Is Biomass Resource the Answer to Ohio's Cleaner and Sustainable Energy Future?

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ABSTRACT

The growing concerns of global warming have initiated increasing use of renewable resources including biomass energy all over the world. Clean and sustainable use of energy resources will be pivotal to mitigate the negative environmental impacts of traditional means of electricity generation such as fossils fuels. These issues are even more relevant in Ohio, as its power industry is heavily based on coal, making Ohio one of the top air polluters in the U.S.

This paper develops a dynamic linear programming model (OH-MARKAL) to analyze key policy issues for Ohio's energy future. Specifically, the model focuses on biomass cofiring as an option to diversify the fuel resource base for Ohio's power industry. The research findings suggest that CO_2 emission will increase by 18 percent by 2029 as compared to 2002 level, if current fuel mix remains unchanged for electricity generation. The model indicates that the proposed use of biomass energy resources will provide up to 7 percent of renewable electricity, thus achieving a 15 percent reduction in the 2002 levels of CO_2 emissions in Ohio. Further, to achieve higher environmental goals, Ohio should also include other renewable resources such as wind, hydro, geothermal, or solar power in its power generation mix.

INTRODUCTION

- Increased use of fossil fuels contributes to significant global warming, according to reports from Inter-Governmental Panel on Climate Change, Natural Resources Defense Council, Pew Center on Global Climate Change, Resources for the Future, Union of Concerned Scientists, and others
- In response to the growing concerns of energy use and climate change, biomass energy as a clean and renewable resource has become a viable alternative for generating electricity
- Two major energy and environmental issues in Ohio:
  - Currently, 90 percent of Ohio's electricity is based on coal and its CO_2, NO_x, and SO_2 emissions rank among the top in the country. Hence, the need to diversify resource base
  - Minimal current use of renewable energy resources – need to increase use of biomass and other renewables to mitigate GHG emissions from power industry

Coal Power Plants


WH Sammis: 2 * 680 MW (1971)


Gavin: 2 * 1.3k MW (1974-75), 25K tpd coal use


Muskingum: 2 * 238 MW (1968)

Electricity Net Generation by Energy Source (percent)

Region	Coal	Nuclear	N. Gas	Oil	Hydro	Other Ren.
Ohio	90.4	7.4	1.3	0.3	0.3	0.3
USA	50.0	20.0	17.0	3.0	7.0	3.0
World	39.1	16.6	19.1	7.2	16.2	1.8

(Source: EIA, DOE 2002 and IEA Renewable Info, 2004)

Ohio's Electricity Generation and Emissions

Description	Value	U.S. Rank
Net Generation (megawatt hours)	139,904,106	3
Emissions (thousand short tons)		
SO_2	1,172	1
NO_x	385	1
CO_2	135,181	2

(Source: State Electricity Profiles, EIA, 2002)

Renewable Electric Power Sector Net Generation by Energy Source and State, 2003
(Thousand KWh)

State	Hydro-electric Conven.	MSW / Landfill Gas	Other Biomass	Wind	Wood / Wood Waste	Total
Michigan	1,310,430	658,861	124,751	2,660	1,018,495	**3,115,197**
Minnesota	721,287	755,142	0	977,760	100,615	**2,554,804**
Wisconsin	1,653,066	387,306	71,629	97,580	61,088	**2,270,669**
Iowa	788,593	97,548	1,149	981,970	0	**1,869,260**
Illinois	138,497	595,850	272,343	18,024	0	**1,024,714**
Ohio	510,835	27,184	0	0	50,561	**588,580**
Indiana	423,953	85,278	0	0	0	**509,231**
Total	**5,546,661**	**2,607,169**	**469,872**	**2,077,994**	**1,230,759**	**11,932,455**

(Source: Energy Information Administration, Form EIA-906,"Power Plant Report")

NOTE: Ohio ranks 42nd at the national level on renewable electricity generation.

PROJECT RATIONALE

- More than 50% of US states are addressing several ways to mitigate effects of global warming by reducing greenhouse gas emissions
- Ohio needs to be also proactive to reduce GHG emissions before any federal mandates; otherwise the consequences may be too expensive for the state

RESEARCH APPROACH

- Focuses on the use of biomass energy resources, as a viable alternative to electricity generation in Ohio. Biomass resources: environmentally clean and carbon neutral with net-zero carbon dioxide (CO_2) emissions
- Addresses two major issues:
  - Importance of diversifying fuel mix for power industry, rather than relying on coal
  - Need to increase the use of renewable and clean energy in Ohio.

