Generation strategies from biomass and waste heat

(Estrategias de generación a partir de biomasa y calores residuales)

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ABISURE
Alliance for Biomass and sustainability Research

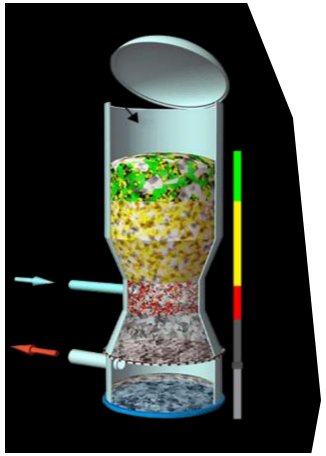
Schedule

- Introduction.
- Biomass.
- Biomass opportunities.
- Use of waste heat for power generation.
- Final remark.

https://www.csiro.au/en/research/technology-space/energy/biomass-to-energy

Electricity

Heating



1. Introduction

CO_2 Balance

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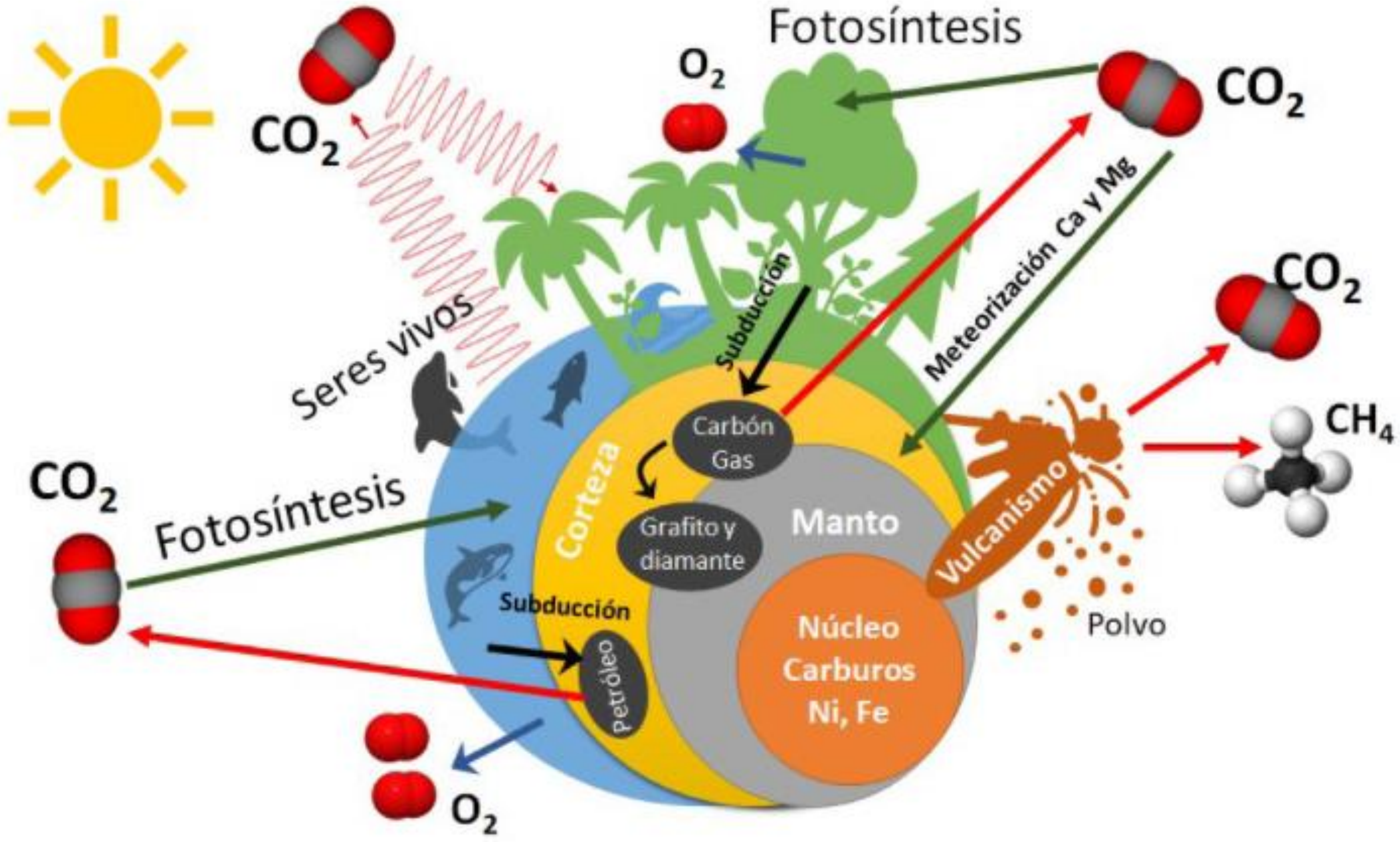
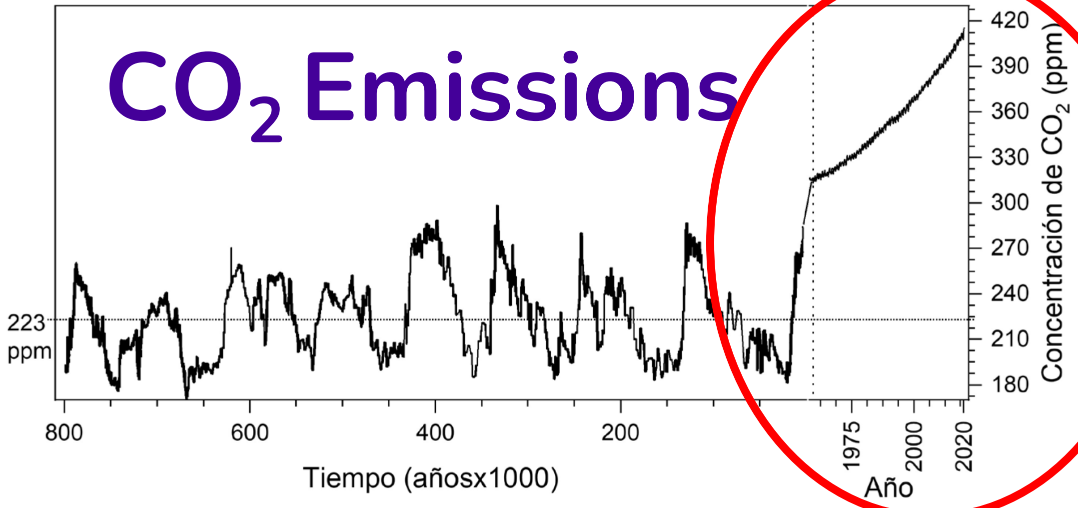
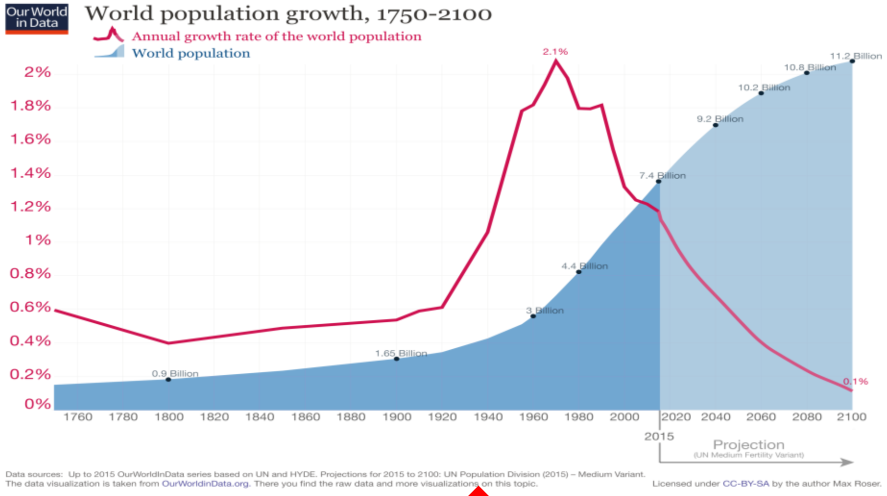
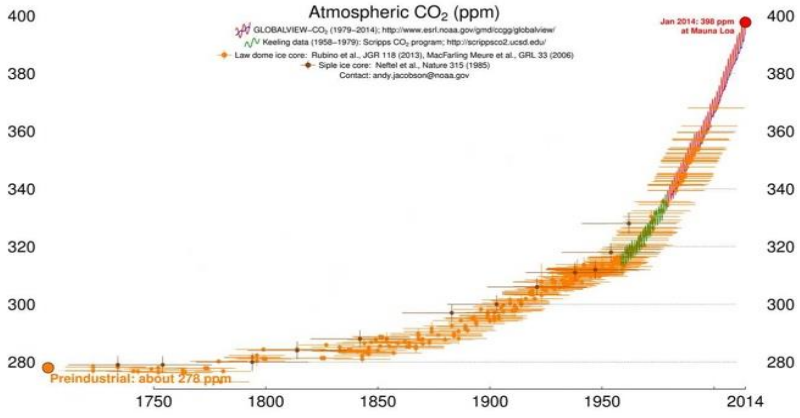


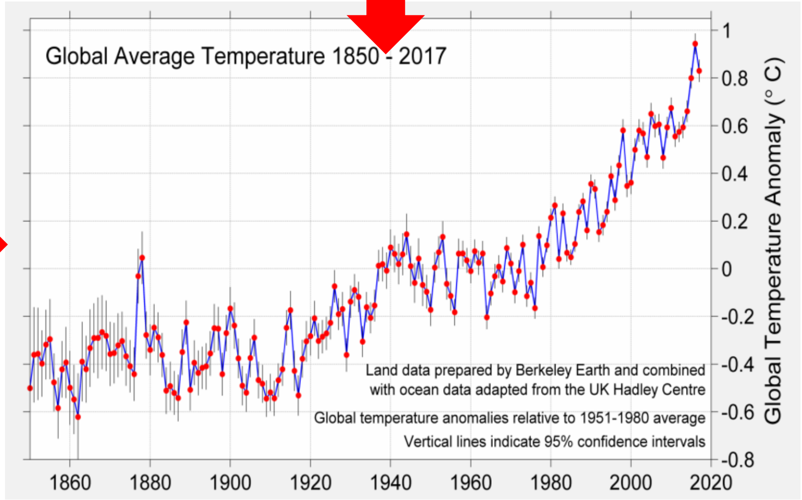
Citación: Mondragón F. Ciclos del dióxido de carbono en la formación y utilización de combustibles fósiles y su efecto en el cambio climático. Rev. Acad. Colomb. Cienc. Ex. Fis. Nat. 2021 Sept 6. doi: https://doi.org/10.18257/ raccefyn.1364

CO_2 Emissions









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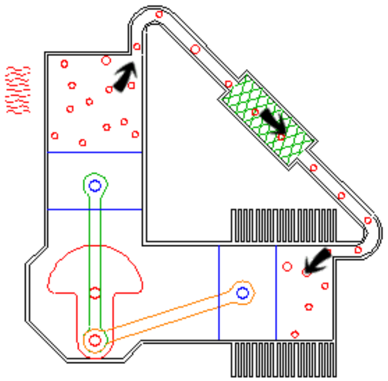
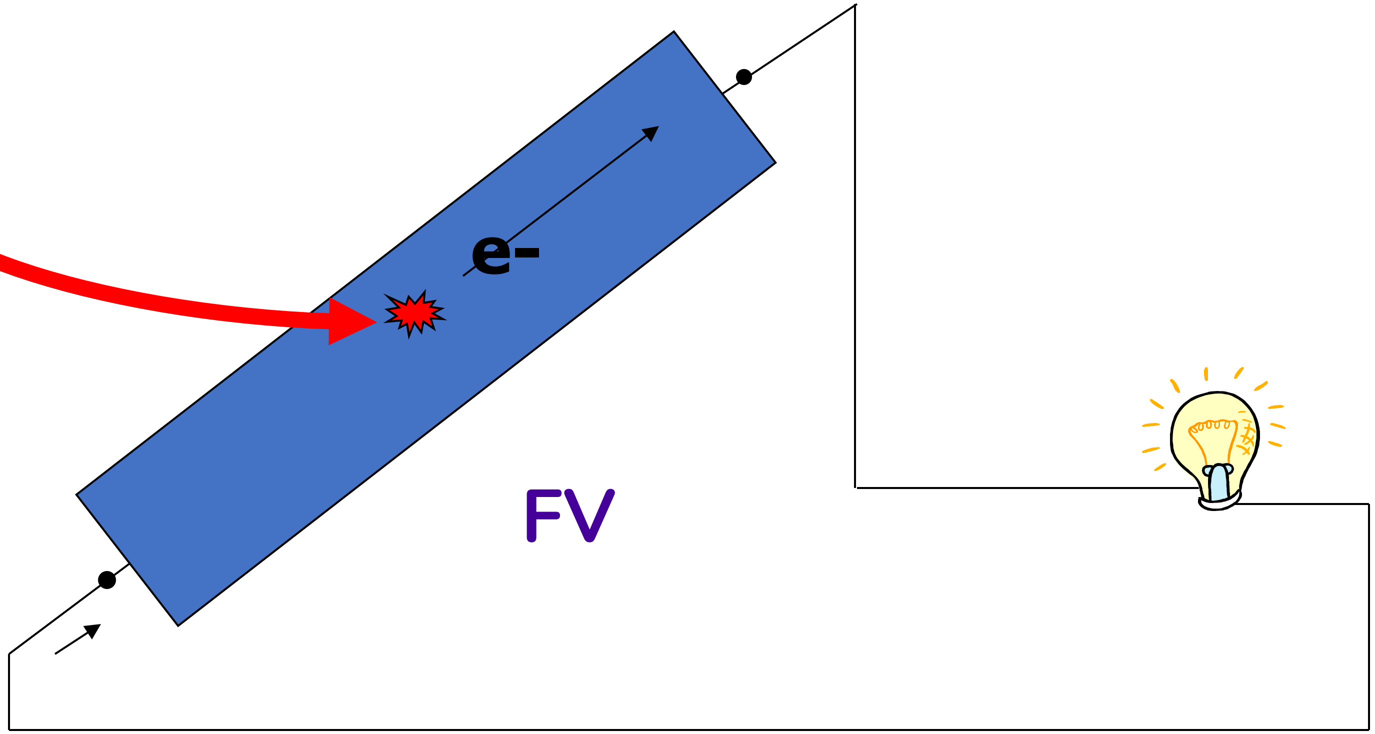
Stirling cycle

