



## Module 1: Introduction to Bioenergy → Topics list

### 1.1 What is bioenergy

- Definitions: bioenergy vs. biomass vs. biofuel vs. biogas
- Bioenergy is diverse but always carbon assembled by solar energy
- Bioenergy is an old, but still evolving, technology
- Scale of bioenergy use: household residential to grid
- Feedstock to energy conversion? combustion; thermochemical; biochemical; chemical

### 1.2 Current & projected energy use

- Current US energy use and primary sources
- RE is still primarily bioenergy; mainly biomass; liquid fuel growing in US
- Global uses of bioenergy: power ~ heat > transportation
- Plans for a changing energy landscape in the US (2035-50)
  - In the US bioenergy is static today
- Change since 2008?
- Greater European use of bioenergy: statistics and problems

### 1.3 Forms of bioenergy

- Three bioenergy categories: biopower; biofuels; bio-heat
- 'Generational' categories: 1<sup>st</sup> (virgin) vs. 2<sup>nd</sup> (waste) vs. third (algal)
- Comparison of bioenergy & fossil fuels: pros and cons
- Energy density favors fossil fuels

### 1.4 Bioenergy feedstock materials

- Bioenergy feedstock materials, processing & supply chain
- Types of bioenergy feedstock: woody vs. non-woody
- Feedstock sources: forest vs. agriculture vs. waste
- Feedstock availability: what's the US potential?
  - Bio-ethanol rules US biofuels
- Perennial vs. annual sources
- Intro to the economics of growing biomass feedstock
- Summary of biomass feedstock supply chain: densification is key

### 1.5 Bioenergy co- & by-products

- Bioenergy co-products: economic value; examples
- Bioenergy by-products: no value yet; externality; examples
- What's the holy grail here for bioenergy?

### 1.6 Drivers of bioenergy development

- What drives the use of bioenergy? Security; local economy; renewable; nutrients
- Policy influences bioenergy development & use: subsidies; tax breaks; exemptions
- Recent policy initiatives lessen support: unfunded roadmaps; opening loopholes
- Bioenergy research: governmental support through EPA, USDA, US DOE
- Overcoming market inertia: chicken and egg problem
- Roadmaps for biofuel development



### 1.7 Bioenergy debate

- Major issues in the bioenergy debate
  - Social; economic; independence; land use; environment; energy balance
- Biofuels are controversial: food vs. fuel; water use; impacts on ecosystems
- Critical thinking about bioenergy: triple-bottom-line at each stage of the supply chain
- Life cycle analysis: cradle-to-grave systems analysis; focus on C costs

### 1.8 Is bioenergy sustainable?

- Sustainability depends on policy and practice (not just technology)
- Concerns & solutions: BMPs; third-party verification; clear and strong guidelines
- Energy balance & EROI values: bioenergy < fossil fuel but can be improved
- Land use concerns: ag and ecosystems
- Land use decision making involves many parties and concerns
- Use of 'marginal' lands for bioenergy
  - US wetlands are scarce and developed
- Deforestation / loss of biodiversity: happening across the globe; focus on rainforest
- Use and spread of invasive species: longer term displacement of ecosystems
- Water use and quality: ethanol example (lower for perennial crops)
- Greenhouse gases (GHG) and global climate change: biofuel ideal vs. reality
- The carbon cycle
- US GHG emissions by sector
- Community impact of bioenergy
- Waste bioenergy is a no-brainer

### 1.9 Food vs. fuel debate

- Intersection (& overlap) of food and energy systems
  - Doubling of corn for bioethanol from 2006 – 2009 (to 30% of US corn crop)
- Global grain trading exposes global inequities
- Use of land for energy crops potentially displaces other food crops as well