USE OF POULTRY LITTER AND OTHER BIOMASS IN ELECTRICITY PRODUCTION AND ITS IMPLICATION FOR ECONOMIC DEVELOPMENT

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Abstract

Poultry litter is a byproduct of poultry production which has potential to cause water quality problem if it is not applied properly on land as a nutrient source. Using survey information available from Louisiana broiler producers, we found that broiler litter is not cost-effective to transport farther than 24 miles from the production facilities given the crops grown in the region and other prevailing cost parameters. Alternative to broiler litter use on land as crop nutrients is its use as electricity production through combustion. We found that biomass-electricity conversion is cost prohibitive if three small plant operations are established. It can be profitable if one large size plant of 10.5 MW is constructed, litter is available free, transportation cost is low and construction cost of electricity plant falls at the lower range. Regional and state level economic impacts (multiplier) of using broiler litter for electricity was found to be in the range of 1.4-1.5 and 1.42-1.55, respectively for the capital expenditure and 1.21-2.67 and 1.27-1.94 respectively for the operation cost. Detail environmental impact assessment may be needed to assess the full benefits of poultry litter-electricity production.

Keywords: broiler, breakeven transportation distance, poultry-electricity production feasibility, impact factor

JEL Classifications: O13, Q42, Q53

Use of Poultry Litter and Other Biomass in Electricity production and its Implication for Economic development

Poultry production is the major agricultural industry in the Southeastern United States. Consider a case of Louisiana which has relatively small number of poultry birds compared to other Southeastern states such as Alabama, Georgia, and Arkansas. Here still it is the largest animal industry that generated approximately $1.2 billion combined in farm revenue ($603.4 million) and value added products ($579.3 million), and employed 4,361 people in 2008. Among many types of poultry operations, broiler production generates the lion share of revenue and employment to the State. However, this huge amount of revenue also translates into the production of large amount of broiler litter (manure) as a byproduct. Broiler litter is both valuable resource and unavoidable byproduct that must be disposed off because of environmental concerns. Broiler litter contains 13 essential plant nutrients but farmers apply broiler litter based mainly on nitrogen, phosphorus and potash content. Because broiler litter has primary nutrients that plants need, it has a market value. However, when broiler litter is overapplied or applied for a long time without consideration of nutrient needs of the crop grown in the soil, the nutrients, such as phosphorus, have tendency to build up in soil. During the rainy weather, phosphorus leaches of to shallow ground water or runoffs to nearby waterbodies causing an eutrophication problem.

After the introduction of the American Recovery and Reinvestment Act of 2009, there has been increased interest in converting biomass into bioenergy. So far greater emphasis has been paid to converting biomass into ethanol, soybean oil/palm oil into biodiesel and corn/sugarcane into ethanol. Campbell et al. (2009) found that using biomass to produce electricity is 80 percent more efficient than transforming the biomass into biofuel. In addition, they reported that the electricity option would be twice as effective at reducing greenhouse-gas emissions. This same view is put forth by authors such as Howarth et al. (2009).

Recently, there has been increased interest in producing electricity from surplus broiler litter (Kelleher et al. 2002; Jensen et al. 2010). It is an attractive alternative as land application of broiler litter may not be always feasible because of a need to haul manure to long distance from broiler operations and a lack of functioning broiler litter despite its high nutrient content. Conversion of poultry litter to electricity has been in existence in the United Kingdom operated by Fibrowatt since 1990s. In the U.S., a similar type of operation is in existence in Minnesota and other states are actively pursuing building one to solve manure disposal problems. Given the increased interest of converting electricity production from broiler litter, we assessed the feasibility of manure as electricity source.

We organized this paper as follow. First, we assessed the economic potential of litter as land application to meet crop nutrient needs. We then assessed the cost-return assessment of broiler litter as energy source. We also showed economic impacts of building broiler based electricity plants in Louisiana. We conclude the paper with major findings and caveats.

Broiler litter as Crop Nutrient Source

One alternative to alleviate broiler litter disposal problem is to apply broiler litter away from production sites to crop production areas. Litter transportation from broiler production facilities to crop production area has been studied by several authors (Paudel et al. 2004; Paudel and McIntosh, 2005, Paudel et al. 2003-2004). They have reported that it is profitable to transport broiler litter but the distance to which it can be transferred depends greatly on the cost of transportation cost, manure cost, loading cost, and spreading cost.

