# Economic Impacts of Green Jobs Development in the Appalachian Region

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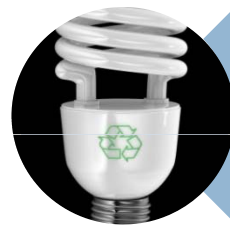
BEAG | Bio-Based Energy Analysis Group

# Green Jobs in Renewable Energy



- The purpose of this study is to project potential economic impacts of adding renewable energy industries to and the effect on “green jobs” in the Appalachian Region (AR).
- Green jobs are defined as “… family-supporting jobs that contribute significantly to preserving or enhancing environmental quality” (Tennessee Department of Labor Workforce and Development, 2008).
- The United Nations Environment Program definition states, “this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution” (UNEP, 2008).

Renewable Energy and Fuels Production



Energy Efficiency Improvement

Alternative Transportation

# The AR and Economic Status



- 205,000-square-mile region, spine of the Appalachian Mountains from southern NY to northern MS. WV and parts of 12 other states: AL, GA, KY, MD, MS, NY, NC, OH, PA, SC, TN, and VA (Appalachian Region Commission, 2010).
- Many counties economically distressed or at risk categories.
- ARC categorizes counties based on 3 yr average unemployment rates, per capita market income, and poverty rates-distressed, at-risk, transitional, competitive, or attainment.
- Distressed counties those ranking worst 10 percent of the nation.

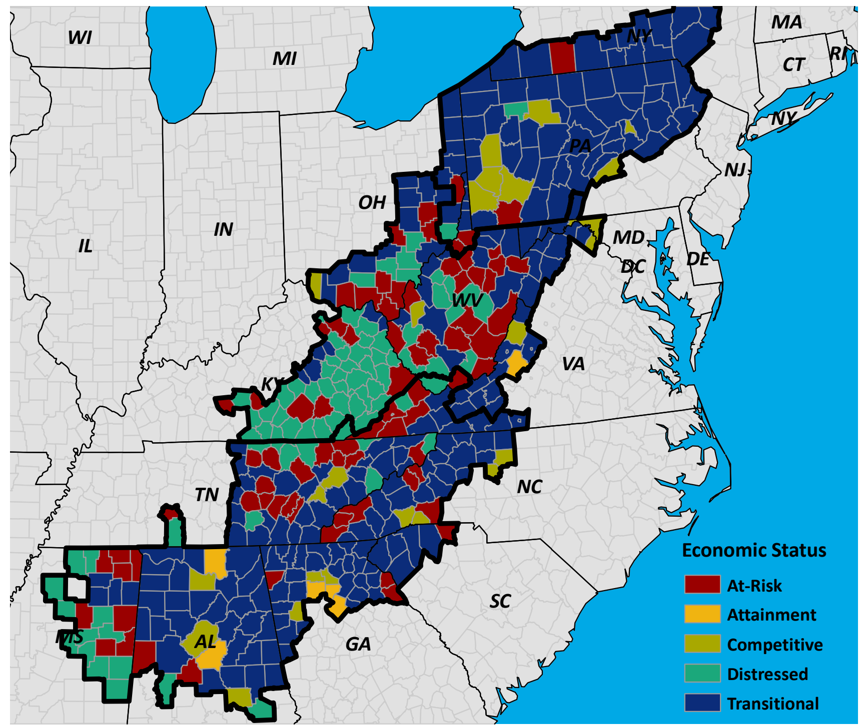



Figure 1. Economic Status of Counties in the AR

Data source: Appalachian Regional Commission

- Where are renewable energy jobs currently located?
- Where is there additional potential for renewable energy?
- How might additional renewable energy impact jobs?

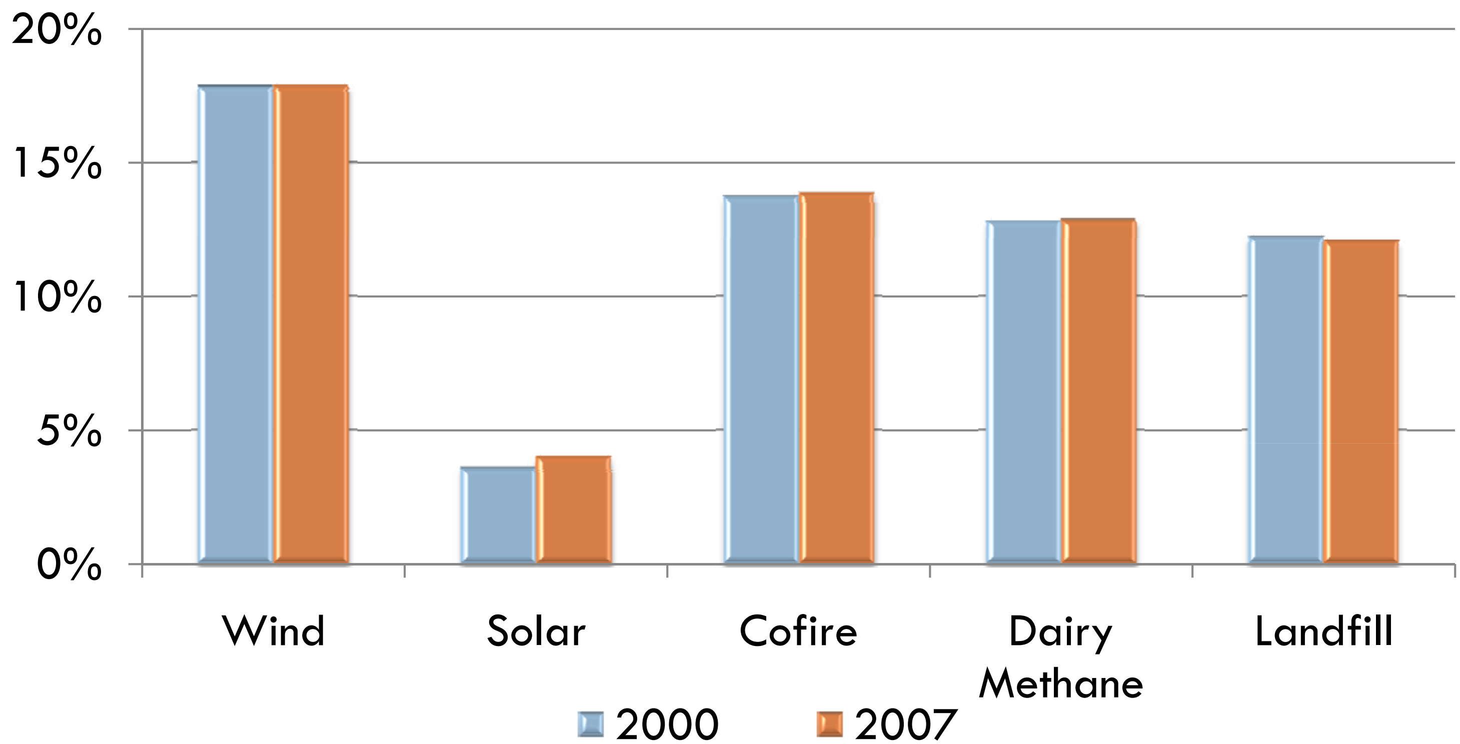
# Energy Sources and Example Sectors in "Green Industry"



| Energy Sources | Sector comprising "Green Industry" |
|---|---|
| Solar | Examples: Semiconductors; Architectural & Engineering Services; Computer System Design |
| Wind | Examples: Turbine & Turbine Manufacturing; Motor & Generator Manufacturing; Computer Systems Design |
| Biofuels-Ethanol, Biodiesel | Examples: Logging or Farming, Transportation; Machine Operators; Process Engineers; Lab technician; Chemical Equipment Operators and Tenders; and Chemist; Metal Tank, Heavy Gauge, Manufacturing; Architectural & Engineering Services; Manufacturing & Industrial Bldgs. (Buildings, Civil/Mechanical/Electrical; Land/Prep/Trans Access); Conveyor & Conveying Equipment Manufacturing (Feedstock & Product Storage and Handling) |
| Landfill Gas | Examples: Iron, Steel Pipe & Tubing; Metal Tank, Heavy Gauge, Manufacturing; Oil & Gas Field Machinery & Equipment; Air Purification Equipment Manufacturing; Electric Power & Specialty Transformer Manufacturing |
| Dairy Methane | Examples: Textile Bag & Canvas Mills; Metal Tank, Heavy Gauge, Manufacturing; Pump & Pumping Equipment Manufacturing |
| Wood / Dedicated Energy Crop Co-Fire | Examples: Logging or Farming; Commercial Machinery Repair & Maintenance; Other New Construction; Prefabricated Metal Buildings and Components; Conveyor & Conveying Equipment Manufacturing; Industrial Process Furnace & Oven Manufacturing; Industrial Process Variable Instruments |

# Figure 2. Share of "Green Sector" Business Establishments in ARC Region (denominator – all business establishments in ARC Region, 2000 and 2007)

