Projected vs. Actual Costs of Low-Carbon Fuel Programs

Low-carbon fuel (LCF) programs in California, Oregon, and Washington have consistently cost less than projected while outperforming carbon-intensity reduction targets. Many states are now considering adding an LCF to their toolbox to encourage cleaner fuels, and it's important that both the costs and benefits of LCF programs are addressed appropriately. This analysis compares prominent pre-program and early-program cost projections with actual per-gallon program costs, by comparing forecasted and actual credit prices (detailed calculation available in Appendix A). We focus on gasoline-equivalent costs and omit diesel, whose costs follow the same pattern at proportionately higher levels due to higher energy density.[1]

California LCFS

Figure 1 presents four examples of forecasts that were performed on the California Low Carbon Fuel Standard (LCFS). These are annotated with the name of the organization and date of forecast release. Referencing the left axis, we calculate the cost of the LCFS per gallon of gasoline for each month. The thick orange line represents the actual calculated values ("Reported Cost").[2] Referencing the right axis, we overlay the carbon-intensity reduction standard (grey area). Additional detail about the LCFS program, descriptions of each forecast, and details regarding our calculation of the per-gallon cost forecasted by the California Trucking Association are included in Appendix B.

Figure 1. LCFS Projected vs. Actual Credit Price and Cost per Gasoline Gallon (Sept. 2012- Dec. 2025)

Forecasts didn't anticipate the rapid growth in RD and RNG and couldn't predict future program amendments.

Oregon CFP

Stillwater did not find any Oregon-specific forecasts to compare against actual observations. However, in evaluating the potential price impacts of the Clean Fuels Program (CFP),[3] the Oregon Department of Environmental Quality (DEQ) relied on studies published by BCG (2012), ICF (2014), and Leidos (2014) that offered price projections for the *California LCFS.* Based on their evaluation of these studies, DEQ correlated the projected costs for the LCFS to the projected price impact of the CFP at 4-19 cents per gallon (cpg) by the end of the first 10-year period of the program based off the ICF and Leidos studies. The added cost to gasoline in Oregon has only exceeded 19 cpg very recently, at the end of 2025, but has not reached the 33-106 cpg levels identified in the BCG study.

---

[1] The energy density of gasoline (CBOB) is 122.48 MJ/gal (in Oregon and Washington) or 119.53 MJ/gal (CARBOB in California) compared to 134.47 MJ/gal for diesel.
[2] Spot market price quotes (by OPIS)
[3] Oregon Department of Environmental Quality Clean Fuel Program Phase II Rulemaking, January 7, 2015

Washington CFS

The Washington Clean Fuel Standard (CFS) is a relatively young program, therefore a projected vs. actual cost analysis that reaches out more than three years is unavailable at this time. Figure 2 presents four forecasts that were performed on the CFS. As with Figure 1, these are annotated with the name of the organization and date of forecast release. Referencing the left axis, the thick orange line ("Reported Cost") represents the calculation for historic prices using volume-weighted average transaction prices reported to the Washington Department of Ecology by the month when the transaction was proposed.[4] As shown in the Reported Cost trend, CFS credit prices have declined somewhat since the beginning of the program. Early, higher, prices were due to a new, illiquid market where participants were establishing fair value for CFS credits. CFS credit prices have stabilized and decreased since the start of the program. As in Figure 1, the annual carbon-intensity reduction standards are plotted as a grey area referencing the right-hand scale. Additional background on the Washington CFS program and descriptions of the four projections plotted in Figure 2 can be found in Appendix D.

Figure 2. Washington CFS Projected vs. Actual Credit Price and Cost per Gasoline Gallon (2023-2030)

Early forecasts didn't anticipate the impact of C&I. Stillwater's projection was based on HB1409 which increased program stringency.

Conclusions

Many forecasts anticipated much higher costs than have been observed. Like all forecasts, they were limited by factors which were known or predictable at the time they were made. Key lessons are:

1. Forecasters were unable to predict where the market will innovate. For instance, early LCFS cost projections did not anticipate the rapid growth in renewable diesel (RD) and renewable natural gas (RNG). Future technology developments, which may be incentivized by an LCF program, can materially lower the cost of compliance.
2. Early forecasts did not consider complimentary carbon reduction policies. Forecasts for the Washington CFS did not consider that Washington's Cap & Invest (C&I) program would offset CFS costs.
3. LCF programs can be adjusted. In fact, each of these programs has been amended regularly in response to evolving market conditions.
4. Forecasts did not highlight the program benefits alongside costs. Each program has succeeded in increasing clean fuel supply, lowering the carbon intensity of the transportation fuel pool, and supporting the electric vehicle market.

