Combined Heat and Power (CHP) Using Agricultural Biomass

OBPC Ag Biomass Day

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Jake DeBruyn P.Eng.

Environmental Management Branch, OMAFRA

jake.debruyn@ontario.ca (519) 826-4584

Ontario

Today's Talk

- Biomass Energy Options
- What is Combined Heat and Power?
- Examples of Biomass CHP and Electricity
- Large Renewables Procurement Program and the OBPC

- Acknowledgement: many of the slides in this presentation are courtesy of Dr. Fernando Preto, Natural Resources Canada CanmetENERGY

Why Biomass Energy (Electricity or Heat?)

- Environmental benefits such as mitigation of greenhouse gas emissions, reduction of acid rain, and soil improvement;
- Political benefits - e.g. reduced dependency on imported fossil fuels; rural development; energy diversification;
- Employment creation - biomass fuels create up to 20 times more employment than fossil fuels.
- Biomass fuel prices have been stable historically and are not directly linked to national or global energy markets. Biomass pricing is not subject to monopolistic control.

Biomass Energy Conversion Basics

- **Combustion** produces heat which can be used directly or used to produce steam for industrial processes or power generation
- **CHP (Combined Heat and Power)** is designed to produce both heat and electricity from a single heat source
- **Organic Rankine Cycle (ORC)** produces electricity from low grade or residual heat using organic fluid with low boiling temperature
- **Gasification** produces a mixture of low molecular gases known as syngas, which can be used to synthesize renewable fuels, polymers, and commodity chemicals
- **Fast Pyrolysis** produces “bio-oil”, which is not really an oil but a liquid mixture of oxygenated organic compounds that can be used as a biofuel a source of specialty chemicals

Energy Conversion Technologies Options

Combustion - Heat

Madsens's Custom Cabinets, Kalwa Biogenics Inc.
Edmonton, Alberta

Combustion - CHP

Grande Prairie EcoPower Centre
Grande Prairie, Alberta

Gasification - Heat

Nexterra/Tolko
Heffley Creek, British Columbia

Pyrolysis – Bio-Oil

Advanced Biorefinery
Portable
Pyrolysis Unit
Ontario

Dynamotive Erie Flooring Plant
West Lorne, Ontario

Enzymatic Fermentation – Ethanol

Iogen Enzymatic Cellulose Ethanol Plant
Ottawa, Ontario

Gasification - Power

Dapp Power Plant
Dapp, Alberta

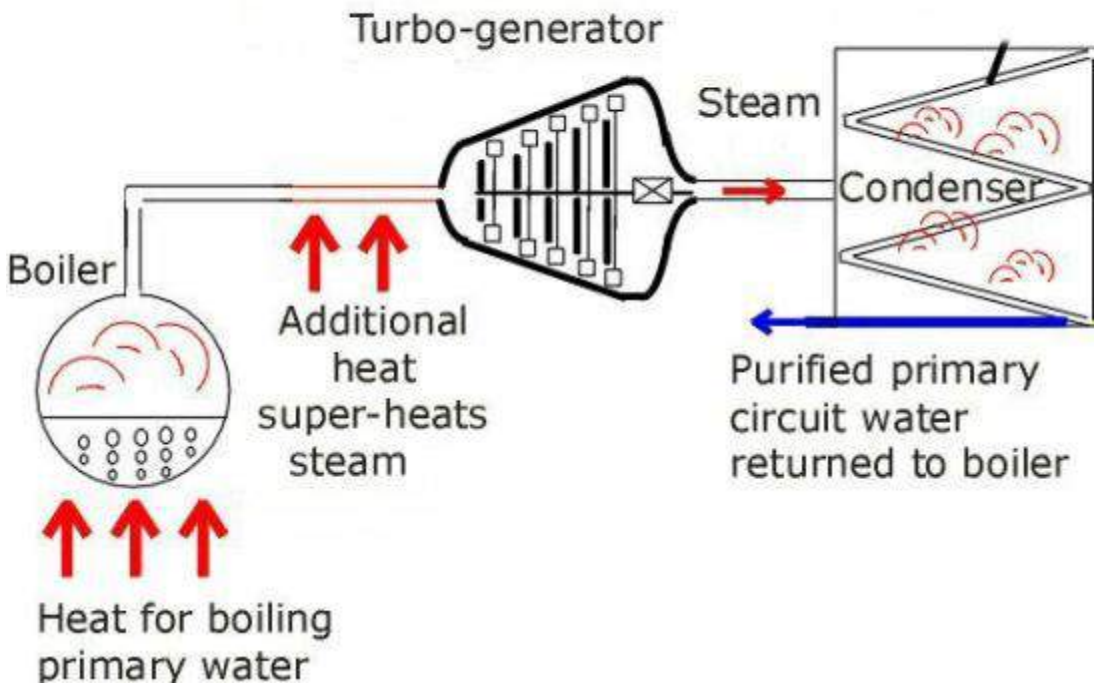
Slide Courtesy: Derek Sidders, Canadian Wood Fibre Centre

