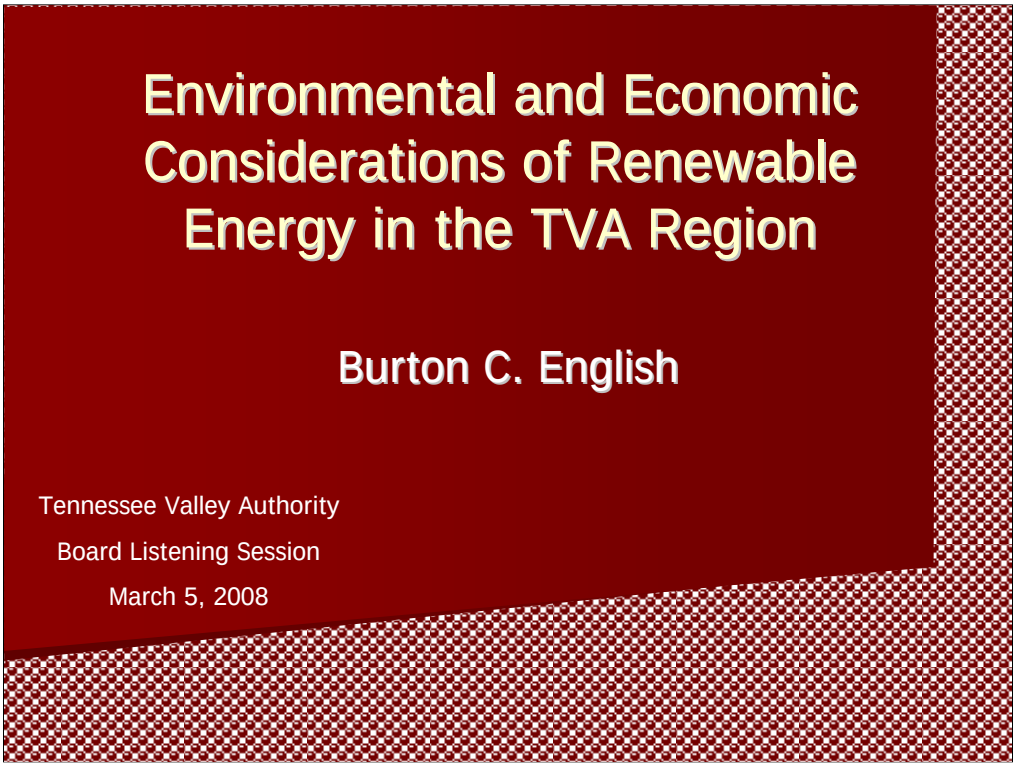

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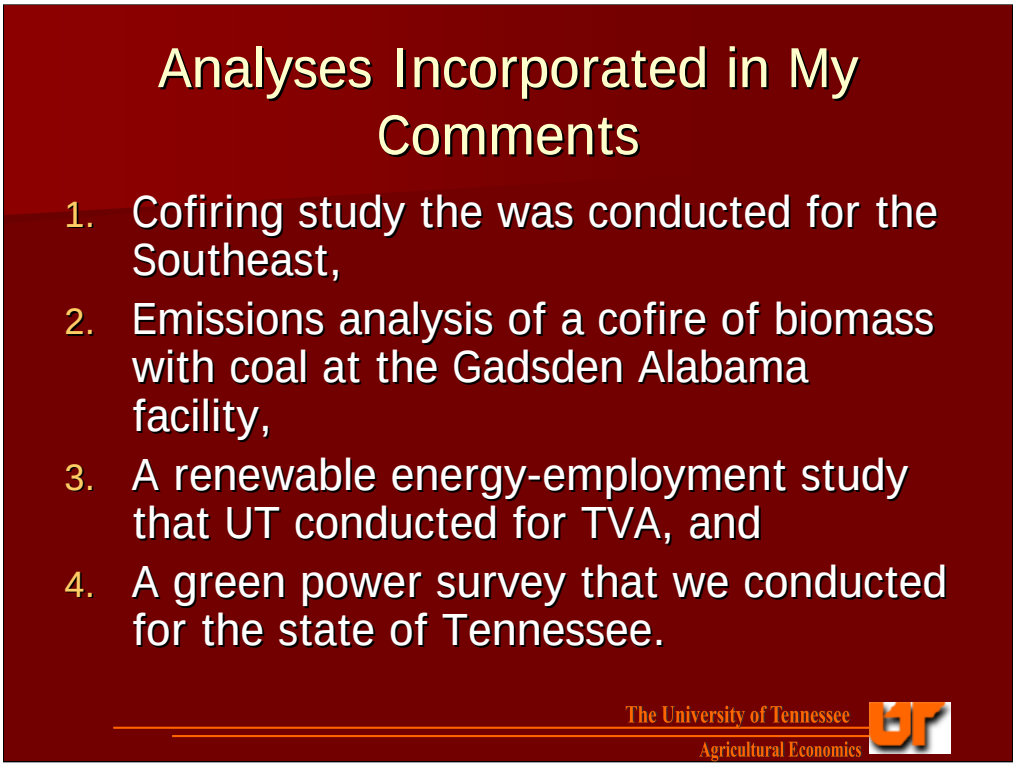


