Second and Third Generation Technologies for Ethanol and Biodiesel Production

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Presentation outline

- Biofuels development: some definitions
- Thermochemical routes for ethanol and diesel substitutes production
  - Ethanol from syngas
  - FT diesel
  - Pyrolysis diesel
- Biochemical routes for ethanol production
- Genetic engineering approaches
  - Ethanol
  - Microdiesel

Brazilian Agroenergy Plan

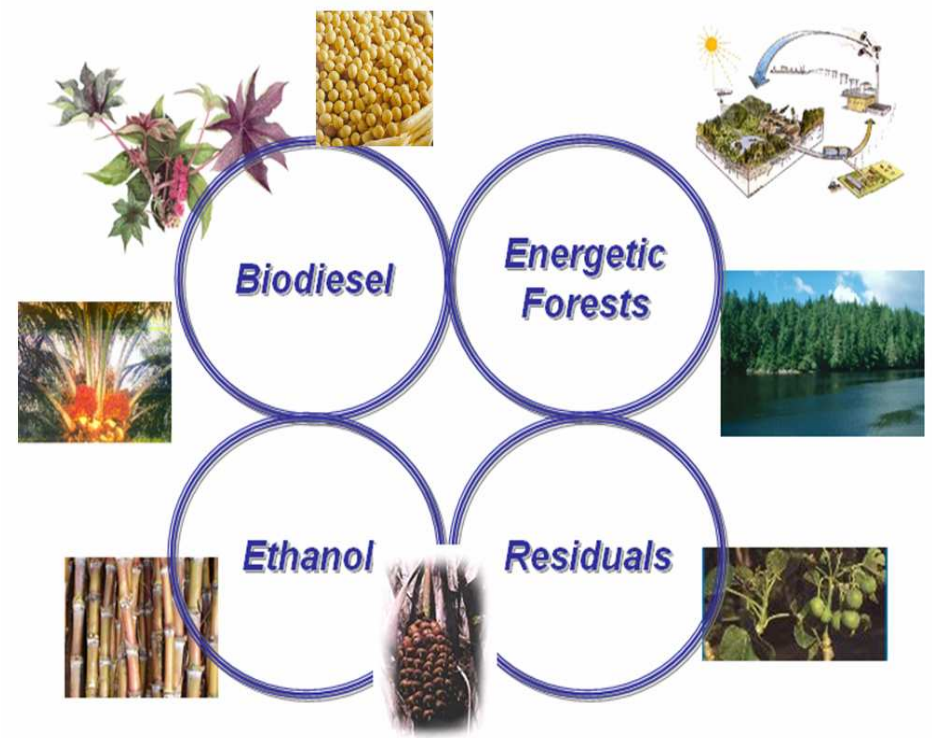
2006 – 2011

OBJECTIVE:

to produce and transfer knowledge and technologies that contribute to the sustainable production of energy from agriculture

