Clúster Bioturbosina

IMP

FONDO DE SUSTENTABILIDAD ENERGÉTICA

Research and technology development in

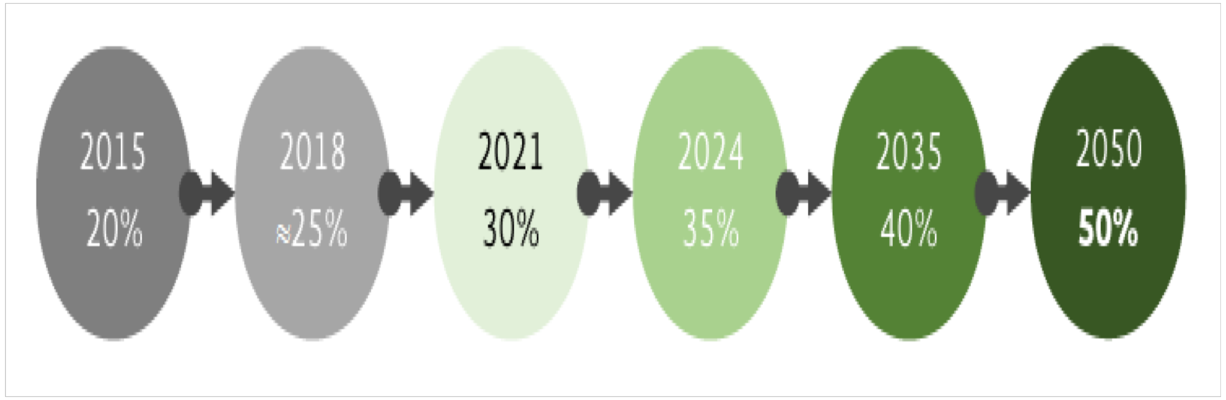
Biojet fuel

Dr. Jorge ABURTO

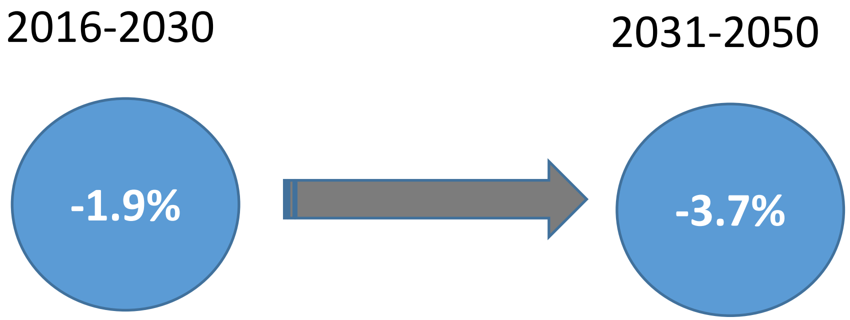
MADE IN MEXICO

Goals of clean energy generation and energy efficiency in Mexico, 2015-2050

Clean energy generation in Mexico



Final energy intensity in Mexico



Source: SENER, CONUEE, 2016.

Instituto Mexicano del Petróleo as a Mexican National Laboratory in Oil, Gas and Bioenergy

AMEXHI

Mission: "Boost the technological development of the national energy sector

The IMP is a Mexican National Laboratory whose purpose is to generate technical and technological capabilities to the oil, gas and bioenergy industries

- We cover all the operational part of the value chain of the oil and gas industry (from upstream to downstream).
- We focus on generation of economic value
- We solve high impact technological problems in order to achieve business goals

Applied research

- We develop, assimilate and transfer technology focused to solve specific problems

Provider of technological products and services

- We offer comprehensive solutions through engineering and technological services

Scientific, technical and technological specialized training

- Postgraduate studies
- Professional Development
- Labor training
- Tailored courses

IMP, with more than 50 years has a large installed capacity with experience and results in the oil and gas industry

Installed Capacity

- **2,820 Researchers, specialists and technicians**
- 28% Master and PhD
- 1.8 MM Engineering man power
- 21 Training Centers
- **12 Laboratories Groups**
- 1,250 Assays and Services
- **11 Pilot Plants**
- 94 Products and services
  - E&P
  - Engineering
  - Talent Developement
- 257 Specialized software
- Library with the greatest oil and gas information in Mexico

Experience

- Oil Basins Mexico Atlas
- **Guidelines for fuel regulation and blends for biofuels**
- **Technology roadmaps for renewable energy**
- Monitoring of 500 operations fracking in 7 years
- 61 Off-shore platforms
- 55 Oil/gas pipelines (2,160 km)
- **230 designs of Downstream plants**
  - 30 Crude oil distillation plants
  - 31 Hydrotreating plants, 6 coker naphta

Results

- 927 patents, 3,122 copyrights and 232 brands up to day
- 22 patents, 143 copyrights , 142 refereed publications per year
- Downstream plants contribute with 1 MMbpd naphta/distillates
- **Proper selection of FCC catalyst saves $10 MM USD/year, for Petroperu**
- **PREGASOL® model for engine gasoline combustion emissions**
- **Application of 25,000 ton IMP chemical products for Pemex in 2015**
- Posgraduate 64 PhD, 76 masters, since 2001
- **Recipient of PRODETES PRIZE** in 2016 (SENER, World Bank, GEF)

Instituto Mexicano del Petróleo as a scientific and technological pole in Bioenergy