[4] CFS Monthly Credit Transaction Reports available via Washington Department of Ecology's Clean Fuel Standard Data & Reports webpage

APPENDIX A: Calculation of Cost per Gallon of Gasoline or Diesel

The cost of low-carbon fuel (LCF) programs in cents per gallon of gasoline or diesel in a given year of an LCF program is calculated by the following equation:

$$C = (CI_{Std} - CI_F) \times ED_F \times P \times 10^{-6} \times 100$$

Where:

- C = cost per gallon of fuel, measured in cents per gallon (cpg);
- CI_{Std} = The CI benchmark (gCO_2e/MJ) for gasoline or diesel in the year;
- CI_F = The CI (gCO_2e/MJ) of gasoline or diesel in the year as defined by the program;
- ED_F = The energy density of gasoline or diesel (MJ/gal) as defined by the program;
- P = The market price of program credits ($/MT);
- 10^{-6} = grams per MT; and
- 100 = cents per dollar

Similarly, the price of credits can be calculated from the cents per gallon of gasoline or diesel at a given point in time by rearranging the above equation to:

$$P = \frac{C}{(CI_{Std} - CI_F) \times ED_F \times 10^{-6} \times 100}$$

For fuels other than gasoline or diesel, costs are commonly cited per gasoline gallon equivalent (GGE) or per diesel gallon equivalent (DGE). One GGE is defined as the quantity of fuel containing the same energy as one gallon of gasoline (119.53 MJ in California or 122.48 MJ in Oregon and Washington); likewise, one DGE is defined as the quantity of fuel containing the same energy as one gallon of diesel (134.48 MJ). For example, one gallon of ethanol (81.51 MJ/gal) represents 0.68 GGE (81.51/119.53) in California (0.67 GGE in Washington and Oregon) and one gallon of biodiesel (126.13 MJ/gal) represents 0.94 DGE (126.13/134.48).

APPENDIX B: California Detail

Background on California LCFS Program

The California Low Carbon Fuel Standard (LCFS) began operating in 2011 and the first spot market price quotes (by OPIS) became available in September of 2012. For purposes of this report, we use the OPIS quotes as the price indicator as they are most representative of what informs the decision-making processes of market participants when buying and selling credits.

The original program regulations were approved in 2009 and took effect in April 2010.[5] The program was amended in 2011 with those amendments taking effect in November 2012.[6] Due to court challenges, program standards were frozen from 2013 through 2015. Program regulations were re-adopted in 2015 in response to court orders and the re-adopted regulations took effect in January 2016.[7] Further amendments were adopted in 2018 and took effect in January 2019.[8] The 2019 program amendments became effective in July 2020.[9] Most recently, the 2024 program amendments were adopted by the Board in November 2024 but did not take effect until July 1, 2025.[10]

[5] California Air Resources Board (CARB): RULEMAKING TO CONSIDER THE PROPOSED REGULATION TO IMPLEMENT THE LOW CARBON FUEL STANDARD (April 23, 2009)
[6] CARB: NOTICE OF PUBLIC HEARING TO CONSIDER AMENDMENTS TO THE LOW CARBON FUEL STANDARD REGULATION (December 16, 2011)
[7] CARB: NOTICE OF PUBLIC HEARING TO CONSIDER A LOW CARBON FUEL STANDARD (Hearing Dates: February 19, 2015 and September 24, 2015)
[8] CARB: Proposed Amendments to the Low Carbon Fuel Standard Regulation and to the Regulation on Commercialization of Alternative Diesel Fuels (Hearing Dates: April 27, 2018 and September 27, 2018)
[9] CARB: Proposed Amendments to the Low Carbon Fuel Standard Regulation (Hearing Date: November 21, 2019)
[10] CARB: Proposed Low Carbon Fuel Standard Amendments (Hearing Date: November 8, 2024)

California LCFS Forecasts (Figure 1)