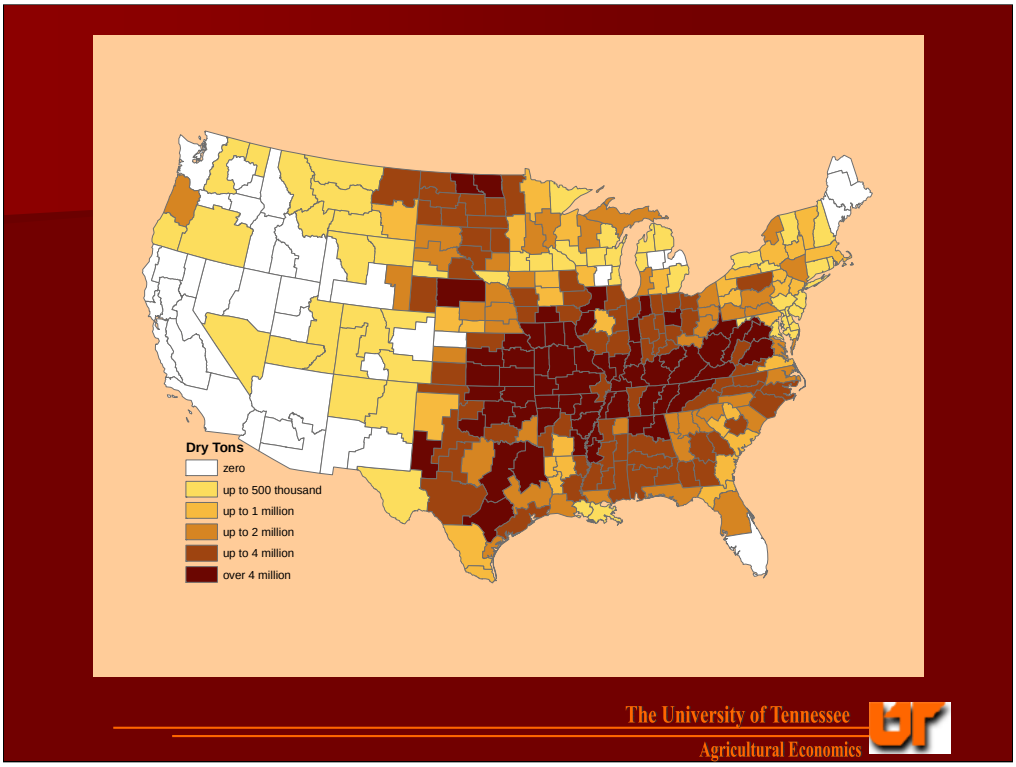
Today, I am here to focus on the impacts on the environment and the economy that renewable energy can achieve.

