# Memorandum

**To:** Bill Peters and Cory Ann Wind | Oregon DEQ

**From:** Philip Sheehy and Jeff Rosenfeld

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**Re:** Task 3: Additional Electrification Final Report

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## Background

The objective of Task 3 of ICF's contract with Oregon DEQ is to consider the potential for inclusion of additional sources of electrification in the Clean Fuels Program (CFP). This memorandum estimates the credit generation potential from additional electrification sources by analyzing the current and projected future electricity use by fixed light rail and street cars, forklifts, and truck stop electrification. The methodologies utilized to estimate future electricity consumption and credit generation potential are the same the methodologies utilized in the CalETC Phase 1 Transportation Electrification Assessment[1], the California Low Carbon Fuel Standard (LCFS) Final Regulatory Order[2] and the recent LCFS Staff Discussion Paper for Electricity as a Transportation Fuel[3].

## Credit Calculation

For calculating credits, ICF utilized the credit calculation formula from the CFP which is the same as the formula in the LCFS program as shown below:

$$Credits(MT) = \left(CI_{Standard} - CI_{technology}\right) * E * C$$

$$CI_{technology} = \frac{CI_{fuel}}{EER_{technology}}$$

The diesel standard carbon intensities, shown in the table below, are used for the credit calculations in this report. ICF utilized the electricity carbon intensity from the Oregon version of the GREET model of 120.27 g/MJ. The electricity carbon intensity of 31.85g/MJ in the Oregon regulation is energy economy ratio (EER) adjusted for light duty vehicles and the formula

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[1] http://www.caletc.com/wp-content/uploads/2016/08/CalETC_TEA_Phase_1-FINAL_Updated_092014.pdf
[2] https://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf
[3] https://www.arb.ca.gov/fuels/lcfs/lcfs_meetings/12022016discussionpaper_electricity.pdf

requires the non-EER adjusted carbon intensity since each technology that is being analyzed has its own unique EER.

Table 1. Annual Diesel Standard Carbon Intensity

| Year | Diesel Standard CI (gCO2e/MJ) |
|---|---|
| 2016 | 99.39 |
| 2017 | 99.14 |
| 2018 | 98.64 |
| 2019 | 98.15 |
| 2020 | 97.15 |
| 2021 | 96.15 |
| 2022 | 94.66 |
| 2023 | 93.16 |
| 2024 | 91.67 |
| 2025 | 89.68 |

The technology specific EER values utilized in the analysis are shown in the table below.

Table 2. Technology Specific EER Values

| Technology | EER Value | Source |
|---|---|---|
| Light Rail, Tri-Met Max | 3.33 | NTD for Portland specific diesel buses and fixed guideway technologies |
| Street Car, City of Portland | 1.81 | |
| Tram, City of Portland | 2.46 | |
| Forklifts | 3.8 | LCFS Regulatory Order |
| Truck Stop Electrification | 3.8 | LCFS Regulatory Order for forklifts |

When quantifying the credit generation potential from additional electrification, it is necessary to identify whether the direct kilowatt hours of electricity or the displaced conventional fuel will be the energy variable (E) in the credit equation. With the example of the California LCFS, the displaced conventional fuel is used when a technology is implemented after the “baseline” of the regulation and the argument can be made that its implementation displaces the consumption of conventional fuel. California set their baseline year at 2010, with any expansion of fixed-guideway systems after 2010 eligible for the displacement credit. For technologies implemented prior to baseline of the regulation, they generate credits based on their direct electricity consumption. The following table identifies which technologies that will be analyzed below generate credits based on direct consumption of electricity or displaced conventional fuel if Oregon were to adopt a baseline with the same logic used by California.

Table 3. Classification of Energy by Technology for use in the Credit Calculation

| Direct Electricity Consumption | Displaced Conventional Fuel |
|---|---|
| • Tri-Met Max Line Prior to 2015<br>• City of Portland Street Car Prior to 2015<br>• Forklifts purchased before 2016<br>• City of Portland Aerial Tram | • Tri-Met Max line expansion in 2015 (7.7 mi)<br>• City of Portland Street Car Expansion in 2015 (1.2 mi)<br>• Forklifts purchased 2016+<br>• Truck Stop Electrification |

# Fixed Light Rail and Street Cars

## Historic and Projected Electricity Consumption

For historic electricity consumption, ICF utilized the data collected through the National Transit Database (NTD) for 2010 – 2014 for TriMet and City of Portland light rail, street cars and trolleys. This data was presented in thousands of kWhs per year of consumption. To project the annual increases in the consumption of electricity from 2014 to 2025, ICF utilized the updated 2040 Household Forecast Distribution for Portland[4] to estimate annual population increases and potential resulting transit use. The forecast showed an average annual growth rate of 1.4%. The figure below shows the NTD historical electricity consumption of light rail (LR), street cars (SR) and trolleys (TR) and the projected annual electricity consumption to 2025.

