Biomass, Bioenergy and Land Use

Pathways to Climate Solutions: Assessing Energy Technology and Policy Innovation
Workshop organized by the Aspen Global Change Institute
24-28 February, 2014

Keith L. Kline klinekl@ornl.gov

Environmental Science Division
Climate Change Science Institute
Oak Ridge National Laboratory
Oak Ridge, Tennessee
http://www.ornl.gov/sci/ees/cbes/
Why bioenergy?

• Do the right thing: conserve resources for future generations
  – “Living within our means”
  – Important “wedge” to reduce fossil fuel dependence
    • IEA, IPCC, WWF... all assume important role for bioenergy
    • 80-250 EJ (2050) to help meet emission targets

• Sustainable development
  – Involving stakeholders in process
  – Integrated land-use planning
  – More sustainable rural livelihoods
  – Landscapes managed for CC mitigation, adaptation, resilience

• Improve land management, efficiency (disturbances including fire and pests destroy over 500 million Ha biomass each year)

• Issues surrounding global “LUC” (land-use change)
U.S. Bioenergy supply model  
Billion Ton Update  
(USDOE 2011)

• Forecasts of potential biomass
  – POLYSYS partial equilibrium model of US agricultural and forestry sectors.
  – 20-year projections of economic availability of biomass (price, location, scenario)

• Forest resources
  – Logging residues
  – Forest thinnings (fuel treatments)
  – Conventional wood
  – Fuelwood
  – Primary mill residues
  – Secondary mill residues
  – Pulping liquors
  – Urban wood residues

• Agricultural resources
  – Crop residues
  – Grains to biofuels
  – Perennial grasses
  – Perennial woody crops
  – Animal manures
  – Food/feed processing residues
  – MSW and landfill gases
  – Annual energy crop (added for 2011)
Residues now projected as primary US source

Resource profile at $63 dry ton\(^{-1}\) which provides 250 million dry tons by 2022 (meeting EISA target).

-Langholtz et al. 2014 (in press, BioFPR)
Supply curve for biomass in US, 2022

- Langholtz et al. 2014 (in press, BioFPR)

[Bar chart showing supply curve for biomass in US, 2022 with categories: Wood residues, Agricultural residues, Dedicated feedstocks.]

ORNL Bioenergy Resource and Engineering Systems Group

OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE U.S. DEPARTMENT OF ENERGY

5
Cost reductions?

- Biofuel conversion costs projected to fall about 40% if/when technologies come to scale (e.g. 500 → 10,000 DMT/day)
  - See DOE “State of Technology” reports for biomass conversion pathways

- Diverse bioenergy technology options in different stages of R&D

- Still awaiting “transformational breakthroughs” on several fronts

- IPCC 2012 Special Report on Renewables and Climate Change Mitigation

Cost reductions in a well-established industry: sugarcane ethanol
Global biomass potential estimates vary: 50-500 EJ (in 2050)

• “Technical Potential”
  750-1500 EJ per year

• 300-500 EJ of
  “sustainable biomass” in 2050
  – Dornburg et al. 2010 (Energy & Env Science)

• “it seems impossible that bioenergy could physically provide more than 250 EJ yr-1 in 2050”
  – Haberl et al. 2013 (Environ. Res. Lett. 8)
  – Risks and limits result from land use assumptions
IPCC Special Report Renewable Energy
“most likely range is 80-190 EJ”

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation
IPCC Special Report Renewable Energy

- IPCC 2012 Special Report on Renewables and Climate Change Mitigation

155 EJ in 2050
IPCC Special Report Renewable Energy
Climate mitigation scenarios

-IPCC 2012 Special Report on Renewables and Climate Change Mitigation
Obstacles to bioenergy include

– Food security and land concerns
– LUC-related effects on biodiversity, carbon debt, water
– Markets: lack of security for investment, increased production
– Distribution of benefits and costs
– Need for integrated policy across agriculture, forestry, waste, environment, energy…
– Sector- and nation-specific challenges (e.g., US “blend wall,” distribution infrastructure)
Bioenergy assessment depends on estimated “land-use change” (LUC) effects

Issues that influence estimated LUC:

1. Economic decision-making assumptions
2. Conceptual framework for drivers of ‘land conversion’
3. Land supply and management specifications
4. Assumed land use dynamics (ref. scenarios, baseline choices)
5. Modeling yield change
6. Issues of time, scale
7. Fire and other disturbances
8. Differentiate correlation versus causation
9. Attribution among different drivers of change
10. Representation of bioenergy/policy in model specifications
11. Data issues related to all above, to test hypotheses

See IEA Joint Task 38-40-43 presentation on LUC: http://ieabioenergy-task38.org/workshops/campinas2011 on CBES website
LUC estimates, compared to what?