I am going to discuss several studies that we have conducted at the University of Tennessee regarding renewable energy.

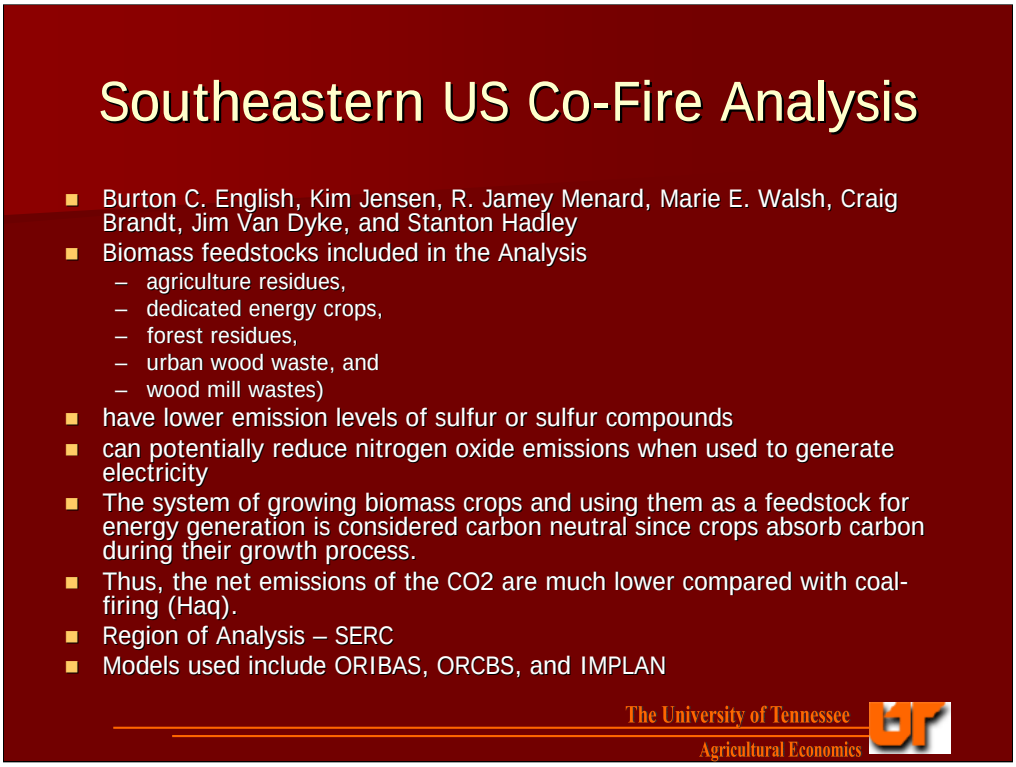
The studies include the following:

1. Cofiring study the was conducted for the Southeast,
2. Emissions analysis of a cofire of biomass with coal at the Gadsden Alabama facility,
3. A renewable energy-employment study that UT conducted for TVA, and
4. A green power survey that we conducted for the state of Tennessee.

The substitution of biomass for coal, whether in a co-fire or direct combustion will reduce green house gases. While there are places where wind works in the Southeast or where solar might be selected, we know that the southeast is blessed with several natural resources water and productive land when it comes to producing biomass.



In a recent analysis that we conducted in the Department of Agricultural Economics for the group 25x'25, we found that the area spanning from the Virginia coast to Oklahoma would be extremely valuable in meeting renewable fuel and electricity needs from biomass resources. In this analysis, 21 quads of energy (1/2 liquid and ½ electricity) came from biomass, wind, and solar. The areas in dark brown supply over 4 million dry tons of biomass per year. Tennessee, as you can see is dark brown.



