Biomass conversion for transport sustainability - SCERG @ Tor Vergata

Lorenzo Bartolucci, Stefano Cordiner, Vincenzo Mulone

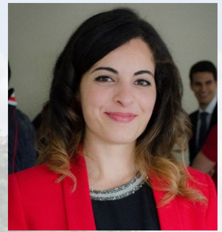
TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

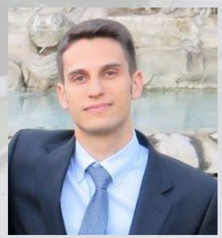
SCERG @ Tor Vergata


Prof. Stefano Cordiner
Full Professor


Prof. Vincenzo Mulone
Associate Professor


Dr. Lorenzo Bartolucci
Research Assistant


Marina Santarelli
PhD Student


Stefano Pasquale
PhD Student

+ 8 ÷ 15 Master students per semester

TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Research Activities

- Biomass Conversion
- Hybrid Renewable Energy Systems
- **Hydrogen Energy Systems and Mobility**
- **Hybrid and Electric Vehicles**
- High Efficiency Natural Gas Engines

TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Biomass Conversion

TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

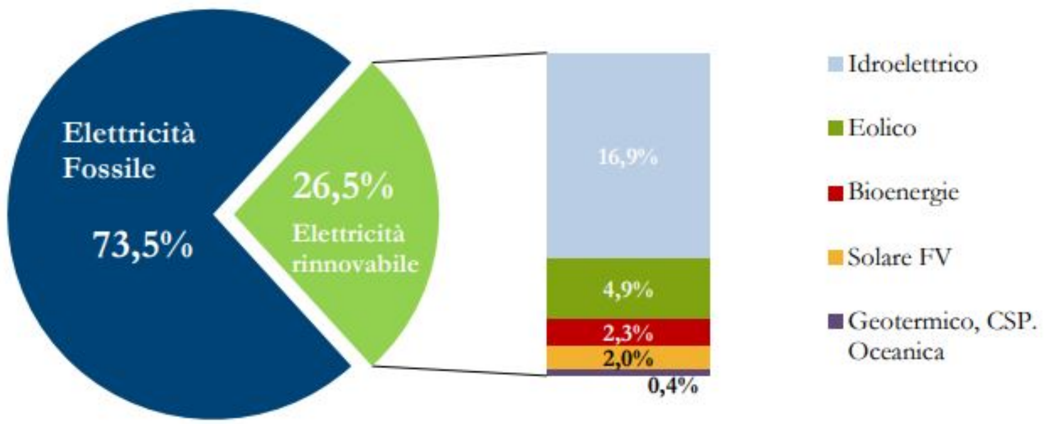
General contest

The sustainability of the existing energy sector and its reliability are currently among the main critical issues for the development

Biomass represent a fundamental contribution towards the resolution of these two problems due to their characteristics, such as:

