Bioenergy Technologies –A Review of Current Commercial Technologies

Making Biomass Work Conference, Klamath Falls, Oregon

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Definition

- **Biomass** – plant material, vegetation or agricultural waste used as a fuel or energy source.*

*American heritage dictionary, third edition

Western U.S. Experience

- Initial plants developed in response to air quality/waste management issues.
- Renewable energy incentives of 1970's and 1980's caused renewed interest and development:
  - PURPA (Public Utility Policy Act of 1978)
  - Incentives as provided by states

Western U.S. Experience – Private Sector Response

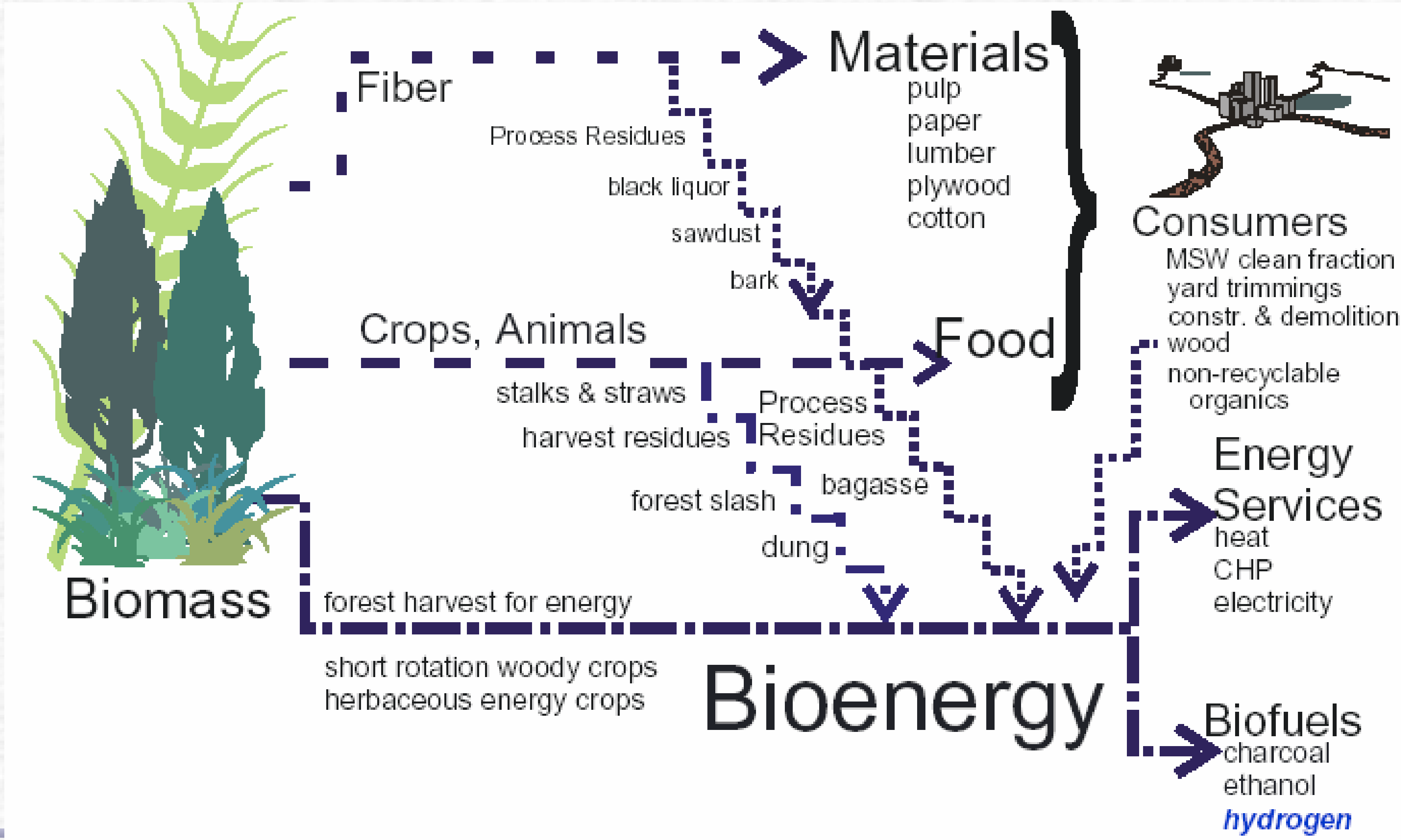
- Approximately 70 plants operational in WA, OR, and CA.
- Produce almost 1,000 MW (enough power for about 1,000,000 homes).
- Consumed around 15,000,000 GT/year:
  - forest biomass
  - agricultural biomass
  - urban biomass
- Generate revenue based upon a variety of power purchase agreements.