Combustion technologies are commercial BUT there are still significant concerns

- Moisture
- Energy Content (Species) and Density
- Form Factor (Handling)
- Fuel Composition
- Emissions and Fouling
- Combustion Chamber Design and Operation

  (MUST be designed for the specific fuel)

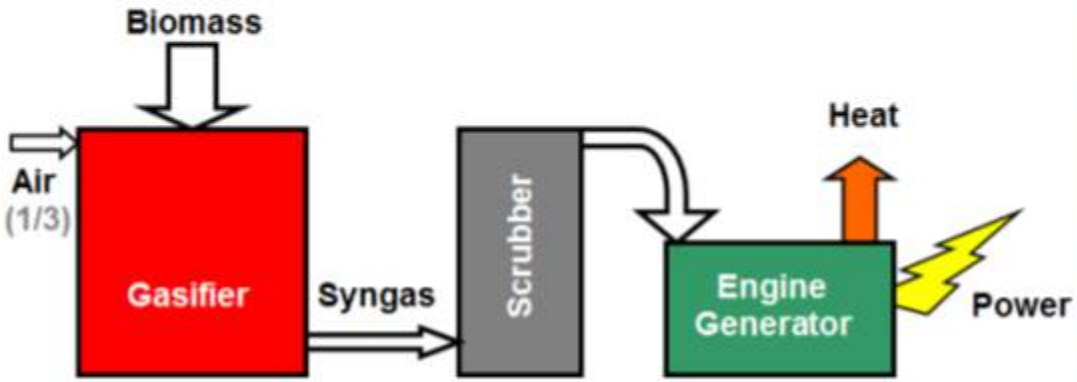
Conventional Electrical Generation



Combined Heat and Power / Cogeneration of Electricity and Heat

- Combustion of biomass or gasification syngas may yield only 20-30% of the inherent energy in the biomass into electricity
- Remaining energy is mostly heat:
  - Combustion vessel, gas cooling, engine block, exhaust stack, etc.
- Locating biomass electrical generation near a thermal demand can mean utilization of significant portion of the “waste” heat.
  - Generally CHP provides hot water.
- Using waste heat in adsorption chiller (refrigeration cycle) means excess heat energy can be converted into a cooling load.
- Insulated pipe heating loop: expensive, thermal losses with distance.
- Existing experience with natural gas CHP district energy in Canada and broadly in Europe. Fewer biomass CHP projects.

Gasifier and GenSet



Gasification allows you to convert biomass into a synthetic gas (syngas) which can be used as a fuel for power generation

