# Cotton Gin Plant Compliance with Air Pollution Regulations in Texas

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## ABSTRACT

**Recent air pollution legislation affects stationary sources such as cotton gins. This study estimated the increase in gin plant costs that resulted from compliance with various levels of air pollution control and the associated impact on returns. Because investment in air pollution control differs by gin plant size and level of pollution control, five plant sizes were examined in combination with control systems that reduce per bale emissions from 4 lb per bale to 2.24, 1.60 and 1.06 lb per bale. Cost increases and rates of return were affected by gin plant size, level of control technology, plant volume, and method of harvest (picked or stripped).**

The Clean Air Act of 1963 was the first major federal involvement in air pollution regulation in the US. This act was subsequently amended in 1967, 1970, 1977, and 1990 and, in general, increased federal involvement in air pollution regulation. The Clean Air Act of 1970 required that emission standards be established for stationary sources of air pollution. These standards were to be established on an industry-by-industry basis and were to consider the cost of air pollution control. The established standards were to represent the "best available control technology" (BACT) available to the industry. The Federal Clean Air Act (FCAA) amendments of 1990 represented a further strengthening of the Clean Air Act and ended more than a decade of Congressional stalemate over air pollution regulations in the US (Smith, 1992). The 1990 legislation represents an important change in air pollution regulation, in particular, as it affects stationary sources such as cotton gins.

Air pollution regulations are implemented at the state level; the implementing agency in Texas is the Texas Natural Resources Conservation Commission (TNRCC), known as the Texas Air Control Board (TACB) prior to September 1993. Cotton gins in Texas are regulated under the nuisance rule (General Rules, Section

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101.4), which states:

> No person shall discharge from any source whatsoever one or more air contaminants or combination thereof, in such concentration and of such duration as are or may tend to be injurious to or to adversely affect health or welfare, animal life, vegetation, or property, or as to interfere with the normal use and enjoyment of animal life, vegetation, or property.

About 160 cotton gin plants in Texas (40%) have not been grandfathered or permitted by the TNRCC. Those gins in isolated locations with favorable community acceptance and no past nuisance compliance violation history will be required to invest in a minimum level of control which is defined as baseline "best available control technology" (BACT). Gin plants which require more control than BACT (the minimum level of control) must propose additional controls to the TNRCC. The complement of control equipment finally required of a particular plant is the result of negotiations between the TNRCC and gin plant management.

## OBJECTIVES

The TNRCC has some flexibility and discretion in administering the clean air statutes by considering the trade-offs between economic and environmental impacts. In particular, the regulation states that a plant will use the best available control technology with consideration being given to its technical practicability and economic reasonableness (TACB, 1992). The term "economic reasonableness" is undefined in law or regulations.

The cost of upgrading selected gin plants with an air pollution control system may be substantial and in some cases may place financial burden on the firm. In view of these concerns, the objectives of this study were to (1) estimate the impact on gin plant costs that result from compliance with various levels of air pollution control and (2) estimate the economic impact on gin plant firms that result from investments in required air pollution control devices. The analysis was designed to evaluate economic impacts that result from incorporating technology that increasingly lowers a plant's emission rate.

## METHODS

Investments in air pollution control were expected to differ by gin plant size and level of pollution control. In this study, five plant size categories were established based on bale per hour (bph) capacity. These include: ≤ 10 bph; 11 to 15 bph; 16 to 25 bph; 26 to 34 bph; and ≥ 35 bph. In addition, three control systems were included in the analysis and represented technology that reduced total per bale emissions from the current 4 lb per bale to 2.24, 1.60, and 1.06 lb per bale, respectively. Costs were estimated for each plant size category, which reflected current control technology (4 lb per bale). Based on current gin revenue schedules, rates of return were estimated and subsequently compared with returns from plants, which reflected upgrading to the three levels of air control (emissions rate of 2.24, 1.60, and 1.06 lb per bale). The calculated rates of return were compared with a predetermined critical or required rate of return to identify plant sizes whose financial viability were threatened by required investments in air pollution control. The required rate of return is that which is thought necessary to attract capital into the cotton ginning industry. Investment in air pollution control is expected to reduce profitability (returns) of gin plant operations as a result of increases in fixed and variable costs and, in some cases, reduce returns to levels that threaten a firm's economic viability.

Gin plant costs were estimated with a computerized economic-engineering model (GINMODEL) which was initially developed by the Economic Research Service of the USDA and more recently updated and maintained in the Department of Agricultural Engineering at Texas A&M University (Shaw et al., 1977; USDA, 1977). An input data file was developed for each plant size category that reflected existing plants and their air pollution control technology (4 lb per bale emission rate). Then for each plant size, the investment in air pollution control and additional connected horsepower associated with the three air pollution control systems were estimated and the new cost relationships generated. Rates of return were generated for each plant size category at alternative volumes. The model was validated with cost data provided by COBANK, the Bank for Cooperatives in Austin, Texas. In general, GINMODEL costs approximated the actual cost data and therefore were judged adequate to carry out study objectives (Childers et al.,1994).