Biomass → Conversion → Up and downstream needs

CEMIE BIO

Clúster Bioturbosina

Clúster Biocombustibles sólidos

Mapa de Ruta Tecnológica Bioturbosina

Processing integration, LCA, Sustainability, Training

Research Institutes involved in the converion of biomass to biojet fuel

QENER

jbei
Joint BioEnergy Institute

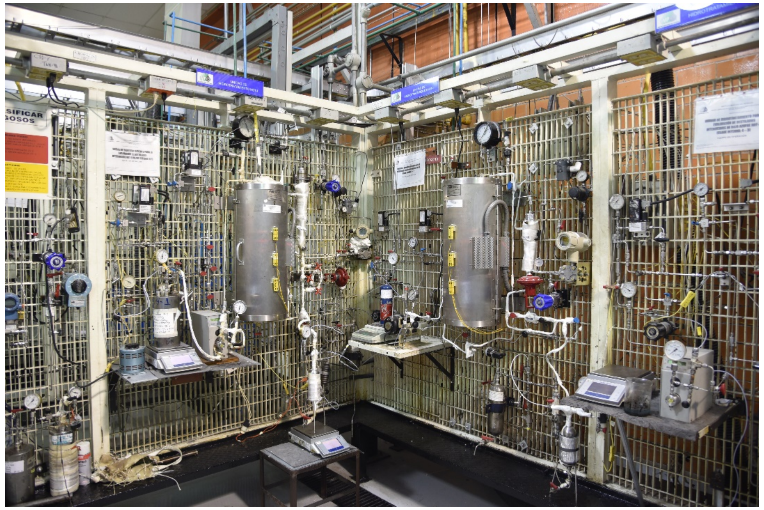
Main research areas:

Hydroprocessed esters and fatty acids (HEFA)
IMP, CIQA

Alcohol to Jet Fuel (ATJ)
CICY, CIATEC, CIATEJ

Pyrolysis of Biomass
IMP

Hydrogen production by alkaline electrolysis
CIDETEQ



1) We carry out theoretical simulations on chemical reactions for biofuels

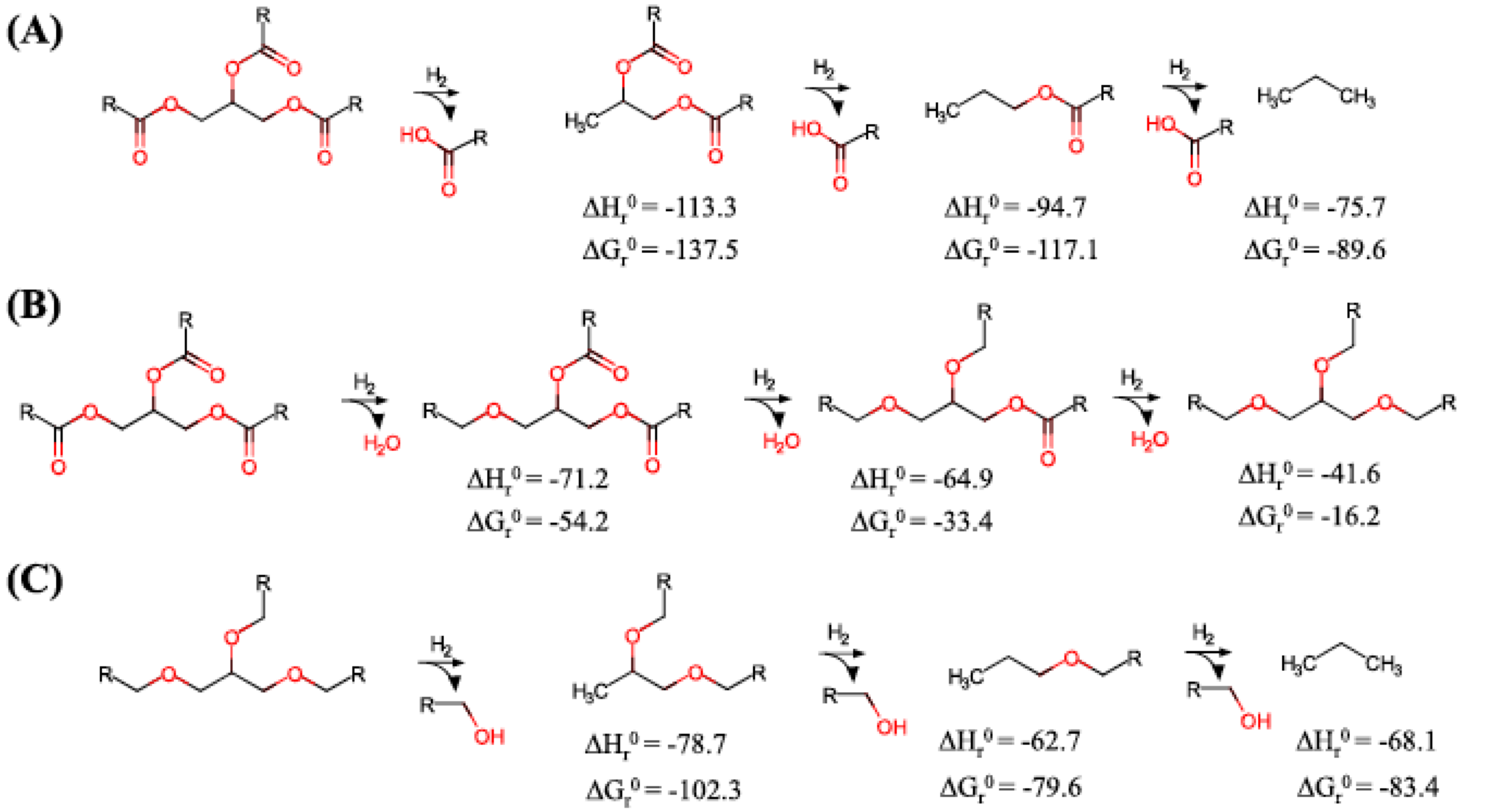
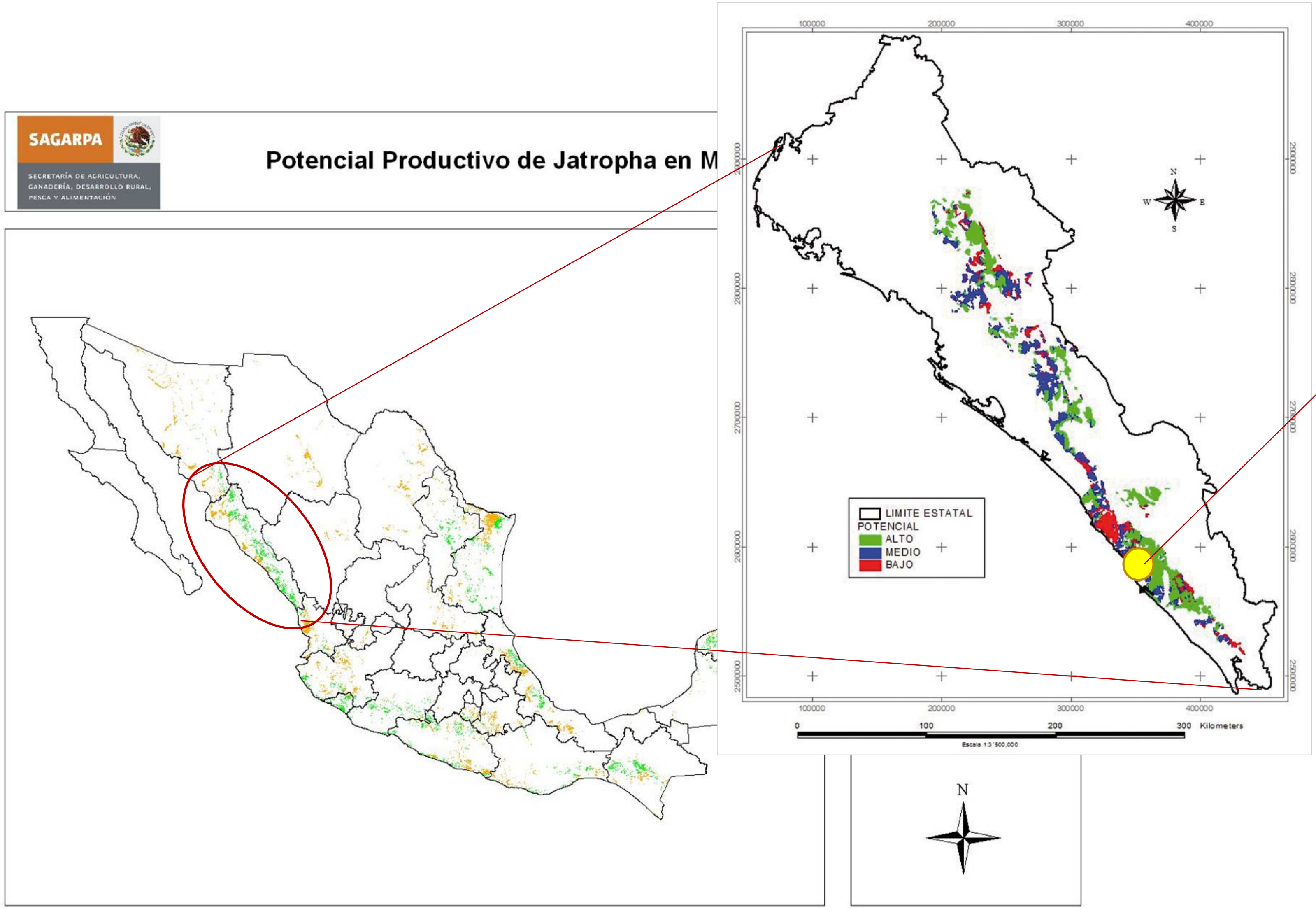


