Bioenergy chains from Perennial Crops in South Europe

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BIO-ENERGY
ENLARGED PERSPECTIVES

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Objectives

The overall objective of this project is to:

- **Evaluate the whole bioenergy chain from biomass production to bio-fuels by thermo-chemical conversion, in terms of technical, economic and environmental feasibility,**
- **Use selected perennial energy crops to ensure, by successive harvesting, year-round availability of raw material.**

Consortium members

Partners		WP	Involvement
CRES	GR	WP1	Biomass production
UPM	ES		
INRA	FR		
UNIBO	IT		
Aston	GB	WP2	Thermal conversion
BTG	NL		
VT-TUG	AT		
AUA	GR	WP3	Economics
IUS	DE	WP4	Environment
IFEU	DE		

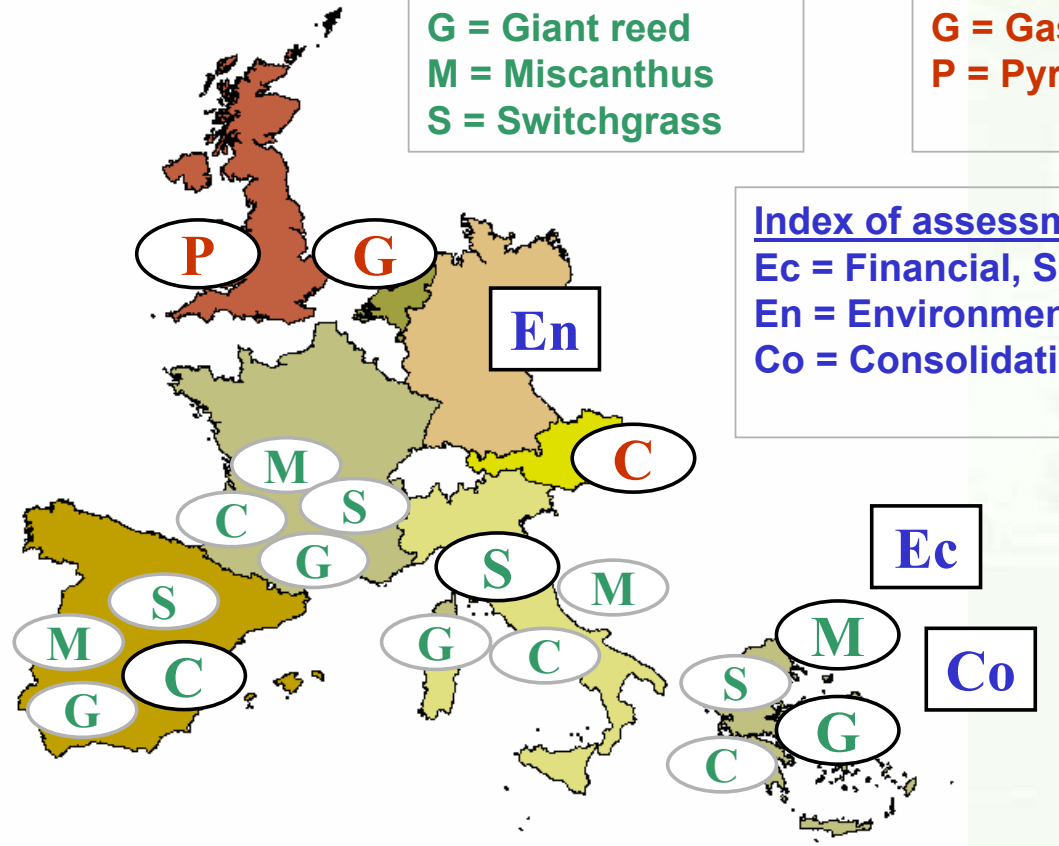
The team

Project activities

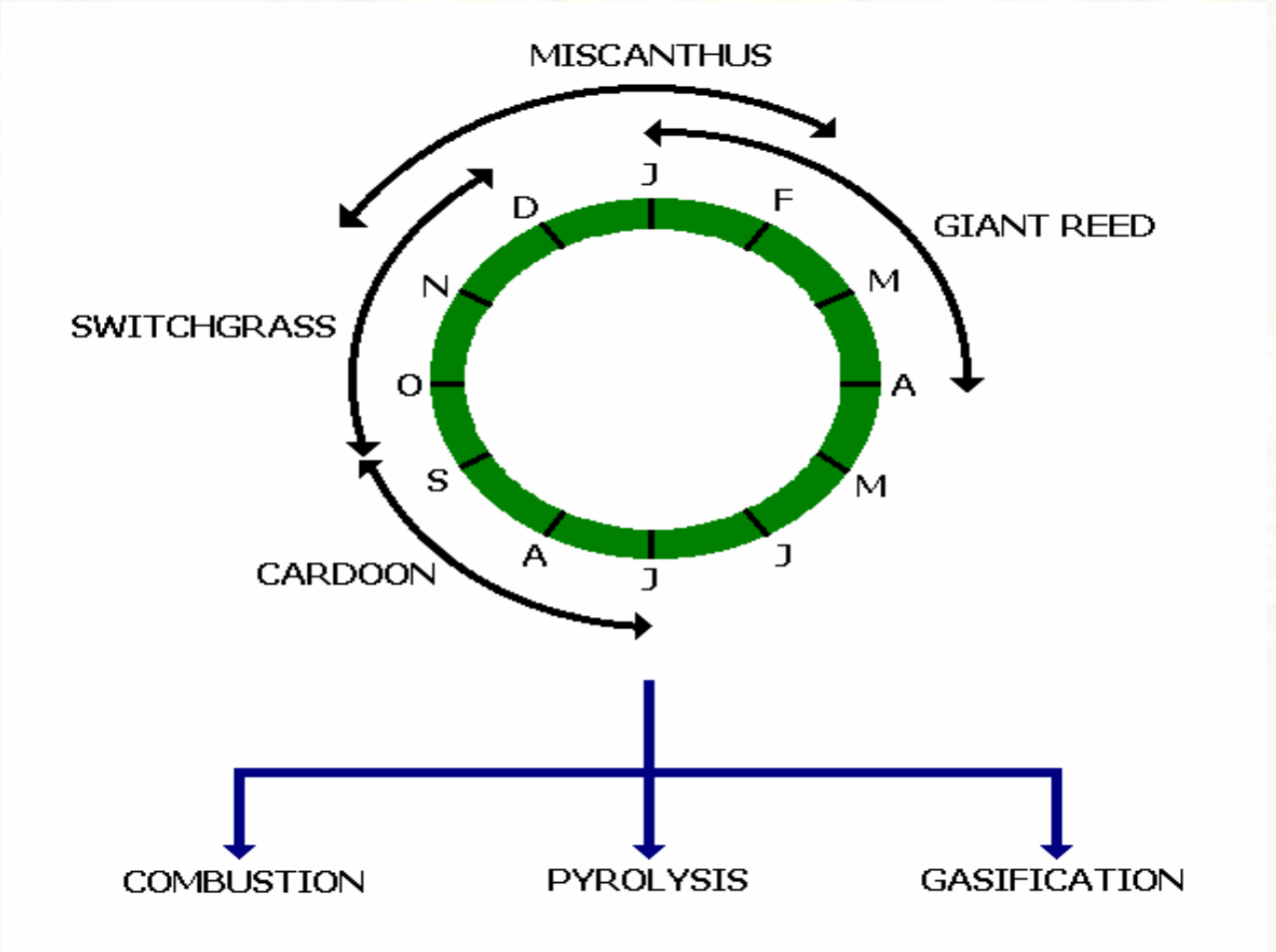
Index of fields
C = Cardoon
G = Giant reed
M = Miscanthus
S = Switchgrass

Index of technologies
C = Combustion
G = Gasification
P = Pyrolysis

Index of assessment
Ec = Financial, Socio-economic
En = Environmental
Co = Consolidation of results



Availability of biomass



Challenges / problems addressed

- Practical demonstration of feedstock-to-energy schemes.
- Achieve year-round availability of raw material.
- Secure fuel supply diversification and reduce raw material shortages.
- Establish practical guidelines for the multi-fuel operation of the thermal conversion plants.

Expected impact

- Through the ***multicropping cultivation*** and successive harvesting, a significant reduction of the procurement cost will be feasible.
- The increased ***feedstock diversification*** leads to fuel security, which is the most decisive parameter in accelerating bioenergy applications.
- More tolerant biomass conversion thermal plants in terms of feedstock variation (***multi-fuel operation***).

