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

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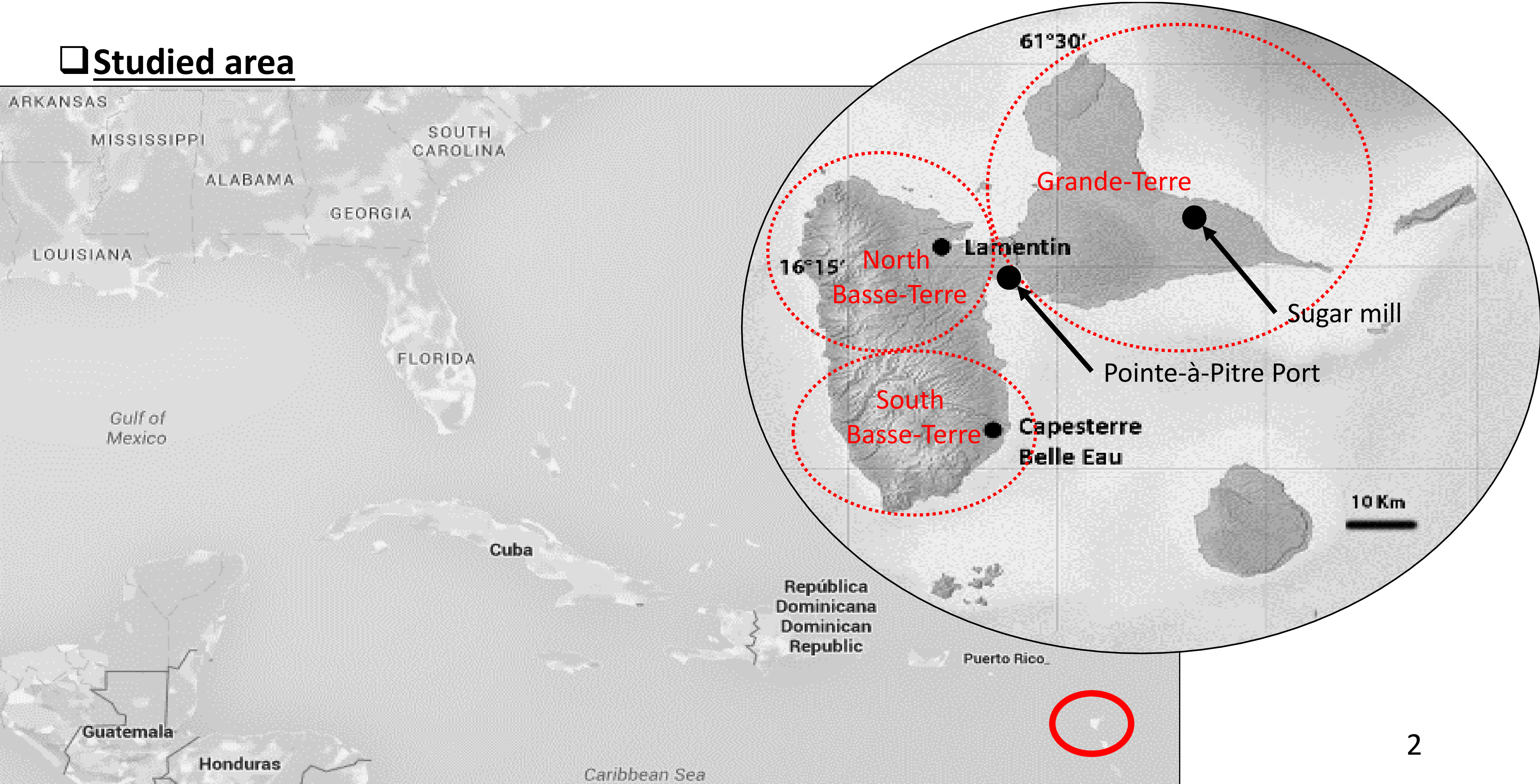
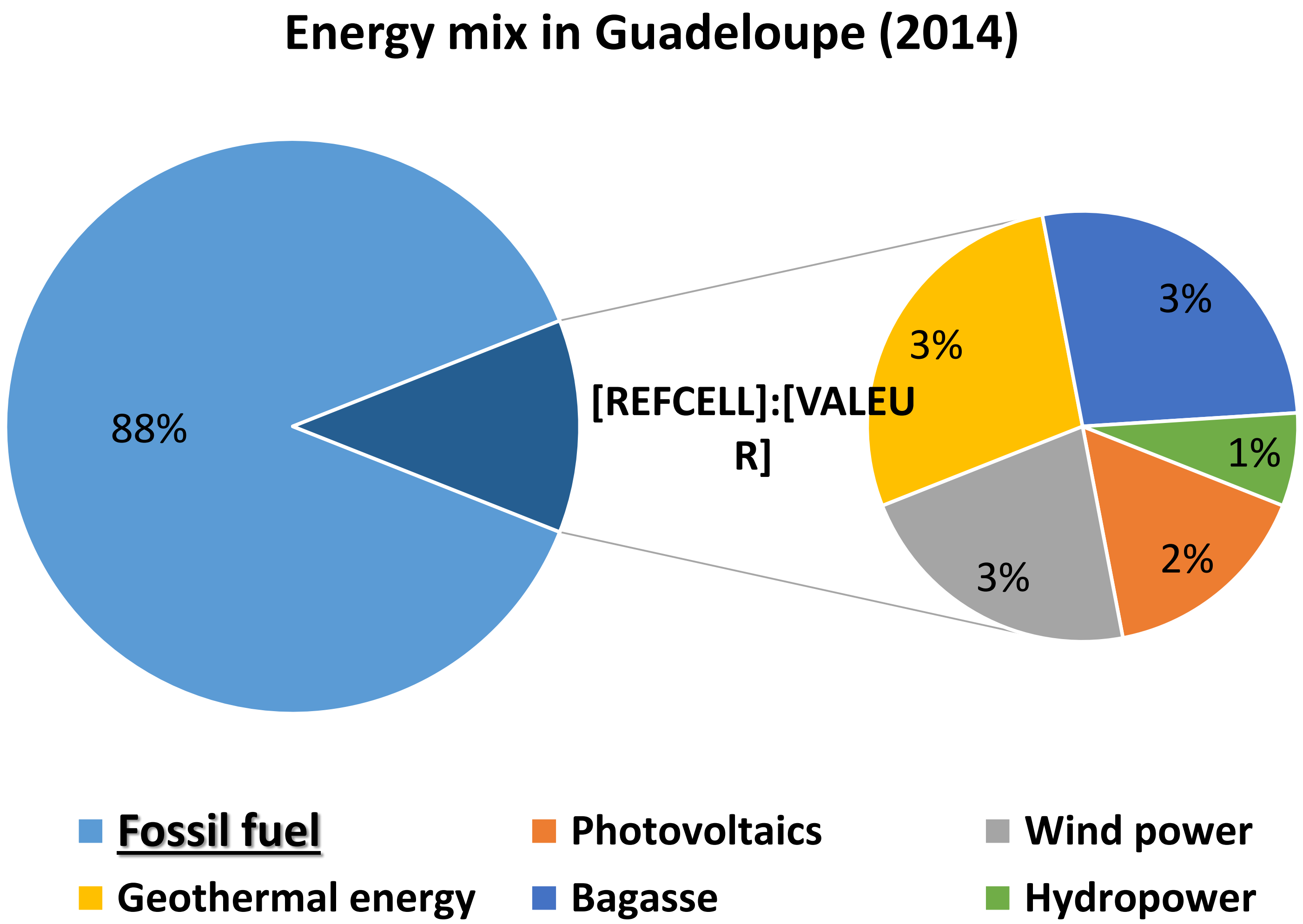
❑ Studied area