Louisiana's commercial broiler production occurs mainly in the 11 north and central parishes (Figure 1a). These parishes, number of broiler farms, amount of meat produced, potential hay and row crops areas where litter can be applied and classification of each parish as surplus and deficit parishes are provided in Table 1. The first step to assess the broiler litter use potential for crop nutrients is through the identification of surplus and deficit parishes. Surplus parishes are those where litter production is more than it can be utilized in crop production as nutrients. Deficit parishes are those where litter can be transported from the surplus parishes and applied in crop production. Theoretically speaking, transportation of manure takes place from surplus to deficit parishes as long as it is economical to do so. This study first identifies the surplus and deficit parishes and then calculates the breakeven distance to which broiler litter can be transferred from the production facilities to crop production areas.

Breakeven distance provides distance from broiler litter production sites to the area where it is equally profitable to apply broiler litter as it is to apply chemical fertilizer. The distance depends on the cost of chemical fertilizer, loading cost of broiler litter, transportation cost of broiler litter, spreading cost of broiler litter, and the amount of fertilizer generally recommended for a crop in a given area. Based on our survey of

Louisiana broiler producers, some of these costs are presented in Table 2.

The major row crops grown in these broiler producing parishes in Louisiana where litter can be applied are corn, cotton, sorghum and wheat. Recommended amounts of $N:P_2O_5:K_2O$ per acre for these crops based on Louisiana Cooperative Extension Service are 180:60:60 pounds (dryland corn), 210:60:60 pounds (irrigated corn), 90:15:18 pounds (dry or irrigated cotton), 120:35:35 pounds (sorghum) and 80:45:45 pounds (wheat). Additionally, broiler litters can be applied on Bermuda grass hay, the nutrient recommended for which is 69:48:48 lbs of $N:P_2O_5:K_2O$ per acre. The nutrient amount in broiler litter varies based on bedding material, weather condition, and feed provided to the broiler birds. The average macronutrient ($N:P_2O_5:K_2O$) content of broiler litter is 62:60:40 pounds per ton. Based on the prevailing fertilizer price in the market (N $0.53 per pound, P_2O_5 $0.88 per pound and K_2O $0.77 per pound), one ton of litter could be worth $115.66. Given the NPK recommendation, breakeven distances for each crop and hay are calculated and shown in Table 3. We applied broiler litter following a phosphorus consistent rule which means broiler litter is applied based on the phosphorus needs of plants. We calculated the breakeven distance– a) based on the cost figure ($3.88 per ton per mile) from our survey of the broiler producers in Louisiana, and b) $0.48 per ton per mile transportation cost with other costs as obtained from the survey. We used the latter value as reflective of Louisiana state mileage reimbursement rate. We have seen much lower transportation cost ($0.10 per ton per mile) used in the broiler litter transportation literature.

The breakeven distance for dry corn, irrigated corn, cotton, sorghum, and wheat are 26, 26, 22, 25, 26, and 26 miles, respectively based on $3.88 per ton per mile cost. If prevailing transportation cost figure (0.48 per ton per mile) is used, the breakeven distances will be 211, 211, 177, 203, 208, and 209 miles for irrigated corn, dry cotton, sorghum, wheat and hay, respectively. If we were to base our decision on these breakeven distances, broiler litter cannot be hauled very far from the parish border. As shown in Figure 1, yellow areas are where litter can be applied in crop production. These crop production areas are much farther than the 22 miles breakeven distance from the broiler production facilities. Given the fact that we have only three deficit parishes (Natchitoches, Vernon, and Winn) out of 11 broiler producing parishes, excess litter production and its safe disposal problem will continue to persist without some form of support provided to farmers to transport broiler litter. However, if the transportation cost is relatively cheap (say $0.48 per ton per mile), litter can be safely transported from surplus broiler litter production parishes to deficit parishes with crop production such as many north and central parishes in Louisiana (Figures 1b and 1c). This should solve the excess litter disposal problem in the state.

Broiler litter as an electricity source

Dried animal manure has been used as heat source for a long time in human civilization. This same concept can be used in modern days to generate electricity using the combustion process. Per pound of broiler litter has heating value in the range of 3400-6300 BTU. To generate one kilo-watt-hour (KWH) electricity, we need 15000 BTU. We used an average value of 4600 BTU per pound of broiler litter which results in the production of 613 KWH of electricity per ton of broiler litter. With an average electricity price of $0.067/KWH, the value of litter comes out to be $41.09. Additionally, the ash amount left after electricity production ranges around 10-34%. The average value of ash per ton is $12/ton. We used 20% ash production after burning litter which adds the value of broiler litter to $2.4 per ton to a total of $43.49/ton.