CanmetENE

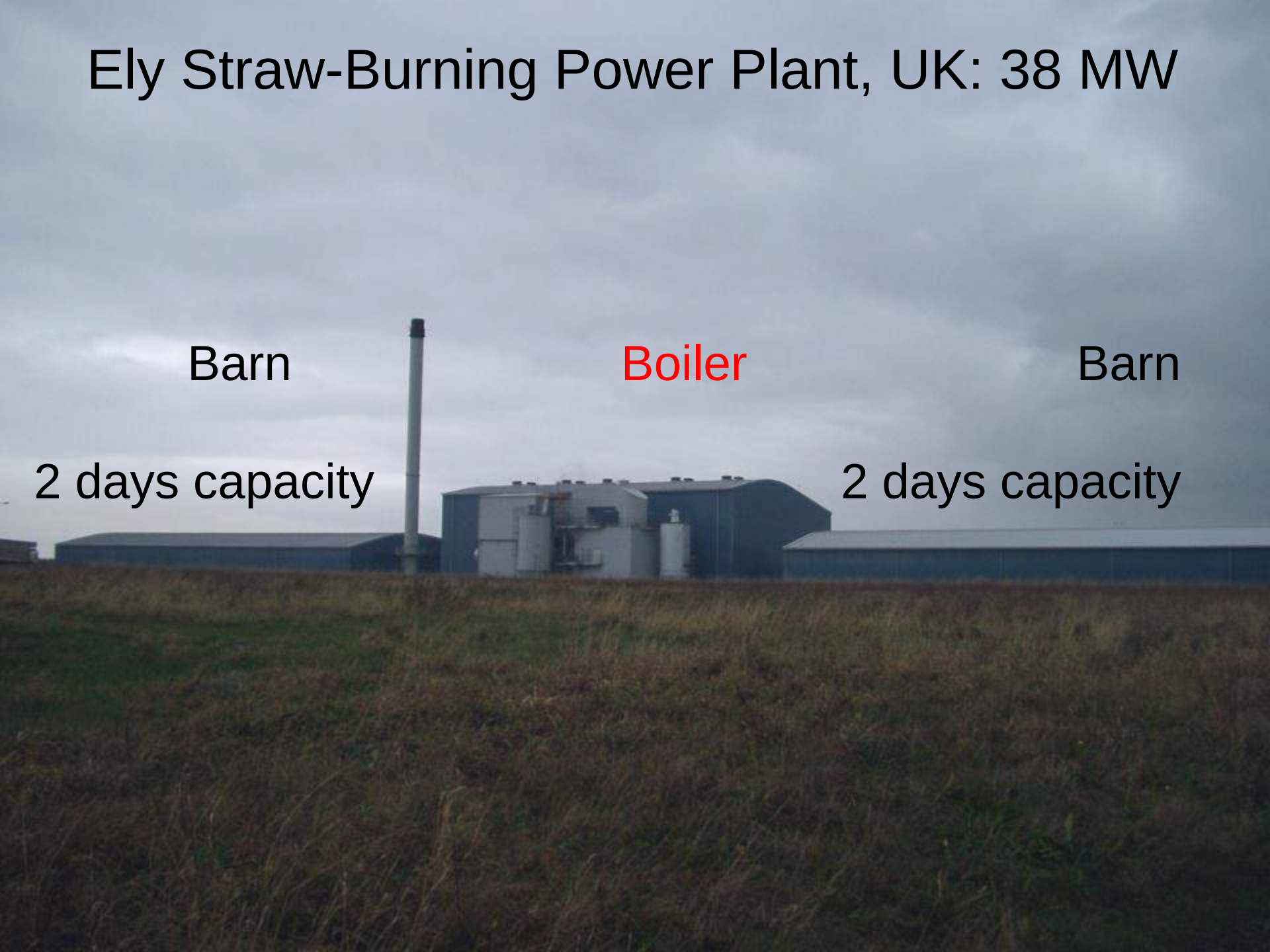
Leadership in

- Borealis Wood Power
  - 45 kW_e 120 kW_{th}
- Woodchips only due to gasification chamber design