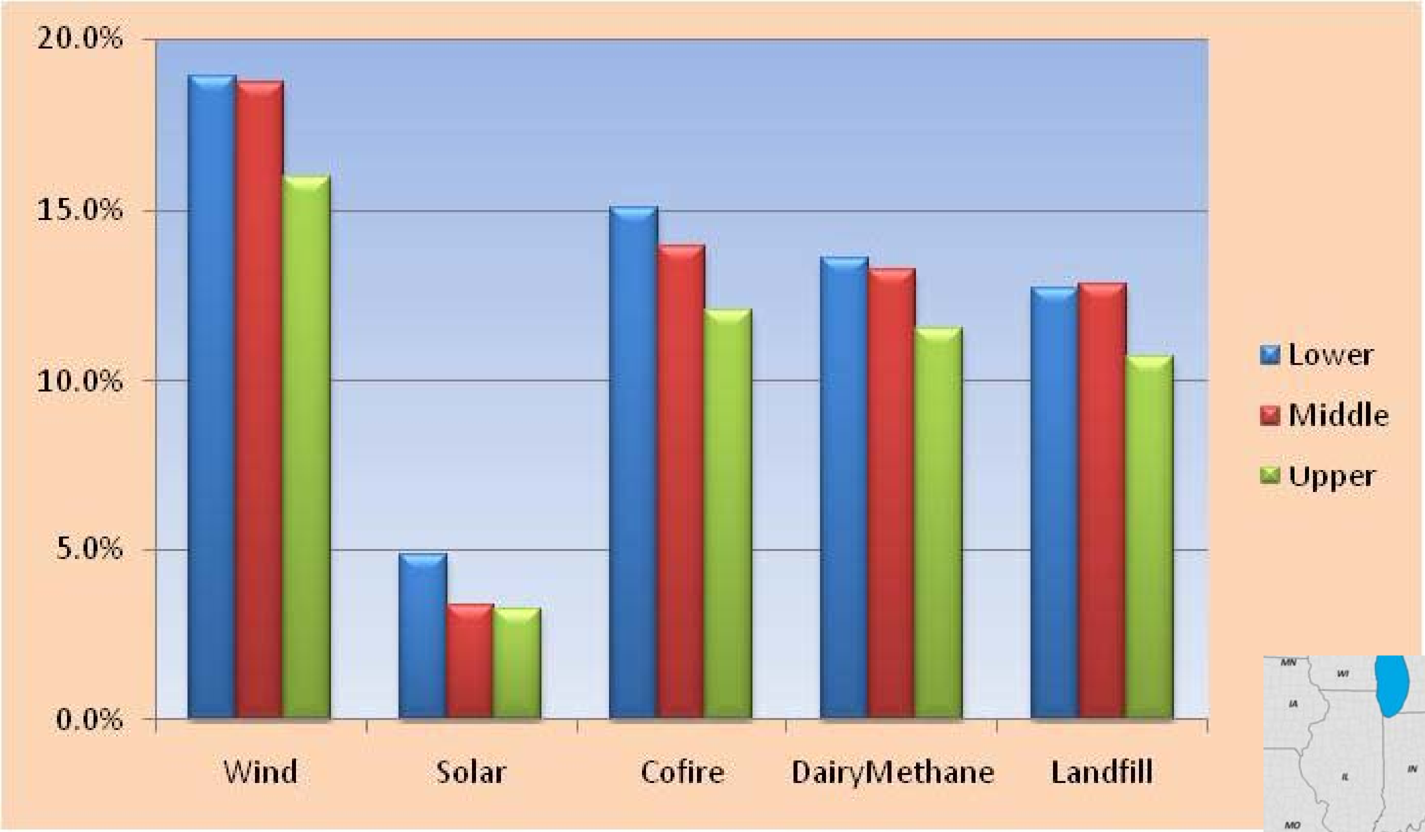





2000 total establishments = 536,515
2007 total establishments = 564,724
Data Source: County Business Patterns

## Figure 3. Regional Distribution of Business establishments Belonging to Wind, Solar, Wood co-fire, Dairy methane, and Landfill Gas Sectors, 2007






# Electricity



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- Variety of technologies used, some are utilities others are industrial generators.
- About 26% of these facilities are coal. AR states comprise nearly 44% of US coal consumption.

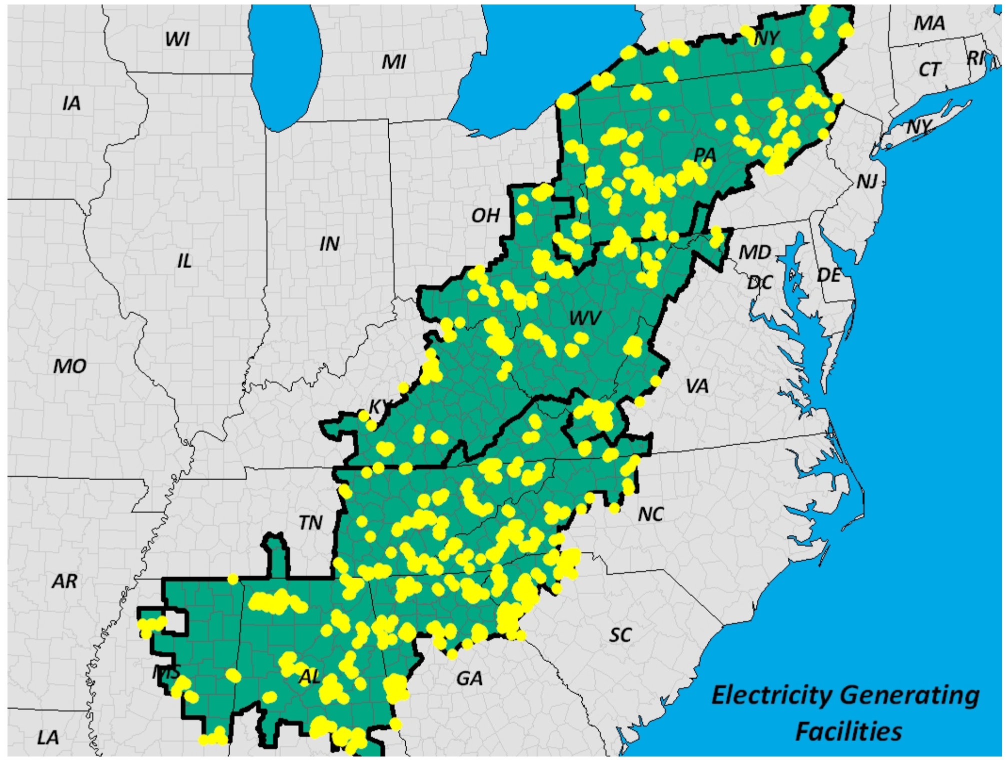


Figure 4. Electricity Generators in the AR Study Region

Data source: Energy Information Administration, Database of Electricity Generators

# Wind Energy



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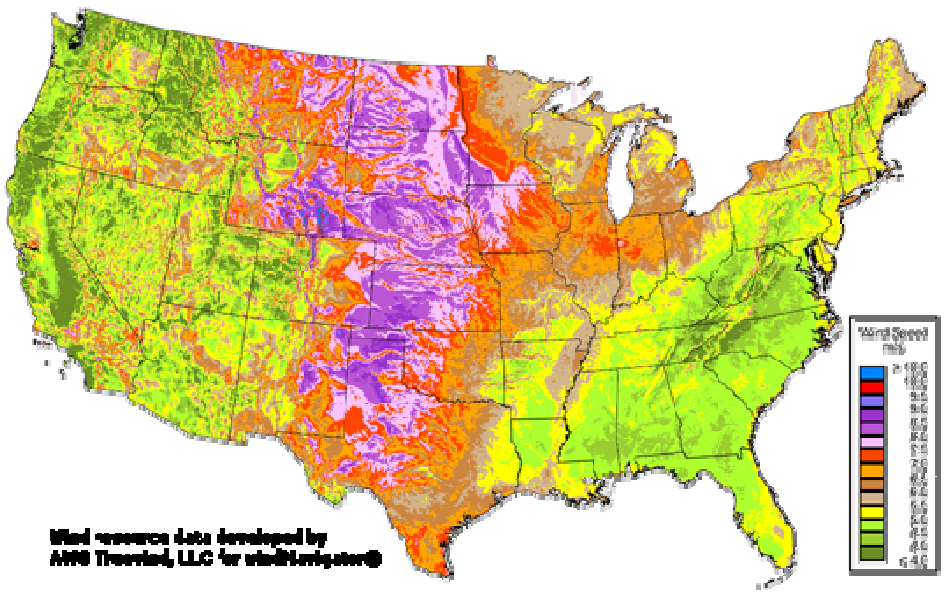

Figure 5. Wind Resources Maps-80 meter height

The U.S. map shows the predicted mean annual wind speeds at 80-m height (at a spatial resolution of 2.5 km that is interpolated to a finer scale). Areas with annual average wind speeds around **6.5 m/s and greater at 80-m** height are generally considered to have suitable wind resource for wind development.