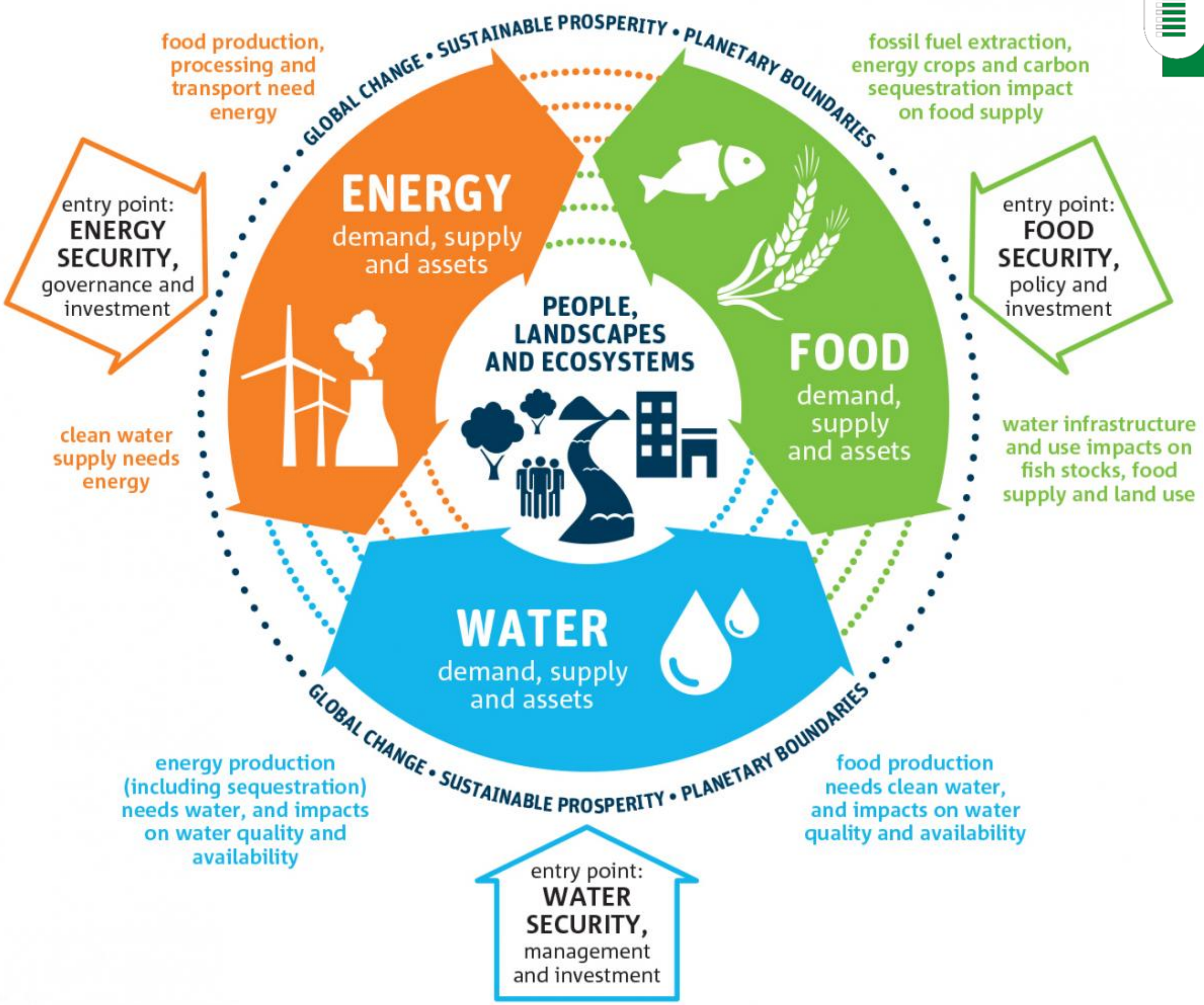
- Programmable use;
- Almost neutral carbon balance;
- Easy of use.

