ISSCT Factory Workshop

"Technologies for profitable Cogeneration"

Factory Processes Research Program

cenicaña

Gold Coast, Australia 8-12 May, 2011

CONTENTS

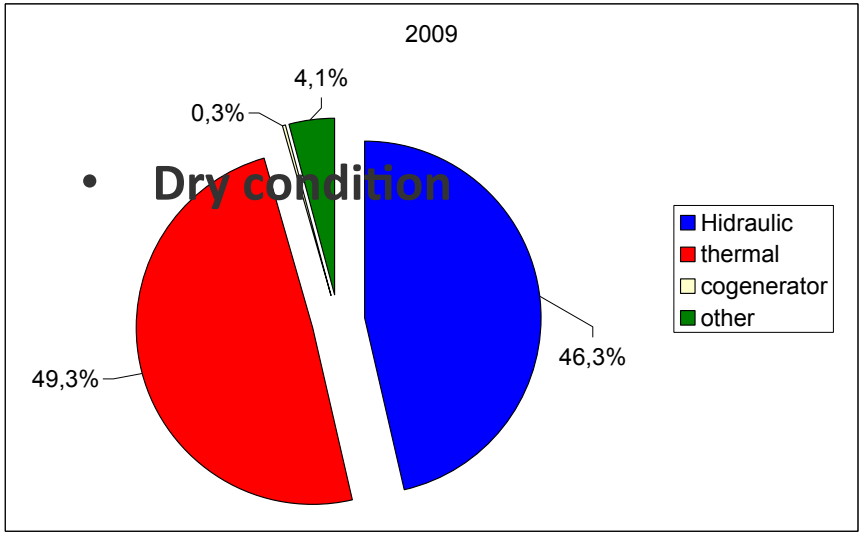
- **Cogeneration: Current situation of the Colombian sugar industry**

- **Cogeneration Project : Methodology for Basic Engineering.**

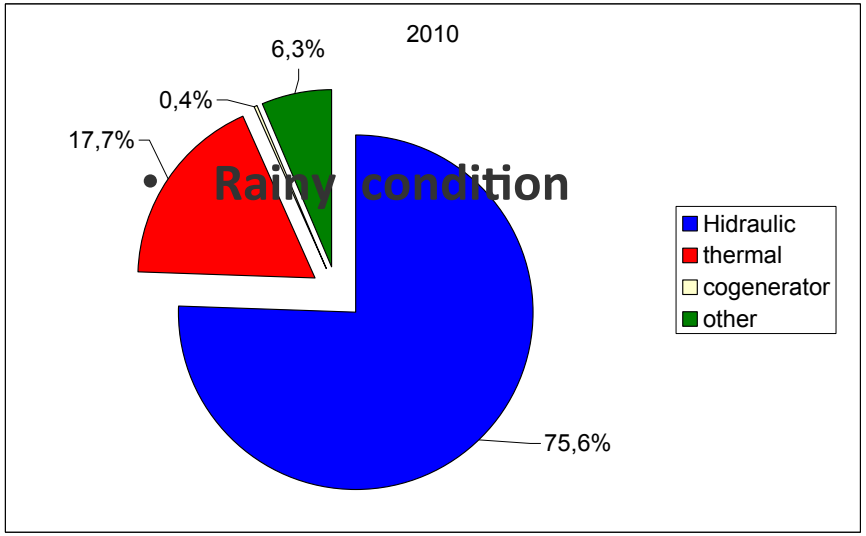
- **Energy Audits -Steam boilers efficiency assessment.**
- **Cogeneration Project –Case analysis**

- **Successful Case Study: Ingenio Providencia**

Seasonal Efect on Power Generation in Colombia



- Dry condition



- Rainy condition

Other conditions

- Some Bagasse is being changed for coal with paper mills.
- The electricity energy prices for 2010 were between 117 $/kWh - 126 $/kWh (0.066 US$/kWh).
- Regulations limit Cogeneration to max. 20 Mw.

Cogeneration: Current situation of the Colombian sugar industry

- 9 of the 13 Colombian sugar mills are considered cogenerators, of these only **3** have technology to sell more of 15 Mwh to the grid.

- **6** can sell up to 1.5 Mwh.

- Several cogeneration projects are under development to allow the Colombian sugar industry to sell more than 101 MWh, about 727 GWh / year