1. **California Trucking Association (CTA),[11] April 2012** – Generated at the beginning of the LCFS, this report reflects the original design of the program. As the main concern of the CTA is diesel fuel prices, they project the per-gallon impact of the LCFS on retail diesel fuel prices for each year from 2012 through 2020.[12] Note that the impact on diesel fuel prices is always slightly larger than the impact on gasoline prices due to the higher energy density of diesel fuel[13] and the different baseline CI of diesel fuel. Stillwater calculated equivalent costs per gallon of gasoline using the methodology detailed in Appendix A. As seen in Figure 1, CTA's estimates far exceed the actual costs for every year of the program.
2. **The Boston Consulting Group (BCG),[14] June 2012** – Among other programs, this study evaluated the LCFS regulation as implemented at the time of the study. BCG estimated a gasoline cost impact of 33 to 106 cpg (average 70 cpg) in 2020. This study was completed before the program revisions with the 2015 re-adoption and the 2018 and 2019 amendments.
3. **California Legislative Analyst's Office (LAO),[15] December 2018** – Issued after CARB's adoption of the 2018 LCFS program amendments, the LAO estimated that the LCFS would have a 13, 19, and 32 cpg impact on gasoline prices in 2018, 2020, and 2025 respectively. This forecast for 2018 and 2020 was close to accurate, but the 2025 forecast is well above the 13 cpg impact observed, even with the implementation of the 2024 program amendments.
4. **Kleinman Center For Energy Policy,[16] October 2024** – This report was produced after the 2024 LCFS amendments had largely taken shape and were anticipated to take effect in January 2025.[17] The authors estimated that LCFS costs added to a gallon of gasoline would rise to 60-70 cpg in 2025 compared to the actual average of 13 cpg. A contributing factor to this error is the 6-month delay in implementation of the 2024 program amendments.

Calculation for CTA's Cost Per Gallon

To generate equivalent costs per gallon of gasoline for the CTA forecast in Figure 1 of this report, we used CTA's diesel price impacts and the annual program standards in effect in 2012 to calculate the predicted price of an LCFS credit each year in their analysis. That CTA-predicted LCFS credit price was then used to calculate each year's predicted gasoline price impact. These calculations are summarized in the table below.

Conversion of CTA's Projected Cost per Gallon of Diesel to Cost per Gallon of Gasoline[18]

Year	Diesel CI (g/MJ)	Diesel Benchmark (g/MJ)	CTA Diesel Price Impact (cpg)	Implied Credit Price ($/MT)	Gasoline CI (g/MJ)	Gasoline Benchmark (g/MJ)	Calculated Gasoline Price Impact (cpg)
2012	98.03	94.24	6	$ 117.73	99.18	95.37	5
2013	98.03	97.05	11	$ 834.72	99.18	97.96	12
2014	98.03	96.56	19	$ 961.19	99.18	97.47	20
2015	98.03	95.58	41	$ 1,244.49	99.18	96.48	40
2016	98.03	94.60	46	$ 997.33	99.18	95.49	44
2017	98.03	93.13	111	$ 1,684.62	99.18	94.00	104
2018	98.03	91.66	120	$ 1,400.93	99.18	92.52	112
2019	98.03	90.19	131	$ 1,242.60	99.18	91.03	121
2020	98.03	88.23	147	$ 1,115.49	99.18	89.06	135

[11] "The Impact of the Low Carbon Fuel Standard and Cap and Trade Programs on California Retail Diesel Prices", prepared by Stonebridge Associates, Inc. for the California Trucking Association, April 25, 2012.
[12] Ibid, p25 Table 2
[13] 134.47 MJ per gallon for diesel compared to 119.53 MJ per gallon of CARBOB.
[14] "Understanding the impact of AB 32," The Boston Consulting Group, June 19, 2012.
[15] "Assessing California's Climate Policies – Transportation," California Legislative Analyst's Office, December 21, 2018.
[16] "California's Low Carbon Fuel Standard," Kleinman Center for Energy Policy, October 7, 2024.
[17] CARB adopted the amendments in November 2024, but implementation was delayed to July 2025 due to challenges raised by California's Office of Administrative Law.
[18] Based on standards in effect in 2012

APPENDIX C: Oregon Detail

Background on the Oregon Clean Fuel Standard
The Oregon CFP, modeled after California's LCFS, was authorized in 2009 and formally implemented in 2016.[19] Expansion of the CFP was approved in 2022, setting more stringent benchmark standards: a 20% CI reduction by 2030 and a 37% reduction by 2035.[20] In 2025, additional rule changes were adopted, updating the OR-GREET 4.0 model.[21] With the new version of the GREET model, the baseline CI for gasoline declined from 98.06 to 96.05 g/MJ and the baseline CI for diesel rose from 98.74 to 102.73 g/MJ.

