INTELLIGENT ENERGY EUROPE
FOR A SUSTAINABLE FUTURE

GRass as a GReen Gas Resource

GR3 Project: Biogas production from grass

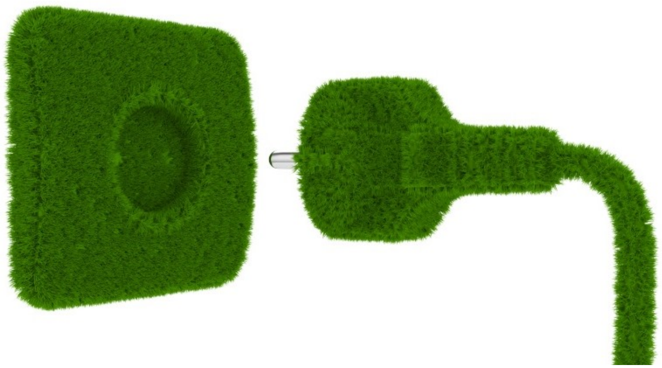
Santino Di Berardino, Luís Silva, João Bidarra, Luís C. Duarte
Partner **LNEG**, *Bioenergy Unit*
Email: Santino.diberardino@lneg.pt

GRASS TO GREEN GAS

ECOMONDO-Worshop WASTE
Rimini November 4, 2015

Co-funded by the Intelligent Energy Europe Programme of the European Union

IEE/12/046/SI2.645700 2013 - 2016



From **Grass** to **Energy**

- **Matchmaking** between **grass producers** and **biogas producers**
- Inventory available grass wastes
- Overview BAT's and best practices
- Design of webtools
- Non-tech strategies

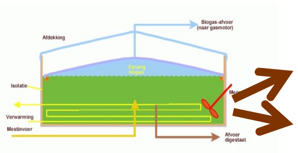
BACKGROUND

Ecologic mowing

Purification

Ensilaging

Digestion



CHP

Biomethane fuel

Composting

SUPPLY

MISSING VALORISATION CHAIN

VALORISATION

± 800 000 tons of grass waste generated

Actually 70% disposed, 30% composted

Due to :

- Missing logistics

  Investments required on both sides
- Legislative framework
- No contact between stakeholders

Possibilities

- Increased renewable energy production

  1 ton grass ~ 340 kWel and 400 kWth
- Primary energy savings (in composting)
- Less uncontrolled grass disposal
- Jobcreation (social economy)

Biogas plants looking for more sustainable feedstock

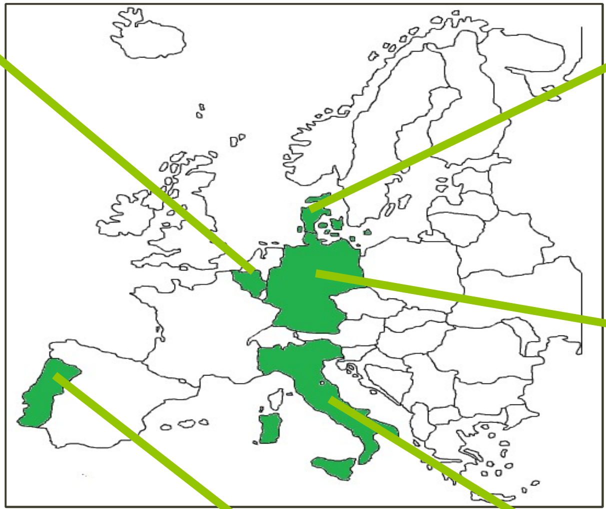
Partners & Contact

Project coordinator : **DLV Belgium cvba**

Rijkelstraat 28, B-3550 Heusden-Zolder, Belgium
T : +32 11 60 90 60 F: +32 11 60 90 69

Contact person : Lies Bamelis

M: +32 499 14 08 58



Flanders (Belgium)

DLV – UW TOEKOMST KRIJGT VORM
UNIVERSITEIT GENT
inagro – ONDERZOEK & ADVIES IN LAND- & TUINBOUW
PHL – PROVINCIALE HOGESCHOOL LIMBURG
pro|natura – Werk maken van Natuur !

Denmark

University of Southern Denmark

Germany

GERBIO – German Society for Sustainable Biogas and Bioenergy Utilisation
izes gGmbH – Institut für ZukunftsEnergieSysteme

