APPENDIX C

ECONOMIC ANALYSIS DETAILS

SUMMARY OF ECONOMIC ANALYSIS METHODOLOGY

SUMMARY

The total cost of the proposed regulation to affected businesses is estimated to be $3.7 million annually over 10 years. This represents the cost of reducing emissions through abatement, alternative chemistries, process optimization, plus permit costs, and annual reporting and recordkeeping costs.

This appendix covers the methodology used in the Economic Analysis presented in Chapter VII. The methodology is similar to what was used in previous ARB regulations (ARB, 1990; ARB, 1991; ARB, 1997; ARB, 1999; ARB, 2000; ARB, 2003; ARB, 2004; ARB, 2005; ARB, 2007) and follows guidelines recommended by Cal/EPA for economic analysis (Cal/EPA, 1996).

METHODOLOGY

For this analysis, we considered the impact to semiconductor operations. Although other entities may be impacted, semiconductor operations will be the primary entities affected.

First, we analyzed data from ARB's survey of semiconductor operations in California to determine which operations would need to reduce their emissions. Thirteen businesses would need to reduce emissions. The survey results are summarized in Table C-1.

Table C-1
Survey Data Inputs for Cost Calculations

Category	Number of Operations in 2006	Number of Businesses in 2006	Number of Businesses After 2008	Number of Complying Businesses	Number of Non-Complying Businesses	Emission Reduction (MMT CO_2e)
Tier 1	5	5	4*	1	3	0.11
Tier 2	11	10	7*	4	3	0.03
Tier 3	12	12	12	5	7	0.04
Reporting Only	57	51	51	51	0	0
Total	**85**	**78**	**74**	**61**	**13**	**0.18**

* From the survey, we were informed that one business in Tier 1 (already in compliance) and three businesses in Tier 2 were planning on ceasing operation before the emission standards were proposed

Second, we evaluated what strategies each of the 13 businesses could use to comply with the emission standards. For abatement, we assumed businesses in Tier 1 and 2 would use end of pipe systems, and businesses in Tier 3 would use point of use systems.

For alternative chemistries, businesses would need to replace higher GWP gases with lower GWP gases or less efficient gases with more efficient gases to comply with the emission standards. While replacement gases would cost more than the existing gases, less of the replacement gases would be needed. Therefore, we considered the cost of using alternative chemistries as an emission reduction strategy to be zero.

Some businesses would need to optimize their processes to lower their emissions. This involves reducing emissions by improving the efficiency of their operations. The cost of this strategy is significantly less than the cost of the abatement strategy.

Based on the emission reductions needed by each business, Table C-2 shows the strategies by tier that would be required to comply with the emission standards.

Table C-2
Emission Reduction Strategies for Businesses

	Tier	Number of Businesses	Abatement Devices	Alternative Chemistries	Process Optimization
	1	3	6	3	1
	2	3	2	2	0
	3	7	11	3	3
Total		**13**	**19**	**8**	**4**

Third, we estimated the cost to comply with the regulation. The cost of reducing emissions includes abatement devices, alternative chemistries and process optimization, plus permit fees and annual reporting and recordkeeping costs. Capital costs and recurring costs were estimated based on discussions with industry and manufacturers (NEC, 2008; SIA, 2008).

Capital costs include the cost of equipment and installation and initial permitting costs. Recurring costs include operation and maintenance costs, as well as energy costs. In cases where a business provided us with an estimate of their cost to meet the emissions standards, we used the figures provided to us. Otherwise, it was estimated that a business using end of pipe abatement would incur $2.2 million dollars in initial capital costs, and have a recurring cost of $65,000 dollars per unit, and businesses using point of use abatement would incur $250,000 in initial capital costs, and have a recurring cost of $25,000 per unit. Businesses using process optimization to reduce emissions would incur an initial cost of $150,000. These cost estimates are summarized in Table C-3. All figures are in 2007 dollars.