Western U.S Experience – Current Situation

- Approximately 50 plants operational.
- Produce 800 + MW (enough power for about 800,000 homes).
- Consume around 12,000,000 GT/year:
  - forest biomass
  - agricultural biomass
  - urban biomass
- Generate revenue based upon a variety of power purchase agreements – non-PURPA rates.


Cone Fire
Unthinned
Thinned
1 1:44PM

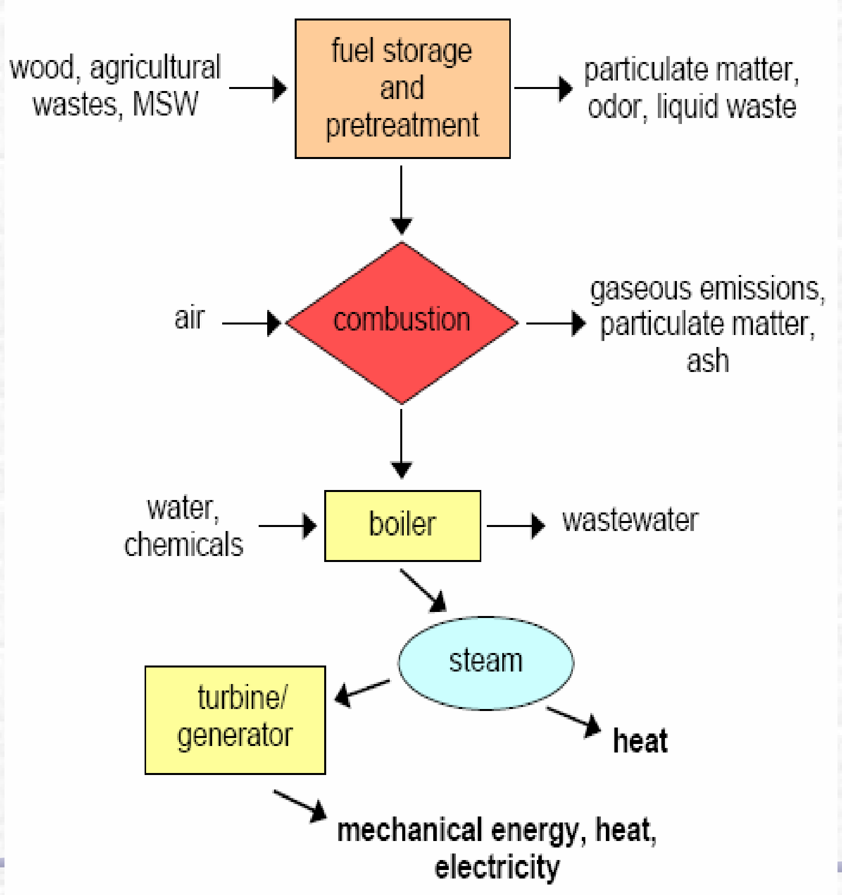
Mapping the Territory



With grateful acknowledgements to Bob Shleser

Combustion

- Most commercial biomass power applications today use direct combustion to produce steam to run turbine generators



