

# **APPENDIX F**

## **INPUTS AND OUTPUTS OF THE REMI MODELING**

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## Appendix F: Inputs and Outputs of the REMI Modeling

As part of the Standardized Regulatory Impact Analysis (SRIA) process required of major regulations, staff calculated the economic impacts of the proposed Alternative Diesel Fuel (ADF) and Low Carbon Fuel Standard (LCFS) regulations. As noted in the SRIA submittal to Department of Finance (DOF), the ADF and LCFS proposals are so intertwined as to make it impossible to separate their individual effects on the California economy. ARB staff has calculated the effects of both the combination of the ADF and LCFS proposals, as well as the alternatives analyzed in the ADF and LCFS staff reports. This appendix contains the inputs required to do these calculations and the outputs of the REMI modeling conducted.

### A. Inputs to the REMI Model

This section includes inputs that staff used for the illustrative compliance scenario and each of the alternatives considered. All of the inputs assume an illustrative credit price of \$100 per metric ton of CO<sub>2</sub>e.

#### 1. Illustrative Compliance Scenario

This section contains the inputs for REMI modeling conducted by ARB staff on the illustrative compliance scenario outlined in the LCFS ISOR. In order to run the REMI model on the illustrative compliance scenario it was necessary to determine the credits and deficits generated in each fuel category, and the resulting changes in consumer expenditures and production costs by NAICS code. The inputs for the illustrative compliance scenario are presented in Tables F-1, F-2, and F-3.

**Table F-1: Deficits and Credits by Year for Illustrative Compliance Scenario (MMTs of Credits or Deficits)**

<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Gasoline</b>	-5.1	-7.3	-9.4	-12.9	-16.2	-15.8	-15.4	-15.0
<b>Ethanol</b>	4.0	4.1	4.4	4.4	4.4	5.1	5.3	5.5
<b>Electricity (LDV and HDV)</b>	0.7	0.8	1.0	1.2	1.4	1.7	2.0	2.4
<b>Renewable Gasoline</b>	0.0	0.0	0.0	0.1	0.2	0.3	0.7	1.0
<b>Hydrogen</b>	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
<b>Diesel</b>	-0.9	-1.6	-2.2	-3.3	-4.4	-4.3	-4.3	-4.3
<b>Biodiesel</b>	1.5	1.8	2.1	1.9	1.9	1.9	2.0	2.0
<b>Renewable Diesel</b>	2.1	2.5	2.6	2.8	3.0	3.7	4.1	4.5
<b>Natural Gas</b>	1.2	1.3	1.7	2.0	2.4	2.9	3.2	3.6

The above values are rounded to the nearest tenth.

**Table F-2: Changes in Consumer Expenditures on Transportation Fuels for Illustrative Compliance Scenario (Millions 2009\$)**

<b>REMI Category</b>	<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Motor vehicle fuels, lubricants, and fluids</b>	<b>Gasoline and Diesel</b>	-498	-548	-518	-347	-214	-757	-1,183	-1,609
	<b>Renewable Diesel, Renewable Gasoline, Ethanol and Biodiesel</b>	961	1,266	1,482	1,706	1,954	2,460	2,853	3,250
<b>Natural Gas</b>	<b>Natural Gas (LNG &amp; CNG)</b>	0	0	0	0	0	0	0	0
<b>Electricity</b>	<b>Electricity</b>	-66	-77	-92	-109	-134	-165	-201	-241

**Table F-3: Distribution of LCFS Credit Value, Represented as Changes in Production Cost (Expenditures in Million 2009\$)**

<b>NAICS Industry</b>	<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Petroleum and Coal Products Manufacturing</b>	<b>Gasoline and Diesel</b>	557	820	1080	1504	1915	1867	1826	1786
<b>Natural gas distribution</b>	<b>Natural Gas (LNG &amp; CNG)</b>	-107	-122	-155	-183	-220	-265	-298	-332
<b>Electric power generation, transmission, and distribution</b>	<b>Electricity</b>	-65	-75	-90	-107	-126	-155	-188	-225

The petroleum and coal products manufacturing values also include the direct cost of the ADF regulation. The direct costs of the ADF proposal are separately identified in section A.4 of this Appendix.