RESEARCH OBJECTIVES

- Evaluate current resource mix in Ohio for power generation and compare level of CO_2 emissions from electricity generation under coal vs. biomass scenarios
- Develop alternative biomass cofiring scenarios in selected coal power plants in Ohio
- Analyze various economic and environmental issues of biomass cofiring to generate electricity
- Examine if biomass cofiring can become an effective option for the sustainable and cleaner electricity generation in Ohio
- Recommend effective strategies and sound renewable policies for the successful development and utilization of biomass energy resources in Ohio

RESEARCH METHODOLOGY

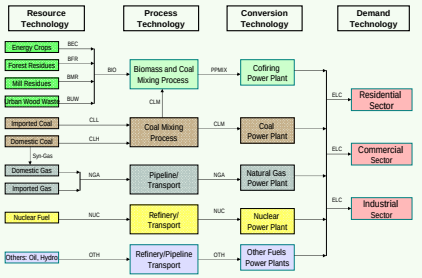
- Develop a dynamic linear programming model **(OH-MARKAL),** based on the MARKAL (MARKet ALlocation) modeling framework
- MARKAL model: specifically developed for energy and environment assessment at the county/state/national or international levels
- A technology-rich model of the energy infrastructure specified with linear equations that includes emissions, costs, efficiency and performance information
- Computes an inter-temporal partial equilibrium on energy markets and provides least-cost optimized assessments of various policy and control options

MODEL STRUCTURE AND DATA SPECIFICATION

The OH-MARKAL Reference Energy System

- **Biomass Feedstock and Cofiring Power Plants**
  - Feedstock Types and Their Prices
  - Potential Cofiring Power Plants
- **Coal and Other Primary Fuel Sources**
  - Fuel prices
  - Emission Levels
- **Electric Power Plants in Ohio**
  - Existing Power Plants: fixed, variable, and other related costs
  - Proposed/Approved New Power Plants in Ohio
  - Potential Future Options in the Power Sector
    - Emission control devices
    - Clean coal technology
- **Electricity Demand and its Future Projections**

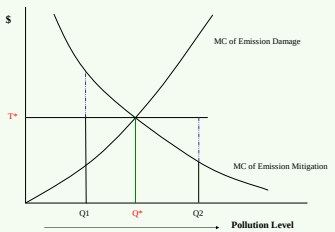
OH-MARKAL Reference Energy System



OH-MARKAL MODEL SCENARIOS

- **Base Case Scenario**
- **Level of Biomass Cofiring**
  - Biomass Cofiring at 10 % Level
  - Biomass Cofiring at 15% Level
- **Renewable Energy Standard for Ohio**
  - Achieve 5 % Level by 2030
  - Achieve 7 % Level by 2030
- **Caps on Carbon Dioxide Emission**
  - Achieve 10 % below 2002 Level by 2030
  - Achieve 15 % below 2002 Level by 2030
- **Tax on Carbon Dioxide Emission**
  - CO2Tax of $ 25 per ton
  - CO2Tax of $ 50 per ton