Burton C. English, Kim Jensen, R. Jamey Menard, Marie E. Walsh, Craig Brandt, Jim Van Dyke, and Stanton Hadley

60 percent of the electricity demand in the SE depends on coal (Department of Energy, 2001b). While coal-fired plants are extremely important sources of electricity in the United States, there are negative environmental impacts associated with this type of electricity generation. Approximately two-thirds of sulfur dioxide (SO2), one-third of carbon dioxide (CO2), and one-fourth of nitrogen oxide (NOx) emissions are produced by burning coal. Particulate matter is also emitted when coal is converted to electricity. The Southeastern Region of the U.S ranks second in emissions of SO2 and NO2 and leads in the nation in CO2 emissions and (Department of Energy, 1999).

Biomass feedstocks (agriculture residues, dedicated energy crops, forest residues, urban wood waste, and wood mill wastes) have lower emission levels of sulfur or sulfur compounds and can potentially reduce nitrogen oxide emissions when used to generate electricity. The system of growing biomass crops and using them as a feedstock for energy generation is considered carbon neutral since crops absorb carbon during their growth process. Thus, the net emissions of the CO2 are much lower compared with coal-firing (Haq).

The power plants studied for this analysis were associated with the Southeastern Electric Reliability Council **(**SERC), the regional organization for the coordination of the operation and planning of the bulk power electric systems in the southeastern United States. This region includes areas in eight states – Alabama, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia.

The analysis uses the Oak Ridge County-Level Biomass Supply Database (ORCBS) and three additional models – Oak Ridge Integrated Bioenergy Analysis System (ORIBAS), Oak Ridge Competitive Electricity Dispatch (ORCED), and Impact Analysis for Planning (IMPLAN). The Oak Ridge Competitive Electricity Dispatch model is a dynamic electricity distribution model that estimates the price utilities can pay for biomass feedstocks. **.** The Oak Ridge Integrated Bioenergy Analysis System is a Geographic Information Systems (GIS)-based transportation model used to estimate the delivered costs of biomass to power plant facilities (Graham et al., Noon et al.). The Oak Ridge Competitive Electricity Dispatch model ORCED simulates the electrical system for a region by matching the supplies and demands for two seasons of a single year. The IMPLAN model uses input-output analysis to derive estimated economic impacts for constructing and operating the power plants, the transporting of the bio-based feedstocks, and the growing/collecting of wastes, residues, and dedicated crops in the eight states.

Base case

- Base Case
- Carbon Tax

Table 2. State Total Potential Biofuel Demands.

State	Plant Capacity	Maximum Quantity of bio-fuel at:	
	Modeled	2% Co-fire	15% Co-fire
	MW	Dry Tons	Dry Tons
Alabama	11,624	677,836.0	5,297,978.0
Georgia	13,155	745,996.9	5,647,020.0
Kentucky	12,700	904,465.1	6,929,630.0
Mississippi	2,228	24,955.4	212,088.9
North Carolina	12,438	775,045.5	5,994,905.0
South Carolina	5,777	346,954.0	2,686,970.0
Tennessee	8,751	598,821.5	4,647,694.0
Virginia	5,099	259,037.5	2,092,228.0
Total	71,772	4,333,111.9	33,508,513.9

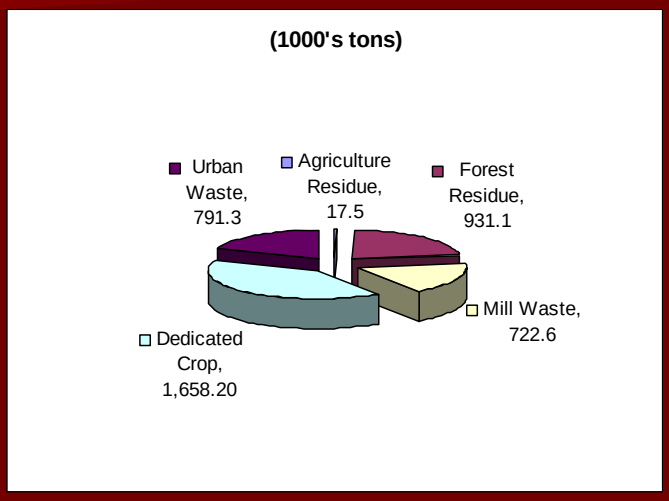
Note: Data on individual plants modeled available upon request.

