Energy and
Resources
Group

The Role of Bioenergy in Climate Change Mitigation

Daniel M. Kammen – *presented by Robert Bailis*

Energy and Resources Group; Goldman School of Public Policy
Director, Renewable and Appropriate Energy Laboratory (RAEL)
University of California, Berkeley
kammen@socrates.berkeley.edu

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Outline of the presentation

- Assessing the problem – a quick review of climate change issues
- The role of biomass energy in climate change mitigation:
  - Large-scale power production
  - Transportation
  - Small-scale applications

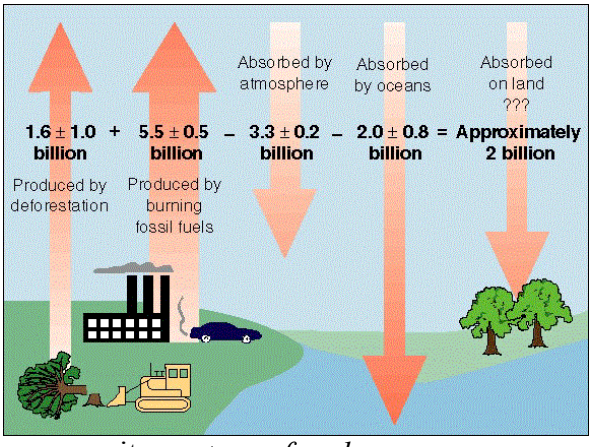
Climate Change – assessing the problem

- Current CO_2 concentrations are 370 ppm
  - Increasing at ~2 ppm yr^{-1}
  - Compared to 265 ppm the existed prior to global industrialization (mid-1800s)
- Additional CO_2 is emitted at about 7 Gton per year
  - Roughly half of this remains in the atmosphere…
- Observed warming to date – roughly 0.6 deg C
  - Will continue to rise – reaching ~2 deg C *even under the best case scenarios…*

Global Carbon Budget

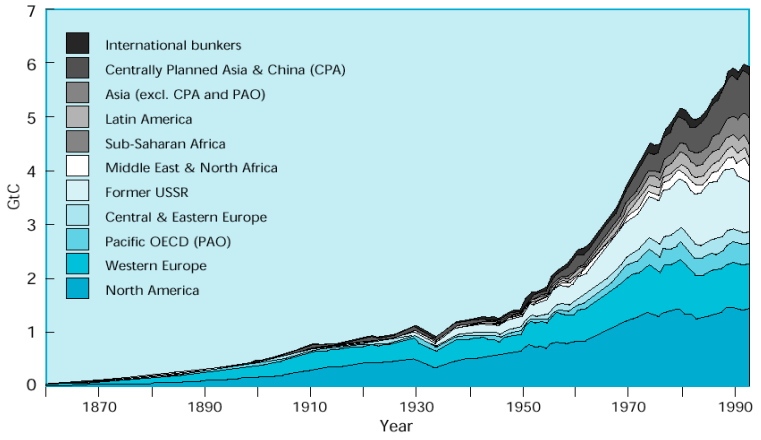
Sources:
~75% Fossil fuel combustion
~25% LUC (more uncertainty)

Sinks:
~50% remains in the atmosphere
~30% absorbed in the oceans
~20% ??



units are *tons of carbon per year*

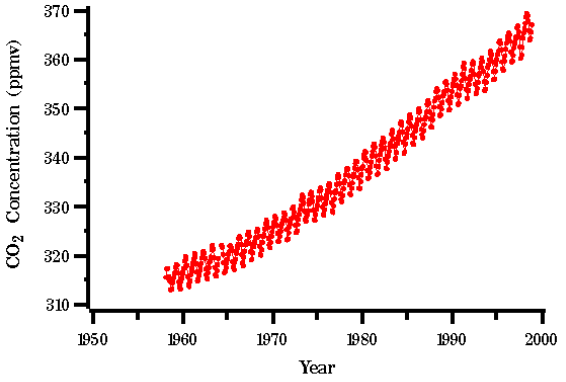
Regional Sources of Energy-related CO_2 emissions (1850-1994)