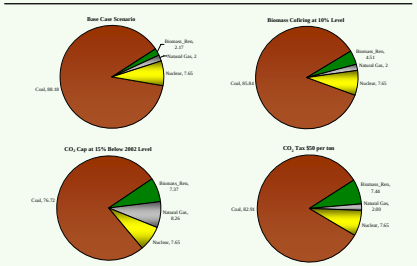
Optimal Carbon Dioxide Emission Tax



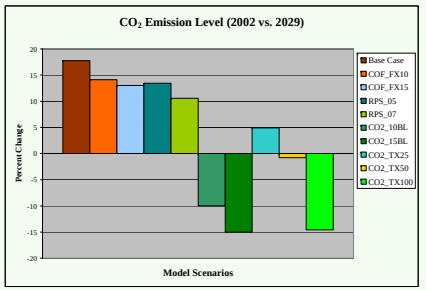
RESULTS AND DISCUSSION

- Model calibration: validate all data and model specifications so that the results simulate "business-as-usual" (base-case) scenario and match the historic data of year 2002
- Results from the **base-case scenario** (without any policy changes):
  - CO_2 emissions increases by 18 percent during the model period from 151.854 to 178.823 million tons in 2002 and 2029 respectively
  - Cofiring coal power plants do not use biomass feedstock up until model year 2020, because it is more expensive than coal
  - New biomass power plants starts generating electricity to meet the growing electricity demand that is not met by coal power plants from 2020
  - Renewable electricity increases from 0.4% in 2002 to only 2.17 % in 2029
  - Marginal price of electricity generation increases from 2.5 to 4.02 ¢/KWh from 2002 to 2029: an increase of 60.8% owing to the increase in demand
- The model suggests that policy interventions are needed to make biomass co-firing competitive with coal
- Various levels of biomass feedstock use in cofiring power plants occur under the RPS, CO_2 cap and carbon tax scenarios (below graphs) in order to meet the constraint imposed by the model
- Only 7.44 % of renewable electricity can be generated with the current level of biomass feedstock, cofiring coal plants and new proposed biomass plants in the model
- Similarly, only a 15% reduction below 2002 levels of CO_2 is achievable by 2029 with biomass as an alternate source of renewable electricity
- Model suggests that CO_2 tax of $100 per ton results in CO_2 emissions 15% below 2002 level by the end of model period
- Several states are already working towards the goals of higher RPS and lower CO_2 caps: Ohio needs to include other renewable such as wind and solar in addition to biomass and also invest on clean coal technologies and power plants with CO_2 sequestration

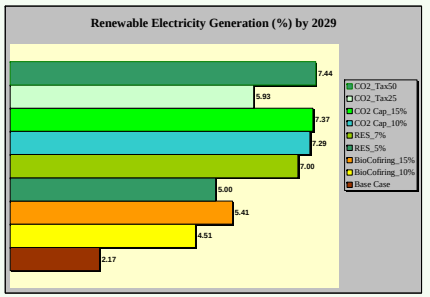
Electricity Generation by Fuel Type in 2029



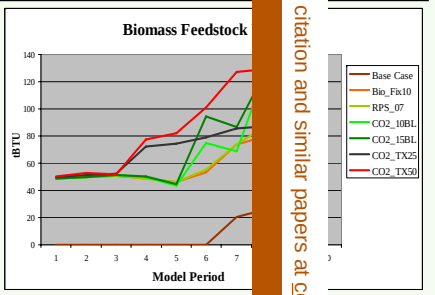
Change in CO2 Emission Level (%) from 2002 to 2029



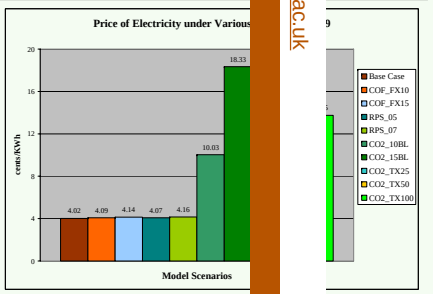
Renewable Electricity Generation by 2029 (%)



Level of Biomass Feedst

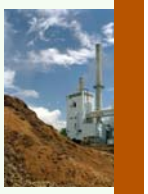


Price of Electricity (cents/KWh) in Year 2029



Existing and Potential Renewa Plants


Wind: Bowling Green, OH (7.2 MW)


Biomass Power Plant (52


Hydro: Greenup, OH (2*23 MW)


Solar (1.4 MW)


ermal Power Plant(30 MW)

SUMMARY AND CON

- CO_2 emissions by power sector in Ohio will increase 2002 (with coal generating about 90 percent of electr
- Proposed biomass cofiring and new biomass plants c electricity generation in Ohio
- Biomass feedstock supply at regional level is sufficie and proposed new biomass plants
- 7 percent of renewable electricity from biomass redu
- Maximum CO_2 Cap feasible using biomass resources
- CO_2 tax at $100 per ton will mitigate CO_2 close to 15
- If future policy in Ohio requires more than 7.44% of reduction to 2002 levels, other renewable energy sou hydro and use of more clean coal technology, power considered
- Future research projects should include other renewal biomass to examine the higher standards of clean ene

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Key Refere

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