

INTEGRATED EX-ANTE EMERGY EVALUATION OF PRODUCING BIOELECTRICITY FROM ENERGY CANE IN A SMALL ISLAND (GUADELOUPE)

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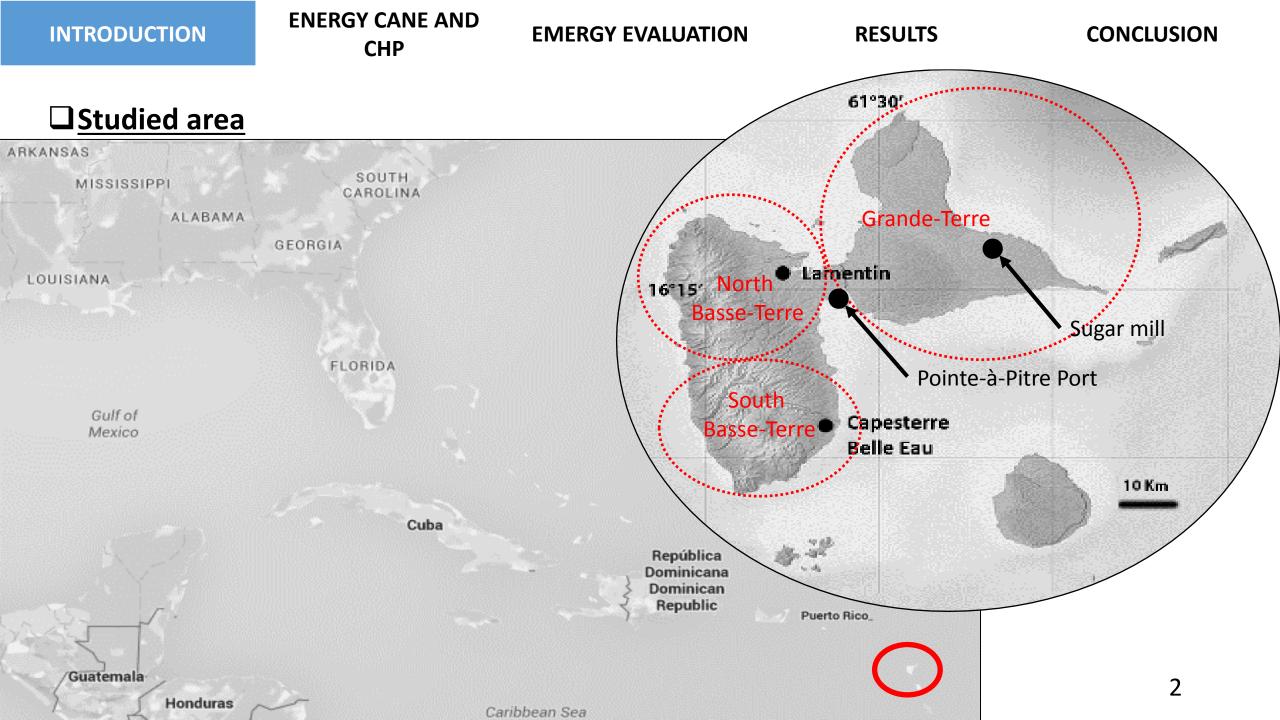




INTEGRATED EX-ANTE EMERGY EVALUATION OF PRODUCING BIOELECTRICITY FROM ENERGY CANE IN A SMALL ISLAND (GUADELOUPE)

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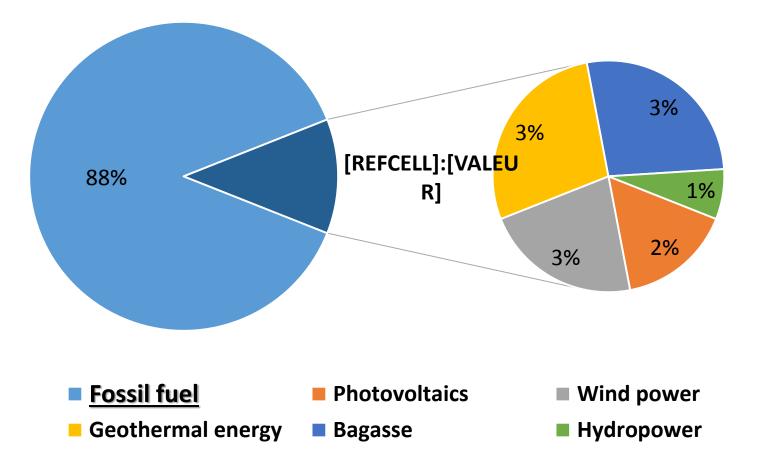
EMERGY EVALUATION