Source: IPCC WG2, Second Assessment Report (1996)

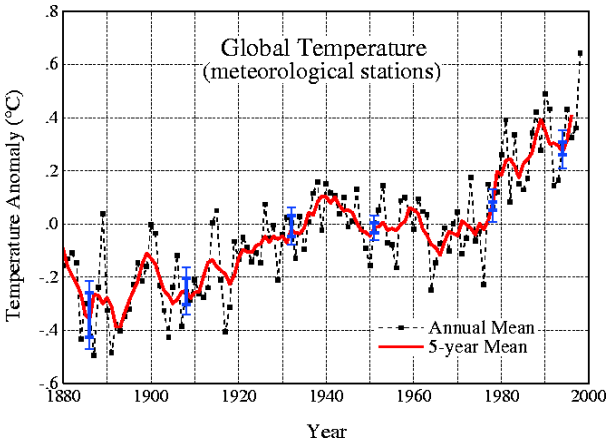
Atmospheric CO_2 Record (1957–1998)

Mauna Loa, Hawaii



Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)

Global Mean Surface Temperature:
(150+ Station Average)



Political-Economic Mechanisms

- International:UNFCCC & Kyoto Protocol
  - "prevent dangerous anthropogenic influence on climate"
  - KP: rich countries reduce by 2012; others exempt
  - Allows for international GHG trading: markets are forming
  - CDM allows for signatories to "reduce" their emissions ERs by funding emission reduction or sequestration activities in LDCs
- Domestic
  - C tax or trading
  - Voluntary programs
  - Targeted R&D or tax breaks

Is Kyoto dead?

- Bush says yes
- Most of the world says no
- Since the US is not offering useful alternatives, it is likely that the US will eventually re-join the international community in some way – *possibly led by industry*.

But the question remains…

- How to make clean energy policy attractive in the US?
- *Regime change?*

The role of biomass energy…

- Large-scale Power Generation
- Transportation
- Small-scale applications
  - HH energy (cooking, lighting, space heating)
  - Small/Micro-enterprises (SMEs)

The Potential of Biomass

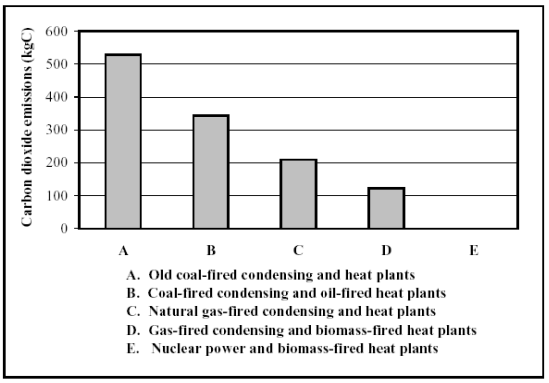
- Biomass provides one of the most attractive opportunities:
  - Globally ~ 55 EJ of biomass combusted (mostly at low efficiency, but widely available & requires high inputs of labor for productive applications)
  - Waste and agricultural/silvicultural products have a potential of ~120 EJ (30% of current Global Primary energy consumption).
  - Costs can be extremely low (~ $1/tC), so also very attractive for international support under the Clean Development Mechanism & other programs
  - Significant implications for economic development in poor countries
  - Massive public health benefits can be derived from making a transition to "modern" biomass fuels

Large-scale power generation

- Commercial applications of biomass only ~4% of primary energy in industrialized countries
  - Cogeneration (CHP)
  - Power generation
  - Space heating (domestic and commercial)

Comparing technologies - I

Carbon dioxide emissions for the production of 1 MWh electricity and 1 MWh heat with different energy systems

