BIOSYNGAS
TECNOLOGIA VERDE

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INSTITUTO DE
PESQUISAS
TECNOLÓGICAS

Biomass gasification
The Piracicaba BioSynGas Project

September, 17, 2012

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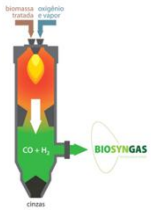
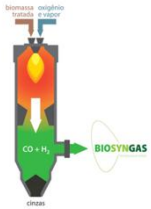


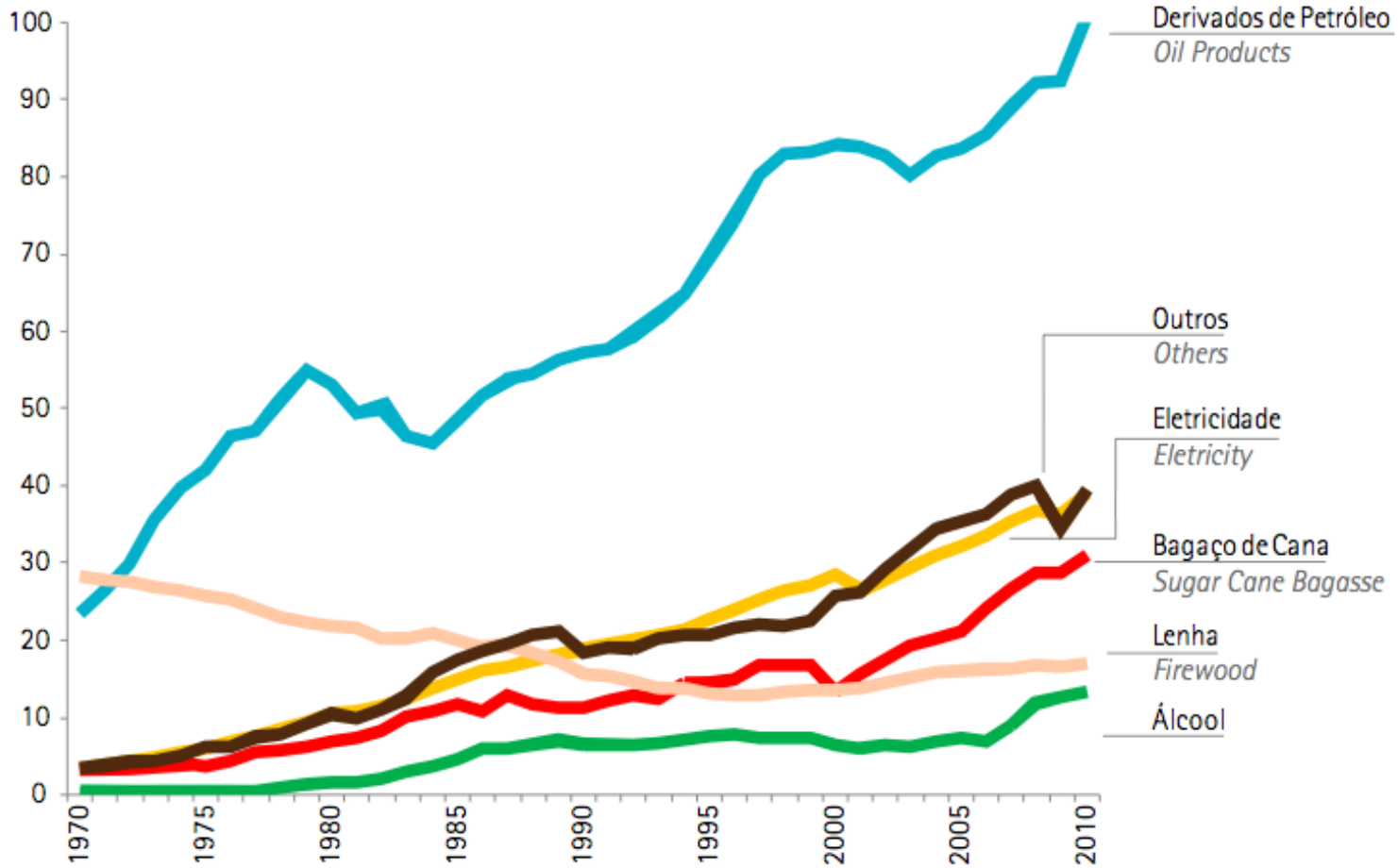
- Market conditions
- Technology choice
- Economic viability
- IPT’s pilot plant proposal