[4] http://pamplinmedia.com/documents/artdocs/00003551437334.pdf

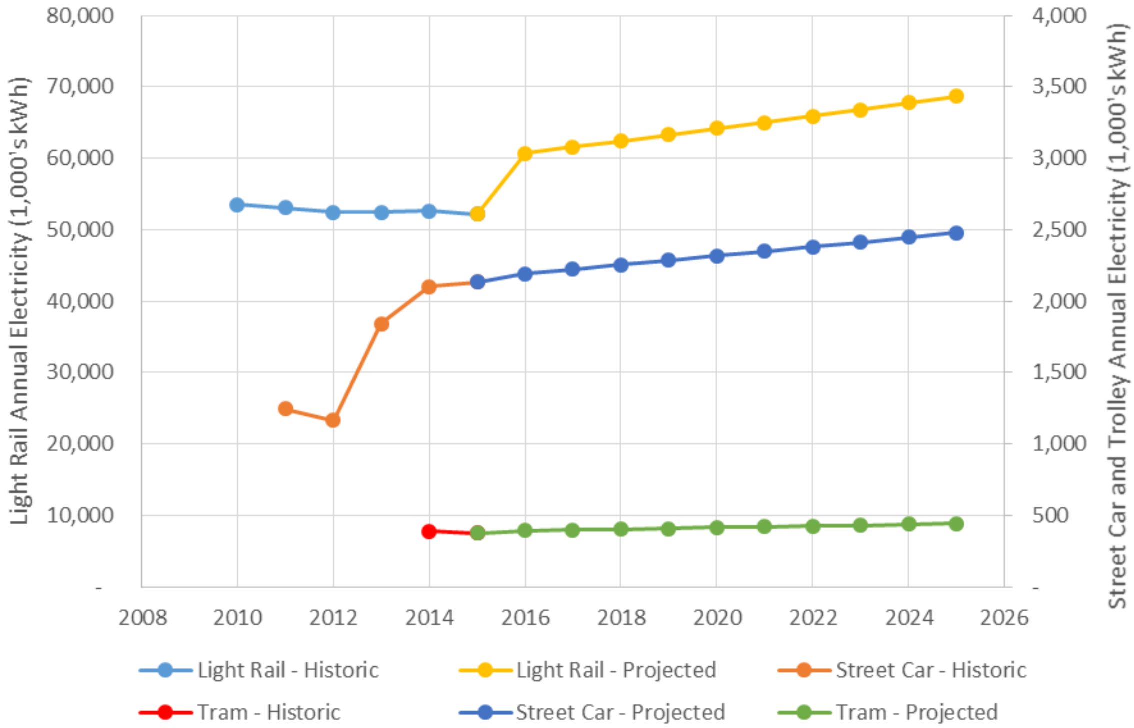


Figure 1. Historical and Projected Fixed Guideway Electricity Consumption

The jump in electricity consumption between 2014 and 2015 for the light rail is due to the line expansion that occurred in 2015. ICF assumed a proportional kWh/track mile from historical data for the new line.

## Credit Generation Potential

ICF utilized the credit generation formula, carbon intensities and EERs in the Credit Generation Section above. The table below presents the annual and total credit generation potential from fixed guideway for 2016 – 2025.

Table 4. Annual and Total Credit Generation Potential from Fixed Guideway

| Year | Light Rail (direct energy) | Light Rail (displaced energy) | Street Cars (direct energy) | Street Cars (displaced energy) | Aerial Tram | Annual Total |
|---|---|---|---|---|---|---|
| 2016 | 12,042 | 5,931 | 279 | 44 | 71 | 18,368 |
| 2017 | 12,160 | 5,989 | 281 | 45 | 72 | 18,546 |
| 2018 | 12,229 | 6,023 | 280 | 45 | 72 | 18,649 |
| 2019 | 12,301 | 6,058 | 280 | 45 | 73 | 18,755 |
| 2020 | 12,269 | 6,042 | 275 | 44 | 72 | 18,701 |
| 2021 | 12,234 | 6,025 | 269 | 43 | 71 | 18,642 |
| 2022 | 12,094 | 5,956 | 259 | 41 | 70 | 18,421 |
| 2023 | 11,946 | 5,883 | 249 | 40 | 69 | 18,187 |
| 2024 | 11,794 | 5,808 | 238 | 38 | 67 | 17,946 |
| 2025 | 11,528 | 5,677 | 223 | 35 | 65 | 17,528 |
| Total | 120,596 | 59,392 | 2,634 | 420 | 703 | 183,745 |