❑ Context



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

❑ Energy-cane

Selection of *Saccharum sp.* for:

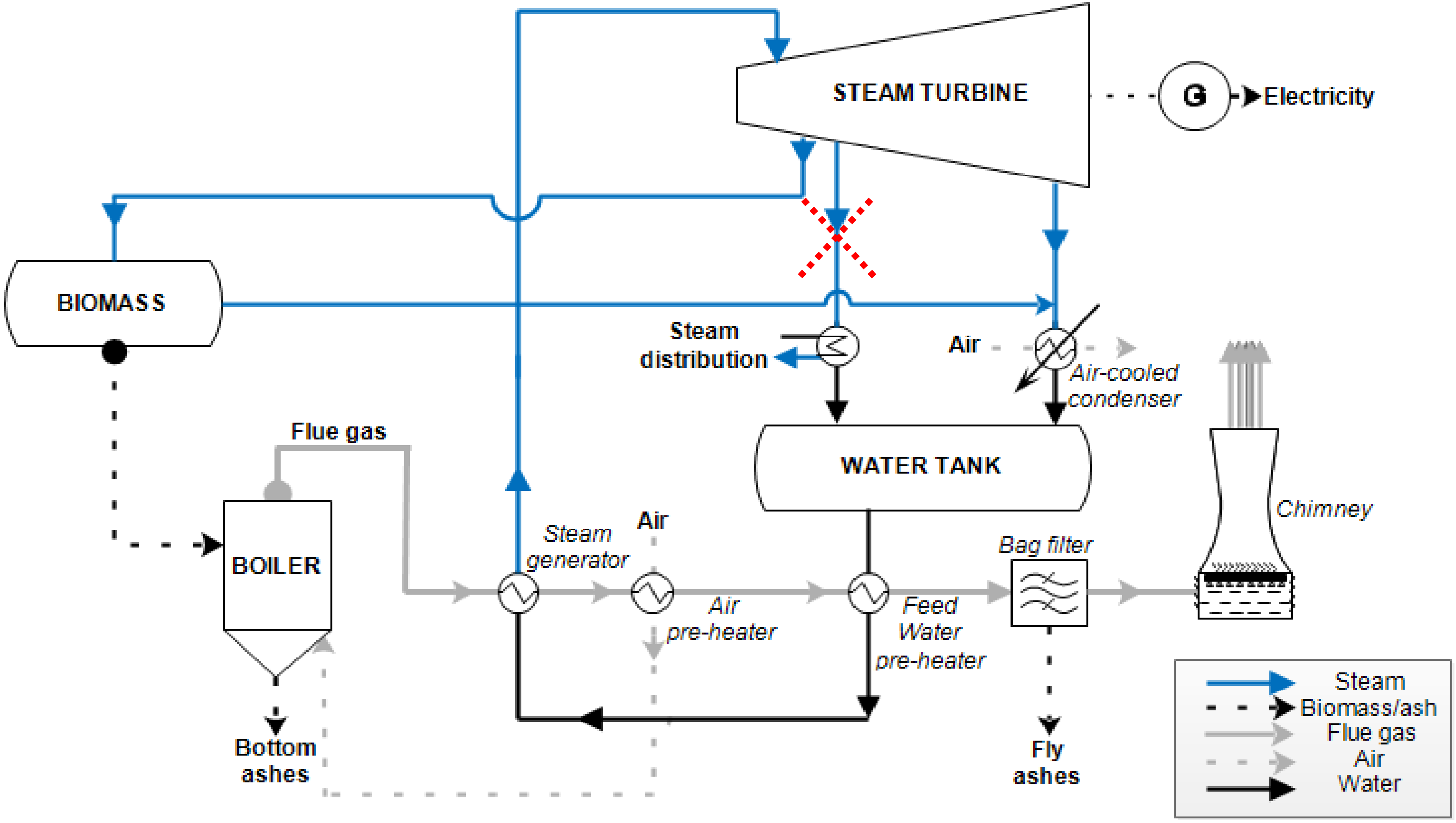
- High fiber content
- High yield and growth rate
- Rusticity

Photo 1: Variety *WI 79 460* at 11.5 months

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

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

❑ The Combined Heat and Power plant (CHP)