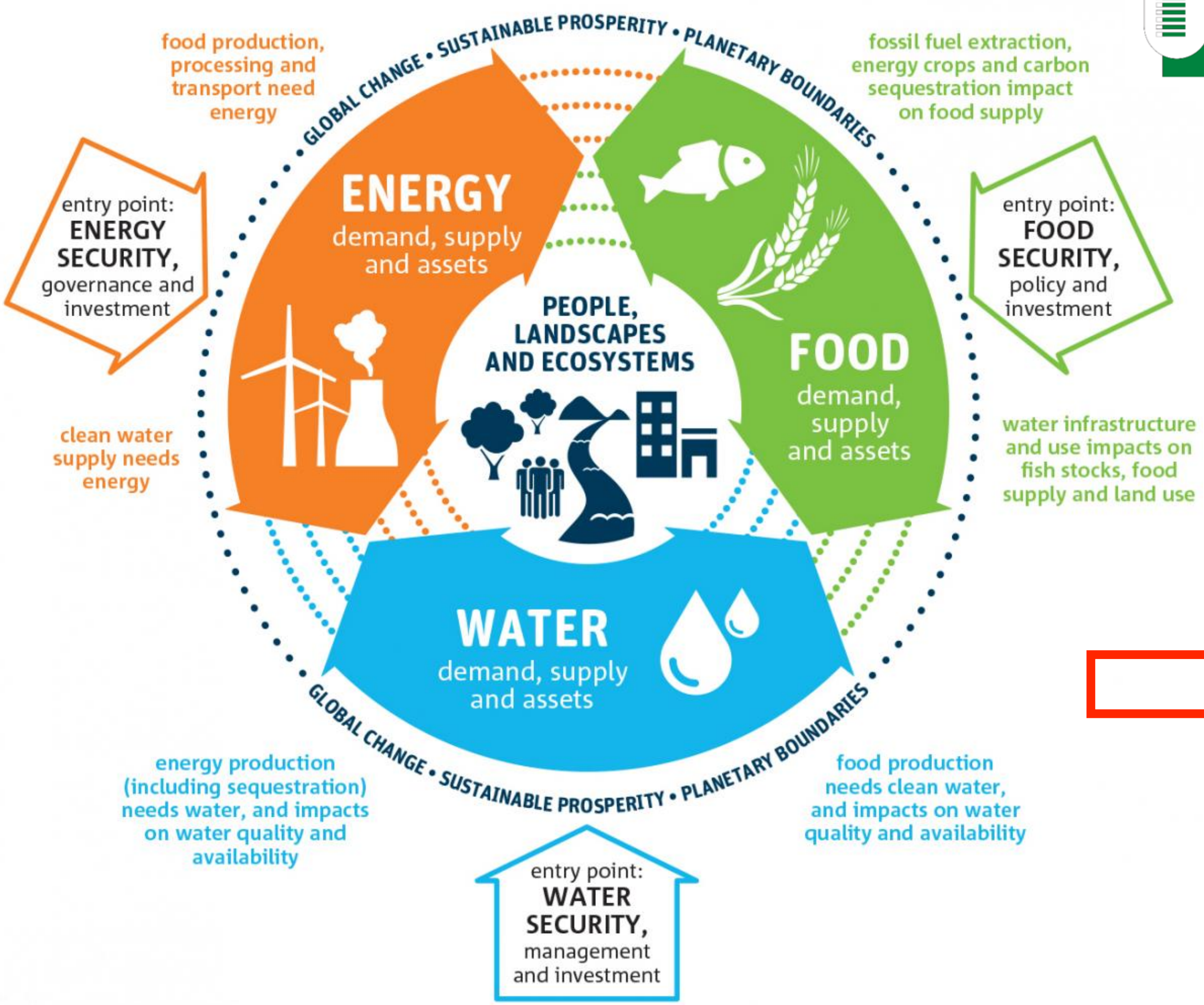
Produzione elettrica globale nel 2017
(fonte: IEA, *Renewables 2018 – Analysis and forecasts to 2023*)