Co-firing does appear economically competitive under the current market conditions except in certain agricultural situations and under low co-fire levels. Very small amounts of residue (2%) are economically feasible for co-fire in the Base Case. Under the two percent co-fire, some plants do find residue at lower costs than coal plus sulfur emissions costs. However, using a 15% co-fire, the analysis indicates paying the sulfur emissions cost is more economical than burning residue. The analysis does indicate that there are areas now that would benefit from generating electricity using forest residues, mill waste, and urban waste. In fact, nearly 2,500-kilowatt hours of electricity could be produced using these residues replacing 355,000 tons of coal. Each state, with the exception of Kentucky, consumes some residue.

the amount of residues consumed will significantly increase from 4 million metric dry tons to 23 (Low Carbon) and 29 (High Carbon) million metric dry tons. This expansion in residue demand resulted in significant increases in regional economic impacts. There is an estimated $1.4 to $2.2 billion dollar impact that occurs to the Southeast Region under the high co-fire levels with Low Carbon and High Carbon emission cost scenarios, respectively. Concurrent with this increase in economic activity is an estimated increase of 25,000 jobs.

$70 Carbon Tax (15% Co-fire)

- **37,616 GWh produced from co-fire**



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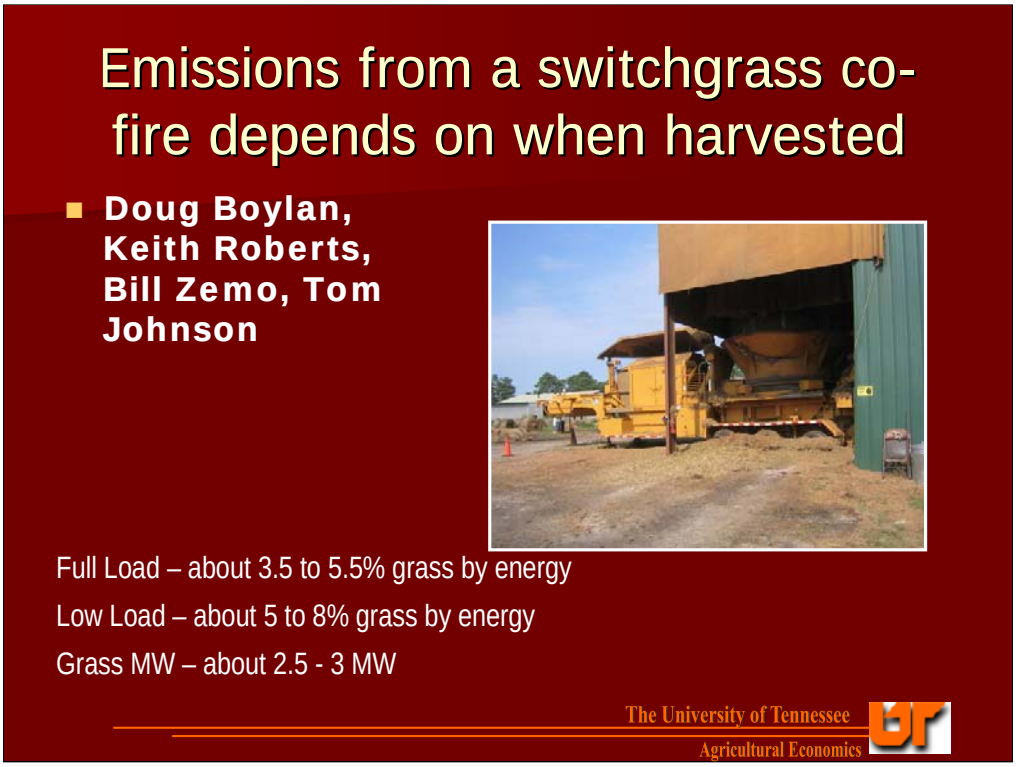
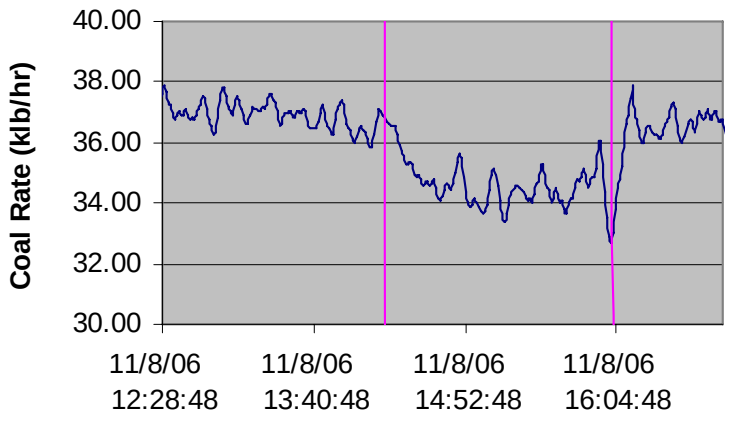
Agricultural Economics