## 2. LCFS Alternative 1: Gasoline Only Case

This section contains the inputs for REMI modeling conducted by ARB staff on alternative 1, the gasoline only case outlined in the LCFS ISOR. In order to run the REMI model on alternative 1 it was necessary to determine the credits and deficits generated in each fuel category, and the resulting changes in consumer expenditures and production costs by NAICS code. The inputs for alternative 1 are presented in Tables F-4, F-5, and F-6.

**Table F-4 LCFS Alternative 1: Gasoline Only, Deficits and Credits by Year (MMTs of Credits or Deficits)**

<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Gasoline</b>	-5.1	-7.3	-9.4	-12.8	-16.1	-15.7	-15.3	-14.9
<b>Ethanol</b>	4.5	4.9	5.5	5.8	6.2	6.7	6.9	7.0
<b>Electricity (LDV &amp; HDV)</b>	0.5	0.6	0.8	1.0	1.2	1.5	1.8	2.2
<b>Renewable Gasoline</b>	0.0	0.0	0.2	0.3	0.7	1.0	1.3	1.6
<b>Hydrogen</b>	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2

The above values are rounded to the nearest tenth. Diesel is not included in the table above because it does not generate credits or deficits in this alternative.

**Table F-5: LCFS Alternative 1: Gasoline Only Changes in Consumer Expenditures (Millions 2009\$) on Transportation Fuels**

<b>REMI Category</b>	<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Motor vehicle fuels, lubricants, and fluids</b>	<b>Gasoline and Diesel</b>	421	601	699	907	1019	815	613	409
	<b>Renewable Diesel, Renewable Gasoline, Ethanol and Biodiesel</b>	49	70	168	281	480	648	818	992
<b>Natural Gas</b>	<b>Natural Gas (LNG &amp; CNG)</b>	0	0	0	0	0	0	0	0
<b>Electricity</b>	<b>Electricity</b>	-45	-56	-71	-89	-108	-137	-171	-208

**Table F-6: LCFS Alternative 1: Gasoline Only Distribution of LCFS Credit Value, Represented as Changes in Production Cost (Expenditures in Million 2009\$)**

<b>NAICS Industry</b>	<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Petroleum and Coal Products Manufacturing</b>	<b>Gasoline and Diesel</b>	479	681	877	1199	1505	1466	1428	1392
<b>Natural gas distribution</b>	<b>Natural Gas (LNG &amp; CNG)</b>	0	0	0	0	0	0	0	0
<b>Electric power generation, transmission, and distribution</b>	<b>Electricity</b>	-45	-56	-71	-89	-108	-137	-171	-208

The petroleum and coal products manufacturing values also include the direct cost of the ADF regulation. The direct costs of the ADF proposal are separately identified in section A.4 of this Appendix.

### **3. Alternative 2: Original Benefits**

This section contains the inputs for REMI modeling conducted by ARB staff on alternative 2, original benefits outlined in the LCFS ISOR. To run the REMI model on alternative 2 it was necessary to determine the credits and deficits generated in each fuel category, and the resulting changes in consumer expenditures and production costs by NAICS code. The inputs for alternative 2 are presented in Tables F-7, F-8, and F-9.

**Table F-7: LCFS Alternative 2: Original Benefits Alternative Deficits and Credits by Year (MMTs of Credits or Deficits)**

<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Gasoline</b>	-8.1	-10.2	-12.3	-14.3	-16.1	-15.7	-15.3	-14.9
<b>Ethanol</b>	4.5	4.4	4.5	4.5	4.5	5.1	5.3	5.5
<b>Electricity (LDV and HDV)</b>	0.7	0.8	0.9	1.1	1.4	1.7	2.0	2.4
<b>Renewable Gasoline</b>	0.0	0.0	0.2	0.3	0.7	1.0	1.3	1.6
<b>Hydrogen</b>	0.0	0.0	0.1	0.1	0.1	0.1	0.2	0.2
<b>Diesel</b>	-1.7	-2.3	-3.0	-3.6	-4.3	-4.2	-4.3	-4.2
<b>Biodiesel</b>	1.4	1.8	1.9	1.9	1.9	1.9	1.9	2.0
<b>Renewable</b>	3.3	4.0	3.9	3.8	3.7	4.1	4.1	4.5

<b>Diesel</b>									
<b>Natural Gas</b>	1.1	1.3	1.6	1.9	2.4	2.9	3.2	3.6	

The above values are rounded to the nearest tenth.