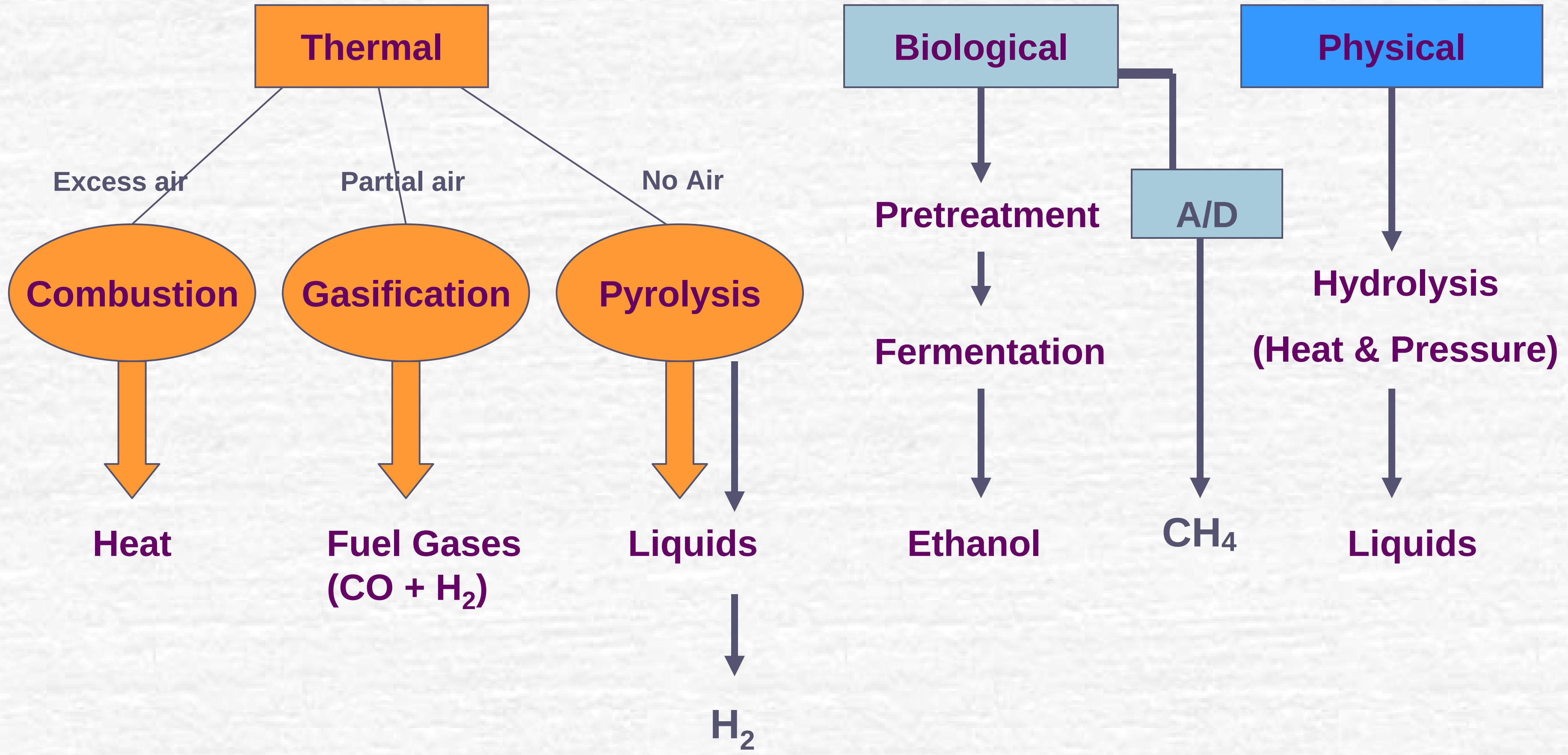
Biomass Power Technology

Two main components:

- An energy conversion system that converts biomass to useful steam, heat, or combustible gases

- A prime mover that uses the steam, heat, or combustible gas to produce power

Biomass Energy Pathways



Scale of the Technology

Industrial:

5 MW+

Commercial:

.5 to 4 MW

Small:

100 to 499 kW

Micro:

15 to 99 kW

Biomass Energy – Some Rules of Thumb

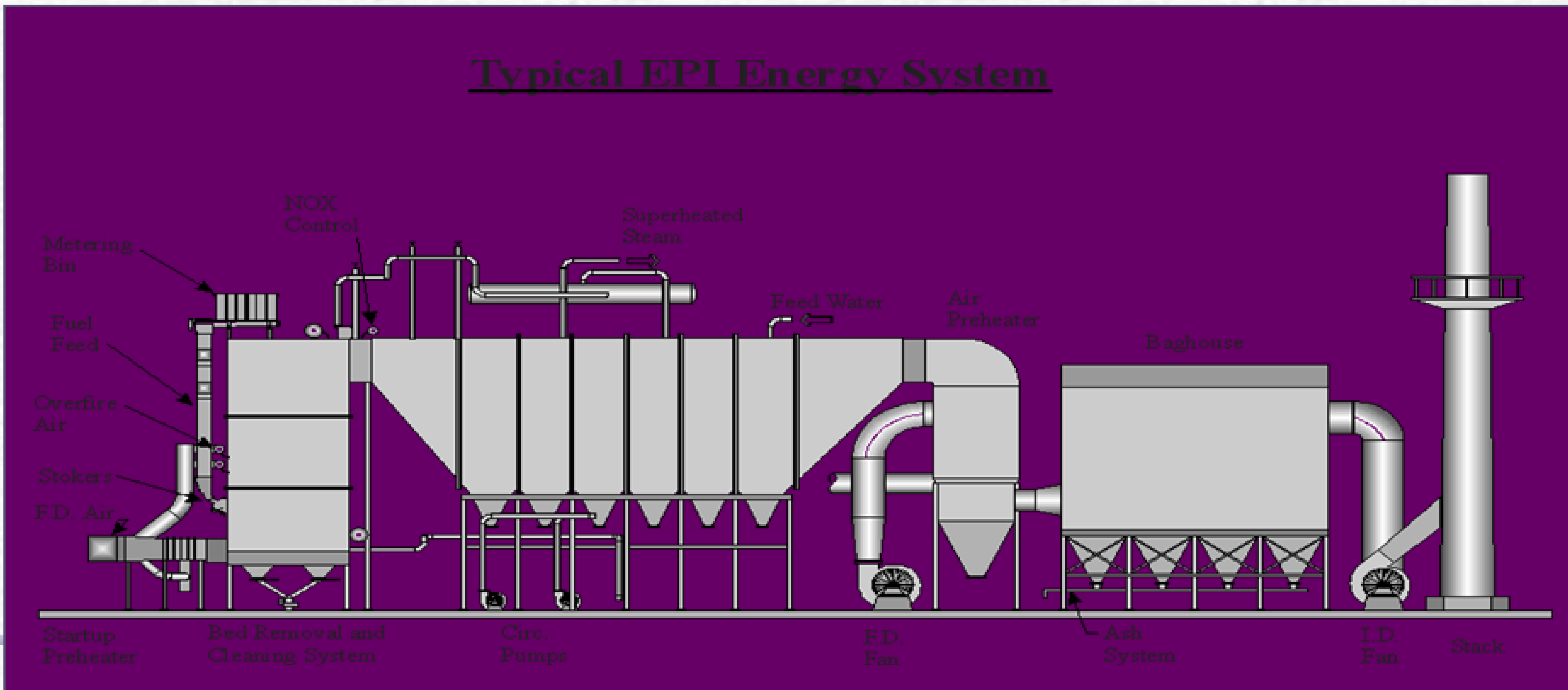
- 1 MW (1,000 kW) is enough power for 1,000 homes.
- Biomass fuel is purchased on a Bone Dry Ton basis.
- Typical amount of biomass recovered during fuels treatment is 10-14BDT/acre.
- Typical “burn rate” is 1 BDT/MW hr.
- 10MW plant consumes 10 BDT/hr.
- Assuming that 14 BDT/ac is recovered, a 10 MW plant would purchase biomass from the treatment of around 5,600 acres/year.