## RESULTS

### Air Pollution Control Systems and Effect on Costs

The three air pollution control systems examined in this study were BBACT (Baseline Best Available Control Technology), BACTD1 (Best Available Control Technology Design 1), and BACTD2 (Best Available Control Technology Design 2). BBACT, BACTD1, and BACTD2 were designed to reduce emissions from the current 4 lb per bale to 2.24, 1.60, and 1.06 lb per bale, respectively. Controls used to reduce emissions to 2.24 lb per bale (BBACT), as described by the TNRCC, include high efficiency cyclones (1D-3D or 2D-2D) on all centrifugal fan exhausts and small mesh screens on all lint cleaner condenser drums and battery condensers. Technologies used to reduce the emission rates to 1.60 lb per bale (BACTD1) and 1.06 lb per bale (BACTD2) were estimated by Parnell and Yarlagadda in the Department of Agricultural Engineering at Texas A&M University (Yarlagadda et al., 1994; USDA, 1993; Mihalski et al., 1993). BACTD1 includes 2D-2D or 1D-3D cyclones on all centrifugal fan exhausts, the replacement of axial fans with centrifugal fans, and the replacement of condenser drums with 2D-2D cyclones. BACTD2 includes a pre-separator/1D-3D cyclone system on all fan exhausts. The capital investment associated with each air pollution control system was estimated using data and procedures prescribed by Cooper and Alley. Unit costs in combination with estimated airflow rates (cubic feet per minute) were used to estimate total capital investment for the BBACT, BACTD1, and BACTD2 control systems in gin plants processing picked and stripped cotton. For plants processing picked cotton, estimates of capital investment ranged from $56,000 for the smallest plant (≤ 10 bph) upgrading to a BBACT system to $333,000 for the largest plant size (≥ 35 bph) upgrading to a BACTD2 system (Table 1). Similarly, for plants processing stripped cotton, estimates of capital investment ranged from \$64,000 for the smallest plant (≤ 10 bph) upgrading to a BBACT system to \$366,000 for the largest plant size (≥ 35 bph) upgrading to a BACTD2 system (Table 2).

Table 1. Total capital investment for BBACT, BACTD1 and BACTD2, picked cotton.

| Gin Size Capacity† | BBACT | BACTD1 | BACTD2 |
|---|---|---|---|
| bph | | \$ | |
| ≤10 | 56,000 | 76,000 | 107,000 |
| 11-15 | 65,000 | 91,000 | 129,000 |
| 16-25 | 95,000 | 135,000 | 197,000 |
| 26-34 | 136,000 | 195,000 | 289,000 |
| ≥35 | 156,000 | 225,000 | 333,000 |

†Representative plants in the five gin size categories are 10, 12.5, 20, 30 and 35 bales per hour, respectively.

Table 2. Total capital investment for BBACT, BACTD1 and BACTD2, stripped cotton.

| Gin Size Capacity† | BBACT | BACTD1 | BACTD2 |
|---|---|---|---|
| bph | | \$ | |
| ≤10 | 64,000 | 80,000 | 113,000 |
| 11-15 | 77,000 | 98,000 | 139,000 |
| 16-25 | 112,000 | 148,000 | 216,000 |
| 26-34 | 158,000 | 216,000 | 316,000 |
| ≥35 | 182,000 | 249,000 | 366,000 |

†Representative plants in the five gin size categories are 10, 12.5, 20, 30 and 35 bales per hour, respectively.

Introduction of air pollution controls affected depreciation, interest, property insurance, property tax, repair, and electrical expenses. Total depreciation and interest expense were determined with the standard present value annuity formula (GINMODEL) based on expected years of life and the representative average interest rate for capital investments (9.8%) in the Fall of 1993. Property insurance was determined by multiplying capital investment in the air pollution control systems by the co-insurance percentage and the insurance rate, while taxes were estimated by multiplying investment by the property tax rate. Electrical charges were based on rate schedules of utility companies in Texas.

To provide insight regarding the increase in costs that result from investment in air pollution equipment, the additional per bale costs associated with upgrading a ≤ 10 bph plant to BBACT was calculated for a plant processing 8,000 bales of stripped cotton (Table 3). The upgrade involved an investment of $64,000 and an increase in connected electrical horsepower from 536 to 722. Per bale cost increased by $2.74 per bale. About 80% of the increase in costs was accounted for by electricity (39%), interest on borrowed capital (27%), and depreciation (15%) (Table 3).