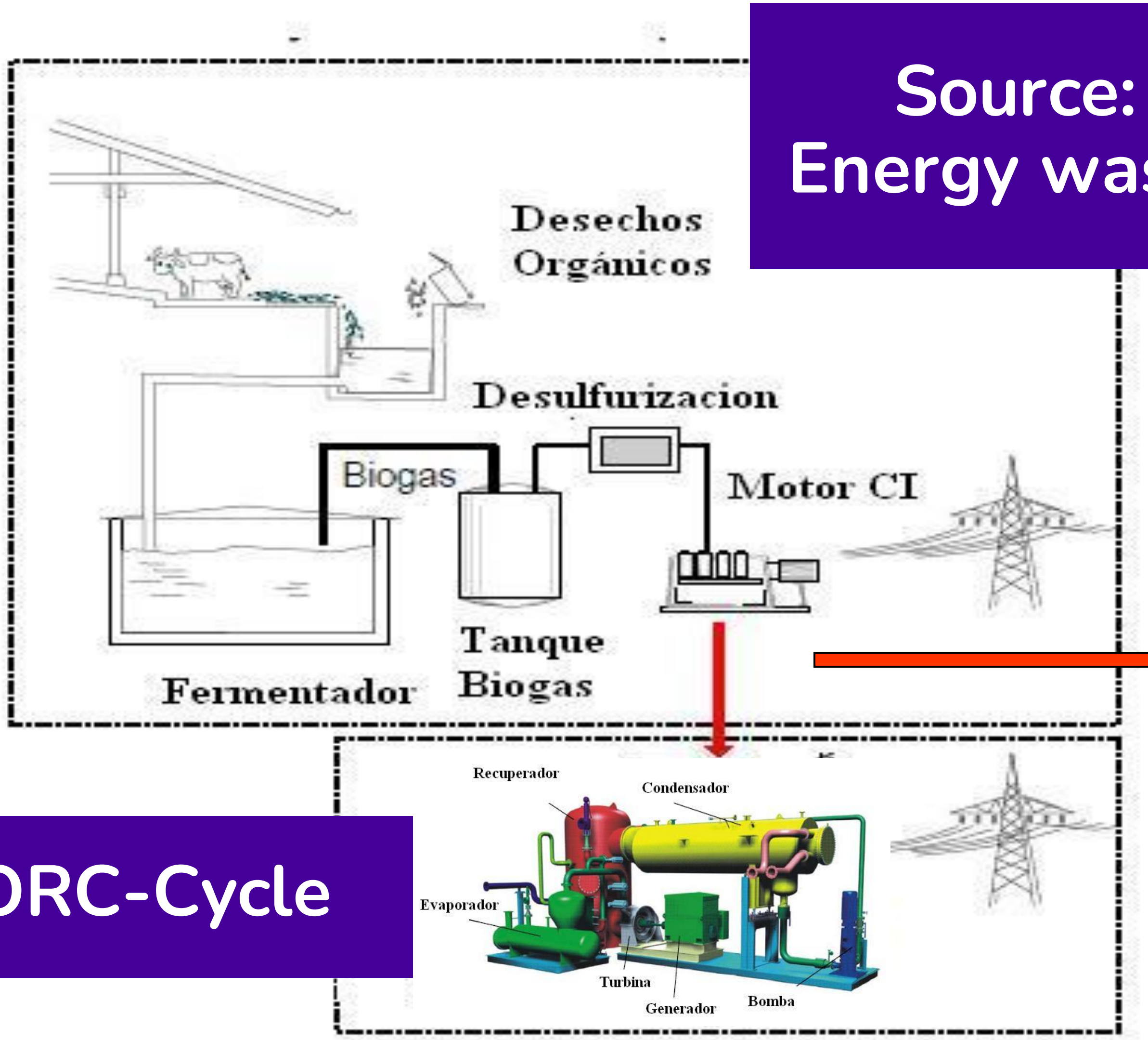


Source: sun

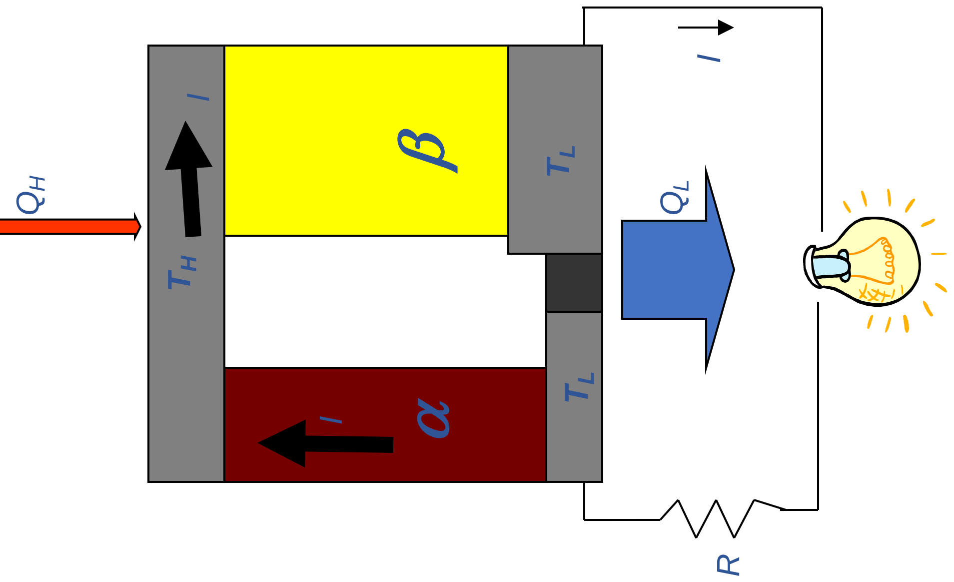
Biomass



Source: Energy waste



ORC-Cycle



Energy by Saline Gradients

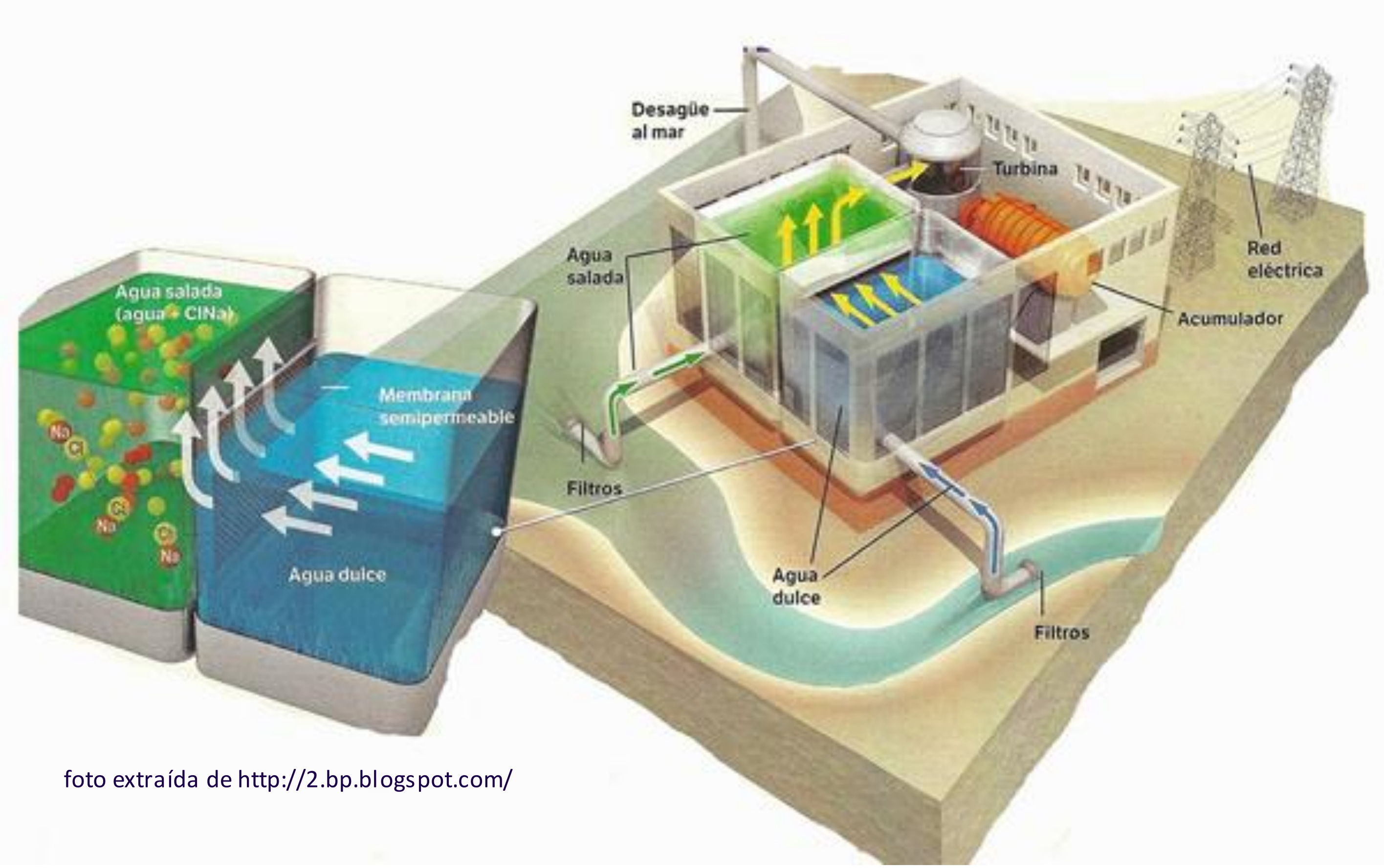


foto extraída de http://2.bp.blogspot.com/

The difference in osmotic pressure between fresh water and seawater is equivalent to 240 m of hydraulic head. In theory, a current flowing at 1 m3/s could produce 1 MW of electricity.

2. Biomass

Biomass sources

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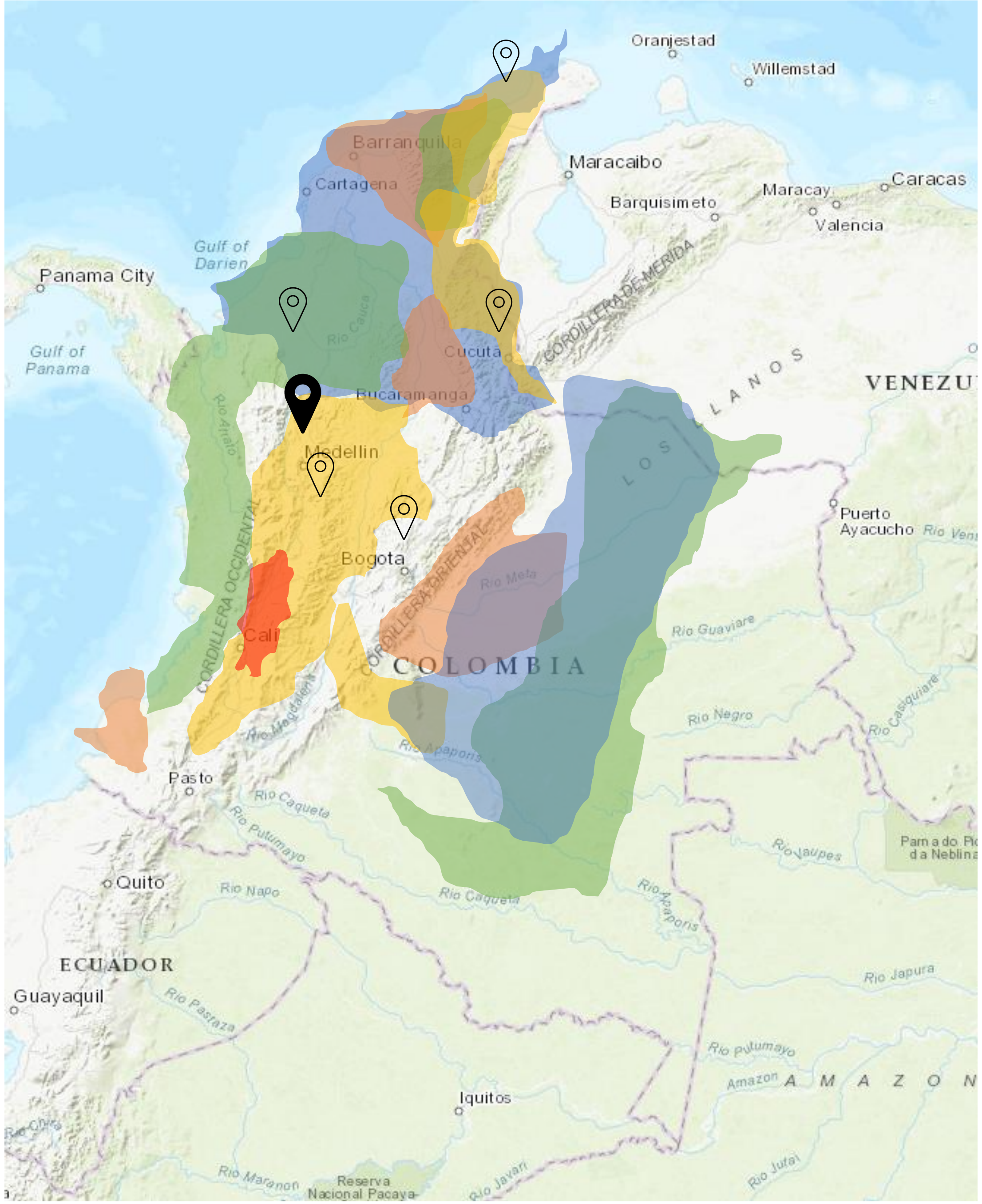
Archana Jain, Surendra Sarsaiya, Mukesh Kumar Awasthi, Ranjan Singh, Rishabh Rajput, Umesh C. Mishra, Jishuang Chen, Jingshan Shi; **Bioenergy and bio-products from bio-waste and its associated modern circular economy: Current research trends, challenges, and future outlooks**; Fuel 307 (2022) 121859



Oil Palm (kernel shell)

Ton/Year *10^3	TJ/Year
1660 (189)	16013 (2627)

Coffee (husk)

Ton/Year *10^3	TJ/Year
5051 (194)	49106 (3338)

Corn

Ton/Year *10^3	TJ/Year
1937	20795

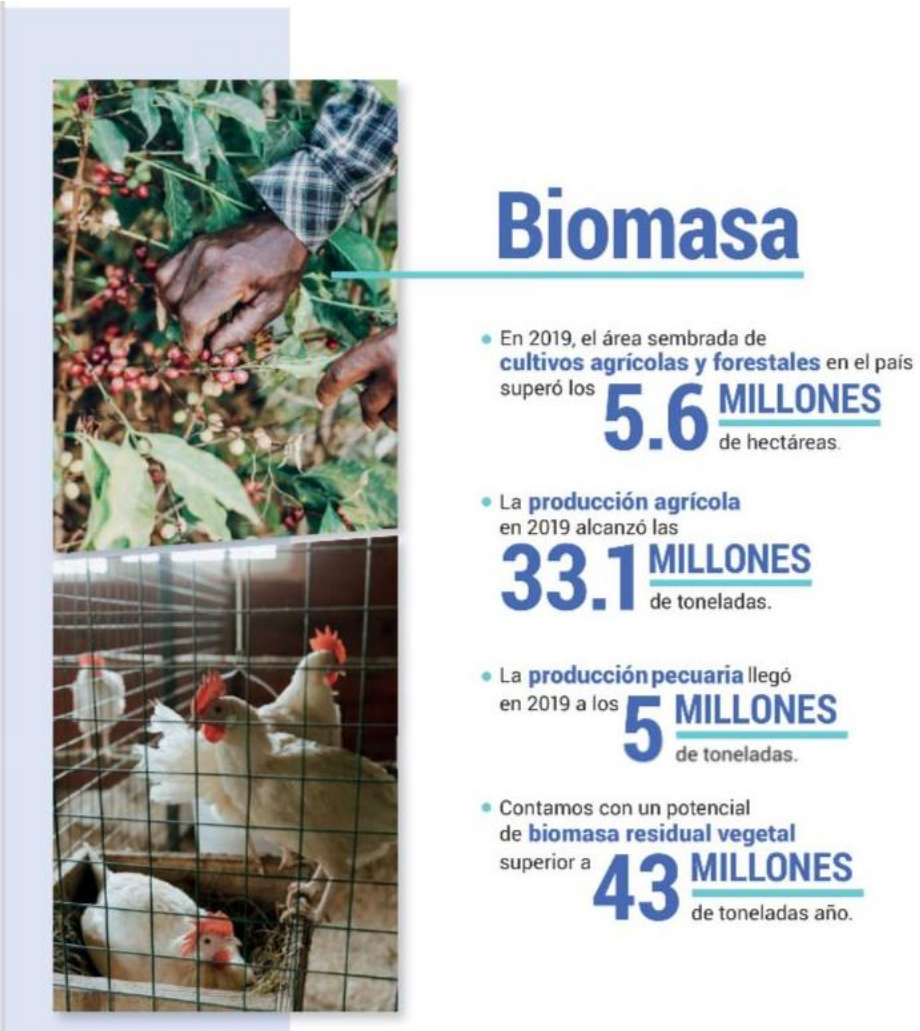
Rice (husk)