Biomass Power in North America
Current Industrial Technology

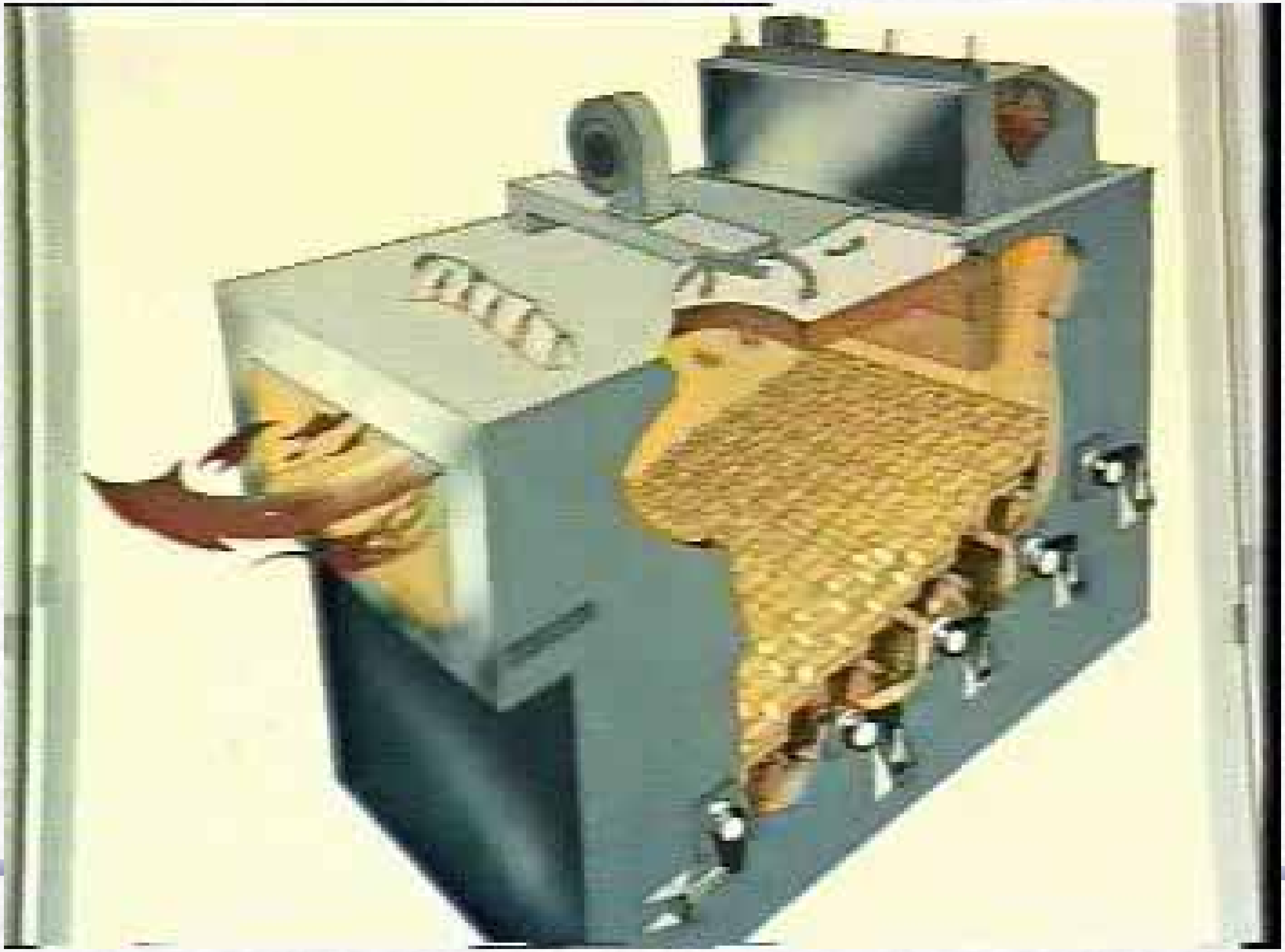
Itasca Power 20 MW Plant
Prince Edward Island, Nova Scotia