General contest – transport sector

- The UE target for renewable energy in the transport sector is 10% in 2020 that will increase up to 14% in 2030.
- *Biofuels* represent almost 7,1% of the total energy used for transport in 2018 and up to 7,3% in 2019.
- The UE aims at reaching a production of 7% for *food-based biofuels*, value that is equal to 4,6% in 2019.
- *Not food-based* target is instead fixed at 0,2 % in 2022 with the aim of increasing it up to 3,5% in 2030.
- Limits for biofuel from L'UE ha messo un limite dell'1,7% per i biofuels prodotti con scarti di acidi grassi e oli.


food production, processing and transport need energy
GLOBAL CHANGE • SUSTAINABLE PROSPERITY • PLANETARY BOUNDARIES
fossil fuel extraction, energy crops and carbon sequestration impact on food supply
entry point: ENERGY SECURITY, governance and investment
ENERGY
demand, supply and assets
PEOPLE, LANDSCAPES AND ECOSYSTEMS
FOOD
demand, supply and assets
entry point: FOOD SECURITY, policy and investment
clean water supply needs energy
water infrastructure and use impacts on fish stocks, food supply and land use
WATER
demand, supply and assets
GLOBAL CHANGE • SUSTAINABLE PROSPERITY • PLANETARY BOUNDARIES
energy production (including sequestration) needs water, and impacts on water quality and availability
food production needs clean water, and impacts on water quality and availability
entry point: WATER SECURITY, management and investment



TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Anaerobic digestion:

- Feed with organic wastes;
- Potential use for water depuration;
- Reduction of indirect pollution;
- Clean and high quality biofuel;