Three parishes out of 11 parishes in Louisiana would be able to contribute litter for electricity production. Other parishes either would contribute litter for nutrients within or in their surrounding parishes. These three parishes – Claiborne, Union and Lincoln – produced around 150,000 tons of surplus litter in 2008. This amount is sufficient to generate 10.5 MW of electricity with annual direct value of $6.1 million. The ash value of broiler litter obtained after electricity production is $360,000. Therefore, the direct value of electricity production from broiler litter in these three parishes is $6.76 million.

We assumed two scenarios – construction of one big plant of size 10.5 MW and construction of three small plants of size 3.5 MW. We calculated the weighted center point among Claiborne, Union and Lincoln parishes by using central feature tool of the ArcGIS software. The ideal location of one big plant (10.5 MW) is shown in Figure 2. We assumed high and low construction and operation costs scenarios. We assumed ($10500/KW for the capital cost, $1800/KW for the variable cost) under the high cost scenario and ($2800/KW for the capital cost and $180/KW for the variable cost) under the low cost scenario.

Under the high cost scenario, with broiler litter cost parameters used from the survey (shown in Table 2), it can be expected that investment in broiler litter based electricity plant will be negative. If we consider a low cost scenario, the investment can generate 16.5% annual return but the return becomes negative if litter cost has to be paid

(See Table 4). We assumed 24 miles as a breakeven distance (identified from its use as crop nutrients) although from the center point identified here to the parish border the distance is as far as 43 miles. Much of the litter cost relates to transportation cost so unless transportation cost is substantially reduced by locating the plant near supply sources or identifying a cheaper alternative to transporting litter, production of electricity from litter will not be profitable.

Economic Impact

Economic impacts under different scenarios are estimated using IMPLAN, an input-output analysis model produced by Minnesota IMPLAN Group, Inc. Economic impacts are estimated at a regional level. Given the fact that impact is not limited to the 11 parish region only, we also estimated state level impacts to capture spillover effects.

IMPLAN provides the estimates of impacts for output (local receipts), employment (average number of individuals employed in a year locally), labor income (benefit paid by the employer and and individual proprietor income) and value added. IMPLAN gives the value associated with direct impacts of the project, indirect impacts resulting from expenditure by the project on local goods and services, induced impact resulting from the spending by project employees or other employees supported by the project.

Since power generation from poultry litter is relatively new technology, IMPLAN does not have data on this sector. Therefore, we estimated the economic impacts using closest sector (i.e. construction of new nonresidential manufacturing structures) based on initial construction activities and subsequent operation and management. For the high cost scenario, it is estimated that the proposed 10.5 MW plant cost about $113 million based on

$10,500 per kilowatt initial installation cost. A total of 1015 people are expected to be employed with $44.7 million dollar labor income during a year of construction period. (These impacts values are estimated on 2010 dollars based on cost estimated in 2008). Additional 482 jobs are expected to be supported from indirect and induced impact with $17.6 million labor income. In terms of value added, this plant is expected to generate $58.4 million direct value added during its construction phase with 1.48 multiplier index.

The operation expenditure is estimated to be $18.9 million in 2008 dollar. We used a per unit operation cost value based on Flora and Riahi-Nezhad (2006). Every year this plant is expected to employ 86 people with $4.1 million in labor wage. Additional 42 jobs are expected to be supported from this operation with $1.5 million labor income. State level analysis also shows similar results albeit results a little higher multiplier effects. Regional and state level economic impact of using broiler litter for electricity was found to be in the range of 1.4-1.5 and 1.42-1.55, respectively for the capital expenditure and 1.21-2.67 and 1.27-1.94 respectively for the operation cost. Regional and state level impacts are shown in Tables 5 and 6.

Conclusions

Broiler production has been expanding dramatically in the Southeastern U.S. This has created the need to properly dispose off broiler litter. The most common method and the one that the US Department of Agriculture and US Environmental Protection Agency have approved is land application of litter as nutrient source. Limited agricultural land suitable for litter application within the parish and transportation cost associated with litter to a long distance necessitate policy makers to look at alternative venue. In fact in Louisiana, based on the survey information collected from broiler producers, it is not possible to transport litter beyond 24 miles. This distance will not cover the suitable land that lies beyond the 24-mile zone. Unless some sort of support is provided by the state for hauling litter, there will be a need to find alternative use of broiler litter.

We advanced the case for using broiler litter for electricity production. This has the advantage that most of the harmful nutrients and hormones will not be disposed off in water. Based on the amounts of excess litter available in the region, we advanced a case of building three small plants (each 3.5 MW) receiving broiler litter from within the parish, and one big regional plant (10.5 MW) receiving litter from surrounding parishes. We identified the location where these plants should be constructed. Based on the high and low cost scenarios and the consideration that plant pays for litter use or not, the impact factor of building an electricity plant would be in the range of range of 1.4-1.5 and 1.42-1.55, respectively for the capital expenditure and 1.21-2.67 and 1.27-1.94 respectively for the operation cost. The rate of return obtained from a 10.5 MW size plant will be 16% under the low cost scenario (construction + operation) but would be negative if litter cost is factored in based on the prevailing cost figures. The rate of return will be negative under the high construction cost and high operation cost scenario.