5 DIMENSIONS:

- Economics
- Social
- Environment
- Regional Differences
- World Insertion



Embrapa Agroenergy

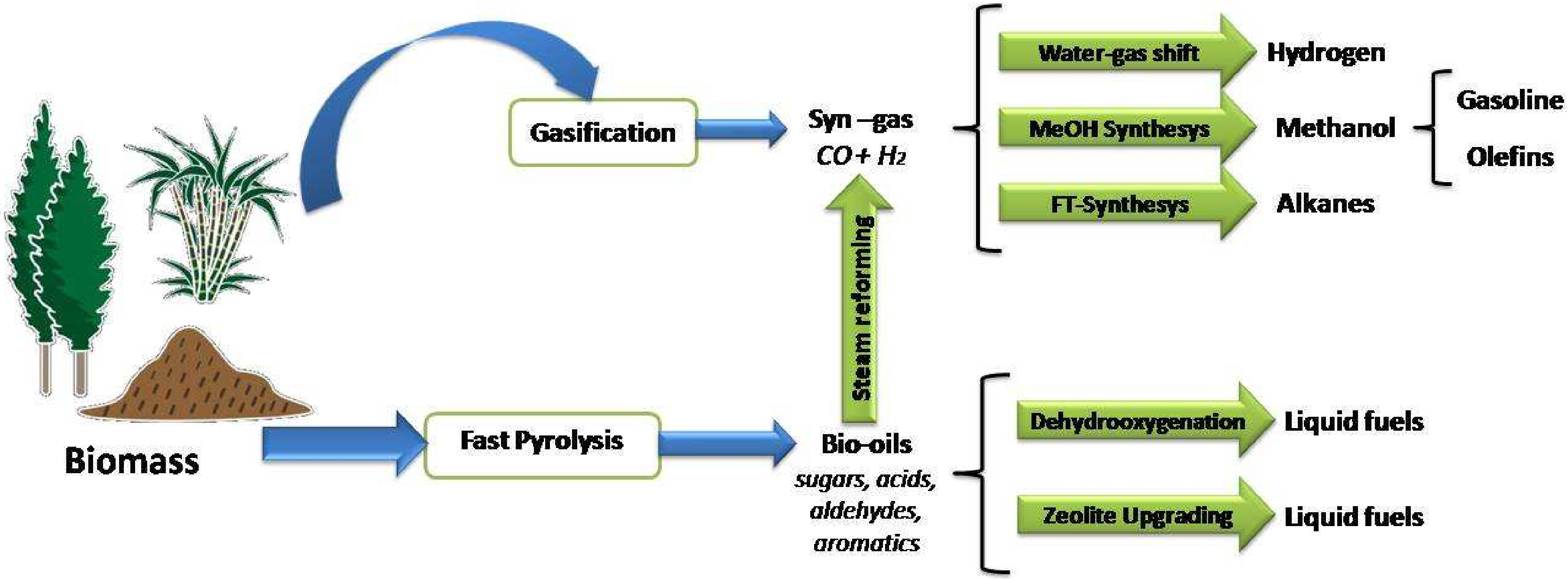
- Basic Information:
  - Creation: May 24th, 2006
  - Installation: January, 2007
  - Staff: 150 employees (in 2011)
  - Location: Brasília – DF (December, 2010)
- Duties:
  - Coordination of Agroenergy R&D actions at Embrapa.
  - Execution of R&D projects

Biofuels development: some definitions

CGIR position paper, 24 April, 2008

- First generation biofuels:
  - Are made from sugar, starch and oils **from a specific (often edible) portion of traditional human and animal feed plants** as sugar cane, wheat, corn, palm, soy and castor bean, **using conventional technologies**
- Second generation biofuels:
  - Produced **from non-edible raw materials** including lignocellulosic biomass, residues of food crop production (e.g. corn stalks or rice husks) or whole plant biomass (e.g. grasses or trees grown specifically for energy). **Require more sophisticated processes, either thermochemical or biochemical.**
- Third generation biofuels:
  - Produced by **energy and biomass crops that have been designed** in such way that their very structure or properties conform to the requirements of a particular bioconversion process. The **bioconvertion agents are engineered** for more efficient process.

Thermochemical routes

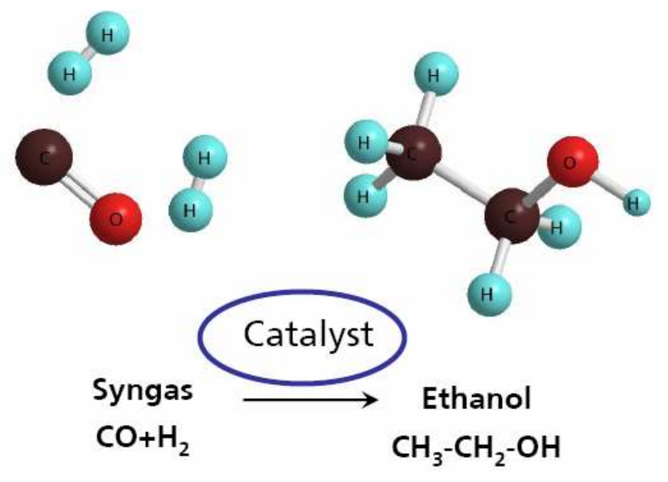


		LIQUID (%)	SOLID (%)	GAS (%)
GASIFICATION	High temperature (over 800 ^{o}C) long residence time	5	10	85
FAST PYROLYSIS	Moderate temperature (400 – 500 ^{o}C), short residence time (less then 2 s)	75	12	13