Ton/Year *10^3	TJ/Year
6282 (492)	27836 (7136)

Sugar Cane

Ton/Year *10^3	TJ/Year
25047	199363

Source: Self elaboration, data from UPME, 2010. Atlas de potencial energético de la biomasa residual en Colombia

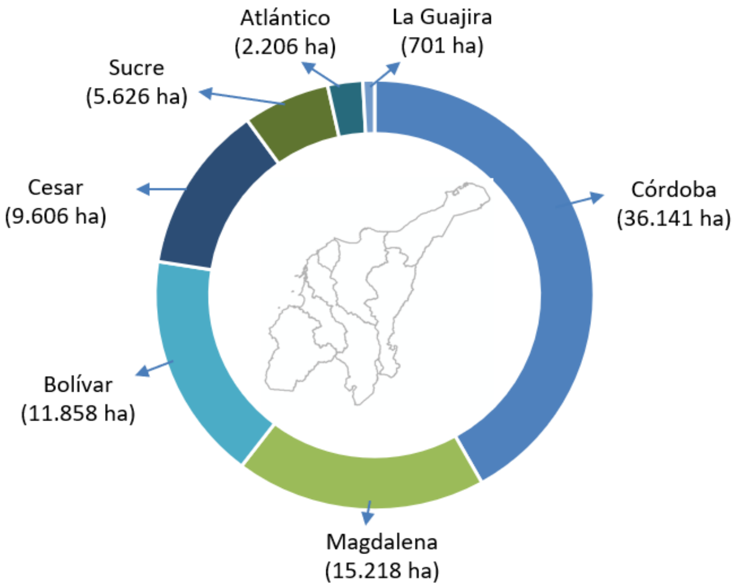


Misión de sabios 2020

10000 MW_{ele}

Value estimated by Farid Chejne

Area of commercial forest plantations established in the Colombian Caribbean region



538,762 hectares of forest plantations for commercial purposes.

81,356 ha (15%) are located in the Caribbean region

Source: prepared from the Ministry of Agriculture (2022)

Example: Using only the "entresacas" in the Colombian Caribbean and with a rotation of 25 years and available area close to **3,000 ha**, the biomass production will be between **65,000** and **130,000 tons/year**

Value estimated by Sergio Orrego

16-30 MW$_{ele}$

400-800 MW$_{ele}$

Value estimated by Farid Chejne

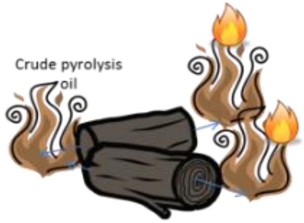
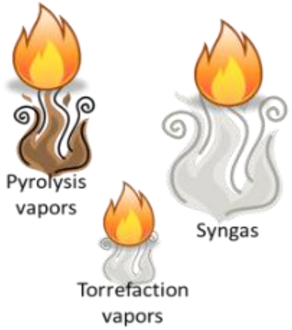
Distributed generation from biomass in Colombia (projects)

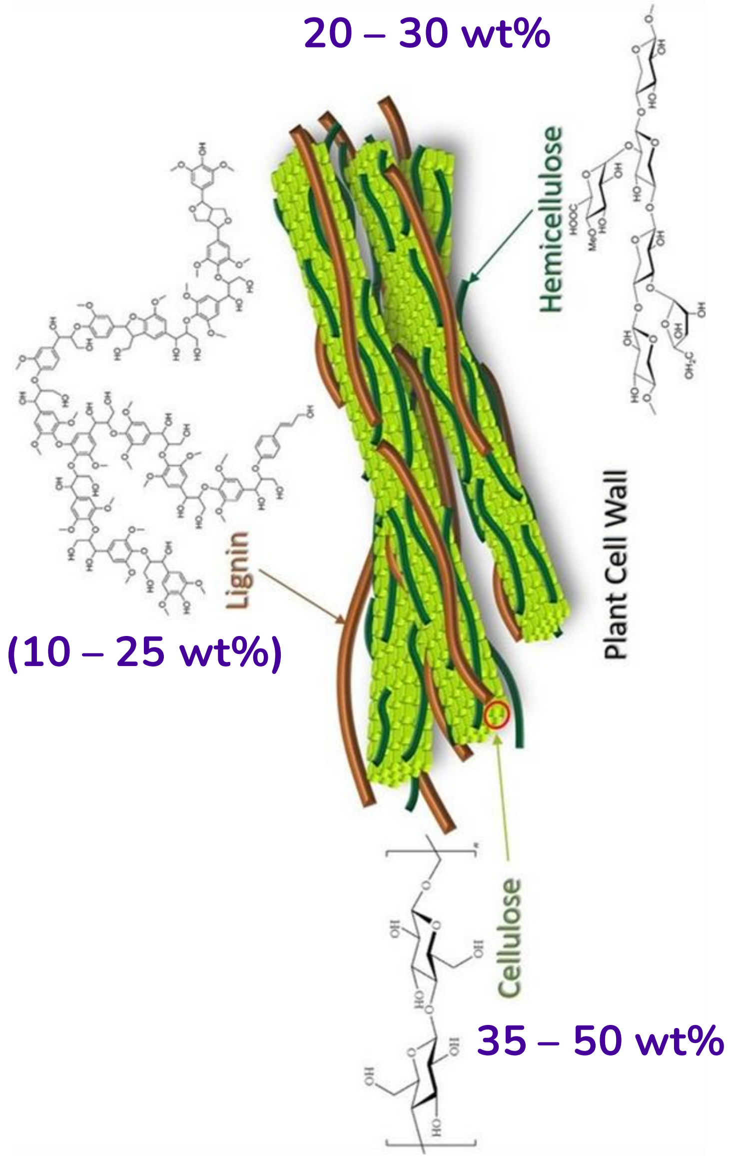
Department	Capacity gap	Project number	Capacity [MW]
Antioquia	10-100 kW	1	0,03
Cundinamarca	>1 MW	2	11,5
Magdalena	>1 MW	1	2,25
Meta	>1 MW	2	21,5
Risaralda	>1 MW	1	15,0
Valle del Cauca	>1 MW	6	72,7
		Total	**122,0**

Values gotten by Carlos Mario Ceballos

3. Biomass opportunities

Diagram illustrating the process that can be felt near a campfire

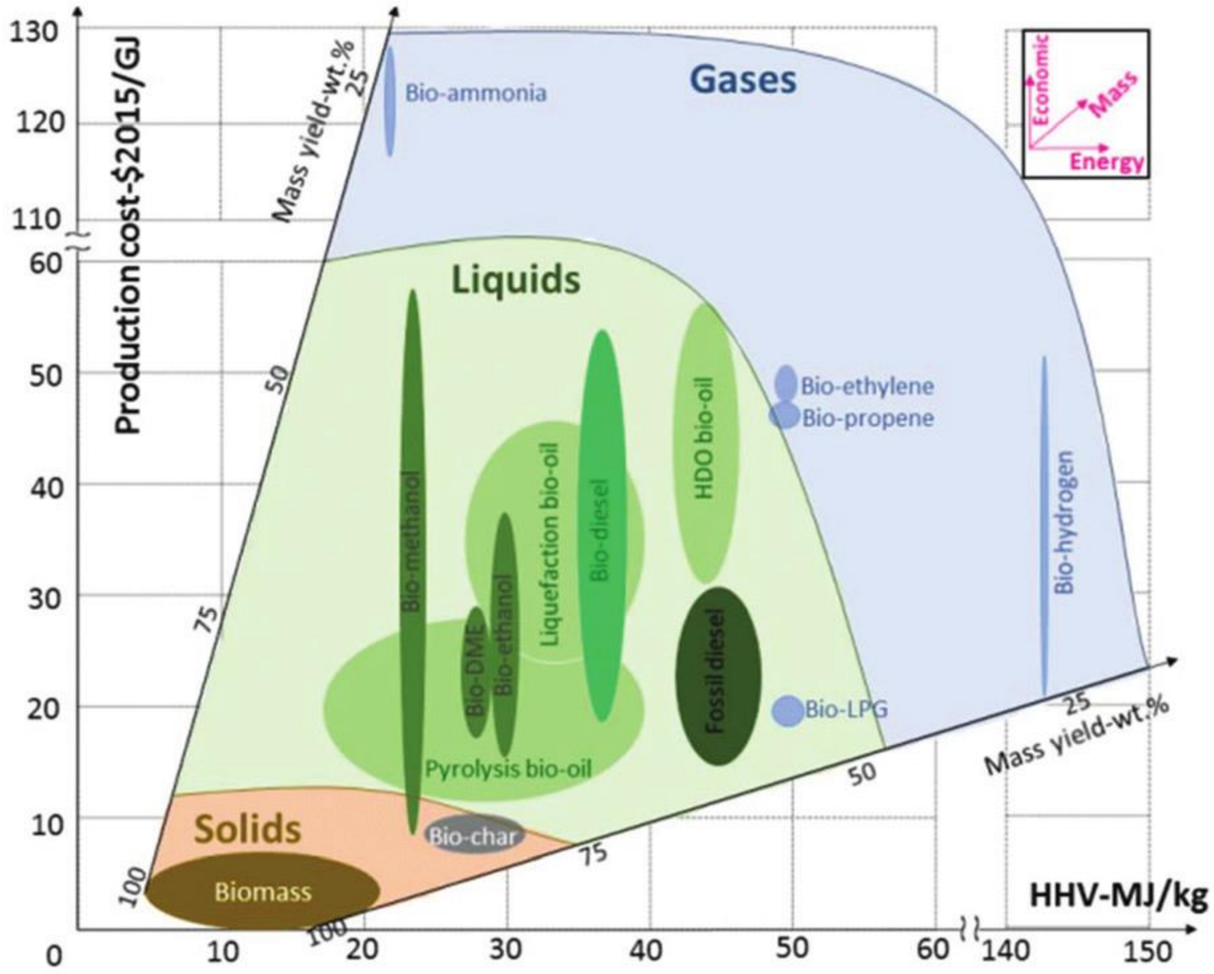
	1. Evaporation	2. Torrefaction	3. Pyrolysis	4. Gasification	5. Combustion of Vapors
					
°T	100-200 °C	225-300 °C	300-650 °C	700-850 °C	450-2000 °C
Products	Solid: Dried wood Vapor: Water	Solid: Roasted wood Vapor: Water, volatile organics	Solid: Charcoal Vapor: Light organics, heavy organics	Solid: Ash Vapor: Syngas (CO, CO_2, H_2. CH_4, H_2O)	CO_2, CO, H_2O
Description	Endothermic; Evaporation; External heat penetrates particle	Endothermic; Hemicellulose and amorphous cellulose decomposition, Light extractives evaporation, Intermolecular dehydration reactions; Mass density decreases; Volatile organics can combust	Endothermic for fast pyrolysis, exothermic for slow pyrolysis; Solid, liquid, and vapor reactions; Cellulose decomposition, Lignin decomposition; Mass density decreases; Volatile organics can combust	Endothermic if water is oxidizing agent, exothermic if oxygen is oxidizing agent; Volatilization of carbon, hydrogen, and oxygen in char; Gasification of volatile pyrolysis oil; Syngas can combust	Exothermic; Consumption of oxygen; Requires ignition at high temperatures and/or pressures
	Time & Temperature →				



Ordoñez (2021)

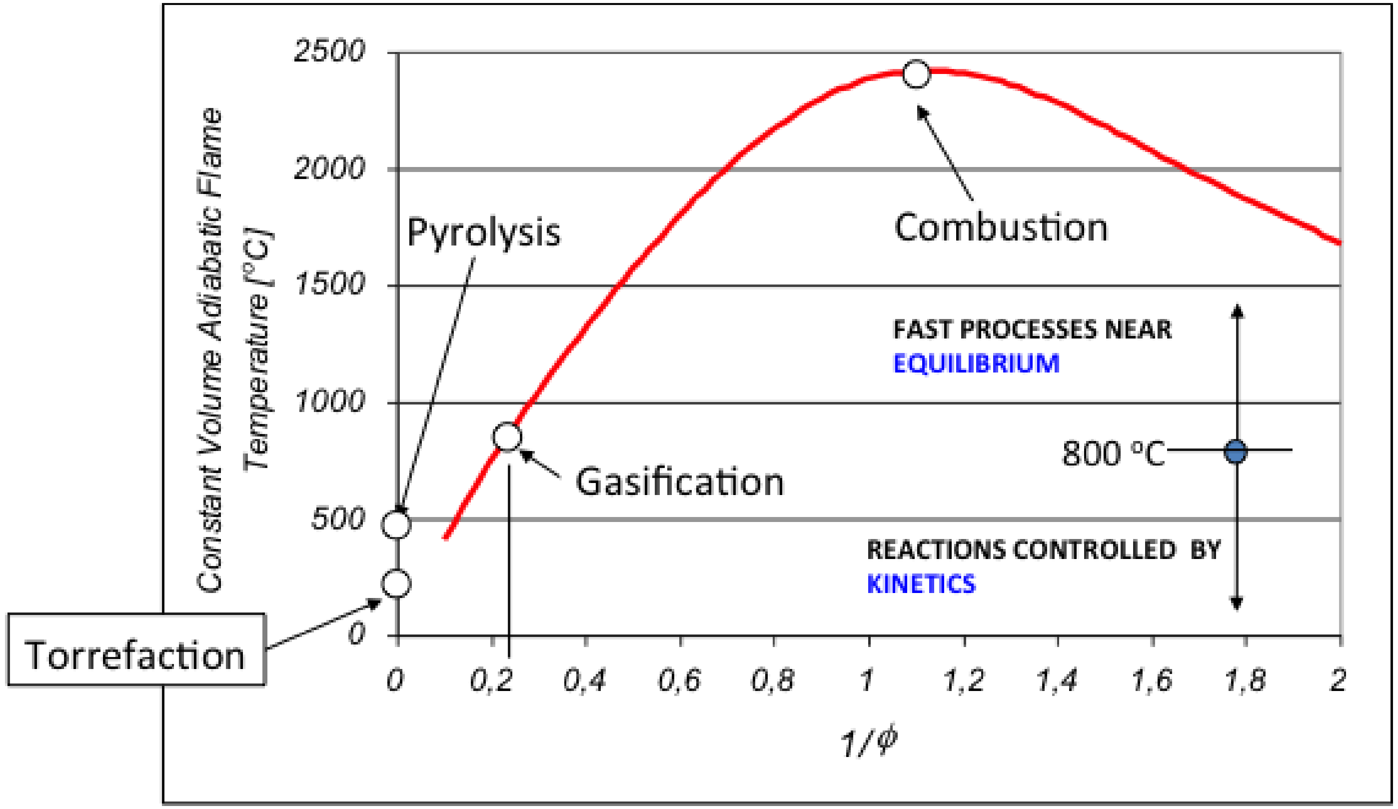
- Peletizing
- Pyrolysis
- Torrefaction
- Gasification
- Hydropyrolysis