Several factors will determine the success of litter-to-electricity generation plant. To reduce increased truck traffics in and around the electric plant, one alternative is to construct the plant accessible by rail transportation. Also, plant should be close to the electric grid and there should be a long term commitment from buyers of electricity. Therefore, identification of location is an important aspect of this process. As water quality regulations become tougher, broiler producers would have to find an alternative place for litter disposal. Litter based electricity provides that disposal avenue to farmers. Broiler farmers can form a cooperative to operate such an electric plant if sufficient loan is provided to them to operate the plant. Alternatively, integrators can take the responsibility of broiler litter disposal and hence utilize the excess litter in electricity production. Recently, there has been increased discontent among farmers and regulators about the lack of integrators' willingness to to solve excessive broiler litter production and disposal problem. By taking an active role on converting litter to electricity, they can earn goodwill from community, broiler farmers as well as increase their returns from integrated broiler operations.

There has been air quality concerns related to electricity production from broiler litter. The major concerns are air emission of arsenic, hydrochloric acid, sulfuric acid, and hydrofluoric acid. The FIBROMINN plant in Minnesota has shown that the 2009 annual emissions for the three primary emissions (CO, NOx, SO_2) were between 22% and 65% of the plant's allowed maximum potential emissions. Still, there should be a careful monitoring of air pollutants if broiler litter based electricity plant is to be socially acceptable.

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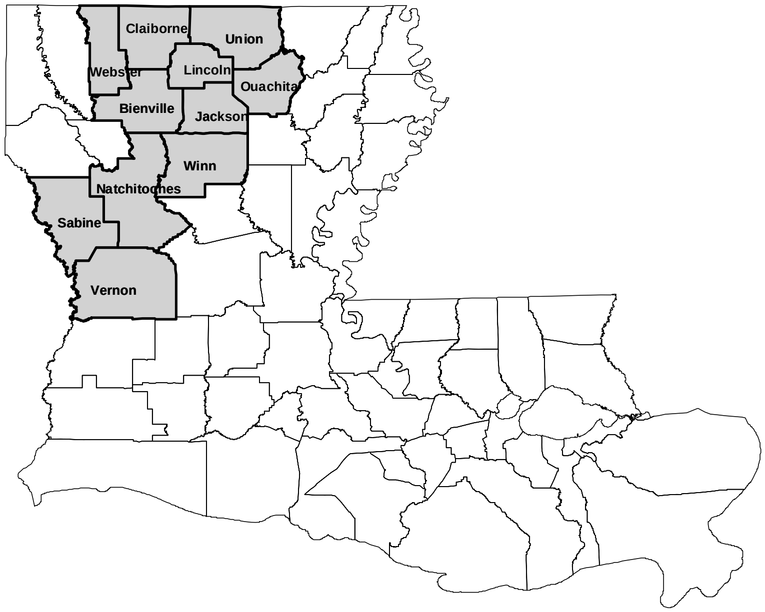