Table 3. Estimated increases in per bale costs that result from upgrading small plant (≤10 BPH) to BBACT stripped cotton[†].

| Cost Component | Pre-Control | Post-Control | Marginal Increase |
|---|---|---|---|
| | -------------------------- | $/bale | ------------------------------ |
| Depreciation | 1.22 | 1.63 | 0.41 |
| Capital Interest | 1.71 | 2.45 | 0.74 |
| Working Interest | 0.70 | 0.72 | 0.02 |
| Property Insurance | 0.14 | 0.21 | 0.07 |
| Property Taxes | 0.55 | 0.78 | 0.23 |
| Repairs | 0.33 | 0.53 | 0.20 |
| Electricity | 3.39 | 4.46 | 1.07 |
| Sub-total | 8.04 | 10.78 | 2.74 |
| Other | 40.58 | 40.58 | 0.00 |
| Total | 48.62 | 51.36 | 2.74 |

†All per bale costs are calculated at an annual volume of 8,000 bales.

In general, the introduction of air pollution control had the expected effect on gin plant costs (Tables 4 and 5). First, per bale gin plant costs increased with the introduction of air pollution controls and with the adoption of control systems which increasingly lowered per bale emissions. For example, a plant in the 16 to 25 bph size category processing 16,000 bales of picked cotton would experience a cost increase of $1.46 per bale by introducing BBACT (emission rate of 2.24 lb per bale); however, by introducing BACTD1 (emission rate of 1.60 lb per bale) and BACTD2 (emission rate of 1.06 lb per bale), respective cost increases of $2.53 per bale and $3.80 per bale were expected (Table 4). Second, for a particular plant size, the increase in per bale cost associated with the introduction of air pollution control was reduced as plant volume increased. For example, the 16 to 25 bph plant processing 10,000 bales of picked cotton would expect costs to increase $2.16 per bale with the introduction of BBACT, but at an output of 20,000 bales, per bale costs were projected to increase a more modest $1.28 per bale. Third, for a particular control system, large plants operating at a specified utilization level

Table 4. Estimated per bale costs for each gin plant size under pre-control and the increase in per bale cost under BBACT, BACTD1 and BACTD2 at alternative volumes, picked cotton.

| Plant Size Category | Volume and Per Bale Costs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ≤ 10 bph | | | | | | | | | | |
| Volume (bales) | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| Pre-Control Cost ($/bale) | 148.49 | 90.35 | 71.37 | 62.35 | 57.48 | 54.42 | 52.70 | 51.48 | 51.22 | 51.00 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 14.37 | 7.20 | 4.91 | 3.77 | 3.09 | 2.63 | 2.30 | 2.05 | 1.95 | 1.78 |
| BACTD1 | 20.34 | 10.23 | 7.10 | 5.54 | 4.60 | 3.97 | 3.53 | 3.19 | 3.04 | 2.82 |
| BACTD2 | 28.56 | 14.63 | 10.23 | 8.03 | 6.71 | 5.83 | 5.20 | 4.72 | 4.52 | 4.20 |
| 11-15 bph | | | | | | | | | | |
| Volume (bales) | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| Pre-Control Cost ($/bale) | 181.56 | 104.88 | 79.55 | 67.13 | 59.96 | 55.37 | 52.26 | 50.06 | 48.70 | 47.74 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 11.29 | 5.67 | 3.88 | 2.99 | 2.45 | 2.09 | 1.83 | 1.64 | 1.56 | 1.43 |
| BACTD1 | 16.20 | 8.38 | 5.87 | 4.62 | 3.86 | 3.36 | 2.99 | 2.73 | 2.60 | 2.43 |
| BACTD2 | 22.95 | 12.02 | 8.48 | 6.71 | 5.64 | 4.93 | 4.42 | 4.04 | 3.87 | 3.62 |
| 16-25 bph | | | | | | | | | | |
| Volume (bales) | 2000 | 4000 | 6000 | 8800 | 10000 | 12000 | 14000 | 16000 | 18800 | 20000 |
| Pre-Control Cost ($/bale) | 181.24 | 101.59 | 75.22 | 62.15 | 54.41 | 49.33 | 45.77 | 43.16 | 41.54 | 39.97 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 9.63 | 4.96 | 3.40 | 2.63 | 2.16 | 1.84 | 1.62 | 1.46 | 1.38 | 1.28 |
| BACTD1 | 14.25 | 7.56 | 5.32 | 4.21 | 3.53 | 3.09 | 2.77 | 2.53 | 2.42 | 2.27 |
| BACTD2 | 20.85 | 11.11 | 7.86 | 6.24 | 5.26 | 4.61 | 4.15 | 3.80 | 3.64 | 3.42 |