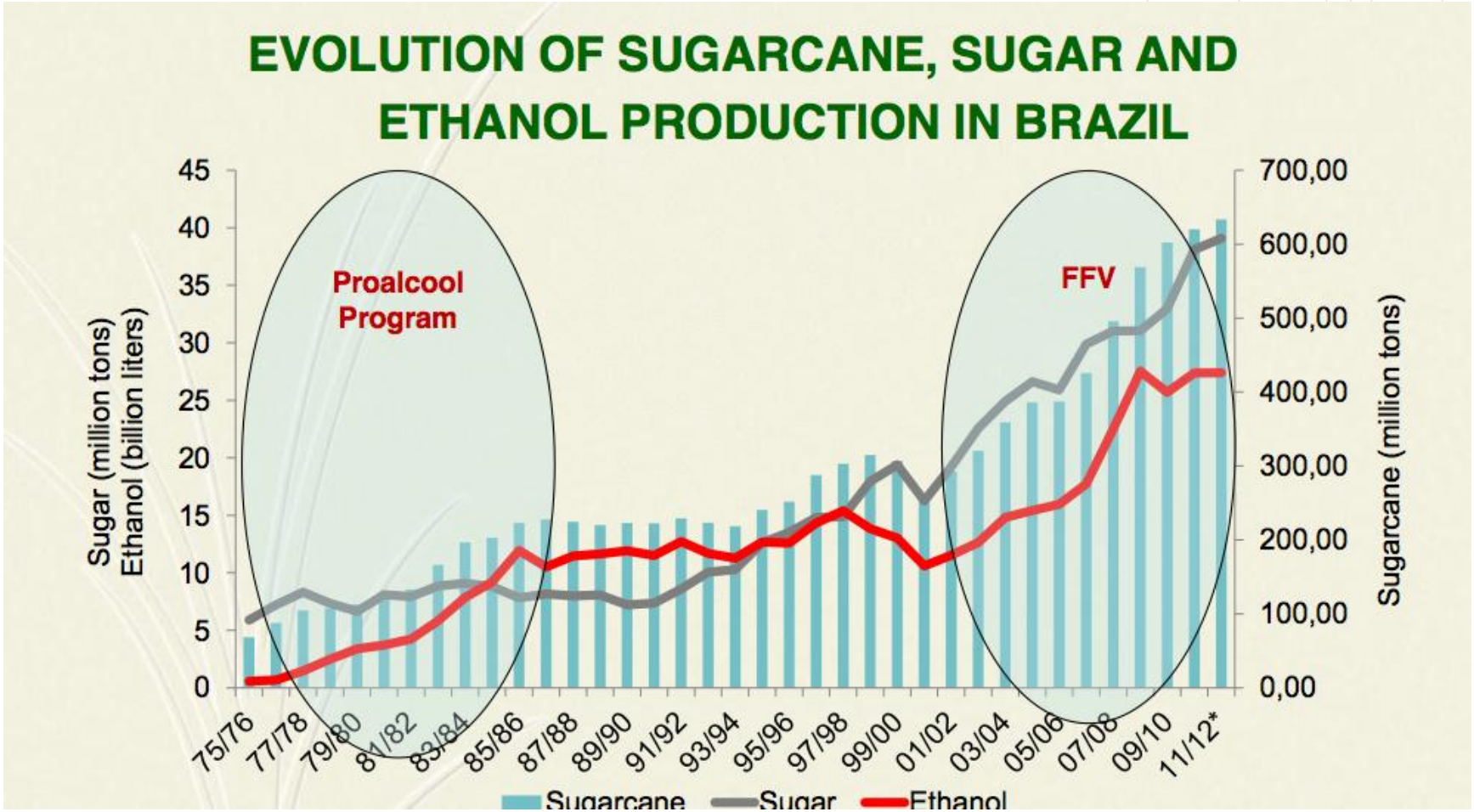


Brazil energy consumption per year

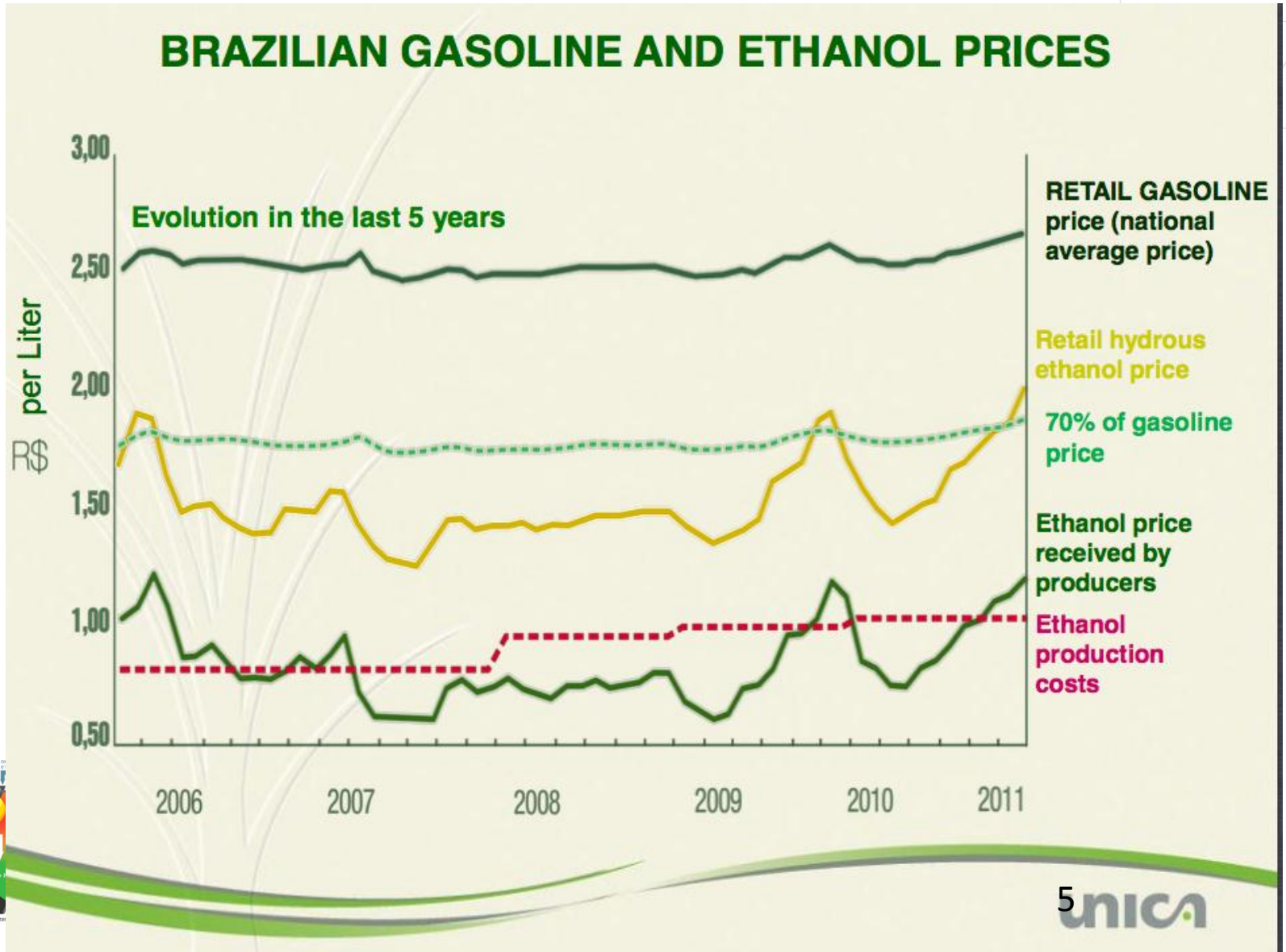
Chart 1.4.a – Final Energy Consumption

10^6 ton equivalent oil



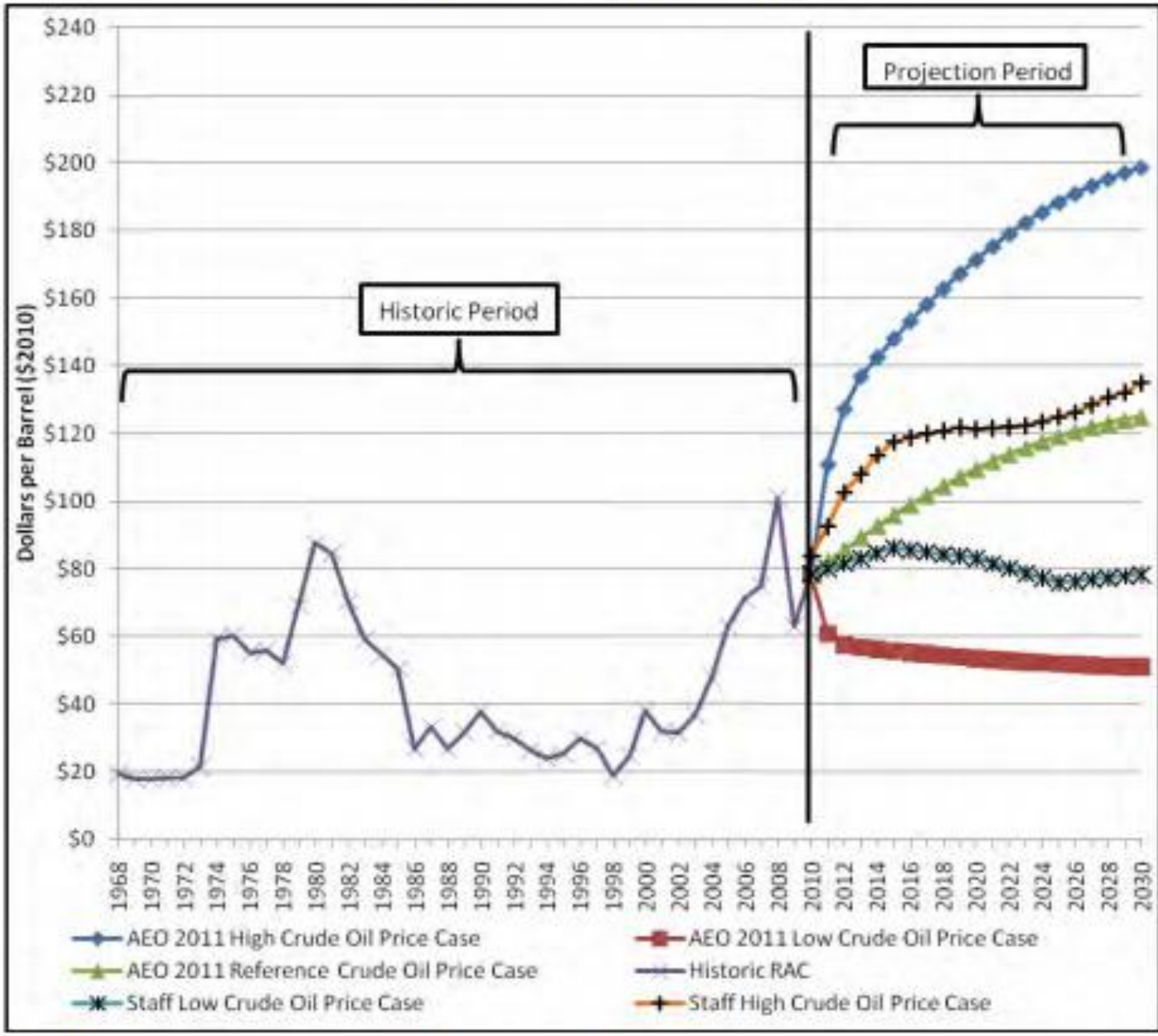

EVOLUTION OF SUGARCANE, SUGAR AND ETHANOL PRODUCTION IN BRAZIL
Sugar (million tons)
Ethanol (billion liters)
Sugarcane (million tons)
Proalcool Program
FFV
45
40
35
30
25
20
15
10
5
0
700,00
600,00
500,00
400,00
300,00
200,00
100,00
0,00
75/76
77/78