At a $70 carbon tax, the simulation indicates that 23 million metric dry tons would be used in a 15% co-fire situation. Remember, this is developed under the assumption that biomass is competing with coal. An estimated 37 thousand GWh would be produced from this biomass. The cost of the delivered feedstock in 2004 dollars would range from $41 - $49/metric dry ton. However given the changes that have occurred between 2004 and now, this probably will have increased by 25 to 30%. 18.2 million tons of coal was replaced in this simulation with a sulfur content around 1.3 percent or nearly 226,000 tons of sulfur.



A study to determine emissions from switchgrass was conducted at the Gadsden Power Plant. A comparison of harvest before first frost to one after the first frost. This would require a harvest of 60,000 pounds in early October and another harvest of 60,000 pounds after the initial frost. At Milan, on the more productive land, this is 6 to 7 acres at approximately 5 tons/acre. We would mark the bales prior to frost with a red circle and the bales following harvest with blue circle. These bales would be transported to Gadsden for the burn. At Gadsden, a sample would be taken for the proximate and ultimate analysis of the material. Records during the two 8 hour burns would be kept on fuel use of the tractor and grinder in addition to the various emission readings at the plant. In addition, emission readings were taken under different loads

Carbon Emissions



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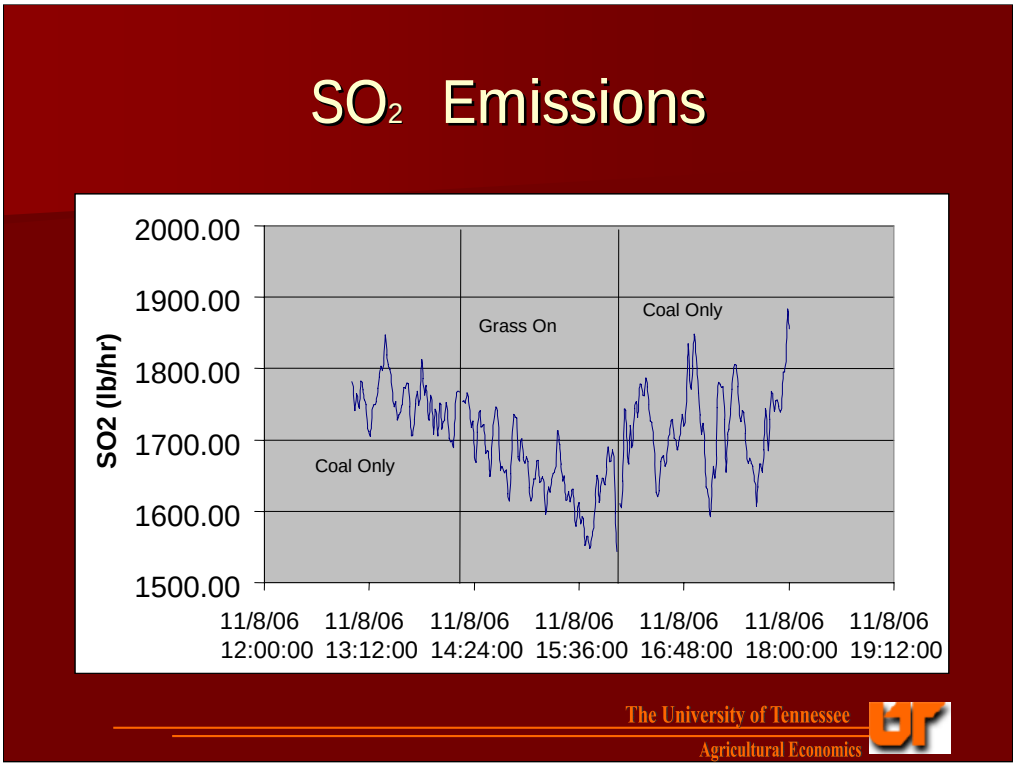


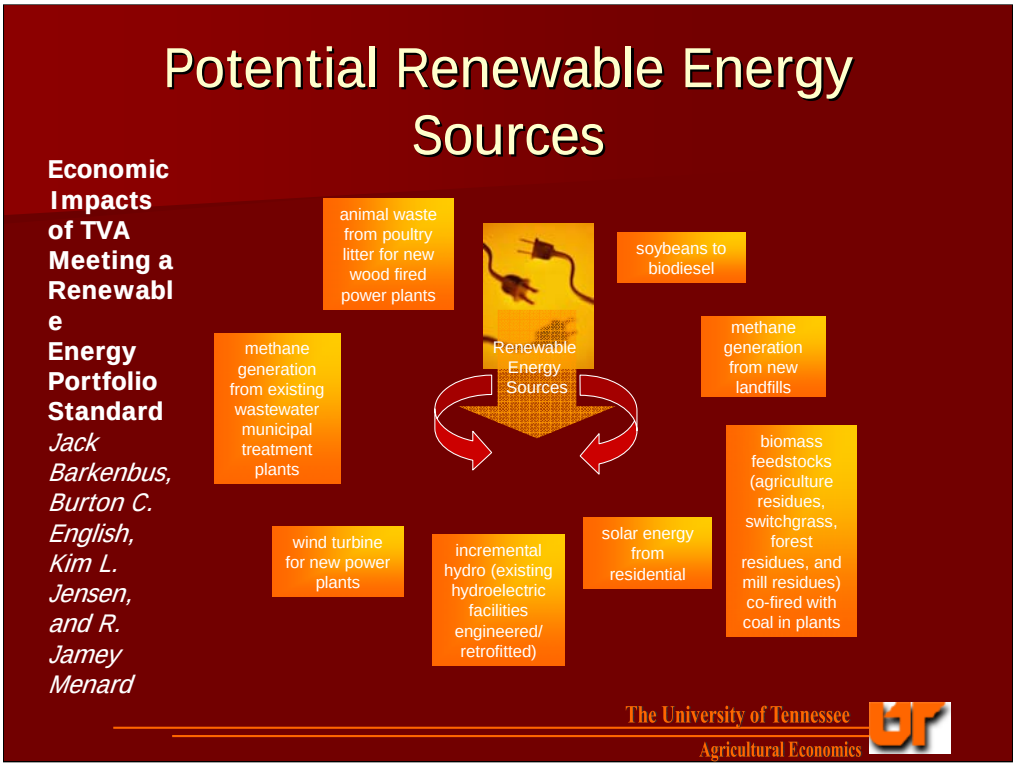
Samples of switchgrass harvested *After Frost* had lower nitrogen content than the *Before Frost* samples

Grass nitrogen content did not appear to affect overall NOx emissions during these co-firing tests

NOx was slightly higher with co-firing than for coal alone. No difference was noted for NOx emissions co-firing *Before* and *After Frost* grasses.