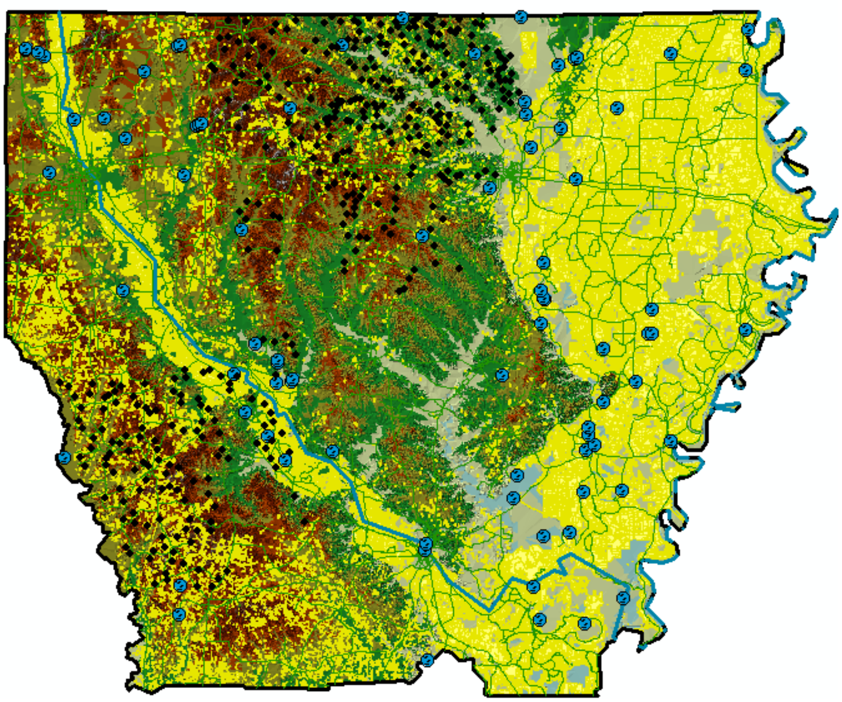


Figure 1a. Louisiana broiler production parishes and potential area where litter can be applied as a nutrient source (Black dots indicate broiler production facilities and yellow area indicates potential area where litter can be applied)

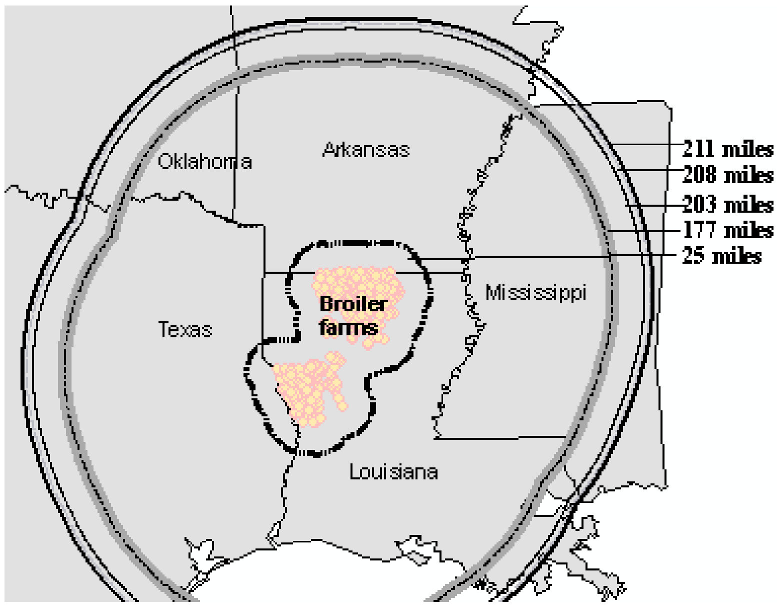


Figure 1b: Breakeven distances showing up to 211 miles radius from the broiler points that cover other neighboring states

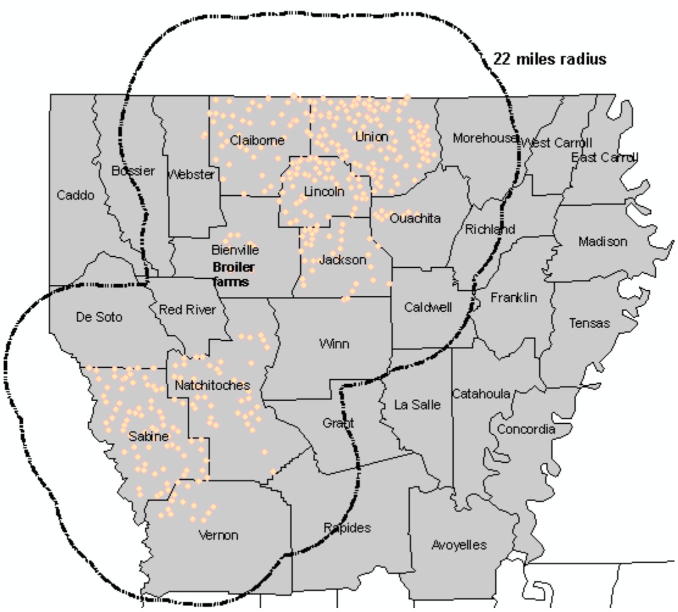
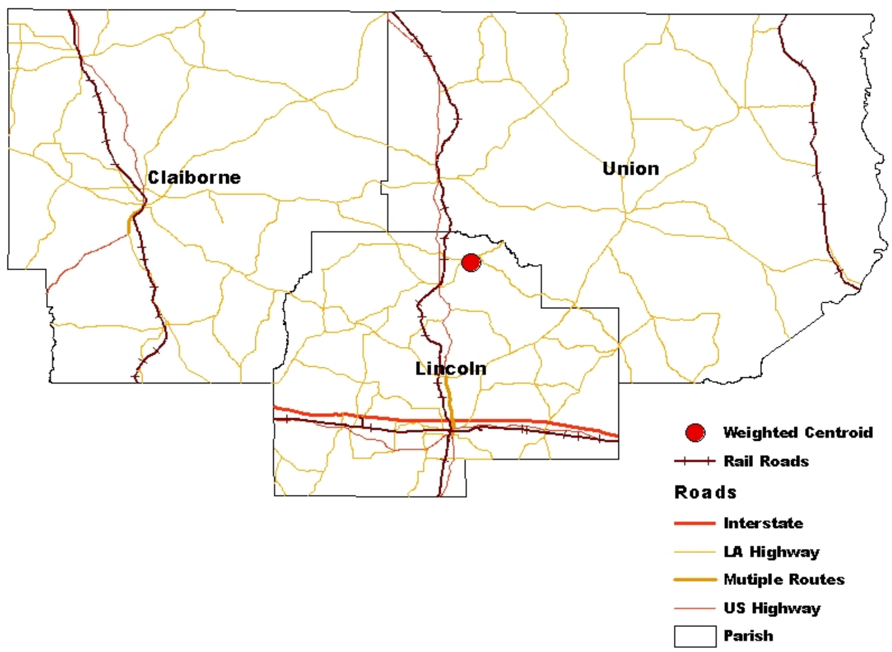


