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The Role of Biomass Wastes in Generating Heat, Electricity, and Transportation Fuels

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  - Utility Energy Savings Contracts
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  - Enhanced Use Leases

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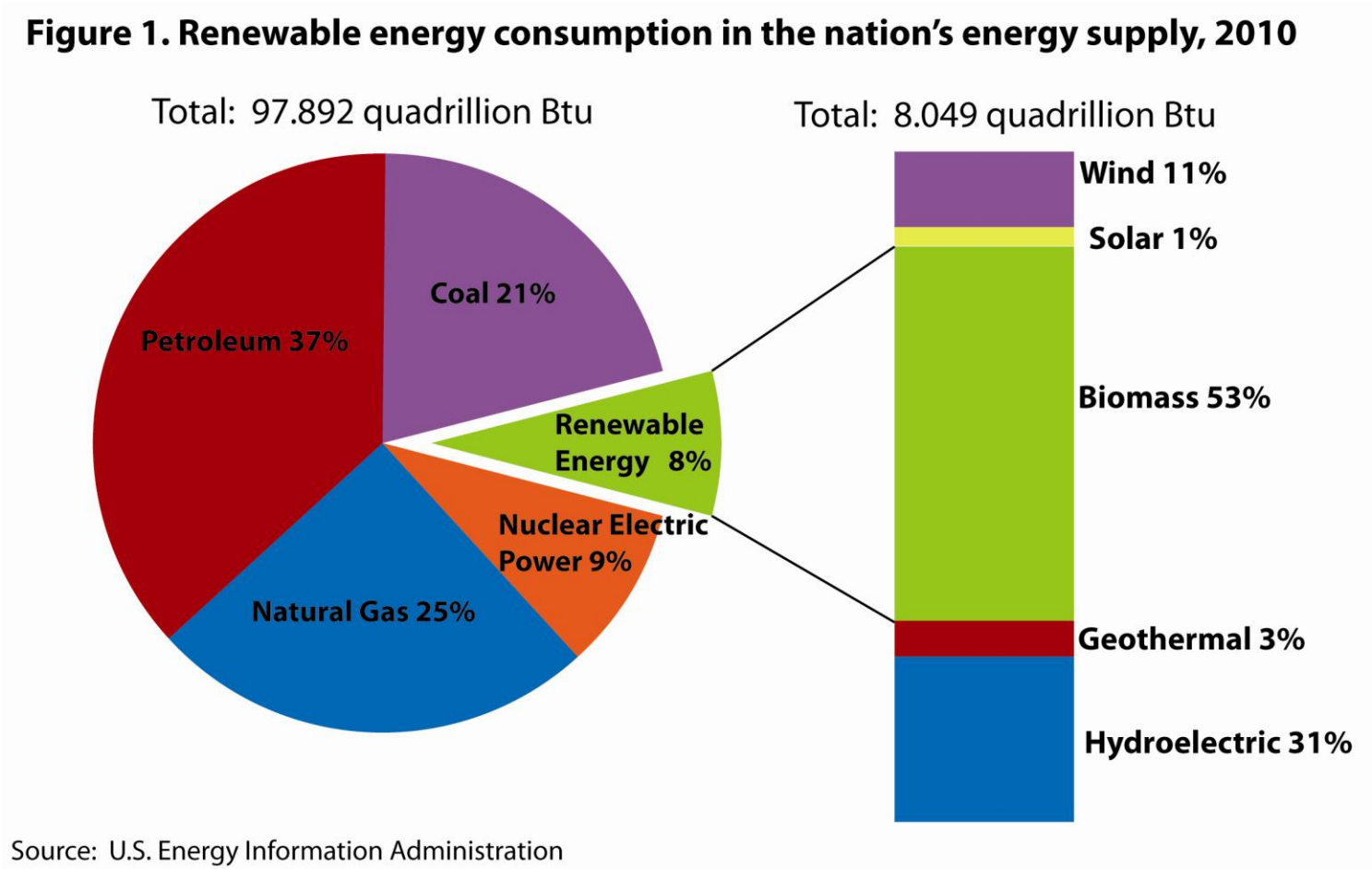
  - Wind
  - Geothermal
  - Biomass
  - Alternative Methane Fuels, e.g. landfill gas, WWTP digester gas, coal bed methane

FEMP Services

- FEMP certified Project Facilitators
- Use of FEMP ESPC IDIQ
- ESPC training
- M&V advice customized for every ECM type
- DOE laboratory expertise on all renewable energy types and the technologies used to convert them to thermal and electrical energy

