

# Steam economy in raw sugar factories - the Reunionese experience

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# Reunion Island

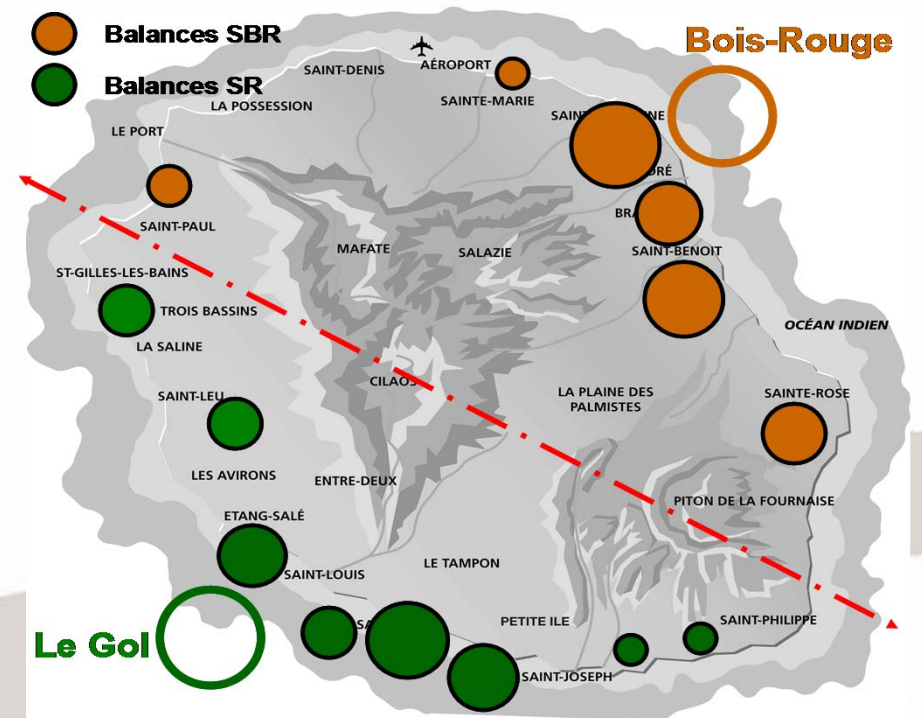
## Geography :

- ✓ 2 500 km<sup>2</sup>
- ✓ Craggy landscape
- ✓ 43 700 ha of agricultural area (17 %)



## Sugarcane :

- ✓ 26 500 ha
- ✓ Objective : 2 millions tons
- ✓ 13 delivering stations
- ✓ 2 sugar mills : Bois Rouge (BR) and Le Gol (GL)
- ✓ Sugar production : 200 000 T



# eRcane

- Research center funded mainly by Reunionese growers and millers.
- Created in 1929 to face cane diseases.
- 4 departments :
  - Breeding (1929)
  - Cultivation techniques (2007)
  - Process automation and industrial electronics (1975)
  - Process and Industrial Innovation (1985)
    - Sugar processing
    - Bio-refinery (2006)
- 90 workers (mainly breeding staff)



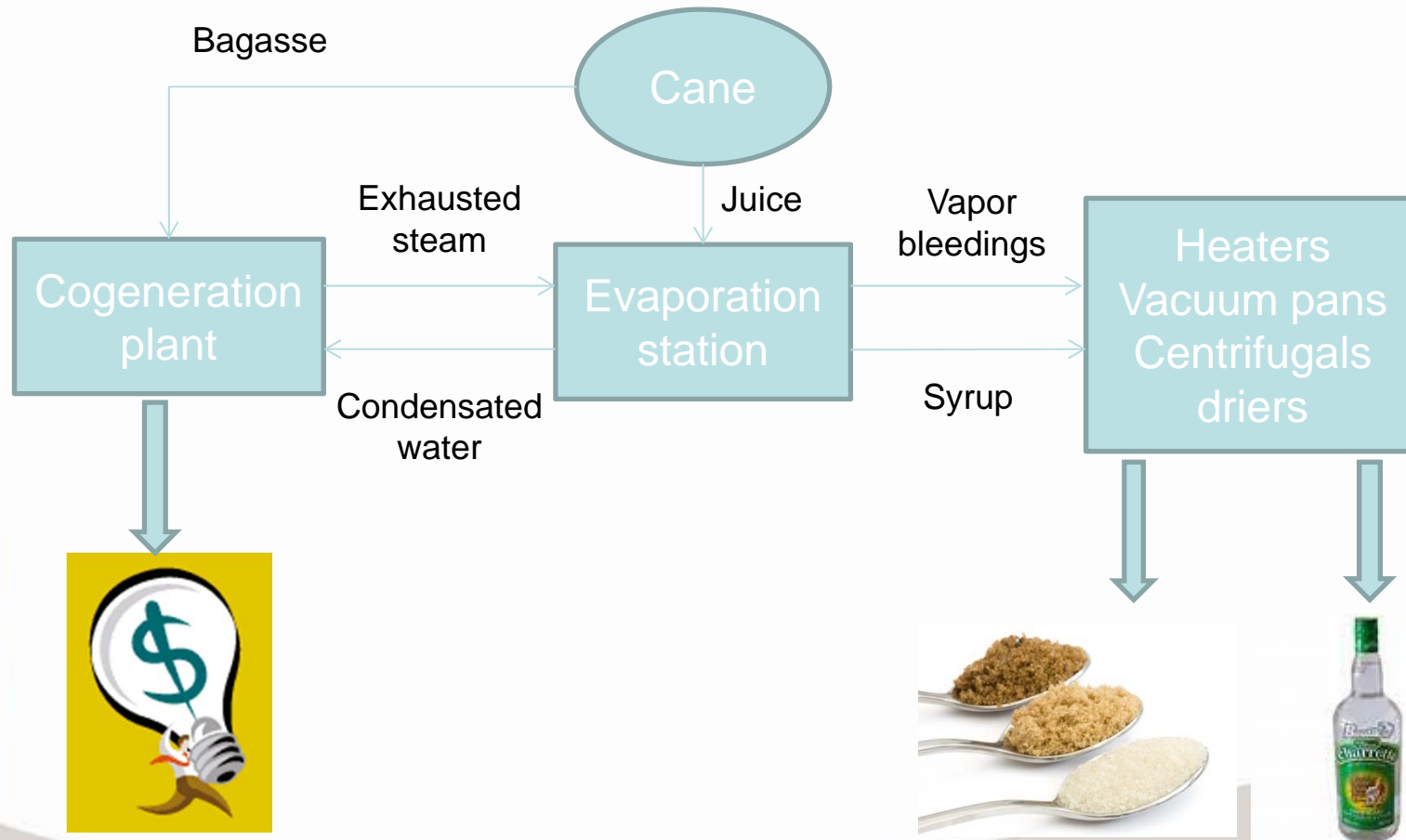
# BR and LG process overview

	Bois rouge	Le Gol
Capacity	8000 tc/day	8000 tc/day
Extraction	1 shredder 1 Bundaberg pre-extractor 1 Desmet diffusor 2 dewatering mills	1 shredder 1 pre-extractor 5 three-roll mills
Clarification	Hot liming Saccharate (syrup) Anionic flocculent SRI clarifier	Intermediate liming (75°C) Milk of lime Anionic flocculent SRI clarifier
Filtration	2 vacuum belt press filters	2 Oliver vacuum rotary filters (123 m <sup>2</sup> )
Evaporation	6 effects	6 effects
Crystallization	VHP scheme for raw sugars Crystallization house specific for special sugars Refinery Continuous pan : strike A & B	VHP scheme Continuous pan : strike A & C Discontinuous pan : footing & B

# LG and BR technical results (2013)

	Bois Rouge	Le Gol
Cane crushed (t)	859 000	858 000
Imbibition%canne	50,1	32,6
Pol%bagasse	0,80	1,06
H <sub>2</sub> O%bagasse	49,4	50,4
Apparent mixed juice purity	85,6	86,4
Clear juice turbidity	< 15	> 25
Pol%filter cake	0,85	0,90
Brix%syrup	69,8	70,1
Boiling House Recovery (%)	88,6	88,8
C molasse true purity (suc%MS)	43,6	44,7
C molasses TPD	8,4	5,9

# Why steam economy ?



Special agreement between sugar factories and cogeneration based on steam consumption.

# Power production context

- Very ambitious program to be self-sufficient in electricity production for 2030
- In 2013 :
  - Hydroelectric plants : 19,8%
  - Cogeneration plants (bagasse) : 8,9%
  - Aeolians, photovoltaic plants, biogaz : 8%
- Bonus for electricity produced with bagasse since 2010 :
  - 11 euros/tc for cane growers
  - 1,5 euros/tc for cane millers
  - 0,5 euros/tc for eRcane.

# First steam saving programm (2003- 2006)

- Reduce imbibition at juice extraction :
  - < 30 %cane, < 200% fibre (GL)
- Create a “cold point” with conversion of cane diffusion process to bagasse diffusion process
  - Optimize extraction
  - Obtain a juice which can be heated by low pressure steam or condensate water
- Limit water in the process
  - B and C sugars remelted with clear juice
  - Sugar dust from driers recovered by clear juice
- Optimize steam bleedings
  - Continuous pan on V2 or V3
  - Heaters up to V4 (for an 5<sup>th</sup> effect evaporation) with efficient heaters (platular)



# Second steam saving program (2006 – 2009)

- Evolution from 5 to 6 effects by adding a highly efficient effect (Falling film evaporator)
  - Increase steam recycling /decrease steam consumption
  - Lower steam loss in condenser
- Optimization of steam bleedings
  - Efficient heaters to use low pressure steam
- 3 years to really manage this new arrangement

# Optimisation of evaporation station

Effect	BEFORE 2006			AFTER 2006		
	Area (m <sup>2</sup> )		Vessel	Area (m <sup>2</sup> )		Vessel
	<i>BR</i>	<i>GL</i>	<i>BR / GL</i>	<i>BR</i>	<i>GL</i>	<i>BR / GL</i>
1	3500	4000	K / R	5000	4000	FF / R
2	3000	3400	R	3500	4000	K / FF
3	2000	1500	R	3000	3400	R
4	1500	1500	R	2000	1500	R
5	1500	1500	R	1500	1500	R
6				1500	1500	R

K : Kestner R : Roberts FF : Falling Film

# Focus on Falling Film evaporator

	BR	GL	
Juice circulation	1 passage	2 passages : juice in series, steam in parallel	
Effect	1	2A	2B
Heating area (m <sup>2</sup> )	5000	2210	1790
Length of tube (m)	12	11.5	11.5
Outside diameter tube (mm)	35	35	35
Thickness (mm)	1.5	1.5	1.5
Vessel diameter (mm)	3900	2700	2400

- Choice of falling film technology for :
  - Good heating surface /volume → small space to erect the vessel
  - Good heat transfert coefficient → low delta T
  - Low juice residence time → low sucrose inversion

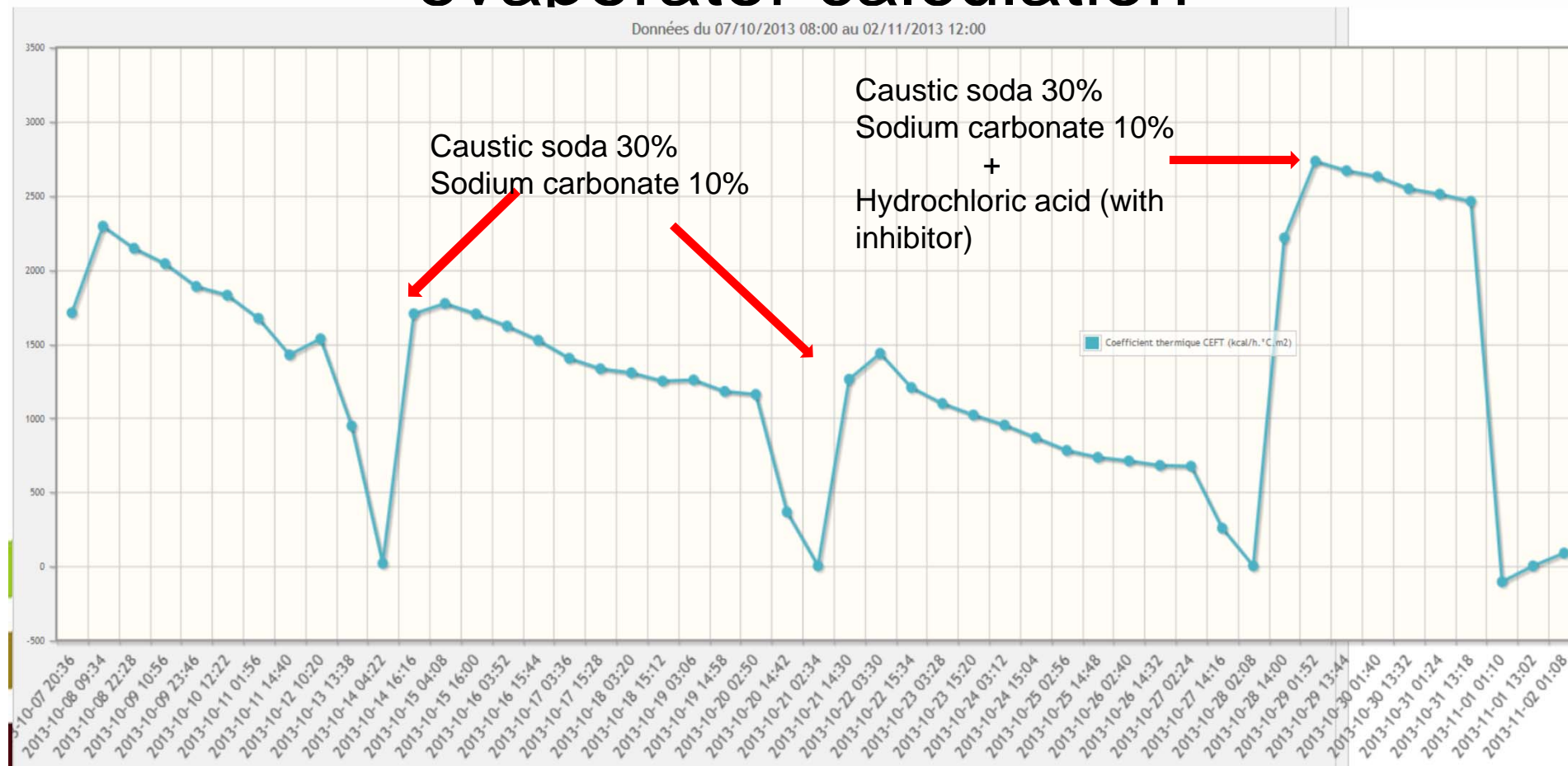
# Heat transfers assessment (BR)

$\Delta P$ (bar)	2011	
Date	16-sept	20-sept
CEFT	0,43	0,39
Kestner	0,55	0,51
3B	0,29	0,31
3A		
4	0,24	0,21
5	0,29	0,30
6	0,39	0,44

K (kcal/h.°C.m <sup>2</sup> )	2011		
Date	16-sept	20-sept	Référence
CEFT	2386	2457	2800
Kestner	1807	1635	1800
3B	1795	1771	2000
3A	887	928	1800
4	1735	2207	1400
5	1115	830	900
6	271	277	300

- FF evaporator had the best thermic performance:
- 3B and 3A : vessels in series on the juice side
  - No flash for juice entering 3A.
- Recurrent problem to assess heat transfer of vessel 4 which seems over estimated.

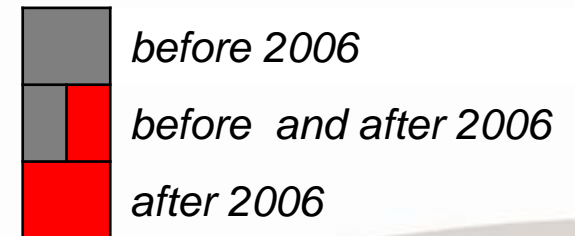
# Automatic heat transfert of FF evaporator calculation



- Difficulties to clean FF evaporator in BR :
  - Caustic soda do not enable to get back performances of previous week
  - Up to 3 hydrochloric acid cleanings during the crushing period
  - Studies in progress to use formic acid.

# Main vapor bleeds arrangements

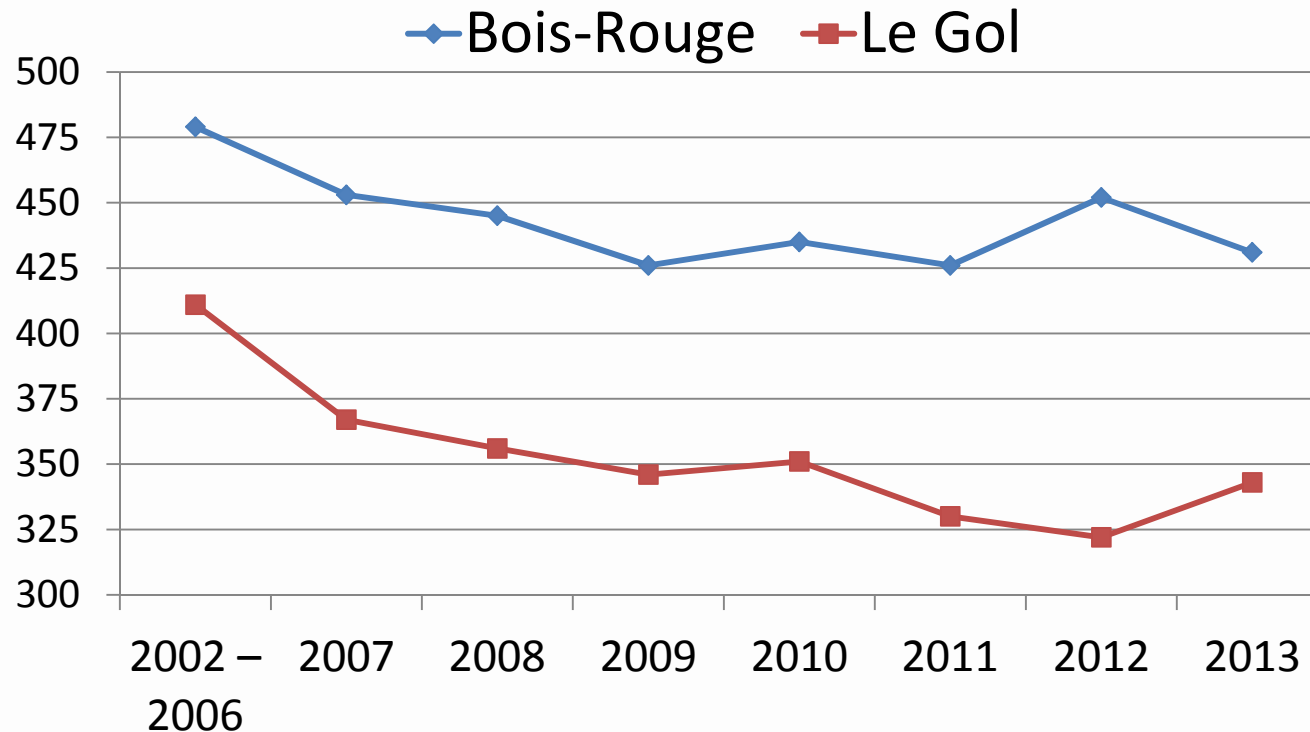
		VE	V1	V2	V3	V4	V5	V6	H2O
Heating	Primary juice								■
	Scalding juice			■	■	■	■		
	Water press			■	■	■	■	■	
	Mixed / limed juice		■	■	■	■	■	■	■
	Clear juice	■	■	■	■				
Crist.	Continuous pan			■	■	■			
	Discontinuous pan		■	■	■	■			



- Investment in platular heaters :

- High heat transfer coefficient to reduce surface when low pressure steam is used
- Multi stages heaters → compact heating arrangement

# Steam specific consumption



- Each tone/h of steam saved allows to produce additional 0,085 MW

# Juice recirculation in FF evaporator

- Juice is coming in the recirculation box at the bottom of the vessel and, after have been flashed, it is pumped at the top of the vessel in the system of juice distribution.
- Possibility of mixing a part of the outlet juice to have a sufficient flow rate juice entering the vessel.
- Minimum wetting rate for tubes:
  - 100 L/tube/h in BR mill
  - 75-80 L/tube/h in GL mill
- Special fear for millers to recirculate juice in first or second effect.
- No sucrose degradation detected by reducing sugars balances
  - Little recirculation at steady working period
  - Low juice residence time
  - masked by alkaline degradation of hexose ?



# Juice level in evaporators

- Low juice level in last effect even at nominal clear juice flow.
- Before 2006 : negative apparent purity drop in evaporation
- After 2006 : slightly positive apparent purity drop
- Significant reducing sugars increase in last effects
- In order to reduce undetermined losses in evaporation station, BR took the decision in 2009 to :
  - Prevent juice coming out FF evaporator to recirculate
  - Reduce heating area of 5th et 6th effect by obstructing tubes
- Reducing sugars increase in last effects was lowered but we have still a positive purity drop.
  - NB : we stop to use lead acetate for polarization assessment in 2008

# Evaporation oversized ?

- Low exhaust steam pressure specially at the start of the week with clean vessels
    - Difficulties to reach the right temperature (105°C) to flash juice
    - Reduction of evaporation capacity in crystallization pans
  - In 2013 GL crushing season, to increase pressure at the head of evaporation :
    - Water injected in clear juice tank,
    - Water injected in last effect .
- Specific steam consumption has increased...

- Linked to a decrease of cane in Reunion Island due to loss of agricultural area and to recurrent drought period for 3 years.
- Fluctuations in vapor 2 pressures, due to the draw-off of the batch pans, strongly destabilize the station

# Conclusions

- Reunionese sugar mills success to decrease steam consumption and so to export more electricity in the grid
- The six effect evaporation was really determinant to get objectives
- Steam consumption was reduced by at least 50 kg/tc
- Perspectives :
  - By pass of one of vessels of third effect to reduce heating area to stop (or decrease) water adding in evaporation because of lack of juice.
  - Installation of a valve to reduce pressure steam of V5 just before steam space of last effect

Thank you for your attention !