Table 4. (continued)

| Plant Size Category | Volume and Per Bale Costs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26-34 bph<br>Volume (bales) | 3000 | 6000 | 9000 | 12000 | 15000 | 18000 | 21000 | 24000 | 27000 | 30000 |
| Pre-Control Cost ($/bale) | 176.56 | 97.31 | 71.03 | 57.99 | 50.23 | 45.12 | 41.52 | 38.87 | 37.23 | 35.61 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 9.18 | 4.73 | 3.24 | 2.49 | 2.05 | 1.75 | 1.54 | 1.38 | 1.31 | 1.20 |
| BACTD1 | 13.64 | 7.23 | 5.09 | 4.02 | 3.38 | 2.95 | 2.65 | 2.41 | 2.31 | 2.16 |
| BACTD2 | 20.32 | 10.80 | 7.63 | 6.03 | 5.08 | 4.45 | 3.99 | 3.65 | 3.50 | 3.27 |
| ≥ 35 bph<br>Volume (bales) | 5000 | 10000 | 15000 | 20000 | 25000 | 30000 | 35000 | 40000 | 45000 | 50000 |
| Pre-Control Cost ($/bale) | 175.21 | 96.13 | 69.89 | 56.84 | 49.07 | 43.94 | 40.53 | 38.07 | 36.25 | 34.91 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 6.42 | 3.34 | 2.31 | 1.80 | 1.49 | 1.29 | 1.19 | 1.07 | 1.04 | 0.96 |
| BACTD1 | 9.75 | 5.29 | 3.80 | 3.05 | 2.61 | 2.31 | 2.17 | 1.99 | 1.95 | 1.84 |
| BACTD2 | 14.49 | 7.88 | 5.68 | 4.58 | 3.92 | 3.47 | 3.26 | 3.01 | 2.94 | 2.78 |

Table 5. Estimated per bale costs for each gin plant size under pre-control and the increase in per bale cost under BBACT, BACTD1, and BACTD2 at alternative volumes, stripped cotton.

| Plant Size Category | Volume and Per Bale Costs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ≤ 10 bph | | | | | | | | | | |
| Volume (bales) | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| Pre-Control Cost ($/bale) | 152.56 | 84.41 | 75.43 | 66.41 | 61.55 | 58.48 | 56.76 | 55.54 | 55.29 | 55.06 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 17.79 | 9.07 | 6.40 | 5.06 | 4.26 | 3.73 | 3.35 | 3.06 | 2.93 | 2.74 |
| BACTD1 | 27.06 | 14.19 | 10.13 | 8.11 | 6.89 | 6.08 | 5.50 | 5.07 | 4.87 | 4.59 |
| | 31.88 | 17.02 | 12.30 | 9.94 | 8.52 | 7.58 | 6.91 | 6.40 | 6.17 | 5.84 |
| 11-15 bph | | | | | | | | | | |
| Volume (bales) | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| Pre-Control Cost ($/bale) | 185.62 | 108.94 | 83.62 | 71.20 | 64.03 | 59.43 | 56.32 | 54.13 | 52.76 | 51.80 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 13.86 | 7.25 | 5.13 | 4.07 | 3.44 | 3.03 | 2.72 | 2.49 | 2.39 | 2.24 |
| BACTD1 | 18.39 | 9.98 | 7.27 | 5.92 | 5.10 | 4.57 | 4.18 | 3.89 | 3.76 | 3.57 |
| BACTD2 | 25.93 | 14.13 | 10.28 | 8.36 | 7.21 | 6.45 | 5.90 | 5.48 | 5.30 | 5.03 |
| 16-25 bph | | | | | | | | | | |
| Volume (bales) | 2000 | 4000 | 6000 | 8800 | 10000 | 12000 | 14000 | 16000 | 18800 | 20000 |
| Pre-Control Cost ($/bale) | 185.30 | 105.65 | 79.28 | 66.21 | 58.47 | 53.39 | 49.83 | 47.22 | 45.60 | 44.03 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 11.87 | 6.34 | 4.49 | 3.57 | 3.02 | 2.65 | 2.39 | 2.19 | 2.10 | 1.97 |
| BACTD1 | 16.58 | 9.17 | 6.70 | 5.47 | 4.72 | 4.23 | 3.88 | 3.61 | 3.49 | 3.32 |
| BACTD2 | 23.93 | 13.19 | 9.61 | 7.82 | 6.74 | 6.02 | 5.51 | 5.13 | 4.96 | 4.71 |

