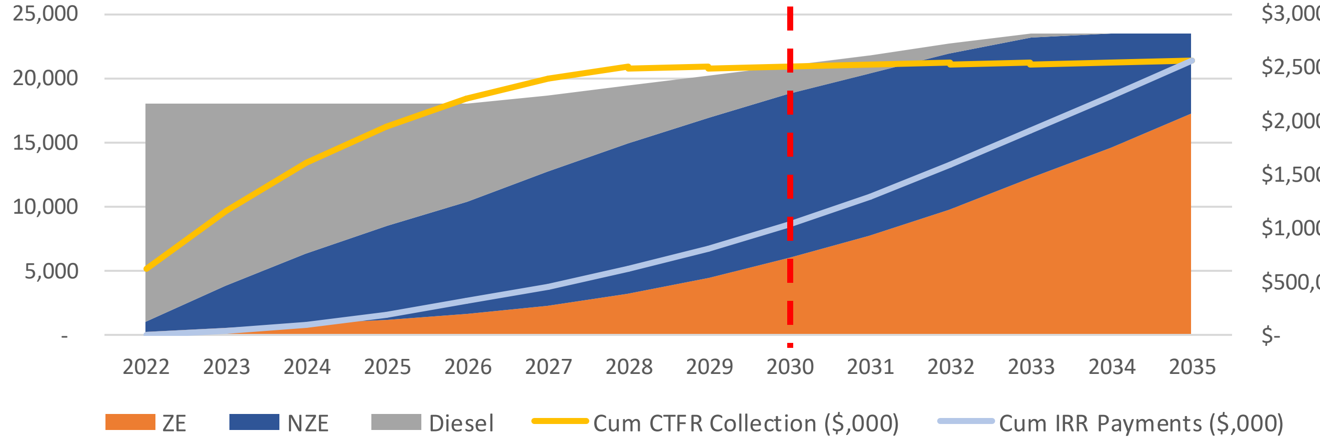
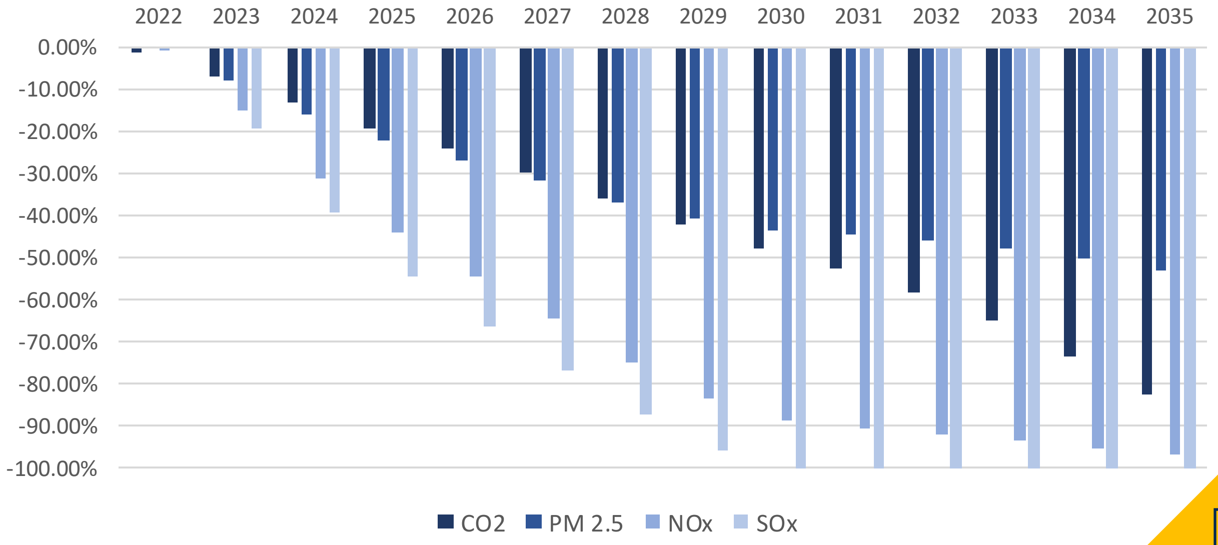
Potential Benefits

Example:

- Can transition 17,000+ trucks by 2035
- Emissions reduction:
  - 10.3 million metric tons CO2
  - ~50% PM
  - ~95% NOx & SOx





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Discussion

- A self-supported rewards program could achieve significant benefits
  - More if other incentives are available
- Considerations:
  - Price gap to bridge
  - Small fleet and owner operators
  - Reward limits
  - Most effective if ZEHDTs conduct local and regional as opposed to near-dock movements
  - Could be tied to e-mileage, or even market-based reward value pricing

Questions?

