JRC Scientific and Technical Reports

Proceedings of the Workshop "Cereals straw and agricultural residues for bioenergy in European Union New Member States and Candidate Countries"

2 - 3 October 2007, Novi Sad, Serbia

Editors N. Scarlat, J. F. Dallemand, M. Martinov

EUR 23550 EN - 2008

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Academy of Sciences and Arts of Vojvodina

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The mission of the Institute for Environment and Sustainability is to provide scientific-technical support to the European Union's Policies for the protection and sustainable development of the European and global environment.

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Joint Research Centre
Institute for Environment and Sustainability

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Preface

The Workshop "Cereals Straw and Agricultural Residues for Bioenergy in New Member States and Candidate Countries" was held on 2-3 October 2007 in Novi Sad, Serbia. The Workshop was organised by the Joint Research Centre (Institute for Environment and Sustainability, "Quality and Performance of Biofuels" Action of the Renewable Energies Unit), in co-operation with the Faculty of Technical Sciences (Department for Biosystems Engineering) of the University of Novi Sad, and the Academy of Sciences and Arts of Vojvodina, Serbia. The Workshop followed a previous seminar on "Sustainable Bioenergy Cropping Systems for the Mediterranean", held in Madrid, Spain, on 9-10 February 2006 and an Expert Consultation on "Cereals Straw Resources for Bioenergy in the European Union", held in Pamplona, Spain, on 18-19 October 2006.

The Novi Sad Workshop addressed the use of crop residues and especially of cereals straw for bioenergy production in European Union New Member States (NMS), Candidate Countries (CC) and Potential Candidate Countries (PCC). A better understanding of the situation on cereal straw and crop residues production and competitive use in NMS, CC and PCC was needed to assess their availability and potential for the use for energy production. The Workshop aimed at collecting more information on the availability and possible use of cereal straw and agricultural residues, status, problems and barriers for implementation, as well as perspectives for development. A list of critical issues to be addressed was proposed and the participants answered questions related to the specific situation in their region and country: basic resources, environmental limits, competitive uses.

The discussions focussed on the implications of using straw for energy on soils and agriculture. Straw is presently mainly used for animal bedding, horticulture, mushroom production and soil fertility. The use of straw for bioenergy can be a good option if it does not affect soil properties, soil organic matter and soil productivity. Straw ploughing in soil influences virtually all soil properties and can lead to some benefits on soil structure, organic mater content, biodiversity, erosion resistance, drought resistance, on cultivation, but can have also some negative effects such as diseases. Some environmental risks caused by the removal of the residues from the field (erosion in sloping and low fertility areas, etc.) were also discussed. The implications of straw removal on soil physical properties, water storage, and soil biology or erosion risk must be considered. In order to use straw for bioenergy, it is necessary to assess the removal rate which can be allowed whilst maintaining soil organic matter, soil properties and fertility. The opinion was expressed that the residues left in the field (roots and stalks) after harvesting might be enough to respond to the environmental requirements.

The meeting participants brought data on the cereal straw production and availability for energy, after considering the current use in other sectors. There are differences in the area cultivated with cereals and yields in EU NMS, CC and PCC, due to different specific geographic and climatic conditions. Yields of cereals are lower than in other EU countries, due to reduced use of fertilizers and pesticides, small scale farms, insufficient machinery and unfavourable climate. This shows that there is quite a big potential to increase the grain production and, consequently the amount of straw available.

Useful data were presented on the competitive uses of cereal straw, which in all these countries are quite important: for animal bedding (cattle, horses), mushroom production, etc. Some data were reported on the available residues from orchards and vineyards, which could be an important source of energy, which has not really been included so far in the assessment of resources availability.

Acknowledgements

The Workshop "Cereals Straw and Agricultural Residues for Bioenergy in New Member States and Candidate Countries" was held in Novi Sad, Serbia on 2-3 October 2007. The organisers of the meeting were N. Scarlat (Renewable Energies Unit, Institute for Environment and Sustainability, Joint Research Centre, European Commission) and M. Martinov (University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia).

The Proceedings were prepared by N. Scarlat and J.- F. Dallemand and the organisers acknowledge the input from all the participants (see detailed list in Annex). Special thanks to M. Martinov (University of Novi Sad, Faculty of Technical Sciences), and M. Tesic (Academy of Sciences and Arts of Vojvodina, University of Novi Sad) for their contribution to the preparation of the meeting and the organisation of the technical visit. Special thanks also to D. Powlson (Rothamsted Research, Harpenden, United Kingdom), whose contribution has been highly appreciated.

This meeting was possible thanks to the support of H. Ossenbrink (Renewable Energies Unit, Institute for Environment and Sustainability, Joint Research Centre, European Commission) within the framework of the activities of the Biofuels Action. The digital version of the Proceedings can be found on the Biofuel web site (http://re.jrc.ec.europa.eu/biof/).

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Current activities, recent developments and trends for bioenergy and biofuels in EU

Nicolae Scarlat, Jean-Francois Dallemand, Robert Edwards
Quality and Performance of Biofuels
Renewable Energies Unit

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The Institute for Environment and Sustainability

...a Research Based Policy Support Provider

IES Mission Statement

The mission of the Institute for Environment and Sustainability is to provide scientific-technical support to the European Union's Policies for the protection and sustainable development of the European and global environment.

Renewable Energies Unit

Core task

Scientific support for EU policies on renewable energies and energy efficiency for a sustainable energy supply with emphasis on

- Research on Photovoltaic Solar Electricity
- Monitoring the implementation of renewable energy sources
- Assessment of Biofuels

Activities

- Performance and Reliability testing of new Photovoltaic Devices
- EU reference system for Renewable Energies and Energy Efficiency
- European Resources and Environmental Impacts of Biofuels

It maintains in-house research on carefully selected, forward-looking fields which need further European efforts to increase share of Renewable Energies in the competitive market

BioF objectives and activities

Study sustainability of biofuels from EU and emerging countries

1. **Availability vs. cost for EU-sourced feedstock for biofuels and bioenergy**
   - **agricultural crops and residues**
   - forest residues and extra fellings
   - energy crops
   - biogas: manure, wastes, crops, municipal waste

Includes: **- soil carbon + degradation constraints**
- water availability

2. **Imported biofuels and feedstocks**

- **Resource assessment in emerging countries**
  Potential production and growth rates
  e.g. **sugar cane in Brasil**, **oilseeds in S-E Asia**
- **Environmental Impact outside EU**
  - carbon stocks, soil, water and biodiversity
  - **bioenergy sustainability standards**

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BioF objectives and activities

3. GreenHouse Gas performance and cost of biofuels

- "JEC" WTW study: costs of road fuel substitution and CO_2 abatement
  - update and expand
  - new biofuels pathways and processes
  - compare different uses of biomass
- Methodology:
  - publish rigorous methodology guidelines
  - simplified version GHG certification of biofuels

4. Wider impact of biofuels/bioenergy policy - cost/benefit analysis

Effect on:

- food prices
- oil prices
- by-products markets: animal feed, glycerine
- EU imports/exports

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Well-to-Wheels study (JRC–EUCAR–CONCAWE)

= Life-cycle analysis restricted to quantitative aspects:

Green-**H**ouse **G**as
fossil energy
total energy
direct costs for given availability.

= Well-to-Tank + Tank-to-Wheels

Why another Life-Cycle Analysis Study?

- LCA studies disagree, mostly because of methodology and assumptions about by-product use.
- Most **LCAs cannot be compared**:
  - methodology differences (/errors !)
  - not transparent

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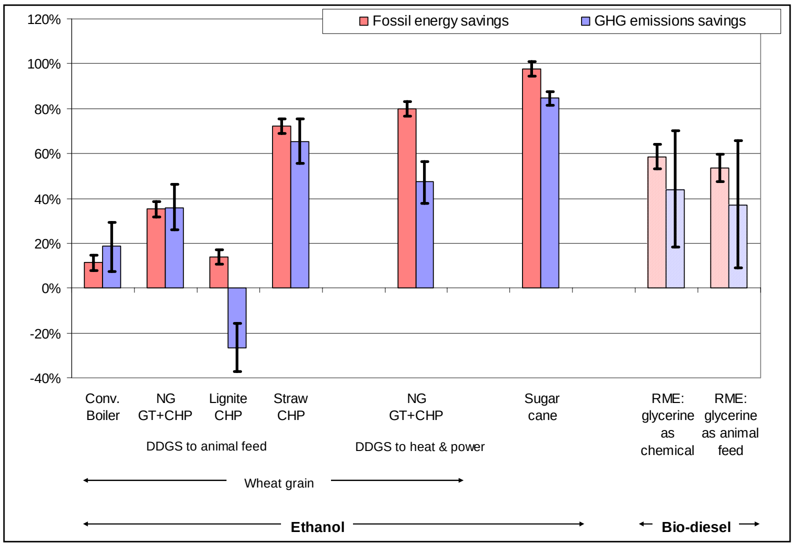
RESULTS DEPEND ON THE PROCESS AND BY-PRODUCT USE:



EUCAR concawe

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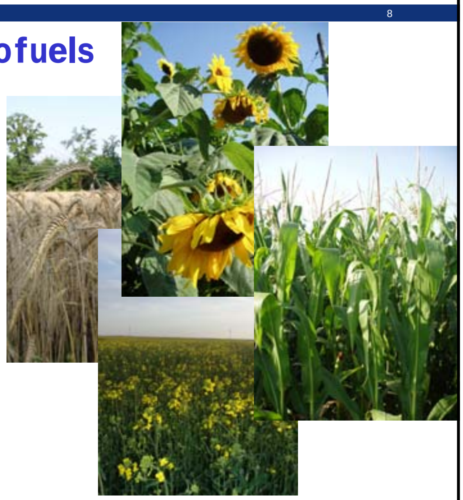
Sustainability Certification of Biofuels



Why carbon and sustainability certification?

- Serious concerns about:
  - real GHG biofuels performances
  - negative environmental effects
  - effects on food security of supply (and prices)
- High complexity of biofuels pathways and feedstock
- High differences and uncertainties between GHG performances of biofuels

- **Sustainable development** - meeting the present needs through adequate management and conservation of the natural resources, without compromising the ability of future generations to meet their own needs.

Main concerns of biofuels production

Environmental

- Land use change, deforestation
- Loss of natural habitats and biodiversity
- Soil erosion, degradation and soil nutrient depletion
- Use of GMOs instead of native species
- Depletion and pollution of water sources
- Emissions to air

Economic:

- Economic prosperity of local communities
- Employment
- Competition for raw material with food production

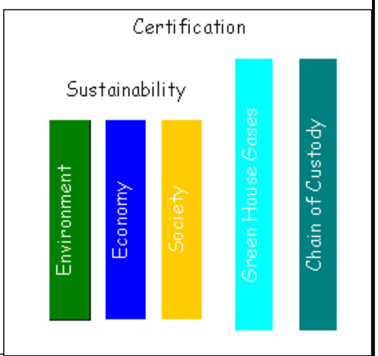
Social concerns

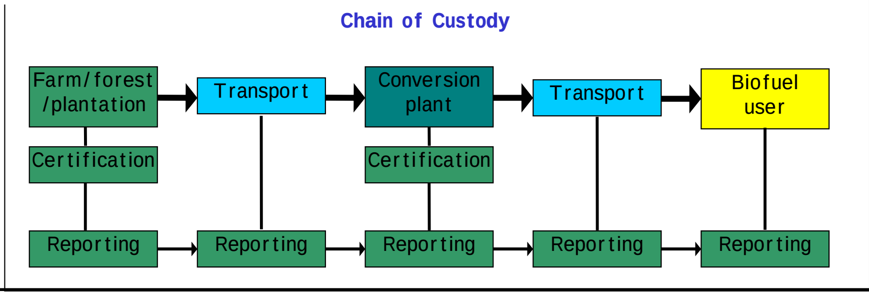
- Property rights and rights of use
- Labour conditions and worker rights
- Human safety and health

Certification framework

Certification- to ensure that biofuels are produced in a sustainable manner-economically viable and without environmental degradation, or social inequity

- Sustainability certification
  - environment
  - economic
  - social
- GHG certification for quantifying GHG savings (carbon intensity)
- Chain of custody certification-info on the origin and supply chain





Existing certification schemes

Agriculture: EUREPGAP, SAN - voluntary certification of agricultural products meeting certain guidelines for sustainability

Forestry : FSC, PEFC certification of sustainable forest management including economic, environmental and social aspects.

New initiatives for biofuels certification

- **Roundtable on Sustainable Palm Oil (RSPO)** social, economic, ecological and general criteria on the entire supply chain for palm oil.
- **Roundtable on Sustainable Soy (RTRS)** - Basel Criteria for responsible Soy - economically viable, socially equitable and environmentally sustainable.
- **Better Sugarcane Initiative (BSI)** - principles and standards for 'better sugarcane' with respect to its environmental and social impacts.
- **UK Renewable Transport Fuel Obligations (RTFO)** - linking biofuels certificates with GHG savings and sustainability reporting scheme
- **Roundtable on Sustainable Biofuels (RSB)** standards for the sustainability (environment, social, GHG and implementation) of biofuels (EPFL, Lausanne, Switzerland).
- **Certification of Sustainable biomass production in The Netherlands** including GHG balance and sustainability criteria

Networking

- Workshop on "*Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries*", 2 - 3 October 2007, Novi Sad, Serbia, in cooperation with University of Novi Sad.
- Expert Consultation on "*Sustainable Bioenergy Cropping Systems for the Mediterranean*", Madrid 9-10 February 2006, in cooperation with EEA, CENER, CIEMAT, Spain.
- Expert Consultation on "*Cereal straw resources for bioenergy in the European Union*", Pamplona, Oct. 2006, with CENER, Spain.
- Expert Consultation on "*SRF, SRC and Energy Grass in the European Union: Agro-environmental component, present use and perspectives*", 17-18 Oct. 2007, Harpenden, U.K, with EEA, Rothamsted Research.
- Expert consultation on *"EU Forest-based biomass for energy: cost/supply relations and constraints"* 18-19 September 2007, Joensuu, Finland, with Metla, European Forest Institute.

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RES policy framework

RES White Paper (1997)

➢**To achieve a share** of renewable energy **from 6% to 12%** of the total energy consumption in EU **by 2010**

Green Paper on Security of Energy Supply (2000)

RES Electricity Directive (2001)

➢ **To establish** a framework to **increase the share of renewables electricity from 14% to 22%** of gross electricity consumption **by 2010**

Directive on liquid biofuels (2003)

➢**To achieve** a share of **5.75 % of biofuels** for transport in the total amount of fuels in Europe **by 2010**

Biomass Action Plan (2005)

Green Paper "A European Strategy for Sustainable, Competitive and Secure Energy" (2006)

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Renewable energy targets 2010

- RES share of 12 % in total primary energy consumption
- RES electricity share of 21 % in gross electricity consumption
- Biofuels share of 5,75 % in transport fuel cosumption

Renewable energy mandatory targets for 2020

- Renewable energies share of 20 % in overall EU energy consumption
- Binding minimum target of 10 % share of biofuels in overall EU transport consumption
- GHG emissions reduction of 20 %

Renewable energy today

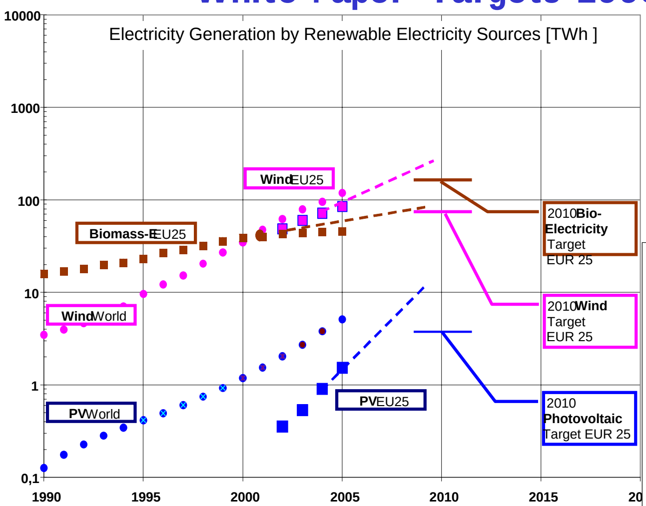
- About 14 % of all EU electricity supply is generated by RES
- About 10 % of heat demand is supplied by RES
- About 1.4 % of transport fuel demand by renewable energy sources

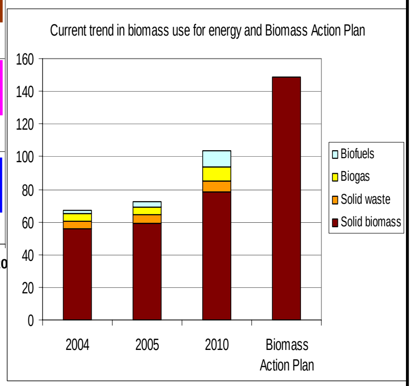
Difficulties of meeting RES targets

- High costs of renewables-external costs not considered for fossil fuels
- Decentralised nature of RES application
- Administrative barriers and discriminatory rules for grid access
- Inadequate information available
- Expressing RES targets against primary energy – disadvantages for wind, solar and hydro energy
- Increased energy consumption, invalidating RES progress