Table 5. (continued)

| Plant Size Category | Volume and Per Bale Costs | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26-34 bph | | | | | | | | | | |
| Volume (bales) | 3000 | 6000 | 9000 | 12000 | 15000 | 18000 | 21000 | 24000 | 27000 | 30000 |
| Pre-Control Cost ($/bale) | 180.62 | 101.37 | 75.10 | 62.05 | 54.29 | 49.18 | 45.58 | 42.93 | 41.29 | 39.67 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 11.13 | 5.93 | 4.19 | 3.32 | 2.80 | 2.45 | 2.21 | 2.02 | 1.94 | 1.81 |
| BACTD1 | 15.92 | 8.77 | 6.37 | 5.18 | 4.47 | 3.99 | 3.65 | 3.39 | 3.28 | 3.11 |
| BACTD2 | 23.19 | 12.71 | 9.21 | 7.46 | 6.42 | 5.72 | 5.22 | 4.84 | 4.67 | 4.43 |
| ≥ 35 bph | | | | | | | | | | |
| Volume (bales) | 5000 | 10000 | 15000 | 20000 | 25000 | 30000 | 35000 | 40000 | 45000 | 50000 |
| Pre-Control Cost ($/bale) | 179.27 | 100.19 | 73.95 | 60.90 | 53.13 | 48.00 | 44.60 | 42.13 | 40.31 | 38.97 |
| Cost Increase ($/bale) | | | | | | | | | | |
| BBACT | 7.91 | 4.30 | 3.10 | 2.50 | 2.13 | 1.89 | 1.77 | 1.64 | 1.60 | 1.51 |
| BACTD1 | 11.58 | 6.59 | 4.92 | 4.09 | 3.59 | 3.25 | 3.08 | 2.90 | 2.85 | 2.72 |
| BACTD2 | 16.87 | 9.53 | 7.08 | 5.86 | 5.13 | 4.64 | 4.39 | 4.12 | 4.04 | 3.86 |

experienced more modest increases in per bale costs than smaller plants operating at the same utilization level. As an example, the ≥ 35 bph plant operating at 80% utilization (40,000 bales) would expect costs to increase $3.01 per bale if BACTD2 were introduced when processing picked cotton whereas the 26 to 34 bph plant and the 16 to 25 bph plant operating at the 80% utilization level would expect costs to increase $3.65 per bale and $3.80 per bale, respectively (Table 4). Finally, the increase in per bale costs for a plant processing stripped cotton were approximately $0.50 to $3.00 per bale higher than for plants processing picked cotton (Tables 4 and 5). This was the result of greater investment in air pollution control equipment and the need for additional connected horsepower in plants processing stripped cotton.

## Air Pollution Control Systems and Effect on Returns

Rates of return after taxes were calculated for each gin plant size category under pre-control (current), and the BBACT, BACTD1, and BACTD2 air pollution control systems. Rates of return were based on projected costs, federal corporate taxes (Internal Revenue Service, 1992), and ginning revenue information taken from a USDA survey of gins (Glade et al., 1993) and data provided by COBANK in Austin, Texas. These data showed gins equipped with a universal-density (UD) press had an estimated revenue of $59.25 and $63.25 per bale when processing picked and stripped cotton, respectively. Since the ≤10 bph gin plant did not typically have a UD press, they were assumed to have an estimated revenue of $51.45 and $55.45 per bale when processing picked and stripped cotton, respectively. The Dun and Bradstreet publication, Industry Norms and Key Business Ratios, showed the simple rate of return on cotton ginning industry assets to average 14.7%; accordingly, this value was selected as the required rate of return. The required rate of return (14.7%) was based on a five year average (1988-1992) and included an annual sample of about 190 cotton ginning enterprises. Investments in air pollution control, which forced returns on gin plant investment below the required rate (14.7%), were judged to jeopardize the long-run economic viability of the cotton ginning enterprise.

Expected outcomes were shown by the rate of return analyses (Tables 6 and 7). First, introducing air pollution control decreased a gin plant's rate of return on investment, and, in general, those controls which increasingly lowered the emission rate tended to lower rates of return. For example, a plant in the 16 to 25 bph category processing 18,800 bales of picked cotton under pre-control conditions (emission rate of 4 lb per bale) experienced a rate of return on investment of 15.36%, but when upgraded to BBACT (emissions rate of 2.24 lb per bale), this plant's return on investment declined to 13.18%. When upgraded to BACTD1 (emissions rate of 1.6 lb per bale) and BACTD2 (emissions rate of 1.06 lb per bale), the returns declined to 12.12 and 10.76%, respectively (Table 6). Second, regardless of the control technology, a gin plant earned a higher rate of return at higher volume levels. As an example, a gin in the 16 to 25 bph capacity range processing 10,000 bales of picked cotton experienced a rate of return on investment of 2.99% under pre-control conditions, whereas at 18,800 bales the return increased to 15.36%. Third, large plants tended to experience higher rates of return than smaller plants when compared at specified utilization levels. As an example, a plant in the ≥35 bph category operating at 80% of capacity (40,000 bales) under BBACT generated a return of 13.64%, whereas plants in the 26 to 34 and the 16 to 25 bph categories