**Table F-8: LCFS Alternative 2: Original Benefits Alternative Changes in Consumer Expenditures (Millions 2009\$) on Transportation Fuels**

<b>REMI Category</b>	<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Motor vehicle fuels, lubricants, and fluids</b>	<b>Gasoline and Diesel</b>	-676	-975	-880	-761	-716	-1,156	-1,412	-1,854
	<b>Renewable Diesel, Renewable Gasoline, Ethanol and Biodiesel</b>	1,558	2,061	2,222	2,390	2,622	3,023	3,244	3,660
<b>Natural Gas</b>	<b>Natural Gas (LNG and CNG)</b>	0	0	0	0	0	0	0	0
<b>Electricity</b>	<b>Electricity</b>	-113	-122	-135	-153	-181	-213	-249	-289

**Table F-9: LCFS Alternative 2: Original Benefits Alternative Production Cost (Expenditures in Million 2009\$)**

<b>NAICS Industry</b>	<b>Fuels</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Petroleum and Coal Products Manufacturing</b>	<b>Gasoline and Diesel</b>	-113	-122	-135	-153	-181	-213	-249	-289
<b>Natural gas distribution</b>	<b>Natural Gas (LNG &amp; CNG)</b>	-103	-117	-149	-180	-220	-265	-298	-332
<b>Electric power generation, transmission, and distribution</b>	<b>Electricity</b>	-63	-73	-87	-105	-126	-155	-188	-225

The petroleum and coal products manufacturing values also include the direct cost of the ADF regulation. The direct costs of the ADF regulation are separately identified in section A.4 of this Appendix.

#### **4. Inputs for ADF and its Alternatives**

The direct costs for the ADF proposal, and the alternatives to that proposal laid out in the ADF ISOR are presented in Table F-10.

Table F-10: ADF Direct Cost Inputs (Millions 2014\$)

	2016	2017	2018	2019	2020	2021	2022	2023
<b>ADF Regulation</b>	0.06	0.06	3.07	1.87	1.31	1.26	0.66	0.06
<b>Alternative 1: NBB Submittal</b>	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
<b>Alternative 2: GE Submittal</b>	72.24	89.60	100.80	100.80	100.80	103.60	103.60	103.60

## B. Outputs of the REMI Model

ARB Staff ran the REMI model using the inputs shown in section A of this appendix. The outputs of the REMI model include changes in the growth of employment, output, gross domestic private investment, personal income, and gross state product. These results are shown for each of the alternatives considered in the LCFS and ADF ISORs in this section. For all of the outputs the value in each year is interpreted as the reference year value less the baseline value in that same year. Therefore the values should not be represented as cumulative values, but instead changes year-by-year.

### 1. Illustrative Compliance Scenario

This section contains the outputs of REMI modeling conducted by ARB staff on the illustrative compliance scenario outlined in the LCFS ISOR. The outputs for the illustrative compliance scenario are presented in Tables F-11 through F-15.

Table F-11: Changes in Employment Growth for Illustrative Compliance Scenario

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Change (Number of Jobs)</b>	-2,400 (-0.01%)	-5,100 (-0.02%)	-8,000 (-0.04%)	-12,700 (-0.06%)	-17,300 (-0.08%)	-17,300 (-0.08%)	-16,500 (-0.07%)	-15,200 (-0.07%)

Table F-12: Changes in Output Growth for Illustrative Compliance Scenario (Millions of 2009\$)