RESULTS

CONCLUSION

Context

Energy mix in Guadeloupe (2014)



- 50% of renewable energy over 2020 horizon
- Intermittent energy sources:
 30% maximum
- REBECCA project: electricity from energy-cane

RESULTS

CONCLUSION

Energy-cane

Selection of *Saccharum sp.* for:

- High fiber content
- High yield and growth rate
- Rusticity



Table 1: Comparison of energy-cane productivity with four others commonbiomasses

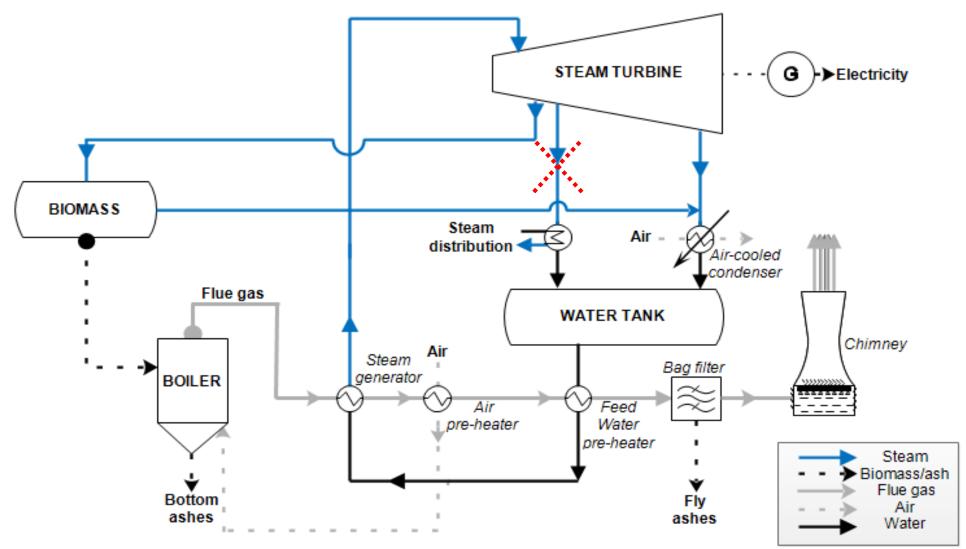
Original form (% moisture)	LCV (MW.h/t)	Yield (t/ha/y)	Yield (MW.h/ha/y)
Energy cane (65%)	1.20	110	132
Miscanthus (20%)	3.80	17	64.5
Bagasse (50%)	2.08	28	58.2
Switch grass (15%)	3.86	20	77.2
Hardwood (50%)	2.50	10	25.0

Photo 1: Variety WI 79 460 at 11.5 months

EMERGY EVALUATION

RESULTS

The Combined Heat and Power plant (CHP)