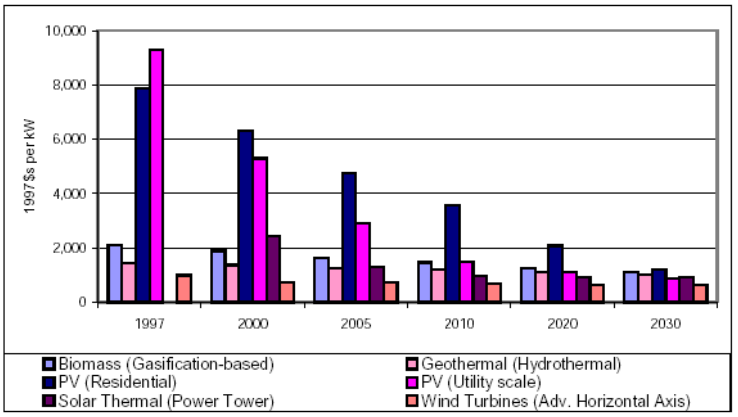


A. Old coal-fired condensing and heat plants
B. Coal-fired condensing and oil-fired heat plants
C. Natural gas-fired condensing and heat plants
D. Gas-fired condensing and biomass-fired heat plants
E. Nuclear power and biomass-fired heat plants

Source: Gustavsson, 1998.

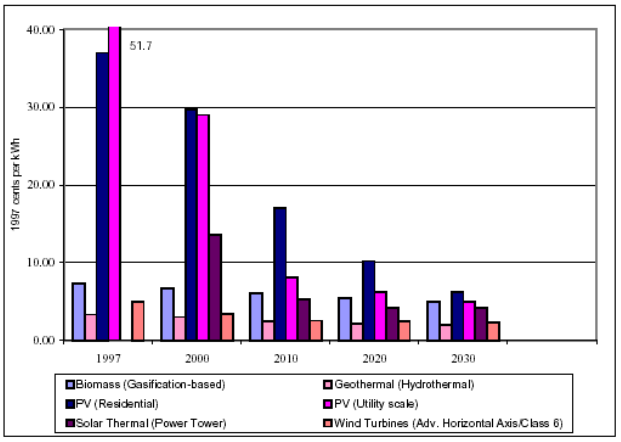
Comparing technologies – costs (1)

Capital cost forecasts for renewable energy technologies (Source: U.S. DOE, 1997)



Comparing technologies – costs (2)

Levelized cost of electricity forecast for renewable energy technologies (Source: U.S. DOE, 1997)



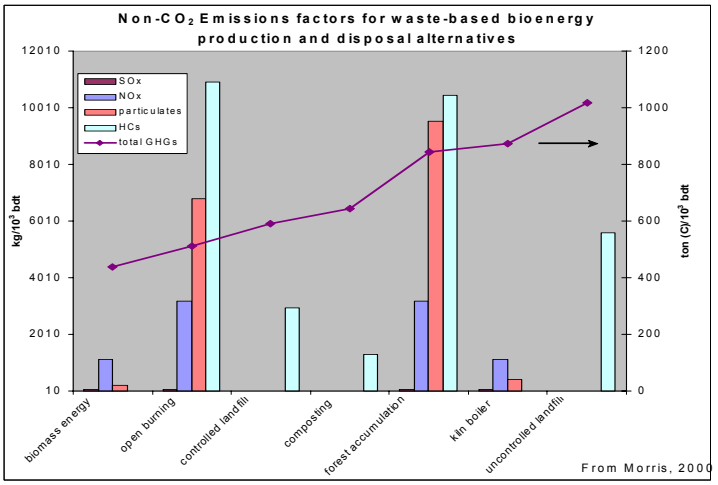
Linking Energy and Agriculture - bagasse

- Over 80 countries in the tropics produce and refine cane sugar.
- Many generate their own power set up to generate only for needs of plant and few sell to the national grid…
- *Brazil*
  9000MW of capacity are identified, but only 18 MW supplied to the grid (Hall)
- *Mauritius*
  ~10% of national electricity production is from bagasse
- *Kenya*
  Largest sugar company now supplies excess power to the grid and is in talks to upgrade hardware and double generation capacity to sell up to 10 MW to the national grid