Portugal

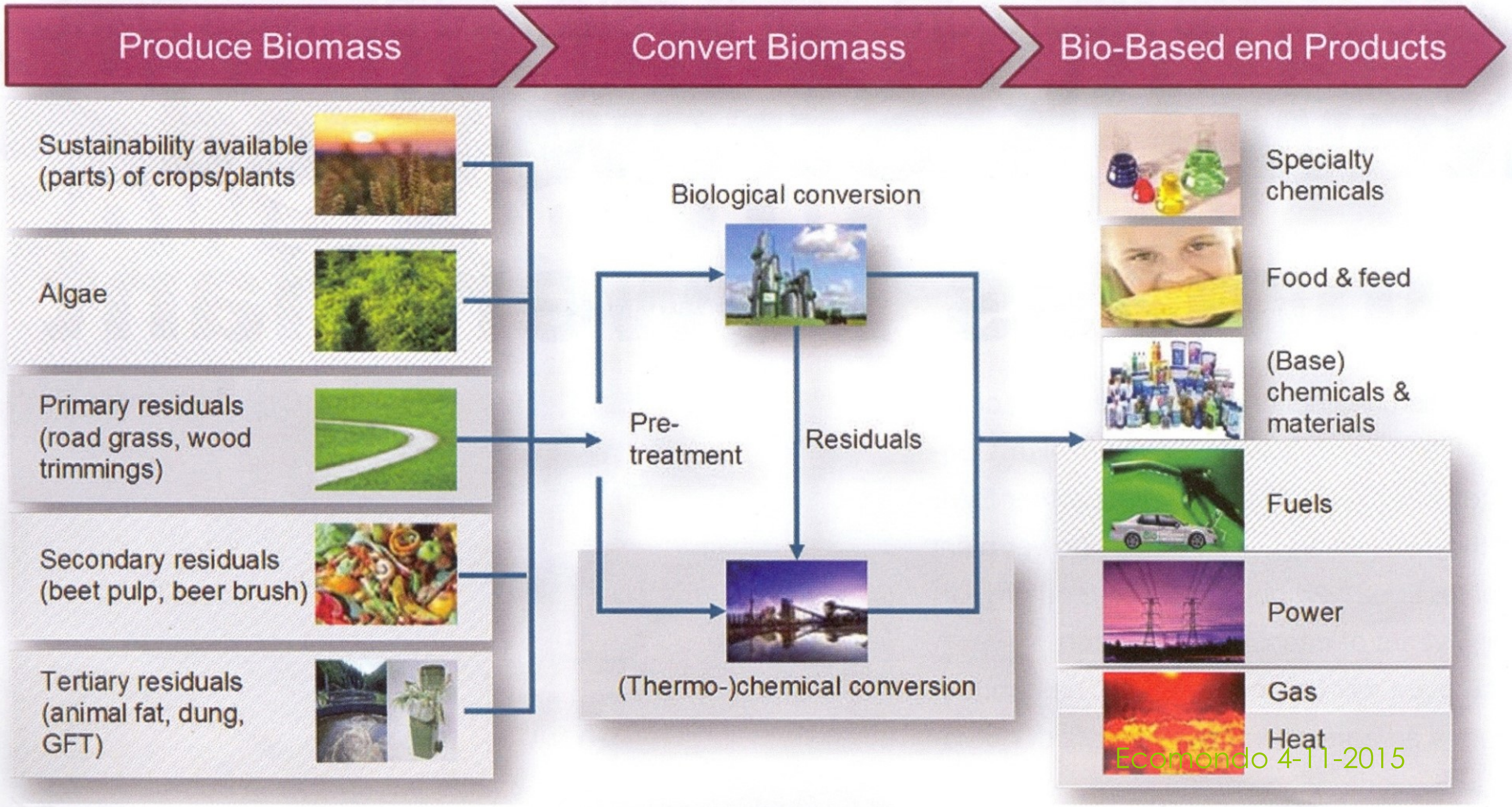
LNEG – Laboratório Nacional de Energia e Geologia, I. P.