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

❑ The biomass production

Conventional energy-cane

- 6 years cycles
- No irrigation
- Herbicides
- Mineral fertilizers
- Mechanical harvesting
- Subsidies

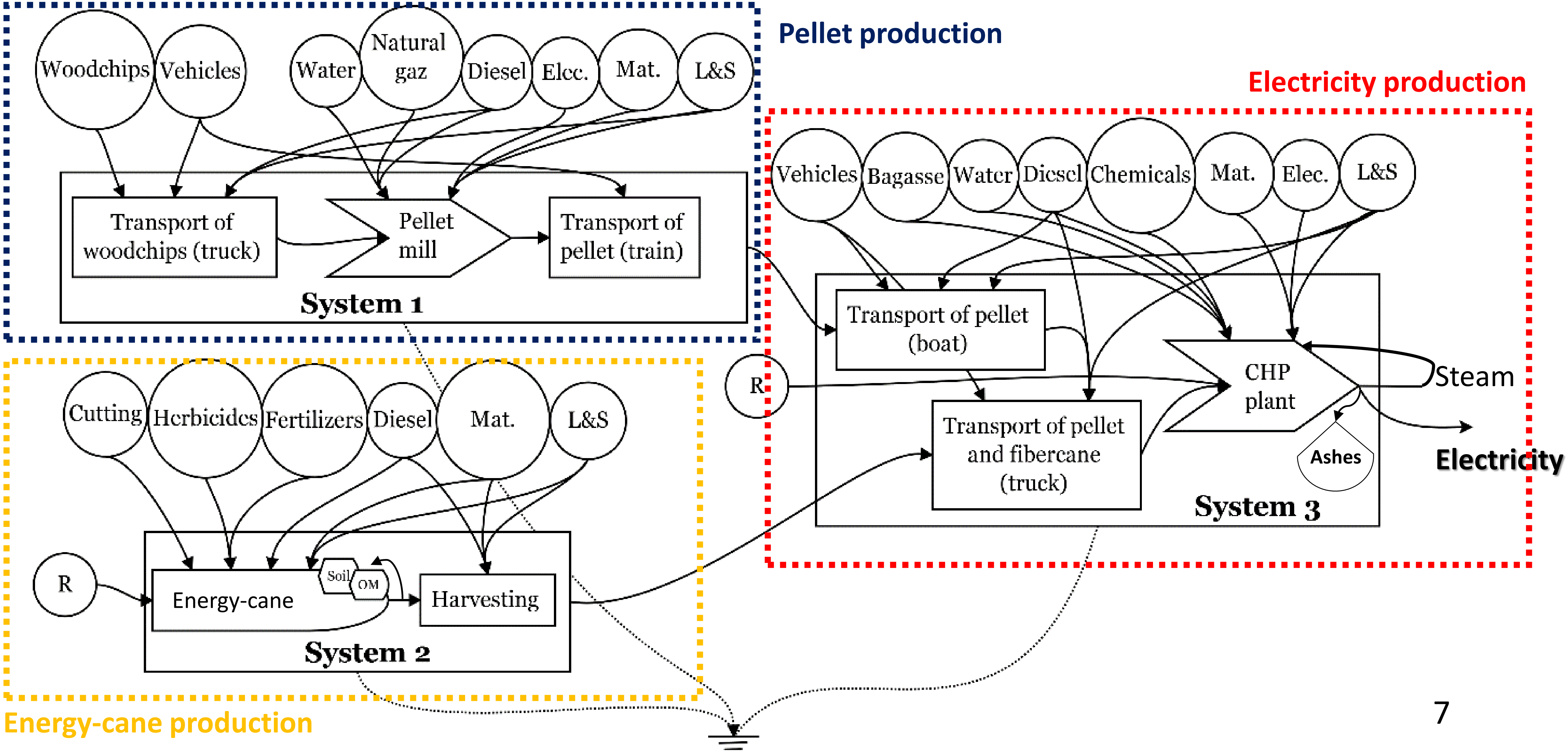
Imported pellet

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

SMART energy-cane

- 6 years cycles
- No irrigation
- Mineral fertilizers
- Mechanical harvesting
- <u>Mechanical weed management</u>
- <u>All the biomass harvested</u>
- <u>Compost amendment</u>
- <u>Additional subsidies</u>