Mass-energy-economic comparison of second-generation bio- fuels generated via thermochemical conversion processes



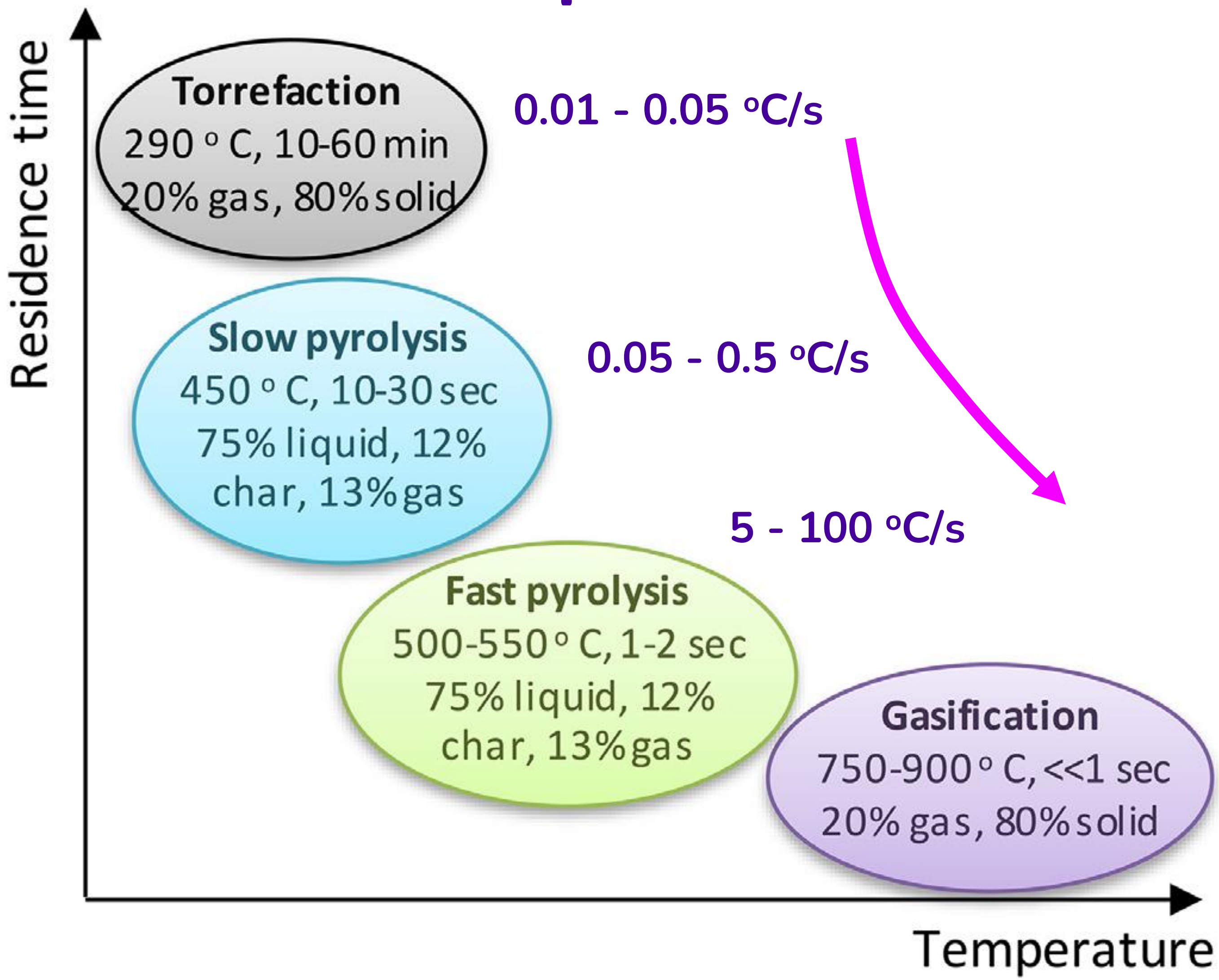
Xiaolei Zhang, Essential scientific mapping of the value chain of thermochemically converted second-generation bio-fuels, Green Chem., 2016, 18, 5086–5117

Solid, gaseous, and liquid product distribution diagram



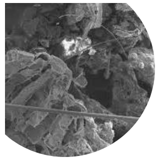
Combustion > 1500 °C, Gasification 600 – 1400 °C, Fast Pyrolysis 350 – 600 °C, Torrefaction: 220 – 300 °C

Operation conditions

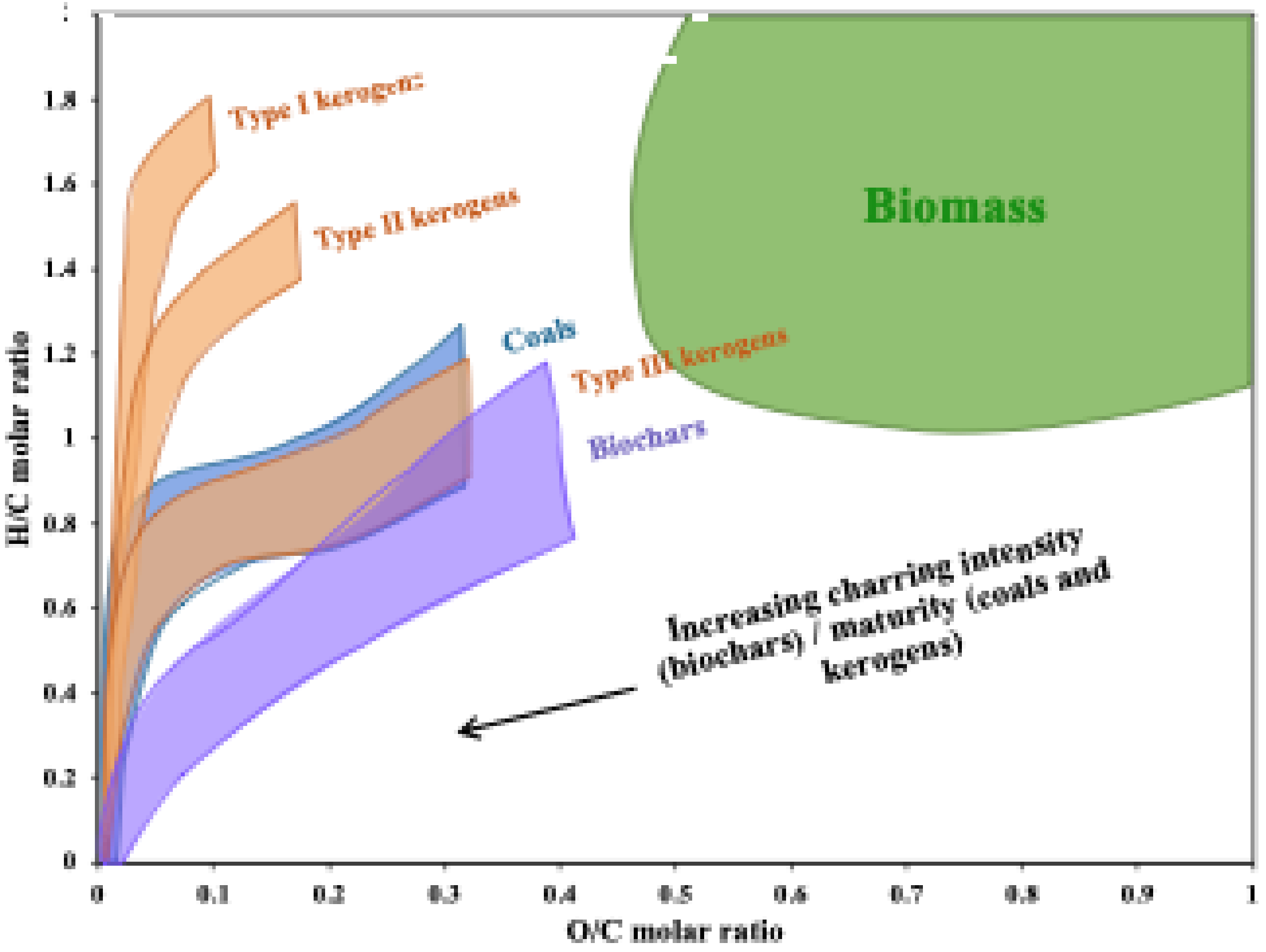


M. Sharifzadeh, M. Sadeqzadeh and M. Guo et al. / Progress in Energy and Combustion Science 71 (2019) 1–80

PYROLYSIS: heating process without oxygen

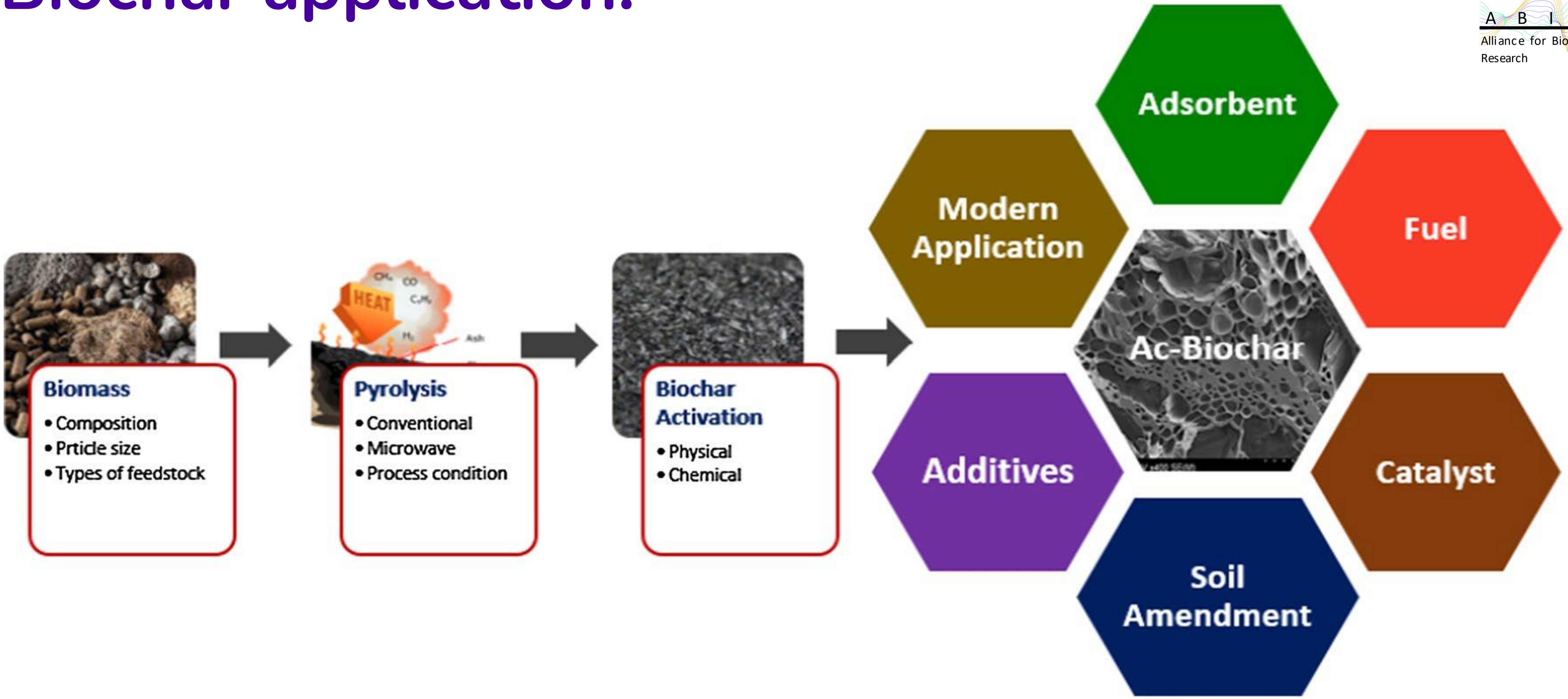


Path from biomass to becoming biochar



Rosie Wood, Ondřej Mašek, Valentina Erastova;Biochars at the molecular level. Part 1 – Insights into the molecular structures within biochars.

Biochar application.



Anil Kumar Sakhiya, Abhijeet Anand, Priyanka Kaushal; Production, activation, and applications of biochar in recent times; Production, activation, and applications of biochar in recent times

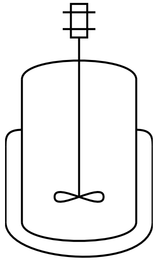
Bio-oil upgrading

Fotografía tomada: Laboratorio de ciencias de la energía, Facultad de Minas, Medellín, Antioquía, Colombia.