79/80
81/82
83/84
85/86
87/88
89/90
91/92
93/94
95/96
97/98
99/00
01/02
03/04
05/06
07/08
09/10
11/12*
Sugarcane
Sugar
Ethanol

Today's difficulties with ethanol price



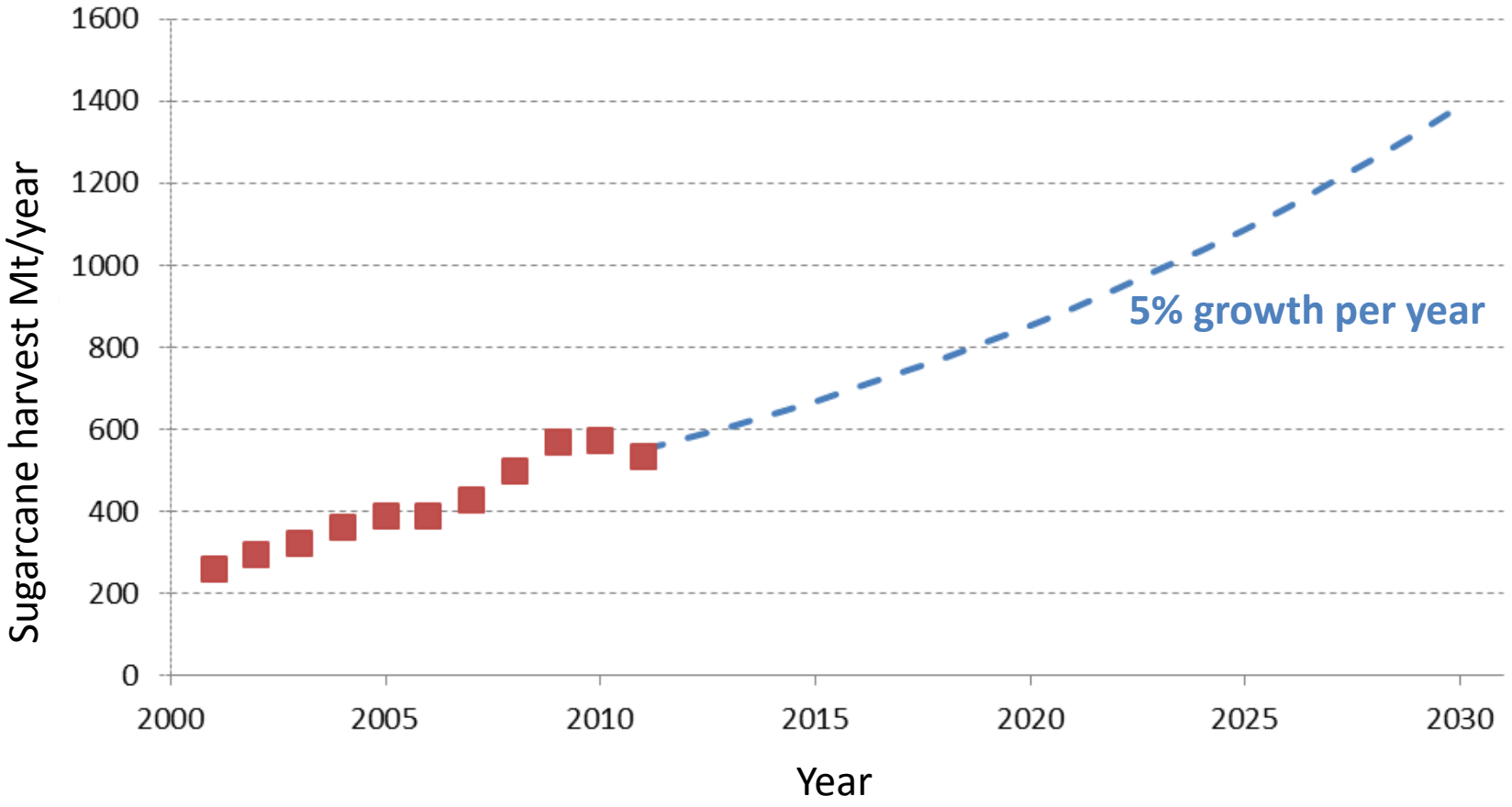
Oil price evolution: if price increase continues, ethanol strives

Figure 2: Energy Commission Staff and EIA *AEO 2011* Crude Oil Price Cases and Historical Prices (in 2010 dollars)



Source: U.S. Energy Information Administration and the California Energy Commission