Expected impact

- The project will provide technical and economic evidence on the evaluation of integrated bioenergy chains and identification of the viable combinations in terms of fuel resource and conversion technology to reach the cost targets for 1500 euro/kWe and 0.05 euro/kWh investment and electricity production cost, as set by the EU.

Exploitation opportunities

Exploitation Perspectives	Period	Target Markets
Development of harvesting machinery for energy crops	Short	Agricultural machinery manufacturers
Feed preparation and handling	Short	Equipment manufacturers
Equipment design and specification for thermal conversion	Medium	Manufacturers
Process design and optimisation for thermal conversion	Medium	Industrial design & construction companies
Multi-fuel conversion	Medium	Industrial design & construction companies
Fuel specifications	Short	Industrial design & construction companies

Large fields

Crops	Area	Plant material		Equipment	
		Type	Density	Planting	Harvest
Cynara cardunculus	Spain (UPM)	Seed	1.5 plants m^{-2}	Grain driller	Drum mower + rotoballer
Panicum virgatum	Italy (UNIBO)	Seed	80 – 150 plants m^{-2}	Grain driller	Mower + baler
Miscanthus x giganteus	Greece (CRES)	Rhizomes	0.9 plants m^{-2}	Semi-mechanically	Maize silage harvester
Arundo donax	Greece (CRES)	Rhizomes	0.9 plants m^{-2}	Semi-mechanically	Maize silage harvester

Biomass production

Cardoon

(*Cynara cardunculus*)

Switchgrass (*Panicum virgatum* L.)

Biomass production

Miscanthus
(*Miscanthus x giganteus*)

Giant reed (*Arundo donax* L.)

Fuel characterisation

- Proximate and ultimate analysis
- Elemental analysis - CHON
- Ash fusion

Results indicate:

- High ash contents for all crops (2.9% to 5.3%).
- C, H, N, content is similar for all materials tested and together with the measured ash content yields.
- Higher Heating Values (HHV) are ~17.5 to 18.5 MJ/kg.

Fuel characterisation

- High concentrations of N, S and Cl in all crops may cause slagging, fouling and corrosion as well as increased emissions like NO_X, HCl and SO_X during combustion when not considered in the design and operation of the combustion plant.
- Cardoon behaved completely different from the other crops. Higher concentrations in ash, alkali (K and Na) and Cl and the ash sinters at relatively low temperatures.

Fuel characterisation

- The chemical composition of the perennial crops is closer to the chemical characteristics of straw than to woody biomass fuels.
- Combustion and gasification may experience problems for the selected crops, unless the operating temperature is below the initial ash melting temperature. Pyrolysis will not experience problems as such, but when the char is combusted to provide process heat, similar problems might be experienced as with combustion.

Thermal conversion

Combustion
(VT-TUG)

Pyrolysis
(ASTON)

Gasification (BTG)

Economic assessment

Biomass Economic Evaluation

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A biomass economic analysis model has been developed by AUA. Some of its features are:

- Windows XP based application.
- Detailed monthly monitoring, factors of production, amount of biomass and energy consumed.
- Detailed cost analysis by agricultural operation or by factor of production, per hectare, per ton, etc.
- Full financial analysis (typical accounting format)
- Identification of monthly cash-flows
- Easy to understand input forms and reports
- Small size, easy transferred case-databases.

Environmental assessment - EIA

- The environmental characteristics of biomass production compared to conventional agricultural production have been analysed by IUS.
- The reference period chosen for the analysis of conventional production covers the 5 years before the establishment of the experimental fields.
- Characteristics of biomass production have been investigated by use of a questionnaire sent to the biomass production group.

Environmental assessment - LCA

- The focus is the comparison of the four crops with fossil energy sources, natural gas and light oil.
- To compile the life cycle inventory, more than 25 parameters (e.g. CO_2, CH_4, NO_X, N_2O, etc.) have been selected.
- LCA will only be carried out for the large fields as some activities at the small fields were performed manually. The collected data of small fields will be used to analyse critical points and model dependencies and sensitivities.
- The environmental impacts for accomplished life cycle steps are calculated country-specific and crop-specific by IFEU.

Summary

- The establishment, cultivation and harvesting of all four species were performed successfully, without needing new agricultural methods.
- The chemical composition of the perennial crops is closer to straw than woody biomass fuels therefore technologies for thermal conversion of straw should be considered for these crops.
- The basis for the economic and environmental assessments have been established. The results will be derived once the plantations have completed a full cycle.