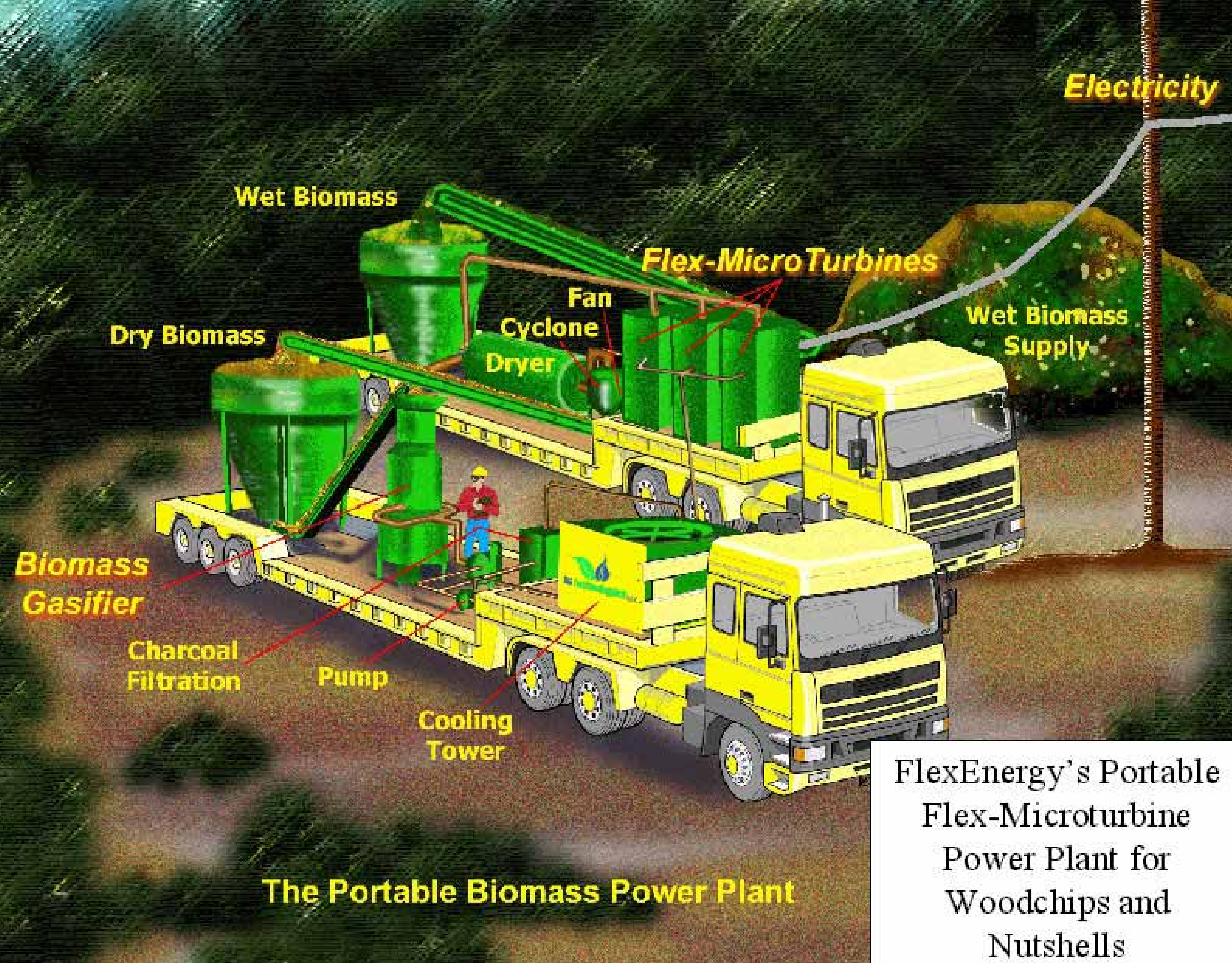
- Almost all systems are combustion / steam turbine.
- Most are grate stokers.
- 5-110 MW (avg. 20 MW).
- Heat rate 11,000-20,000 BTU/kWh.
- Installed cost $1.7-$3.5 million per MW.

EPI System Technology



Moving Grate System



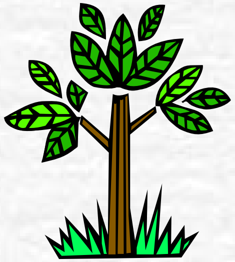


FlexEnergy's Portable Flex-Microturbine Power Plant for Woodchips and Nutshells

Community Power Gasifier: 12.5 KW

Gasification

Air (0.3)
O_2 (0.3)
Steam



Heat

Producer Gas (mol%)

CO	24
H_2	13
CH_4	3
CO_2	8
N_2	52

(CO, H_2, CH_4: Fuel Gases)

(tars & particulate)

Synthesis Gas (mol%)

CO	39
H_2	20
CH_4	17
C_2H_2	6
CO_2	18
N_2	0

(CO, H_2, CH_4, C_2H_2: Fuel Gases)

(tars & particulate)

NREL

CURRENT SMALL SCALE BIOMASS POWER INSTALLATIONS IN U.S.

- Schools/community buildings. Primarily in the northeast.
- Remote locations, where alternative energy sources are costly or not readily available.
- Forest Products manufacturing operations with limited waste disposal markets/options.

SMALL SCALE BIOMASS POWER INSTALLATIONS - ADVANTAGES

- Relatively easy to site.
- Community acceptance is typically good.
- Low capital investment.
- Simple to operate.
- Can supply heat and power.

SMALL SCALE BIOMASS POWER INSTALLATIONS - DISADVANTAGES

- Relatively inefficient (high heat rate).
- Costly to own/operate/maintain. No economies of scale.
- Best operated as a CHP. Site should have demand for heat and power.
- Air emissions may limit where facility is sited.
- Consumes relatively little biomass.

Biomass Cost of Electricity

Year --- >	1990	2000	2010	2020
		(cents/kWh)		
Utility Scale and Large Distributed Power				
Cofiring (incremental)	NA	2 - 4	1 - 3	1 - 2
Direct-Fired Biomass	10 - 15	8 - 12	7 - 8	6 - 7
Gasification	NA	6 - 8	5 - 7	4 - 6
Small Modular - Distributed Generation				
Solid Biomass	NA	15 - 20	8 - 12	6 - 10
Biogas	NA	8 - 12	5 - 8	2 - 8

NREL

Source: Biopower Technical Assessment: State of the Industry and Technology, March 2003

Advantages of Biomass Energy When Compared to Wind and Solar

- Provides base-load renewable energy (24/7) on a cost effective basis.
- Has numerous societal benefits:
  - Supports hazardous fuels reduction
  - Reduces waste material destined for landfills
  - Net improvement in air quality
  - Provides employment (4.9 jobs/MW)

Fatal Flaw Issues to Consider

- Community Support
- Fuel Supply
- Project Economics
- Appropriate Technology
- Siting/Infrastructure

Community Support

- Best to have grass roots support. Pride of ownership carries well.
- Poll key stakeholders:
  - Local peer groups
    - Tribal Council
    - Bd of Supervisors
    - Chamber of Commerce
    - Green organizations
    - Local, State and Federal agency representatives
    - Private sector resource managers, landowners

Fuel Supply

- Sustainable long term supply located within close proximity (25 to 75 mile radius)
- Economically available
- Environmentally available
- Meets quality specifications
- Available in quantities and from diverse sources that support project financing:
  - Minimum 10 year supply, 70% under contract
  - Quantities that are 2 – 3 times minimum volume for plant operation

Project Economics

- Markets for heat and power
  - Market support justifies capital investment
- Return on investment
  - Minimum ROI of 17%
- Economies of scale
  - Combustion efficiencies
  - Labor and overhead

Appropriate Technology

- Search for most appropriate technology considering project location and fuel supply
  - Ability to convert local fuel supply into heat/power
  - Must meet local permitting specifications
- Technology must be proven:
  - Commercially available
  - Operates efficiently on available fuel supply
  - Operates cleanly on available fuel supply
  - Appropriate for site and local resources

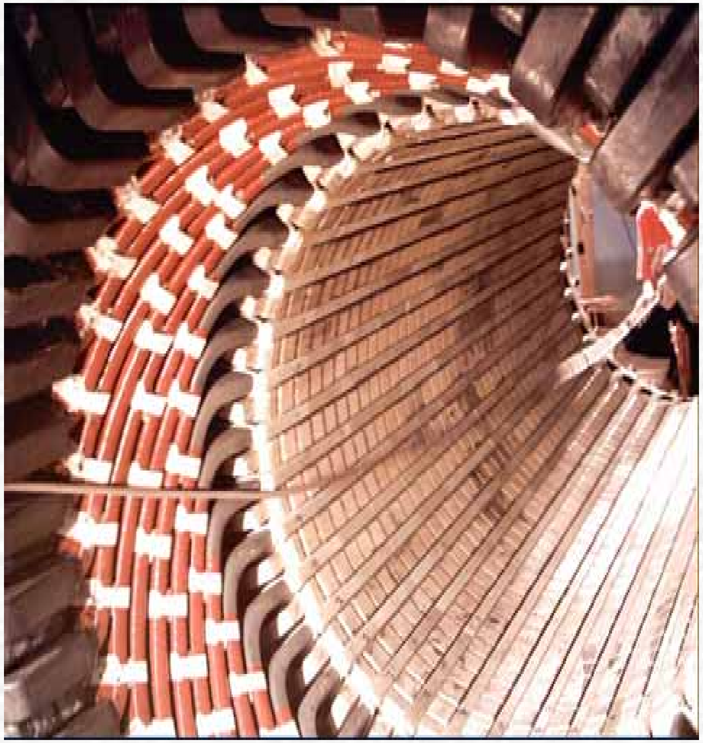
Siting Infrastructure

- Strategically located near:
  - Customer base
    - Community
    - Commercial heat and power user
  - Within economic haul distance of sustainable/long term resource
  - Water supply
  - Transmission/distribution system

Project Development: Step-by-Step

1. Confirm community support.
2. Assess fuel resource availability.
3. Consider siting and infrastructure issues.
4. Complete due diligence feasibility study.

Step-by-Step (cont.)



5. Seek experienced developers and/or equity partner.
6. Secure power purchase agreement.
7. Secure financing.
8. Build project.
9. Generate renewable energy.
10.

Questions?