Bio-oil

Cracking for obtaining chemical blocks

Liquid fuels

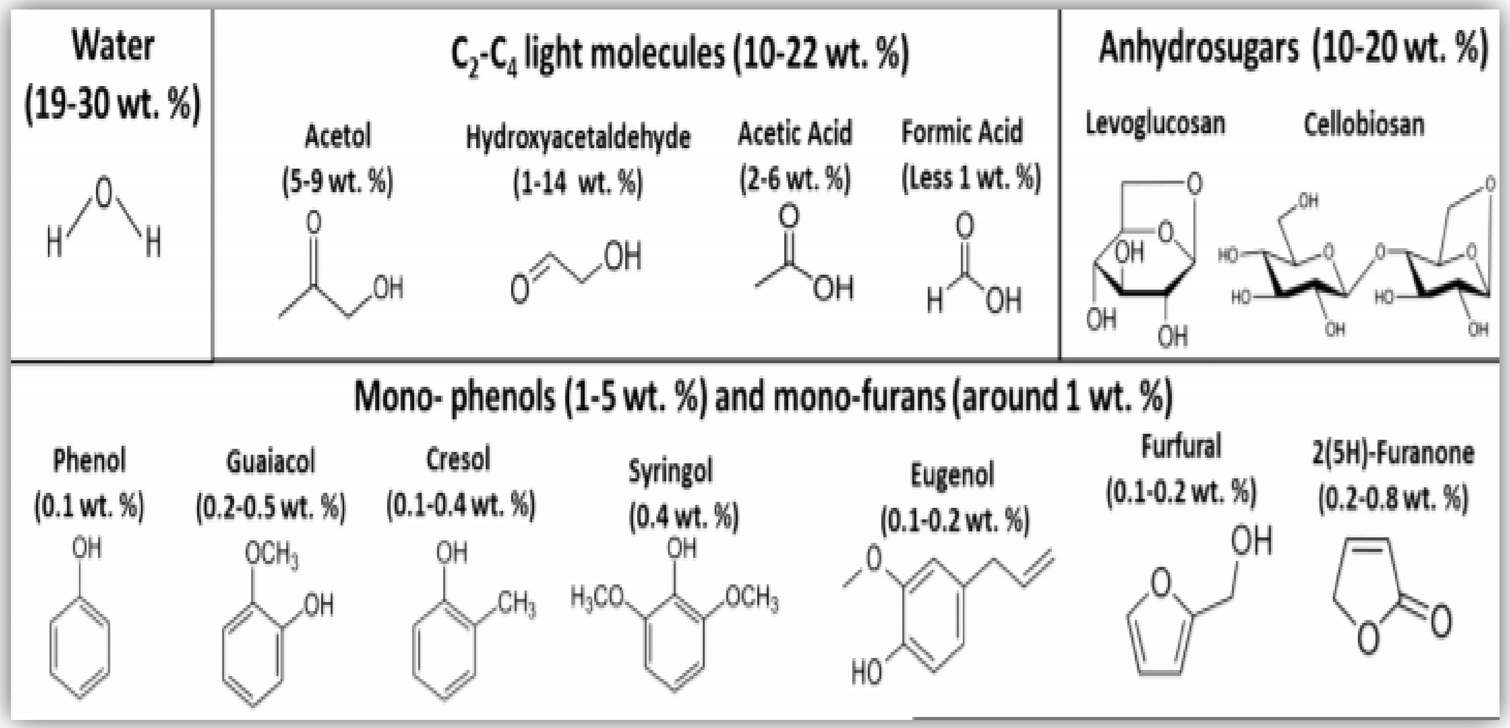


HDO process (Upgrading)

Combustion

PhD thesis of Raiza Manrique, UNAL

BIO-OIL Production



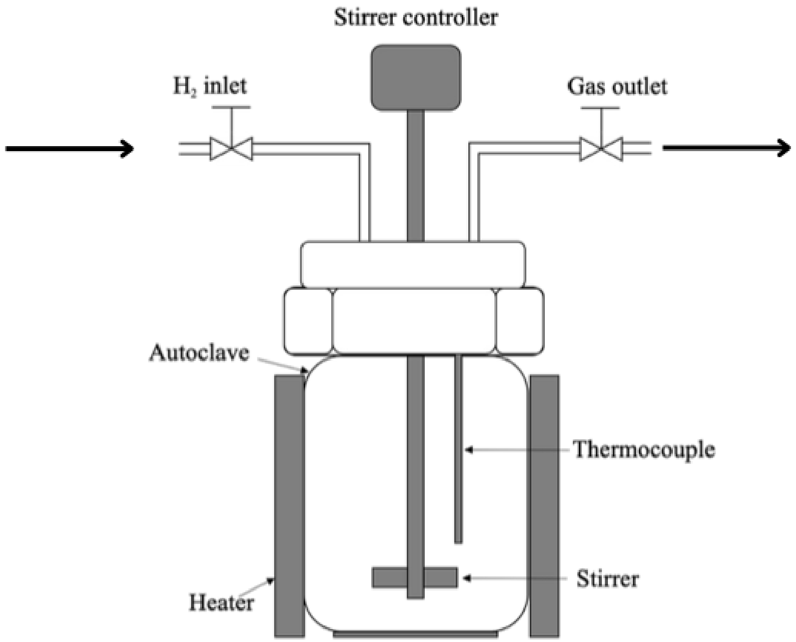
Humins (3-7 wt. %)

Pyrolytic lignin (15-27 wt. %)

Hybrid Oligomers (11-18 wt. %)

Hydrotreatment process

H_2
N_2



H_2
CH_4
CO_2
CO
C_2H_6
C_3H_8

Initial pressure: 1100 psi
Catalyst: PNNL

1 Stabilization

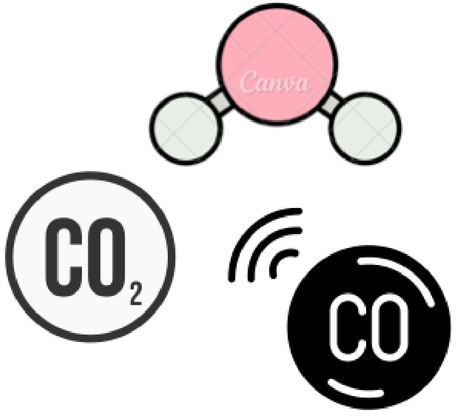
100-300°C

Carbonyl and carboxyl groups

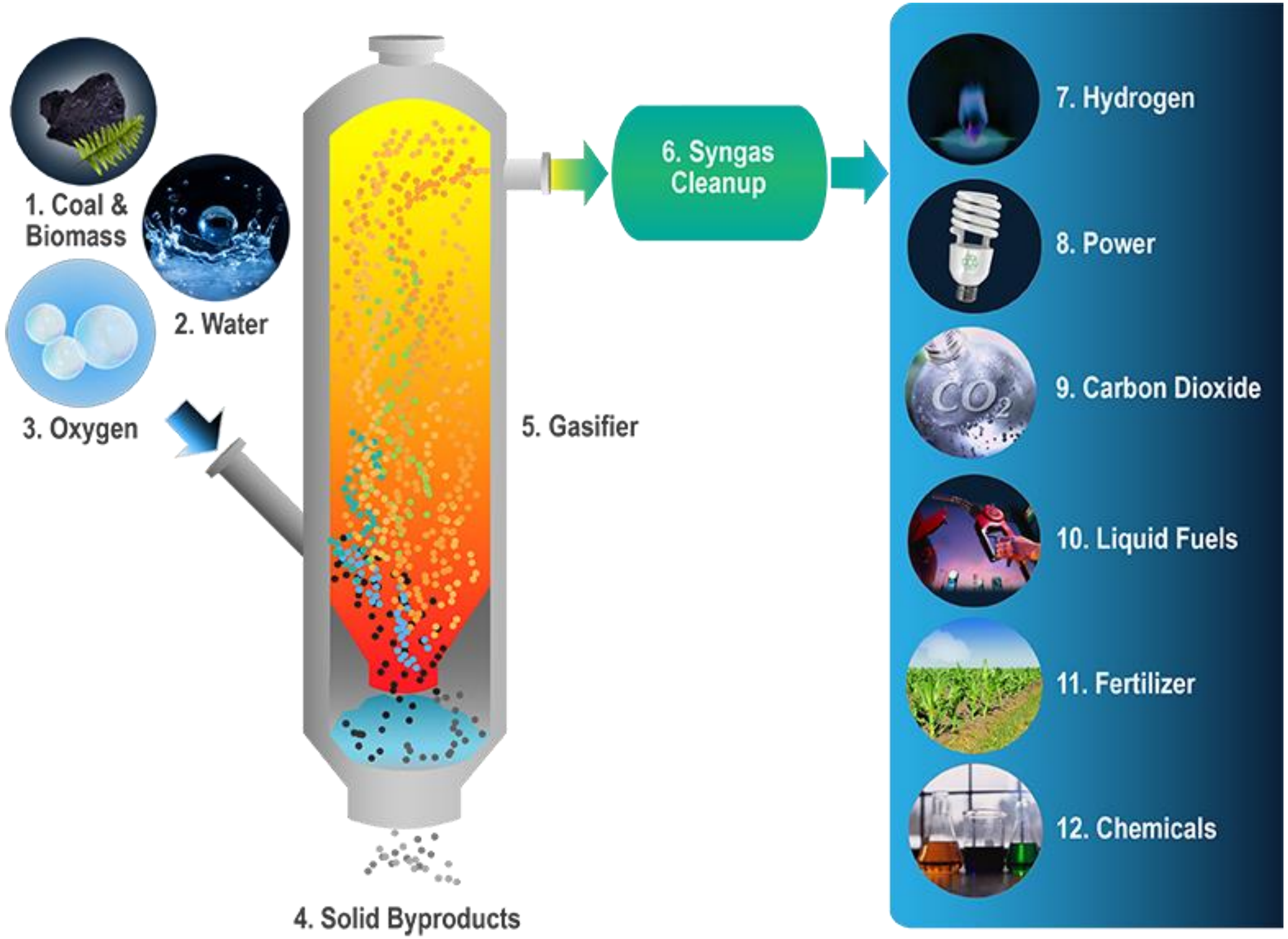
2 Deoxygenation

350-400°C

Cracking and HDO occur

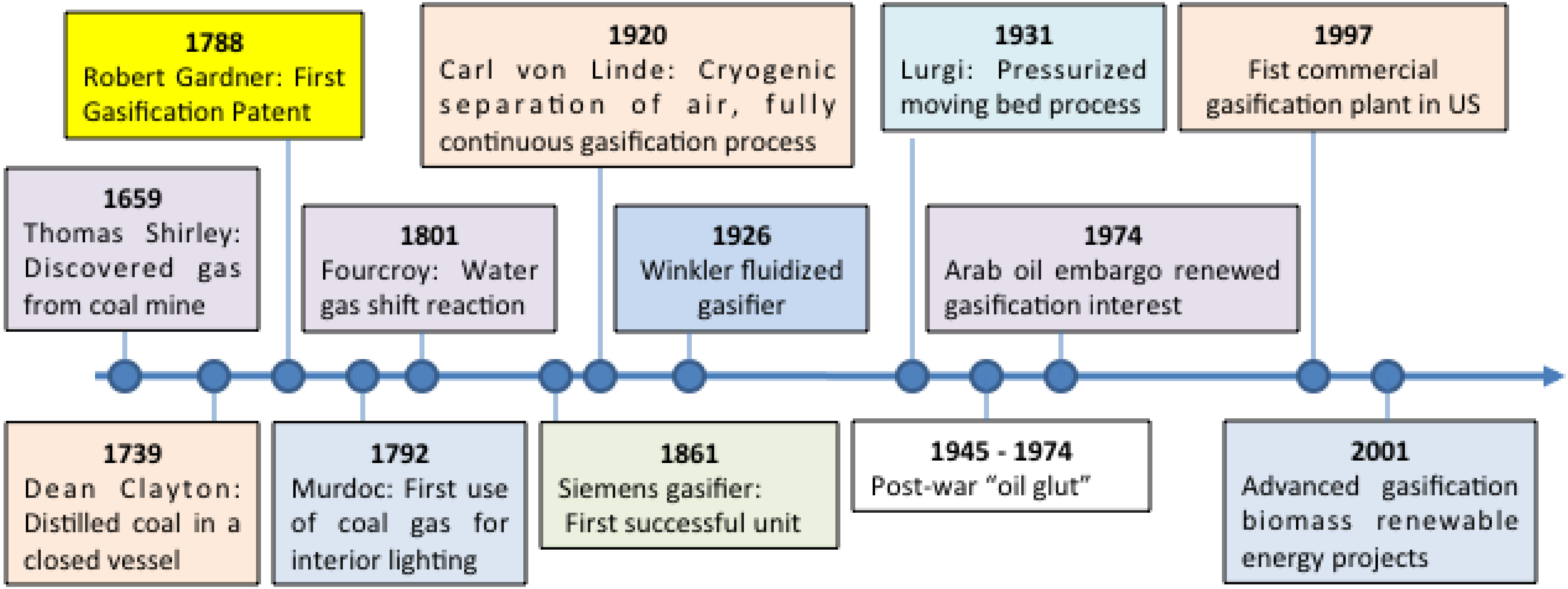


Gasification: Oxidation process

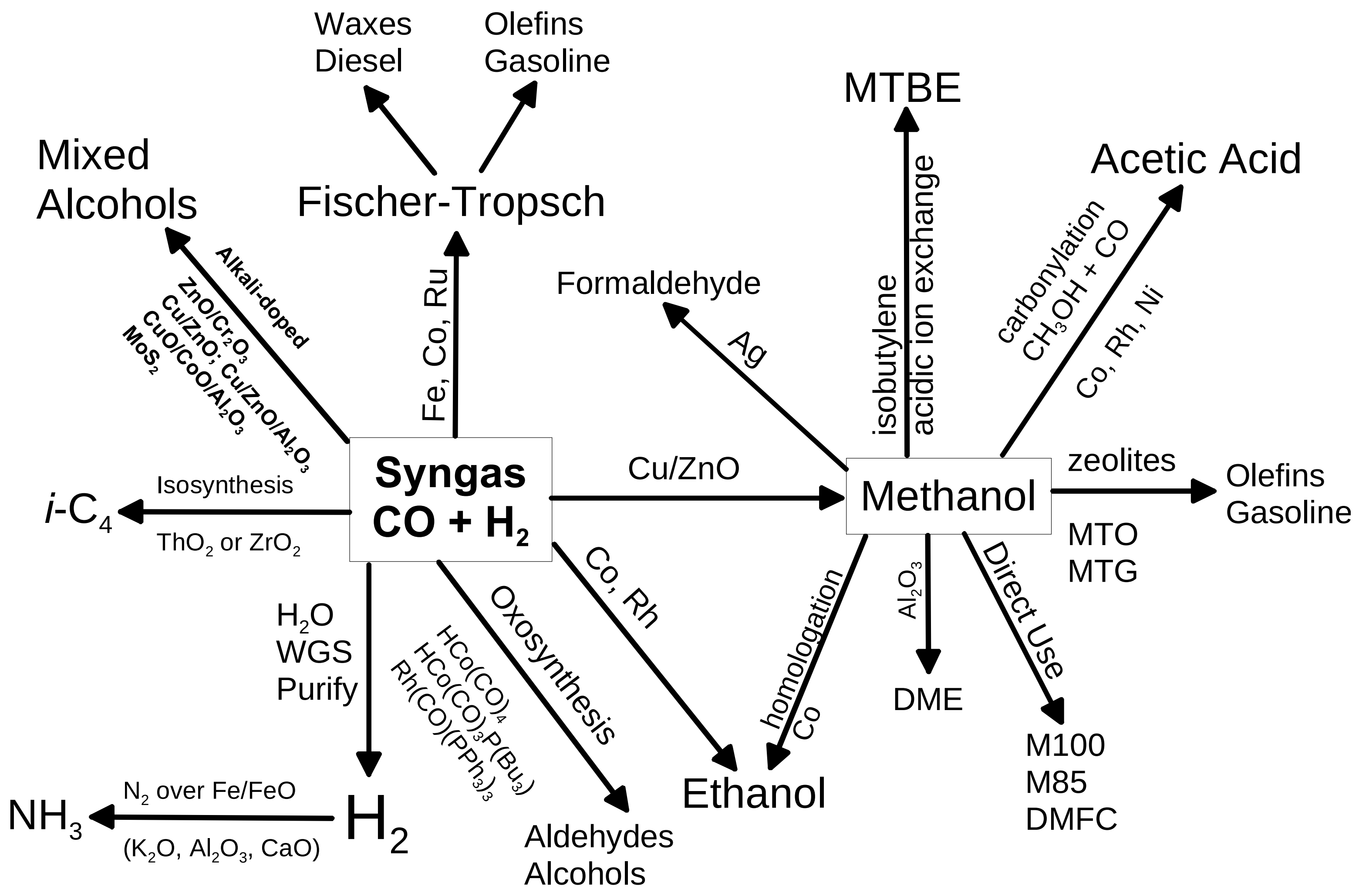


NETL implements this effort as part of DOE's Advanced Energy Systems Program.