Figure 1c. Breakeven distances that cover 22 miles radius which goes beyond the broiler producing Parishes



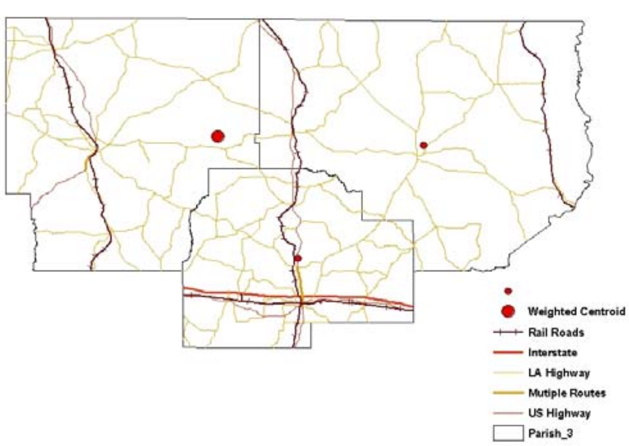


Figure 2. Locations where one 10.5 MW plant should be constructed (Red dot on the upper figure and green dot on the lower figure) and three 3.5 MW plants (red dots) should be constructed.

Table 1: Crop area, crop-nutrient demand and the nutrient supply from broiler production

Production broiler/major crops	Total meat production (lbs) harvestd crop areas (acres)	No of broiler birds (number of firms)	Litter produced (tons/year)	N (tons)	P_2O_5 (tons)	K_2O (tons)	Litter based Parish classification (surplus/deficit)
Bienville Parish							
Broilers	24,174,220	5,494,141 (8)	6,285.3				
Corn	679			61.1	20.4	20.4	
Hay	5,000			172.5	48	48	
Total crop nutrient requirements				233.6	140.4	140.4	Surplus
Nutrients equivalent supplied by parish's broiler production				194.8	188.6	125.7	
Claiborne Parish							
Broilers (Total)	125,101,000	28,432,045 (43)	28,432				
Hay	25,000			862.6	600	600	
Total crop nutrient requirement				862.6	600	600	Surplus
Nutrients equivalent supplied by parish's broiler production				1,008.3	975.8	650.5	
Jackson Parish							
Broilers (Total)	92,702,725	21,068,801 (30)	24,102.7				
Hay	10,500			362.3	252	252	
Total crop nutrient requirement				362.3	252	252	Surplus
Nutrients equivalent supplied by parish's broiler production				747.2	723.1	482.1	
Lincoln Parish							
Broilers	201,450,000	45,784,091 (51)	52,377				
Total crop nutrient requirement				0	0	0	Surplus
Nutrients equivalent supplied by parish's broiler production				1623.7	1571.3	1047.5	
Natchitoches Parish							
Broilers (Total)	97,100,000	22,068,182 (43)	25,246.0				
Corn	17,010			1530.9	510.3	510.3	
Wheat	8,900			356	200.3	200.3	
Cotton	2,750			123.75	20.6	24.8	
Sorghum	2,150			129	37.6	37.6	
Hay	20,500			707.25	492	492	
Total crop nutrient requirement				2846.9	1260.8	1264.925	Deficit
Nutrients equivalent supplied by parish's broiler production				782.6	757.4	504.9	
Ouachita Parish							
Broilers (Total)	23,939,000	5,440,682	6,224.1				Surplus