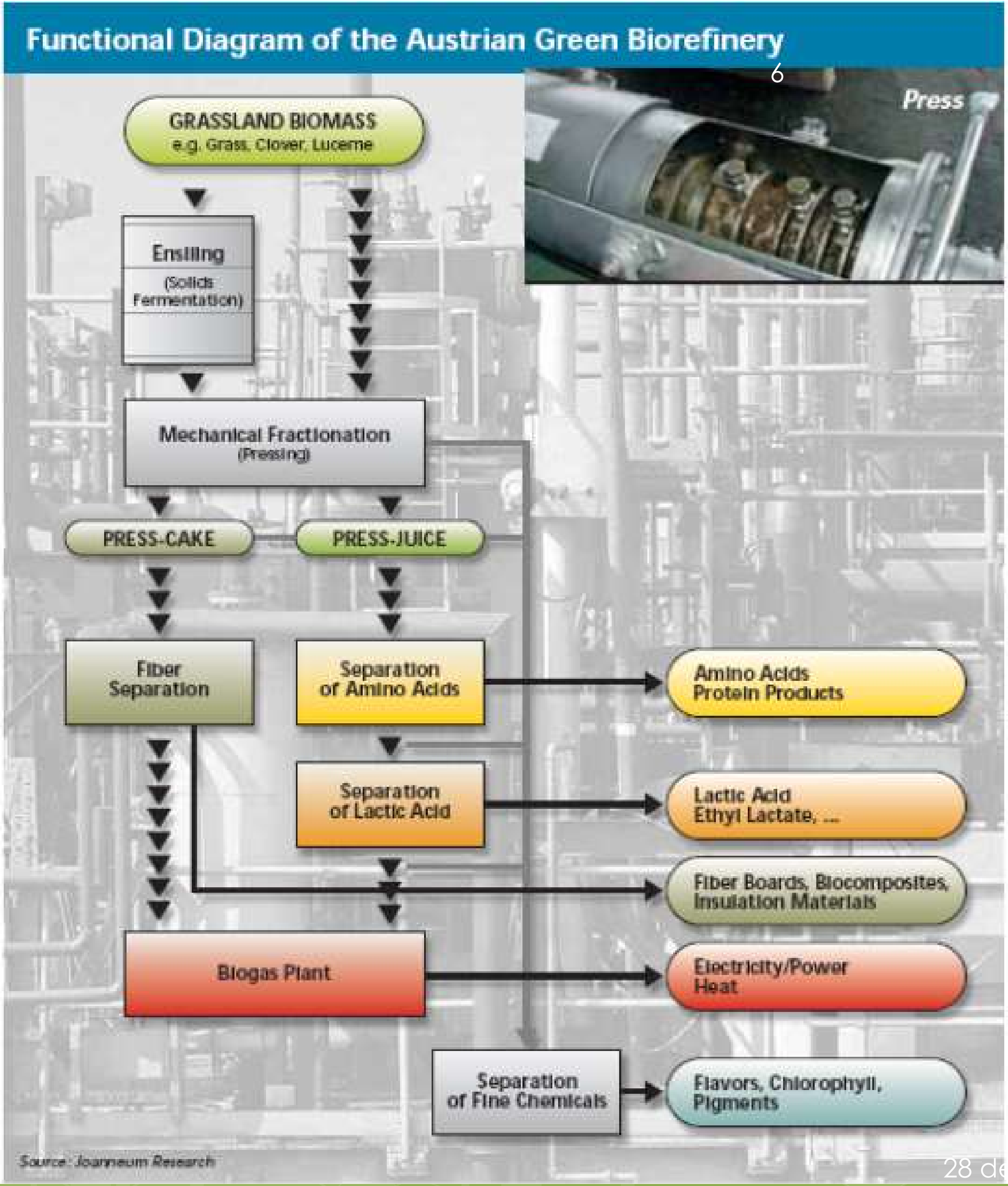
Italy

Università degli Studi di Verona
Veneto Agricoltura – Azienda Regionale per i settori Agricolo, Forestale e Agro-Alimentare

Biomass based Economy

From: Bioenergy International N 56, Feb 2012

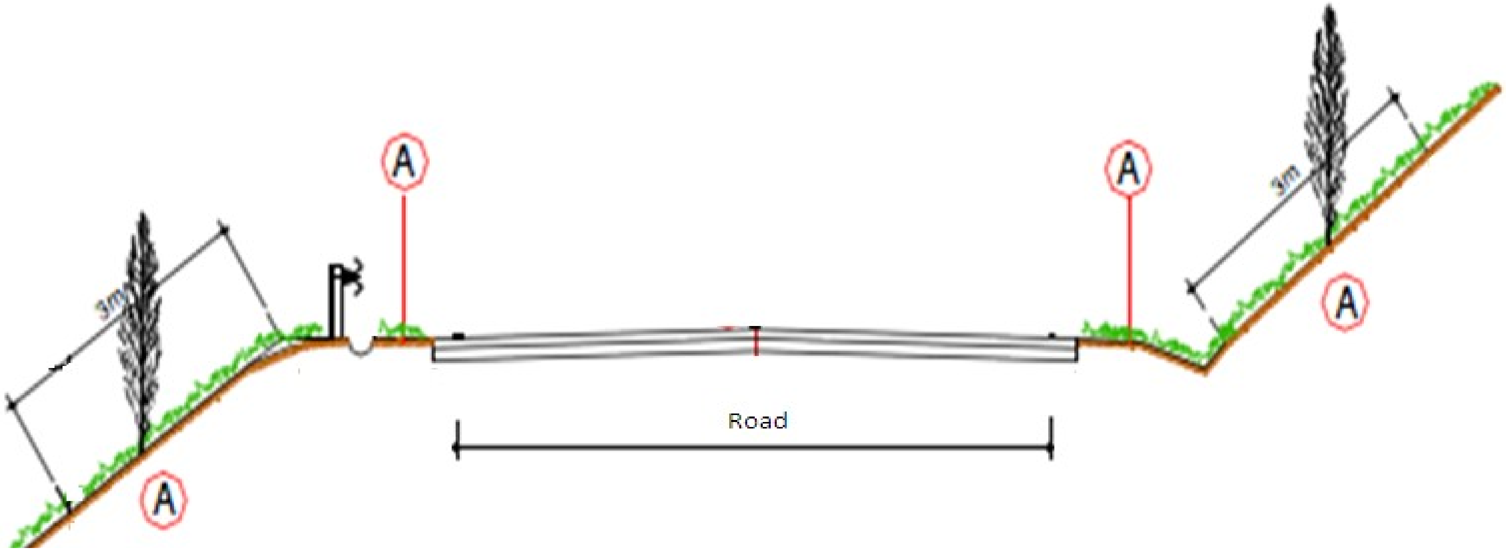




GRASS The Future biorefnery

- Temperature is the main factor determining geographical distribution of grass. Grass of cool season (most used are *Agrostis, Festuca, Poa* and *Lolium*) is adapted and predominant in temperate and boreal regions.
- In Algarve region predominates the warm season grass which has a good tolerance to drought. The main species are *Cynodon dactylon* (in the golf lawns a mix of *Cynodon dactylon* with *Cynodon transvaliensis*), *Stenotaprhum secundatum, Paspalum notatum,*