Milestones in the Development of gasification

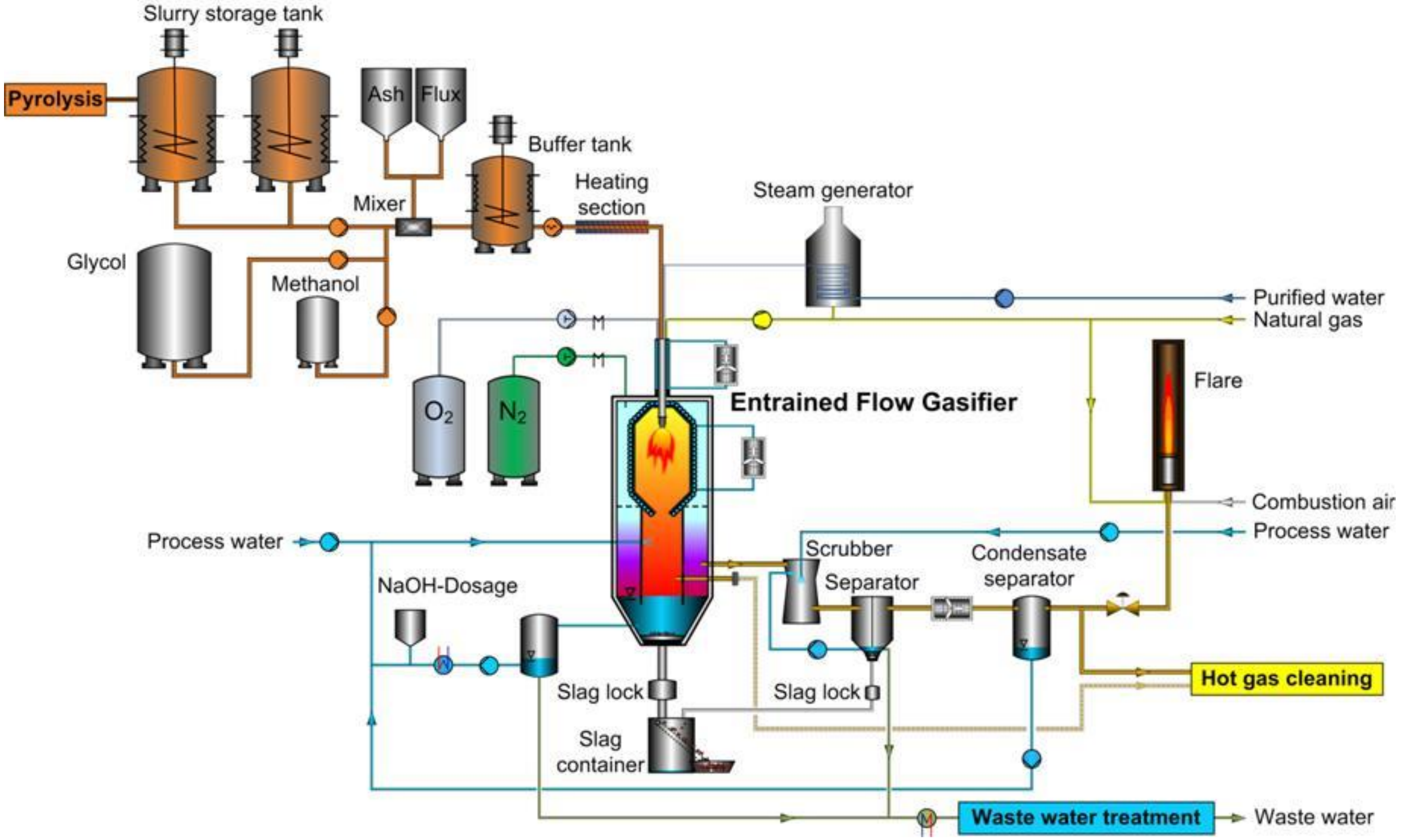


Products from Syngas



Spath, P. L., & Dayton, D. C. (2003). *Preliminary Screening – Technical and Economic Assessment of Synthesis Gas to Fuels and Chemicals with Emphasis on the Potential for Biomass-Derived Syngas.* http://www.osti.gov/bridge

Bio Syncrude gasification flow process diagram

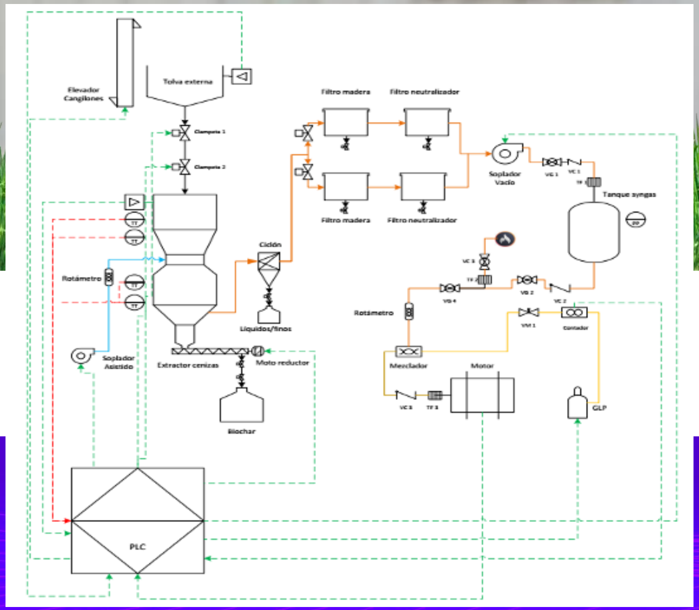


Carlos Mario Ceballos, KIT Institute, Germany

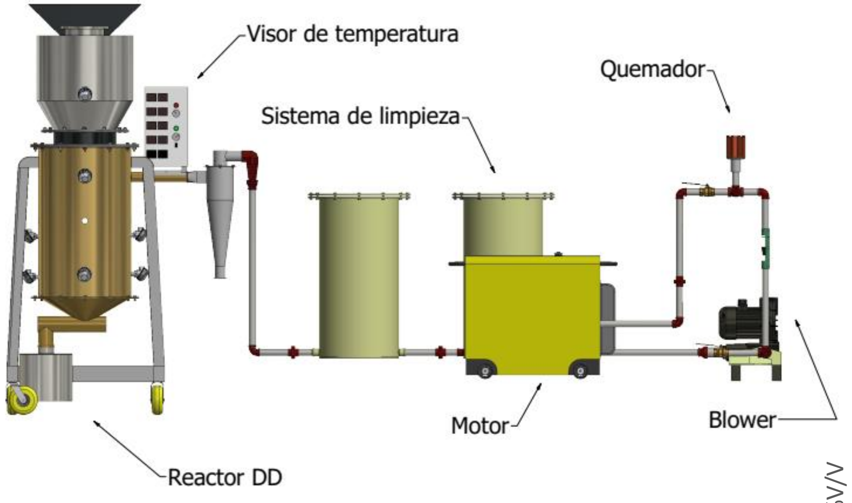
TAYEA laboratory, Universidad Nacional de Colombia

Mobile laboratory, Universidad de la Guajira

Fotografía tomada: Universidad de la Guajira, laboratorio móvil gasificación downdraft.

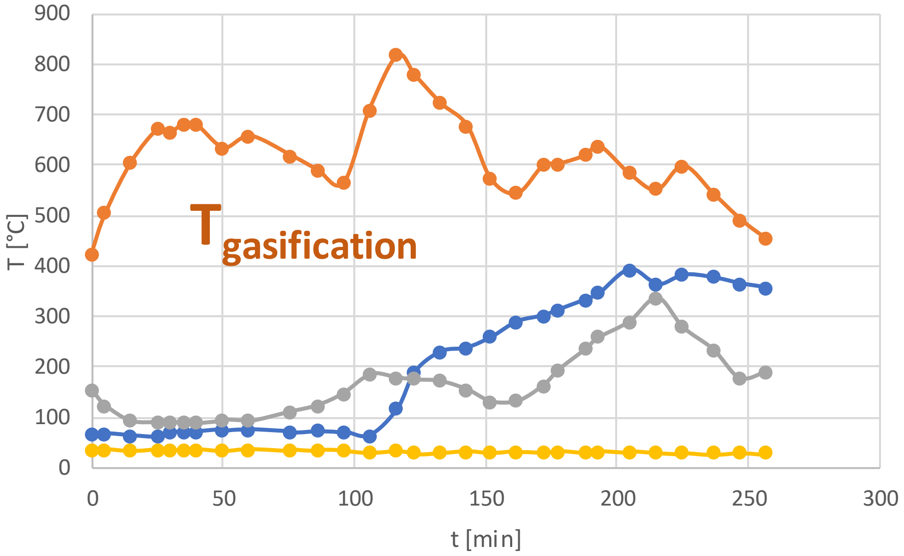


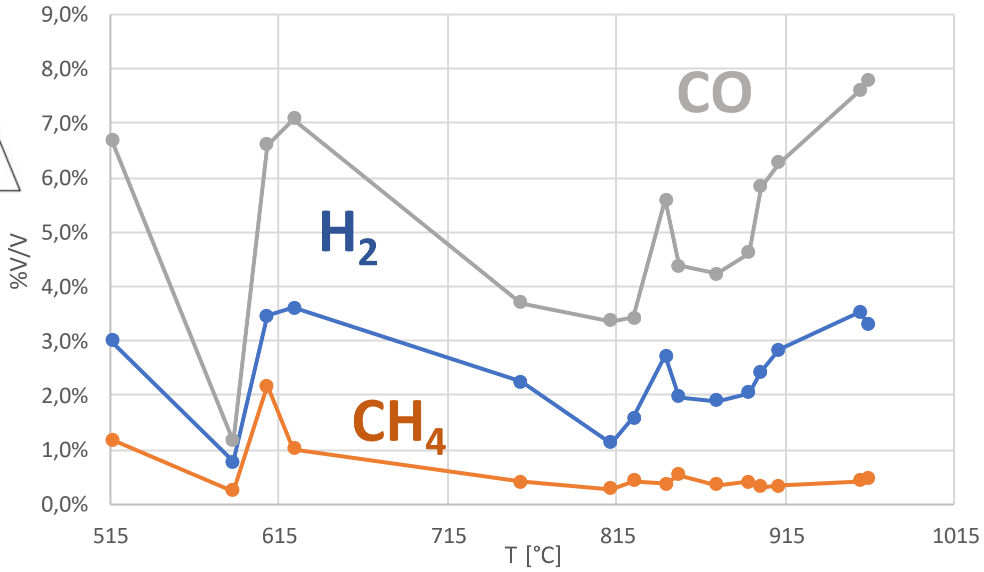
Experimental essays



20 kW

PhD thesis of Robert Macias, UNAL





Energy Management System (EMS)

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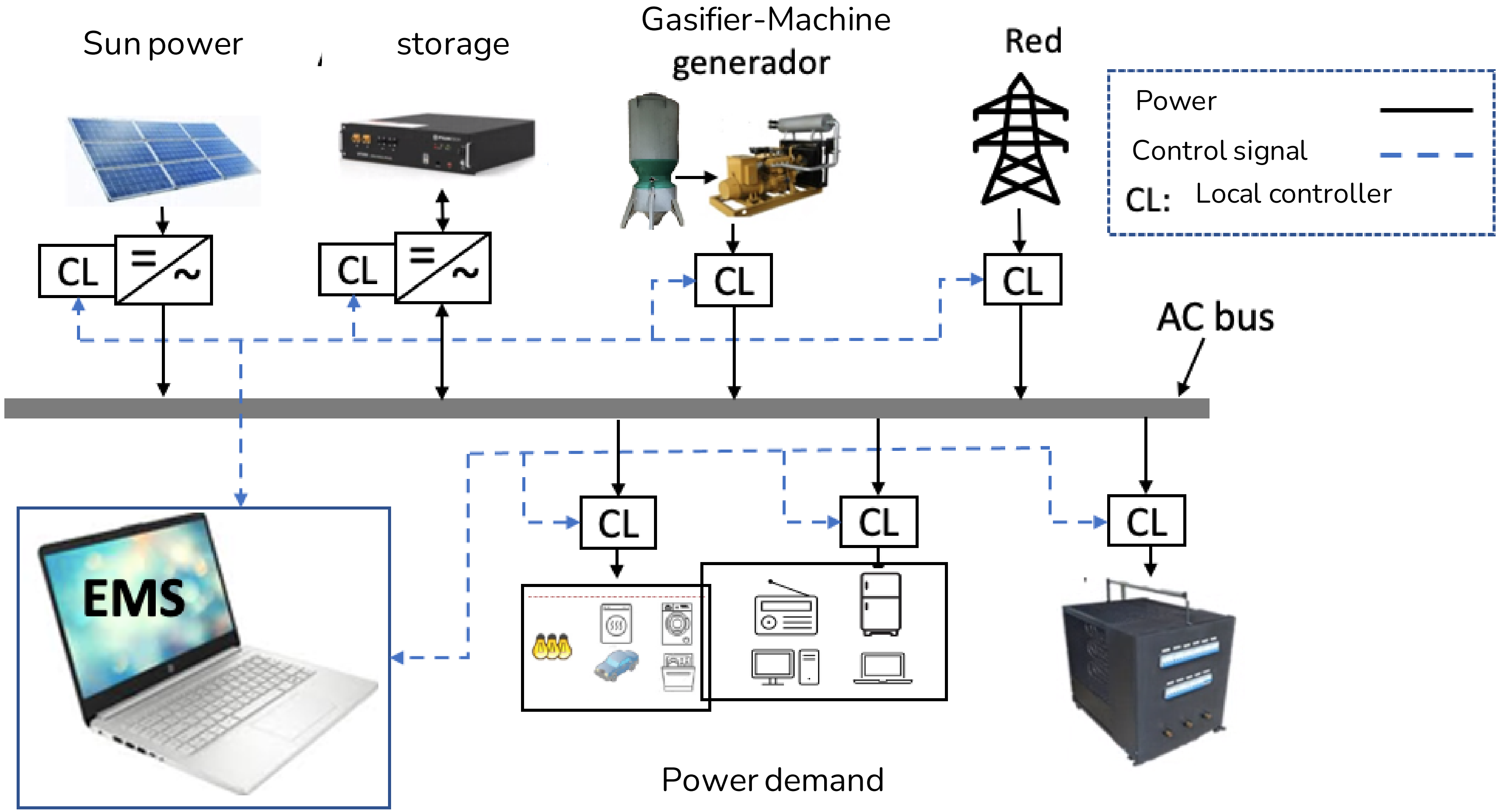
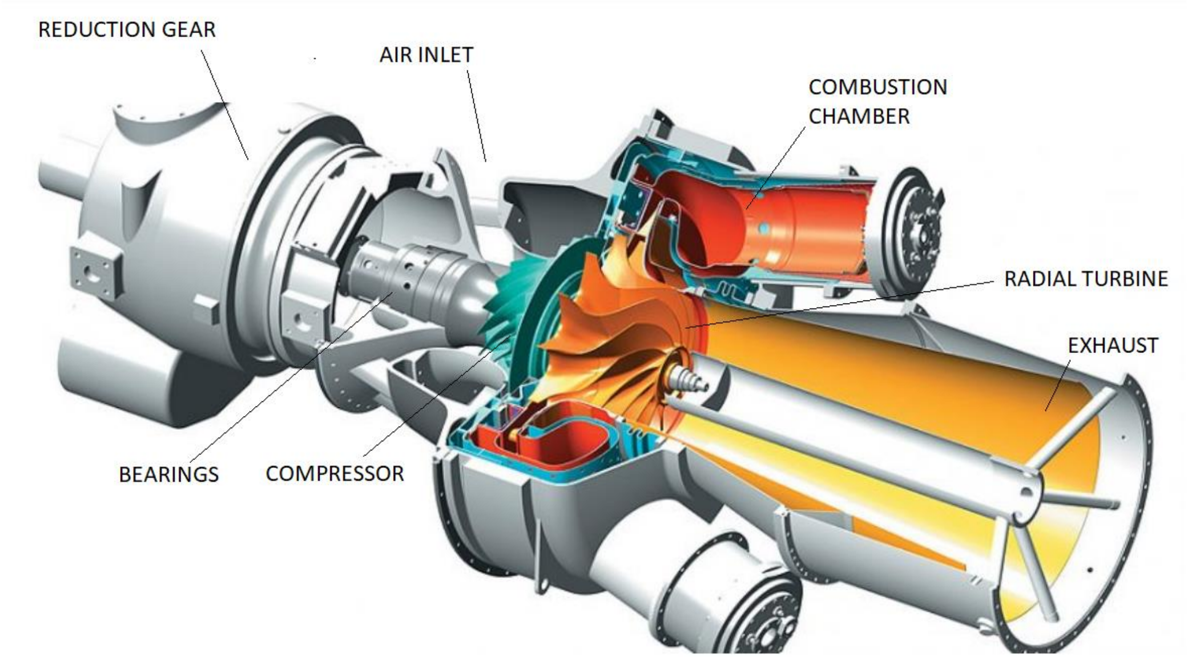
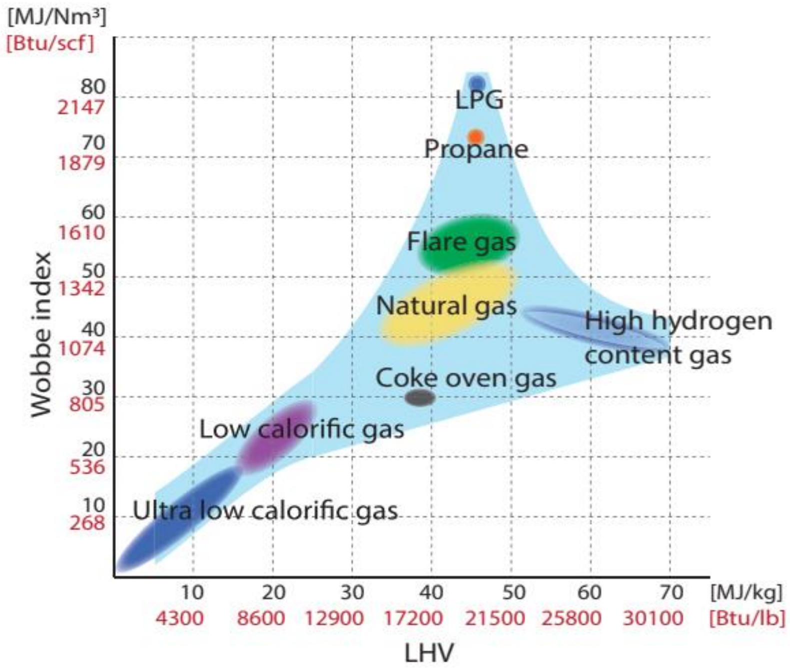
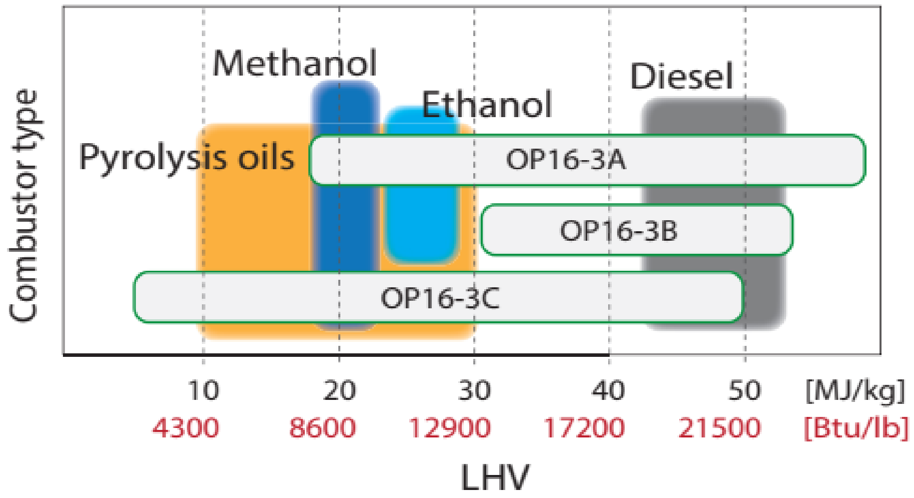