Source: WRE, 4(1) 2001

Ethanol from synthesis gas – Catalytic route

- Produced in the lab from syngas over different catalysts
- The existent ethanol synthesis catalysts are not sufficiently efficient.
- Development of a better ethanol synthesis catalyst is the critical need for this pathway.



Ethanol from synthesis gas – Biological route

- Gasification and subsequent fermentation of the produced gas enables fermentation of all carbon and hydrogen containing material also non degradable materials like plastics.
- The processes take place at 37℃, and the pH is con trolled.
  - *Clostridium ljungdahlii.* This bacterium produces acetic acid as a side-product.
- Bench-scale studies

FT- conversion

- In the Fischer-Tropsch conversion, the syngas is normally used for the production of synthetic diesel and gasoline, but can also be used for the synthesis of methanol, ethanol or other higher alcohols
- The earlier catalysts used were iron (Fe) and cobalt (Co). These catalysts degrade when exposed to toxic impurities in the syngas.
- In thermochemical conversion, Fischer-Tropsch (FT) synthesis promises high potential because it gives a liquid with superior fuel properties for use in diesel engines.

FT-diesel: research gaps

- Improve the economics of the process.
- Longevity and robustness of the catalysts, as well as more cost-effectively achieving cleanup of the syngas.
- Improve the quality of the feedstock for FT synthesis and to reduce the down-stream costs for equipment and processing both due to clean-up of the product and systems that guard the catalysts from potential poisons that reduce their life.
- For the development of FT synthesis, knowledge about kinetic principles of catalytic conversion is necessary.
- Catalysts specifically designed for FT synthesis of feedstocks derived from renewable resources are needed to increase the desired liquid fuel yields.