Anaerobic Digestion

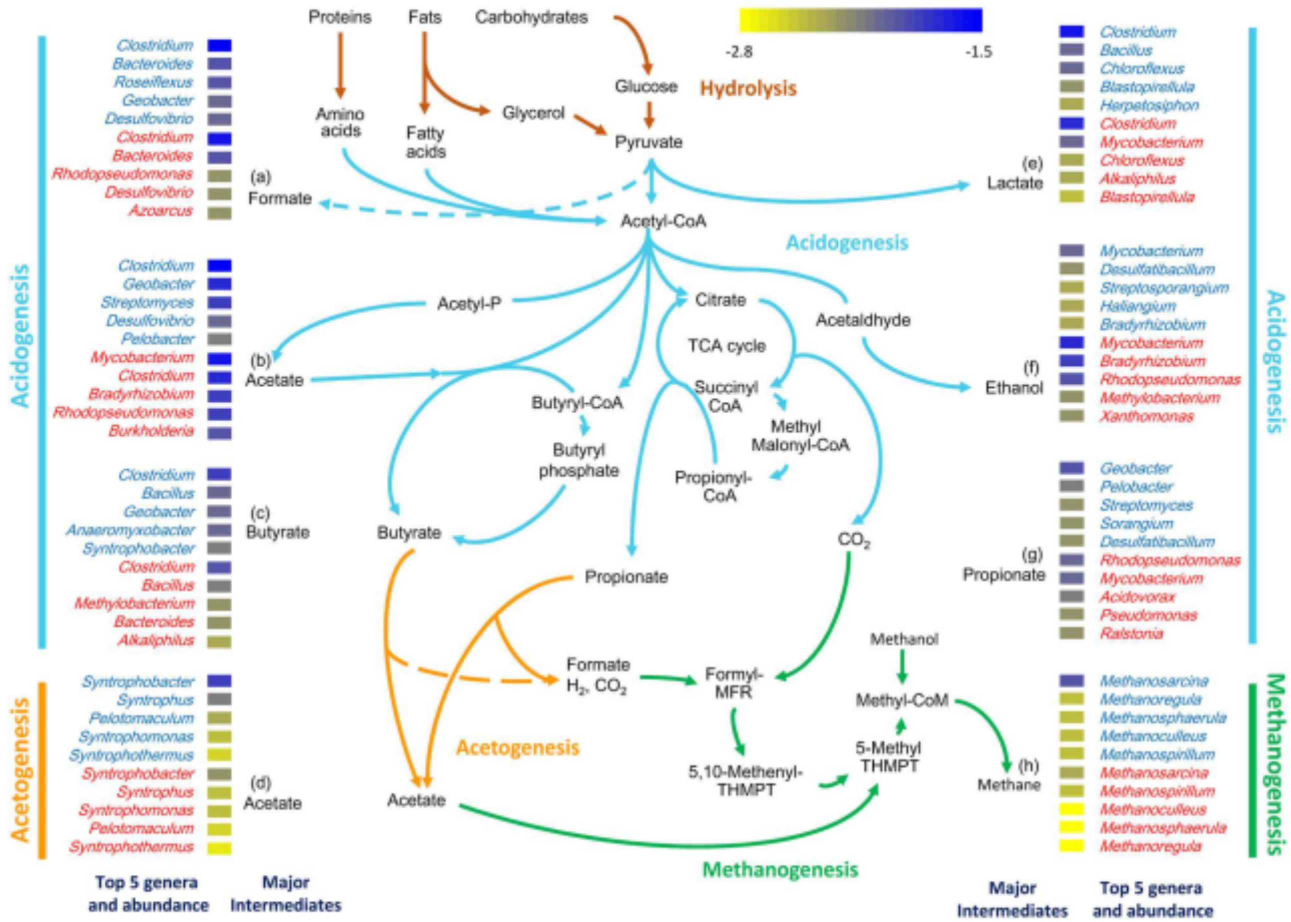
There are four main phases in the anaerobic digestion process:

i. Hydrolysis;

ii. Acidogenesis;

iii. Acetogenesis;

iv. Methanogenesis.



Experimental test rig

The main goal of the analysis is to evaluate the feasibility of small anaerobic digestion plants and the possibility to enable their wide-spread diffusion by increasing the overall conversion efficiency of the process.

Critical parameters:

- Thermo-physical conditions (T, p_H2, pH);
- Biological characteristics (Bacterial communities, VFS accumulation);
- Feedstock characteristics and variability;
- Costs;
- Conversion Efficiency.

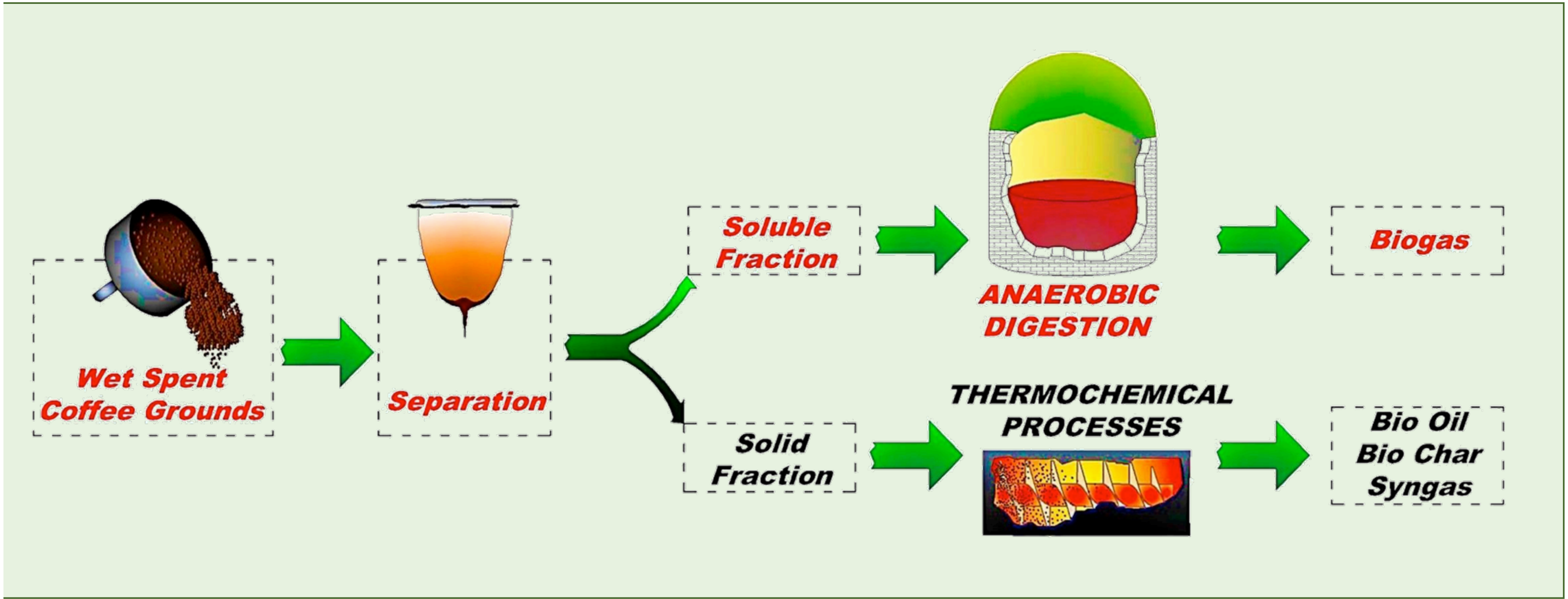
Tests have been performed on:

- Spent Coffee;
- Organic Food Waste;

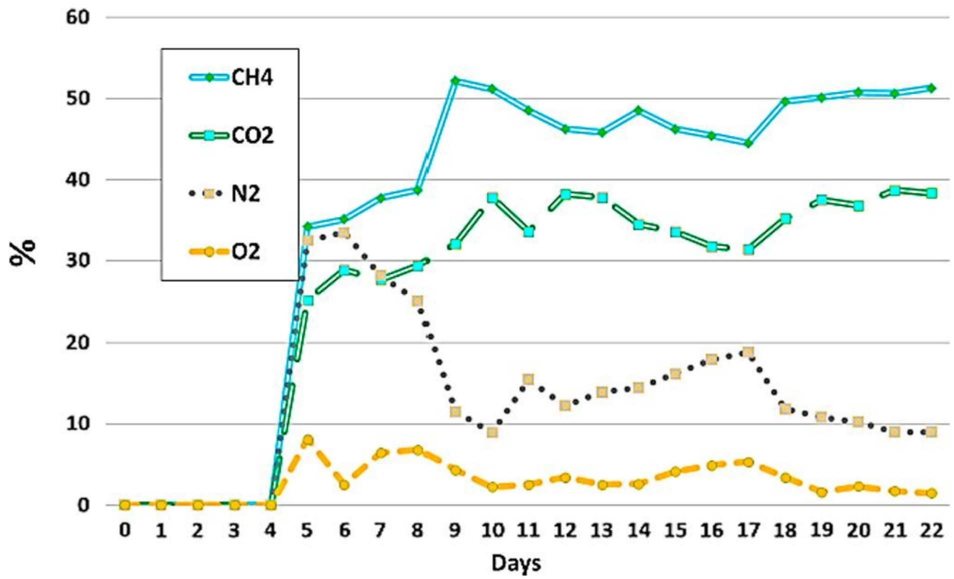
Using as inoculum for bacteria:

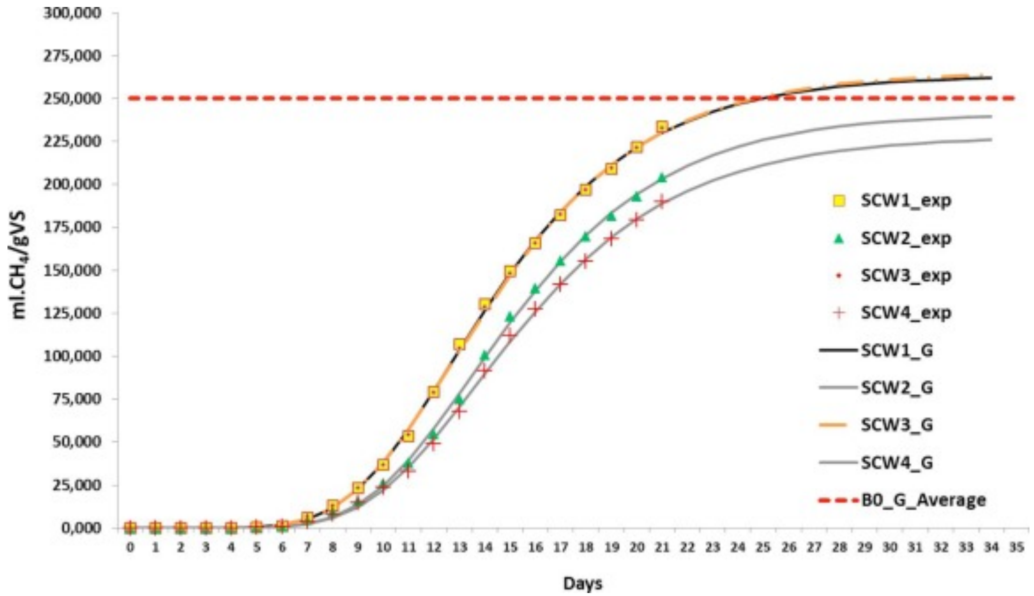
- Cattle manure.