Opra OP16 Turbine:

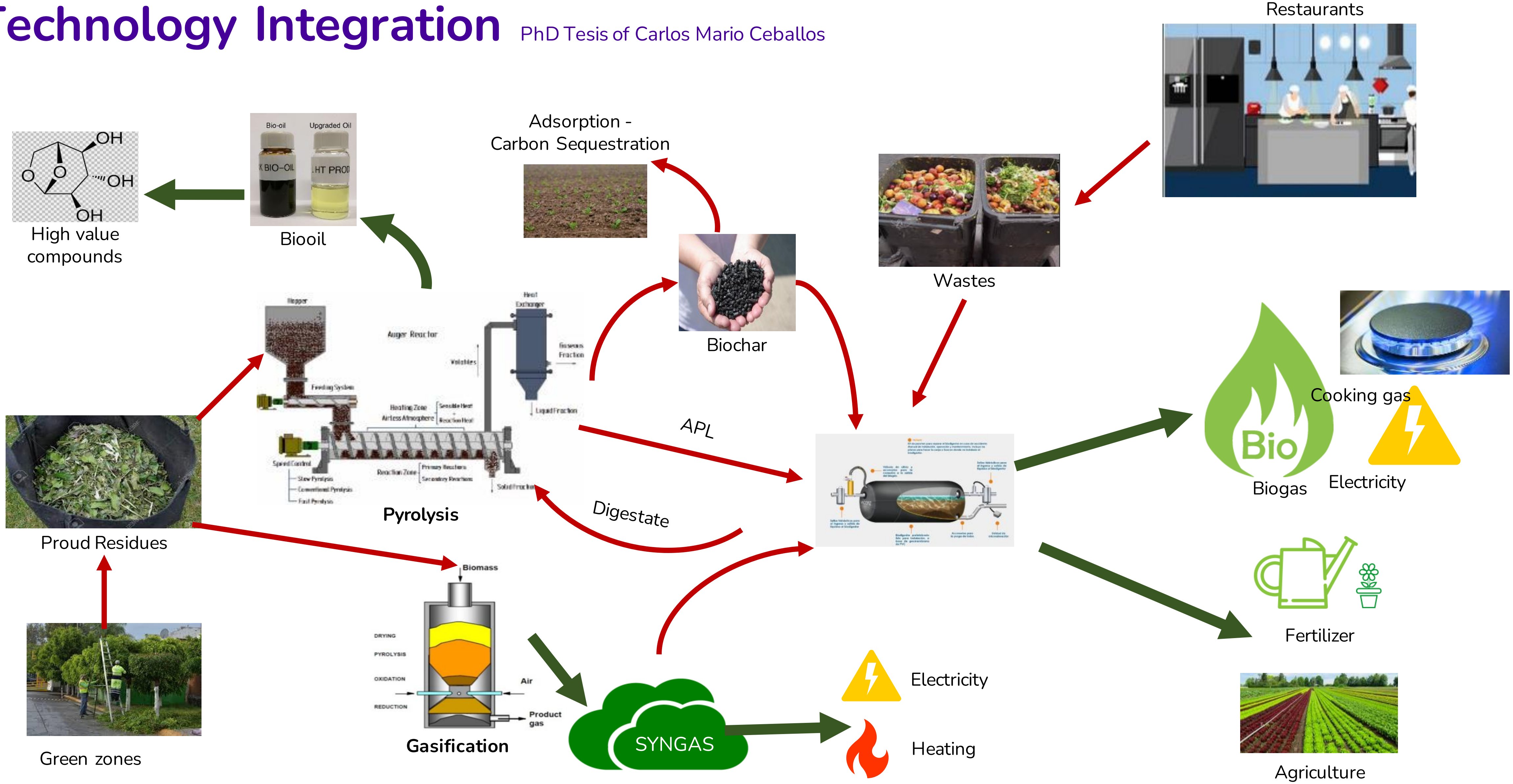






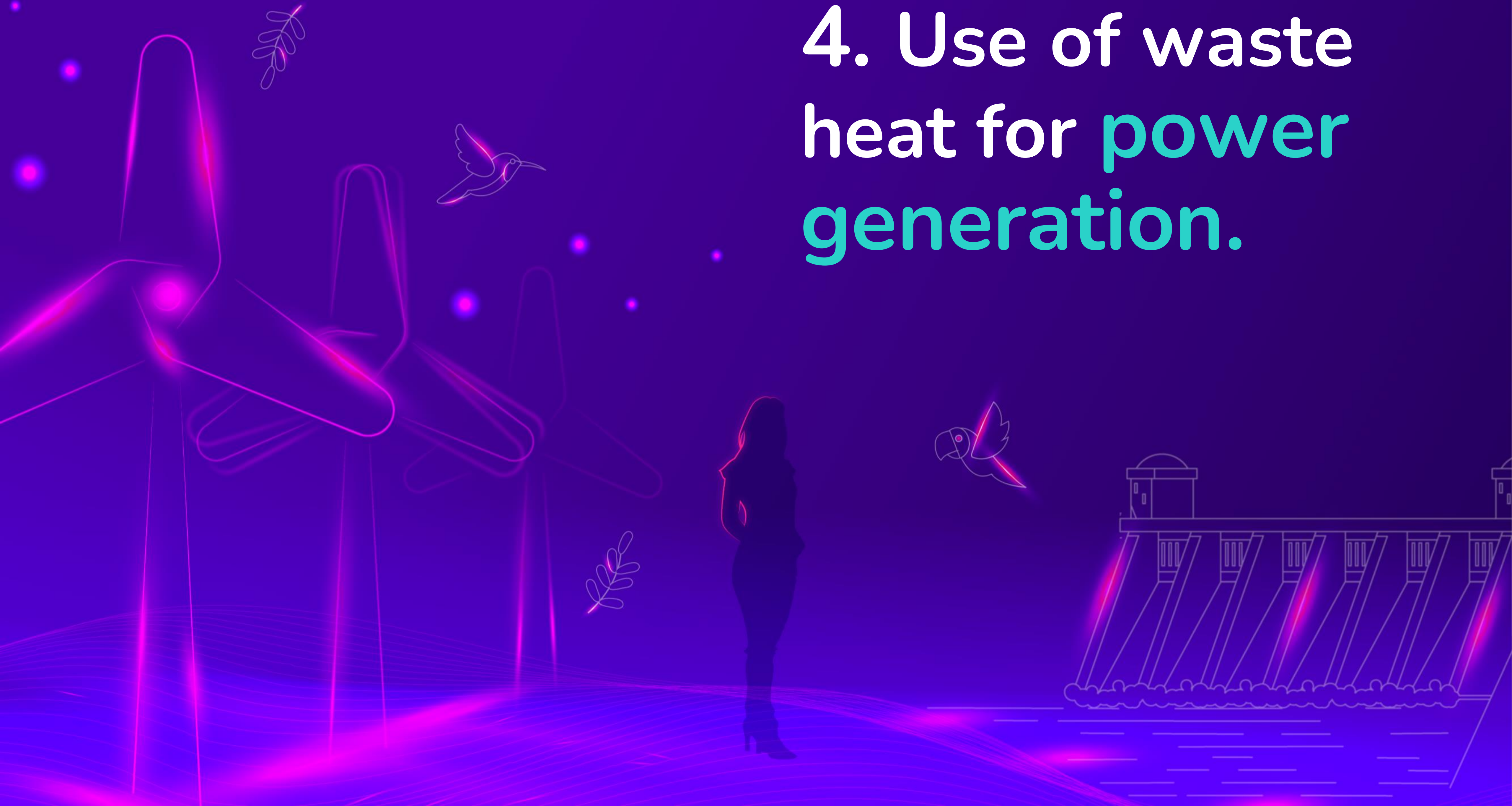
Technology Integration

PhD Tesis of Carlos Mario Ceballos

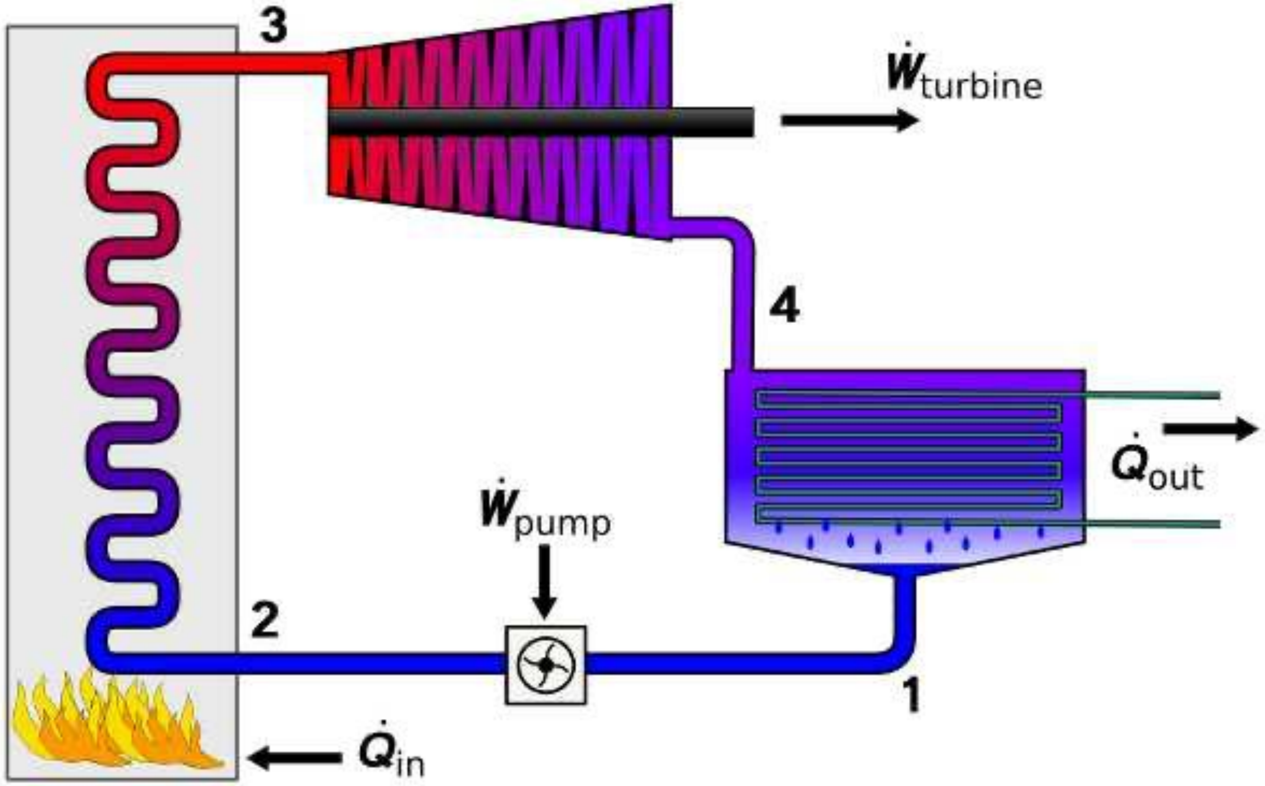


Project: "**Esquema híbrido de poligeneración (Termoquímico - Biológico) para la sustitución de fósiles a partir de residuos orgánicos**" (contrato ICETEX 2022-0666) de la convocatoria 890 del Ministerio de Ciencias, innovación y tecnología del gobierno nacional.