Fig. 7. Reaction network of TAGs under H_2 environments. (A) Direct fatty acid elimination (DFAE) route, where TAG reacts with H_2 to release FAs and propane, (B) Carboxylic partial reduction (CPR) route, where the carboxylic groups within TAG molecule is reduced to form an ether group and water and (C) Fatty alcohol elimination (FAE) route, the reduced molecule of TAG under H2 eliminates a fatty alcohols, by the cleavage of the C-O bond, and propane. All the reaction energies correspond to tricaprylin and related products. Values are given in $kJ mol^{-1}$.

D. VALENCIA, I. GARCIA-CRUZ, V.H. UC, L.F. RAMIREZ-VERDUZCO, M. AMEZCUA-ALLIERI, J. ABURTO, Biomass and Bioenergy, 2018, 112: 37-44.

2) Mazatlán, Sin. Biorefinery: winner of PRODETES Prize (World Bank, GEF, Sener)



Project between UASinaloa, IMP and InTrust

1st biorefinery location

Currently:

- Jatropha oil to biodiesel
- Seed cake as fish meal
- Shells as briquettes

- Sinaloa state is the 1st corn producer and the 6th grain sorghum producer in Mexico.
- Jatropha shells, corn stover and sorghum stalks can feed a multifeedstock biorefinery

Biomass for multifeedstock biorefineries

Component	Corn stover	Sorghum stalks	Jatropha fruit shell
Ash	5.22	5.98	14.9
Cellulose	31.40	32.22	33.8
Hemicellulose	24.86	23.06	9.71
Lignin	14.90	17.08	11.7
Other solids	5.12	3.52	6.03
Water	18.50	18.14	23.86
% yield relative to main crop	53.4%	53.4%	72%

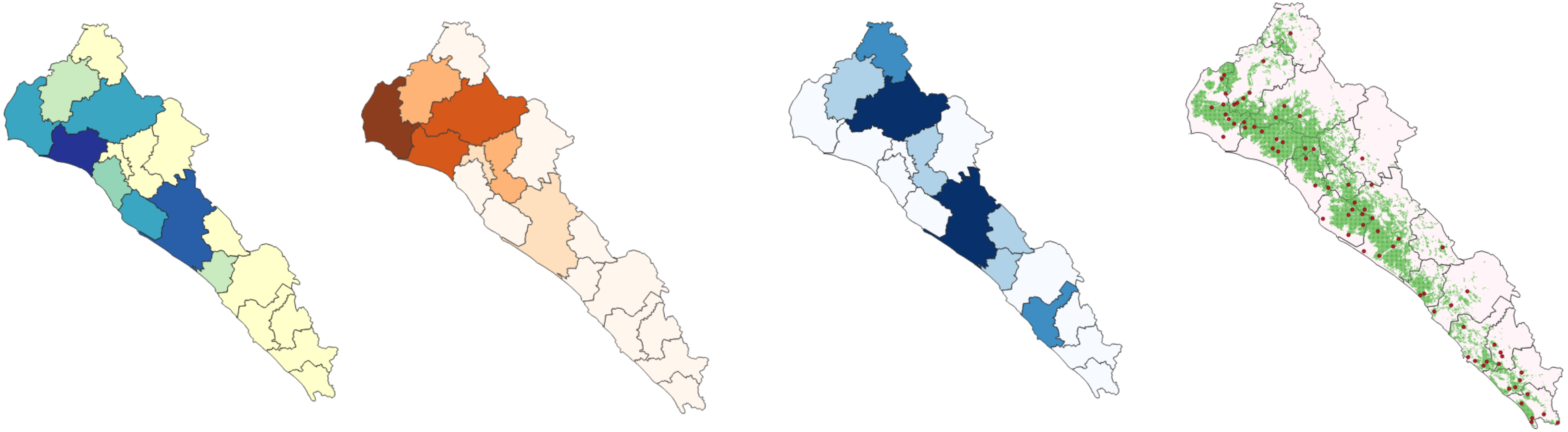
Biomass distribution and location candidates