- **Roadside maintenance operations. A- Cutting Areas**



Conversion Factors for evaluating grass quantities in Lisbon Region

	Irrigated park	Not irrigated areas
Number of cuts/year	18	4
Grass Harvest Yield tWM/h/Year	15	7,5
Moisture (%)	73	73
Methane Yield m^3CH_4/t	100	90

Road cuttings

	Harvest time	Periodicity
Northern area of Portugal (Braga, Vila Real, Bragança, Viana do Castelo, Porto, Aveiro, Viseu, Guarda, Coimbra, Castelo Branco, Santarém, Portalegre and Leiria	From April to June and September to November	2 interventions per year
Southern área of Portugal (Lisboa, Setúbal, Évora, Beja and Faro)	Since April to September	2 interventions per year

Grass composition

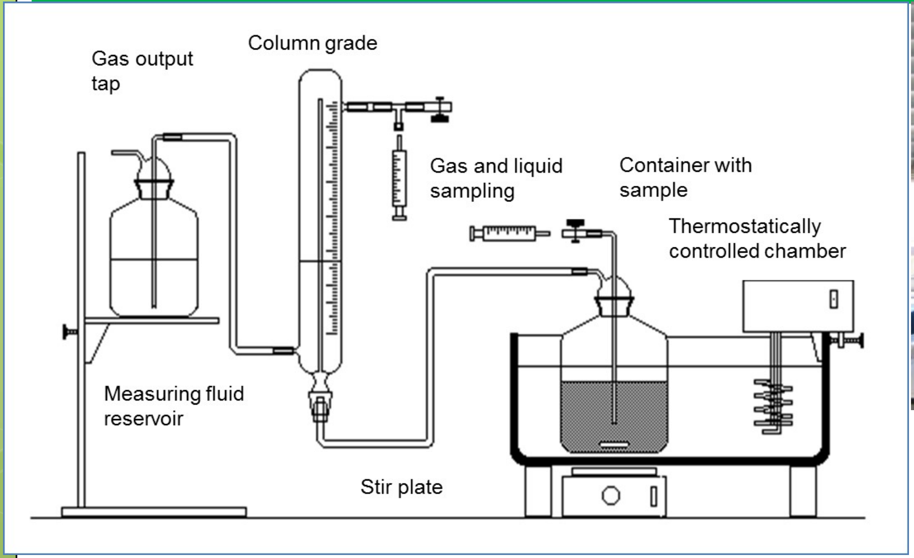
Parameter	GG
pH	6,3
Humidity(%)	65,5
TS (mg/gr of fresh matter)	345
VS (mg/gr of fresh matter)	310
Nitrogen KN(mg/g dry matter)	8
Carbon [total](mg/g dry matter)	423
Hydrogen[total](mg/g Dry matter)	55
Sulfur [total](mg/g dry matter)	20
TOC (organic carbon mg/g dry mat)	395
Phosphorus (mg/g dry matter)	0,7
Cellulose(%)	19
Xylan (%)	9
Arabian(%)	2
Acetyl Groups(%)	1
Hemicelulose(%)	13
Lignin(%)	14
Gross Calorific Value (GCV) [MJ/Kg]	16,35
Ashes Production (%bs)	11,76

Garden Grass Composition from Almada council green areas

Parâmeter	Sample 1	Sample 2
Total solids - TS (%)	35,8	51,4
Fixed Solids - FS (%)	4,85	8,0
Volatile Solids VS (%)	30,9	43,4
TOC (% DM)	57,0	54,6
COD (g O2/kg DM)	1556	1537
Nitrogen Kjeldhal – N (% DM)	1,03	1,79
C/N	49,5	30,5
Total Psphorous (g P/kg DM)	1,25	1,93

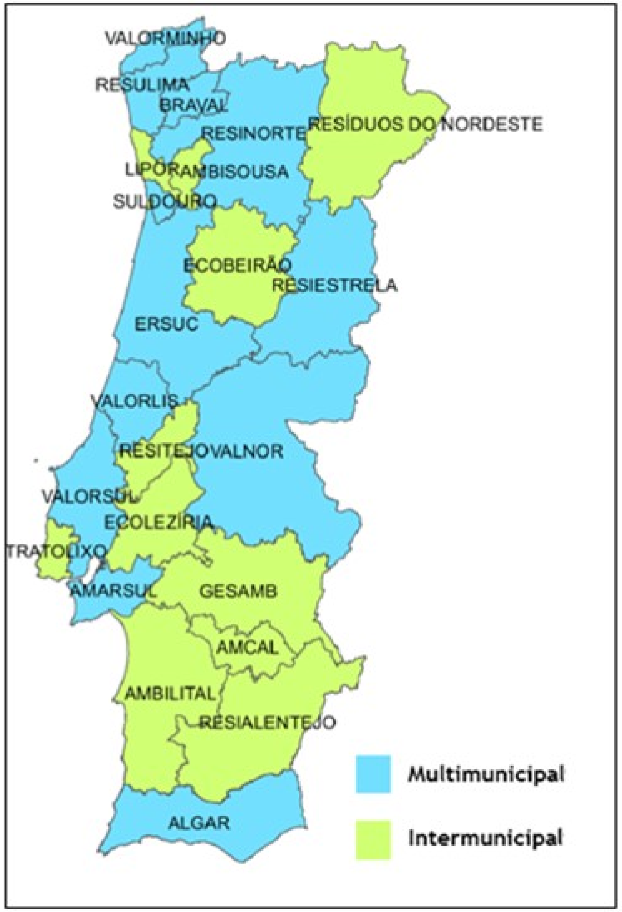
Biomethane Potential

- according to Batch BMP tests carried-out at LNEG laboratory
- 131,8 m^3CH_4/ton fresh matter
- 381,9 m^3CH_4/ton TS
- 425,7 m^3CH_4/ton VS
- 509,1 m^3CH_4/ton TOC