Table C-3
Cost and Number of Emission Reduction Strategies

Strategy	Number of Devices	Estimated Cost for One Unit	Recurring Costs for One Unit	Total Initial Cost	Total Recurring Cost
End of Pipe Abatement	8	$2,200,000	$65,000	$17,600,000	$520,000
Point of Use Abatement	11	$250,000	$25,000	$2,750,000	$275,000
Process Optimization	4	$150,000	0	$600,000	0
Total				**$20,350,000**	**$795,000**

The non-recurring costs are annualized into discounted, equal annual payments when multiplied with an appropriate cost recovery factor (CRF), a standardized method recommended by Cal/EPA for annualizing costs (Cal/EPA, 1996) and is consistent with the methodology used in previous cost analyses of regulations by the ARB (ARB, 2000; ARB, 2007).

The CRF is calculated as follows:

$$CRF = \frac{i(1+i)^n}{(1+i)^n - 1}$$

where,

CRF = cost recovery factor
i = discount rate (assumed 5 percent)
n = project horizon or useful life of equipment (assumed 10 years)

All costs of the control devices are annualized over 10 years. The total annualized cost is obtained by adding the recurring costs to the non-recurring costs using the CRF method. Using this method, the CRF is 0.13, which represents the portion of the initial capital cost that is repaid each year over the life of the equipment.

Some businesses chose to provide us with their own cost estimate to comply with the emission standards. These estimates were used in place of our assumptions where appropriate. This resulted in an increase to the total initial cost to businesses that needed to reduce emissions by $1.3 million, or to a total of $21.8 million. Using the CRF of 0.13, this equates to annual costs of $2.8 million. Each of the 13 businesses would incur an annual cost of $600 for recordkeeping and reporting, and 11 businesses would incur an annual cost of $1,000 for permits. These costs will total $18,800 per year, as shown in Table C-4. Combined with the recurring cost from operation and maintenance of $795,000 per year, the total recurring cost is

$814,000 per year. The total cost to the 13 businesses that need to reduce emissions is estimated to be nearly $3.7 million per year. These costs are summarized by tier in Table C-4.

Table C-4
Total Costs to Businesses That Need to Reduce Emissions by Tier

Tier	Initial Costs	Recurring Costs	Costs for Recordkeeping, Reporting, and Permits	Total Annual Cost
1	$14,500,000	$390,000	$4,800	$2,280,000
2	$4,400,000	$130,000	$3.800	$700,000
3	$2,900,000	$275,000	$10,200	$680,000
Total	**$21,800,000**	**$795,000**	**$18,800**	**$3,660,000**

The cost for recordkeeping and reporting was estimated to be $600 dollars per year. As shown in Table C-5, the total cost is estimated to be $36,600 annually for businesses that do not need to reduce emissions. For the 61 businesses that do not need to reduce emissions, and only need to conduct recordkeeping and reporting, this would be the only cost incurred. This includes the 10 businesses that already comply with the emission standards, and the 51 businesses that are only required to keep records and submit annual reports.

Table C-5
Cost to Businesses That Do Not Need to Reduce Emissions

Number of Businesses	Cost for Recordkeeping and Reporting	Total Annual Cost
61	$600	$36,600

Cost-effectiveness was determined by dividing the total annual cost by the expected emission reduction. As shown in Table C-6, this ranged from $17 per metric ton of carbon dioxide equivalent reduced, to $23.40 per metric ton reduced. Overall, the cost-effectiveness of this regulation is estimated to be $21 per metric ton of carbon dioxide equivalent reduced.

Table C-6
Cost-Effectiveness by Tier

Tier	Total Annual Cost	Total Emission Reduction	Cost-Effectiveness
1	$2,280,000	0.11	$20.70
2	$700,000	0.03	$23.40
3	$680,000	0.04	$17.00
Total	**$3,660,000**	**0.18**	**$21**

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