Potential sugarcane harvest growth growth



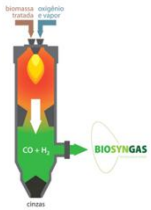
Sugarcane Biomass power potential in 2010

$$P_{th} = M_{cane} \cdot F_{bagasse+straw} \cdot LHV \cdot / 8000h$$

$ = (600 Mt/year . 0,20 . 17 GJ/t . 0,277 MWh/GJ / 8000 h/year) =

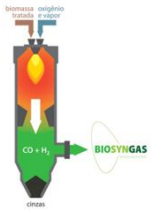
$$= 70\ GW_{th}$$

Instaled cogeneration capacity in 2011: 3GW



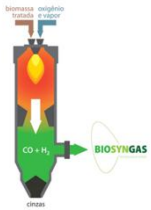
New technologies for a better use of sugarcane bagasse and straw

- Biochemical route
  - hydrolysis
- Thermochemical route
  - Improvement of boilers technology
  - Gasification
    - Fluidized bed technology
    - Entrained flow technology

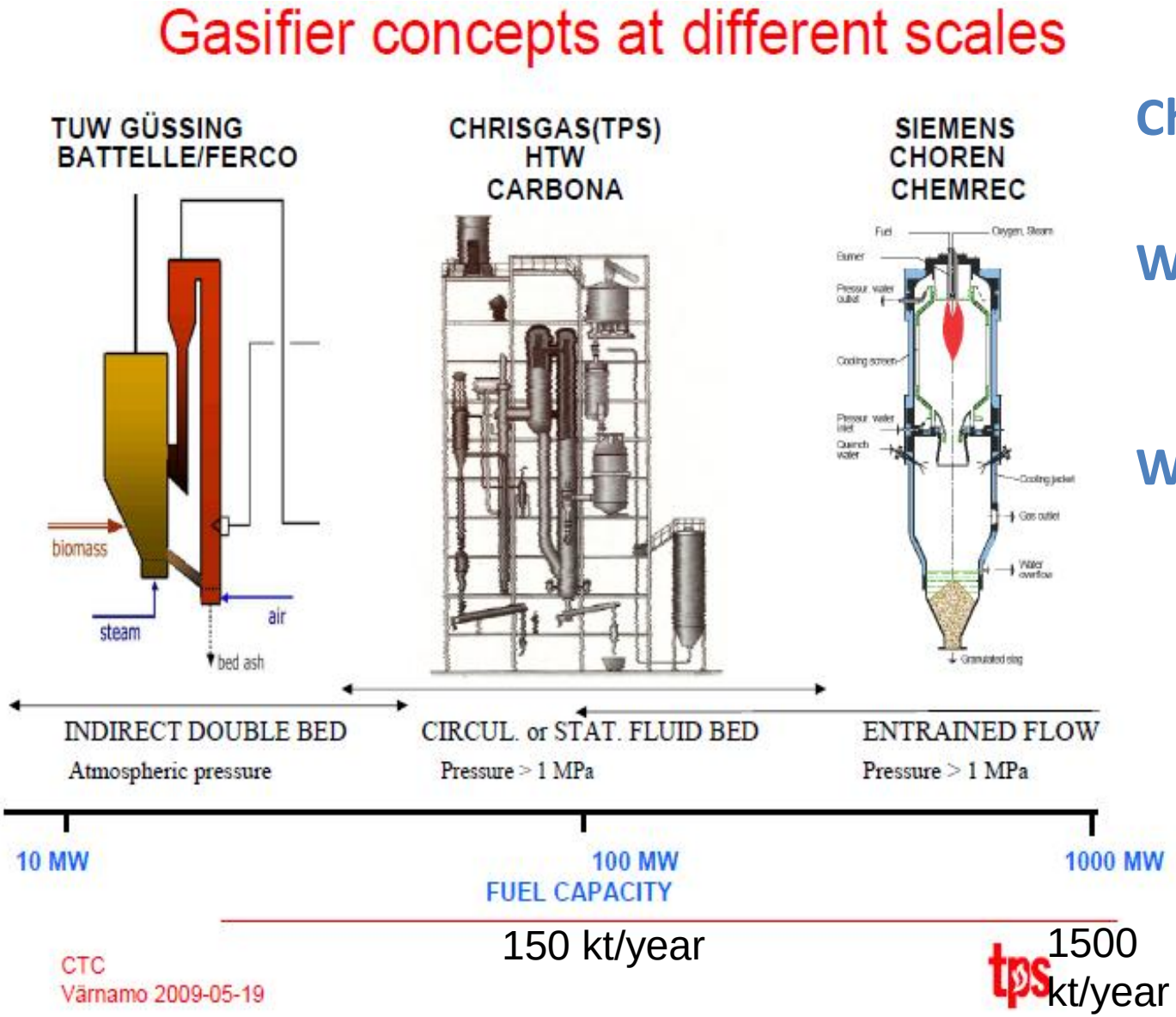


Gasification

- **Gasification** is a process that converts organic or fossil based carbonaceous materials into a gas mixture of carbon monoxide, hydrogen and carbon dioxide, called synthesis gas, or syngas.
- The Syngas can be used to generate electrical power, liquid fuels or chemicals.



Main gasification concepts



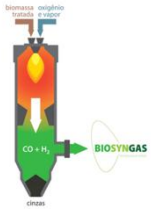
Choice depends:

Which is the most adequate scale

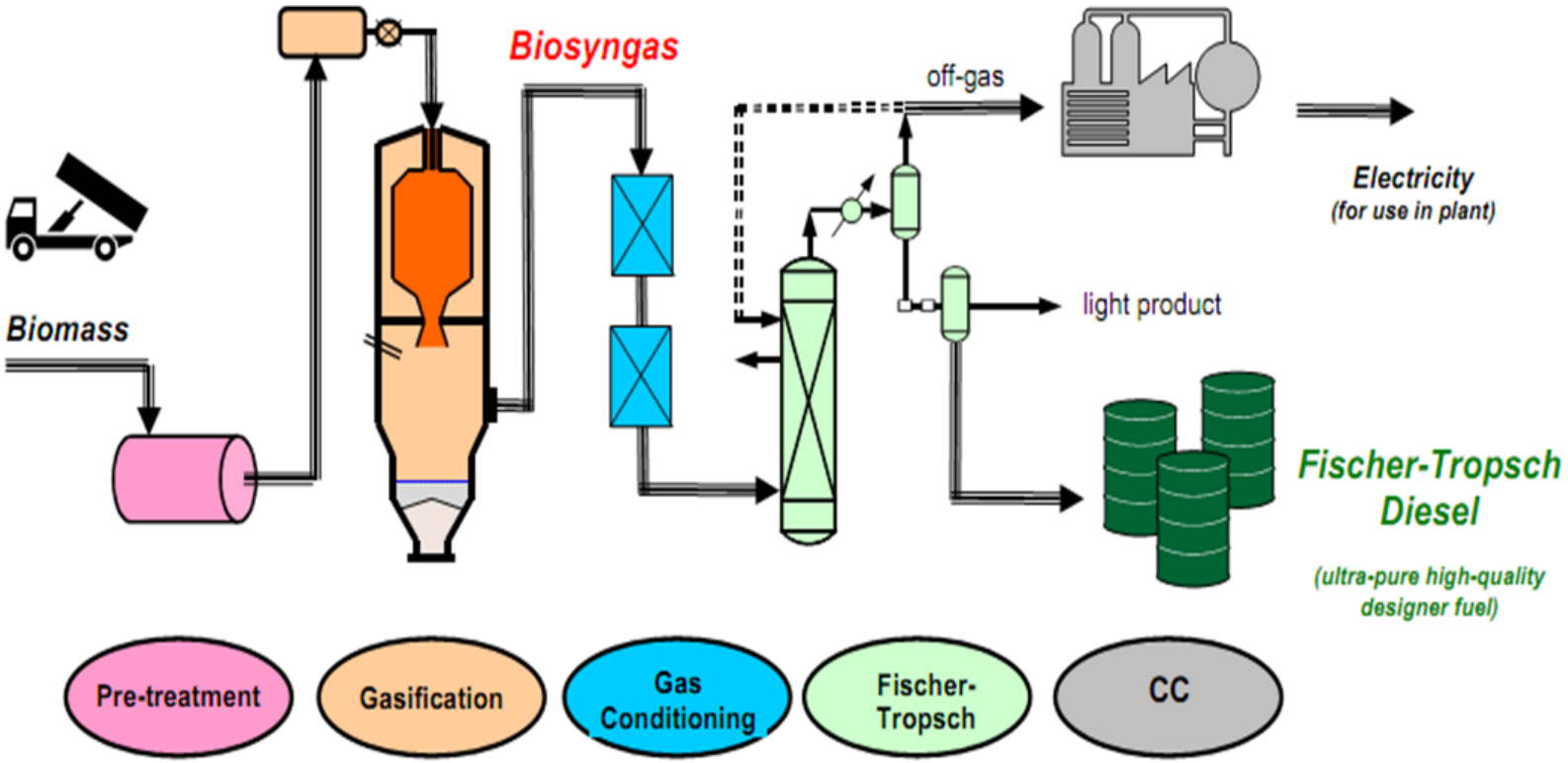
Which products are desired

Scale

- A typical Brazilian sugarcane mill harvests 4 Mt/year of sugarcane.
- Each ton gives 150kg of sugar, 140kg of bagasse and 60kg of available straw.
- So, 800 kt of dry biomass /year is available.
- It is possible to envision a mill where all biomass is gasified to produce power and chemical products.
- For this scale, Entrained Flow Gasification is the best solution

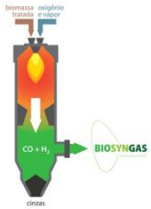


Commercial Gaseification plant

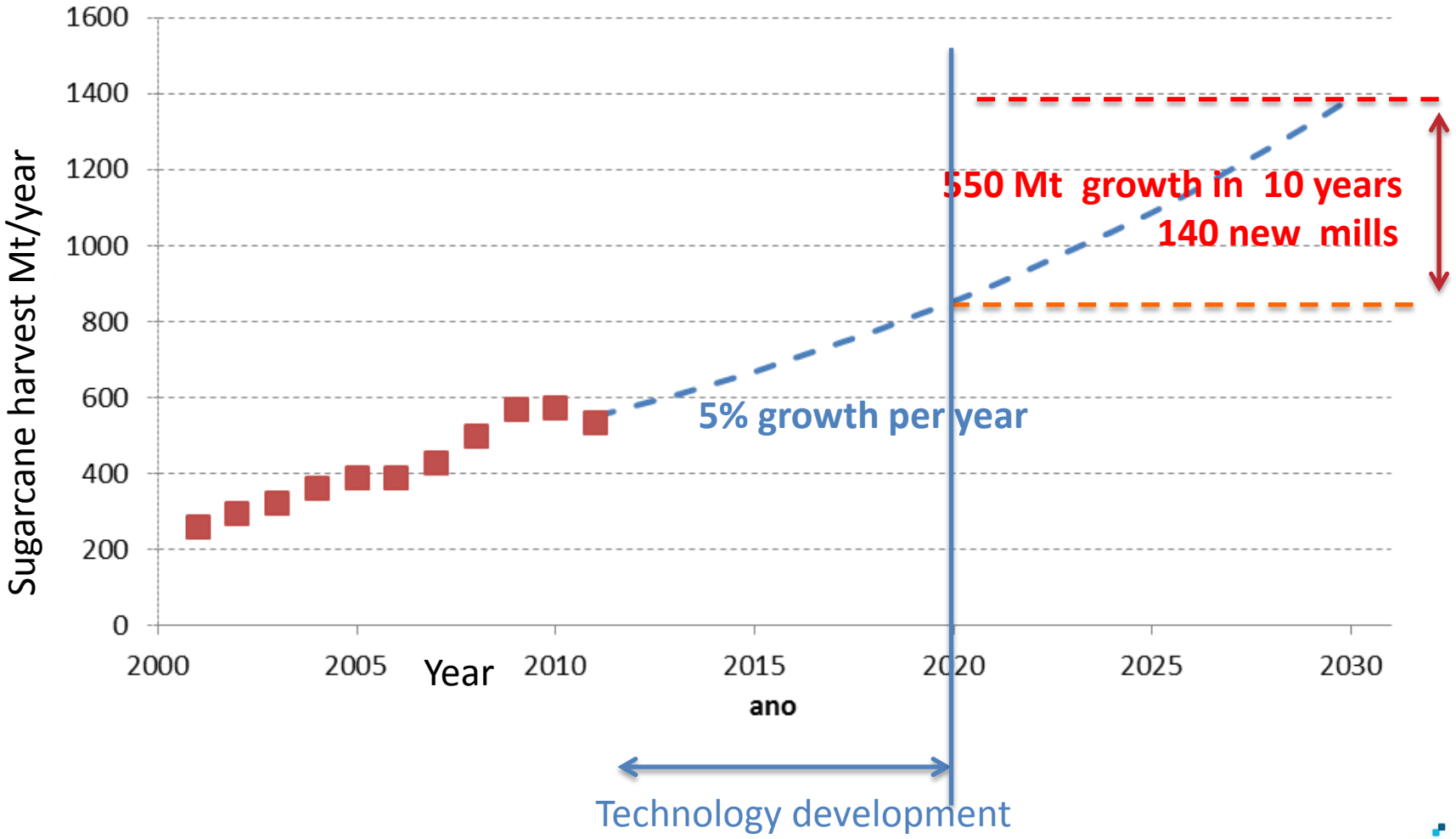


Why choose entrained flow gasification:

- Large scale commercial plants for petrochemical waste and coal gasification are in use today.
- Quality of generated gases: low tar and methane levels due to high operating temperatures (greater than 1300 ° C) and high CO and H2 levels.
- The ability to operate with liquid flows or low granulometry particulate materials (bio-oil and torrified grounded biomass).
- High pressures and high power.
- The ability to remove molten ashes



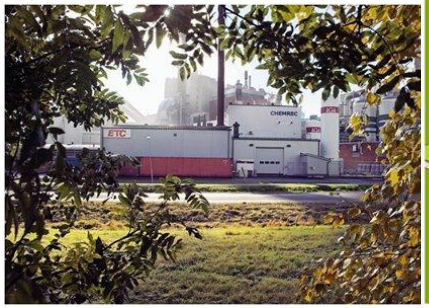
Potential for gasification plants the greenfields of the 2020's:



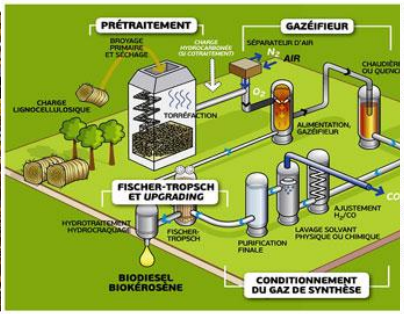
Present situation of Biomass gasification in the world

- No commercial plants
- Several pilot plants and many technological challenges
- Large R&D investments: Germany, USA, Sweden,
- Large coal gasification commercial plants in China (1Mt coal/year), South Africa and USA

Projeto Chemrec, Suécia

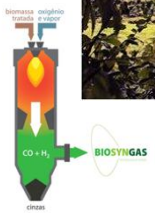


Projeto Choren, Alemanha

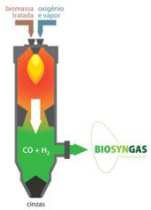


Projeto BioTfuel - França

Comercial Carvão: China

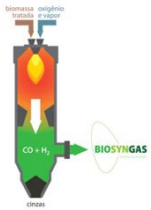


Economic viability



Data from literature

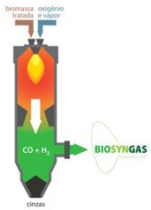
	Swanson et al (2010)	**Boerrigter (2006)**
Biomass	Corn stover	Woody biomass from European forest chipped and dried
Pre-treatment	Grinding and drying via steam	Torrefaction with fixed cost of 1,5 Euro/GJ
Gas cleaning	Cold gas cleaning; SWGS	Rectisol (CAPEX 59 M US$ 2011)
Plant size (MWth)	389	4.250
Method	ASPEN Plus & Icarus	Engineering analogy with a GTL plant



Investment

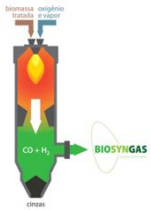
Gasification plant size: 800MT/year (100t/h)

Stages	***Investment (M US$2011)***
Pretreatment	**45**
Gasification	**60**
Gas cleaning and conditioning	**60**
Fischer Tropsch Unit	**75**
ASU (air separation unit)	**45**
20MW Electric generation unit	**65**
OBL	***340***
total	***690***



Scenarios for 2020 - 2030

scenario	Bagasse cost (US$/ton)	Discount rate	Diesel price 2020-2030 (US$/litro)
Optimist	30	0,08	2,1
probable	50	0,10	1,8
Pessimist	70	0,12	1,5

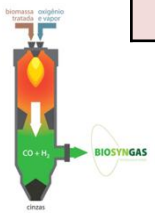


647 ***MWth gasification plant*** *800 mtb/a*

FT Fuel production ; Energy efficiency = 55%

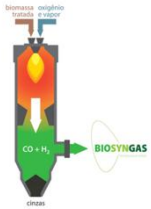
	TCI (M US$2010)	*NPV (M US$)*	*ROI*
optimist	549	786	286%
probable	689	334	114%
pessimist	917	-2	-1%

TCI: Total Capital Investment



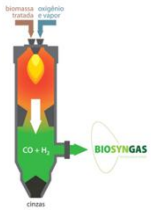
Brazilian Biosyngas project

- IPT (São Paulo State Research Institute) is coordinating a proposal to build a 500kg/h biomass gasification pilot plant in Piracicaba (SP)
- Objective is to be able to define the Conceptual Design of a 800 kt/year (100t/h, 470MW_{th}) plant in 2020, with CAPEX of US 500M
- 5 year project budget is US$ 40M.
- Three industrial partners (Oxiteno, Petrobras and Vale) are interested in developing, outside the project, the technologies from gas to biofuels, biochemicals or Electrical Energy.

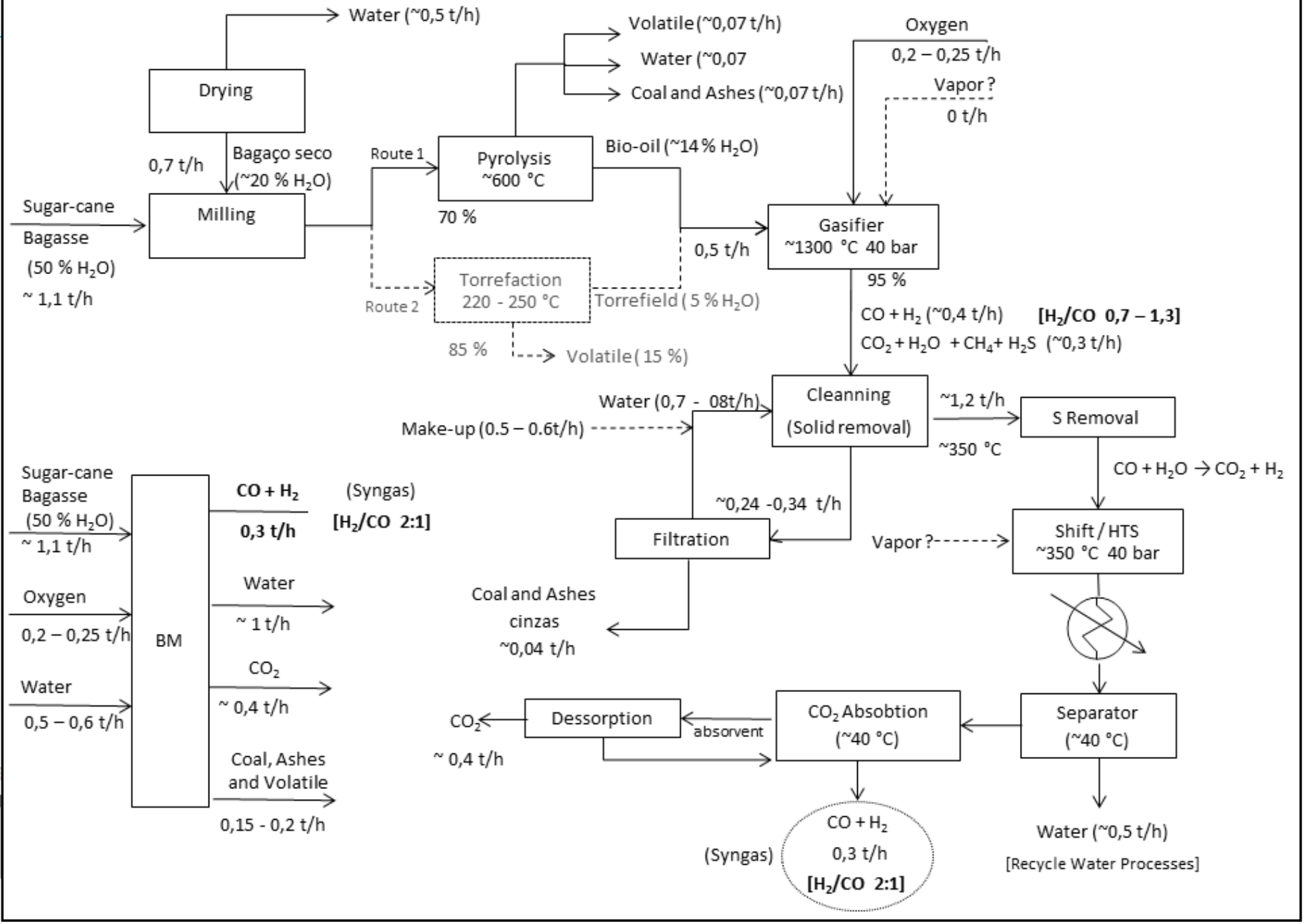


Pilot Plant gasifier specification

- 2,5MW_{th} , approx. 500kg biomass/h capacity
- "flex": able to gasify powder or biooil
- Oxygen blown
- no heat recovery
- Gas composition targets:
  - 80% ($CO+H_2$)
  - < 0,5% CH_4
  - <1g tarr / Nm^3
  - < 0,5%N_2