- Grass Waste has an interesting Biogas potential.
- Grass are collected in cities and roads and imply costs.
- Grass can be a good feedstock for AD
- Can be used as co-substrate in existing digester

Solid Waste operators in charge for waste management in Portugal



Quantities of green waste received separately by each municipal solid waste plant in 2012

Management System of Urban Waste	Total waste (ton)	Green waste (t) (LOW Code 200201)	Street Waste (t) (LOW Code 200303)
ALGAR	338 095	23 647	3 058
AMARSUL	402 882	21 756	13 574
AMBILITAL	62 205	2 311	345
AMCAL	14 107	541	0
BRAVAL	112 636	481	0
ECOLEZIRIA	58 944	502	0
ERSUC	389 21	735	4 122
GESAMB	77 427	752	0
LIPOR	476 216	20 351	0
RESIALENTEJO	46 050	362	416
RESINORTE (c)	348 295	1 151	3 048
RESITEJO	93 764	1 426	118
SULDOURO	186 958	758	7 725
VALORLIS	114 692	7	2 079
VALORSUL	758 412	1 582	698
VALNOR	116 351	77	0
Planalto Beirão	122 414	621	0
TRATOLIXO	386 950	24 837	47 455
VALORMINHO	35 330	a	a
RESULIMA	128 097	d	d
AMBISOUSA	126 534	b	b
Resíduos Do Nordeste	57 802	106	0
RESIESTRELA	71 996	d	d
Total parcial		102003	82638 82638
Total	**4 136 157**	**184 641**	

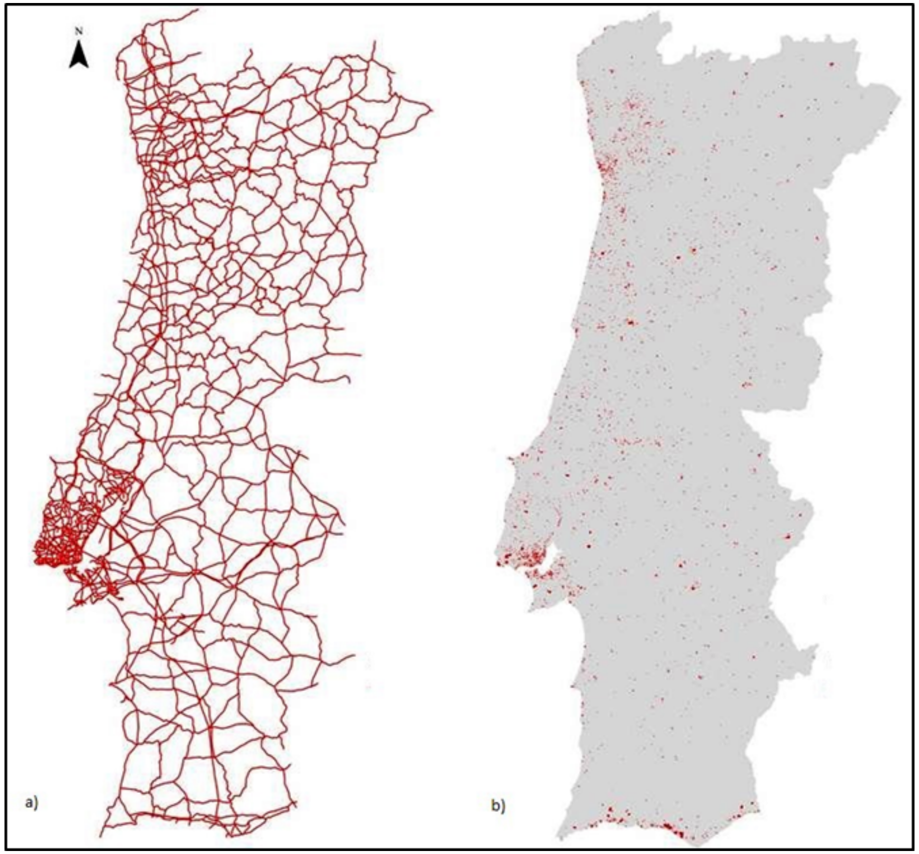
Quantities of green waste from national roadsides

Material	Managed area	Quantity ton WW/Y
herbaceous waste	11 000 ha	25 000
Ligno Cellulosic Waste	11 000 ha	7 500