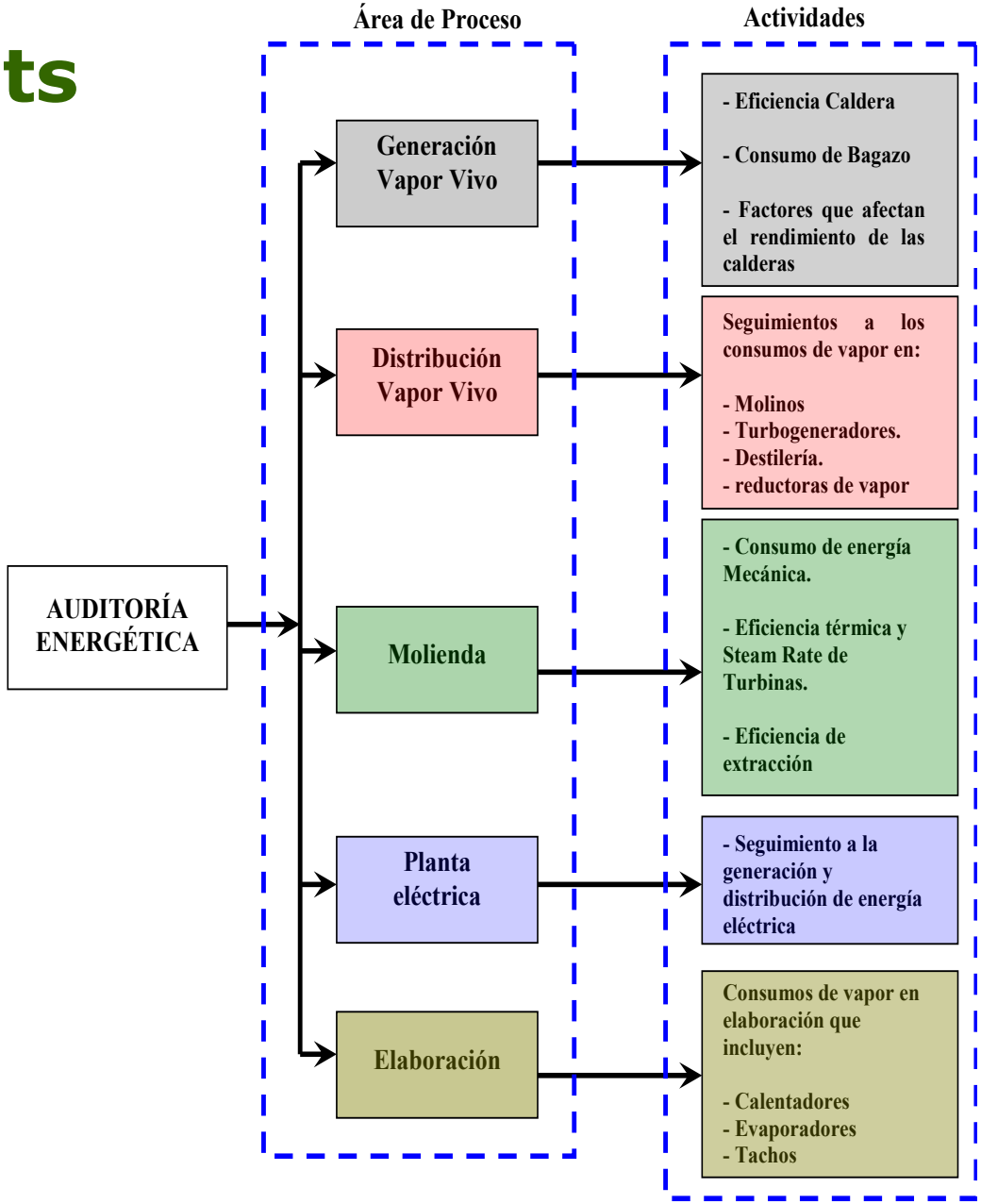


Basic Engineering Methodology

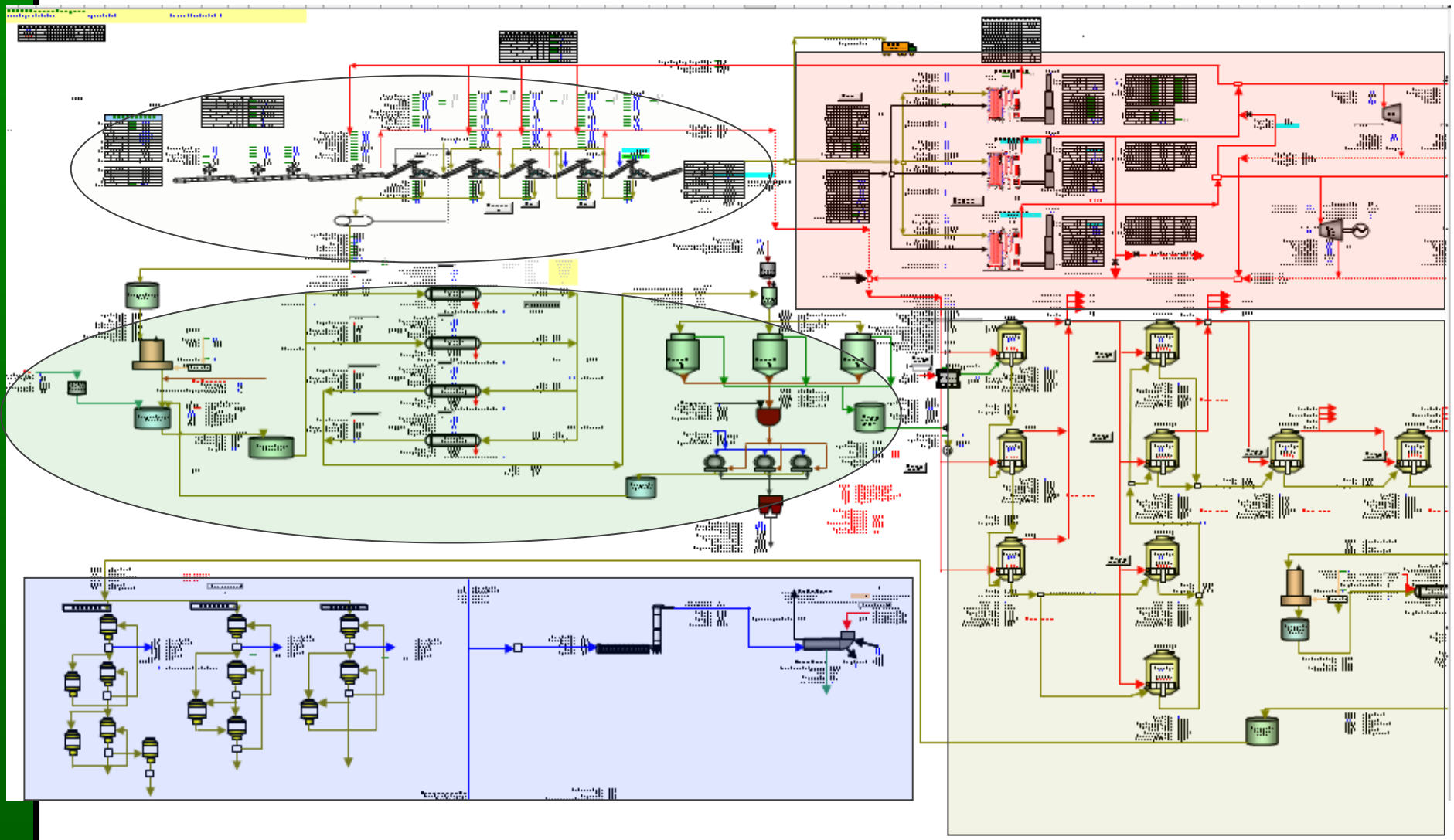
- Base Line: Mass and energy balances under current conditions.
- Reduction of steam consumption through energy integration.
- Defining electrification level.
- Cogeneration potential.