U.S. Energy Consumption Profile



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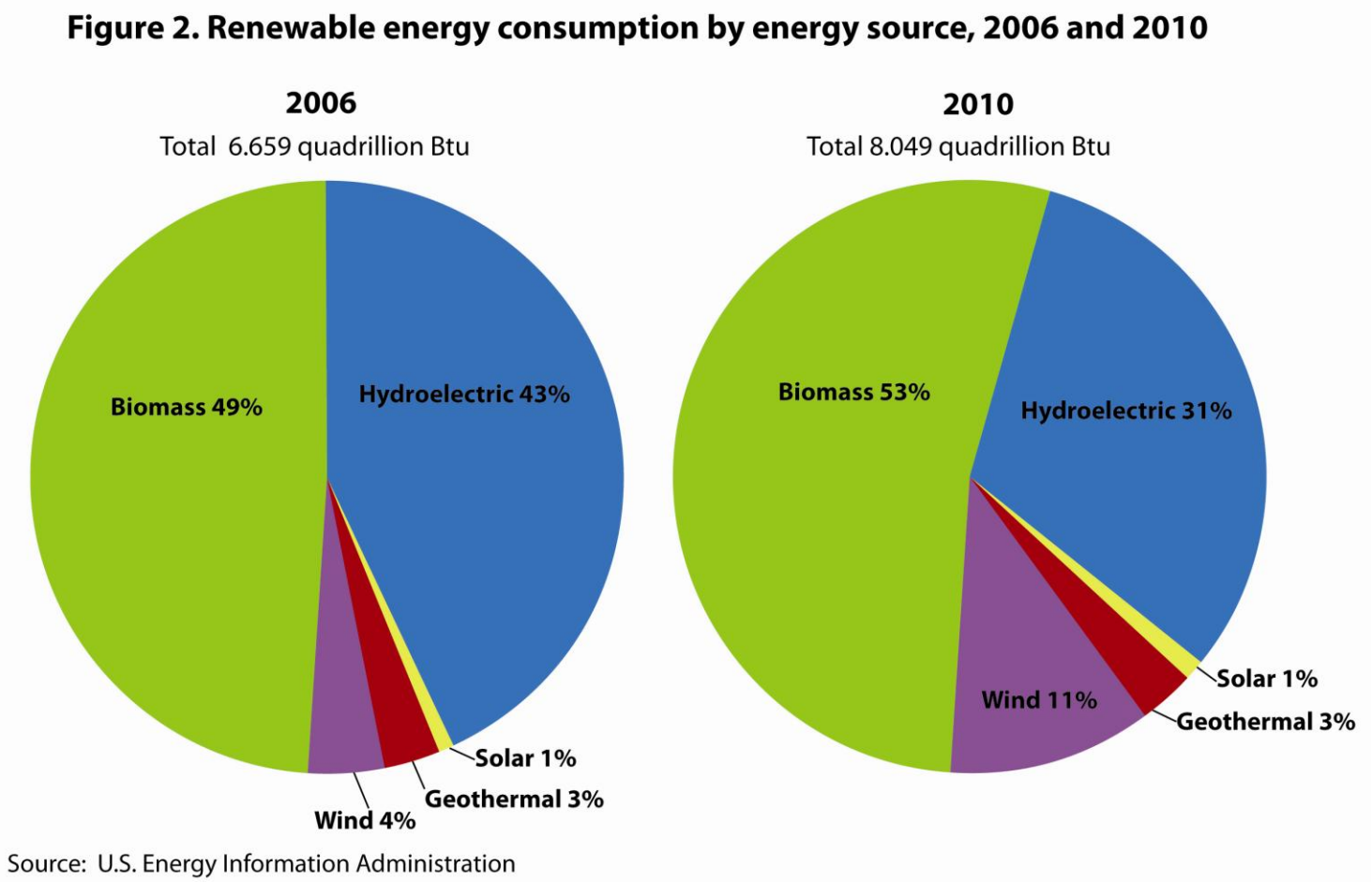
U.S. Renewable Energy Consumption Profile



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Biomass Availability in the U.S.