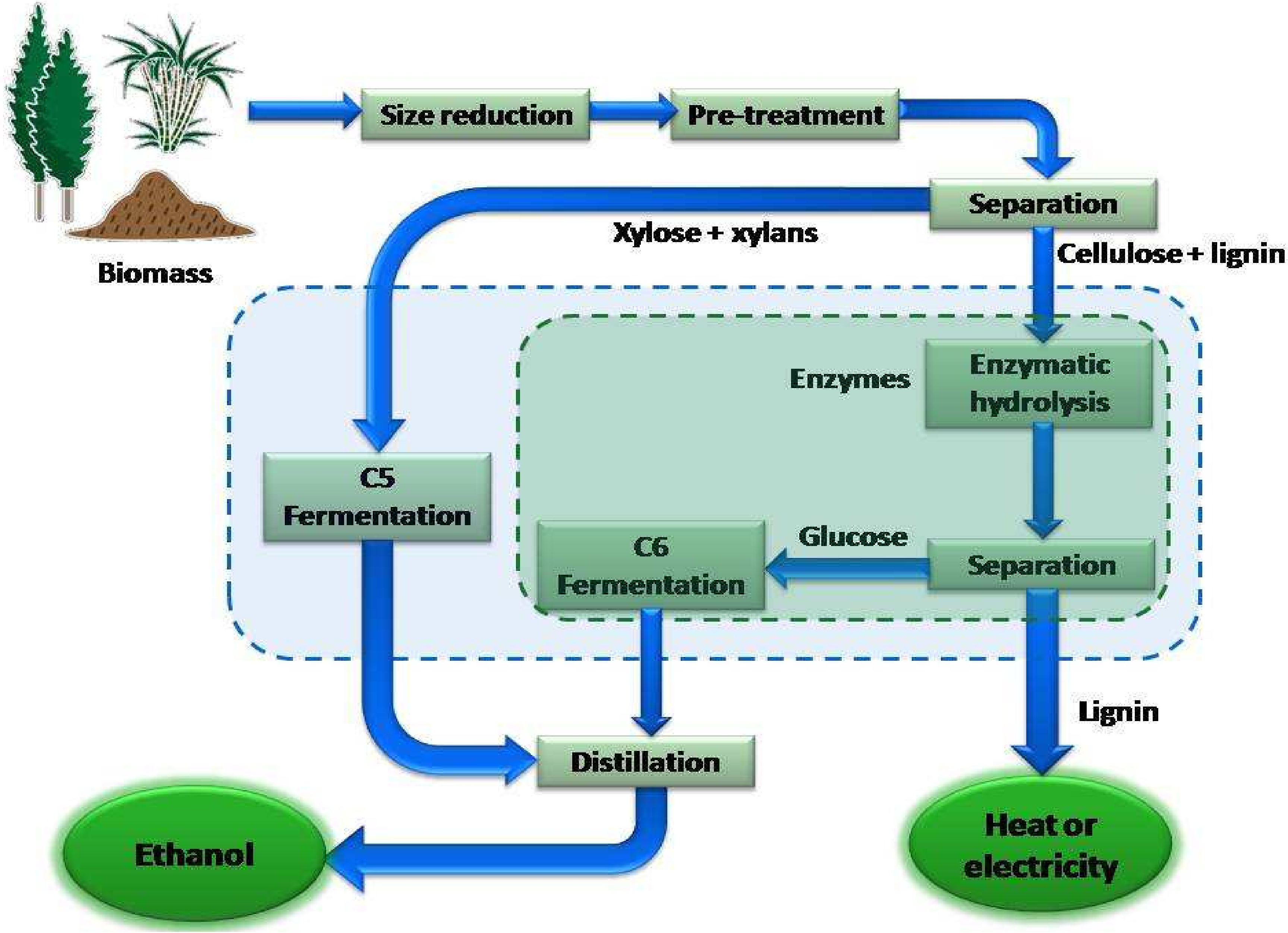
Pyrolysis-diesel

- After the production of bio-oil by pyrolysis, it must be upgrated because of the heterogeneity of the bio-oil which makes it unsuitable for diesel engines.
- Two main pathways:
  - hydrodeoxygenation and zeolite upgrading.
  - this processes can be made in modified but existing oil refineries (reduction of capital cost and the cost for additional infrastructure).
- Not a commercial product at the moment.

Pyrolysis-diesel: research gaps

- Development of stabilizers for the oils so they are not too viscous during transport.
- Improvements in catalysts so that oils are formed that are more stable in the first place.
- Improvement of the catalytic conversion so that the bio-oil exhibits stability over time, which is a requirement for long-distance transport.

Biochemical routes for ethanol



Biochemical Routes: Technical challenges

- Lignocellulose pre-treatment
  - Very strong bonds
- Enzymatic hydrolysis
  - Unlyke starch, isn’t hydrolysed by conventional enzymes
- Pentoses fermentation
  - Novel microorganisms are required
- Process integration
- Residues generation

Status of each sub-process involved

Sub-process	State of development
Pretreatment	Demonstration/commercial – needs optimization for different feedstocks
Enzyme production	Commercial – needs further costs reduction
Enzymatic hydrolysis	Early demonstration
Hexose fermentation	Commercial
Pentose fermentation	Research/pilot plant (moving towards commercialization)
Ethanol recovery	Commercial
Lignin recovery and applications	Research/pilot plant – to improve economic performance
Waste treatment	Research/commercial

