Appendix L

Cost Methodology

A. Introduction

This appendix provides additional detail on inputs used in direct cost calculations described in Appendix C, the Standardized Regulatory Impact Assessment (SRIA). Specifically, it provides assumptions and dates used to estimate equipment cost described in the SRIA, and provides additional information describing how the emissions calculation methods were adapted to estimate direct costs. Finally, this document provides a cost effectiveness calculation that is not included in the SRIA.

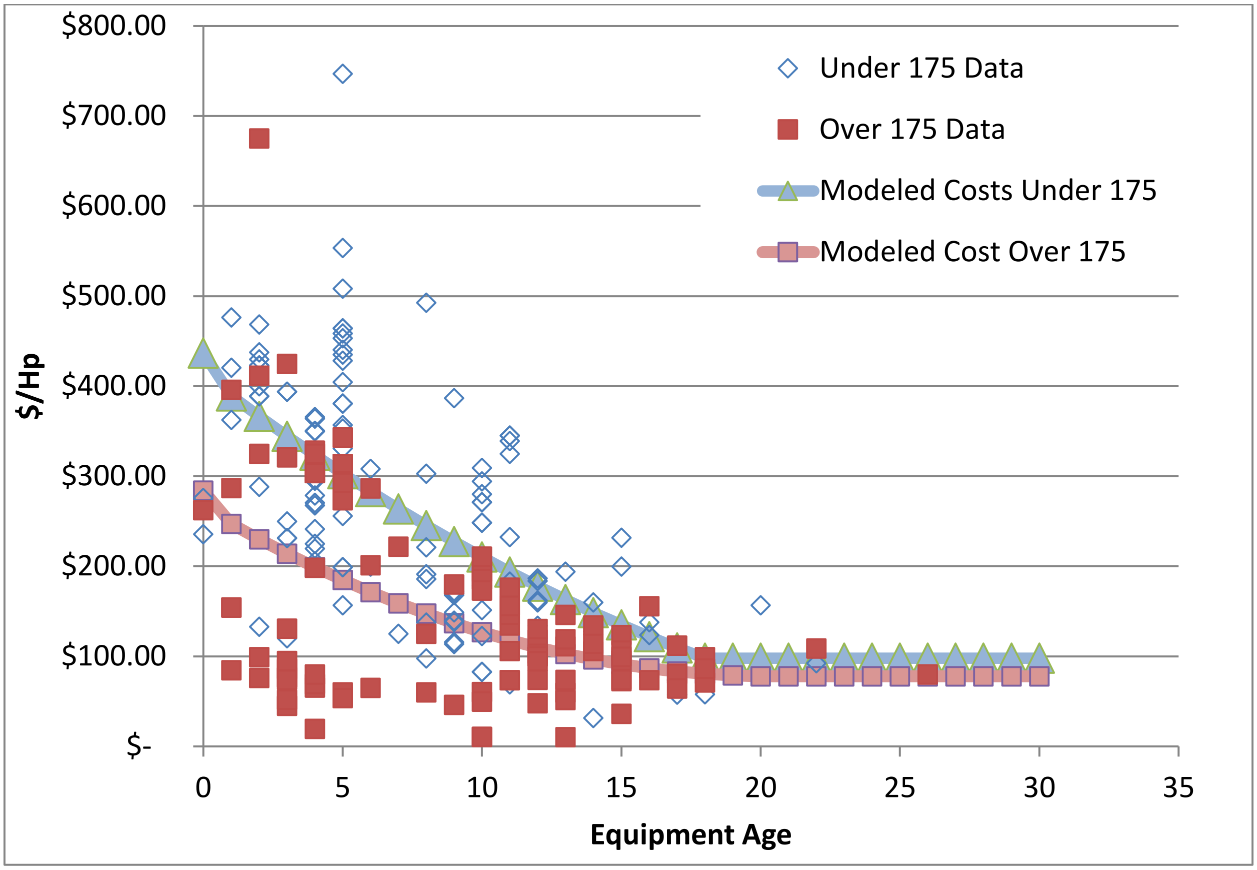
B. Equipment Costs

Equipment cost is an input in the calculation of direct costs to businesses associated with the amendments, as described in Appendix C, page 27:

> "Equipment replacement represents the majority of costs of the Portable Regulatory Amendments. During the Portable Regulatory Amendments process, ARB collected data on recently sold or listed for sale new and used portable equipment using cost data for equipment provided by stakeholders, as well as a variety of online sources. A cost curve was developed based on data from more than 230 pieces of portable equipment with various engine tiers, horsepower, and age, representing generators, compressors, and pumps. The cost curve was then used in ARB's equipment turnover model to calculate equipment replacement cost on a per unit basis by taking the cost of newly purchased equipment required and subtracting it from the existing equipment's resale value. Any equipment costs in the BAU are then subtracted to identify costs as a result of the Proposed Regulatory Amendments only."

To estimate equipment costs, staff gathered portable equipment cost data on sales occurring in 2016 of over 240 pieces of portable equipment in California of varying equipment type, engine size, hours of use, and equipment age from several websites including, but not limited to, https://www.rbauctions.com/, http://www.machinio.com, and http://www.auctiontime.com. Figure L-1 shows a scatter plot of the dollar per horsepower ($/hp) cost versus equipment age with a data point for sales data on each piece of portable equipment gathered. The data points were statistically analyzed to determine if any trends in $/hp exist between equipment type, engine size, and age. Staff found a higher average $/hp trend for equipment with engines greater than or equal to 175 horsepower (hp) than equipment with engines less than 175hp indicated by the two trend curves representing the average sales price in $/hp for equipment of various age.

Figure L-1: Sales Data and Average Equipment Cost ($/hp) by Equipment Age



Concurrently used with the cost curve are additional cost adjustment factors for equipment with interim Tier 4 and Tier 4 final engines based on discussions with manufacturers and dealers as shown in Table L-1 below. Each time equipment is purchased or sold, the cost, based off the cost curves in Figure L-1, is multiplied by the appropriate cost adjustment factor per Tier in Table L-1.

Table L-1: Cost Adjustment Factors by Tier

Tier	Cost Adjustment Factor
1	1.0
2	1.0
3	1.0
4 interim	1.7
4 final	2.1

C. Using the Inventory to Estimate Equipment Costs at a Fleet Level

The SRIA (in Section 2Aii-iv) describes the general methodology used by the emissions inventory model to estimate equipment costs at a fleet level. Appendix I in Sections 4b, 4c and Appendix I-1 describe how the emissions inventory model estimates fleet turnover. To estimate costs associated with fleet turnover, staff applies the cost curve described above by equipment age and horsepower. Whether by natural turnover or through regulatory compliance, staff assumes the fleet will realize the residual value of the retired equipment by selling the equipment outside of California. The difference between the cost of new equipment in a fleet and the residual value of old equipment in the fleet in a given year is the direct cost to that fleet in that year.

The following example shows a fleet before natural turnover, after natural turnover, and after rule standards are implemented to describe the cost of natural turnover and the cost of the regulation. The fleet, before natural turnover, shown in Table L-2 below has four engines of various horsepower and age which each have their own cost ($/hp) calculated using the cost curves in Figure L-1. The cost ($/hp) is then multiplied to the engine value to determine the equipment value ($).

Table L-2: Fleet of Four Pieces of Portable Equipment, Before Natural Turnover

Equipment Number	Horsepower	Age	Cost ($/HP, Figure L-1)	Value
1	150	10	$122.50/HP	$18,375
2	200	5	$313.60/HP	$62,720
3	100	2	$230.09/HP	$23,009
4	50	2	$230.09/HP	$11,504.50

The total equipment value of the fleet is the sum of the values for each piece of equipment in the fleet:

$$Fleet\ Equipment\ Value = Value1 + Value2 + Value3 + Value4 \qquad Eq. 1$$
$$Value, Before\ Turnover = \$18{,}375 + \$62{,}720 + \$23{,}009 + \$11{,}504.50 = \$115{,}608.50$$

The value of the fleet’s equipment before natural turnover is $115,608.50. In this example, natural turnover dictates the fleet will replace their oldest equipment with a new equipment of equal horsepower as shown in Table L-3 below.

Table L-3: Fleet of Four, After Natural Turnover

Equipment Number	Horsepower	Age	Cost ($/HP, Figure L-1)	Value
1	150	0	$275.99/HP	$41,398.50
2	200	5	$313.60/HP	$62,720
3	100	2	$230.09/HP	$23,009
4	50	2	$230.09/HP	$11,504.50
1 (replaced)	150	10	$122.50/HP	$18,375

The total equipment value of the fleet after natural turnover is the sum of the values for each piece of equipment in the fleet:

$$Value, After\ Turnover = \$41{,}398.50 + \$62{,}720 + \$23{,}009 + \$11{,}504.50 = \$138{,}632$$

The cost of natural turnover can be calculated by taking the sum of all equipment values in the fleet that have been added to the fleet in a given year minus the value of each replaced piece of equipment from the fleet in the same year as shown in Equation 2. This method of calculating equipment replacement cost takes the cost of the added engine and subtracts out the residual value of the replaced engine.

$$Cost\ of\ Natural\ Turnover = \sum_{i=1}^{x} Value_i - Value_i(replaced) \qquad Eq. 2$$

$$Where\ x\ is\ equal\ to\ the\ total\ number\ of\ engines\ replaced\ in\ a\ given\ year.$$

$$Cost\ of\ Natural\ Turnover = \$41{,}398.50 - \$18{,}375 = \$23{,}023.50$$

In the next example, the regulatory performance standards require this fleet to replace their two oldest engines with new engines as shown in Table L-4 below.

Table L-4: Fleet of Four, After Regulatory Standards

Equipment Number	Horsepower	Age	Cost ($/HP, Figure L-1)	Value
1	150	0	$275.99/HP	$41,398.50
2	200	0	$437.00/HP	$87,400
3	100	2	$230.09/HP	$23,009
4	50	2	$230.09/HP	$11,504.50
1 (replaced)	150	10	$122.50/HP	$18,375
2 (replaced)	200	5	$313.60/HP	$62,720

To calculate the cost of the regulation, we must find the costs the fleet will incur above the costs that would be incurred under natural turnover. To do this, we would use Equation 2, but compare the “After Regulatory Standards” scenario in Table L-4 to what is replaced under the “After Natural Turnover” scenario shown in Table L-3.

$$Cost\ of\ The\ Regulation = \$87{,}400 - \$62{,}720 = \$24{,}680$$

For this example the cost of natural turnover, or the cost of equipment replacement to the fleet if no regulations existed, in this year is $23,023.50. Under a scenario where a regulation required the replacement of an additional piece of equipment, the cost of the regulation would be $24,680 more than the cost of natural turnover.

D. Cost Effectiveness

The regulatory cost of new equipment across the industry in each year is the sum of all fleet level compliance costs in each year. This is described and summarized in Appendix C, pages 15 and 16. This is added to other costs as described in the SRIA. To calculate cost effectiveness, staff amortized costs at an eight percent interest rate over a five year period, in each year. The total cost of the regulation is estimated at $242,767,163 over the years 2017 to 2040. The total NOx and PM benefits of the regulation are estimated as 28,567,990 lbs and 1,515,414 lbs, respectively, over the years 2017 to 2040. Cost effectiveness is the ratio of the total cost divided by total emission reductions for a pollutant. The cost effectiveness for the regulatory amendments is $8.50/lb of NOx and $160.20/lb of PM.

Table L-5: Cost-effectiveness Compared to Previously Adopted ARB Regulations (in 2016 dollars)

Rule	NOx ($/lb)	PM ($/lb)	Source of Estimate
Stationary Compression Ignition Engine Airborne Toxic Control Measure (ATCM)	$1.96	$20.09	(ARB, 2003) https://www.arb.ca.gov/regact/statde/isor.pdf
In-Use Off-Road Diesel Vehicle Regulation	$4.74	$83.87	(ARB, 2010) https://www.arb.ca.gov/regact/2010/offroadlsi10/offroadisor.pdf
Public Fleet Rule	$14.10*	$195.40	(ARB, 2005) https://www.arb.ca.gov/regact/dpmcm05/isor.pdf
Diesel Auxiliary Engines on Ocean-Going Vessels at Berth in California Port	$3.70	$199.68	(ARB, 2007) https://www.arb.ca.gov/regact/2007/shorepwr07/isor.pdf
Portable Regulatory Amendments	$8.50	$160.20	Shown Above

*Combined HC + NOx

Table L-5 compares the cost effectiveness of the amendments to other regulations. The cost effectiveness is lower than other regulations because:

- The Portable Engine ATCM already phased out Tier 0 equipment from fleets
- More affordable compliance options such as retrofits and repowers are not available in portable equipment.
- Many fleets upgraded to Tier 3 equipment which while cleaner than older tiers, do not meet the final set of emission standards. This Tier 3 equipment must be replaced through the proposed amendments.

Equipment replacement with Tier 4 engines is the only viable path to reduce fleet emissions for the portable sector which is composed of all certified engines with relatively low emission rates. The low cost effectiveness of the Portable Regulatory Amendments can be attributed to the high equipment replacement cost coupled with the relatively low emission benefits from equipment replacement.