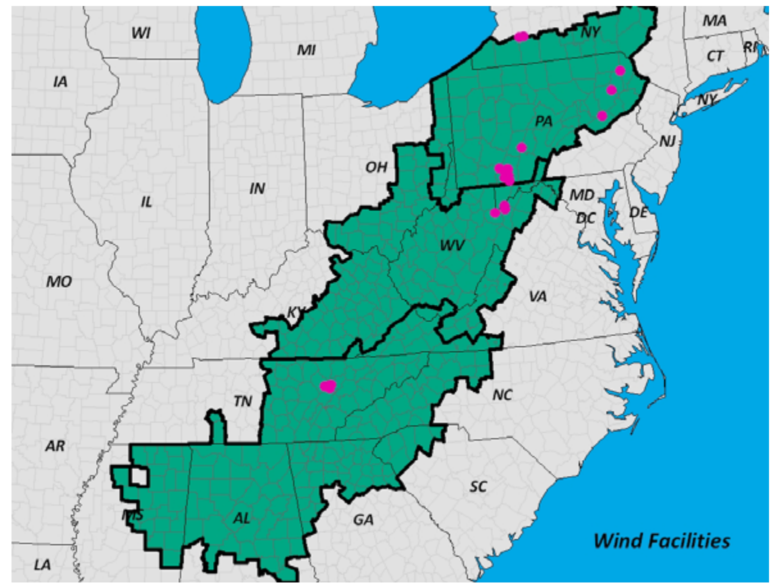


Figure 6. Wind Electricity Generators in the AR Study Region

Data source: Energy Information Administration, Database of Electricity Generators

Current nameplate in AR of about 827 MW

# Wind Energy with Employment Location Quotient



- Counties where the concentration of sectors in supporting operations of the Wind Energy sector is high (in red) and low (in blue)
- Provides idea of "regional comparative advantage" for industry and possibly industry potential

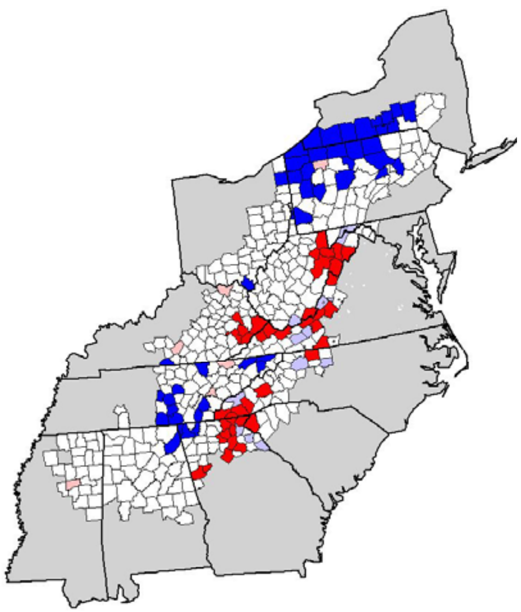

Figure 7. Concentration of Wind Energy Sector in the AR Study Region

- Counties where the concentration of employment in industries supporting the Wind Energy sector is high (in red) and low (in blue)

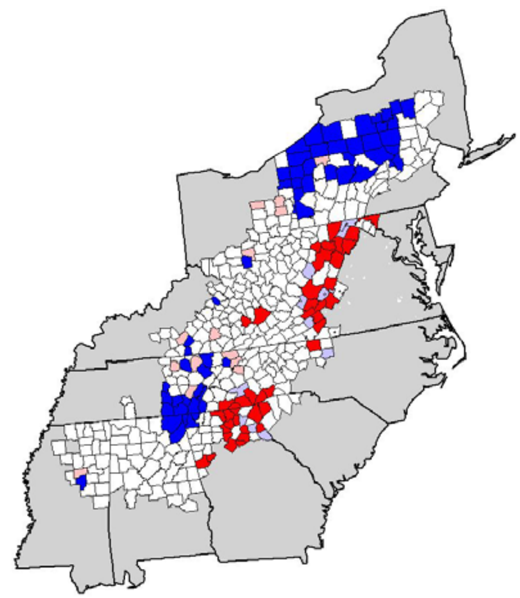

Figure 8. Concentration of Wind Energy Sector Employment in the AR Study Region

# Landfill Gas



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- Red=Operational landfills generating LFG electricity , Nameplate capacity=128.5
- Yellow=candidate landfills with at least 2 million tons of waste in place (in yellow)
- Based on existing MW capacity/tons of waste and the tons of waste in candidate landfills, additional potential=94.2MW

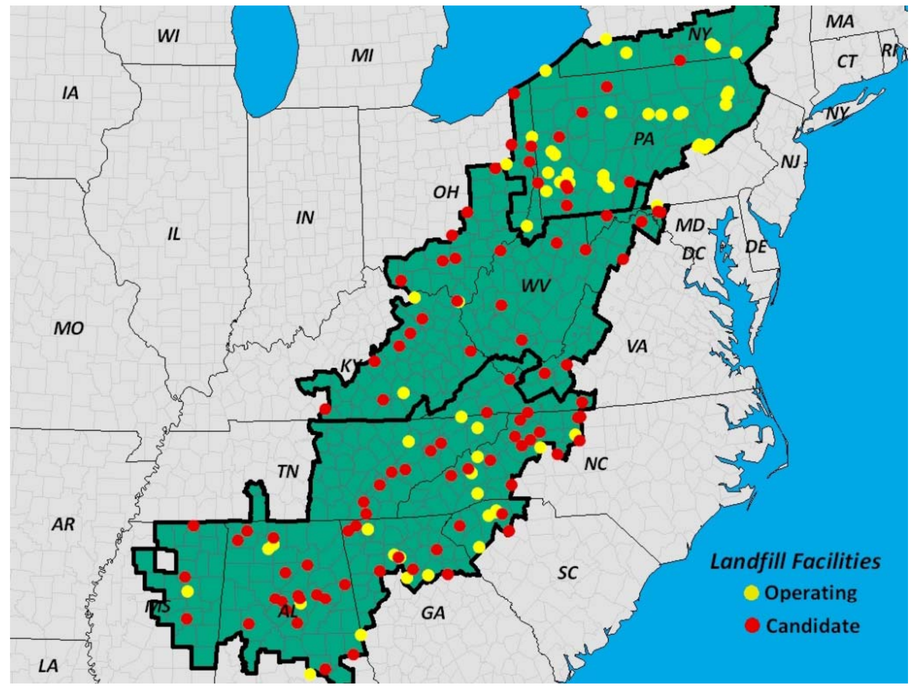


Figure 9. Landfill Gas Electricity Generators and Candidate Landfills in the AR Study Region

Data source: EPA Landfill Methane Gas Outreach Program

# Landfill Gas Energy with Employment LQ



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- Counties where the concentration of sectors in the LFG sector is high (in red) and low (in blue)
- Provides idea of "regional comparative advantage" for industry and possibly industry potential
- Counties where the concentration of employment in the Landfill energy sector is high (in red) and low (in blue)

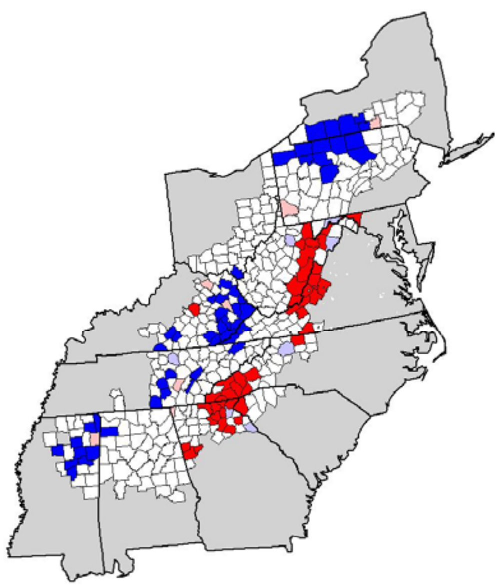


Figure 10. Concentration of Landfill Gas Energy Sector in the AR Study Region

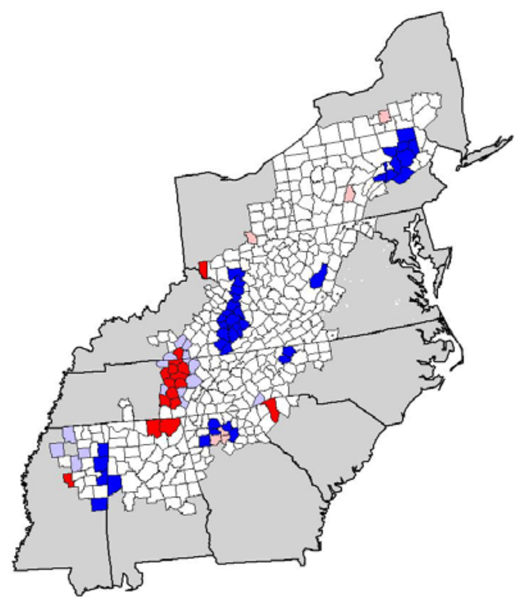


Figure 11. Concentration of Landfill Gas Energy Sector Employment in the AR Study Region