Ethanol – Genetic Engineering Approaches

- Biomass modification (GMOs) – plants designed for deconstruction

❖ Microorganisms modification – consolidated bioprocessing

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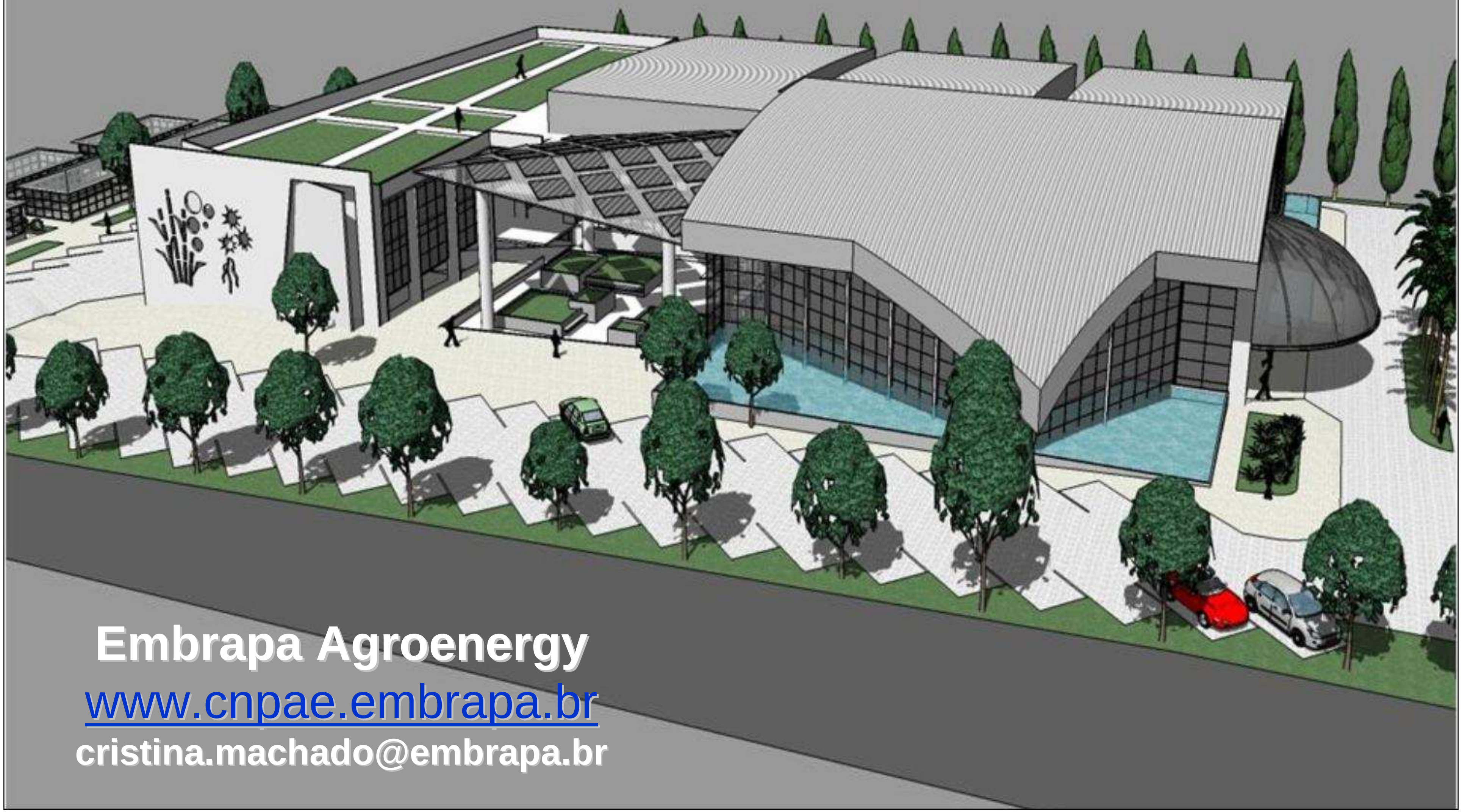
Microdiesel Development – Genetic Engineering

Some synthetic biology initiatives

- Amyris/Crystalsev (Campinas, SP)
  - “No Compromise™ renewable diesel fuel”
  - GMO fermentation converting sugar to hydrocarbons
- LS9 (San Francisco, CA)
  - “Renewable Petroleum™”
  - GMO fermentation converting fatty acid intermediates into petroleum replacement products via fermentation of sugars.
- Synthetic Genomics (La Jolla, CA)
  - GMOs
  - Plants genomes

THANK YOU !!



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