Energy Audits

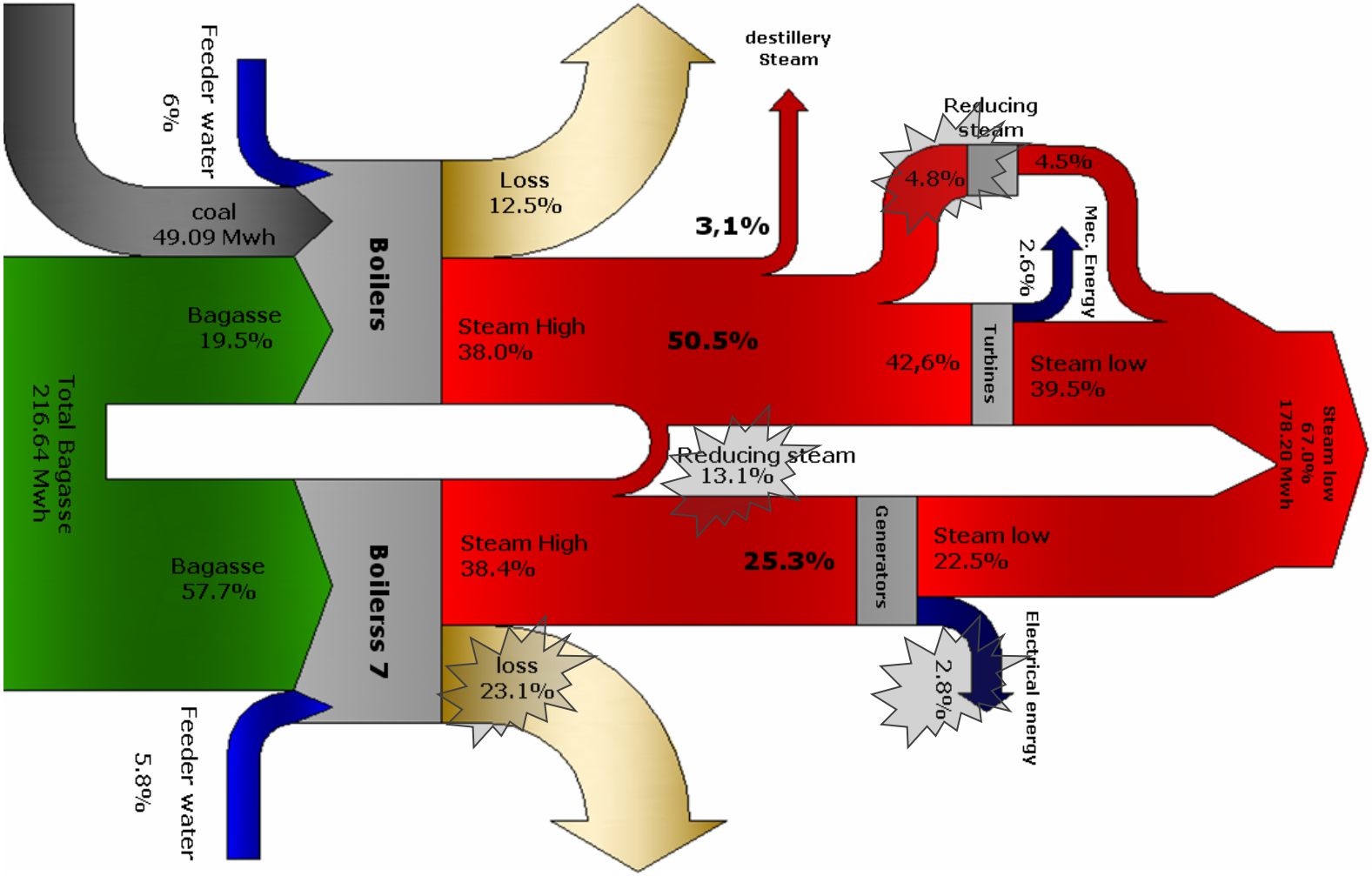
- Gross and detailed mass and energy balances are performed as an Energy Audit toghether with calculations using CENIPROF.