From Kartha and Larson, 2000

Bagasse, the fiber residue from milling of sugar cane

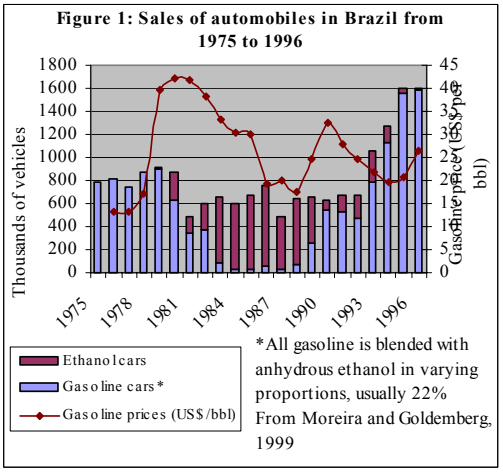
Large-scale bioenergy's role in waste disposal



Transportation

- Alternative fuel vehicles
  - Flexi-fuel: mixing fossil fuels with biofuels
  - Ethanol
    - Brazil, US (very political), Africa (Zimbabwe, Malawi, Kenya)
  - Biodiesel
    - Huge potential in commercial fleets
    - Some grass-roots movements – *can consumers drive policy?*

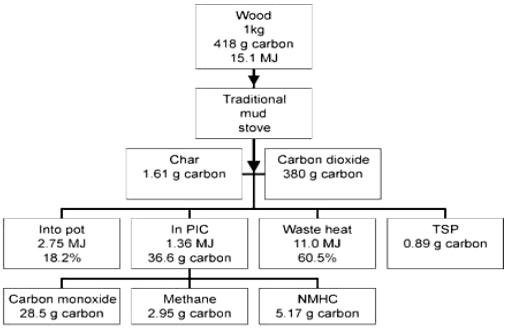
Brazil's experience



Small-scale applications

- HH energy (cooking, lighting, space heating)
- Small/Micro-enterprises (SMEs)

Biomass – *not GHG neutral*

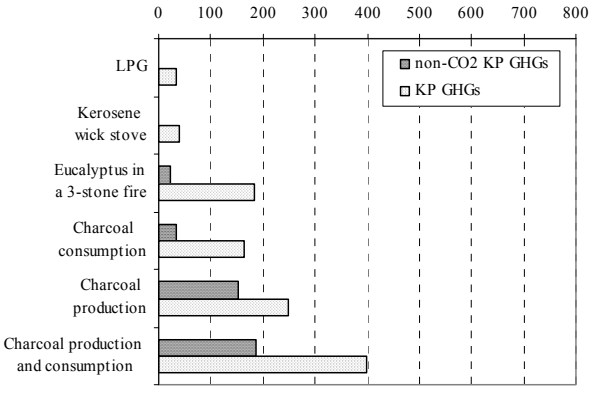


This diagram depicts the carbon and energy balance that results from the combustion of 1 kg of wood in a traditional Indian mud cookstove (the most common woodfuel cooking device in the country). Note the mass of carbon for each combustion product is given in terms of absolute mass and not CO_2-equivalent units, so that the global warming potential of the stove's emissions is fully apparent from this diagram. From Smith, et al., 2000b

- At small scales, incomplete combustion leads to the emission of PICs (CO, CH4, NMHCs, PM)
- This is damaging to health and to the environment

Charcoal

- Main fuel for urban African households
  - Kenya uses 2.4 Million tons of charcoal per year: 40% of their Primary Energy Supply.
- Charcoal production releases large amounts of PICs



Some Alternative HH fuels

"Cane-coal" – bagasse based charcoal briquettes (costs competitive with traditional charcoal) but with controlled production emissions.

Gel-fuel: Ethanol fuel made from sugar cane (cost about 30% higher than kerosene)

Conclusions

- There is a role for biomass energy in climate change mitigation *at all scales*.
- Policies need to be designed to address non-electrical energy options (CHP, transportation, HH sector)
- Small-scale applications are at a disadvantage (higher costs, difficult to monitor and verify ERs)

For more information

ERG:

http://socrates.berkeley.edu/erg

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