Total amount of green waste

source	National Potential of Wet herbaceous waste (t/year)	Biomethane potential (m^3 CH_4/Y)
Green National Areas (above 1 ha)	364 000	32760000
Roadside	57 000	7410000
Green National Areas (below 1 ha)	20 000	2000000
Total	441 000	42170000

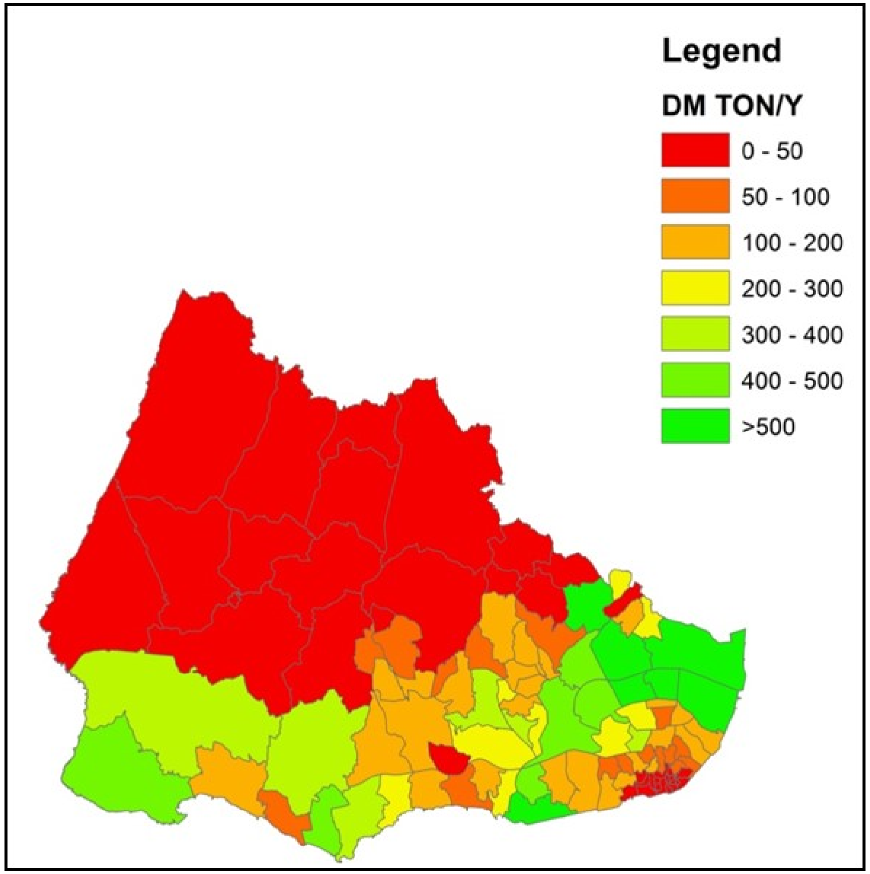
Representation of green areas from a) Roads in Portugal; b) Urban green areas in country. (Scale 1:1.950.000)



Quantities of green waste received at Municipal Solid Waste Treatment Plant

		Green Waste (20 02 01) Total 2012 (t)
Tratolixo	Cascais	19563.94
	Mafra	1831.6
	Oeiras	1950.8
	Sintra	1261.2
	Private	2298
Valorsul	Amadora	1188
	Lisboa	0
	Odivelas	0

Grass waste availability in the Lisbon region



Estimated recoverable grass per municipality and biomethane potential

Municipality	Estimated (Quantity DW t/y)	Estimated Quantity (WW t/y)	Biomethane potential (m^3CH_4/Y)
Amadora	987,7	3655,4	472 000
Odivelas	458,4	1697,5	220 000
Lisboa	9463,7	34923,2	4 380 000
Sintra	796,1	2933,0	362 000
Oeiras	1361,5	5024,9	631 000
Cascais	1237,5	4578,1	589 000
TOTAL	14.305	52.812	6 654 000

Why the GR3 Project?

- Urban and suburban areas are rich in green areas already planted for recreational, aesthetic, leisure etc. reasons, suitables for AD feedstock
- Its **production cost is zero**, once it is supported by the beneficiaries of green areas, presenting a favorable situation with regard to energy crops, which must be specifically cultivated and harvested.
- The GW is generated within the areas served by the **collection of municipal solid wastes (MSW)**, another potentially favorable circumstance, if well managed.
- A significant percentage of GW is forwarded to the regional MSW treatment system and eventually is converted into biogas, if any anaerobic digester is available.
- This is the case of GW from small producers, up to 110 l/day, who see their waste delivered to recycling centers without any fees or burden.

Grass costs

- Cultivation of one hectare of upland meadow (grass or energetic crop) costs **350-550** €/ha, depending on the price of seeds and method of plowing, corresponding to **8-11** €/t, according to the price os seeds and the kind of farming.

- Economic analysis **in Portugal** of a biogas plant using this raw material concluded that incentives are not enough to offset the cost of production, collection, preparation and processing. Consequently the use of energy crops for biogas production does not yet exist.