Corn stover

Sorghum straws

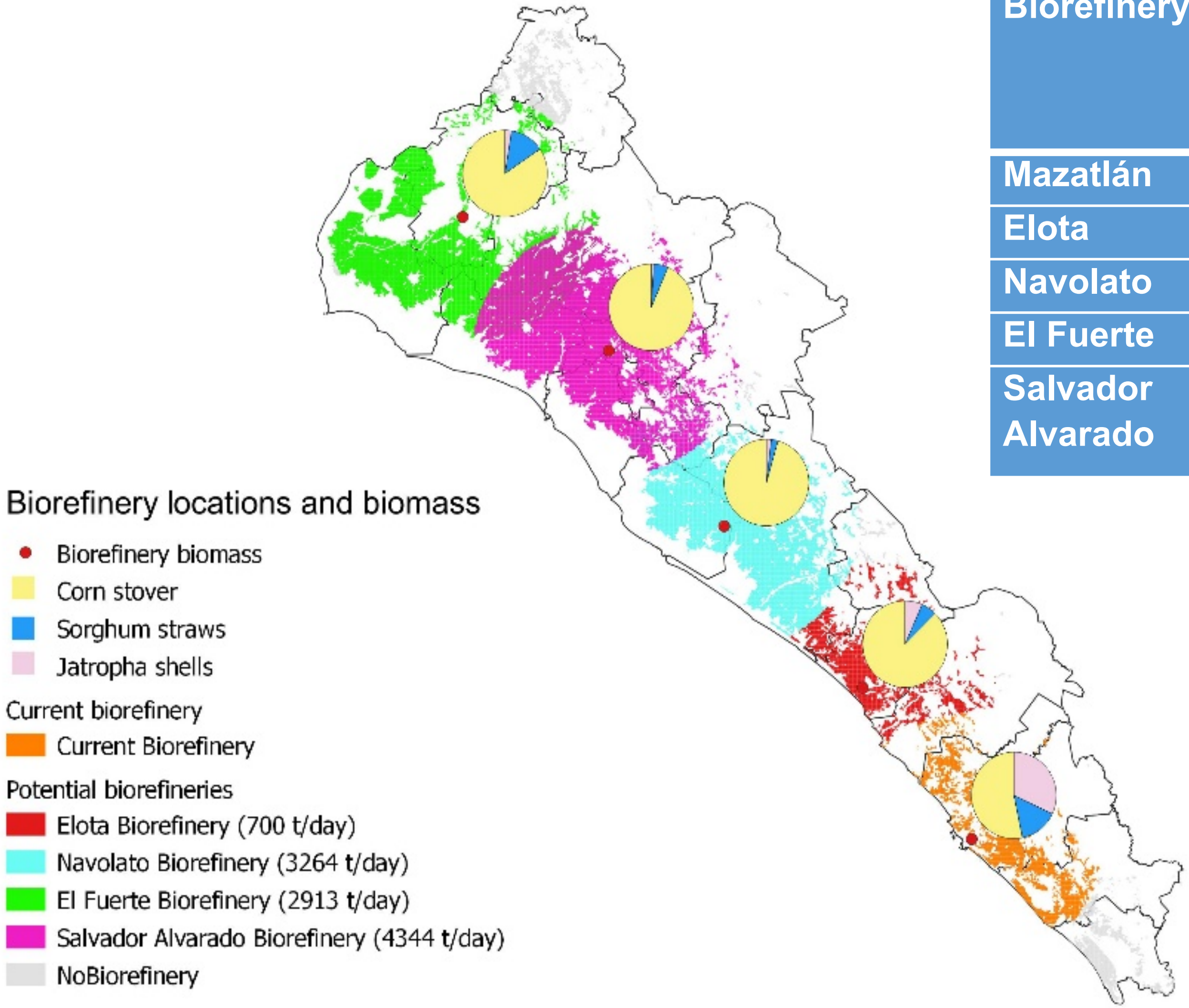
Jatropha shells

Base map



- Base map of agricultural land and localities as per CONABIO, was gridded to cells of 1 km x 1 km
- Biomass production at municipal level from Agricultural Information System of SAGARPA, Agricultural cycle 2016
- Biomass shed equal to biomass available within a 50 km radius

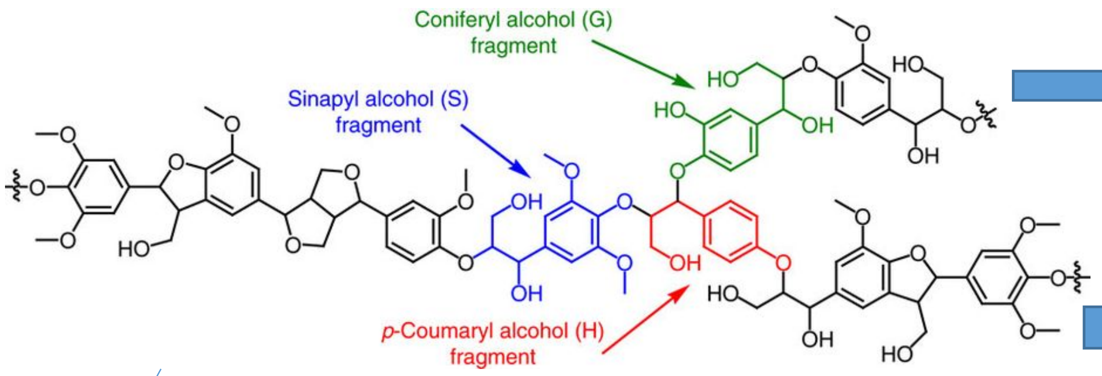
Locations for Biorefineries and biomass farms