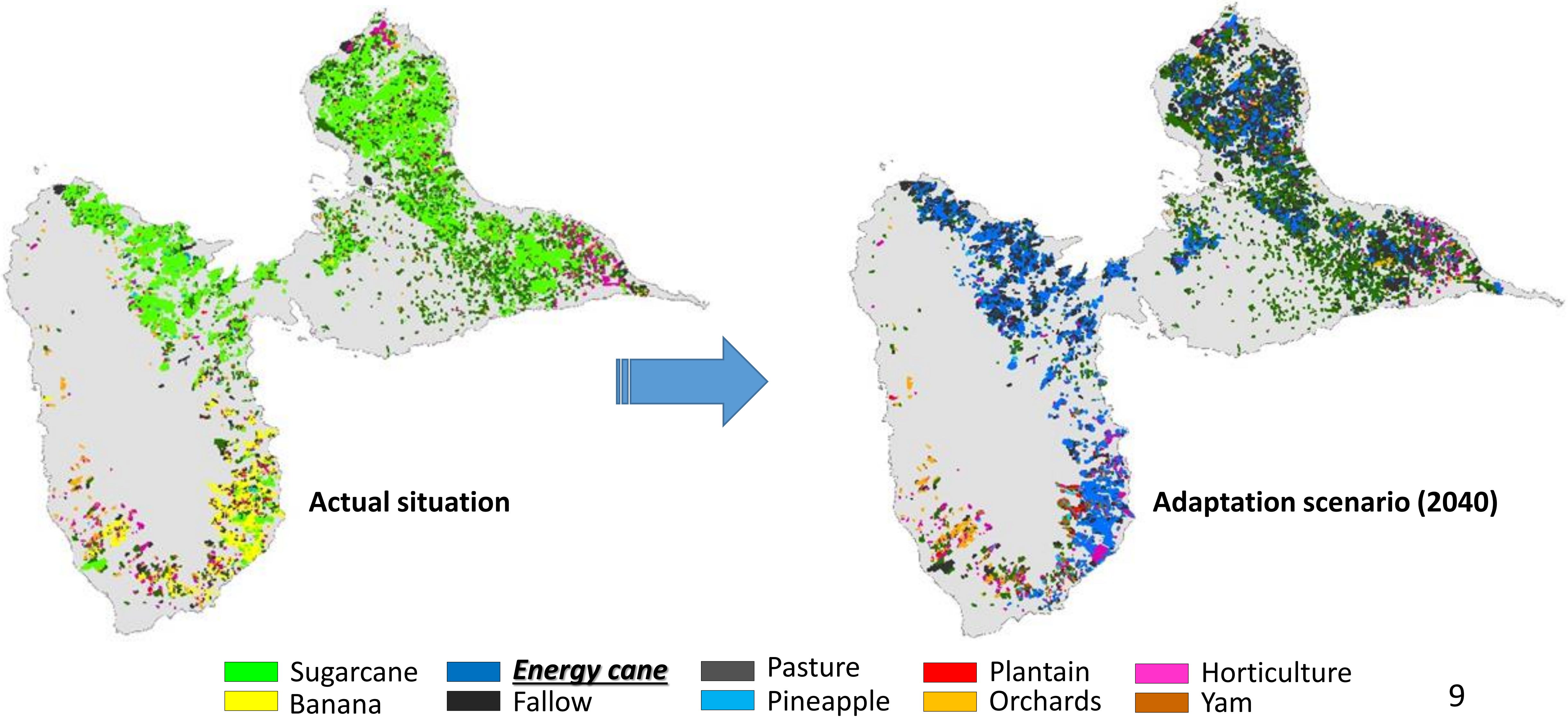
❑ The agro-industrial sector



❑ 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

❑ **<u>Energy cane crop adoption by farmers</u>** <u>(MOSAICA, *Chopin et al.,2015*)</u>