- Although there are a number of obvious potential advantages, Strenghts and Opportunities, for using GW in anaerobic digestion, the potential of this biomass is still underutilized. Only a portion of GW is forwarded to the regional MSW treatment system in available anaerobic digesters.
- In practice, this value chain suited to valorization of residual grass in biogas plants is mostly missing in GR3 partner countries.
- There are several **technical, not technical and economic barri**ers that lead to this occurrence. Among them, the lack of awareness regarding technologies for cutting, storage and anaerobic digestion of grass waste, beyond the scarce cooperation between value chain actors and obstacles of a legal nature.
- Using the information collected in previous report of GR3 project it was possible to uncover and classify **in a SWOT analysis Matrix**t he NTBs standing in the five countries, as well as the Strengths, Opportunities and the Trheaths, obtaining a visualization of status, advantages and disadvantages, and potential drivers for grass use in anaerobic digestion.

Why the GR3 Project?

- The greatest barriers arise when larger GW producers are involved, due to the rules guiding the interface between the municipalities and the multi-municipal or regional system of waste management.
- An established gate fee, variable from case to case, discourages the delivery of the GW, that are not forwarded to the central system and are buried locally or send to an alternative cheaper treatment such as grinding, composting, etc.,.

Why the GR3 Project?

- It is necessary to introduce measures that stimulate interest and cooperation among all stakeholders (producers of waste, companies which collect the grass, waste management companies, farmers, etc.), which should dialogue to each other.
- The GR3 project, funded by the Intelligent Energy Europe program (IEE), seeks to promote the appreciation of the grass clippings from any source (urban green areas, roads and protected areas). The main objective is the production of renewable energy, in the form of biogas and fertilizer, thus contributing to the reduction of emissions of greenhouse gases (GHG) and to improve the ecological management of green spaces.

The energy potential of GW

- several parameters influence the biodegradability of the GW and biogas potential (the species, irrigation, the number of cuts, the reactor model, etc.) Table 1 shows the production values of grass evaluated in national green area and the methane yield rate obtained in laboratory experiments carried-out at LNEG:
- In Portugal the estimated amount of GW processed by waste operators is 115,000 t/year, a methane potential of 12.65 million m^3/year. In terms of electricity production, the corresponding total electric energy is in the order of 44,275 MWh/year (amounting to approximately EUR 6.6 million). Furthermore 60,000MWh/year of utilizable thermal energy is available, an important wastage of our society.

Type of grass cultivation	Production per hectare (t/ha/y)	Methane production (m^3CH_4/t)	Methane production (m^3CH_4/ha/y)
No watering and infrequent cutting	7.5	90	675
With irrigation and frequent cutting	15	130	1950

Economic potential

- In economic terms biogas from GW provides revenues as electric energy, organic fertilizer and heat generation. Table 2 contains the economic values per ton of GW in terms of electricity (0.015 €/kWh), heat and fertilizer:
- This income may offset the production cost of energy crops.
- Each 50 ha of land to feed a new digester allows two new jobs, saving at least € 14,000/year in unemployment benefits.
- Taxes paid for each new job should be evaluated: 3,500 €/year (€ 7,000/year for both). So such funds from unemployment can favorably finance biogas and the energy area, helping the local development.

Type of grass	electricity (€/t)	fertilizer (€/t)	heat (€/t)	Total Value (€/t)	Total Value (€/ha.y)
No watering and cutting infrequent	45	4.5	15	64.5	485
With irrigation and frequent cutting	70	4.5	21	95.5	1430

This income may offset the production cost of energy crops.

Benefits, environmental, economic and social

- The production, recovery and use of biogas from GW provides environmental benefits can be summarized as follows:
- Decrease of CO_2, NOx, SOx and CH_4 emissions due to fossil fuel replacement to produce electricity and heat;
- Decrease of odors;
- Improvement of sanitary conditions in the transportation of waste;
- Decrease the wet waste and nitrogen content, improving the performance of the digester;
- Contribution to the treatment and final disposal of grass;
- Promoting a more favorable environmental image.
- From a macroeconomic point of view, the use of GW will contribute to the creation of regional added value and reduce the import of fossil fuels.
- One m^3 of biogas with 70% methane, when used, prevents considerable amounts of CO_2

This income may offset the production cost of energy crops.

Emissions reduction

Reduction of emissions provided by Biogas

Fuel replaced	Fuel Economy	Saving of CO_2 Emissions (kg/m^3)
Natural gas (m^3)	0.7	1.36
Propane (lt)	0.73	1.09
Diesel (lt)	0.52	1.3
Coal (kg)	0.47	1.15

This income may offset the production cost of energy crops.

Benefits,

- The **carbon market** can be a strong incentive to the production of biogas. But Green Energy Certification is not yet available to producers of renewable electricity in Portugal, preventing obtaining carbon credits and significant revenues.
- The Implementation of sustainable system, using the GW as a renewable resource for the production of endogenous energy leads to the following social benefits:
- **Less pollution**;
- **Creation of employment and income**;
- **The promotion of an environmental consciousness**;
- **Participation of local community to waste management, encouraging source-separation collection**;
- Stimulus to **practice gardening and defense of the territory**, in accordance with regional policies in this area.