- Electrical yield: 27%
- No steam outlet
- > Air-cooled condenser

EMERGY EVALUATION

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The biomass production



Conventional energy-cane

- - Herbicides

 - Mechanical harvesting
- Subsidies



pellet

Imported

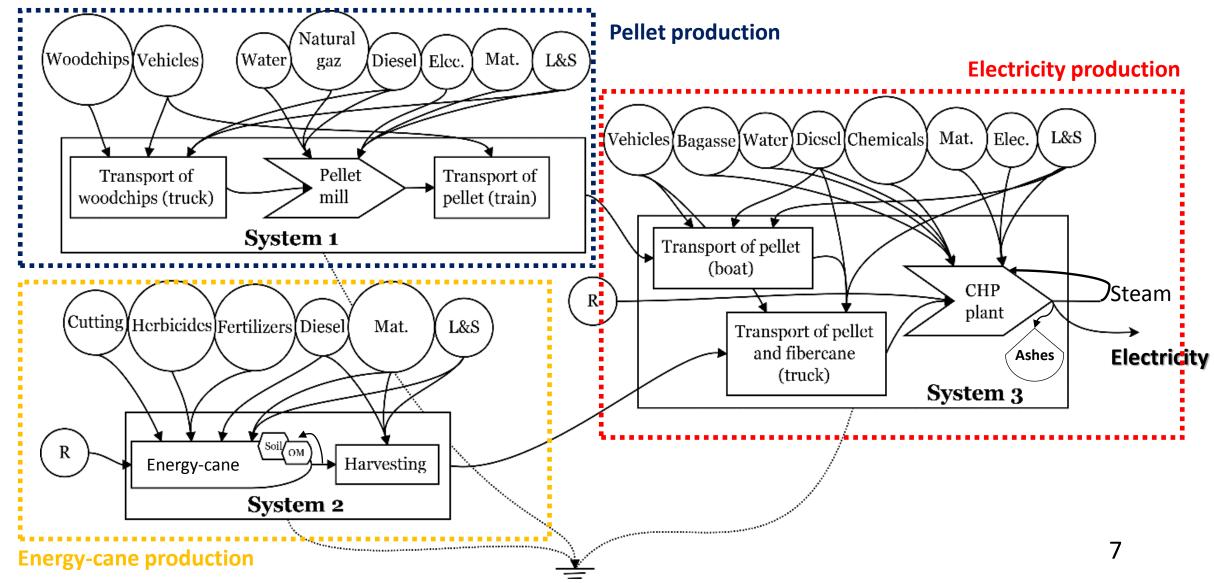
- Data from literature
- Plant located in Georgia (US)
- Woodchips from natural
- forest logging
- 9000 t/yr pellet plant

ne	• 6 years cycles
cal	 No irrigation
-Yg	Mineral fertilizers
energy-cane	Mechanical harvesting
	Mechanical weed mana
MART	All the biomass harvest
SM/	• <u>Compost amendment</u>

- cal weed management
- omass harvested
- Compost amendment
- Additional subsidies



□ <u>The agro-industrial sector</u>



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The four scenarios

SENARIOS	S0 Baseline	S1 ("SMART")	S2 (Pellet)	S3 (Micro-"SMART")
Plant's capacity (MWth)	40	40	40	4
Energy-cane in energy mix	70%	70%	25%	100%
Pellet in energy mix	25%	25%	70%	0%
Bagasse in energy mix	5%	5%	5%	0%
Plant localisation	Lamentin	Lamentin	Capesterre	Capesterre
Crop management system	Conventional	SMART	Conventional	SMART

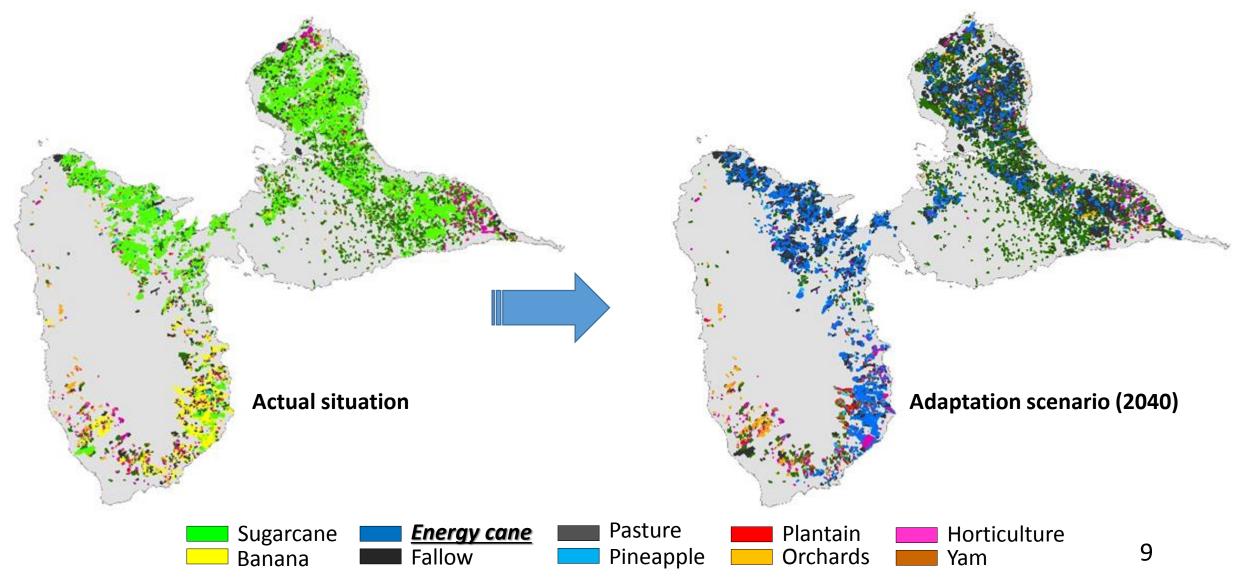
ENERGY-CANE AND CHP

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Energy cane crop adoption by farmers (MOSAICA, *Chopin et al.,2015*)