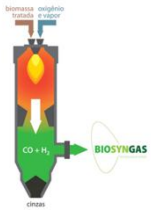


Biomass Gasification



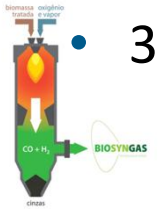
Technical challenges

- Bagasse drying unit design choice
- Bagasse torrefaction unit design choice
- Gasifier design for 3% ash content
- Earth separation before gasifier, to lower ash silica content
- Gas cleaning



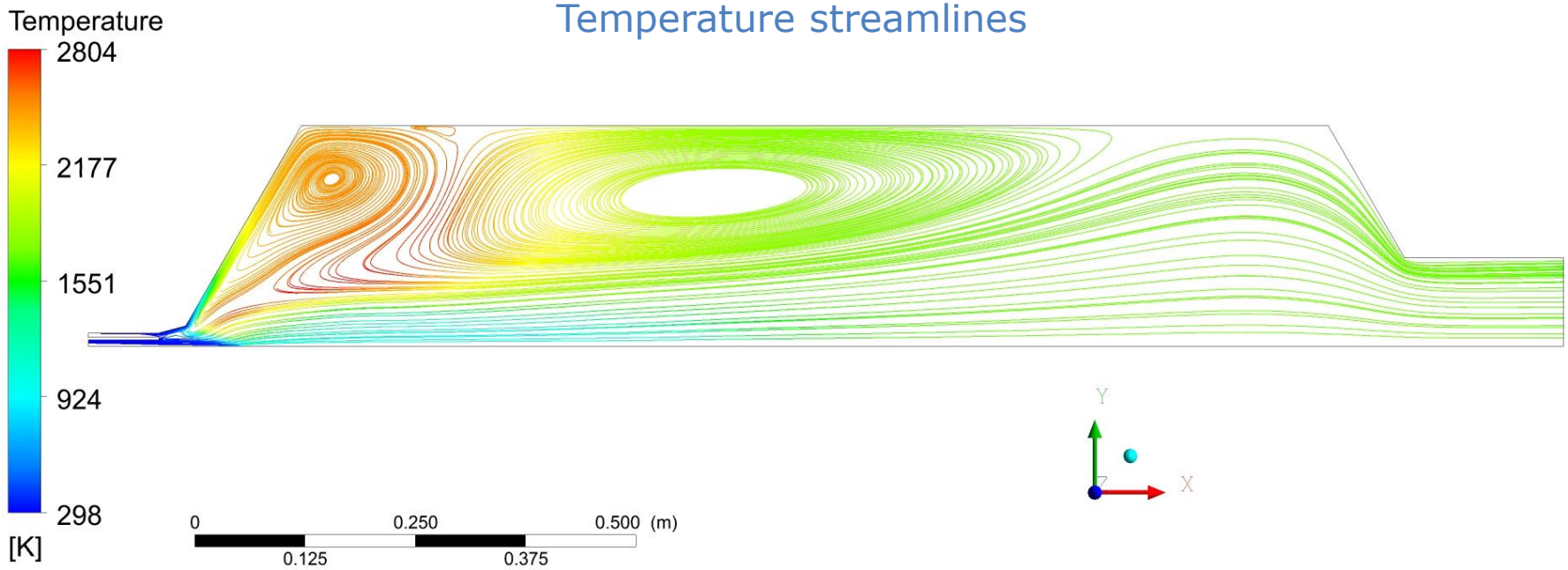
Project status

- 3.5 years of negociation and planning
- 20 *workshops* with companies and ICTs for business structuring
- Partners formally committed
- IP negotiations completed
- Environmental licences granted
- BNDES and FINEP approval in final stages
- Sao Paulo State resources available, to fund Plant Basic Design
- Personnel hiring in process
- 30 researchers already involved



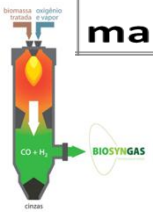
Results from the modeling team

Temperature streamlines



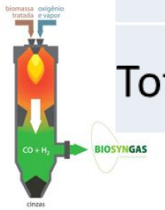
Time Chart.

BIOSYNGAS PROJECT – TIME CHART												
	2012		2013		2014		2015		2016		2017	
	1°	2°	1°	2°	1°	2°	1°	2°	1°	2°	1°	2°
Project management												
Defining intellectual property rights												
Defining governance												
Signing contracts (BNDES, FINEP, GESP, companies)												
Conceptual design phase												
Preliminary design phase												
Detailed engineering phase												
Pre-treatment system implementation												
Gas cleaning system implementation												
Utilities												
Instrumentation and control center												
Civil engineering												
Gasifier Development and assembly												
System integration												
Cold commissioning												
Hot commissioning												
Long duration testing (totally 3.000 h)												
Economic feasibility and risk management												



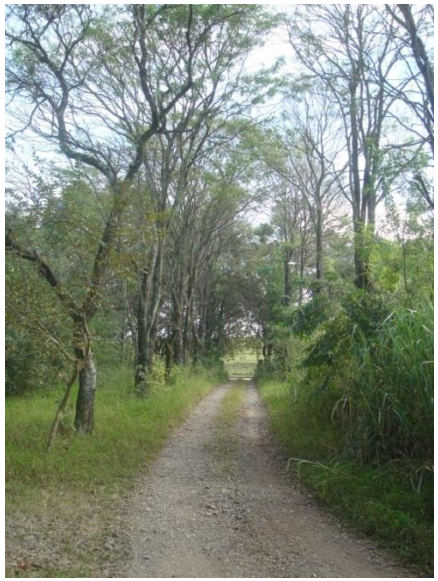
Budget

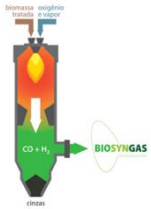
BUDGET	
ITENS	VALOR (MILLION R$)
Equipments	38.2
Facilities	3.6
Travel costs	1.2
Consumables	3.3
Man power (IPT, CTC, companies)	11.4
Subcontracted services	20.4
Administrative costs	2.9
Contingencies	5.7
Total	86.8