Table 6. Estimated simple rate of return on investment for each gin plant size under pre-control, BBACT, BACTD1 and BACTD2 at alternative volumes, picked cotton.

| Plant Size Category | Volume and Rates of Return | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ≤ 10 bph | | | | | | | | | | |
| Volume (bales) | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -17.25 | -13.83 | -10.62 | -7.75 | -5.36 | -3.17 | -1.56 | -0.04 | 0.31 | 0.68 |
| BBACT | -17.31 | -14.33 | -11.58 | -9.12 | -7.09 | -5.22 | -3.86 | -2.59 | -2.41 | -2.07 |
| BACTD1 | -17.14 | -14.34 | -11.83 | -9.60 | -7.76 | -6.08 | -4.88 | -3.76 | -3.69 | -3.46 |
| BACTD2 | -17.83 | -15.20 | -12.84 | -10.75 | -9.04 | -7.49 | -6.41 | -5.39 | -5.48 | -5.32 |
| 11-15 bph | | | | | | | | | | |
| Volume (bales) | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -19.57 | -14.60 | -9.74 | -5.04 | -0.57 | 3.17 | 6.54 | 9.33 | 11.50 | 13.47 |
| BBACT | -19.39 | -14.89 | -10.53 | -6.31 | -2.29 | 1.32 | 4.45 | 7.17 | 9.17 | 10.95 |
| BACTD1 | -19.60 | -15.29 | -11.11 | -7.08 | -3.23 | 0.38 | 3.37 | 6.07 | 8.07 | 9.81 |
| BACTD2 | -19.61 | -15.56 | -11.65 | -7.88 | -4.29 | -0.85 | 2.06 | 4.72 | 6.65 | 8.35 |
| 16-25 bph | | | | | | | | | | |
| Volume (bales) | 2000 | 4000 | 6000 | 8800 | 10000 | 12000 | 14000 | 16000 | 18800 | 20000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -17.74 | -12.32 | -6.97 | -1.69 | 2.99 | 6.50 | 9.59 | 12.64 | 15.36 | 18.51 |
| BBACT | -17.70 | -12.72 | -7.82 | -2.98 | 1.53 | 5.09 | 7.94 | 10.74 | 13.18 | 15.98 |
| BACTD1 | -17.88 | -13.10 | -8.38 | -3.73 | 0.73 | 4.32 | 7.10 | 9.78 | 12.12 | 14.74 |
| BACTD2 | -17.96 | -13.44 | -8.99 | -4.60 | -0.26 | 3.32 | 6.06 | 8.59 | 10.76 | 13.21 |

Table 6. (continued)

| Plant Size Category | Volume and Rates of Return | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26-34 bph<br>Volume (bales) | 3000 | 6000 | 9000 | 12000 | 15000 | 18000 | 21000 | 24000 | 27000 | 30000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -15.61 | -10.13 | -4.70 | 0.57 | 4.40 | 7.62 | 10.90 | 14.32 | 17.40 | 19.93 |
| BBACT | -15.72 | -10.64 | -5.60 | -0.61 | 3.34 | 6.33 | 9.30 | 12.47 | 15.29 | 17.71 |
| BACTD1 | -15.90 | -11.00 | -6.14 | -1.34 | 2.74 | 5.65 | 8.50 | 11.52 | 14.21 | 16.59 |
| BACTD2 | -16.05 | -11.40 | -6.79 | -2.23 | 1.92 | 4.78 | 7.50 | 10.30 | 12.83 | 15.15 |
| ≥ 35 bph<br>Volume (bales) | 5000 | 10000 | 15000 | 20000 | 25000 | 30000 | 35000 | 40000 | 45000 | 50000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -15.63 | -9.94 | -4.30 | 1.10 | 4.64 | 8.17 | 11.66 | 15.07 | 18.41 | 21.65 |
| BBACT | -15.72 | -10.33 | -4.99 | 0.27 | 3.84 | 7.13 | 10.40 | 13.64 | 16.76 | 19.82 |
| BACTD1 | -15.88 | -10.65 | -5.47 | -0.32 | 3.34 | 6.50 | 9.66 | 12.80 | 15.79 | 18.75 |
| BACTD2 | -16.23 | -11.14 | -6.09 | -1.08 | 2.79 | 5.83 | 8.89 | 11.94 | 14.83 | 17.71 |