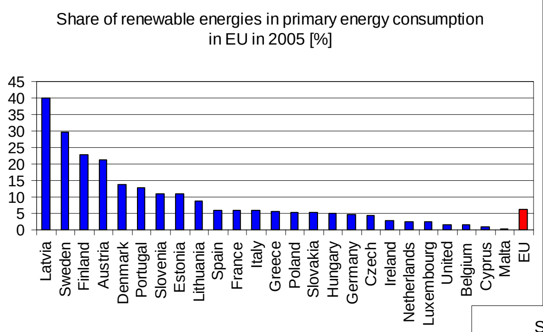
- RES heating
  - Not single market for renewable heating
  - Market is not regulated
  - Difficulties for monitoring of sales
- RES deployment depends on a coherent, predictable, supportive political & legal framework

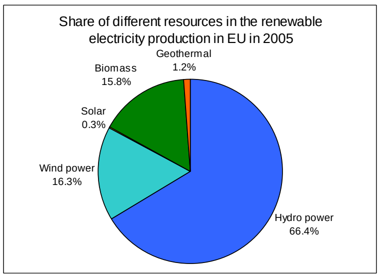
White Paper-Targets 1995...2010

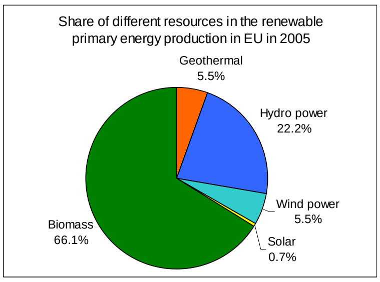


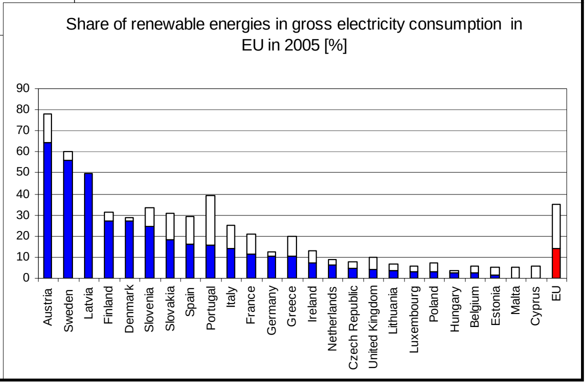


Renewable energy sources in EU in 2005



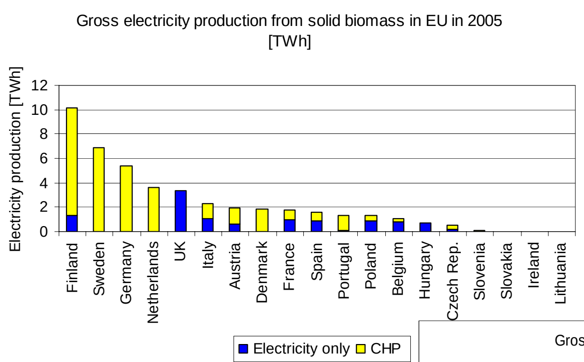


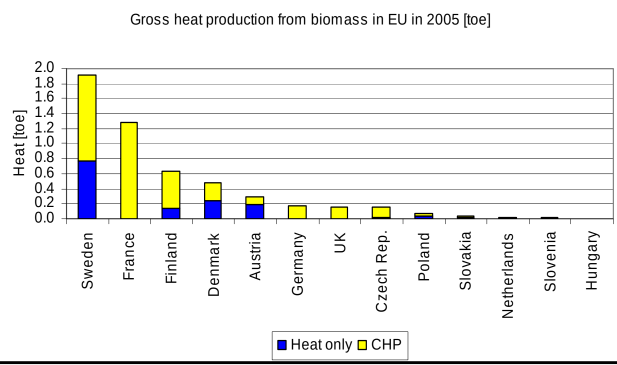




Source: EurObserv'ER

Energy production from biomass in 2005





Source: EurObserv'ER

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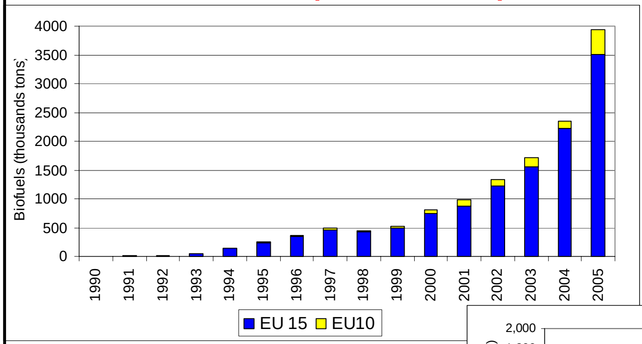
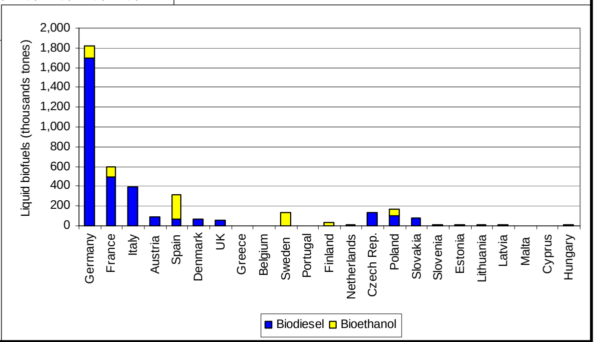
Liquid biofuels production in EU





Source: EurObserv'ER

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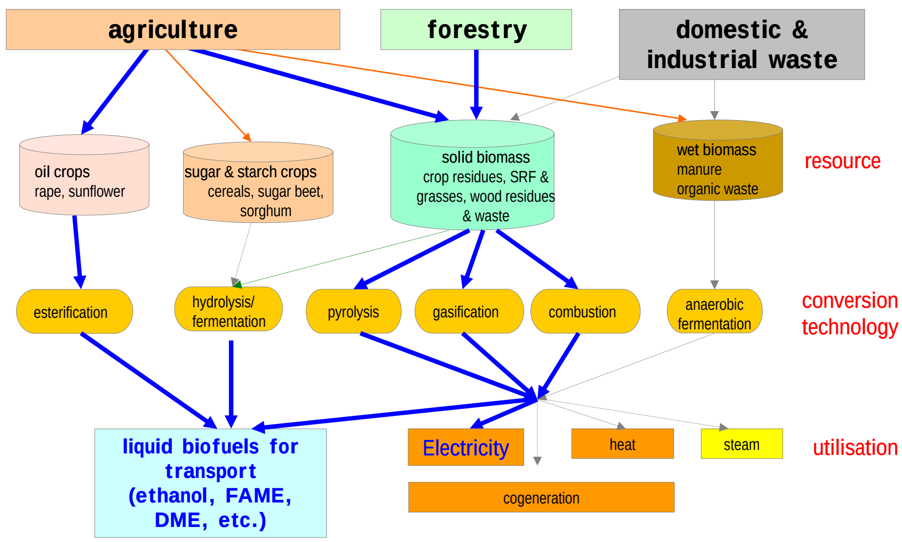
Bioenergy pathways



Straw potential in EU

- abundant throughout Europe
- easily available resource
- available scalable technology

however…

- high capacity installations only in DK, UK and ES
- slow transfer of know-how to other regions
- little information below national level
- factors are site sensitive

Straw plants

- 11 Plants in Denmark
- Ely (38 MW) power station, UK
- Sangüesa (25 MW), Spain

GIS-based assessment of cereal straw energy in the EU

Objectives

Inventory of straw from wheat and barley in EU25+2

- actual production
- environmental constraints
- competitive use
- availability for energy

Suitability for large scale electricity generation

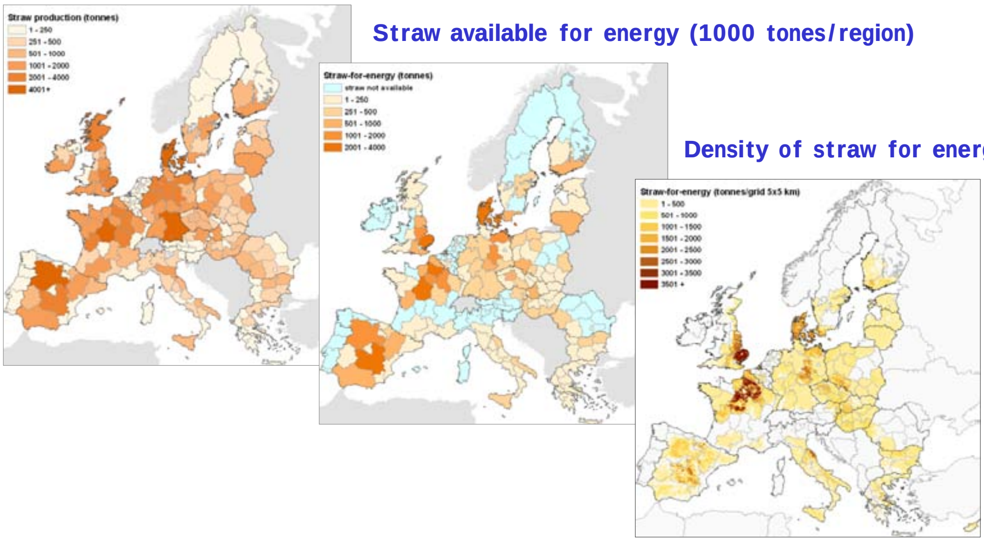
- example of Ely power station (UK, 38MW)
- economics
- suitability maps
- localization/optimization

Straw inventory

Straw from wheat & barley in 2003 (1000 tones/region)

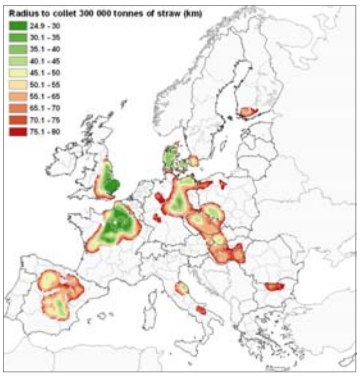
Straw available for energy (1000 tones/region)

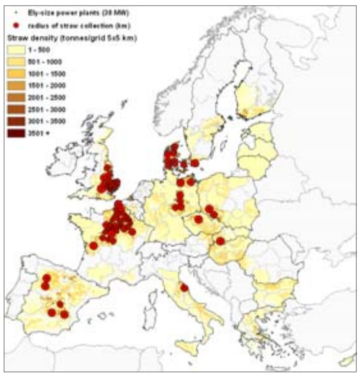
Density of straw for energy



Suitability map for localization of Ely-sized (38 MW) power plants

Collection radius for Ely straw consumption (+50% reserve)





EU could host up to 67 "Ely clones" (38MW)

FR: 28	PL: 2
UK: 15	IT: 1
DK: 7	SE: 1
DE: 6	SK: 1
ES: 5	CZ: 1

Total capacity: **2.5 GW**
Straw energy utilized: **230 PJ** (LHV thermal)
(out of a total available **820PJ**)

Assumptions:

- *yearly consumption 200 000 ton + 50% reserve*
- *transport distance up to 50km*

BUT... straw-collection logistics needs to be assessed for each potential location

Aspects of using straw for energy

Resources

- Straw availability depends on the agricultural markets, climatic conditions
- Sustainability of straw removal is important
- Vulnerability to market change, short term weather and long-term climate change
- Local sustainability of straw removal
- Competitive use – traditional use – energy use
- Trade

Logistics

- Transport logistics crucial
  - Limit the plant size to ~50 MW_{el}
  - Size is site-specific - optimal 10-15 MW max. 36 MW
- Storage is an important aspect- large storage areas required
- Large volumes involved as only 2 month harvest window for straw
- Limitations due to low heat demand, grid connection - rural sites, limited grid capacity

Aspects of using straw for energy

Technical issues

- Available technology, demonstrated, high plant availability
- CHP should be preferred where heat demand is high: in industry and district heating
- Local heating boilers is a cheap and practic way to use straw
- Co-firing could be an option
- Feedstock quality impacts plant operation.
- Necessary to standardize the fuel input

Economic issues

- Costs for collection, transport, storage
- Conversion vs. size
- Competition with other use may offer better prices to farmers
- Development of support schemes are needed

Using straw for energy – implications for soils & agriculture

David Powlson

Lawes Trust Senior Fellow, Rothamsted Research, UK

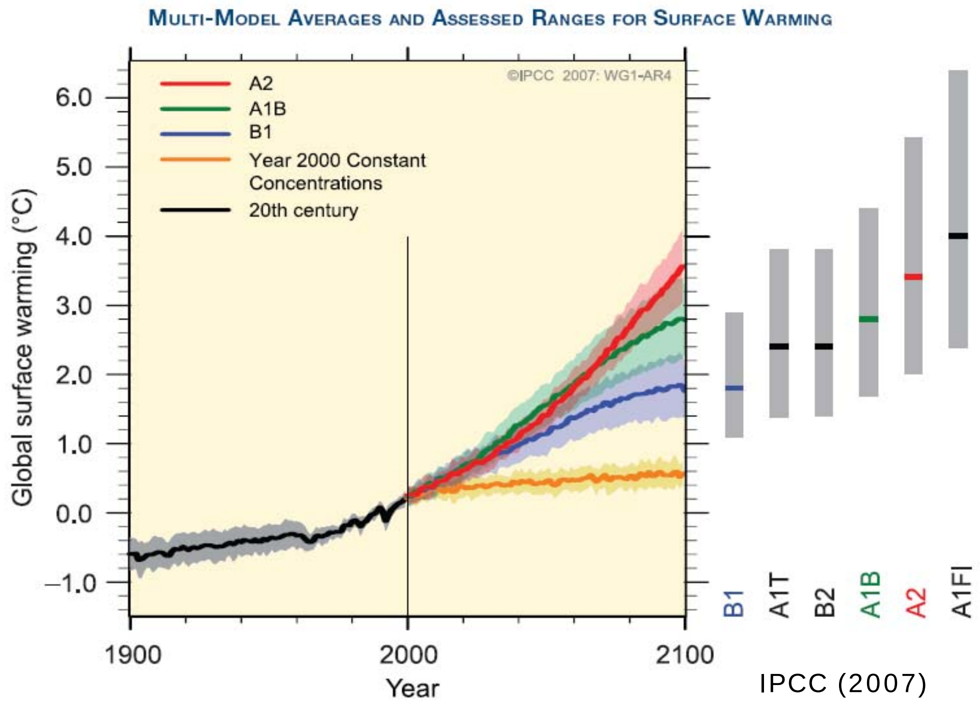
Climate change

"The greatest long-term challenge we face"

- *Tony Blair, former UK Prime Minister*

"A greater threat than terrorism"

- *David King, UK Government Chief Scientific Adviser*



IPCC (2007)

Responses

- Decrease CO_2 emissions from fossil fuels
- Decrease trace GHG emissions
  - N_2O, CH_4

ROTHAMSTED RESEARCH

To decrease CO_2 emissions:

- Energy saving
- Lifestyle changes
- Renewable energies (electricity, heating, transport)
- Carbon sequestration (biological, geological)

ROTHAMSTED RESEARCH

Renewable energies

Bioenergy

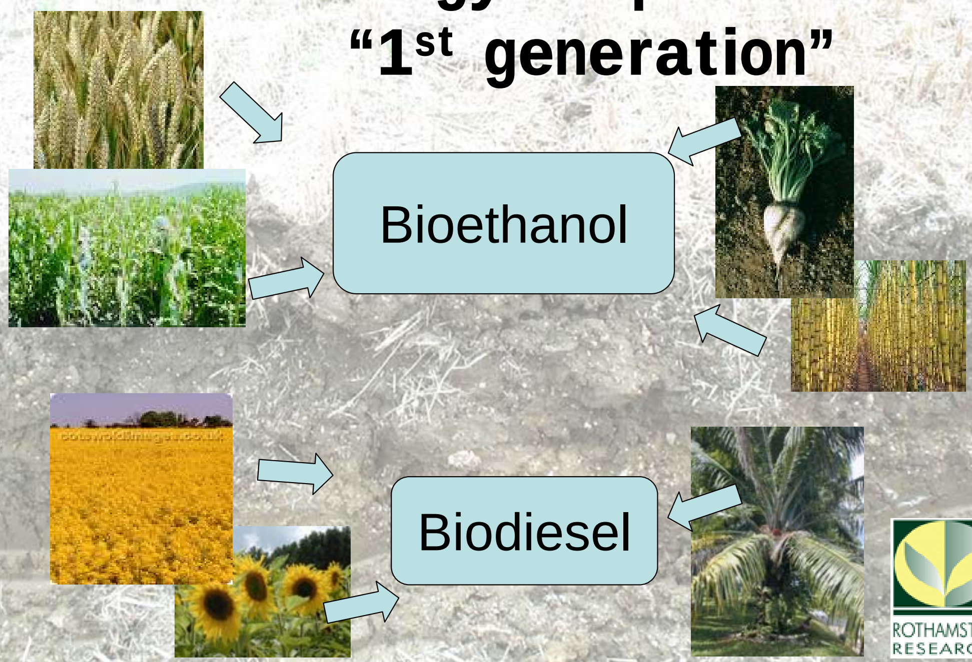
ROTHAMSTED RESEARCH

Types of bioenergy

- Agricultural crops used for energy instead of food (bioethanol, biodiesel)
  - **"1st generation bioenergy crops"**
- Dedicated biomass crops
  - **"2nd generation bioenergy crops"**
- Crop residues and other "wastes" incinerated for electricity or CHP
- Anaerobic digestion of animal slurry
- Photosynthetic algae in solution culture

ROTHAMSTED RESEARCH

Bioenergy crops – "1st generation"



ROTHAMSTED RESEARCH

Using agricultural crops for energy (bioethanol, biodiesel)

Advantages

- Easy to grow – farmers familiar with crops
- Easy processing
- Produce liquid transport fuels
- No major infrastructure changes
- Soil requirements - as for food
- Environmental impacts - as for food

ROTHAMSTED RESEARCH

Using agricultural crops for energy (bioethanol, biodiesel)

Disadvantages

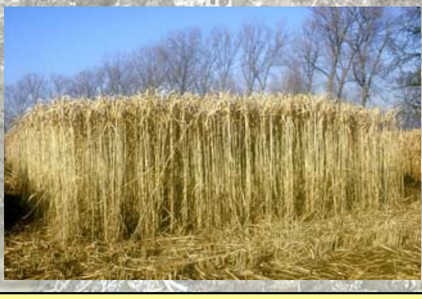
- ***Little CO_2 saving!***
  - – CO_2 emissions from N fertilizer production
  - – energy for processing
  - – N_2O from soil where N applied
- Impacts on world food supplies
- Perverse incentives – e.g. clearing forests to grow palm oil – extra CO_2 emissions!

ROTHAMSTED RESEARCH

Bioenergy crops – "2nd generation"

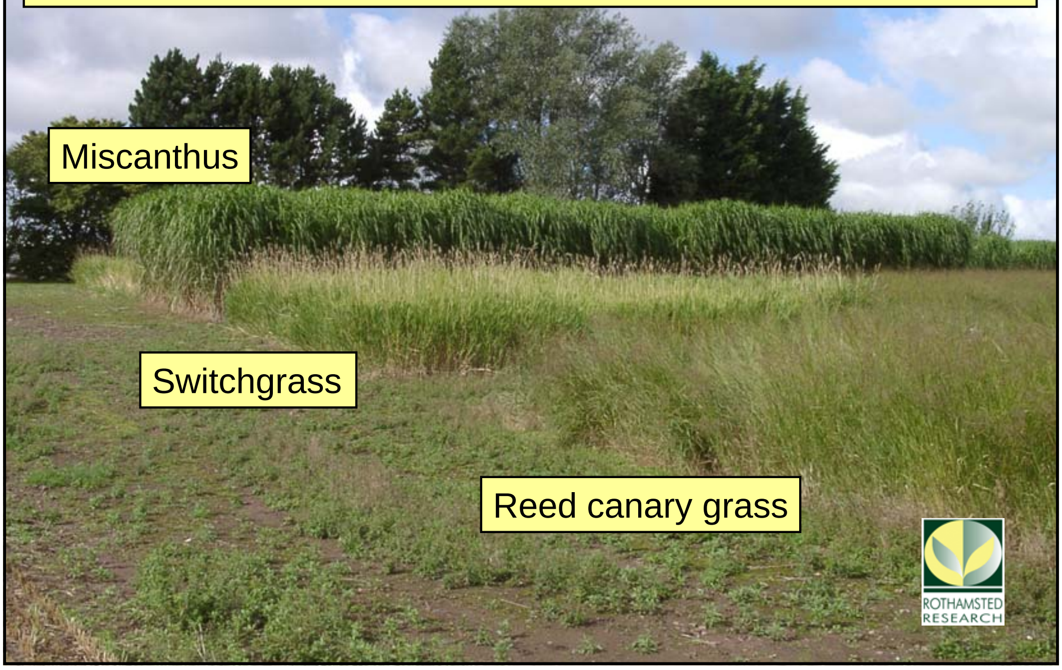
Dedicated biomass crops – mainly perennials

