

# AN ECONOMIC MODEL OF A STEAM PLANT FOR DECISION MAKING

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## ABSTRACT

A pulp and paper mill using many sources to generate steam needed a tool to facilitate decision making for production, operation and planning. Since energy costs are rising and markets are increasingly competitive, managers must ensure that everything is done to maintain low costs.

This tool is useful for managers since it helps them develop scenarios and make rational decisions. The simulator has also been used to test new operation modes previously rejected and now commonly used. Finally, the simulator includes a calculator that helps determine where automation could be added to improve efficiency and operate differently.

## INTRODUCTION

As many industries, the pulp and paper industry capitalizes on economic variables and benefits from a favorable market cycle. In the recent years, the situation of the pulp and paper market has been difficult and competition has been pushing plants to their limit.

To remain competitive, managers must leverage strategic resources. This paper shows how a simulation tool has helped improve operation and control of a steam plant.

## STEAM PLANT

The plant generates steam from the following sources:

- External supplier (biomass)
- Hogged boiler (bark and sludge) with extra gas and heavy oil burners
- Heavy oil boiler
- Gas and heavy oil boiler
- TMP

The sludge and ashes disposal costs are taken into account.

Depending on conditions, seasons, contract clauses and sludge disposition costs, the best way to operate the steam plant varies. For example, should the plant use the hog boiler to burn sludge even if it implies buying bark at a high price?

The steam plant has been optimized recently and all sources are available. The plant master control handles variation in combustibles costs to use the less expensive combustible and source.

Table 1 summarizes the steam sources of the mill.

External Supplier (Biomass)	100-300 T/h
Heavy Oil Boiler	10-50 T/h
Gas and Heavy Oil Boiler	8-80 T/h
Hogged Boiler (extra burners)	25-80 T/h
TMP	30 T/h

**Table 1. Steam Generation of the Mill**

## STEAM USAGE

The steam generated is used to supply paper machines (5), the pulp mill and utilities.

Four paper machines use low pressure steam and if one source is stopped, the mill can run 30 minutes using the header capacity before the pressure becomes too low and paper machines have to stop.

One paper machine uses high pressure steam and shuts down within 10 minutes if another boiler does not restart to compensate for the loss of one source.

The time to restart each boiler is known and the cost of losing one or more paper machine is also well known.

Table 2 summarizes the steam usage.

Paper machines	4 x 40 T/h
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Paper machine	1 x 45 T/h
Pulp mill	0- 20 T/h
Utilities	10-15 T/h

**Table 2. Steam usage**

## OBJECTIVES

The objective of this simulator is to better manage the steam house.

If extra steam is needed, which boiler should be added?

Should we maintain a back-up boiler?

Should we bury the sludge or buy extra residues to burn a large proportion?

Is it possible to run using only biomass?

## SIMULATOR

The simulator has been developed in Microsoft Excel.

### Parameters

The simulator uses a list of parameters that can be modified by an administrator user.

#### Costs

##### Combustibles

- Heavy oil
- Gas
- Biomass (bark and residues)
- External biomass supplier

##### Disposition

- Sludge (deinked and regular)
- Ashes (flying and grid)

#### Ratios

##### Moisture content

- Bark
- Sludge, deinked and regular
- Ashes, flying and grid
- Bark
- Sludge, deinked and regular

#### Efficiency

- Boilers
- Combustibles
- Impacts depending on
  - % sludge, % moisture
  - Load

#### Losses

Per equipment (customer)

- Number per day
- Time per breakdown
- Production losses

Time before an extra boiler is needed

#### Gas emission

Equivalent emission per combustible

#### Characteristics

Sources, Minimum, Maximum

- Production for each supplier
- Cold start-up time
- Warm start-up time

Combustibles

- Energy content
- Steam tables

## Inputs

The simulator inputs are:

- Plant demand
- Boilers running, fuel selected, production
- Extra gas burners in biomass boiler
- Sludge tonnage
- Expected ratio Sludge/Bark in biomass boiler
- Estimated number and duration of boiler breakdown

## Outputs (tables, graphics and trends)

The simulator outputs are:

- Vented steam
- Most economical solution
  - Load for each boiler
  - Choice of combustible
  - Need to start an extra boiler
  - Ratio Sludge/Bark in hog boiler
- Costs and values
  - Each combustible
  - Each boiler
  - Sludge disposal
  - Ashes disposal
  - Steam
  - Production losses
- Efficiency, ratios
- Hourly and daily statistics
- Gas emissions

# RESULTS

Results are presented with tables, graphics and diagrams.