Table 7. Estimated simple rate of return on investment for each gin plant size under pre-control, BBACT, BACTD1 and BACTD2 at alternative volumes, stripped cotton.

| Plant Size Category | Volume and Rates of Return | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| ≤ 10 bph | | | | | | | | | | |
| Volume (bales) | 800 | 1600 | 2400 | 3200 | 4000 | 4800 | 5600 | 6400 | 7200 | 8000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -17.26 | -13.85 | -10.66 | -7.79 | -5.42 | -3.23 | -1.63 | -0.13 | 0.22 | 0.59 |
| BBACT | -17.86 | -14.93 | -12.30 | -9.96 | -8.05 | -6.30 | -5.07 | -3.92 | -3.87 | -3.65 |
| BACTD1 | -18.13 | -15.52 | -13.19 | -11.14 | -9.48 | -7.98 | -6.96 | -6.03 | -6.19 | -6.13 |
| BACTD2 | -18.31 | -15.89 | -13.75 | -11.87 | -10.38 | -9.04 | -8.17 | -7.37 | -7.68 | -7.74 |
| 11-15 bph | | | | | | | | | | |
| Volume (bales) | 1200 | 2400 | 3600 | 4800 | 6000 | 7200 | 8400 | 9600 | 10800 | 12000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -19.58 | -14.62 | -9.78 | -5.09 | -0.62 | 3.12 | 6.49 | 9.27 | 11.45 | 13.41 |
| BBACT | -19.77 | -15.36 | -11.10 | -6.98 | -3.06 | 0.58 | 3.63 | 6.38 | 8.40 | 10.18 |
| BACTD1 | -19.92 | -15.76 | -11.73 | -7.85 | -4.16 | -0.64 | 2.32 | 5.03 | 7.02 | 8.75 |
| BACTD2 | -20.02 | -16.15 | -12.41 | -8.81 | -5.39 | -2.13 | 0.83 | 3.34 | 5.29 | 7.04 |
| 16-25 bph | | | | | | | | | | |
| Volume (bales) | 2000 | 4000 | 6000 | 8800 | 10000 | 12000 | 14000 | 16000 | 18800 | 20000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -17.75 | -12.33 | -6.99 | -1.72 | 2.95 | 6.47 | 9.55 | 12.60 | 15.31 | 18.45 |
| BBACT | -18.01 | -13.11 | -8.28 | -3.51 | 1.01 | 4.63 | 7.46 | 10.21 | 12.61 | 15.31 |
| BACTD1 | -18.20 | -13.54 | -8.95 | -4.43 | 0.03 | 3.65 | 6.45 | 9.05 | 11.30 | 13.83 |
| BACTD2 | -18.35 | -13.98 | -9.67 | -5.42 | -1.23 | 2.46 | 5.30 | 7.74 | 9.81 | 12.18 |

Table 7. (continued)

| Plant Size Category | Volume and Rates of Return | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 26-34 bph<br>Volume (bales) | 3000 | 6000 | 9000 | 12000 | 15000 | 18000 | 21000 | 24000 | 27000 | 30000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -15.61 | -10.14 | -4.73 | 0.54 | 4.38 | 7.59 | 10.86 | 14.27 | 17.35 | 20.70 |
| BBACT | -15.97 | -10.95 | -5.98 | -1.05 | 3.01 | 5.98 | 8.90 | 12.01 | 14.78 | 17.86 |
| BACTD1 | -16.18 | -11.39 | -6.64 | -1.93 | 2.25 | 5.16 | 7.95 | 10.85 | 13.47 | 16.40 |
| BACTD2 | -16.40 | -11.86 | -7.37 | -2.92 | 1.26 | 4.22 | 6.85 | 9.53 | 11.98 | 14.74 |
| ≥ 35 bph<br>Volume (bales) | 5000 | 10000 | 15000 | 20000 | 25000 | 30000 | 35000 | 40000 | 45000 | 50000 |
| Rate of Return (%) | | | | | | | | | | |
| Pre-Control | -15.64 | -9.96 | -4.33 | 1.08 | 4.61 | 8.14 | 11.61 | 15.03 | 18.36 | 21.60 |
| BBACT | -15.92 | -10.60 | -5.32 | -0.08 | 3.56 | 6.80 | 10.02 | 13.21 | 16.28 | 19.31 |
| BACTD1 | -16.11 | -10.99 | -5.92 | -0.88 | 2.94 | 6.00 | 9.08 | 12.15 | 15.07 | 17.97 |
| BACTD2 | -16.30 | -11.40 | -6.54 | -1.72 | 2.28 | 5.17 | 8.08 | 11.01 | 13.77 | 16.53 |

under comparable conditions experienced returns of 12.47 and 10.74%, respectively (Table 6). In addition, under analogous conditions, the rates of return for plants processing picked cotton were slightly higher than returns for plants processing stripped cotton (Tables 6 and 7).