Anaerobic Digestion of Spent Coffee



Current results

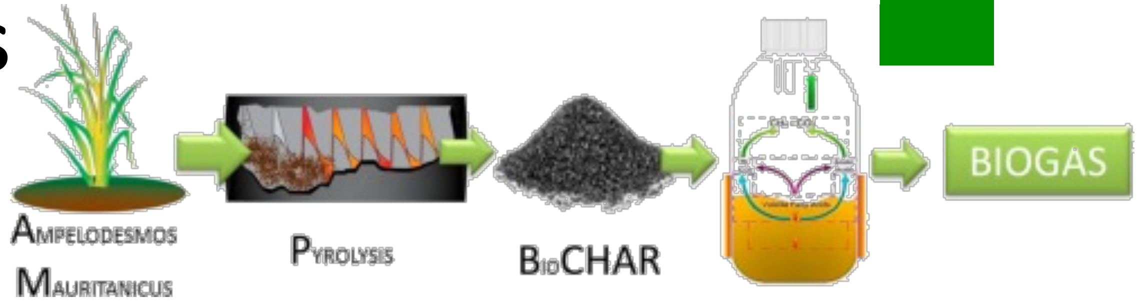


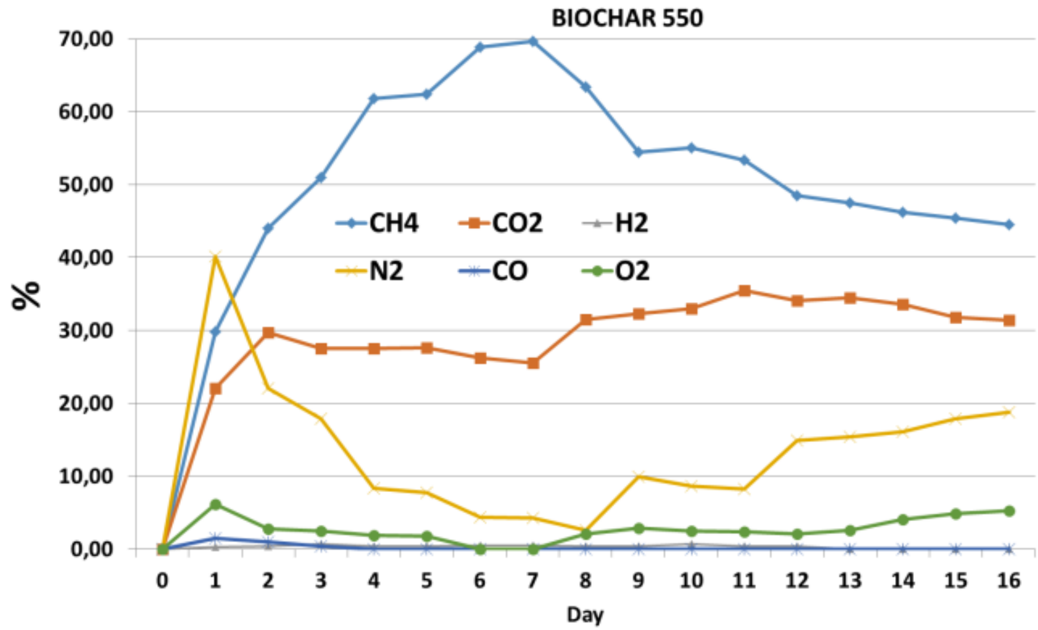


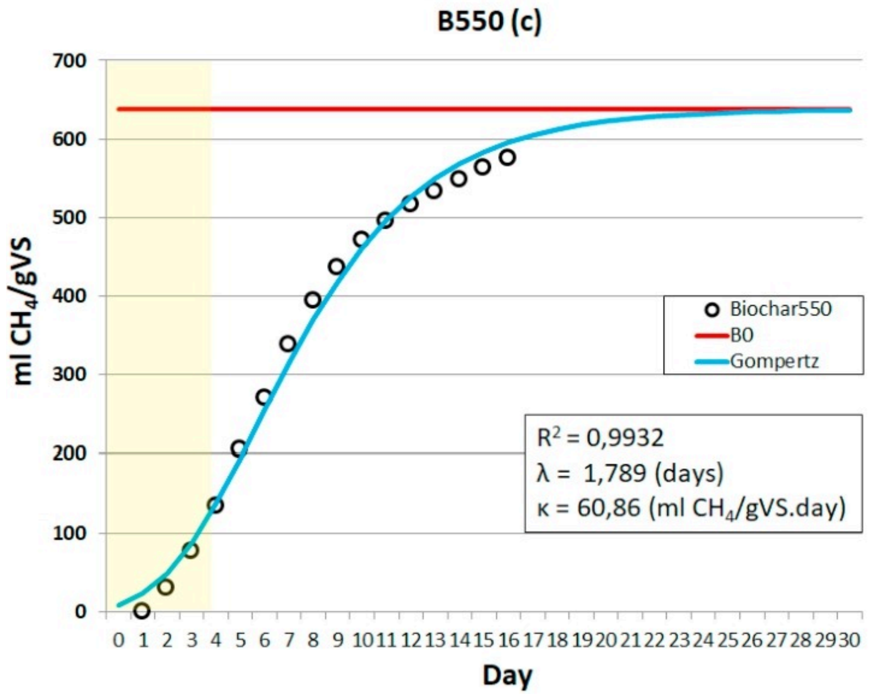
- Production up to 250 mlCH4/gVS in about 22 days
- Methane yield up to 50%
- Quite narrow conversion variability (between 225 to 260 mlCH4/gVS)

Anaerobic digestion of coffee grounds soluble fraction at laboratory scale: Evaluation of the biomethane potential FC Luz, V Mulone, S Cordiner, A Manni Applied Energy

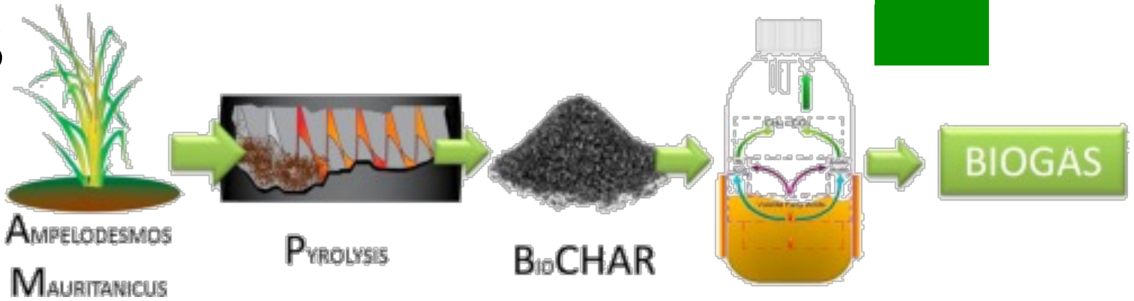
Integration of Anaerobic Digestion and Pyrolysis

