Potential of Kentucky Freeway Rights of Way to Displace Fossil Fuel Consumption through Production of Prairie Switchgrass, *Panicum virgatum*

Michael Bomford, Tamara Sluss, Sharmali Hansford and Ken Bates
Ky GHG emissions are twice US average and growing
KY Plans to Increase Fossil Fuel Use, but Offset Some Of the Increase with Biofuels

Figure 10: Kentucky Total Energy Consumption and Savings Potential (2025 Goal)

* Historical renewable energy was derived from hydroelectric (52-75%) and biomass (24-45%); remainder was unspecified "other." 
(Source: EIA, http://www.eia.doe.gov/emeu/states/slp_use/tot_use_tot_ka.html)
Transportation Projected to Become Second Largest Source of GHG in KY after Electricity
Kentucky freeways
Kentucky spends ~$4 million per year to mow grass in freeway rights of way

• How much biomass could be produced if currently mowed areas were used for switchgrass production?
• How much ethanol or electricity could be made?
• What proportion of the fuel used on Kentucky freeways could be offset by switchgrass grown in their rights of way?
Methods

- Total mowed area of freeway medians and shoulders determined using GIS
Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freeway length</td>
<td>$D$</td>
<td>km</td>
</tr>
<tr>
<td>Mowed area</td>
<td>$A$</td>
<td>ha</td>
</tr>
<tr>
<td>Annual traffic volume</td>
<td>$V$</td>
<td>vehicles</td>
</tr>
</tbody>
</table>

This study
This study
KYTC Traffic Counts System 2010
## Assumptions

<table>
<thead>
<tr>
<th></th>
<th>Constant</th>
<th>Value</th>
<th>Unit</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgrass yield</td>
<td>( Y )</td>
<td>15</td>
<td>Mg ha(^{-1}) y(^{-1})</td>
<td>1</td>
</tr>
<tr>
<td>Net ethanol yield</td>
<td>( E )</td>
<td>0.33</td>
<td>L kg(^{-1})</td>
<td>2-4</td>
</tr>
<tr>
<td>Net electricity yield</td>
<td>( L )</td>
<td>1.0</td>
<td>W h g(^{-1})</td>
<td>2-4</td>
</tr>
<tr>
<td>Highway ethanol</td>
<td>( F )</td>
<td>0.17</td>
<td>L km(^{-1})</td>
<td>Fuel consumption (5) converted to EtOH equiv.</td>
</tr>
<tr>
<td>consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highway electricity</td>
<td>( W )</td>
<td>0.32</td>
<td>kW h km(^{-1})</td>
<td>Consumption of existing elec. vehics. compared to conventional equivs. (4)</td>
</tr>
<tr>
<td>consumption</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Energy and Resources Group Biofuel Analysis Meta-Model (Berkeley, 2007)
## Calculations

<table>
<thead>
<tr>
<th></th>
<th>Calculation</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgrass production</td>
<td>$AY$</td>
<td>Mg $y^{-1}$</td>
</tr>
<tr>
<td>Ethanol production</td>
<td>$10^3AYE$</td>
<td>L $y^{-1}$</td>
</tr>
<tr>
<td>Electricity production</td>
<td>$AYL$</td>
<td>MW h $y^{-1}$</td>
</tr>
<tr>
<td>Vehicle distance traveled</td>
<td>$DV$</td>
<td>Km $y^{-1}$</td>
</tr>
<tr>
<td>Ethanol production/consumption</td>
<td>$10^3AYE / DVF$</td>
<td>%</td>
</tr>
<tr>
<td>Electricity production/consumption</td>
<td>$10^3AYL / DVW$</td>
<td>%</td>
</tr>
</tbody>
</table>
Results

- 9,151 ha of mowed grass along 2,260 freeway Km
Results

- 9,151 ha of mowed grass along 2,260 freeway Km
- Switchgrass potential: 137,000 t y\(^{-1}\)
  - 45 million L ethanol
  - 137 GWh electricity
Potential production and consumption of Ky freeways
(assumes no change in traffic volume)

Ethanol pathway – 1.1%

Electricity pathway – 1.8%
Relationship between traffic volume and fuel reduction potential for Ky freeways growing switchgrass converted to ethanol (log scales)

\[ y = 42x^{-0.8} \]

\[ R^2 = 0.84 \]
Relationship between traffic volume and fuel reduction potential for Ky freeways growing switchgrass converted to ethanol (log scales)

\[ y = 42x^{-0.8} \]

\[ R^2 = 0.84 \]
Relationship between traffic volume and fuel reduction potential for Ky freeways growing switchgrass converted to ethanol (log scales)

- Louie B. Nunn, 8.3%
- Martha Layne Collins, 1.6%
- I-24, 2.3%
- I-264, 0.3%
Vehicle Distance Traveled in KY, 1980-2009, with projections to 2025

- **Observed VDT**
- **Projected VDT (Ky DoT)**
- **Projected VDT (Extrapolation)**

**Legend:**
- Observed ΔVDT
- Projected ΔVDT (Ky DoT)
- Projected ΔVDT (Extrapolation)

**Graph:**
- **X-axis:** Years (1980-2030)
- **Y-axis:** VDT (km y⁻¹) x 10⁹
- **ΔVDT (% y⁻¹)**

**Lines:**
- Black: Observed VDT
- Red: Projected VDT (Ky DoT)
- Green: Projected VDT (Extrapolation)

**Points:**
- Black dots: Observed ΔVDT
- Red dots: Projected ΔVDT (Ky DoT)
- Green dots: Projected ΔVDT (Extrapolation)
Possible contributors to future decline in vehicle distance traveled

- Rising fuel prices
  - Falling supply
  - Increasing foreign demand
  - Fuel taxes for infrastructure

- Changing travel needs
  - Telecommuting
  - More urban population
  - Improved transit
  - Improved pedestrian and bicycle infrastructure

![Graph showing VDT per capita vs. Income per capita (thousand $) from 1980 to 2009.](image)
Conclusions

• Ky freeway rights of way have about 9,000 ha (22,000 ac.) of mowed land

• Switchgrass grown on this land could make
  – Enough ethanol to offset 1.1% of freeway fuel use
  – Enough electricity to offset 1.8% of freeway fuel use

  (Assuming no change in traffic volume)

• Differences in traffic volume have much greater effect on fuel offset potential than differences in mowable area

• Continuation of trend toward annual declines in traffic volume has much greater potential to reduce fuel use on Ky freeways than dedication of mowed areas to switchgrass for biofuel feedstock
More...

Blogs:
• Energy Farms
  – Energyfarms.net
• Organic Kentucky
  – oak-ky.org/blog

Published in 2009
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Released in October...
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