Biorefinery	Total biomass (t/y)	Corn stover (%)	Sorghum stalks (%)	Jatropha fruit shells (%)
Mazatlán	61,716	53.2%	14.8%	32.0%
Elota	231,219	87.5%	5.9%	6.6%
Navolato	1,077,285	95.6%	2.5%	1.8%
El Fuerte	961,467	84.6%	12.9%	2.5%
Salvador Alvarado	1,433,471	93.6%	5.4%	1.0%

- **5 potential biorefinery locations and sizes**
- Mazatlan, Elota and El Fuerte biorefineries are multifeedstock (more diverse biomass inputs)
- Navolato and Salvador Alvarado biorefineries based mainly on corn stover (>90%)
- Mazatlan and Elota are small scale (<1000 t/d), the rest are medium scale (1000-14000 t/d).

Valorization of lignin streams from lignocellulosic biorefineries is key for economic viability and sustainability of biojet fuel production



Pyrolysis
Phenols, alkykphenols, acetic acid
CO, CH4

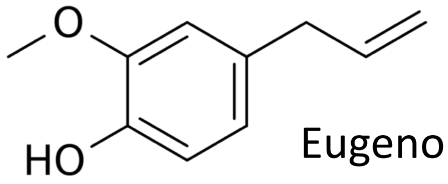
→ **HDO** →

- Benzene, Toluene Xylene (BTX)
- Cyclic paraffins

Catalytic hydrogenolysis
High-value methoxyphenols

→

- Eugenol
- 4-Ethylguaiacol
- Syringols
- Polyphenols



Eugenol
$C_{10}H_{12}O_2$

Oxidation
Vanillin, DMF

Energy
Phenolic resins
Lignosulfonates
Gasification

Microbial conversion
Ferulic, vanillic, coumaric acid

We carry out theoretical simulations and fondamental research on pyrolysis

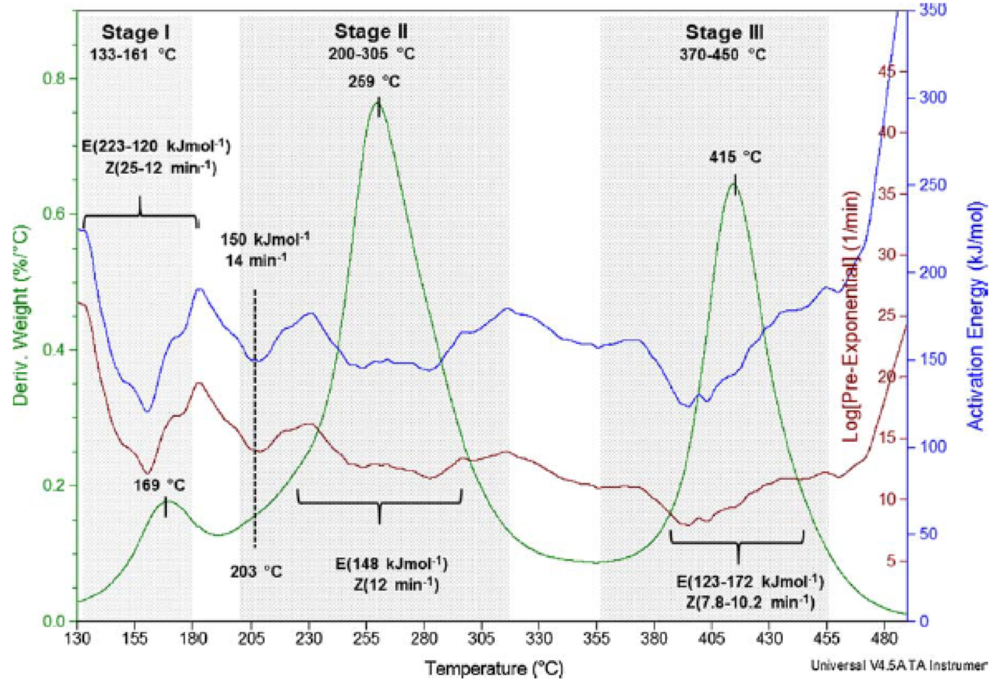
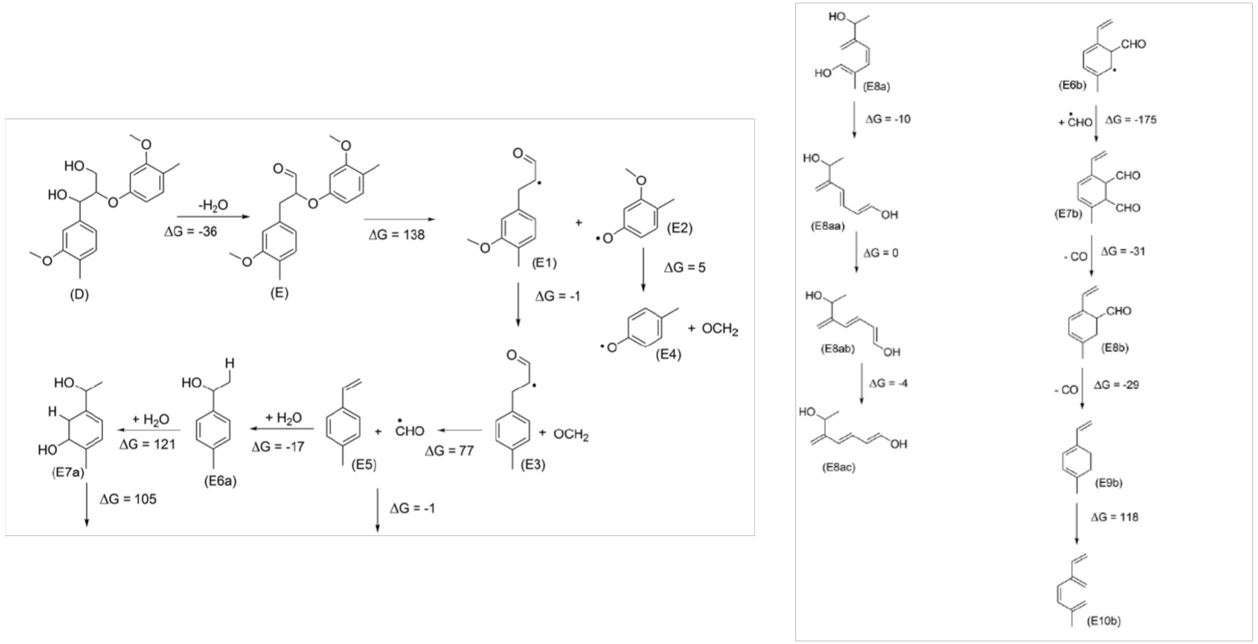