Yield		Boiler losses	
Steam production	3.62 \$ /GJ	Extra steam needed	0.66 \$ /h
Disposal	0.63 \$ /GJ	Cardboard machine	16.67 \$ /h
<b>Cost</b>	<b>4.25 \$ /GJ</b>	<b>Total</b>	<b>17.33 \$ /h</b>
<b>Totaux</b>		Bark consumption	
External supplier	1,028 \$ /h	7.2 Th/h	
Gas, Heavy Oil	191 \$ /h	174 Th/d	
Bark	156 \$ /h		
Sludge Disposal P/S	78 \$ /h		
Sludge Disposal dip	86 \$ /h		
Flying ashes disposal	56 \$ /h		
Grid ashes disposal	21 \$ /h		
<b>Total</b>	<b>1,616 \$ /h</b>		

	Production	Disposal	Losses	Total
<b>Total</b>	1,375 \$	241 \$	17.33 \$	<b>1,633 \$</b>
	33,003 \$	5,774 \$	415.90 \$	39,193 \$
	990 \$	173 \$	12.48 \$	1,176 \$
	11.9 \$	2.1 \$	0.15 \$	14.1 \$
<b>Cost</b>	<b>3.62 \$</b>	<b>0.63 \$</b>	<b>0.05 \$</b>	<b>4.30 \$</b>

	Total	9493	GJ/d	100%
Heavy oil	0		GJ/d	0%
Gas	575		GJ/d	6%
Biomass+External +PTM	8918		GJ/d	94%

CO2 Emissions	
Equivalent CO2 Emissions	28.6 T/d
	10314 T/y
Fossil/Biomass ratio	6%

Figure 1. Result summary - table

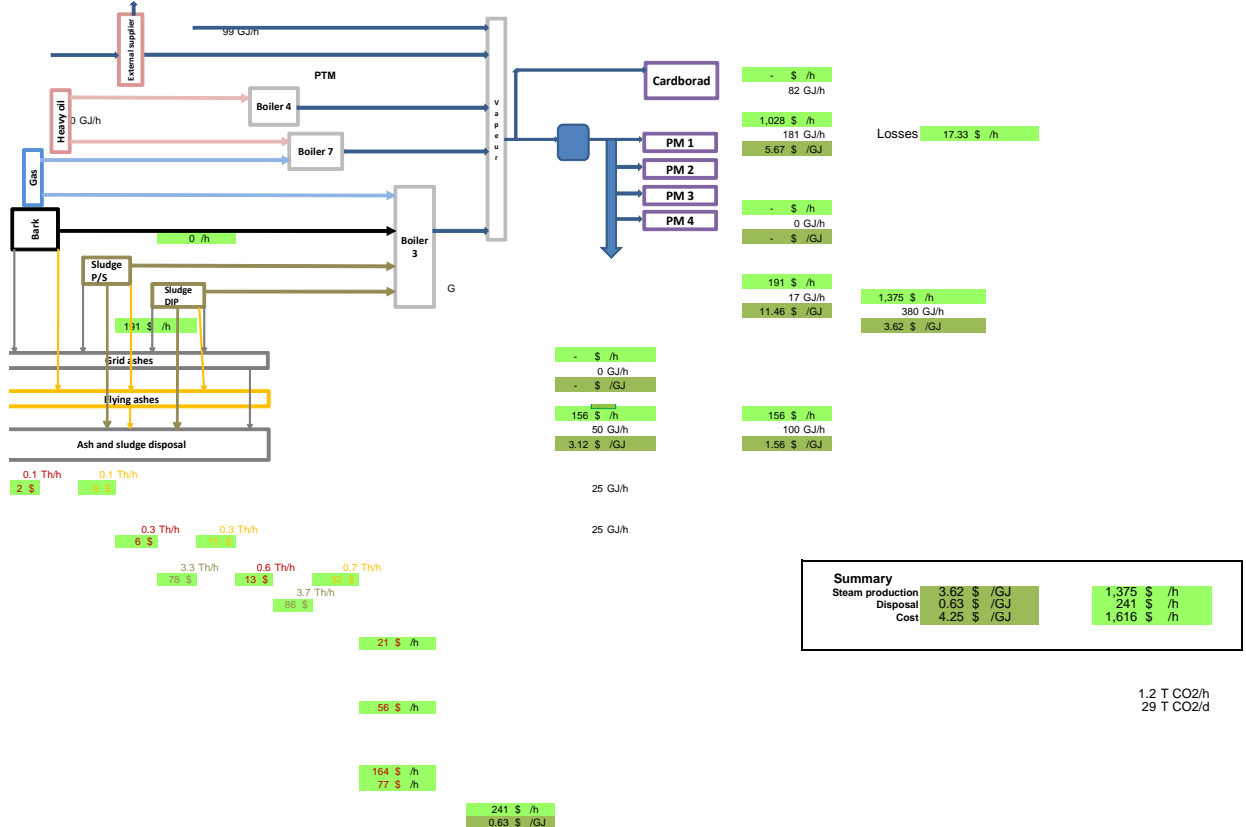


Figure 2. Result summary - diagram

# SCENARIOS

The simulator can generate scenarios, for example, to vary the cost or characteristics, seasonal changes, operation strategies, etc.