# Facilities Using Wood and Potential Co-Firing Facilities



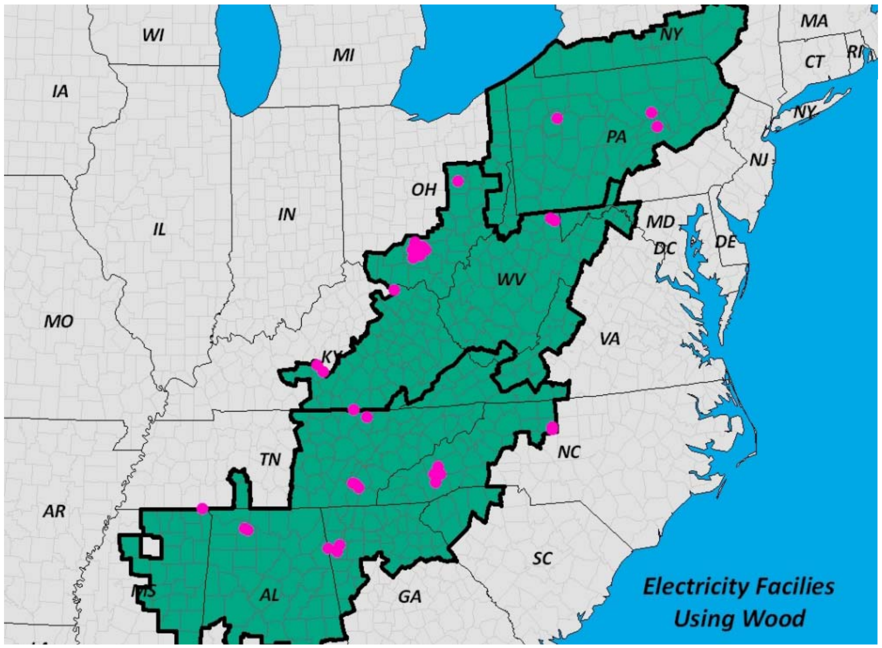
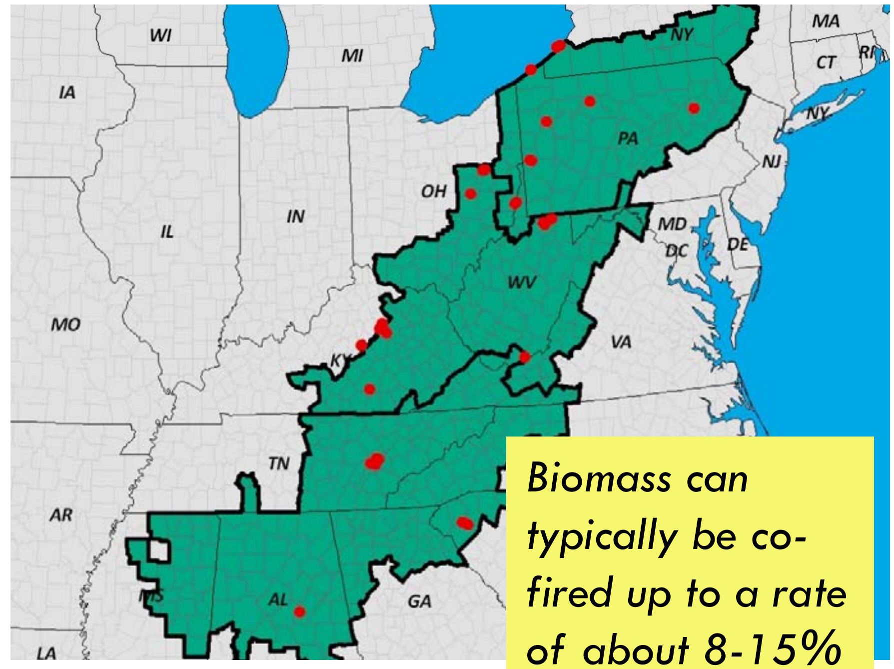



Figure 12. Electricity Generators Using Wood in the AR Study Region

*About 1,125.2 MW of capacity.*



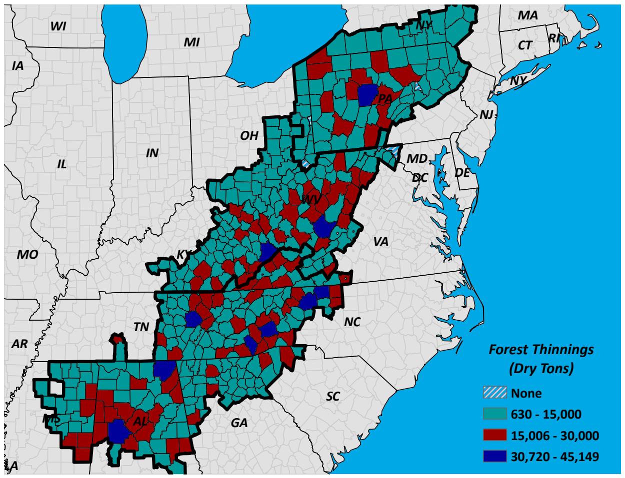

*Biomass can typically be co-fired up to a rate of about 8-15%*

Figure 13. Electricity Generators Using Coal, Not Currently Using Wood or other Biomass, <200MW Capacity

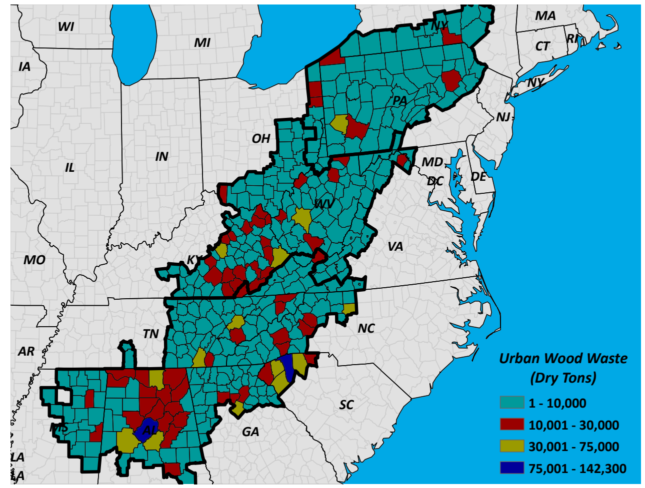
*Constitute about 2,988.7 MW of potential capacity. At a co-fire rate of 15%, this would be about 448.3 MW of co-fire.*

# Figure 14. Potential Biomass Availability (Tons) at $70/ton, Wood and Switchgrass

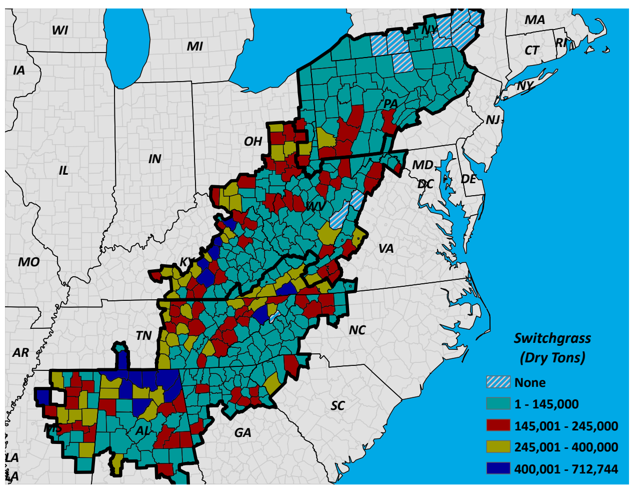





Thinnings
4.7 million




Urban Wood Waste
3.2 million




Switchgrass
57.0 million

*The co-fire facilities discussed in Figure 12. would require about 1.67 additional million dry tons of biomass*

# Direct Wood Energy with Employment Location Quotient



- Counties where the concentration of sectors involved in operating the Co-firing sector is high (in red) and low (in blue)
- Provides idea of "regional comparative advantage" for industry and possibly industry potential

- Counties where the concentration of employment in sectors involved in the Wood co-fire energy sector is high (in red) and low (in blue)

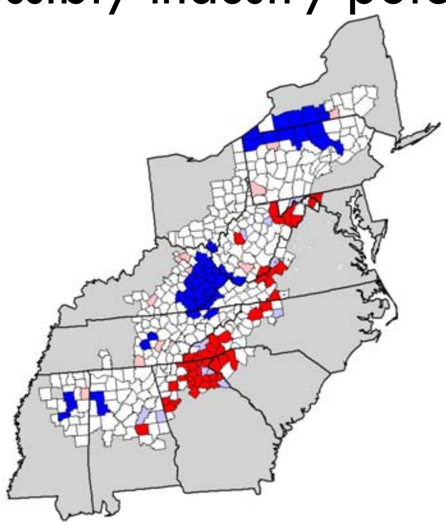


Figure 15. Concentration of Co-Firing Energy Sector in the AR Study Region

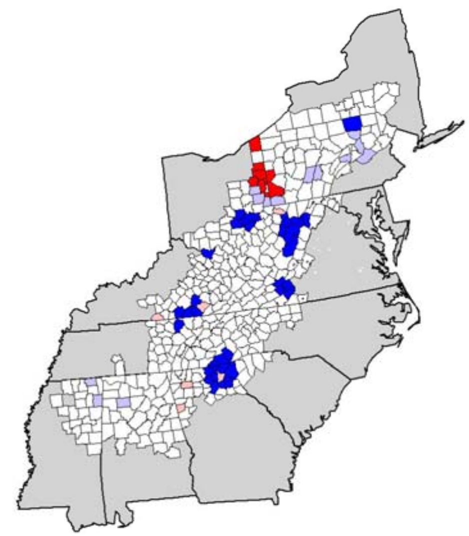


Figure 16. Concentration of Co-Firing Energy Sector Employment in the AR Study Region

# Dairy Cows and Animal Methane Facilities



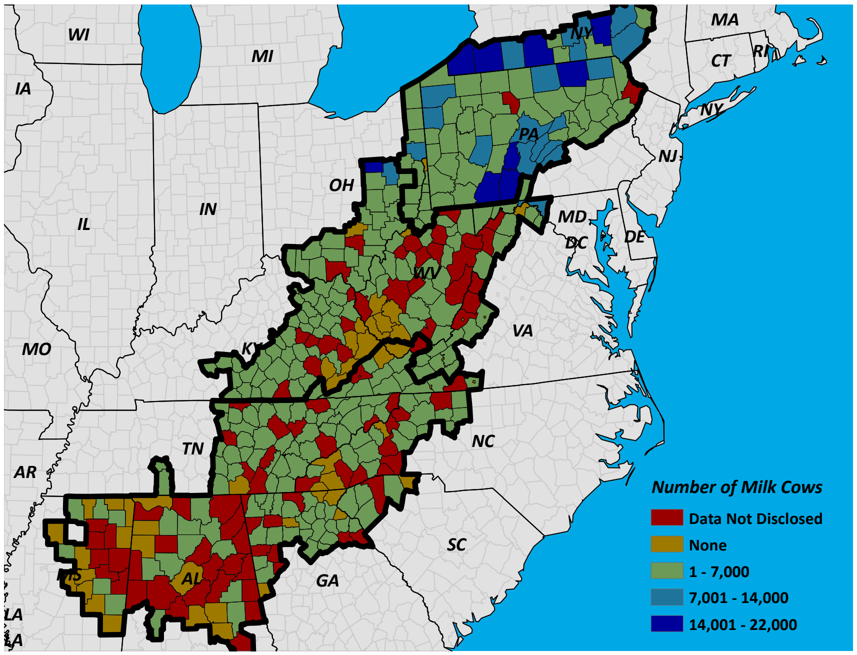



Figure 17. Number of Milk Cows, by County, in the AR Study Region

Source: USDA/NASS

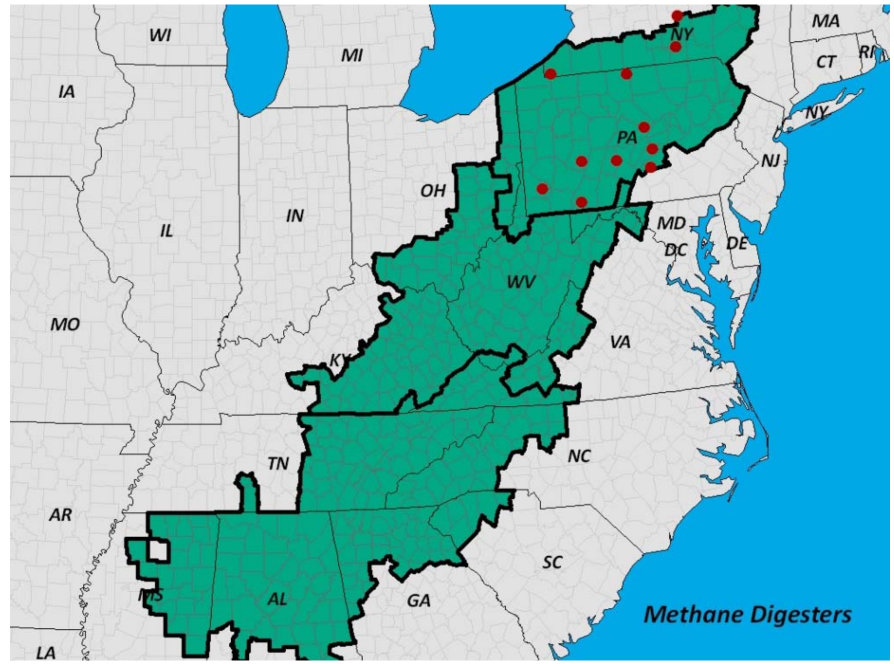



Figure 18. Animal Methane Facilities in the AR Study Region

Source: EPA AgStar Program

Current dairy methane digester capacity is about 1.3 MW. Generally, methane facilities are feasible at about 1,000 cow dairies or larger, about .2kW per cow. If dairy cow numbers if counties with at 5,000 cows per county are totaled, the sum is 454,495 dairy cows, or enough to support about 80.4 MW of digester capacity.

# Dairy Methane Gas



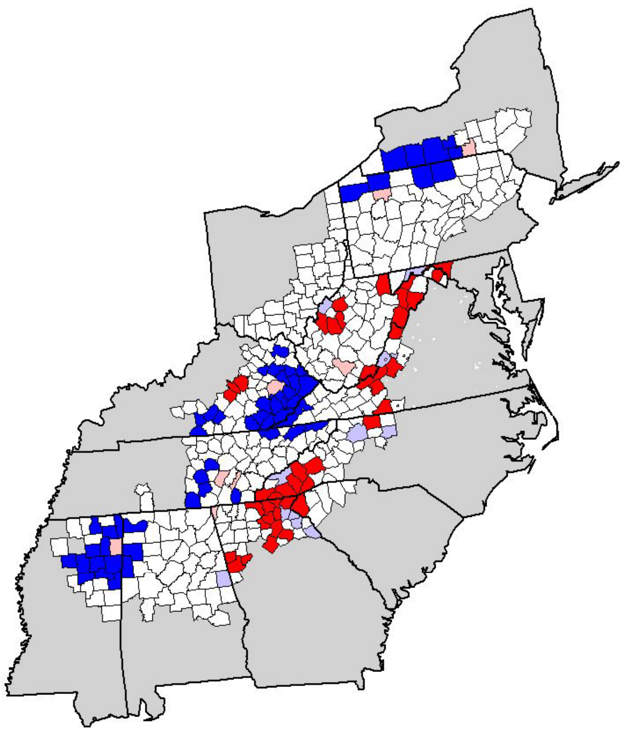


Figure 19. Concentration of Dairy Methane Gas Energy Sector in the AR Study Region

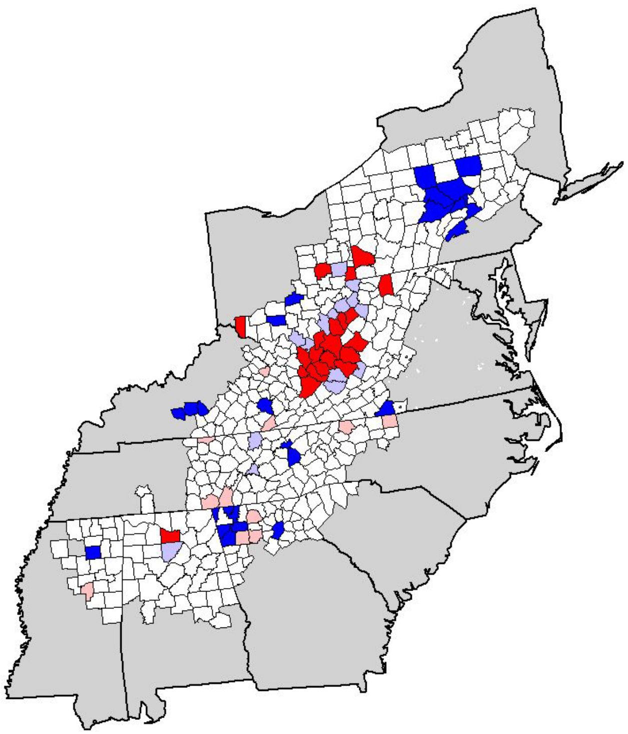


Figure 20. Concentration of Dairy Methane Gas Energy Sector Employment in the AR Study Region

# Biodiesel Feedstocks



- Not highly soybean production intensive.
- Many facilities in the ARC region are multifeedstock.
- Yellow grease-used frying oils from deep fryers, or rendering plants.
- 1.5 billion lbs yellow grease (estimated 185.6 million gallons) in 2007.
- Theoretical yield of yellow grease per cap. 9 pounds/yr and biodiesel yield is .13 gallons/pound yellow grease.
- ARC Region population is 25 million, so the yellow grease biodiesel potential is about 29 mill. gal./year