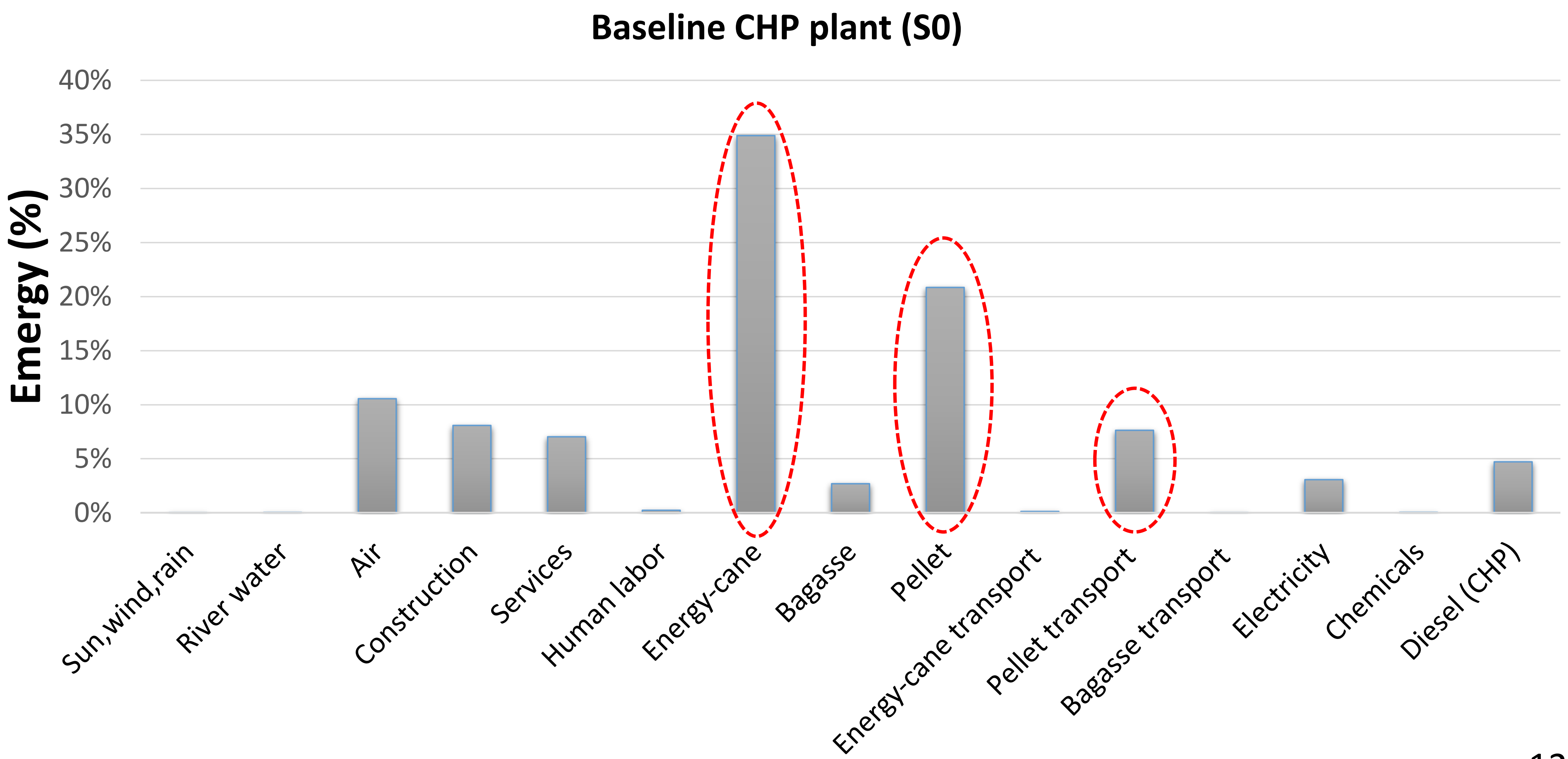
❑ Emergy indicators

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

❑ Indicators obtained for the four scenarios