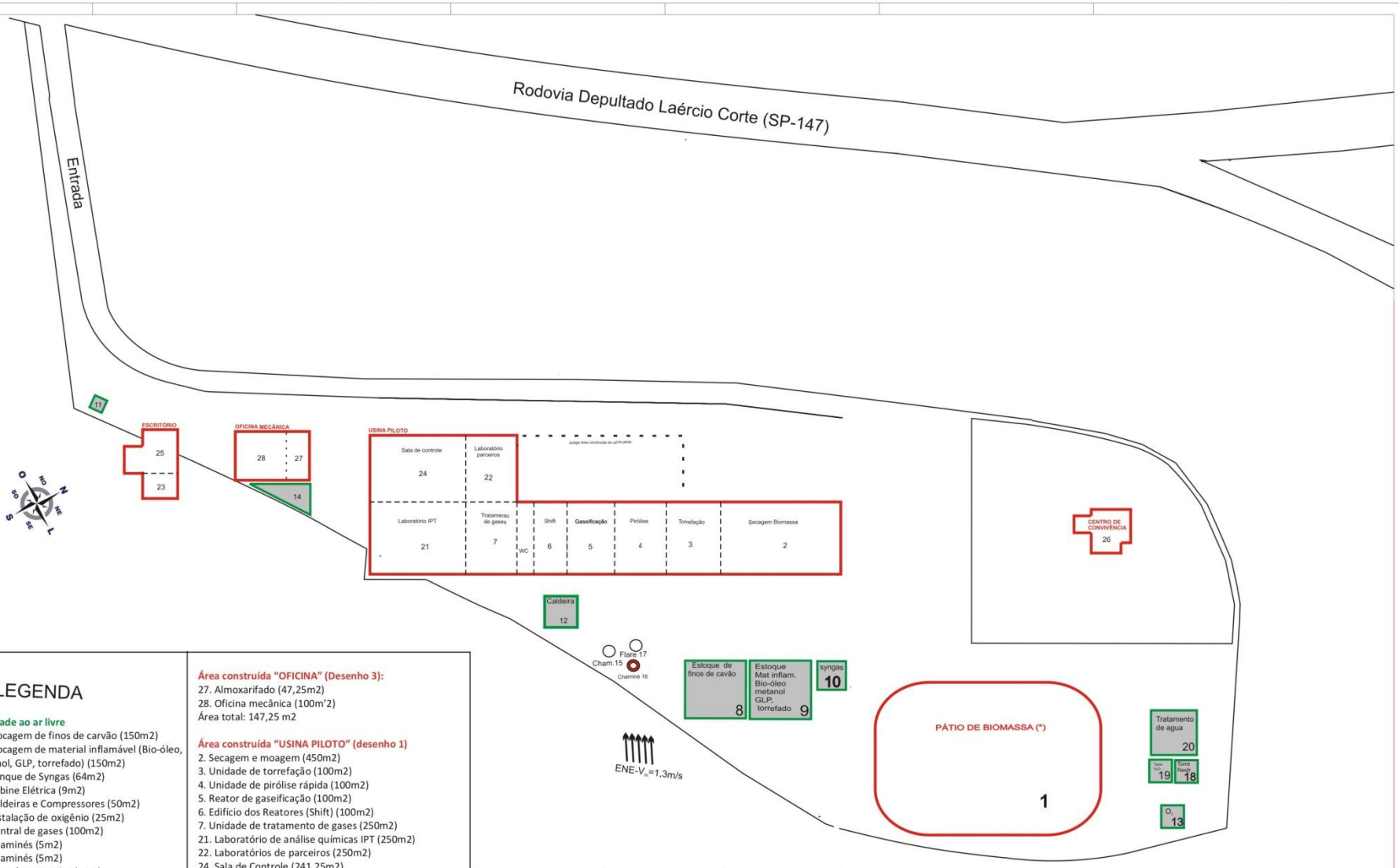


Pilot plant: Piracicaba

Piracicaba IPT Plant – Old Sugar Cane Plant in ESALQ area







LEGENDA

Atividade ao ar livre

8. Estocagem de finos de carvão (150m2)
9. Estocagem de material inflamável (Bio-óleo, metanol, GLP, torrefado) (150m2)
10. Tanque de Syngas (64m2)
11. Cabine Elétrica (9m2)
12. Caldeiras e Compressores (50m2)
13. Instalação de oxigênio (25m2)
14. Central de gases (100m2)
15. Chaminés (5m2)
16. Chaminés (5m2)
17. Flare / Queimador (5m2)
18. Torre de Resfriamento (25m2)
19 Torre reservatório de água (65m2)
20. Tratamento de água processo (100m2)

Área total: 753m2

Área construída "ESCRITÓRIO" (desenho 2):

23. Escritório IPT (50m2)
25. Auditório /salas de aula (50,65m2)

Área total: 100,65 m2

Área construída "OFICINA" (Desenho 3):

27. Almoxarifado (47,25m2)
28. Oficina mecânica (100m'2)

Área total: 147,25 m2

Área construída "USINA PILOTO" (desenho 1)

2. Secagem e moagem (450m2)
3. Unidade de torrefação (100m2)
4. Unidade de pirólise rápida (100m2)
5. Reator de gaseificação (100m2)
6. Edifício dos Reatores (Shift) (100m2)
7. Unidade de tratamento de gases (250m2)
21. Laboratório de análise químicas IPT (250m2)
22. Laboratórios de parceiros (250m2)
24. Sala de Controle (241,25m2)

Área total: 1.841.25 m2

Área construída "CENTRO DE CONVIVÊNCIA" (desenho 4):

26. Vestiário/Sanitários/refeitório (100m2)

Área total: 71,65 m2

Área construída " PATIO DE BIOMASSA" (desenho 5):

1. Pátio coberto de armazenagem de Biomassa (1600m2)

Construção	ÁREA ÚTIL (m2)	ÁREA TOTAL CONSTRUÍDA (m2)
Usina piloto	1.841,25	2.000,60
Escritório	100,65	111,20
Oficina	147,25	168,00
Centro de Convivência	71,65	80,10
Pátio de Biomassa (*)	3.000	3.000
Área total	5.160,80	5.359,90

(*) Área a ser construída

AUTOR	Gerhard Ett		
DATA	30/10/11		

Disposição física dos equipamentos

ESALQ - Piracicaba

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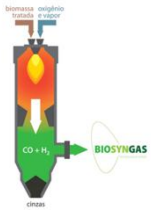
Figura elaborada para solicitação de licença Ambiental junto à CETESB

Final remarks

- Gasification is an important option for a better use of bagasse in the 2020's, depending on oil price evolution.
- Entrained Flow gasification technology is a viable alternative.
- No commercial technology is available, so a pilot plant is a necessary step.
- The team wants to incentive Brazilian research groups to join the effort and face the scientific challenges that lay before us.



Partners

ipt INSTITUTO DE PESQUISAS TECNOLÓGICAS

ESALQ 1901 • 2011 110 ANOS

USP

Partner Companies

BR PETROBRAS

OXITENO

VALE

Financing

BNDES

FINEP
FINANCIADORA DE ESTUDOS E PROJETOS
MINISTÉRIO DA CIÊNCIA E TECNOLOGIA

SP PRO-BRASILIA-FIANT-EXIMIA