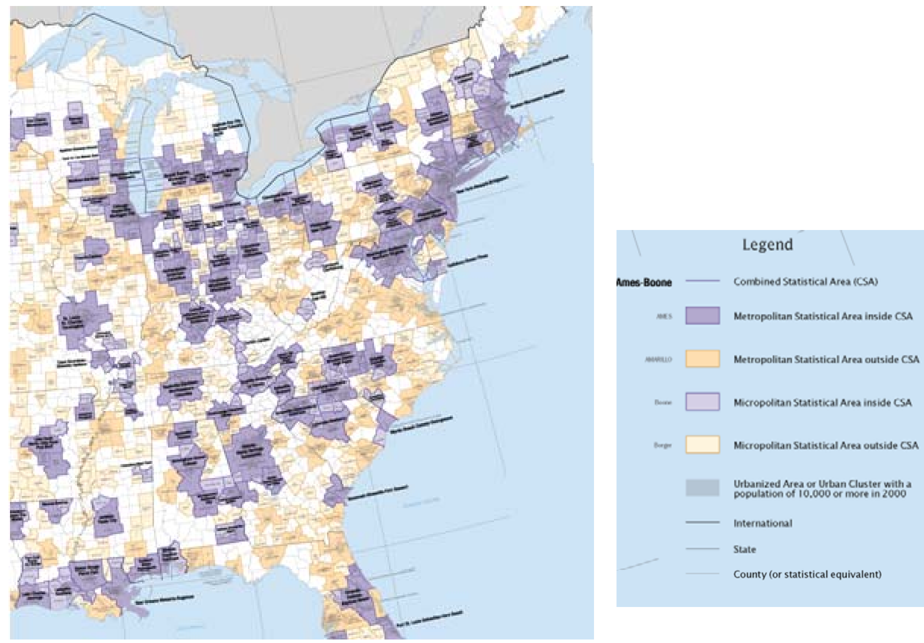



Figure 21. Population MSA's

# Ethanol Feedstocks



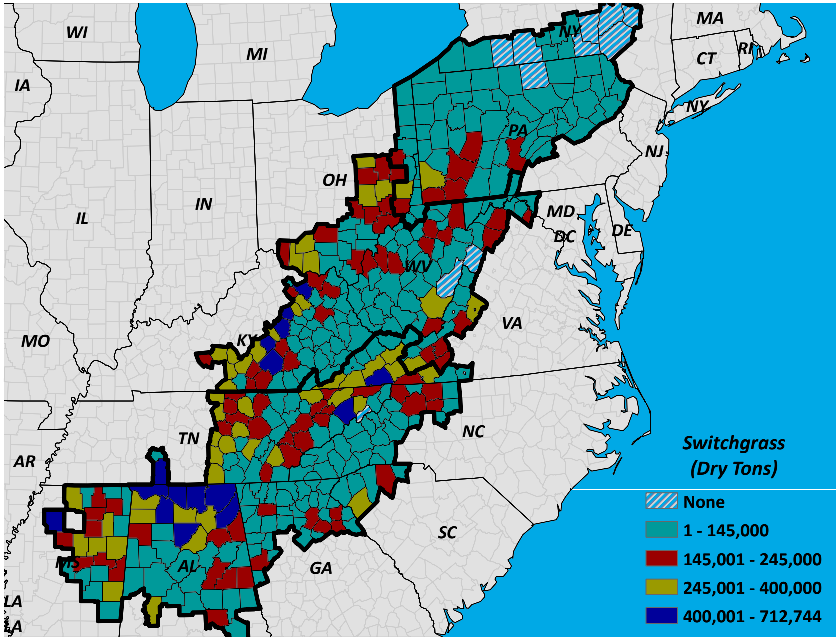



Figure 22. Potential Biomass Availability of Switchgrass at $70/ton

- Ethanol is often made from corn, however, corn is not heavily planted in the AR.
- Feedstock could potentially be transported into the region.
- Commercialization of cellulosic ethanol could open up new capabilities to use feedstocks such as switchgrass or wood wastes.
- Total availability is about 57 million tons, with 990,000 tons required for a commercially sized facility.

# Biodiesel and Ethanol Facilities



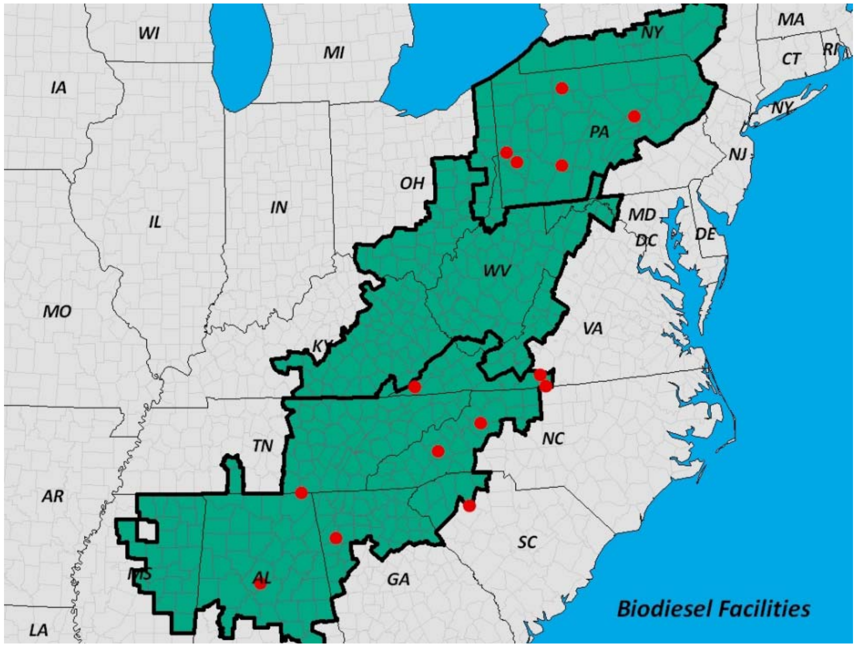



Figure 23. Biodiesel Conversion Facilities in the AR Study Region

Data source: National Biodiesel Board

Current capacity is 108.5 MGPY

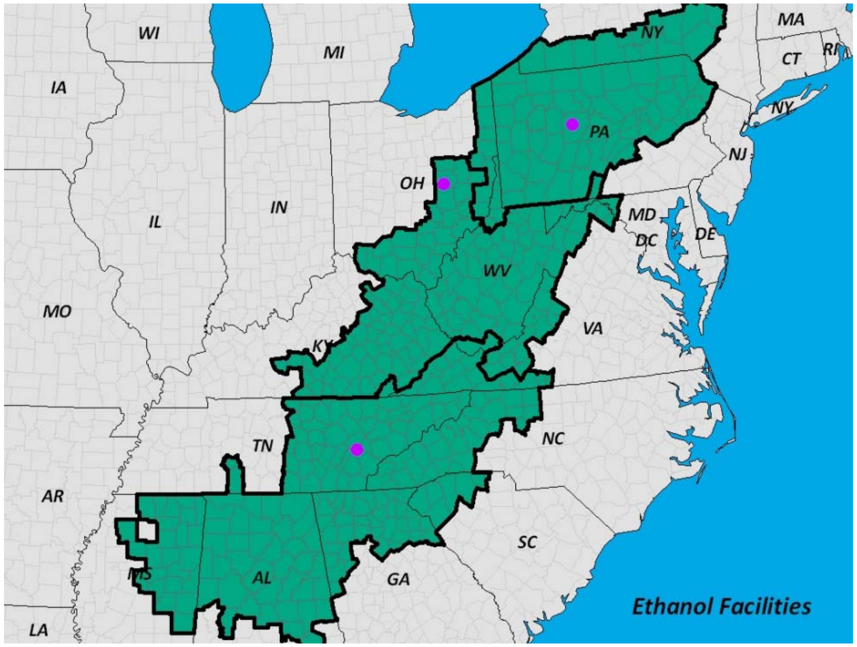



Figure 24. Ethanol Conversion Facilities in the AR Study Region

Data source: Renewable Fuels Association

Current capacity is 237 MGPY

# Projecting Additional Jobs



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- IMPLAN (Impact Analysis for Planning) employs a regional social accounting system to provide descriptive measures of the economy including total industry output and employment for over 500 industries in the economy.
- Renewable energy industries are not already included in the IMPLAN model
- Built in renewable energy industries based upon cost and output information from other studies such as from Department of Energy, Electric Power Research Institute, or other universities.
- Direct measures are those from the activity of the industry itself. Total measures include both direct and the multiplier or economic “ripple” effects from the additional activity in the industry.

# Estimated Current Operating Renewable Energy Impacts (2010)



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| Type | Capacity | Capacity Units | Direct TIO | Total TIO | Direct Jobs | Total Jobs |
|---|---|---|---|---|---|---|
| | | | Million $ | | Jobs | |
| Wind | 897.4 | MW | $300.4 | $629.0 | 393 | 2,923 |
| Solar | 0.0 | MW | n/a | n/a | n/a | n/a |
| Wood | 1,134.5 | MW | $813.8 | $1,645.6 | 509 | 6,502 |
| Landfill Gas | 146.2 | MW | $111.6 | $239.8 | 954 | 2,016 |
| Dairy Methane | 1.3 | MW | $0.8 | $1.5 | 11 | 18 |
| Ethanol | 237 | MGPY | $570.7 | $928.0 | 178 | 4,020 |
| Biodiesel | 108.5 | MGPY | $329.6 | $524.1 | 109 | 1,426 |

# Scenario 1: Projected Operating Renewable Energy Impacts for 2020 (2010$)



| Type | Capacity | Capacity Units | Direct TIO | Total TIO | Direct Jobs | Total Jobs |
|---|---|---|---|---|---|---|
| | | | Million $ | | Jobs | |
| Wind | 1,153.1 | MW | $385.9 | $807.9 | 504 | 3,755 |
| Solar | 100.0 | MW | $37.7 | $50.0 | 10 | 107 |
| Wood | 1,970.8 | MW | $1,413.7 | $2,858.6 | 884 | 11,294 |
| Landfill Gas | 176.5 | MW | $134.7 | $289.3 | 1,151 | 2,433 |
| Dairy Methane | 1.3 | MW | $0.8 | $1.5 | 11 | 18 |
| Ethanol | 277.5 | MGPY | $600.0 | $867.0 | 308 | 2,021 |
| Biodiesel | 215.3 | MGPY | $654.0 | $1,040.0 | 215 | 2,829 |

* Assumes EIA growth rates for all electricity and biofuels, solar is assumed to incorporate solar PV to meet RPS for NY and PA (geographically wtd), dairy methane assumed to grow at USDA baseline projections of dairy cattle.