Emergy indicators

Indicators	Expression	Meaning
Unit emergy value (UEV)	Y / E	 The ratio of the emergy of the output (Y) to the energy of the products (E)
Renewability (%R)	100*(R + M _R + S _R) / Y	 The ratio of local renewable emergy (R) plus purchase renewable materials (RM) and services (RM) input, to the total emergy output (Y)
Renewable efficiency indicator (REI)	UEV / (%R)	 The ratio of efficiency to the percentage of renewability
Environmental loading ratio (ELR)	$(N + M_N + S_N) / (R + M_R + S_R)$	 The ratio of non-renewable emergy to renewable inputs
Emergy yield ratio (EYR)	$Y/(M_N + S_N)$	 The ratio of total emergy used to the emergy of non-renewable inputs from the economy
Emergy sustainability index (ESI)	EYR/ELR	 Indicates the relative sustainability of the system

INTRODUCTION ENERGY-CANE AND EMERGY	EVALUATION RESULTS	CONCLUSION
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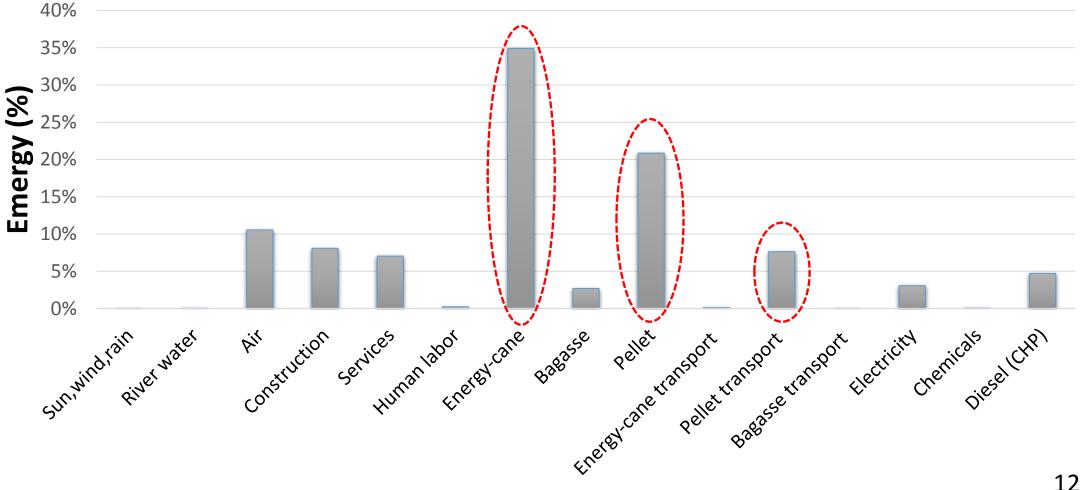
Indicators obtained for the four scenarios

Indicators	SO (Baseline)	S1 ("SMART ")	(Δ)	S2 (Pellet)	(Δ)	S3 (Micro-"SMART")	(Δ)
UEV (seJ/J)	3.11E+05	3.05E+05	-2%	3.88E+05	+25%	2.94E+05	-5%
%R	30.21	38.07	+26%	30.94	+2%	36.91	+22%
ELR	2.31	1.63	-29%	2.23	-3%	1.45	-37%
EYR	1.12	1.12	0%	1.09	-3%	1.13	+1%
ESI	0.48	0.69	+44%	0.49	+2%	0.78	+63%
REI (seJ/J)	(1.03E+04)	8.01E+03	-22%	(1.25E+04)	+22%	7.97E+03	-23%



Emergy signature of electricity production (baseline scenario S0)

Baseline CHP plant (S0)