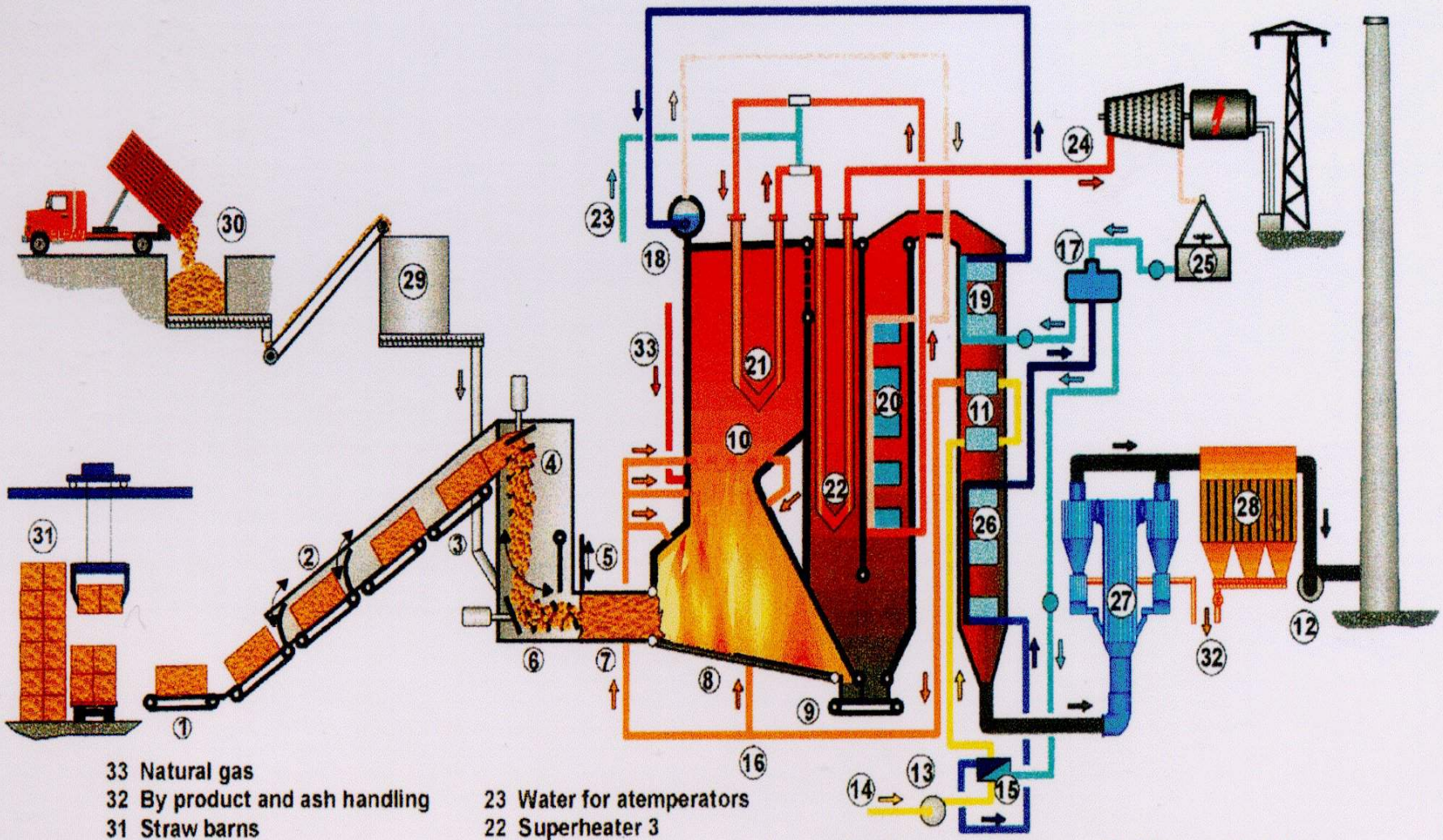

Maabjerg, Denmark
Co-firing Co-generationPlant 28 MWe

Cigar Burning Uses Whole Bale

Ely Straw-Burning Power Plant, UK: 38 MW

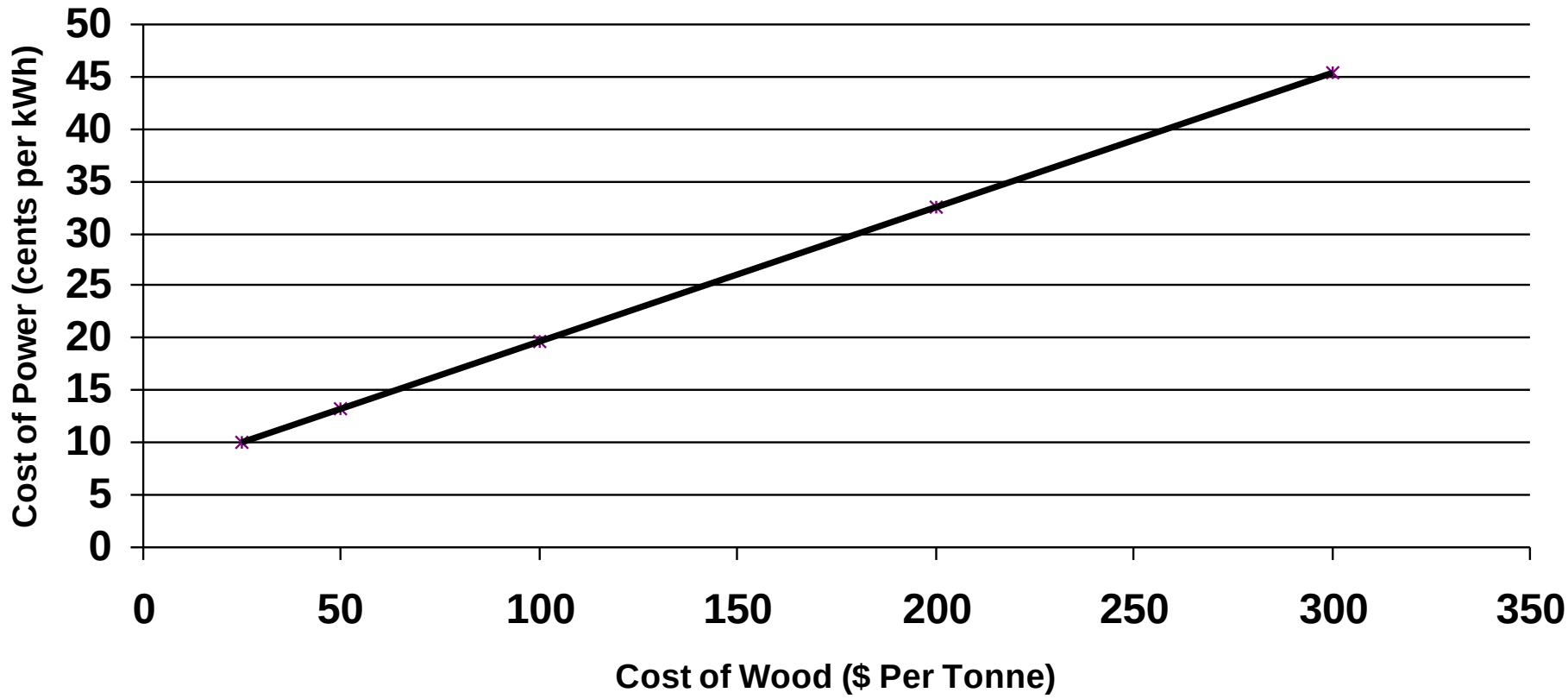


Bales are shredded just prior to entering furnace



33 Natural gas
32 By product and ash handling
31 Straw barns
30 Wood chip
29 Wood chip silo
28 Fabric filter
27 Gas Suspension Absorber
26 Flue gas cooler
25 Aircooled condenser
24 High pressure steam to turbine
23 Water for atemperators
22 Superheater 3
21 Superheater 2
20 Superheater 1
19 Economiser
18 Steam drum
17 Feedwater tank
16 Preheated combustion air
15 Air preheater
14 Combustion air intake
13 Forced draught fan
12 Induced draught fan
11 Air preheater
10 Combustion chamber
9 Slag conveyor
8 Vibrating grate
7 Water cooled duct
6 Stoker
5 Fire dampers
4 Scarifier
3 Dosing unit
2 Seal gates
1 Chain conveyor

Estimated Cost of Power for 25MWe Biomass Plant



Based on wood feedstock, 25 yr plant life and 27 employees to operate plant

Courtesy COOK Engineering
A Division of Genivar

Large Renewable Procurement (LRP) Program

- The Ontario Power Authority (OPA) merged with the Independent Electricity System Operator (IESO). Now known as the IESO.
- LRP Program: competitive process for procuring large renewable energy projects (generally > 500 kW)
- Request for Qualifications (RFQ) stage: LRP 1 RFQ
  - Mandatory requirements focused on past development experience and financial capability.