	2016	2017	2018	2019	2020	2021	2022	2023
<b>Electric Power Generation, Transmission, and Distribution</b>	50 (0.19%)	60 (0.23%)	70 (0.27%)	80 (0.31%)	100 (0.36%)	130 (0.44%)	150 (0.53%)	190 (0.64%)
<b>Natural Gas Distribution</b>	30 (0.11%)	40 (0.16%)	60 (0.21%)	80 (0.25%)	90 (0.30%)	120 (0.37%)	140 (0.44%)	170 (0.51%)
<b>Basic Chemical Manufacturing</b>	0 (0.00%)	0 (-0.01%)	-1 (-0.02%)	-1 (-0.03%)	-1 (-0.04%)	-1 (-0.04%)	-1 (-0.03%)	-1 (-0.03%)
<b>Petroleum and Coal Products Manufacturing</b>	340 (0.34%)	170 (0.16%)	-120 (-0.12%)	-570 (-0.54%)	-1,080 (-1.01%)	-1,150 (-1.06%)	-1,190 (-1.10%)	-1,150 (-1.04%)

These are rounded to the nearest ten million except for the Basic Chemical Manufacturing.

**Table F-13: Change in Gross Domestic Private Investment Growth for Illustrative Compliance Scenario**

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Private Investment (millions 2009\$)</b>	-20 (-0.01%)	-90 (-0.03%)	-190 (-0.05%)	-340 (-0.09%)	-520 (-0.13%)	-570 (-0.14%)	-540 (-0.13%)	-470 (-0.11%)

**Table F-14: Changes in Personal Income Growth for Illustrative Compliance Scenario**

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Personal Income (millions 2009\$)</b>	-120 (-0.01%)	-320 (-0.01%)	-580 (-0.02%)	-1,000 (-0.04%)	-1,470 (-0.06%)	-1,600 (-0.06%)	-1,640 (-0.06%)	-1,600 (-0.05%)

**Table F-15: Changes in Gross State Product Growth for Illustrative Compliance Scenario**

	2016	2017	2018	2019	2020	2021	2022	2023
<b>GSP (millions 2009\$)</b>	-30 (0.00%)	-300 (-0.01%)	-630 (-0.03%)	-1,160 (-0.05%)	-1,730 (-0.07%)	-1,740 (-0.07%)	-1,670 (-0.06%)	-1,510 (-0.06%)

## 2. Alternative 1: Gasoline Only Case

This section contains the outputs of REMI modeling conducted by ARB staff on alternative 1, gasoline only case outlined in the LCFS ISOR. The outputs for alternative 1 are presented in Tables F-16 through F-20.

Table F-16: Changes in Employment Growth for Gasoline Only Case

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Change (Number of Jobs)</b>	-5,000 (-0.02%)	-8,040 (-0.04%)	-10,880 (-0.05%)	-14,940 (-0.07%)	-18,830 (-0.07%)	-19,250 (-0.08%)	-18,980 (-0.08%)	-18,130 (-0.08%)

Table F-17: Changes in Output Growth for Gasoline Only Case (Millions of 2009\$)

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Electric Power Generation, Transmission, and Distribution</b>	30 (0.11%)	40 (0.14%)	50 (0.17%)	60 (0.21%)	70 (0.25%)	90 (0.32%)	120 (0.41%)	150 (0.51%)
<b>Natural Gas Distribution</b>	-1 (0.00%)	-3 (-0.01%)	-5 (-0.02%)	-9 (-0.03%)	-13 (-0.04%)	-15 (-0.05%)	-17 (-0.05%)	-16 (-0.05%)
<b>Basic Chemical Manufacturing</b>	0 (-0.01%)	-1 (-0.02%)	-1 (-0.02%)	-1 (-0.03%)	-2 (-0.04%)	-2 (-0.04%)	-2 (-0.04%)	-2 (-0.04%)
<b>Petroleum and Coal Products Manufacturing</b>	-320 (-0.32%)	-620 (-0.61%)	-900 (-0.87%)	-1,300 (-1.23%)	-1,700 (-1.59%)	-1,910 (-1.77%)	-2,040 (-1.88%)	-2,090 (-1.91%)

These are rounded to the nearest ten million except for Basic Chemical Manufacturing and Natural Gas Distribution.