# Scenario 2: Projected Operating Renewable Energy Impacts for 2020 with "Candidate Facilities"* (2010$)



BEAG

| Type | Capacity | Capacity Units | Direct TIO | Total TIO | Direct Jobs | Total Jobs |
|---|---|---|---|---|---|---|
| | | | Million $ | | Jobs | |
| Wind | 1,153.1 | MW | $385.9 | $808.0 | 504 | 3,755 |
| Solar | 100.00 | MW | $37.8 | $50.0 | 10 | 107 |
| Wood Co-Fire | 1,970.8 | MW | $1,413.7 | $2,858.6 | 884 | 11,294 |
| Switchgrass Co-Fire | 448.3 | MW | $321.6 | $486.4 | 201 | 1,701 |
| LFG | 270.7 | MW | $206.6 | $443.7 | 1,765 | 3,731 |
| Dairy Methane | 81.8 | MW | $47.2 | $93.6 | 682 | 1,091 |
| Cellulosic Ethanol | 3,872.9 | MGPY | $8,372.2 | $12,098.0 | 4,303 | 28,206 |
| Biodiesel | 250.0 | MGPY | $759.5 | $1,207.6 | 250 | 3,285 |

* EIA growth rates for wind, geographic wtd RPS requirements for solar in NY and PA, coal facilities< 200 MW not already using biomass, candidate landfills > 2 million tons of waste in place, biodiesel using all potential yellow grease, ethanol using all potential switchgrass not used in co-fire, dairy methane in counties with at least 5,000 cows.

# Scenario 2: Projected Investment in Renewable Energy Facilities Impacts for 2020 with "Candidate Facilities"* (2010$)

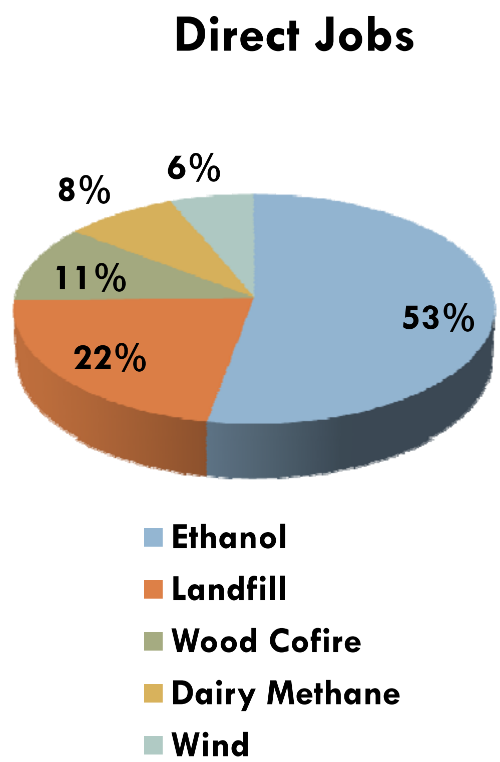


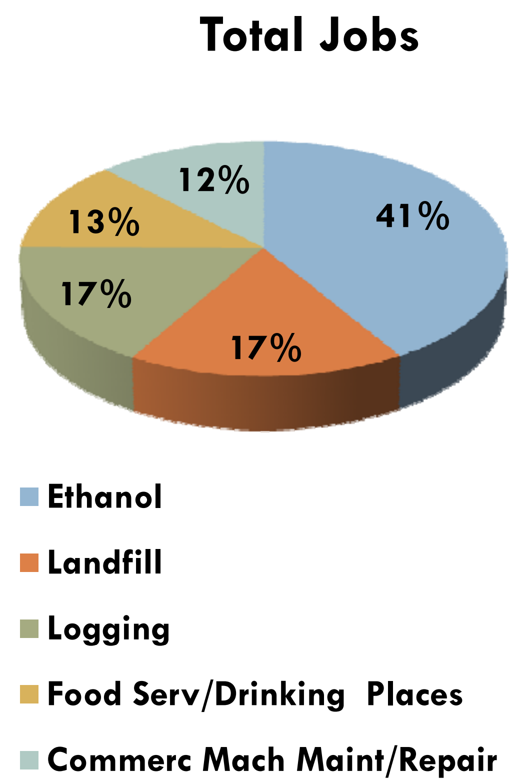
| Type | Added Capacity | Capacity Units | Direct TIO | Total TIO | Direct Jobs | Total Jobs |
|---|---|---|---|---|---|---|
| | | | Million $ | | Jobs | |
| Wind | 255.7 | MW | $680.8 | $1,312.2 | 3,530 | 8,692 |
| Solar | 100.0 | MW | $547.5 | $1,234.5 | 2,814 | 8,467 |
| Wood Co-Fire | 836.3 | MW | $263.3 | $545.0 | 2,125 | 4,532 |
| Switchgrass Co-Fire | 448.3 | MW | $141.1 | $292.10 | 1,138 | 2,428 |
| LFG | 124.5 | MW | $227.2 | $414.7 | 1,069 | 2,533 |
| Dairy Methane | 80.4 | MW | $326.3 | $634.6 | 1,876 | 4,355 |
| Cellulosic Ethanol | 3,635.9 | MGPY | $7,842.7 | $14,383.0 | 32,639 | 82,613 |
| Biodiesel | 141.5 | MGPY | $148.3 | $275.9 | 691 | 1,723 |

* EIA growth rates for wind, geographic wtd RPS requirements for solar in NY and PA, coal facilities< 200 MW not already using biomass, candidate landfills > 2 million tons of waste in place, biodiesel using all potential yellow grease, ethanol using all potential switchgrass not used in co-fire.

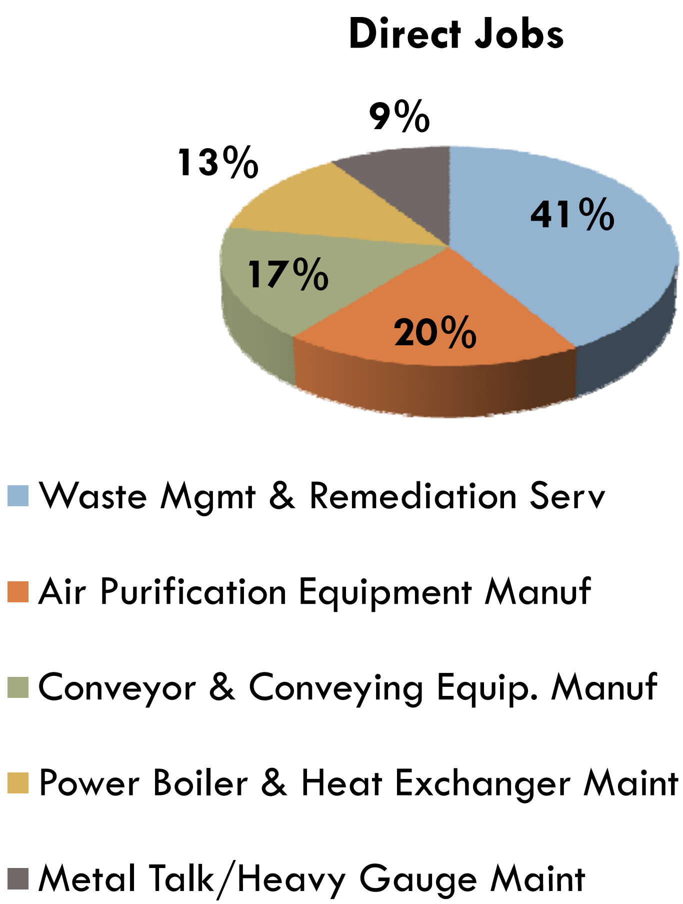
# Figure 25. Scenario 2: Shares of Operating Jobs Among Top 5 Industries Across All Renewables, 2020