Corn	2,532			1,121	448	448	
Sorghum	137			245	71	71	
Cotton	8,540						
Total crop nutrient requirement				620.4	142.4	155.2	
Nutrients equivalent supplied by parish's broiler production				192.9	186.7	124.5	
Sabine Parish							
Broilers	165175000	37539773 (71)	42945.5				
Hay	2200			75.9	52.8	52.8	
Total crop nutrient requirement				75.9	52.8	52.8	Surplus
Nutrients equivalent supplied by parish's broiler production				1331.3	1288.4	858.9	
Union Parish							
Broilers (Total)	272,975,931	62,039,984 (105)	70,973.7				
Total crop nutrient requirement				0	0	0	Surplus
Nutrients equivalent supplied by parish's broiler production				2200.2	2129.2	1419.5	
Vernon Parish							
Broilers (Total)	1,450,000	329,545.5 (13)	377				
Hay	3,000			103.5	72	72	
Total crop nutrient requirement				103.5	72	72	
Nutrients equivalent supplied by parish's broiler production				11.7	11.3	7.5	Deficit
Webster Parish							
Broilers (Total)	9,480,000	2,154,545	2,464.8				
Corn	265			23.9	8.0	8.0	
				23.9	8.0	8.0	Surplus
Nutrients equivalent supplied by parish's broiler production (tons)				76.4	73.9	49.3	
Winn Parish							
Broilers (Total)	7,400,000	1,681,818	1,924				
Hay	3,000			103.5	72	72	
Total crop nutrient requirement				103.5	72	72	Deficit
Nutrient equivalent supplied by parish's broiler production (tons)				59.6	57.7	38.5	

Note: Number of broilers is estimated using an average of 4.4 lb weight per bird. Amount of litter is calculated based on 0.52 lbs of litter per ton of meat production. Parish classification is based on the phosphorus consistent rule. Values in this table are generated based on information obtained from Louisiana Agriculture Summary 2008 and Louisiana crop enterprise budget 2009.

Table 2. Loading, spreading, transportation and broiler litter purchase cost in Louisiana

Variables	Mean	Std. Dev	Min	Max
Litter loading cost per ton	1.77	4.61	0	25
Litter spreading cost per acre	5.40	12.16	0	60
Litter transportation cost per ton per mile	3.88	8.28	0	50
Cost ($) of litter per ton	6.99	16.79	0	80

Table 3. Breakeven distance calculation

Crops	Chemical fertilizer cost ($/acre)	Litter used (tons/acre)	Cost of litter use (litter purchase cost + loading cost + spreading cost)	Cost savings from using broiler litter plus remaining needed chemical fertilizer ($/acre)	Breakeven distance (miles)	
					Based on mileage cost obtained from the survey ($3.88/ton/mile)	Based on current state reimbursement mileage cost ($0.48/ton/mile)
Dry corn	193.20	1	14.16	101.5	26.2	211.5
Irrigated corn	209.10	1	14.16	101.5	26.2	211.5
Cotton	74.40	0.25	7.59	21.325	22.0	177.7
Sorghum	120.65	0.58	10.51	56.95833	25.2	203.4
Wheat	115.75	0.75	11.97	74.775	25.7	207.7
Hay	114.81	0.80	12.408	80.12	25.8	208.6

Table 4. Calculation of cost and return of 10.5 MW capacity broiler litter based electricity plant under high and low cost scenarios

	High Cost Scenario			Low Cost Scenario	
Variables	Construction cost	Annual operation cost		Construction cost	Annual operation cost
Cost per KW	$10,500	$1,800		$2,800	$180
Plant size 3500KW	$36750000	$6300000		$9800000	$630000
Plant size 10500 KW	$110250000	$18900000		$29400000	$1890000
Cost of litter (@$6 per ton for 150 K tons)	$900000				
Cost of loading	$265500				
Cost of transportation	$13968000				
Total litter related cost	$15133500				
Annual Revenue from Ash and Electricity			$6760000		
Annual rate of return without broiler litter related cost	negative		16.5%		
Annual rate of return with broiler cost added	negative		negative		

Table 5. Regional impact of building one big and three small broiler litter based electricity plants in Louisiana