Commodity	BEAM (Million tonnes per year)	Billion Ton Study (million tonnes per year)
Agricultural Residues	227.1	102.5
Wood Residues	328.7	124.3
Manures	32.0	34.8
Total	587.8	261.6

Biomass

- Woody Biomass Wastes
  - Forest thinnings
  - Primary and secondary mills
- Agricultural Wastes
  - Crop residues
  - Live stock manures
- Municipal Organic Wastes

Technologies Used to Convert Biomass to Energy

- Combustion
  - Burning biomass in the presence of excess combustion air
  - Generated heat converts water to steam
  - Steam drives a steam turbine
  - Turbine drives an electrical generator

Technologies Used to Convert Biomass to Energy

- Emissions Issues associated with combustion:
  - Particulates
  - Carbon dioxide
  - SOx
  - Nox
  - Hg
  - Flyash and Bottom ash

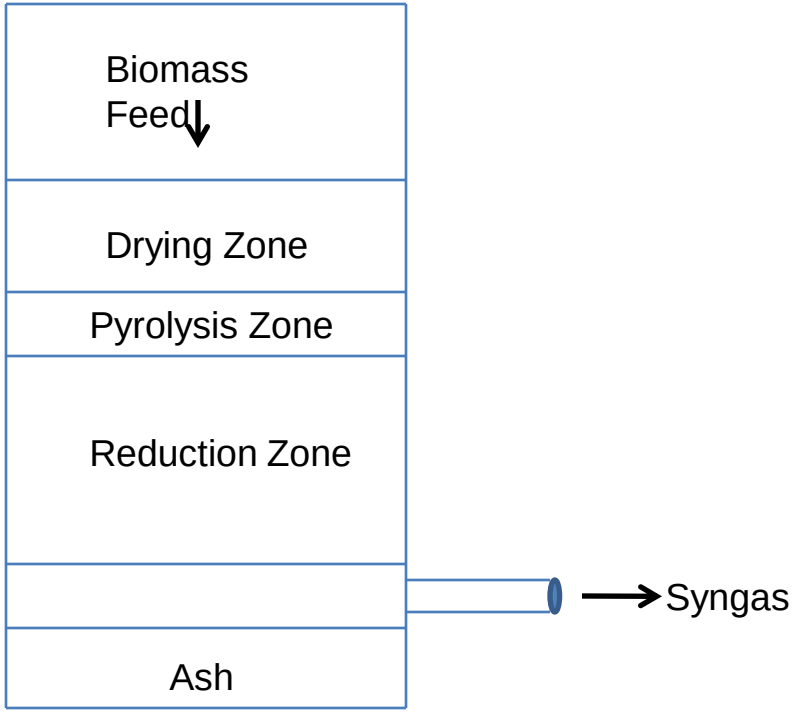
Technologies Used to Convert Biomass to Energy

- Limitations of combustion:
  - Relatively low thermal efficiency (~15% - 20%) although slightly better in CHP systems
  - Heat is the output of combustion systems. You cannot use combustion systems to generate commercial chemicals or produce transportation fuels.

Technologies Used to Convert Biomass to Energy

- Gasification is a thermal-chemical process that converts solid fuel materials into combustible gases that can then be used for heat, power, and the production of liquid transportation fuels and commercial grade chemicals.

Generic Gasifier Schematic



Biogas

- Any gas derived from the natural decomposition of organic matter or the gasification of organic matter.
- Typically H_2, CO, CO_2, CH_4 and mixes of these gases.
- With the exception of CO_2 these gases individually and collectively can be used as fuels or can be used in down-stream processing to generate other useful end-products.

Technologies Used to Convert Biomass to Energy

- Gasification
  - Converting biomass to various gaseous phase products under controlled temperature and pressure conditions in an oxygen-limited environment
  - Thermal efficiency: ~35%
  - The specific gases generated can be manipulated by controlling the temperature, pressure, and amount of oxygen provided.
  - The general term for the gaseous products is syngas

Technologies Used to Convert Biomass to Energy

- Gasification
  - Regardless of the specific gas composition syngas, itself, is a fuel.
  - Carbon monoxide and hydrogen are the most common gases formed through gasification.
  - Both are combustible
  - A separation process can split these gases into separate streams if desired.

Technologies Used to Convert Biomass to Energy

- Gasification
  - Gasification reactions:
    - Exothermic reactions
      - $C + O_2 = CO_2$ Carbon combustion
      - $C + ½ O = CO$
      - $CO + H_2O = CO_2 + H_2$ Water-gas shift
      - $CO + 3H_2 = CH_4 + H_2O$ Methanation
      - $C + 2 H_2 = CH_4$

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Technologies Used to Convert Biomass to Energy

- Gasification
  - Gasification reactions:
    - Endothermic reactions
      - $C + CO_2 = 2CO$ — Boudouard reaction
      - $C + H_2O = CO + H_2$ — Steam-Carbon reaction
      - 2H (in biomass) = H_2 (gas) — Hydrogen liberation