When the two largest plant sizes (26 to 34 and ≥ 35 bph) were operating at 100% capacity and processing either picked or stripped cotton, they generated returns in excess of the rate required (14.7%) to upgrade to an emission level of 1.06 lb per bale (BACTD2). But as shown by information in Table 6, no other plant size generated adequate returns to upgrade to this low emission rate. At peak volume (100% utilization), the rate of return was adequate to upgrade the 16 to 25 bph plant to an emission rate of 1.60 lb per bale (BACTD1) when processing picked cotton and to upgrade to an emission rate of 2.24 lb per bale (BBACT) when processing stripped cotton. Returns were insufficient for the ≤ 10 bph plants and the 11 to 15 bph plants to add air pollution controls. When plant utilization declined to 90% and the plant was processing picked cotton, the ≥ 35 bph plant generated returns that were adequate to upgrade to an emission rate of 1.06 lb per bale (BACTD2) while returns for the 26 to 34 bph plant would permit upgrading to an emission level of 2.24 lb per bale (BBACT) (Table 6). However, when processing stripped cotton and operating at 90% utilization, the ≥ 35 bph plant generated returns that allowed upgrading to an emission rate of only 1.60 lb per bale (BACTD1), whereas returns for the 26 to 34 bph plant would permit upgrading to an emissions rate of 2.24 lb to bale (BBACT) (Table 7).

## SUMMARY AND CONCLUSIONS

Analysis regarding gin plant costs showed (1) per bale costs increased with introduction of air pollution controls, and controls which increasingly lowered per bale emission rates increased per unit processing costs; (2) for a particular gin plant size, the increase in per bale cost associated with introduction of air pollution control was reduced as plant volume increased; and (3) for a particular air pollution control system, large gin plants operating at a particular utilization level experienced more modest increases in per bale costs than smaller plants operating at similar utilization levels.

In general, the rates of return were inversely related to per bale plant costs. In particular, (1) introducing air pollution controls decreased a plant's rate of return on investment, and rates of return decreased as controls introduced increasingly lowered emission rates; (2) regardless of the air pollution control system, a gin plant earned a higher rate of return at higher volume levels; and (3) large plants tended to experience higher rates of return than smaller plants when compared at specified utilization levels.

The following observations were made regarding the ability of Texas gin plants to invest in air pollution controls:

(1) Neither the ≤ 10 bph nor the 11 to 15 bph plants had returns which permit investment in air pollution controls when processing picked or stripped cotton.

(2) The 16 to 25 bph plant, when processing picked cotton and operating at 100% utilization, had returns which permit investment in BACTD1 (1.60 lb per bale emission rate). However, when processing stripped cotton,

returns permitted investment in only BBACT (2.24 lb per bale emission rate) for the 16 to 25 bph plant. Upgrading was not feasible when the 16-25 bph plant operated at less than the 100% utilization level.

(3) The 26 to 34 bph plant, processing picked or stripped cotton at 100% utilization, had returns that permitted investment in BACTD2 (1.06 lb per bale emission rate). At 90% utilization, plants processing picked or stripped cotton upgraded to only BBACT (2.24 lb per bale emission rate). No investment in air pollution control was permitted when utilization levels fell below 90%.

(4) In the largest plant size category (≥ 35 bph), plants processing picked or stripped cotton and operating at 100% of capacity had returns which permitted upgrading to BACTD2 (1.06 lb per bale emission rate), whereas at 90% utilization, plants processing picked cotton upgraded to BACTD2 (1.06 lb per bale emission rate). But when processing stripped cotton, returns allowed upgrading to only BACTD1 (1.60 lb per bale emission rate). No investment in air pollution control was warranted when utilization levels were below 90%.

In conclusion, gin plant's rate of return on investment was unfavorably affected by the introduction of air pollution controls. Many Texas plants operate at comparatively low utilization levels and, as such, careful attention must be given to a plant's historic variability in processing levels when prescribing air pollution controls since their economic viability is sensitive to these investments.

This study had several shortcomings which should be noted. First, it was assumed that gin revenue schedules were unchanged with investments in air pollution controls. If ginning charges increased as a result of the higher cost, then the calculated rates of return were underestimated. Second, in the long run, new innovations may lower air pollution control costs and create uses for the removed pollutants. In which case, the unfavorable effects on the cotton ginning industry may be overstated by this study.

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