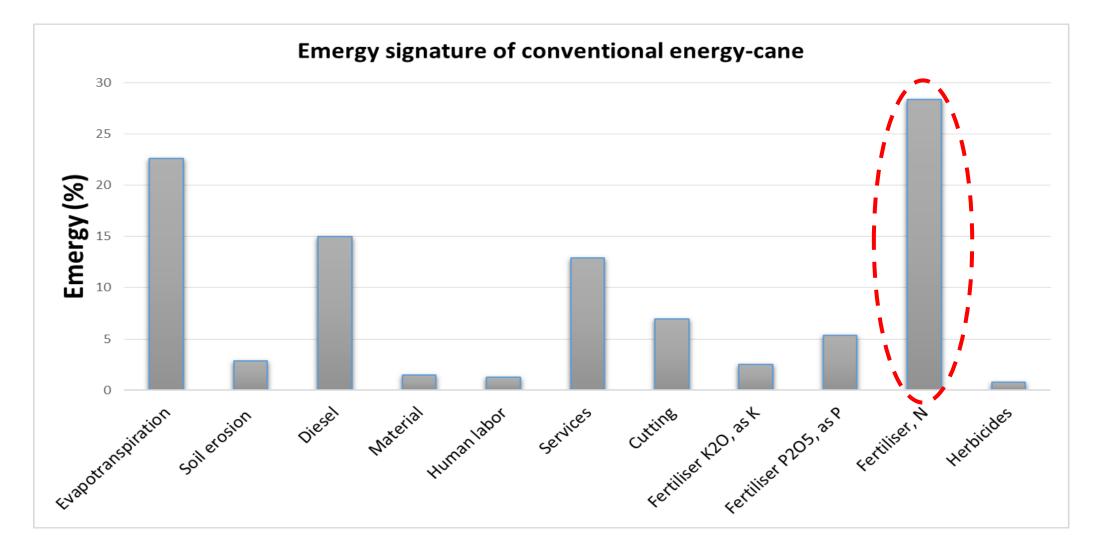
UEVs and renewable fractions calculated for the different biomasses

Biomass	UEV (seJ/J)	%R (%)	REI (seJ/J)
Conventional Energy-cane	(4.14E+04	26	1.59E+03
Conventional Energy-cane (with transport for SO)	5.95E+04	18	3.31E+03
Pellet	6.63E+04	47	1.41E+03
Pellet (with transport for SO)	1.65E+05	15	1.10E+04
"SMART" energy-cane	3.98E+04	54	7.37E+02
"SMART" energy-cane (with transport for S1)	4.53E+04	48	9.44E+02

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Emergy signature of conventional energy-cane (without transport)

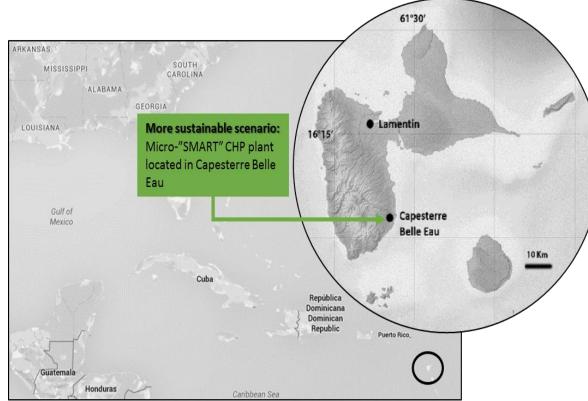


EMERGY EVALUATION

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- Overall, even without steam market the baseline scenario presented emergy indicators in range of values found in similar studies.
- Pellets presented better indicators than local energy-cane, but the weight of the transport reversed the results.
- □ REI should be used for the comparison of UEV and renewability between different products
- □ Through the three other scenarios analysed, we showed that the indicators of electricity produced was very sensible to the biomass used, except for EYR indicator.
- □ The use of "SMART" crop management system allowed to produce a biomass more sustainable with an UEV (with transport) of 4.53E+04 seJ/J and a high renewability of 48%.
- The implantation of the smaller CHP plant which operated with 100% "SMART" energy-cane was more sustainable than baseline scenario, surpassing the scale economy issue.
- □ Nitrogen fertilizers was the most impacting input in energy-cane crops.



Thank you for your attention!