Thirty five values and parameters can be modified or override.

The user enters minimum and maximum values for each one and the system

generates intermediate values to build ten cases.

For example, figure 3 represents ten scenarios where an entire set of conditions and characteristics vary in ten steps. In this case, ratios of sludges and bark vary.

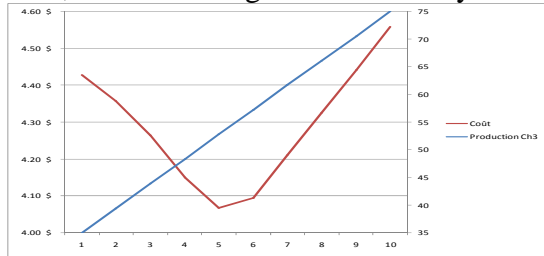


Figure 3. Scenario where bark and sludges ratios vary

## OPTIMIZATION

The calculator will estimate savings and equivalent CO<sub>2</sub> emissions if process parameters are modified:

- Oxygen excess
- Percentage of make-up in condensate
- Rate of production
- Type of fuel

This can be done for one boiler or the entire steam plant.

For example, figure 4 shows expected results if operation is improved.

## CONCLUSION

The purpose of this paper was to show the benefits of using simulation for decisions making regarding operation, management and optimization.

Using simulation, plants can review their operations and reduce their costs. They can also decide which areas will benefit more of more automation.

## REFERENCES

Ruel, Michel, Performance and Optimization – An Economic Point of View, ISA Management Division, July 2005 Newsletter.

[http://www.topcontrol.com/fichiers/en/Performance\\_Optimization\\_Economic\\_POV.pdf](http://www.topcontrol.com/fichiers/en/Performance_Optimization_Economic_POV.pdf)

Boiler name	Ch3	CH4	Ch7			
Steam Flow	70,000	45,000	60,000	0	0	(kg/h) 1kg/h = 2.2 lbs/h
Days of operation per year	300	12	160	310	365	
O2 % in flue Gas	5%	4%	3%	3%	3%	
Actual Water Make-up	10%	10%	10%	10%	10%	
Fuel [Enter O or G or B]	Bark	Oil	Gas	Gas	Gas	O or G or B
Targeted water make-up	7%	7%	7%	7%	7%	
Targeted O2 in flue	2.5%	1.5%	1.0%	1.0%	1.0%	
Steam Press	125	125	125	125	125	PSI (select 125 or 600 or 1250)
<b>Summary</b>	<b>Boiler 1</b>	<b>Boiler 2</b>	<b>Boiler 3</b>	<b>Boiler 4</b>	<b>Boiler 5</b>	<b>Total</b>
	Ch3	CH4	Ch7	0	0	
Fuel	Bark	Oil	Gas	Gas	Gas	
Equivalent Steam Flow	57,534	1,479	26,301	0	0	85,315 (kg/h)
Steam header pressure	125	125	125	125	125	PSI
Actual O2 in flue	5.0%	4.0%	3.0%	3.0%	3.0%	
Targeted O2 in flue	2.5%	1.5%	1.0%	1.0%	1.0%	
Actual water make-up	10%	10%	10%	10%	10%	
Targeted water make-up	7%	7%	7%	7%	7%	
<b>Potential economy</b>						
Combustion	24,485 \$	3,314 \$	70,268 \$	- \$	- \$	98,067 \$ /y
Water treatment	10,908 \$	2,033 \$	49,086 \$	- \$	- \$	62,027 \$ /y
Total	35,393 \$	5,347 \$	119,354 \$	- \$	- \$	160,094 \$ /y
CO2 eq	0	16	520	0	0	536 T CO2 equ/y
<b>Fuel economies</b>						
	0	10,689	0	0	0	10,689   Oil
	0	0	175,669	0	0	175,669 M³ Gas
	2,226	0	0	0	0	2,226 T Bark
	1,002	0	0	0	0	1,002 Tdry Bark

Figure 4. Improving operation