4. Use of waste heat for power generation.

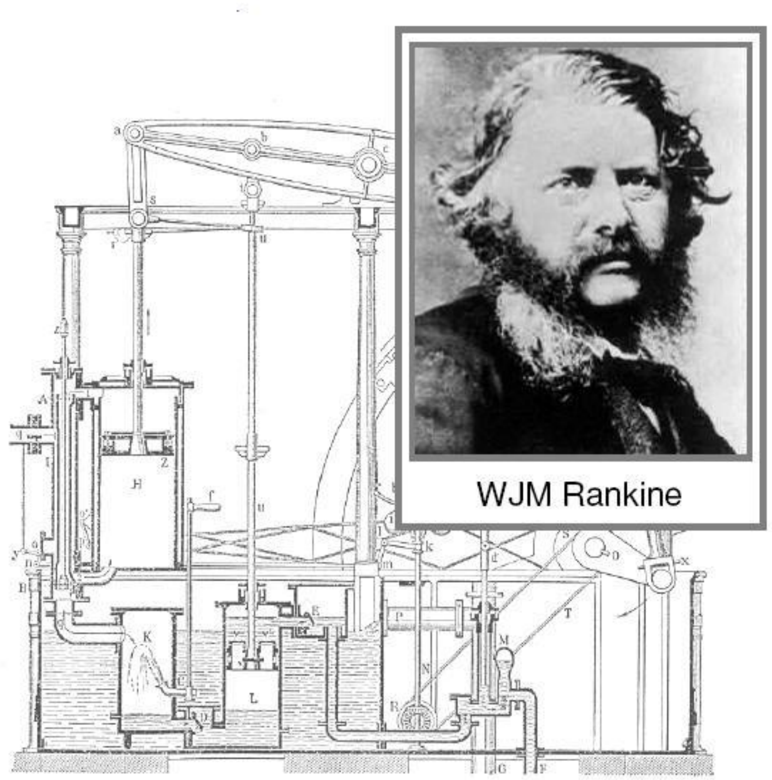


Organic Rankine Cycle-ORC

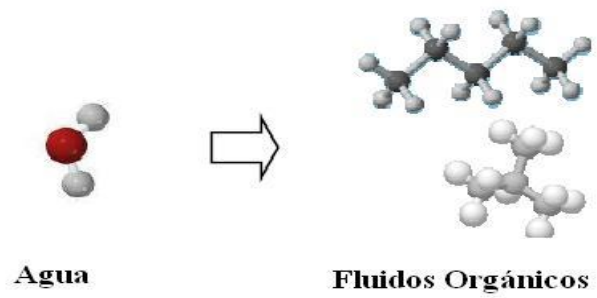


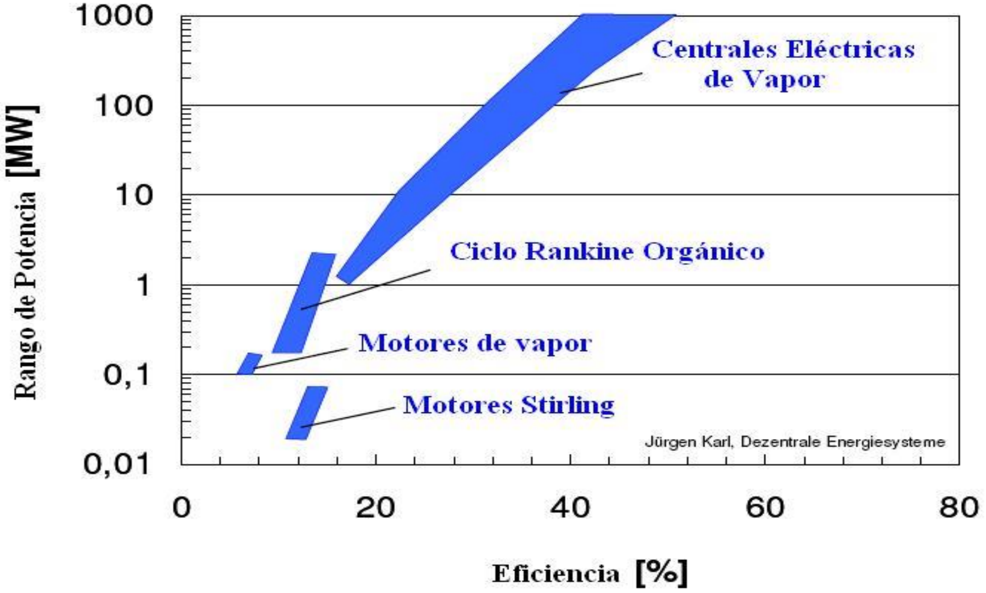
https://www.ideegreen.it/orc-ciclo-rankine-31439.html.

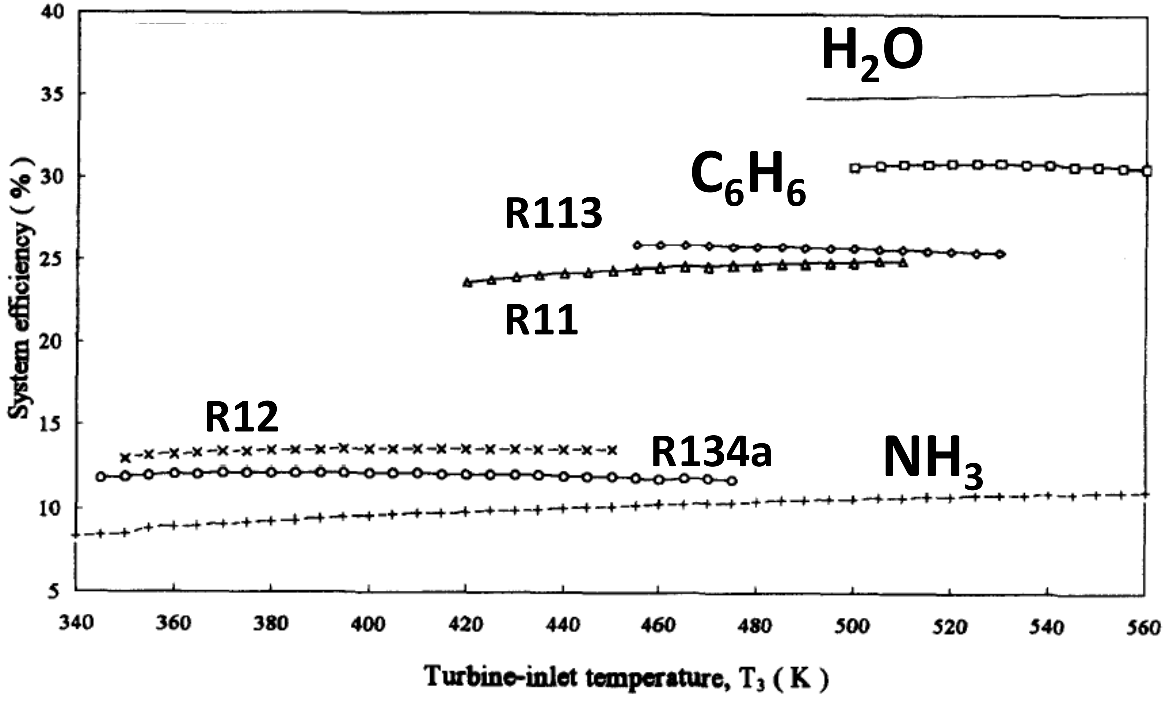
William John Macquorn Rankine, Escocés, Físico e Ingeniero(5 Julio 1820 - 24 Diciembre 1872).



ORC for low power plant





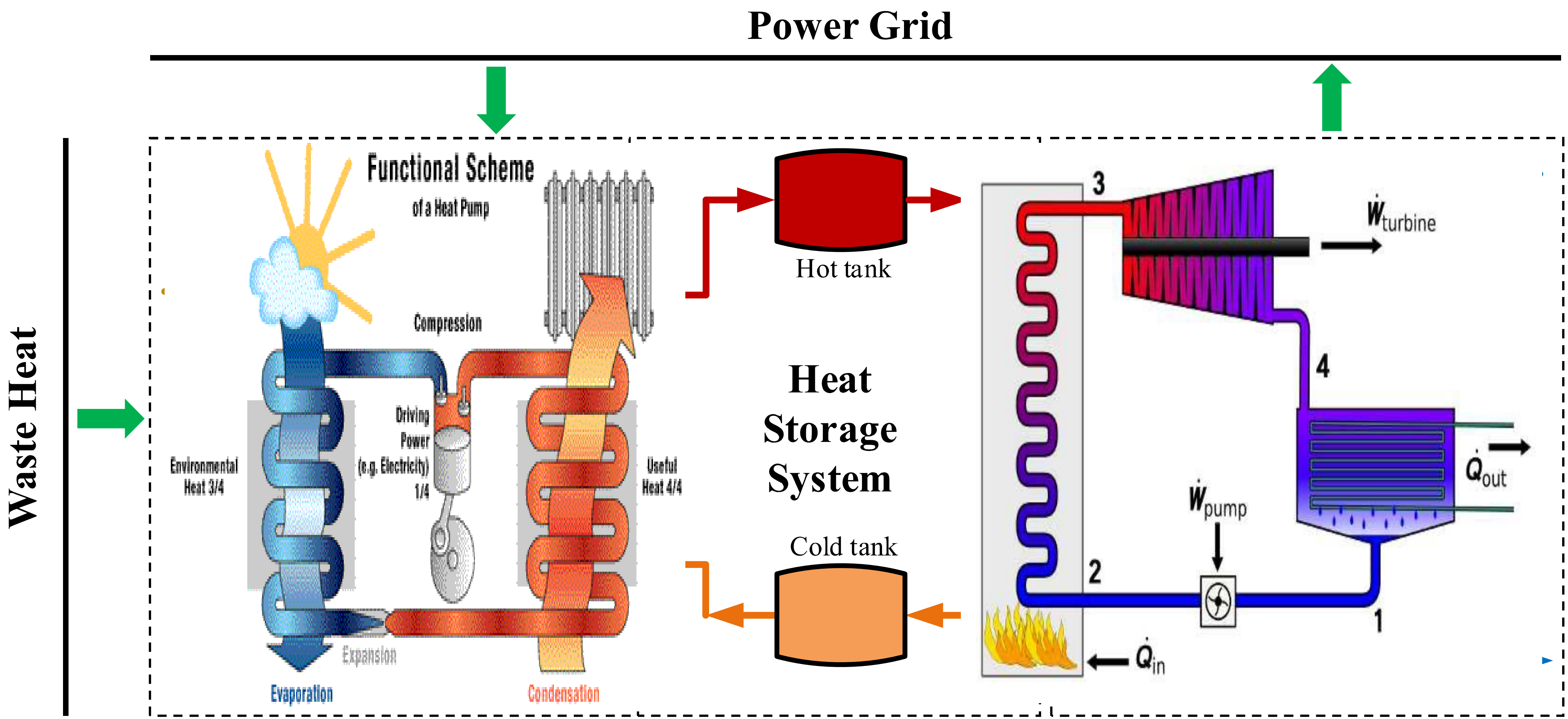


Variations of system efficiency with turbine-inlet temperature for various working fluids ($P_3 = 2.5$ MPa, $T_t = 293$ K).

PhD thesis of Fredy Vélez, Spain

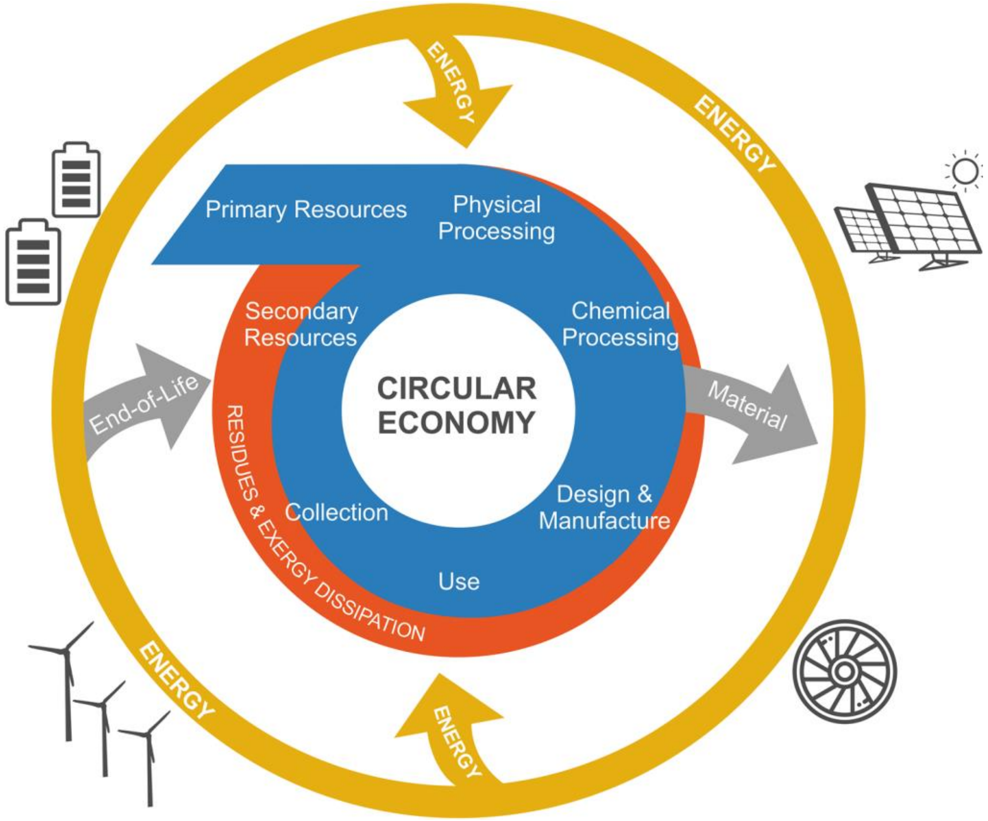
Integration of solar energy-E.E. generation-water desalination

Heat waste- Power generation integration.



5. Final remark

Representation of the circular economy



A. Abadías Llamas· N. J. Bartie· M. Heibeck · M. Stelter · M. A. Reuter; Simulation-Based Exergy Analysis of Large Circular Economy Systems: Zinc Production Coupled to CdTe Photovoltaic Module Life Cycle; **Journal of Sustainable Metallurgy** **https://doi.org/10.1007/s40831-019-00255-5**

PhD Tesis of Carlos Mario Ceballos

This entropy creation means that resources, which include materials, minerals, metals, energy

It is important

Hard engineering: high-level technology.

Soft engineering: advanced mathematical modelling.

Basic science: generating new efficient processes

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¡Gracias!

Agradezco al Ministerio de Ciencias, innovación y tecnología del gobierno nacional por la finaciación del proyecto "**Esquema híbrido de poligeneración (Termoquímico - Biológico) para la sustitución de fósiles a partir de residuos orgánicos**" (contrato ICETEX 2022-0666) de la convocatoria 890 del Ministerio de Ciencias, innovación y tecnología del gobierno nacional.