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Vehicle Efficiency Forecasts

Year	Fully Loaded Container (mile)	Empty Container (mile)	No Container (mile)	Battery Capacity (kwh)
Present*	60	85	100	240
Present 2**	93	131	154	
2022-2025	156	250	328	525
2025-2030	204	323	433	650
Freightliner eCascadia Battery Electric	119	168	198	475
Kenworth T680E Battery Electric Truck	99	140	165	396
Lion Electric LION8 Class 8 Truck	80	113	133	320
Peterbilt 579EV Battery Electric Truck	99	140	165	396
Volvo VNR Electric Rev 1	66	94	110	264
Volvo VNR Rev 2	170	265	300	565

*The first row of data is based on demonstration results; **Based on HVIP offerings

Year	Consumption Rate with Fully Loaded Container (kWh/mile)	Consumption Rate with Empty Container (kWh/mile)	Consumption Rate with No Container (kWh/mile)	Battery Capacity (kWh)
Present*	4	2.82	2.4	240
Present 2**	4	2.82	2.4	370
2022-2025	3.37	2.1	1.6	525
2030	3.18	2.01	1.5	650
2035	3	2	1.5	900

*240kwh for present year is based on demonstration interview results & US Hybrid Battery Electric Class 8 Truck Spec Sheet.

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Truck Movement Efficiency

Category	One Way Miles	% of Gate moves	Adjusted % of Gate moves	Loaded	Empty	Loaded Miles	Empty Miles	kWh Loaded	kWh Empty	kWh Full & Empty	kWh Full & Empty - Single-tour	Time Single-tour (ST)	Max ST per shift	kWh Full & Empty - Single-Tours Per Day
2022														
Near Dock	2	9.2%	9.8%	4.7%	4.5%	0.09	0.09	0.38	0.25	6.85	11.65	2.53	3.92	18.64
Local (near)	5	16.2%	17.2%	15.7%	0.5%	0.78	0.03	3.13	0.07	19.81	31.81	2.83	3.49	50.89
Local (away)	20	14.2%	15.1%	13.7%	0.5%	2.75	0.09	10.99	0.26	79.23	127.23	4.35	1.89	203.57
Regional (near)	40	43.0%	45.7%	22.3%	20.7%	8.92	8.28	35.67	23.36	137.27	233.27	5.24	1.03	373.24
Regional (away)	75	11.4%	12.1%	5.9%	5.5%	4.43	4.12	17.73	11.61	257.39	437.39	7.44	0.55	699.82
Long Distance	300	6.0%		6.0%	0.0%	18.00	-	72.00	-	1,200	1,920.00	20.27	0.13	3,072.00
2025														
Near Dock	2	8.0%	8.8%	4.1%	3.9%	0.08	0.08	0.28	0.16	5.50	8.70	2.53	3.92	13.92
Local (near)	5	15.0%	16.5%	14.5%	0.5%	0.73	0.02	2.45	0.05	16.64	24.64	2.83	3.49	39.43
Local (away)	20	13.0%	14.3%	12.6%	0.4%	2.52	0.08	8.48	0.18	66.57	98.57	4.35	2.27	157.72
Regional (near)	40	40.0%	44.0%	20.7%	19.3%	8.30	7.70	27.96	16.18	110.34	174.34	5.24	1.89	278.94
Regional (away)	75	15.0%	16.5%	7.8%	7.2%	5.83	5.42	19.66	11.38	206.89	326.89	7.44	1.33	523.02
Long Distance	300	9.0%		9.0%	0.0%	27.00	-	90.99	-	1,011	1,491	20.27	0.35	2,385
2030														
Near Dock	2	7.0%	8.0%	3.6%	3.4%	0.07	0.07	0.23	0.14	5.22	8.22	2.53	3.92	13.15
Local (near)	5	14.0%	15.9%	13.5%	0.5%	0.68	0.02	2.15	0.05	15.71	23.21	2.83	3.49	37.14
Local (away)	20	13.0%	14.8%	12.6%	0.4%	2.52	0.08	8.00	0.17	62.84	92.84	4.35	2.27	148.54
Regional (near)	40	36.0%	40.9%	18.7%	17.3%	7.47	6.93	23.74	13.94	104.67	164.67	5.24	1.89	263.46
Regional (away)	75	18.0%	20.5%	9.3%	8.7%	7.00	6.50	22.26	13.07	196.25	308.75	7.44	1.33	494.00
Long Distance	300	12.0%		12.0%	0.0%	36.00	-	114.48	-	954.00	1,404.00	20.27	0.46	2,246.40

Summary

	2022	2025	2030	2035
Average One-Way Miles	47.58	57.76	67.34	67.34
Adj. Avg One-Way Miles	29.58	30.76	31.34	31.34
Avg kWh	175.46	177.75	198.22	198.22
Adj. Avg kWh	103.46	86.76	83.74	83.74
Average kWh/ST	289.66	270.17	299.23	299.23
Adj. Avg kWh/ST	185.60	149.42	148.58	148.58
Avg Max ST/shift (Avg daily turns)	1.71	2.12	2.03	2.03
Adj. Avg Max ST/St (Adj. Avg daily turns)	1.81	2.29	2.25	2.25
Avg. kWh/day	463.46	432.27	478.76	478.76
Adj. Avg kWh/day	296.96	239.08	237.72	237.72
*Adjusted values do not consider the "Long Distance" trips				

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