CENIPROF

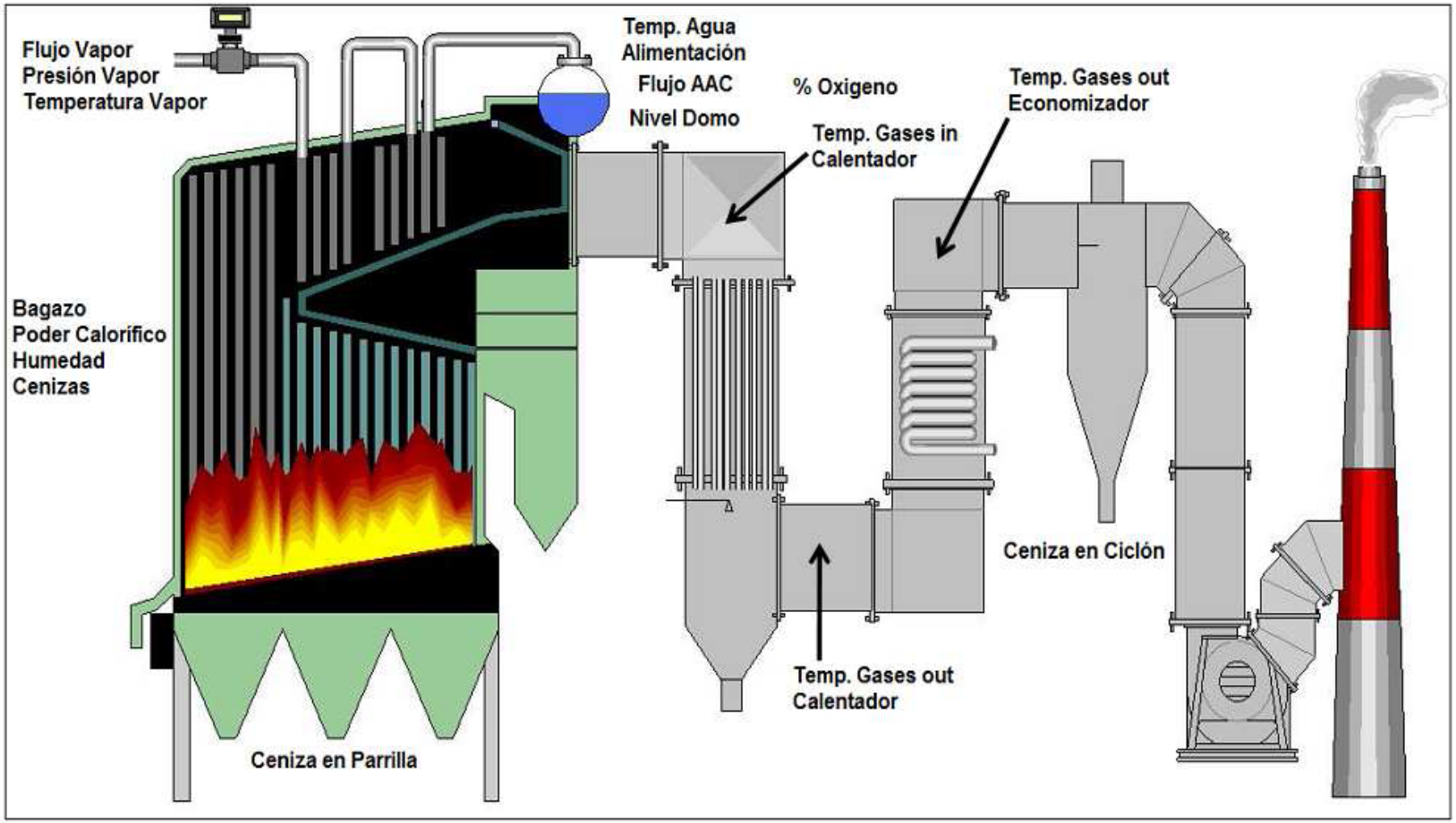


Mass and energy balances.

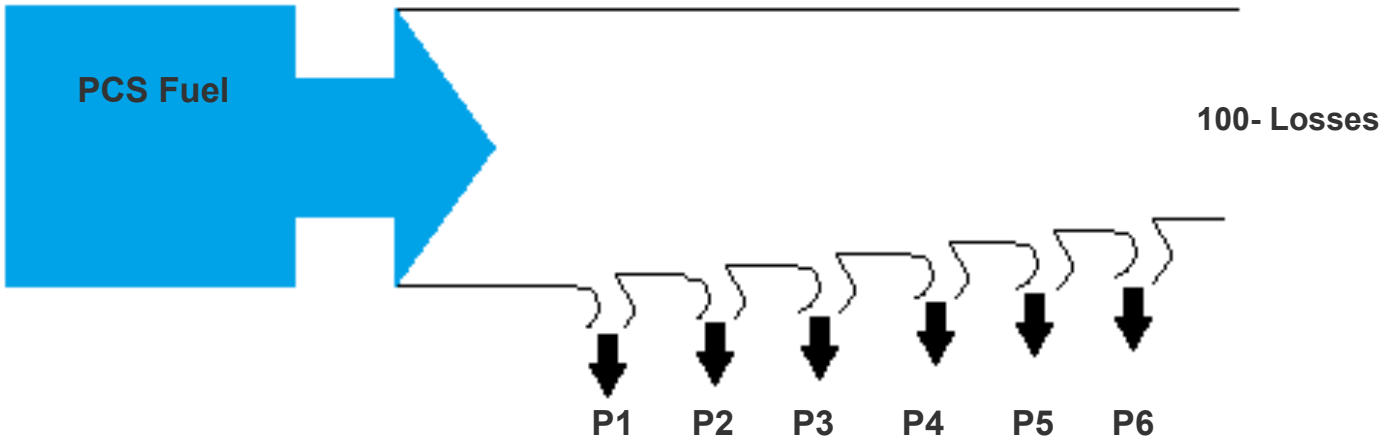


- Sankey Diagram, showing thermal energy distribution from fuels to low pressure steam.

Input and output variables for boiler efficiency assessment



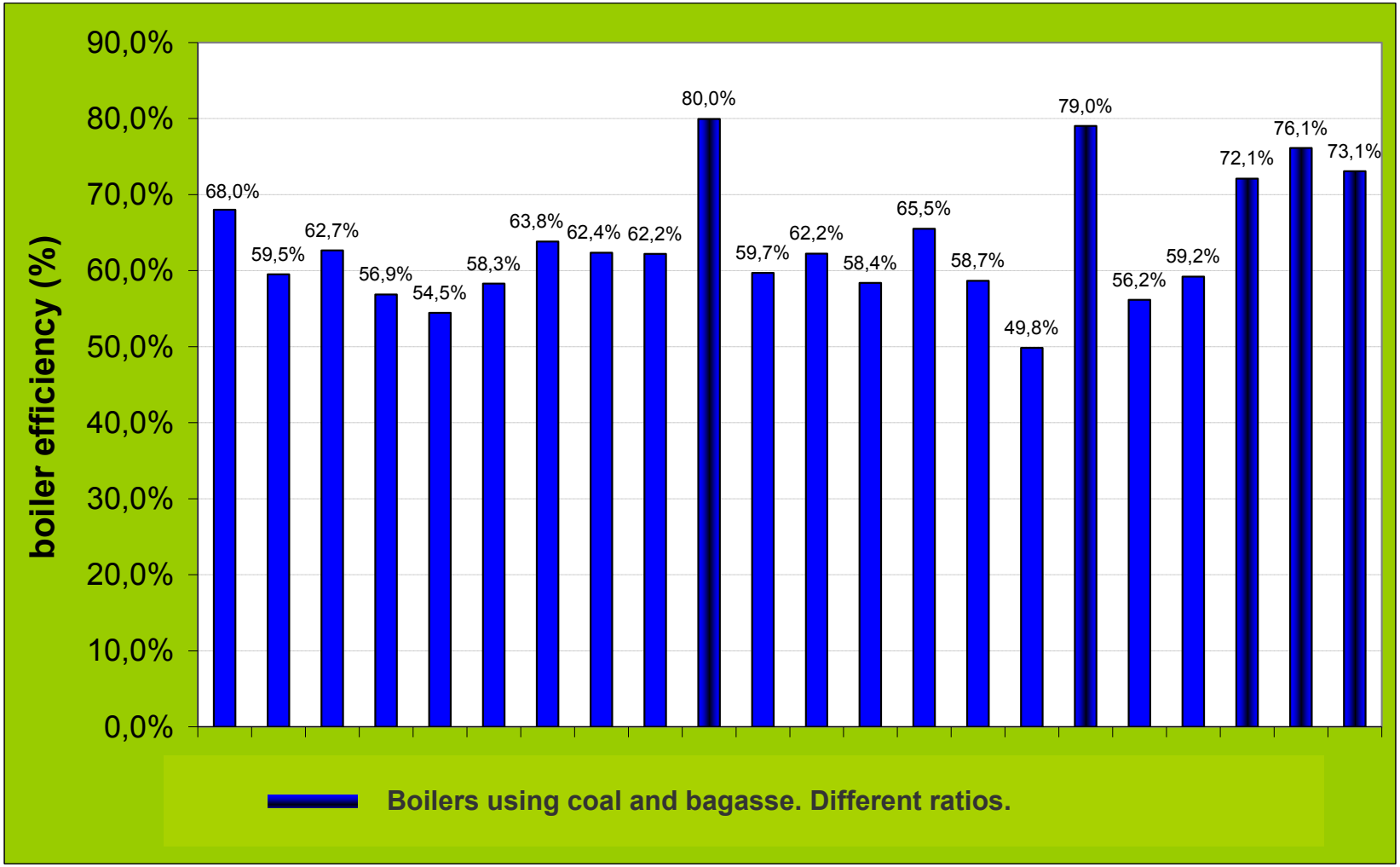
Direct and Indirect Methods for fuel requirements determination