Barriers

- The **Legislative issues is the main barrier on all the countries**. GW should be **regarded as a potential biomass source,** Environmental classification attributed the category of **biowaste**, being subjected to the waste operators management.
- Consequently the delivery of grass to a biogas plant requires a **payment of a gate fee** (variable from 20 to 50€/ton) and of **significant transportation costs**. Discourages the delivery, facilitating cost-effective "in loco" alternative treatment/disposal solutions. Grass does not display harmful or offensive properties as manures Composting is a cost-effective solution. A lot of non-collected-grass never ends up in a digester for valorization.
- For AD valorization, grass has to comply **high-level of sanitary and quality co**ntrol before and after AD, and before disposal or reuse, increasing significantly analytical costs.
- the waste operator **does not deduce the biogas benefits in the gate fee tari**ff. The greatest barriers in interface between the regional waste operator and grass producers.
- The **stakeholders** throughout the grass valorization chain **do not know each other and work together**, a key point for the establishment of a successful valorization chain .
- **Grass originating from nature conservation** areas as well as permanent grassland is currently **used as feeding or bedding material**; *(Economical and operational issue)*
- **Grass from roadsides is seen like a complex substrate**, with chemical pollution, requiring pre-treatments (cleaning and grinding) involving significant processing costs;
- I n countries like Germany, Belgium, Denmark and Veneto, the promotions for AD are today reduced. There are no specific incentives for grass for biogas, no extra fee for biomass from nature conservation and no claim for a biomethane bonus. (. The **Incentives for co-digestion, today are not sufficient to promote grass to AD**.
- Upgrading costs to get a biomethane meeting all quality requirements for the natural gas grid **are very expensive today**.

Threats

- **The legal status of grass is not always as clear as it should be (waste vs. energy crop**).
- The viability of grass digestion **suffers the competition of high quality biowaste** on the market, subsideised, does not requires pre-treatments and is not subjected to strong analytical control.
- It **is hard to have enough grass collected** to make a difference in the biomass-feedstock of the digester, and grass can be used as **co-substrate**. In some countries co-digestion with green wastes requires **a weight proportion from 60 % streams directly coming from agriculture** (grass as a product) and 40 % streams not coming from agriculture.
- In some countries there are **too many waste regulations** that apply for the handling of waste in the municipality and for the land use management techniques
- Sorting the organic grass waste and sending to biogas plants suffers the **competition of other sanitation treatments**, (incineration, composing plants), threatening "composters" work.
- In co-digestion of grass clippings the digestate is considered a waste and can be imposed Heat-treatment and even post-composting, while digestate produced from agricultural feedstock can be used as bio-fertilizers.
- The maintenance of road network is governed by bureaus looking **at cheaper options than AD**.
- Digesters localization can be unfavorable for grass collection at suitable distances in some countries.
- Bank and **financial institutions are often reluctant to lend money** for biogas projects, these being frequently judged as risky.
- Incentives seem the only way for collect this material to AD plants. Incentives are slowing down and the numbers of new plants are very limited.

This income may offset the production cost of energy crops.

Incentives

- Removal of gate fee for green wastes.
- Review environmental legislation.
- Promote in place practices for cleaning of grass.
- Increase of the price of produced energy, in order to compensate the transportation and treatment costs and facilitate cooperation with the plant owners.
- Introduce measures that stimulate interest and cooperation among all stakeholders (producers of waste, companies which collect the grass, waste management companies, farmers, etc.), which should dialogue to each other.
- Motivate the companies in charge for grass management to look at biogas as a complement of its main agricultural practice. The owner of the digester must be positively motivated to increase the construction of new digesters and the related energy production in cogeneration system.

For all this

- Grass should not be considered as waste but a energetic curop available without direct production costs.

Laboratório Nacional de Energia e Geologia, I. P.

www.lneg.pt

GOVERNO DE PORTUGAL

MINISTÉRIO DA ECONOMIA E DO EMPREGO

Ecomondo 4-11-2015

BARRIERS all countries

- Green wastes are **classified in the same category of biowaste** in municipal solid wastes regulatory legislation. *(Operational /Market Issue)*
- Grass wastes, biogas plant and digestate are subjected to significant **national environmental regulation,** high sanitary and quality control before agricultural appliance. *(Legislative and Operational issue)*.
- Grass originating from nature conservation areas as well as permanent grassland are currently used as feeding or bedding material; *(Economical and operational issue)*
- Mowed grass is usually mulched and left in place (unless it is prohibited in certain countries), or used like fertilizer and sent to composting plants.
- Collection and transportation of waste greeneries is an expensive task. *(Legislative Issue)*
- There is a high gate fee to deliver grass to a biogas plant (from 20 to 50€/ton); *(Economic Issue)*. The biogas value of Green wastes is not deducted from the gate fee tariff. *(legislative/Economic Issue)*
- Grass from roadsides is seen like a complex substrate due to pre-treatment and processing costs; *(Economical and operational issue)*.
- There are no specific incentives in place applying for grass in biogas plants, no extra fee for biomass from nature conservation and no claim for a biomethane bonus. *(Legislative issue)*.
- Incentives for co-digestion are not sufficiently high to promote grass to AD; *(Economic Issue)*
- The stakeholders throughout the grass valorization chain do not know each other and does not work together. *(General Issue)*
- Grass as crop or grass as wastes are not accurately specified in the legislation. *(Legislative/Administrative Issue)*
- Composting of green waste is cost-effective solution to A.D. *(Operational Issue)*