  - Final Qualified Applicants can submit to Request for Proposals (RFP)
- LRP 1 RFP procurement targets:
  - 50 MW bioenergy, 300 MW wind, 140 MW solar, 75 WM waterpower
- Maximum LRP biomass price: 15.6 ¢/kWh

OBPC and CHP (1)

- OBPC was approached by a 'Qualified Applicant' who is developing several large combined heat, power and cooling biomass electricity projects.
  - Biomass electricity
  - Heating loop and cooling loop (absorption chillers) for green-field industrial parks
  - Vision to replicate model broadly with consistent feedstock and equipment

- LRP maximum price (15.6 ¢/kWh) likely only works for wood-based biomass electricity if no additional benefits captured.
- However, combining electricity, heating, and cooling in a district energy loop theoretically provides 60% energy conversion (compared to 30% for electricity generation alone). This extra revenue can allow a project to pay a higher price for biomass.

OBPC and CHP (2)

- The proposed first projects would be located in Southwest Ontario.
- One objective of the developer is to include a significant proportion of “local” biomass as part of the feedstock blend:
  - “Sustainability” and “Local” as corporate priorities
  - Reduced GHG footprint (vs. hauling wood from the North)
  - Security of supply
- OBPC has provided an estimate of possible biomass supply
- IESO has extended contract finalization to August 2015.
  - Stay tuned!

- Questions?