Ecuación 9. Eficiencia Caldera Método Directo.

$$\eta_{caldera} = \frac{Q_{vapor}}{Q_{combustible}} = \frac{\overset{o}{m}_{vapor} \cdot \Delta h}{\overset{o}{m}_{combustible} \cdot PCS}$$

Boiler efficiency assessment.



Some Results

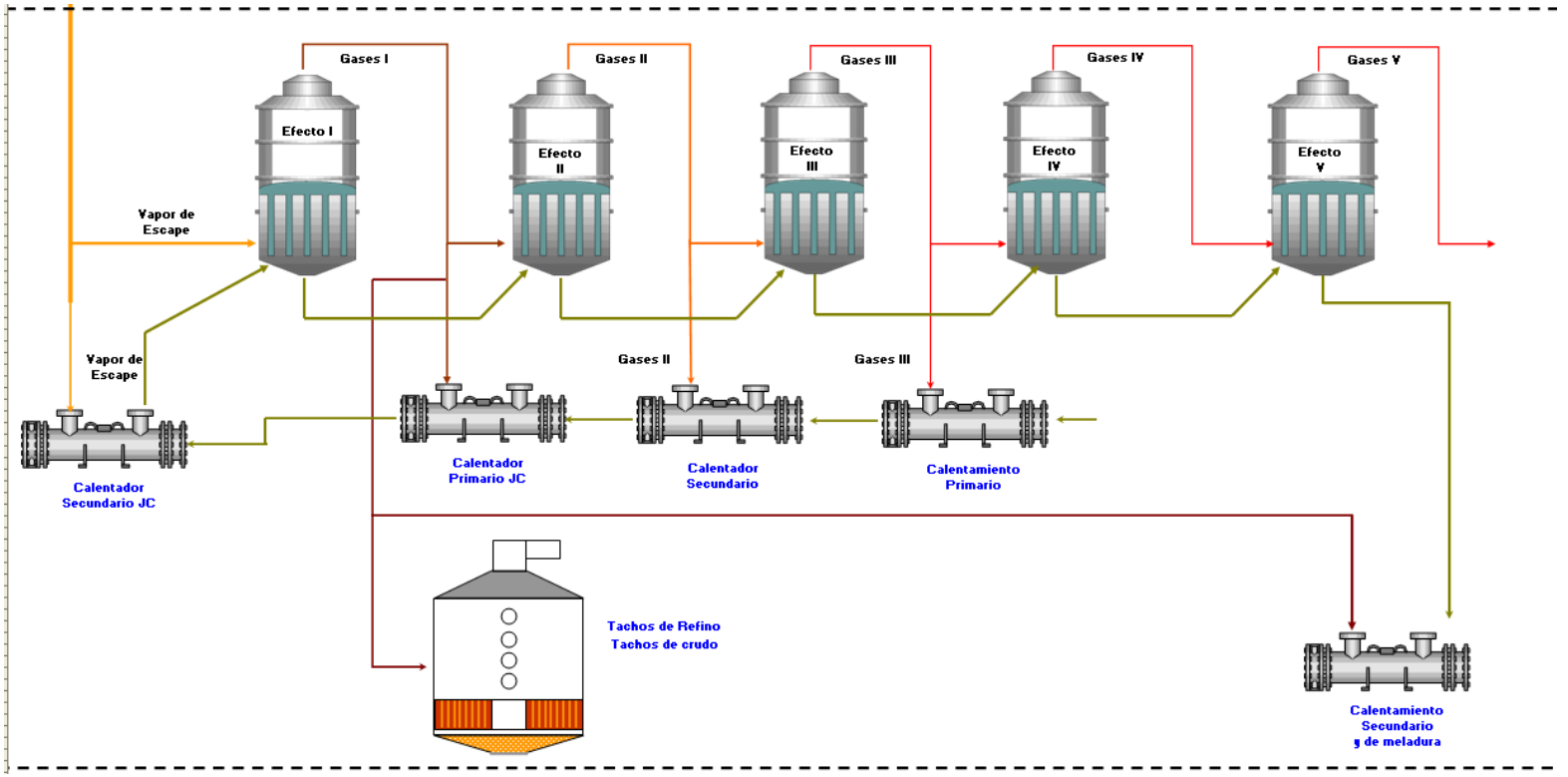
- With the results of the energy audit a Base Line is established.
- Three factors were found as critical for energy performance of the mill….
  - Bagasse HV (moisture and ash) affected by weather and operation.
  - Lost time.
  - Automatic Control strategies.

Cogeneration

Conditions studied for a mill

- **Case 1:** Current conditions.
- **Case 2:** Energy Integration for current conditions-
- **Case 3:** Energy Integration for new crushing rate and Imbibition 280% fibre .
- **Case 4:** Energy Integration for new crushing rate and 350% fibre Imbibition . Includes cogeneration project.

CASE 1-2: Current conditions-Some energy integration



Steam consumption

Consumo especifico	48.4%	Vapor % Caña
Consumo especifico	1067	lb vapor/ton caña

CASE 3: New crushing rate , Energetic integration.

- **500 TCH, fiber 16% cane.**
- Imbibition 280% fiber.
- All Electric drives.
- Low pressure steam as Case 2.
- New Boiler (**950 psig – 480°C**)

Steam consumption- Refinery and ethanol plant

Consumo especifico	48,4%	ton/h	Vapor % Caña
Consumo especifico	1067	ton/h	lb vapor/ton caña

Required area

Evaporador 1	6053	m2
Evaporador 2	7876	m3
Evaporador 3	7265	m4
Evaporador 4	678	m5
Evaporador 5	821	m6

Bagasse surplus

Caldera Nueva	125,0	ton/h
Caldera 7	0	ton/h
Caldera 5	0	ton/h
Bagazo % Caña	32, 0	%
Bagazo producido	161	ton/h
Bagazo excedente	36	ton/h

Estimated 1.94 lb vapor/lb bagasse

CASE 4: New crushing rate,Energy integration and Cogeneration-

- **500 TCH, fibre 16.0%**
- Imbibition **350%**
- Total electric drives
- Energy integration Case 2
- Steam Boiler **950 psig – 480ºC**

Steam consumption

Consumo especifico	51.5%	ton/h	Vapor % Caña
Consumo especifico	1136	ton/h	lb vapor/ton caña

Evaporators area required

Evaporador 1	6240	m2
Evaporador 2	7869	m3
Evaporador 3	8156	m4
Evaporador 4	951	m5
Evaporador 5	1136	m6

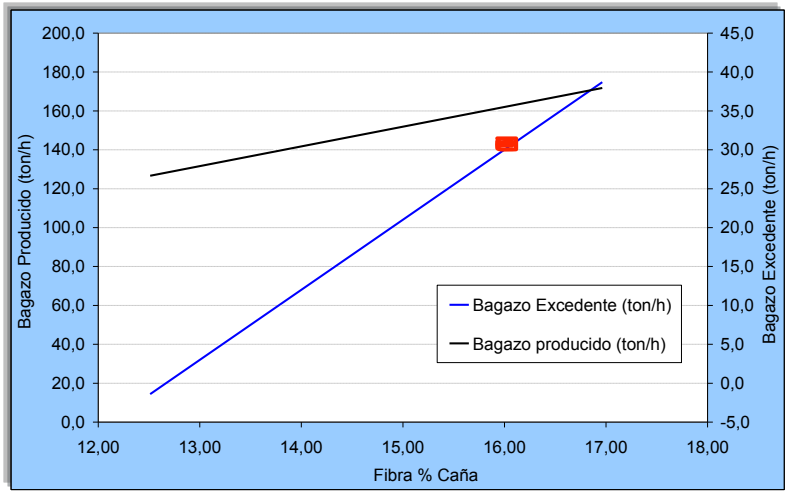
Electricity

Turbogenerador Contra	43016	kWh
Turbogenerador Condens	0	kWh
Total	43016	kWh
Steam rate Turbo Contrapresión	13,0	lb vapor/kWh

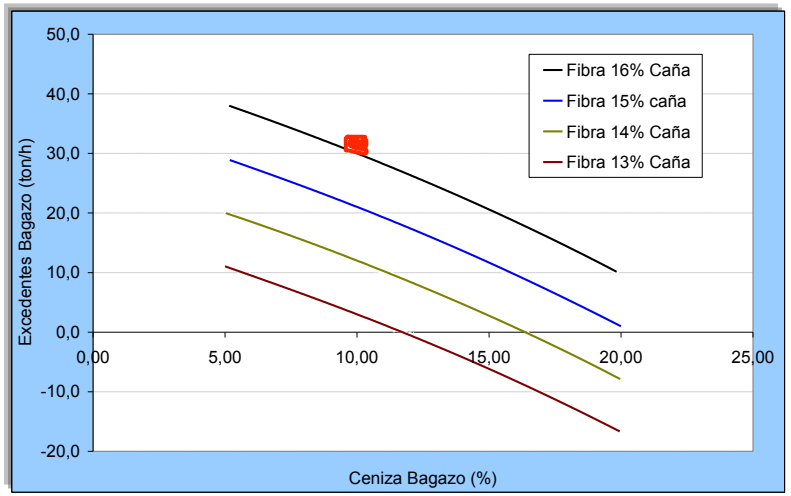
- Internal electricity consumption **20500 kWh.**
- Available to the grid**22516 kWh.**
- **Bagasse surplus : 29.5 ton/h.**

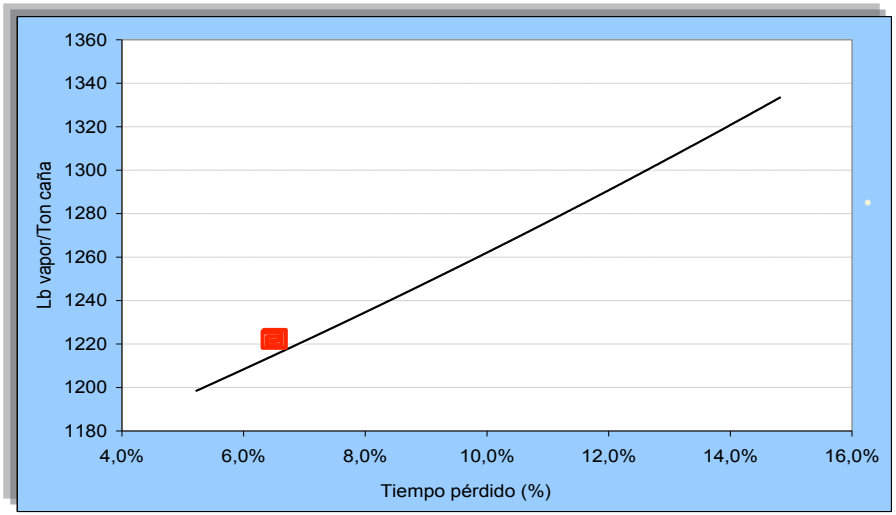
CASE 4: SENSITIVITY

Bagasse surplus to fiber % cane



Bagasse surplus to fuel quality





Specific steam consumption vs. Lost time.

Summary

- It is possible to sell to the grid > 20000 kWh with only bagasse.
- Effects of weather- cane quality and lost time were considered.

INGENIO PROVIDENCIA S.A.

COGENERACION DE ENERGIA ELECTRICA EN EL INGENIO PROVIDENCIA S.A









ADOLFO LEON VIVAS
Gerente de Fabrica

Boilers

Antes



Ahora



Power Plant



Electric Sub/Station



Milling train drives

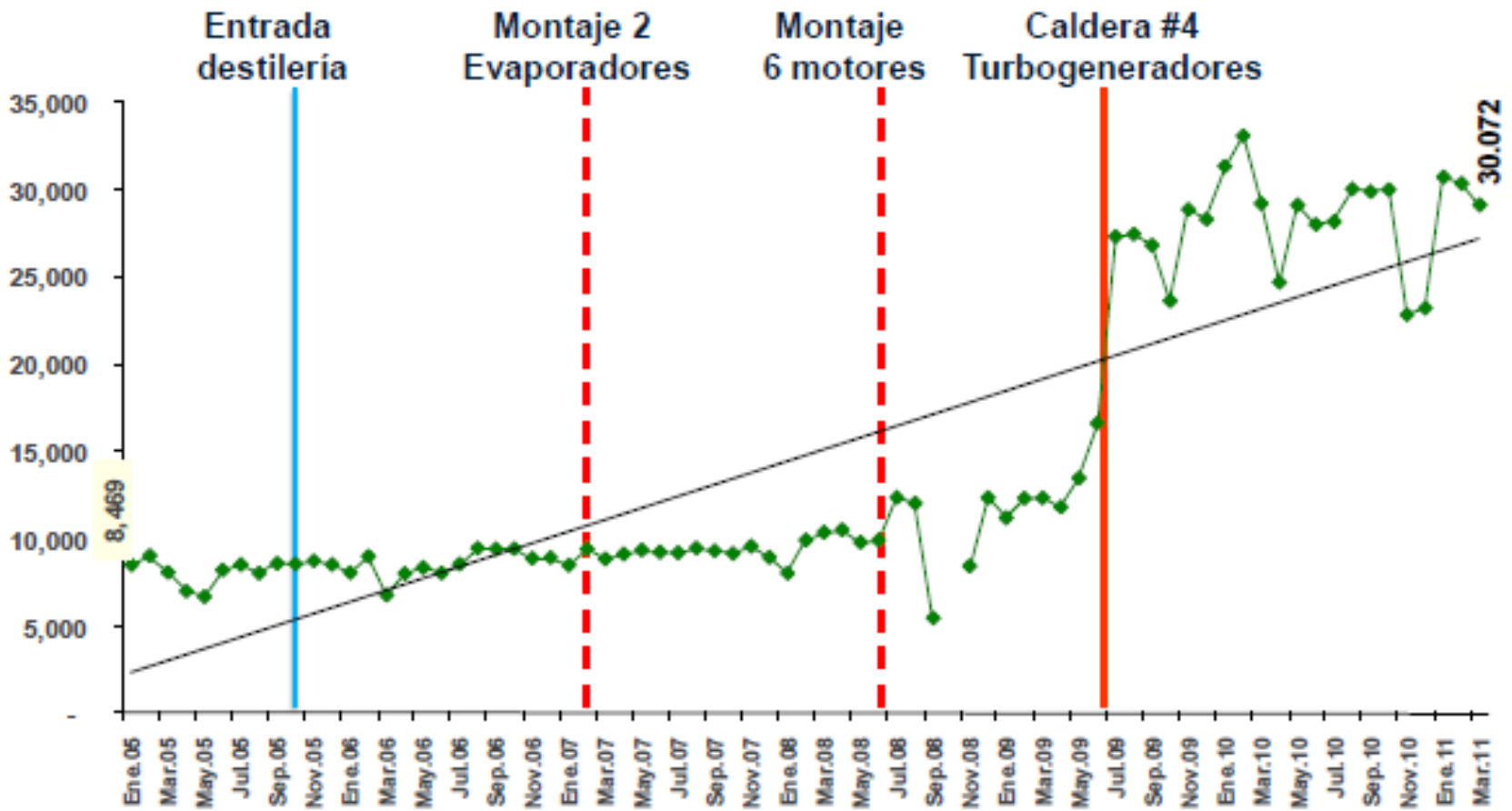


Molinos con Turbinas

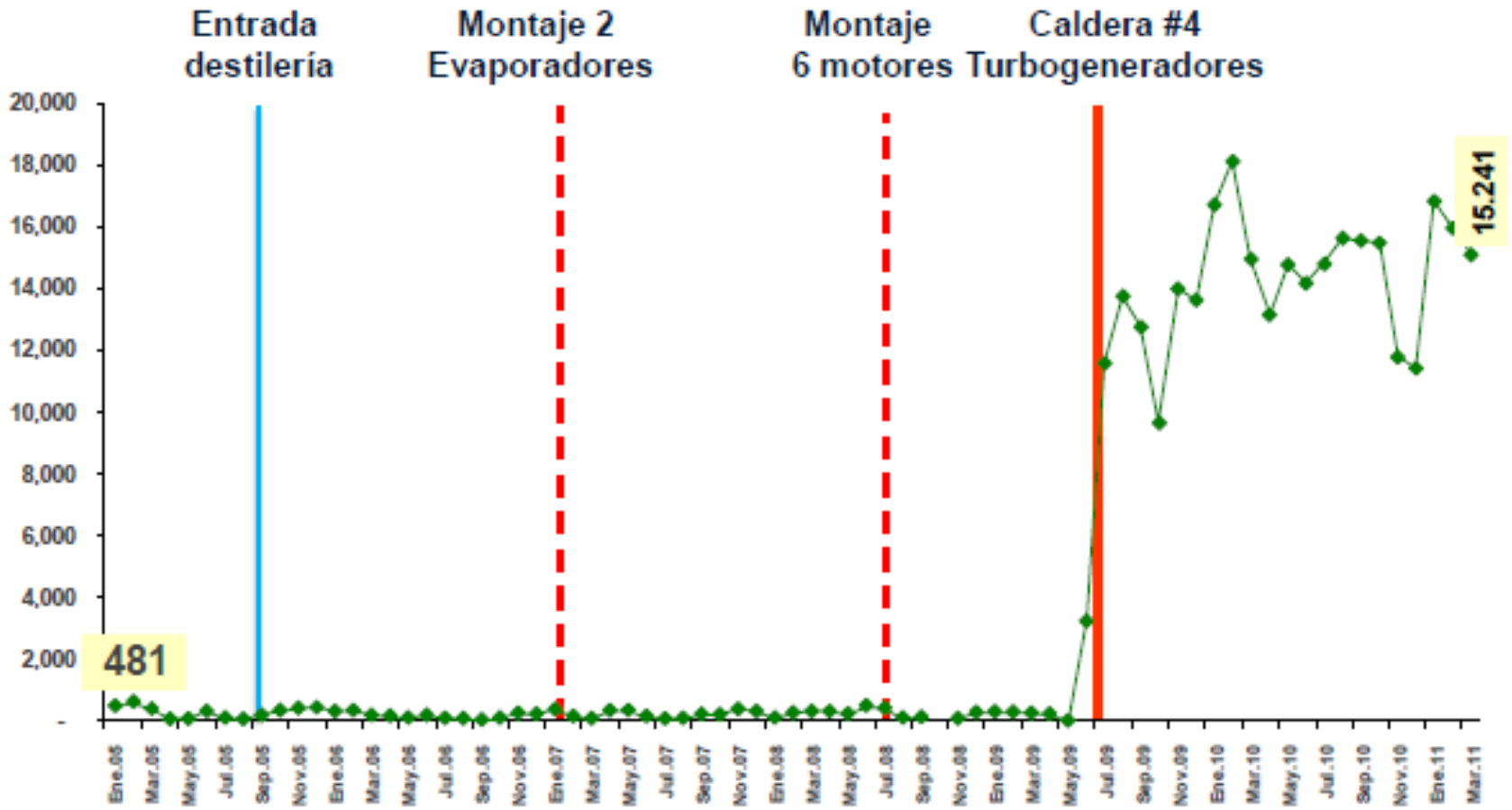


Molinos con Motores Eléctricos

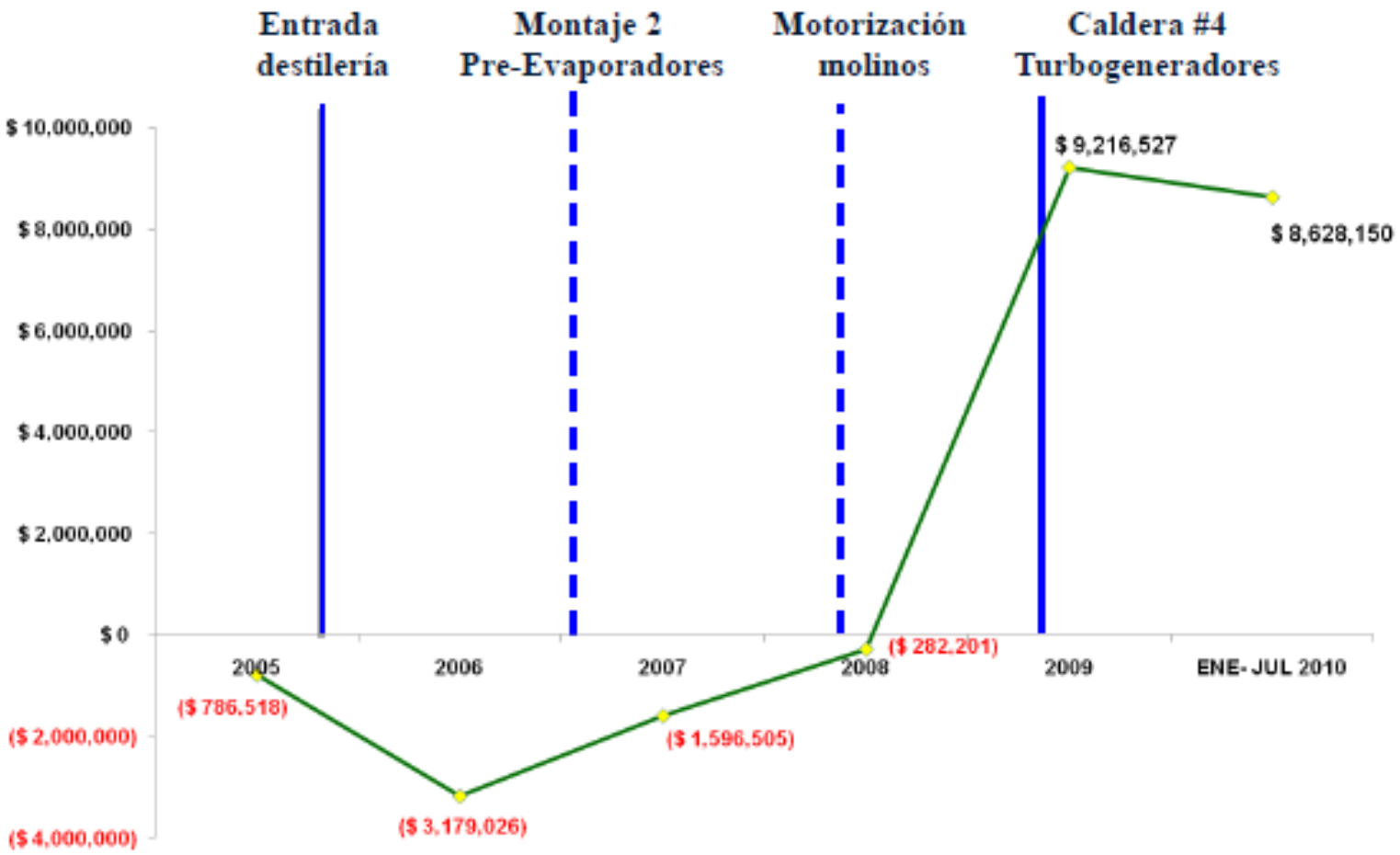
Generated Power
01/2005 to 03/2011



Power to the grid 01/2005 to 03/2011



Balance of Electricity-Bagasse-Coal (Col$x1000)



Kyoto Protocol Analysis

Equivalencias

1 Tons Carbón ahorrado → 2,7 Ton CO_2 (Equivalente)

1 Mw/h Generado → 0,35 Ton CO_2 (Equivalente)

	Unidades	Equivalencia	Tons. CO_2
Toneladas de Carbón Reducción de 3.160 ton.carbón mes * 12 meses	37,920		
Factor Equivalencia en CO_2		2.70	
Total toneladas de CO_2 / Ton. Carbón			**102,384**
Mw. de Energía Generados 16519 kw / h en 340 días	134,795		
Factor Equivalencia en CO_2		0.35	
Total toneladas de CO_2 / kw Energía			**47,616**
Total toneladas de CO_2 **No emitidas**			150,000

Total Cost for a Cogeneration Project

PROYECTO DE COGENERACION	EJECUTADO
EVAPORADORES	2,873,807 USD
MOTORES ELECTRICOS	4,116,282 USD
TURBOGENERADORES	14,016,233 USD
INTERCONEXION CON EPSA Subestación eléctrica de 13,2 kvoltios Subestación eléctrica de 115 kVoltios Redes Electricas de 115 kVoltios	3,556,872 USD
CALDERA	24,609,218 USD
PRECIPITADOR	2,785,424 USD
TOTAL OTROS	967,124 USD
COSTOS TOTALES DEL PROYECTO	52,924,960 USD



THANKS….