# Forklifts

## Projected Population and Electricity Consumption

There are limited data sources for forklift populations around the United States with little to no state level sources for forklift populations. ICF estimated the United States electric forklift populations by utilizing the same methodology as the CalETC Phase 1 TEA and ARB Electricity Discussion paper. The Industrial Truck Association (ITA) historical forklift sales[5] and estimated forklift lifetime of 8 years for gas/diesel forklifts (Classes 4 and 5) and 9 years for electric forklifts (Classes 1 and 2) were combined to quantify the estimated forklift populations. Recent trends in forklift sates were used to forecast future sales from 2016 – 2025. Oregon's share of the national population (1.2%) was used to determine Oregon's share of the US forklifts population. The figure below shows the projected United States forklift populations and percent of total rider forklifts that are electric.

[5] http://www.indtrk.org/market-intelligence

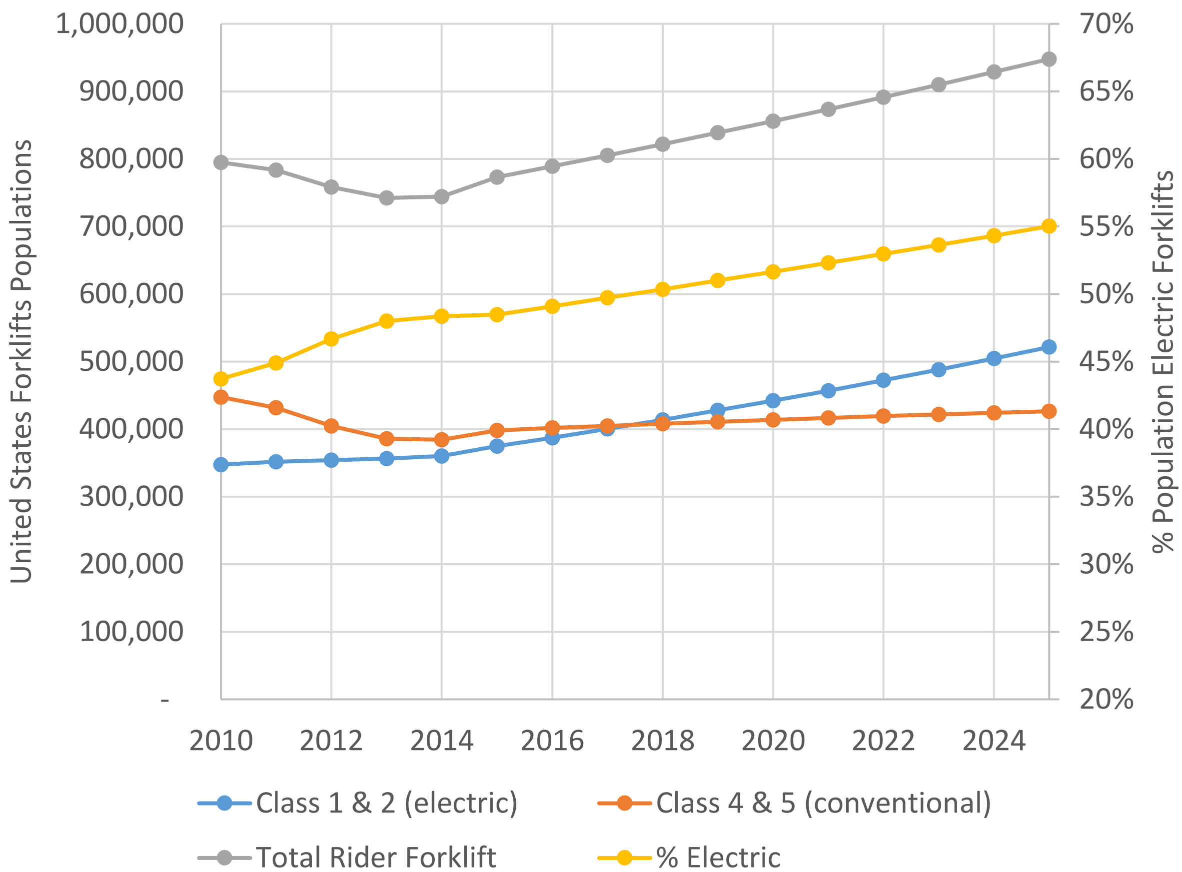


Figure 2. Historical and Projected US Forklifts Populations

The CalETC Phase 1 TEA estimates 18,312 kWh annually per 6,000lb electric forklift. This analysis assumes all electric forklifts are similar to the 6,000lb forklifts and no larger forklifts (similar to 18,000lb forklifts from the CalETC Phase 1 TEA) are electrified. In the LCFS, forklifts purchased before the start of the regulation (<2011) generate credits based only on their electricity consumption but forklifts purchased after the start of the regulation (2011 or later) generate credits based on conventional fuel displaced. ICF utilized the same methodology for Oregon's forklifts but adjusted the initial year the regulation to 2016. The table below shows the estimated Oregon forklift population purchased in 2015 or earlier and those forklifts purchased 2016 or later, and the estimated electricity consumed by each category.

Table 5. Oregon Forklift Populations and Annual and Total Electricity Consumption

| Year | Oregon <2015 Forklifts | Oregon 2016+ Forklifts | Total Oregon Forklifts | Oregon <2015 Forklift Electricity (kWh) | Oregon 2016+ Forklift Electricity (kWh) |
|---|---|---|---|---|---|
| 2016 | 4,101 | 721 | 4,822 | 75,097,512 | 13,202,952 |
| 2017 | 3,747 | 1,237 | 4,984 | 68,615,064 | 22,651,944 |
| 2018 | 3,352 | 1,800 | 5,152 | 61,381,824 | 32,961,600 |
| 2019 | 2,795 | 2,530 | 5,325 | 51,182,040 | 46,329,360 |
| 2020 | 2,184 | 3,320 | 5,504 | 39,993,408 | 60,795,840 |
| 2021 | 1,526 | 4,162 | 5,688 | 27,944,112 | 76,214,544 |
| 2022 | 810 | 5,070 | 5,880 | 14,832,720 | 92,841,840 |
| 2023 | - | 6,077 | 6,077 | - | 111,282,024 |
| 2024 | - | 6,281 | 6,281 | - | 115,017,672 |
| 2025 | - | 6,492 | 6,492 | - | 118,881,504 |

## Credit Generation Potential

ICF utilized the credit generation formula, carbon intensities and EERs in the Credit Generation Section above. The table below presents the annual and total credit generation potential from forklifts for 2016 – 2025 taking into account energy displacement for forklifts purchased 2016 or later.

Table 6. Annual and Total Credit Generation Potential from Forklifts

| Year | Credits from Oregon <2015 Forklifts | Credits from Oregon 2016+ Forklifts | Annual Total |
|---|---|---|---|
| 2016 | 18,314 | 12,235 | 30,549 |
| 2017 | 16,671 | 20,914 | 37,585 |
| 2018 | 14,803 | 30,207 | 45,010 |
| 2019 | 12,253 | 42,147 | 54,400 |
| 2020 | 9,430 | 54,476 | 63,906 |
| 2021 | 6,489 | 67,249 | 73,737 |
| 2022 | 3,365 | 80,028 | 83,392 |
| 2023 | - | 93,639 | 93,639 |
| 2024 | - | 94,438 | 94,438 |
| 2025 | - | 94,374 | 94,374 |
| Total | 81,324 | 589,705 | 671,029 |

# Truck Stop Electrification (TSE)

## Projected Population and Electricity Consumption

Currently in Oregon there are five truck stops that TSE bays available for connecting. The table below identifies the trucks and bays located at each one.

Table 7. Oregon TSE Locations

| Truck Stop | Number of Bays | City |
|---|---|---|
| Jubitz | 28 | Portland |
| Arrowhead | 46 | Pendleton |
| Baker | 24 | Baker City |
| Truck n Travel | 26 | Coburg |
| Seven Feathers | 36 | Canyonville |
| Total | 160 | - |

ICF was supplied data from Shorepower that was collected in an ARRA funded project from 2011-2015. The most complete data in the set was for the Jubitz truck stop in Portland. From 2012 – 2014, the Jubitz truck stop TSE bays had a total usage 24,490 hours. This equates to an average space usage of 3.4%. This is comparable to the usage value supplied by Jubitz of around 2% capacity. From the data, ICF was able to calculate a weighted average load of 0.69 kW per visit. Based on the current bays and capacity, ICF estimates 32,920 kWh per year from TSE within the State of Oregon.

### Credit Generation Potential

ICF utilized the credit generation formula, carbon intensities and EERs in the Credit Generation Section above. The table below estimates the credit potential from TSE based on 32,920 kWh per year.

Table 8. Annual and Total Credit Generation Potential from TSE

| Year | Credits |
|---|---|
| 2016 | 31 |
| 2017 | 30 |
| 2018 | 30 |
| 2019 | 30 |
| 2020 | 29 |
| 2021 | 29 |
| 2022 | 28 |
| 2023 | 28 |
| 2024 | 27 |
| 2025 | 26 |
| Total | 289 |

## Comparison with 2014 Illustrative Compliance Scenarios

The 2014 Illustrative Compliance Scenarios quantified 10.0 – 13.6 million credits required for compliance. Based on the calculations and methodology above, fixed guideway electrified transportation could contribute between 1.4-1.9% of the credits for compliance, forklifts could contribute between 4.9 – 6.7% of the credits for compliance and TSE could contribute between 0.002-0.003%.

## Comparison of Direct vs Displacement Credit Generation

The following tables show credit generation potential from all of the technologies analyzed above when they all are generating credits from the direct electricity consumption methodology or the displaced conventional fuel methodology. Each table also includes a column with the total credit generation potential from the technology specific methodology utilized above.

Table 9. Credit Generation Potential with All Technologies Utilizing the Direct Electricity Methodology

| Year | Light Rail | Street Cars | Aerial Tram | Forklifts | TSE | Total | Technology Specific Total |
|---|---|---|---|---|---|---|---|
| 2016 | 13,826 | 304 | 71 | 21,533 | 8 | 35,742 | 48,947 |
| 2017 | 13,961 | 305 | 72 | 22,175 | 8 | 36,521 | 56,161 |
| 2018 | 14,040 | 305 | 72 | 22,752 | 8 | 37,178 | 63,689 |
| 2019 | 14,122 | 304 | 73 | 23,344 | 8 | 37,851 | 73,185 |
| 2020 | 14,085 | 299 | 72 | 23,766 | 8 | 38,230 | 82,637 |
| 2021 | 14,045 | 293 | 71 | 24,186 | 8 | 38,603 | 92,409 |
| 2022 | 13,885 | 282 | 70 | 24,424 | 7 | 38,669 | 101,842 |
| 2023 | 13,715 | 271 | 69 | 24,642 | 7 | 38,704 | 111,854 |
| 2024 | 13,540 | 260 | 67 | 24,852 | 7 | 38,727 | 112,411 |
| 2025 | 13,235 | 242 | 65 | 24,835 | 7 | 38,384 | 111,929 |
| Total | 138,454 | 2,866 | 703 | 236,510 | 76 | 378,609 | 855,063 |

Table 10. Credit Generation Potential with All Technologies Utilizing the Displaced Conventional Fuel Methodology

| Year | Light Rail | Street Cars | Aerial Tram | Forklifts | TSE | Total | Technology Specific Total |
|---|---|---|---|---|---|---|---|
| 2016 | 45,982 | 550 | 176 | 81,827 | 31 | 128,565 | 48,947 |
| 2017 | 46,431 | 554 | 177 | 84,263 | 30 | 131,456 | 56,161 |
| 2018 | 46,696 | 553 | 178 | 86,459 | 30 | 133,916 | 63,689 |
| 2019 | 46,968 | 552 | 179 | 88,708 | 30 | 136,436 | 73,185 |
| 2020 | 46,846 | 542 | 177 | 90,311 | 29 | 137,906 | 82,637 |
| 2021 | 46,712 | 531 | 176 | 91,905 | 29 | 139,354 | 92,409 |
| 2022 | 46,179 | 512 | 173 | 92,813 | 28 | 139,705 | 101,842 |
| 2023 | 45,615 | 491 | 170 | 93,639 | 28 | 139,942 | 111,854 |
| 2024 | 45,034 | 470 | 166 | 94,438 | 27 | 140,135 | 112,411 |
| 2025 | 44,017 | 439 | 161 | 94,374 | 26 | 139,017 | 111,929 |
| Total | 460,480 | 5,193 | 1,732 | 898,737 | 289 | 1,366,432 | 855,063 |