For the same grass, moisture content did not appear to affect NOx emissions (range 18% to 26% moisture)

CO emissions co-firing *Before* and *After Frost* grasses were about the same. CO emissions with co-firing was slightly lower at full load and about the same at low load compared with coal alone.



Barkenbus, Jack, R. Jamey Menard, Burton C. English, Kim L. Jensen. Resource and Employment Impact of a Renewable Portfolio Standard in the Tennessee Valley Authority Region. Report to Tennessee Valley Authority. July 2006.

The primary objective of this analysis is to project the potential economic impacts on the Tennessee Valley Authority (TVA) region from adoption of a renewable portfolio standard. In order to meet the renewable energy goal, a variety of renewable sources will be required, as well as use of renewable energy credits. To project the employment impacts of providing energy from renewable energy sources, IMPLAN was augmented with the renewable electricity generation sectors. They include the following:

- animal waste from poultry litter was used to provide feedstock for new wood fired power plants;
- soybeans were used to provide feedstock for new biodiesel facilities;
- biomass feedstocks (agriculture residues, switchgrass, forest residues, and mill residues) to be co-fired with coal in existing power plants;
- incremental hydro (existing hydroelectric facilities engineered/retrofitted for increased efficiency or additions of new capacity);
- methane generation from new landfills;
- solar energy from residential photovoltaic systems;
- wind turbine for new power plants; and
- methane generation from existing wastewater municipal treatment plants.

Using these renewable resources, we estimated that 15 million mega watt hours might come from renewable energy resources.

Investment in and operation of renewable energy production facilities will also be needed. This investment and operating activity is projected to result in 15,482 jobs directly, with 2,229 of these jobs being continuing jobs from operating activity. In

My final slides are centered around the dedicated energy crop that I have been researching and it's environmental benefits and feasibility. Switchgrass is a native perennial plant that thrives in Tennessee. It will produce at current levels of technology 6 to 8 tons per acre on our more marginal cropped soils. It does well in drought and on periodically flooded lands. Being a perennial, it does not require much tillage and therefore erosion and sediment is minimal. Farmers are willing to grow switchgrass as we found out in a 2005 study. The results from this study suggest that many farmers, at the time of the survey, were still not familiar with switchgrass. Even so, almost 30 percent would be willing to grow switchgrass if it were profitable. Farmers felt positively about the importance of increasing biomass use in energy production to help control emissions. However, they were concerned that they would need technical assistance and that markets were not yet sufficiently developed. They did not generally believe that planting and harvesting switchgrass would conflict with current planting and harvesting schedules. Only 25% stated that they would not grow it. The remainder indicated that they would need further information.

In a study titled **AN ANALYSIS OF THE RESIDENTIAL PREFERENCES FOR GREEN POWER-THE ROLE OF BIOENERGY by**

Kim Jensen, Jamey Menard, Burt English, and Paul Jakus, a sample of Tennessee's consumers of electricity were surveyed and while the respondents indicated a lower preference for electricity of forest wastes when compared to solar and wind, they still were will ing to pay a premium for biomass based electricity ($0.03 to $0.04 compared to $0.05- $0.06/kWh. Concerns expressed included bioenergy from crops, environmental impacts of agriculture and displacement of acreage for food, and for

bioenergy from forest products wastes, deforestation and concerns air emissions from burning were cited.

Questions

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