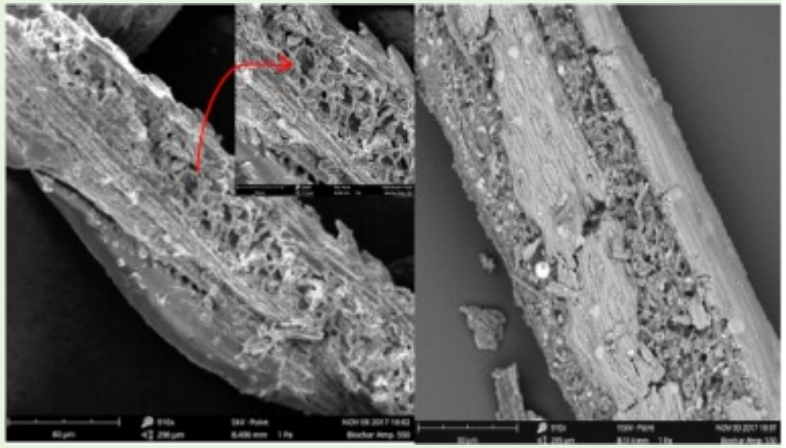






Integration of Anaerobic Digestion and Pyrolysis

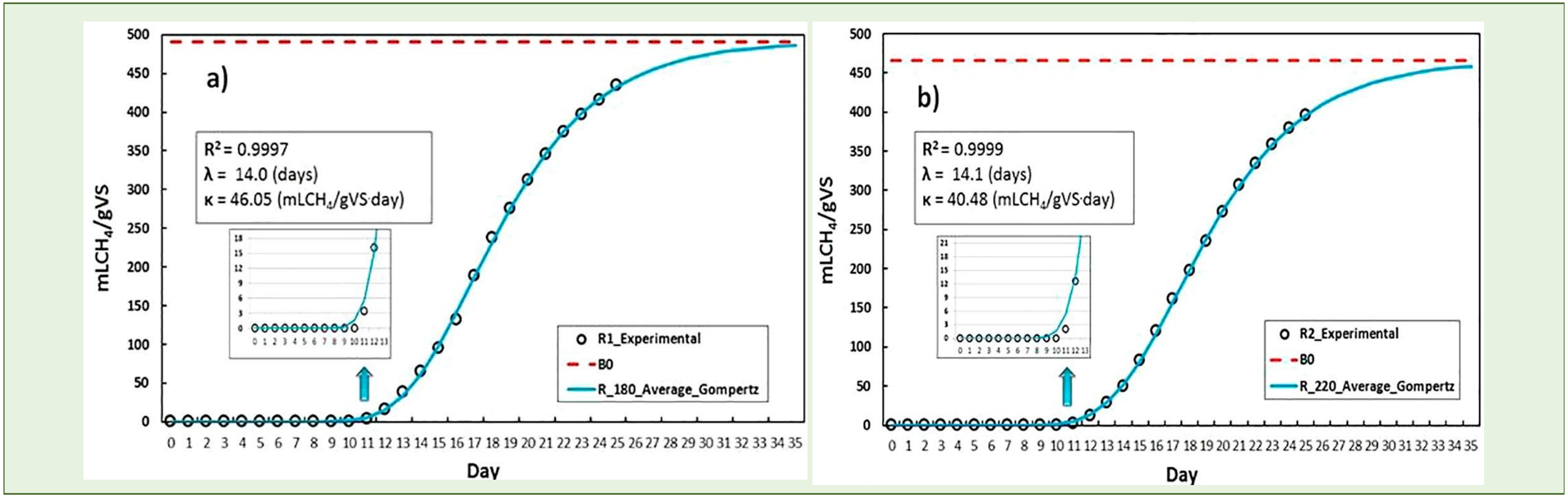




Component	Biochar			Inoculum
	450 °C	500 °C	550 °C	
Energy Input (kJ)	168	171	177	59
CH_4 Th (ml_CH4/g-VS)	584.51	600.82	637.83	158.65
CH_4 Exp (ml_CH4/g-VS)	496.5	540.4	547.6	147
η	61%	45%	34%	–

Biochar 550 °C SEM closeups

Integration of Anaerobic Digestion and HTC



Potential benefits from the integration of the two systems in terms of conversion efficiency and flexibility

Spent coffee enhanced biomethane potential via an integrated hydrothermal carbonization-anaerobic digestion process FC Luz, M Volpe, L Fiori, A Manni, S Cordiner, V Mulone, V Rocco, Bioresource Technology

Integration of Anaerobic Digestion and HTC

TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA

Data	SCG_{HC180}	SCG_{HC220}	SCG_{HC250}
Mass of hydrochar [g]	7.1	7.1	7.1
SY (hydrochar yield)	87.2%	72.5%	61.7%
Mass of SCG equiv. [g]	8.14	9.79	11.51
LHV of SCG [MJ/kg]	21.15	21.15	21.15
$E_{in\text{-}SCG}$ [MJ]	0.172	0.207	0.243
Mass of fresh wet inoculum [g]	291	256	237
LHV of fresh inoculum [MJ/kg]	0.23	0.23	0.23
$E_{in\text{-}INO}$ [MJ]	0.067	0.059	0.055

Data	SCG_{HC180}	SCG_{HC220}	SCG_{HC250}
$E_{in\text{-}HTC}$ [MJ]	0.107	0.156	0.203
$E_{in\text{-}AD}$ [MJ]	0.003	0.003	0.003
Processes Energy input [MJ]	0.109	0.159	0.205
Total Energy input [MJ]	0.348	0.424	0.503
Total biomethane production [mL]	3388	2788	2270
LHV volumetric CH_4 [MJ/mL] $\times 10^5$	3.27	3.27	3.27
Total Energy output [MJ]	0.111	0.091	0.074
Biomethane Energy Efficiency	31.8%	21.5%	14.7%

Potential benefits from the integration of the two systems in terms of conversion efficiency and flexibility

Spent coffee enhanced biomethane potential via an integrated hydrothermal carbonization-anaerobic digestion process FC Luz, M Volpe, L Fiori, A Manni, S Cordiner, V Mulone, V Rocco, Bioresource Technology

Future Developments

Double step reaction of Spent Coffee and Food Waste:

- Hydrolysis;
- Acidogenesis, acetogenesis and methanogenesis;

Test of different biomass (Castor beans, industrial wastes, etc) - Test of AD as waste-water treatment;

Integration of AD with other thermochemical processes (HTC, Pyrolysis and Fermentation);

Biogas upgrading to biomethane at small scale;

Thanks for your attention

TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA