Biomass Conversion to Electricity

Woody Biomass Workshop

Eureka, CA

March 25, 2010

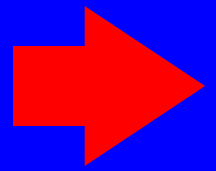
John R. Shelly, UC Berkeley

Combustion of Woody Biomass to produce heat and/or power

Small scale – units are available for space or process heat. Combined heat and power may be feasible

Large scale – California has biomass power plants that consume large quantities of woody biomass

Combustion of Wood

Wood + Air + Ignition 

$CO_2 + H_2O + O_2 + N_2$

+ **Heat**

+ **Ash**

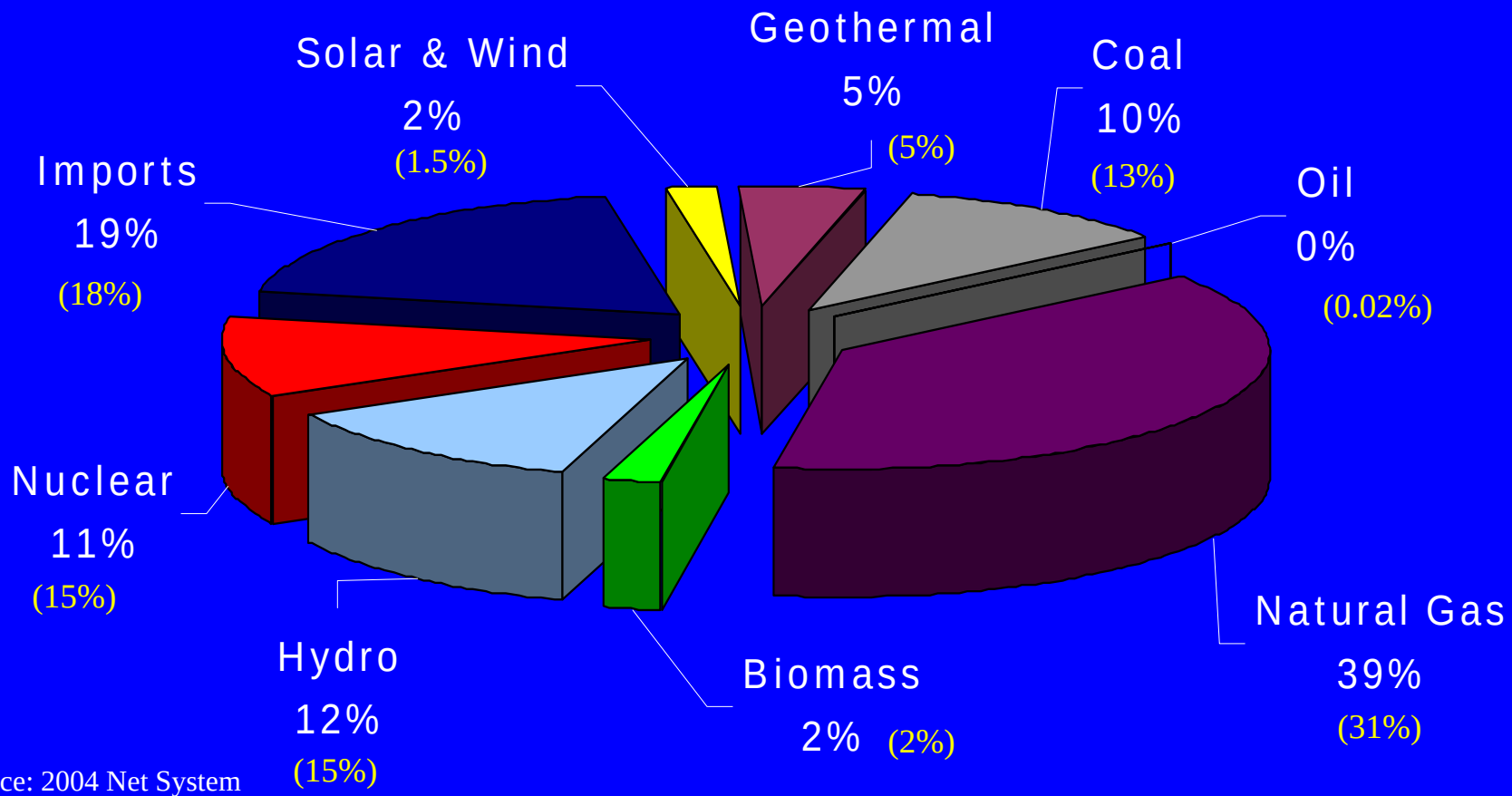
+ **Emissions**

particulates, Nox, Sox, etc.

20 MW Biomass Power Plant

Biomass Gasification Unit coupled to an
Internal Combustion Engine and Generator - 500 Kw

2004 CA Electricity Production



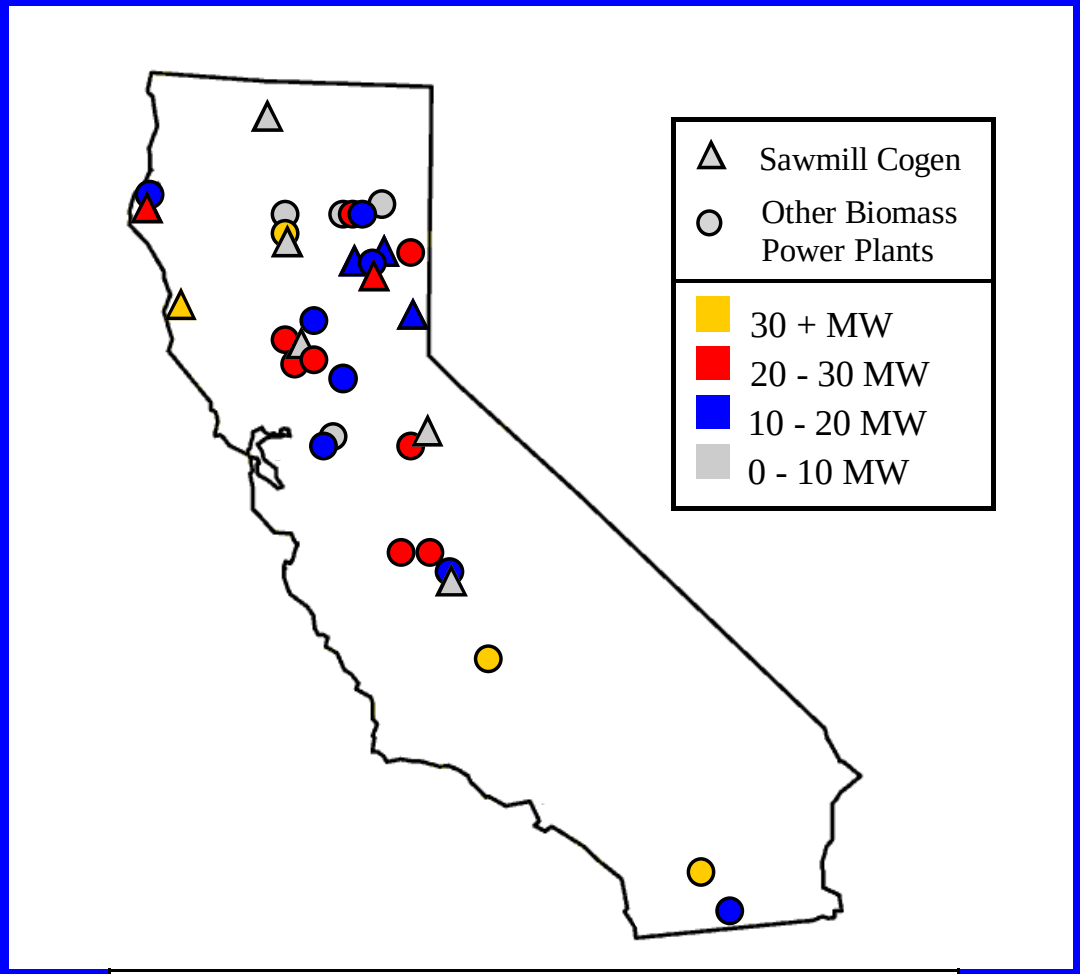
Source: 2004 Net System Power Calculation Report, CEC-300-2005-004, CA Energy Commission

Total Production: 275,091 GWh

Biomass: 5, 997 GWh

(values in parenthesis are for year 1999)

California Biomass Energy Facilities



A 10 MW (megawatt) generator can supply electricity to about 10,000 homes.

The 7 cogeneration facilities are co-located with sawmills

27 facilities with total capacity of about 626 MW using 4.5 million bone dry tons of biomass per year

- 22% forest-based
- 29 % manuf. residue
- 28% landfill diverted
- 21% ag residue

About 15% of total biomass available and about 12% of forest-based biomass available

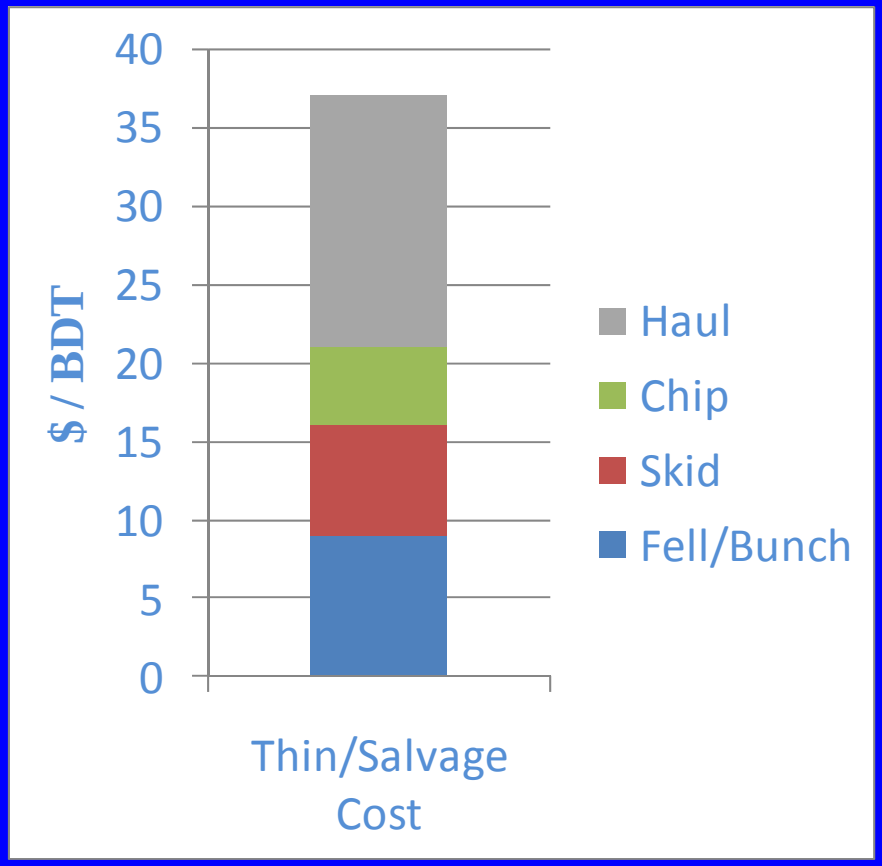
Typical Biomass-Fired Powerplant

- 20 MW capacity, combustion/steam turbine
- Installed cost = $1700 - $3500 per kW
- Processes 140 - 200 thousand tons/yr (1BDT/MW/hour)
- Biomass transported up to 50 miles
- Delivered biomass valued at $15 - 60 per BDT
- Average production cost ~ $0.07 - $0.10/kWh

Biomass Combustion Concerns

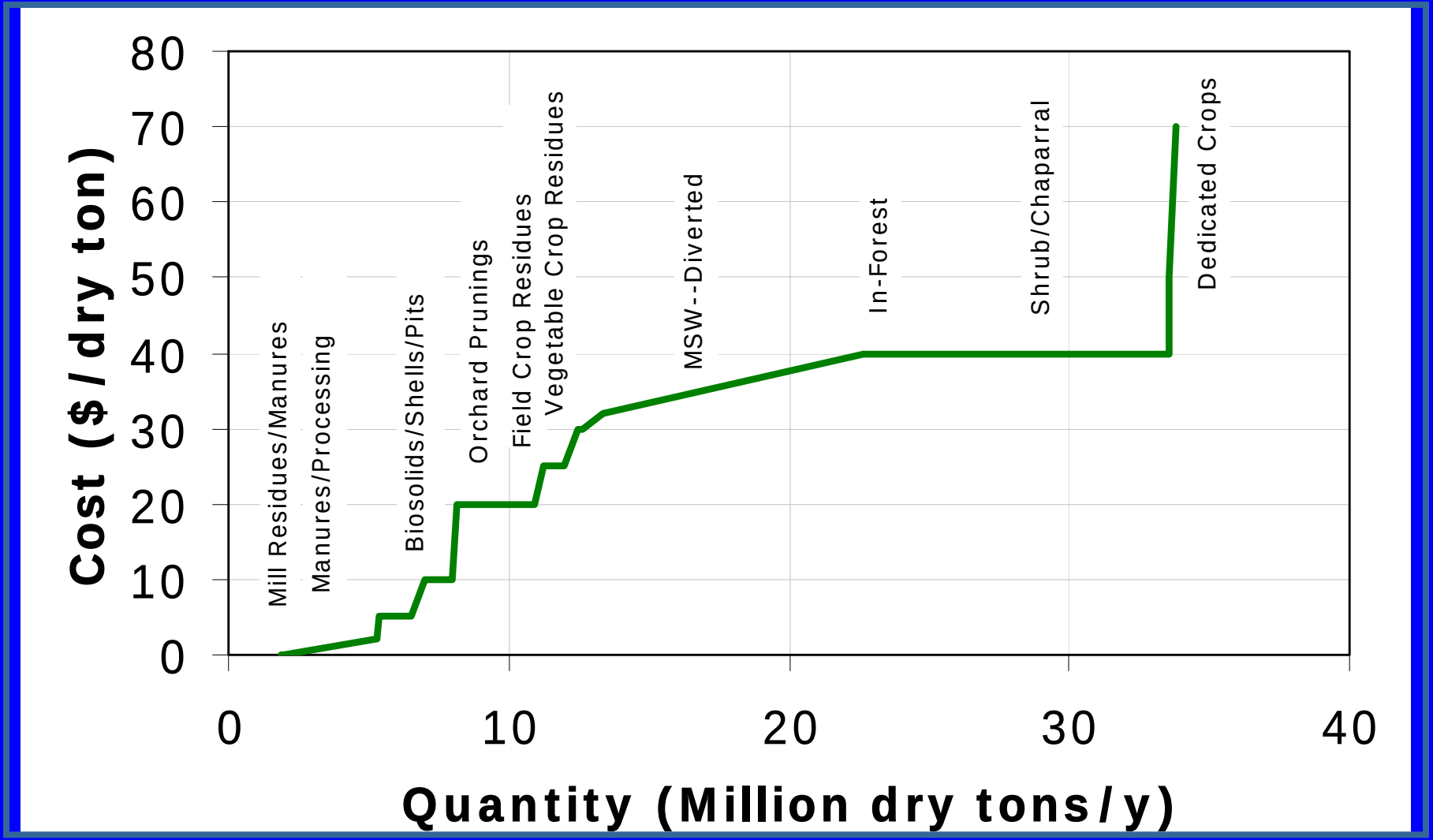
- Availability and cost of Fuel
- Emissions
- Higher maintenance compared to other fuel types
  - Inorganic (ash) transformations lead to fouling of combustion chamber surfaces and slag formation on bottom
  - Increased corrosion from acidic gases
- Maintenance issues can lead to reduced capacity and efficiency

Example of Costs of Forest Thinning or Salvage Operations with a 50 Mile Haul



Value of biomass delivered to a powerplant ranges from about $15 - $40 per BDT

California Statewide Resource Supply Curve



Source: California Biomass Collaborative

Emissions by type of Combustion in pounds emitted per ton of Woody Biomass consumed

	PM- 2.5	NO_x	CO	VOC	N_2O
Industrial (dry fuel)	0.7 – 6.5	8.8	10.8	0.31	0.23
Industrial (wet fuel)	0.4 – 5.0				
Residential Stove	6 - 23	45 – 100	2 – 14		
Prescribed Burn	12 - 34	3	300	19.0	0.46
Wildfire	17	4.0	140	12 - 24	0.46

Environmental Impact

Air Emissions	Open Field Burning	Biomass Fueled Boiler	Natural Gas Boiler
	lb/Million Btu		
CO	6.89	2.267	0.058
CO_2 fossil		0	114.6
CO_2 non fossil	100 - 350	350.0	0
NO_x	0.36	0.250	0.301
SO_x	0.03	0.013	0.073
VOC	0.74	0	0.009
Methane		0	0.003
Particulates	0.66	0.028	0.009

Power Plant Efficiency

	Heat Rate (Btu/kWh)	Efficiency (%)
Natural gas combined-cycle	7,500	45.5
Coal-fired steam/electricity	10,000	34.1
Biomass-fired steam/electricity	15,000	22.7
Biomass-fired, combined heat and power (co-gen)	8,500	70.0

Barriers

- Emissions
- Grid Interconnect
- Fuel Availability

The Future of Biomass Power Plants Depends on …

- Biomass utilization policies
- Relative price of natural gas and electricity
- Environmental issues
  - Emissions – particulates, CO_2
  - Carbon Accounting -- does biomass CO_2 have a zero emission impact?
- Societal value placed on biomass disposal/use (e.g. reducing wildfire hazards)

How Can We Increase Woody Biomass-Produced Electricity?

- Offset high costs of processing in thinning and salvage operations
  - Assign values to environmental and social benefits
  - Apply economic incentives
- Educate public to the value of well managed, sustainable, and productive forests
- Improve the conversion efficiency of powerplants
- Compare life cycle assessments of various energy alternatives
- Encourage policies and incentives that level the playing field with other fuels