- Land available for ag-expansion without deforestation (previously cleared, underutilized) = 500 million to 4 000 million ha\(^{(1)}\)
  Circle size assumes 1500

- Global land area impacts: [million hectares per year]
  - Fire = 330-430 \(^{(2)}\) est. 380
  - Dev./Urban exp. \(^{(1)}\) = 1.5
  - LUC bioenergy est. \(^{(3)}\) = 0.2
  
\(^{(1)}\) Enormous range due to pasture, grassland, marginal land estimates

Sources: \(^{(1)}\) Kline et al. 2009; calc. by author based on FAO 2007. \(^{(2)}\) Giglio et al. 2010. \(^{(3)}\) Tyner et al. 2010 (3 m ha total/14 years = 0.2/year)
Check assumptions about price-driven LUC

Contrary to some modeling assumptions, in the US, expectations of commodity prices and risk affect choices of what to grow on previously defined agricultural landscapes, not how much total area is dedicated to agriculture.

Putting global “Land Use Change” emissions into perspective (1960-2012)

- Over 90% of current CO2 emissions from fossil fuels (GCP 2013)
- LUC emissions, uncertain, small and shrinking
- Land management: high importance as potential sink

Opportunity:

Improve NET land SINK via better management.

Investments in management requires incentives.

Who pays?
For what services?
On whose land?

Source: Global Carbon Project 2013
Other opportunities

- More emphasis on win-win scenarios
- Build consensus on:
  - Goals
    - Criteria and indicators
    - How to measure them
    - Speak “common language”
  - Models
- Empirical data to test hypotheses
- International collaboration to resolve contentious issues
Thoughts for discussion

• Is further debate over the EJ of sustainable energy potential from biomass useful?

• Analyses all begin with land, but land is not the primary constraint
  – Social, political, economic-market issues
  – Institutions, governance... water

• Needed: Incentives for improved soil/water resource management
  – Increase carbon and nutrient retention
  – And capacity to store carbon

• On the radar
  – Integrated production systems (ILUP)
  – Urban food-energy systems (nutrient and energy recycling)
Thank you!
Win-Win Opportunities

- **Improve soil & water management**
  - Precision management and nutrient recycling
  - Reduce disturbance/tillage intensity
  - Crop mix, rotations, cover crops
  - Land restoration
  - Technology (seed, microbe, equipment)

- **Increase Efficiency**
  - Reduce inputs/increase yields
  - Open, transparent markets
  - Minimize transaction costs
  - Prioritize, incentivize, measure

- **Diversify**
  - Uses and markets
  - Substitution options
  - Bases of production

- **Adopt Systems Perspective**
  - Multi-scale
  - Long term and adaptive
  - Integrated land-use plans
Research challenges for consistent measures of LUC

- Accurate representations based on clear **definitions** for variables and conditions of concern:
  - land attributes
  - management practices
  - baseline trends and change dynamics
- **Causal analysis** that can be validated at multiple scales
- Adequate empirical **data** to test models and hypotheses
- Multi-disciplinary, multi-institutional **learning** and problem-solving mechanisms
- **Approaches with low transaction costs and high value-added**
How to effectively involve society?

• Stakeholder engagement in process: define problem, goals and priorities, assess options, and validate proposed solutions
  – How does society define the problem?
  – What are priority objectives?
    • Define spatial and temporal scales
    • Consider constraints and opportunities
  – Apply tools to obtain range of solutions
  – Analyze trade-offs and complementarities
  – Extract general rules, guidance for decision makers
  – Monitor to guide further improvements over time
    • Use of indicators to measure change
References

- USDoe State of Technology updates: [http://www1.eere.energy.gov/bioenergy/key_publications.html](http://www1.eere.energy.gov/bioenergy/key_publications.html)
- IPCC 2012 Special Report on Renewables and Climate Change Mitigation.
Acknowledgements

Collaborators include
LM Baskaran, VH Dale, M Davis, B Davison, ME Downing, LM Eaton, RA Efroyimson, C Farley, NA Griffiths, M Hilliard, H Jager, S Kang, PN Leiby, M Langholtz, LR Lynd, G Marland, A McBride, S Surendran Nair, GA Oladosu, ES Parish, RD Perlack, T Wilbanks, SB Wright, LL Wright...

DOE OBP staff –
Z Haq, K Johnson, A Lindauer, P Grabowski, A Goss-Eng.

Other labs and organizations –
H Chum, D Inman (NREL), M Wang (ANL), MTU-PIRE project, others

Research supported by the U.S. Department of Energy (DOE) under the Office of the Biomass Program and performed at Oak Ridge National Laboratory (ORNL). Oak Ridge National Laboratory is managed by the UT-Battelle, LLC, for DOE under contract DE-AC05-00OR22725.

The views in this presentation are those of the author who is responsible for any errors or omissions.