Fig. 4. Thermal and energetic profiles for lignin pyrolysis obtained by modulated-temperature (MTGA) for an experiment performed at 5 °Cmin^{-1} with temperature perturbation amplitude of ± 3 °C and periods of 200 s.

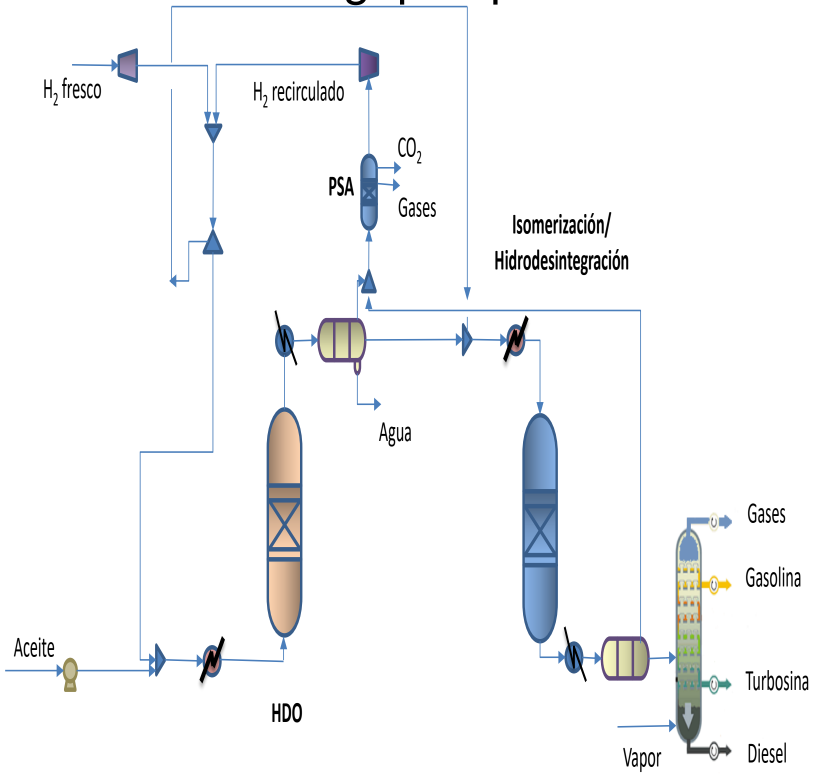


Scheme 1. Chemical routes proposed as the most likely ones (from those studied by molecular simulation) for the thermal decomposition of β-O-4 linkages in lignin and secondary reactions which promote the aromaticity loss of products. (a): by water addition to the aromatic rings and (b): by free radical addition. The Gibbs free energy of each step (ΔG) is provided next to, or below the arrow, indicating the conversion, and are expressed in kJ/mol.

A. GALANO, J. ABURTO, J. SADHUKHAN, E. TORRES-GARCÍA. (2017). Journal of Analytical and Applied Pyrolysis 128:208–216.

4) IMP develops processes and catalysts for biofuel production: The First Mexican process producing aviation biofuels on a pilot plant scale

- IMP's propietary catalysts and processes tecnology contibutes to:
  - Reduction till 50% in CO_2 emissions in airplanes depending of biofuel dosage
  - The demand of clean fuels for airline companies
  - Close the gap of price between biojet fuel and conventional jet fuel