**Table F-18: Change in Gross Domestic Private Investment Growth for Gasoline Only Case**

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Private Investment (millions 2009\$)</b>	-113 (-0.04%)	-235 (-0.07%)	-357 (-0.10%)	-514 (-0.14%)	-682 (-0.17%)	-755 (-0.18%)	-767 (-0.18%)	-735 (-0.17%)

**Table F-19: Changes in Personal Income Growth for Gasoline Only Case**

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Personal Income (millions 2009\$)</b>	-322 (-0.02%)	-584 (-0.03%)	-862 (-0.04%)	-1,257 (-0.05%)	-1,679 (-0.07%)	-1,858 (-0.07%)	-1,958 (-0.07%)	-1,990 (-0.07%)

**Table F-20: Changes in Gross State Product Growth for Gasoline Only Case**

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>GSP (millions 2009\$)</b>	-482 (-0.02%)	-834 (-0.04%)	-1,171 (-0.05%)	-1,654 (-0.07%)	-2,133 (-0.09%)	-2,249 (-0.09%)	-2,266 (-0.09%)	-2,204 (-0.08%)

### 3. Alternative 2: Original Benefits

This section contains the outputs of REMI modeling conducted by ARB staff on alternative 2, gasoline only case outlined in the LCFS ISOR. The outputs for alternative 2 are presented in Tables F-21 through F-25.

Table F-21: Changes in Employment Growth for Original Benefits Case

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Change (Number of Jobs)</b>	-5,690 (-0.03%)	-8,050 (-0.04%)	-11,470 (-0.05%)	-15,060 (-0.07%)	-18,250 (-0.08%)	-17,880 (-0.08%)	-16,500 (-0.07%)	-17,170 (-0.07%)

Table F-22: Changes in Output Growth for Original Benefits Case (Millions of 2009\$)

	2016	2017	2018	2019	2020	2021	2022	2023
<b>Electric Power Generation, Transmission, and Distribution</b>	70 (0.29%)	70 (0.32%)	80 (0.36%)	100 (0.41%)	120 (0.48%)	140 (0.57%)	170 (0.68%)	200 (0.80%)
<b>Natural Gas Distribution</b>	20 (0.12%)	40 (0.19%)	50 (0.26%)	60 (0.33%)	80 (0.41%)	100 (0.51%)	130 (0.61%)	150 (0.72%)
<b>Basic Chemical Manufacturing</b>	0 (-0.01%)	-1 (-0.01%)	-1 (-0.02%)	-1 (-0.03%)	-2 (-0.04%)	-2 (-0.03%)	-2 (-0.03%)	-2 (-0.03%)
<b>Petroleum and Coal Products Manufacturing</b>	480 (0.50%)	350 (0.36%)	-70 (-0.07%)	-510 (-0.50%)	-910 (-0.88%)	-990 (-0.94%)	-1,110 (-1.04%)	-1,020 (-0.94%)

These are rounded to the nearest ten million except for the Basic Chemical Manufacturing.

**Table F-23: Change in Gross Domestic Private Investment Growth for Original Benefits Case**

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Private Investment (millions 2009\$)</b>	-95 (-0.03%)	-181 (-0.05%)	-294 (-0.08%)	-425 (-0.11%)	-551 (-0.14%)	-568 (-0.14%)	-532 (-0.12%)	-446 (-0.10%)

**Table F-24: Changes in Personal Income Growth for Original Benefits Case**

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>Personal Income (millions 2009\$)</b>	-302 (-0.01%)	-515 (-0.02%)	-830 (-0.04%)	-1,185 (-0.05%)	-1,538 (-0.06%)	-1,624 (-0.06%)	-1,658 (-0.06%)	-1,594 (-0.05%)

**Table F-25: Changes in Gross State Product Growth for Original Benefits Case**

	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2023</b>
<b>GSP (millions 2009\$)</b>	-250 (-0.01%)	-489 (-0.02%)	-907 (-0.04%)	-1,356 (-0.06%)	-1,761 (-0.07%)	-1,752 (-0.07%)	-1,708 (-0.07%)	-1,520 (-0.06%)