Gasification Process and Equipment

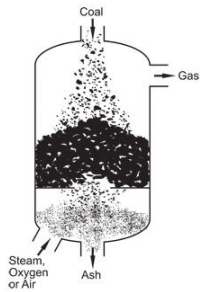
1. Gasifiers
2. Air Separation Unit
3. Water Gas Shift Reactor
4. Carbonyl sulfide hydrolysis unit
5. Selexol Unit (removal of H_2S and CO_2
6. Acid Gas Removal unit
7. Sulfur Polishing Unit
8. H_2 Recovery Unit

Gasification Process and Equipment

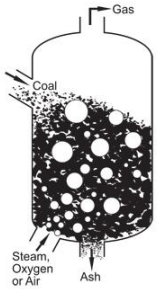
When transportation fuels are the desired end-product then

9. Fischer-Tropps Synthesizer Reactor
10. Boiler/Superheater

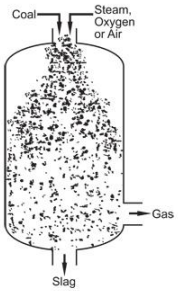
GasifierTypes Used with Biomass



Moving Bed Gasifier

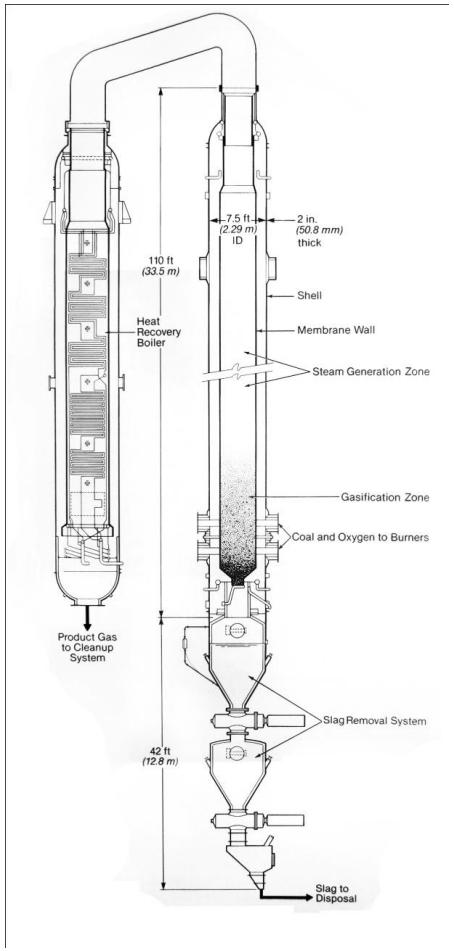


Fluidized Bed Gasifier



Entrained-Flow Gasifier

Typical Entrained-Flow Gasifier Design



Environmental Dimensions of Biomass Gasification

- Greater than 99% sulfur removal as salable product
- Very low NO_x
- Very low particulate emissions
- In slagging systems fuel ash is chemically inert and can be used for road bases and light aggregate

Biomass Gasification Development Challenges

- Economics,
- Economics, and
- Economics

Conclusions

- Use of available, sustainably harvested biomass resources can significantly increase the government's and public's use of renewable energy
- These biomass resources are <u>wastes</u> generated from the forestry, primary and secondary mill, agricultural, and building industry. <u>No trees need to be planted for use as fuels and no acreage used for commodity crops need be lost.</u>

Conclusions

- Combustion technologies for biomass are in common use and have environmental benefits over the combustion of coal.
- The technology for gasifying biomass to produce transportation fuels was mature in the 1940s but has been largely unused since the end of WWII due to availability of petroleum.

Conclusions

- Gasification of biomass to generate electricity is on-going around the world, albeit on a limited basis.

Conclusions

- Increased use of biomass as a renewable energy resource benefits the government, the public, and the world:
  - Converts wastes into an economic commodity and thereby decreases demand for landfill space and use of controlled burns, while generating long-term revenue streams
  - Create both short-term and long-term jobs especially in rural areas

Conclusions

- Would reduce GHG emissions by significantly reducing CO_2, SO_x, NO_x, and particulate emissions
- Reduce the demand for foreign oil imports by
  - Supplanting the oil currently being used to generate heat and electricity, and
  - Addressing the military's National Security need for reliable, uninterruptable, domestic sources of non-petroleum-based transportation fuels

Conclusions

- We have the biomass resources. We have a proven set of conversion technologies.
- We have the responsibility as government employees and government contractors to be the Leaders and Champions for the increased use of biomass in generating thermal and electrical energy and transportation fuels.

Information Sources

- Federal Energy Management Program
- Energy Information Administration
- Babcock & Wilcox's STEAM its generation and use
- USDA

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