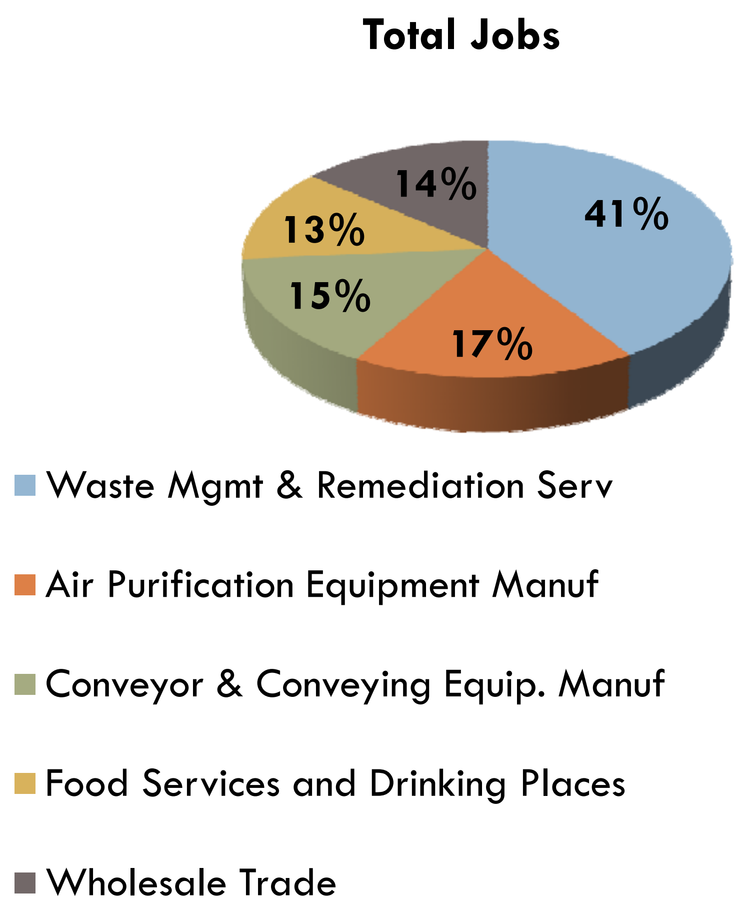




# Figure 26. Scenario 2: Shares of Investment Jobs Among Top 5 Industries Across All Renewables, 2020



# Sub-Regional Comparisons



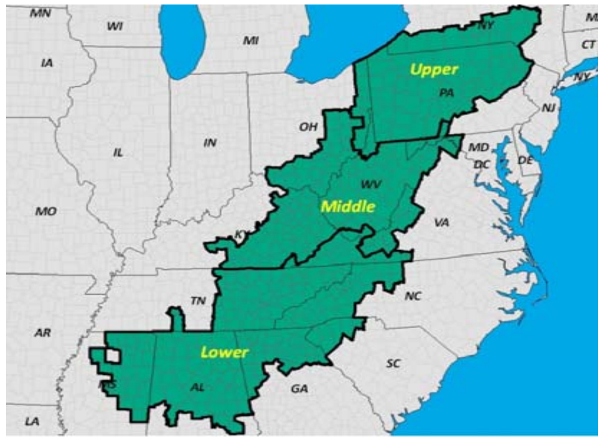
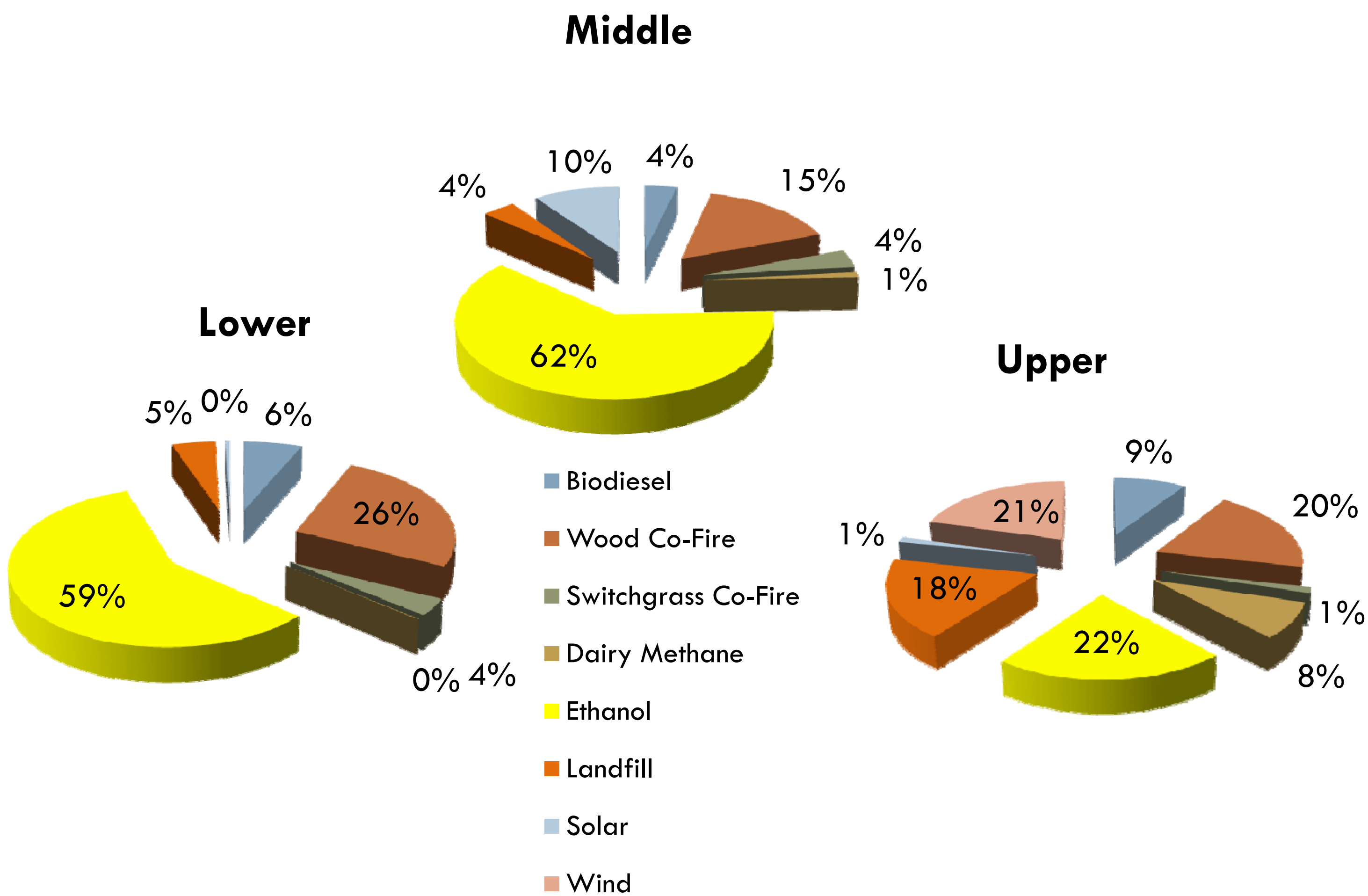



Figure 27.  Sub-Regions Within the AR Study Region


Figure 28. Projected Renewable Energy Jobs in the AR Study Region for 2020, by Sub-Region Under Scenario 2

# Figure 29. Projected Renewable Energy Jobs in the AR Study Region for 2020, by Sub-Region and Renewable Type, Under Scenario 2





# Conclusions



- The AR has great biomass production potential
- Biomass-linked renewable energy will potentially have the largest overall impact in the lower sub-region
- The renewable energy industry will likely be comprised of a mixture of technologies
- The renewable energy industry will have ripple effects through the economy as evidenced by comparing the direct and total impacts
- Potential policies on the horizon could impact renewable energy and associated jobs in the region
- Growth in these industries will likely be reliant on job skill training

# Potential Jobs With Renewable Energy



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| | Projected Jobs Per Million $ Operating * | | |
|---|---|---|---|
| ***Technology*** | Direct from the Industry | Total Including Multiplier Effects | Jobs from Multiplier Effects |
| Biodiesel (Soybeans) | 0.17 | 6.31 | 6.14 |
| Biodiesel (Yellow Grease) | 0.33 | 4.33 | 4.00 |
| Co-fire (Switchgrass) | 2.30 | 9.86 | 7.56 |
| Co-fire (Wood) | 0.63 | 7.99 | 7.36 |
| Dairy Methane | 14.43 | 23.08 | 8.65 |
| Direct Fire Wood | 1.46 | 10.63 | 9.17 |
| Ethanol (Switchgrass) | 2.63 | 9.17 | 6.53 |
| Ethanol (Wood) | 0.46 | 11.56 | 11.10 |
| Landfill | 8.55 | 18.06 | 9.51 |
| Solar Commercial | 0.26 | 2.83 | 2.57 |
| Wind | 1.31 | 9.73 | 8.42 |

*Jobs from year-to-year operations of a facility. An additional set of **investment impacts** would occur at the time the facility is constructed.

# Renewable Energy Policies



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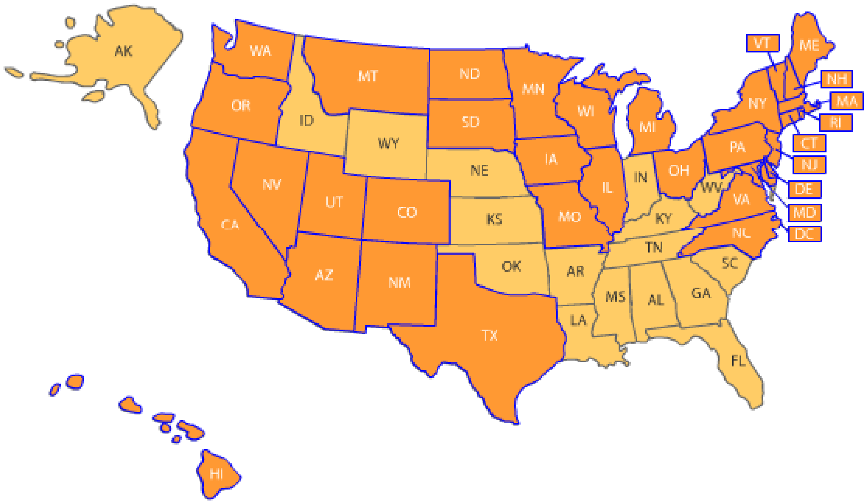
State Level Renewable Energy Standards




| State | Amount | Year |
|---|---|---|
| **Maryland** | 20% | 2022 |
| **New York** | 24% | 2013 |
| **North Carolina** | 12.50% | 2021 |
| **Pennsylvania** | 8% | 2020 |
| **Virginia*** | 12% | 2022 |

*Virginia has set voluntary goals for adopting renewable energy instead of portfolio standards with binding targets.

WV and parts of 12 other states: AL, GA, KY, MD, MS, NY, NC, OH, PA, SC, TN, and VA

Federal Renewable Fuel Standard-The RFS program was originally created under the Energy Policy Act (EPAct) of 2005, requiring the volume of renewable fuel required to be blended into gasoline to 7.5 billion gallons by 2012 (RFS1). Under the Energy Independence and Security Act (EISA) of 2007, the Renewable Fuel Standard program increases the volume of renewable fuel required to be blended into transportation fuel from 9 billion gallons in 2008 to 36 billion gallons by 2022 (RFS2).