Green diesel **Biojet fuel**

InTrust Global Investments

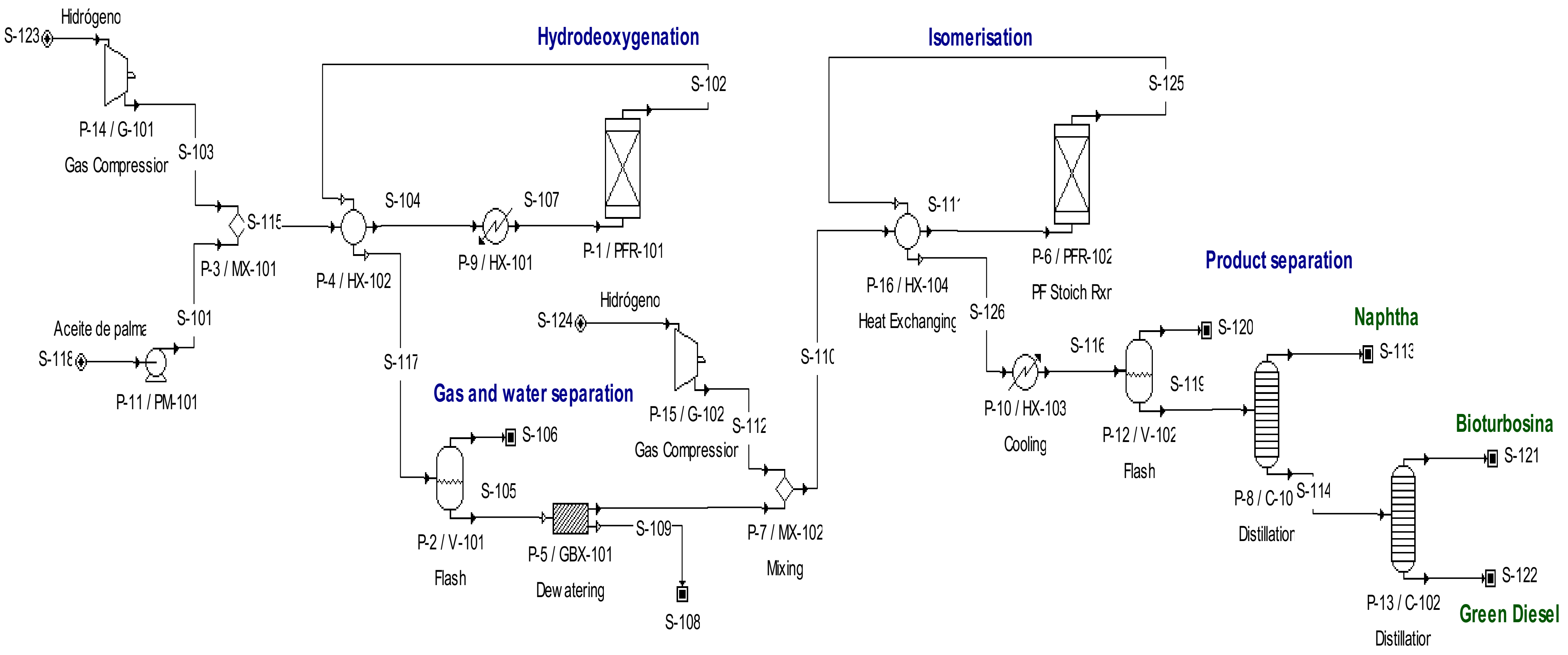
University of Oxford

University of Surrey

jbei Joint BioEnergy Institute

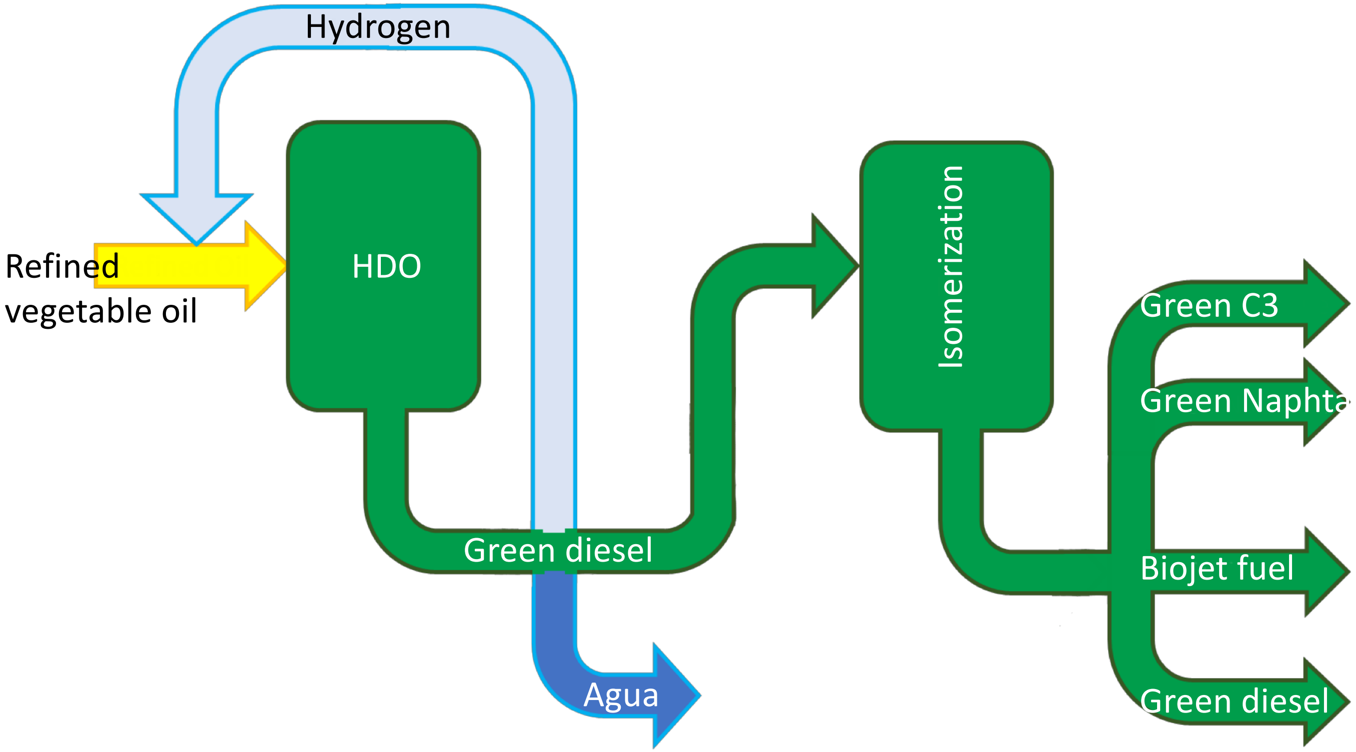
Harvard T.H. Chan School of Public Health Center for Health and the Global Environment

We carry out process simulation for techno-economical assessment as well as life cycle analysis