Indicators	S0 (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%*

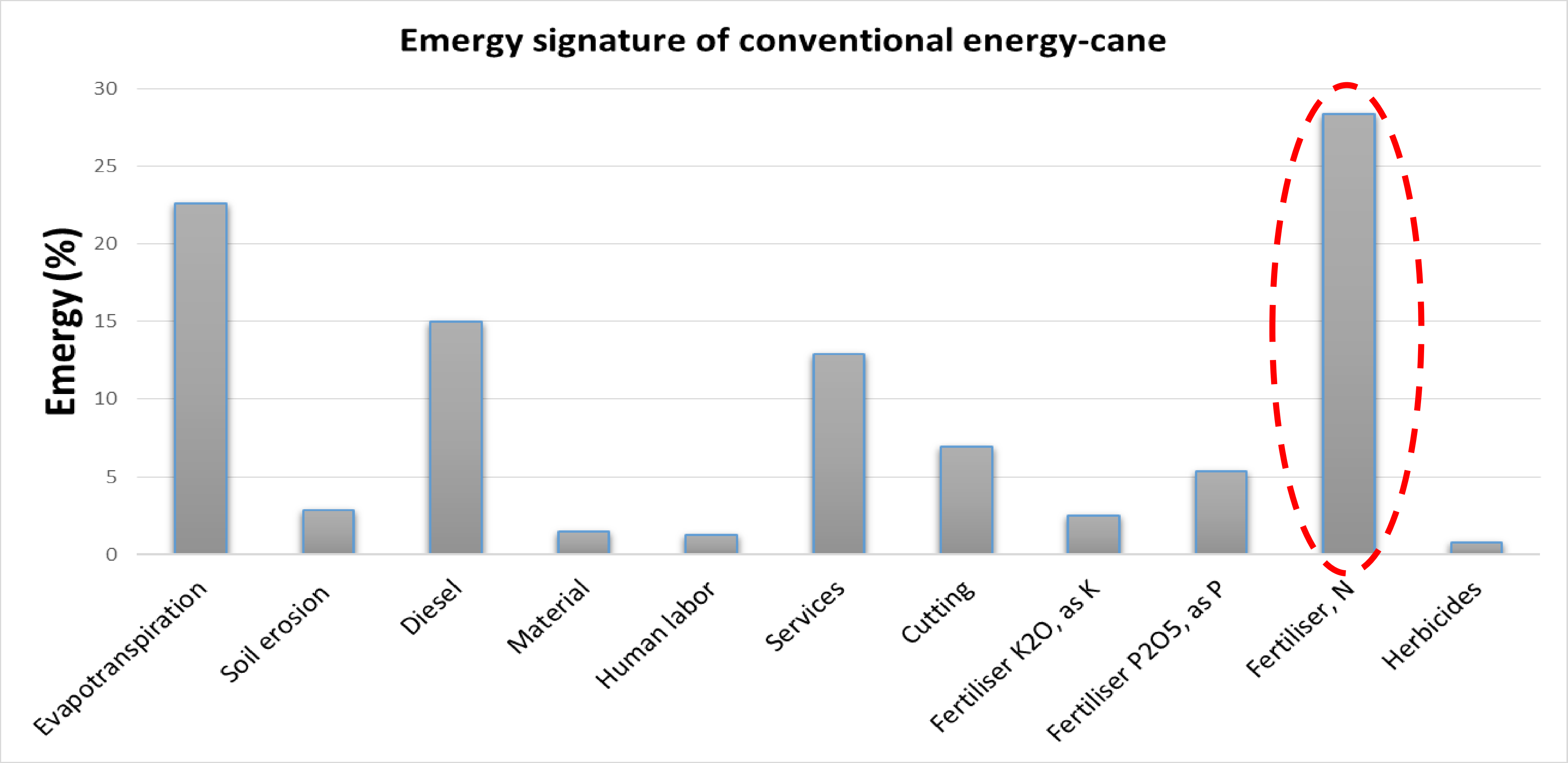
❑ Emergy signature of electricity production (baseline scenario S0)



❑ UEVs and renewable fractions calculated for the different biomasses

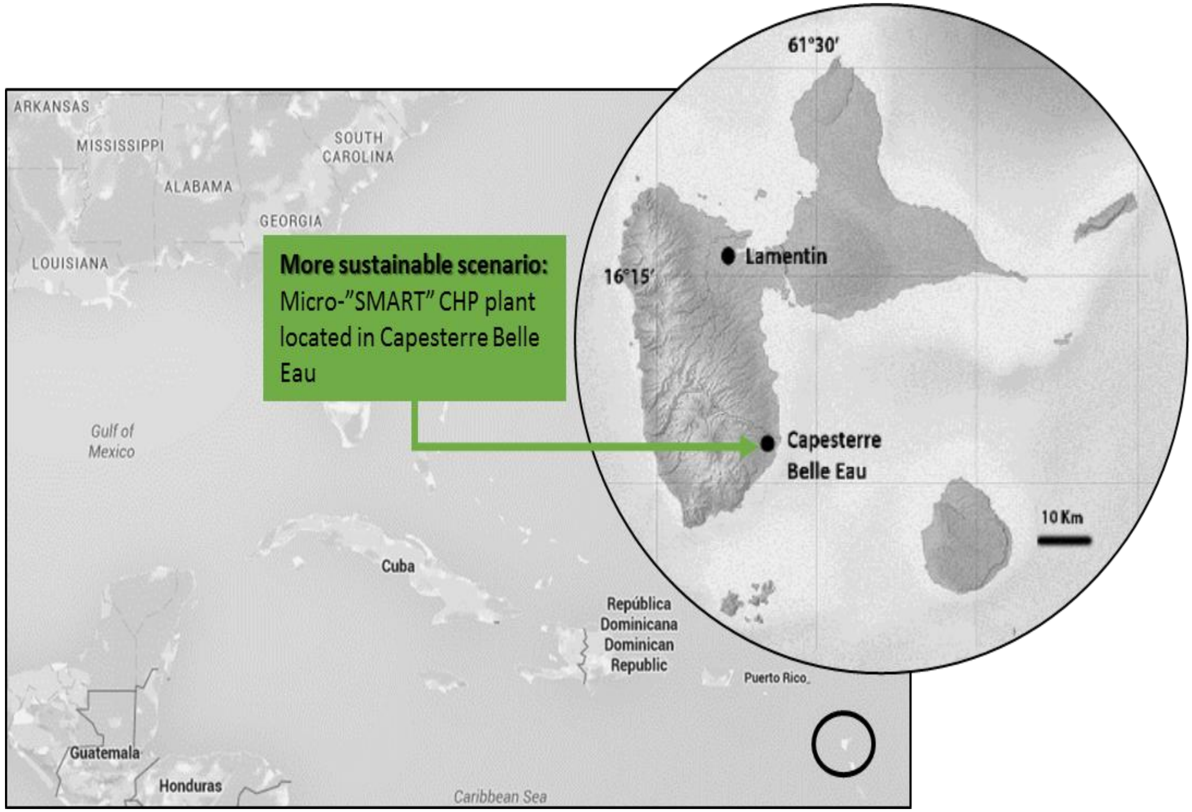
Biomass	UEV (seJ/J)	%R (%)	REI (seJ/J)
Conventional Energy-cane	4.14E+04	26	1.59E+03
Conventional Energy-cane *(with transport for S0)*	5.95E+04	18	3.31E+03
Pellet	6.63E+04	47	1.41E+03
Pellet *(with transport for S0)*	1.65E+05	15	1.10E+04
"SMART" energy-cane	3.98E+04	54	7.37E+02
"SMART" energy-cane *(with transport for S1)*	4.53E+04	48	9.44E+02

❑ Emergy signature of conventional energy-cane (without transport)



❑ Conclusion

- ❑ 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!