	One Big Plant (10.5 MW)				Three Small Plants (each 3.5 MW)	(Effect representative of each parish - Union, Lincoln and Claiborne)			
High Cost	$110,250,000								
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**	**Impact Type**	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	1015	$44,672,460	$58,394,343	$113,017,808	Direct Effect	338	$14,890,820	$19,464,780	$37,672,608
Indirect Effect	190	$8,779,066	$12,680,819	$26,785,918	Indirect Effect	63	$2,926,354	$4,226,941	$8,928,641
Induced Effect	292	$8,918,682	$15,888,779	$29,658,447	Induced Effect	97	$2,972,894	$5,296,261	$9,886,148
Total Effect	1497	$62,370,206	$86,963,940	$169,462,171	Total Effect	499	$20,790,068	$28,987,980	$56,487,396
Impact factor	1.47	1.40	1.49	1.50	Impact factor	1.47	1.40	1.49	1.50
Low Cost	$28,350,000								
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**	**Impact Type**	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	261	$11,487,203	$15,015,683	$29,061,724	Direct Effect	87	$3,829,068	$5,005,229	$9,687,241
Indirect Effect	49	$2,257,474	$3,260,782	$6,887,809	Indirect Effect	16	$752,491	$1,086,927	$2,295,935
Induced Effect	75	$2,293,375	$4,085,687	$7,626,457	Induced Effect	25	$764,458	$1,361,896	$2,542,152
Total Effect	385	$16,038,051	$22,362,155	$43,575,987	Total Effect	128	$5,346,018	$7,454,052	$14,525,328
Impact factor	1.47	1.40	1.49	1.50	Impact factor	1.47	1.4	1.49	1.50

Operation Impact

High Cost	$18,900,000				**High Cost**				
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**	**Impact Type**	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	44.3	$4,122,885	$14,544,270	$19,604,731	Direct Effect	15	$1,374,295	$4,848,090	$6,534,910
Indirect Effect	15.6	$729,115	$1,191,363	$2,554,263	Indirect Effect	5	$243,038	$397,121	$851,421
Induced Effect	26.3	$803,531	$1,431,361	$2,671,931	Induced Effect	9	$267,844	$477,120	$890,644
Total Effect	85.9	$5,655,531	$17,166,994	$24,830,923	Total Effect	29	$1,885,177	$5,722,331	$8,276,974
Impact factor	1.94	1.37	1.18	1.27	Impact factor	1.94	1.37	1.18	1.27

Table 6. State level impact of building one big and three small broiler litter based electricity plants in Louisiana

One big plant (10.5 MW)	High Cost	$110,250,000		
High Cost				
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	918	$47,534,676	$62,175,070	$113,017,816
Indirect Effect	186	$9,876,811	$14,234,990	$28,457,220
Induced Effect	296	$10,325,159	$18,210,720	$33,489,350
Total Effect	1,400	$67,736,648	$94,620,780	$174,964,384
Impact Factor	1.53	1.42	1.52	1.55
Low Cost		$28,350,000		
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	236	$12,223,202	$15,987,880	$29,061,722
Indirect Effect	48	$2,539,752	$3,660,426	$7,317,570
Induced Effect	76	$2,655,040	$4,682,757	$8,611,546
Total Effect	360	$17,417,994	$24,331,060	$44,990,840
Impact Factor	1.53	1.42	1.52	1.55

Three small plants	36,750,000	Each		
High cost				
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	306	$15,844,892	$20,725,020	$37,672,608
Indirect Effect	62	$3,292,271	$4,744,998	$9,485,744
Induced Effect	99	$3,441,719	$6,070,239	$11,163,115
Total Effect	467	$22,578,882	$31,540,260	$58,321,468
Impact Factor	1.53	1.42	1.52	1.55
Low Cost			**9,450,000**	
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	79	$4,074,401	$5,329,292	$9,687,241
Indirect Effect	16	$846,584	$1,220,142	$2,439,190
Induced Effect	25	$885,014	$1,560,919	$2,870,515
Total Effect	120	$5,805,998	$8,110,353	$14,996,946
Impact Factor	1.52	1.42	1.52	1.55

Operation Impact

High Cost	18,900,000			
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	26.1	$4,167,775	$14,543,070	$19,603,116
Indirect Effect	17.2	$888,877	$1,402,105	$2,867,480
Induced Effect	26.3	$915,470	$1,614,641	$2,969,308
Total Effect	69.6	$5,972,122	$17,559,820	$25,439,904
Impact factor	2.67	1.43	1.21	1.30

High cost				
Impact Type	**Employment**	**Labor Income**	**Value Added**	**Output**
Direct Effect	8.7	$1,389,259	$4,847,691	$6,534,372
Indirect Effect	5.7	$296,292	$467,368	$955,827
Induced Effect	8.8	$305,157	$538,214	$989,769
Total Effect	23.2	$1,990,707	$5,853,273	$8,479,968
Impact Factor	2.67	1.43	1.21	1.30