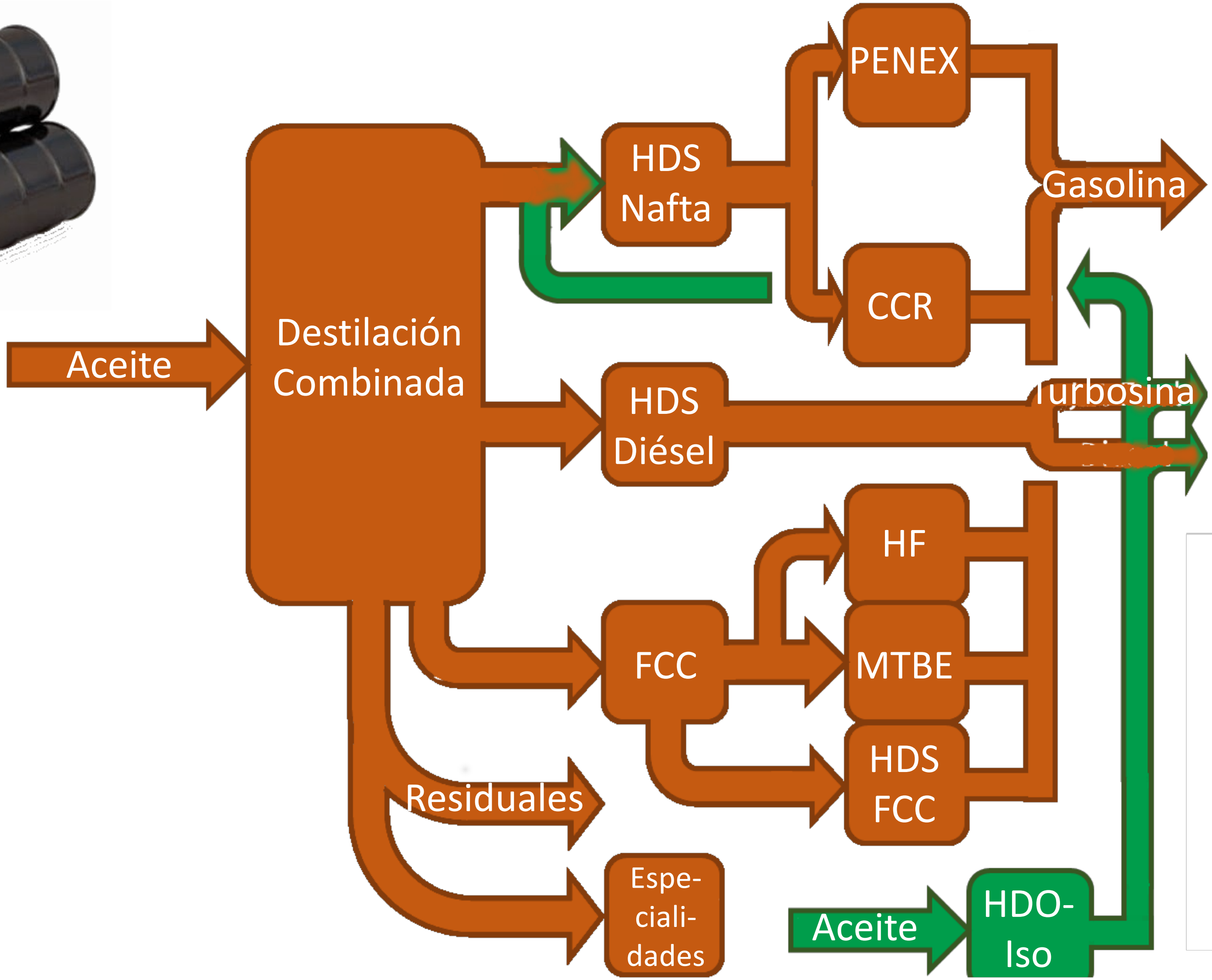


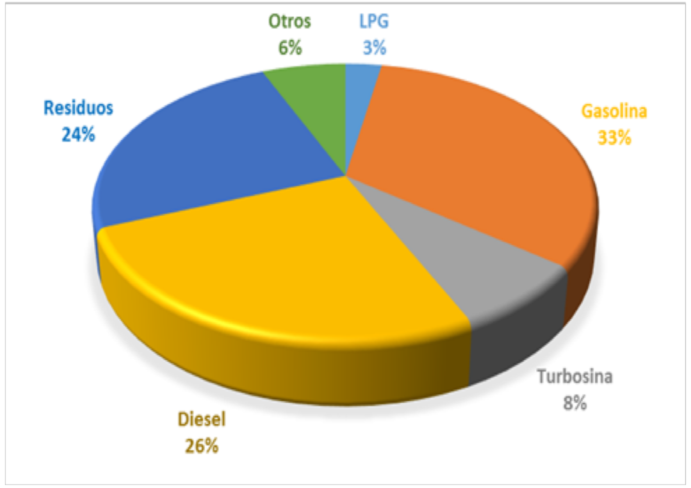
Three pending patents as well as trademarks on catalysts and processes for HEFA green diesel and biojet fuel

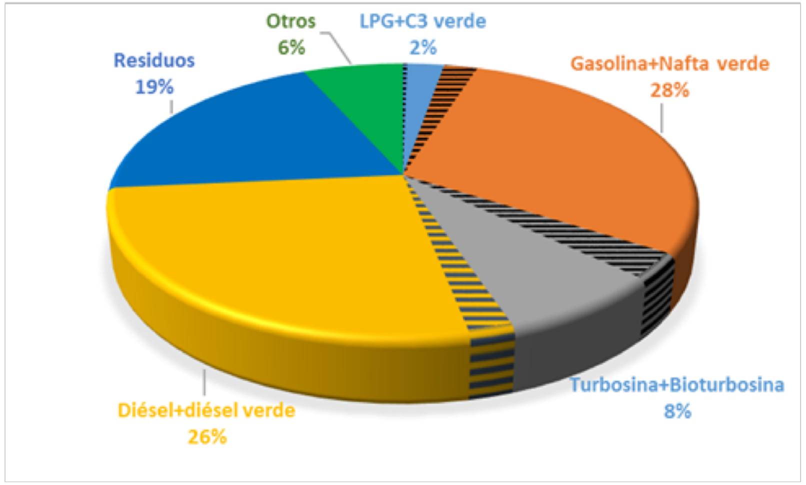
IMP's propietary technology on green diesel and biojet fuel: IMP is the largest Engineering oil and gas firm in Mexico



Process and energy integration with conventional petroleum refineries







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