LCFS Forecasts used by DEQ to Determine Possible Program Costs

- **The Boston Consulting Group (BCG),[22] June 2012** – Among other programs, this study evaluated the LCFS regulation as implemented at the time of the study. BCG estimated a gasoline cost impact of 33 to 106 cpg (average 70 cpg) in 2020. This study was completed before the program revisions with the 2015 re-adoption and the 2018, 2019, and 2024 amendments.
- **ICF International,[23] April 2014 –** This study evaluated the LCFS regulation and characterized the macroeconomic impacts of LCFS compliance, and the co-benefits. ICF estimated LCFS compliance cost ranging from 6-19 cpg per gasoline gallon equivalent. This study was completed before the program revisions with the 2015 re-adoption and the 2018, 2019, and 2024 amendments.
- **Leidos,[24] 2014 –** This study is referenced in DEQ CFP Phase 2 Rulemaking as projecting potential fuel price impacts at 4-6 cpg.
- DEQ concluded the assumptions used to develop fuel prices in the ICF International and Leidos studies were more likely to occur for Oregon than the assumptions in the BCG analysis.

APPENDIX D: Washington Detail

Background on the Washington Clean Fuel Standard
The Washington CFS took effect in 2023 following adoption of program regulations on November 30, 2021. In May 2025 the governor signed into law HB1409[25] which directed the Washington Department of Ecology to significantly increase the CI reduction schedule of the CFS beginning in 2026. This program adjustment was enacted primarily to bring the program in closer alignment with the California LCFS and Oregon CFP.

Washington CFS Forecasts (Figure 2)

- **BRG,[26] May 2012** – This projection results from modeling performed by BRG under contract to the Washington Department of Ecology based on the CFS's original schedule of CI reductions. This forecast steps up annually from 0.7 cpg in 2023 to 16.4 cpg in 2030. Their 2023 forecast was below the 2.3 cpg actual average, while their 2024 forecast of 1.7 cpg was slightly above the 1.5 cpg observed. In 2025, BRG's projection was well over the actual average, likely due to the impact of the state's Cap and Invest regulations which provide a substantial additional incentive for the use of renewable fuels.
- **IFC Puget Sound Study,[27] 2019** – This study, which evaluated a proposed LCF program covering only the Puget Sound region of the state, projected a 57 cpg price impact by 2030. While the scope of this study was not identical to the CFS, its findings were cited by the Association of Washington Business and Washington House Republicans in opposition to the CFS.

---

[19] Department of Environmental Quality Chapter 340, Oregon Clean Fuels Program
[20] Office of the Secretary of State, Permanent Administrative Order, Clean Fuels Program Expansion 2022
[21] DEQ Fuel Pathways – Carbon Intensity Values, 2025 update
[22] "Understanding the impact of AB 32," The Boston Consulting Group, June 19, 2012
[23] "California's Low Carbon Fuel Standard: Compliance Outlook & Economic Impacts," ICF International, April 2014

[24] "Low Carbon Fuel Standard Clarifications", Leidos, 2014. As noted in Oregon Department of Environmental Quality Clean Fuel Program Phase II Rulemaking, January 7, 2015

[25] Second Substitute House Bill 1409 (HB1409), Clean Fuels Program – Modification, Effective July 27, 2025.
[26] "Clean Fuel Standard Cost Benefit Analysis Report," BRG Energy & Climate, May 12, 2022.
[27] "Puget Sound Regional Transportation Fuels Analysis Final Report," ICF, September 2019.

- **Washington Policy Center,[28] 2022** – This analysis also covered the original CI reduction schedule of the CFS. The Washington Policy Center forecast of 1-2 cpg in 2023 came in below the actual average of 2.3 cpg. They also projected a 20 cpg impact on gasoline prices in 2030.
- **Stillwater HB1409 Study,[29] March 2025** – Unlike the other three forecasts discussed, this projection was based on the then-proposed version of HB 1409. This bill was subsequently adopted and incorporated into regulation. Stillwater's study projected annual increases in CFS costs reaching 40 cpg in 2030.

[28] "The unnecessary and costly mess of Washington's climate legislation," Washington Policy Center, May 17, 2021.
[29] "Impacts of the Proposed Washington HB-1409 CFS Changes on Fuel Prices," Stillwater Associates, March 28, 2025.