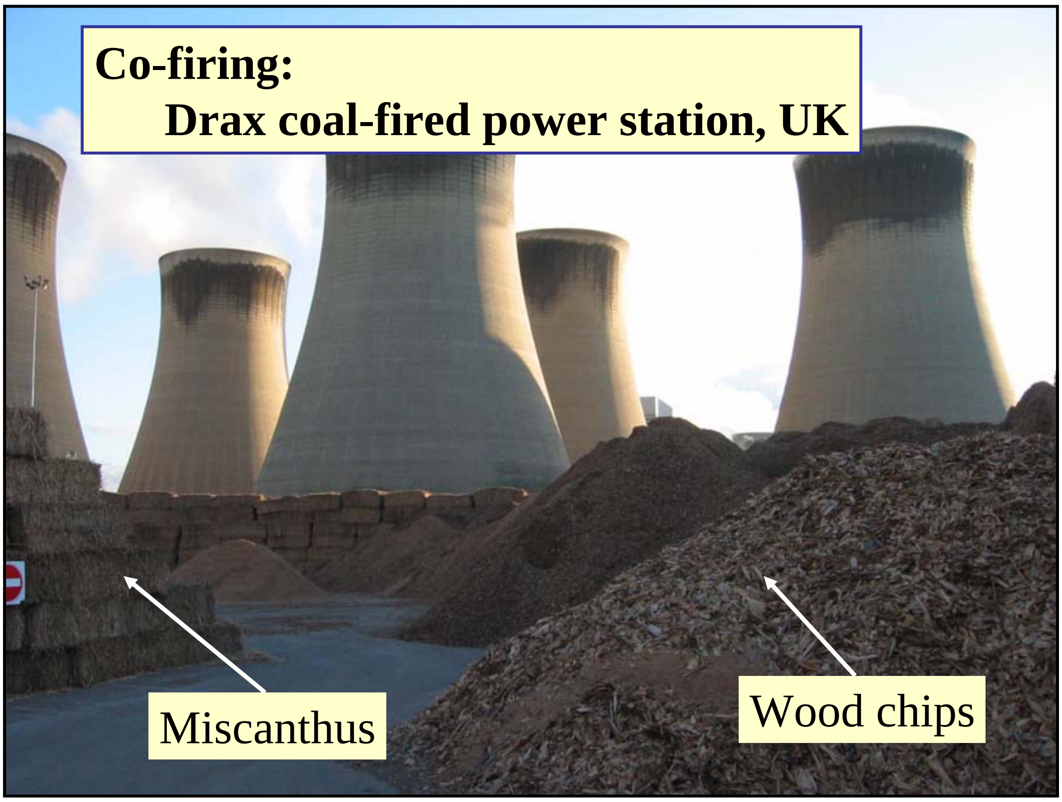
Willow

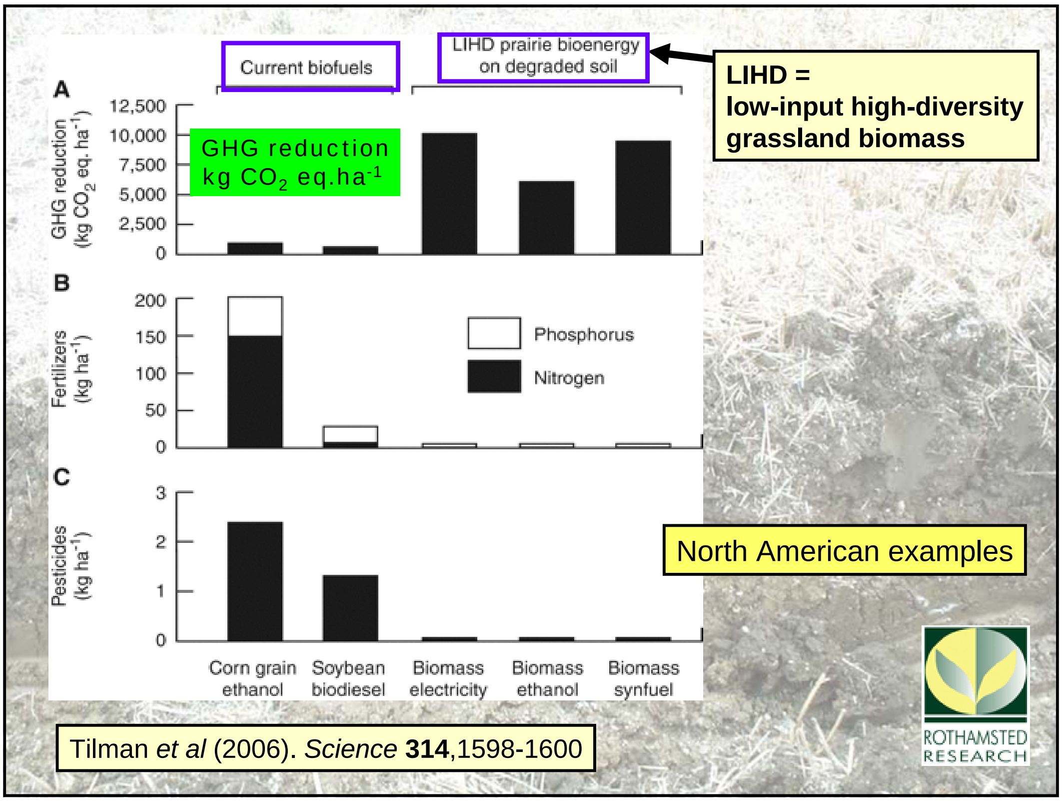


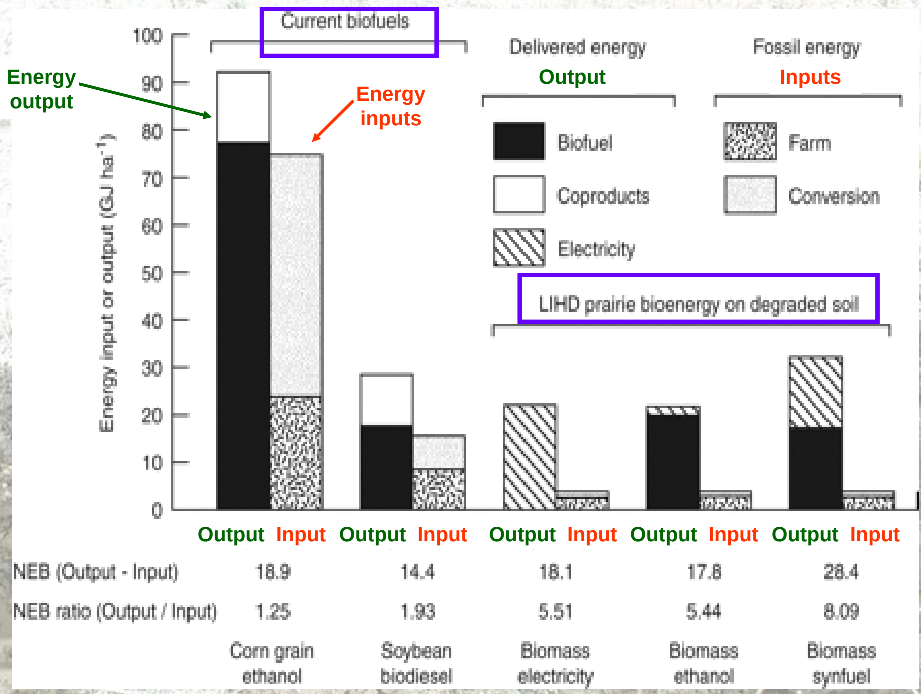
Miscanthus giganteus

Perennial energy grasses growing in Dundee – Topgrass project (DTI/Defra)




Co-firing:
Drax coal-fired power station, UK
Miscanthus
Wood chips


Current biofuels
LIHD prairie bioenergy on degraded soil
LIHD =
low-input high-diversity grassland biomass
A
GHG reduction (kg CO2 eq. ha-1)
GHG reduction kg CO2 eq.ha-1
12,500
10,000
7,500
5,000
2,500
0
B
Fertilizers (kg ha-1)
200
150
100
50
0
Phosphorus
Nitrogen
C
Pesticides (kg ha-1)
3
2
1
0
North American examples
Corn grain ethanol
Soybean biodiesel
Biomass electricity
Biomass ethanol
Biomass synfuel
Tilman et al (2006). Science 314,1598-1600
ROTHAMSTED RESEARCH



Tilman *et al* (2006). *Science* **314**,1598-1600

North American examples

Crop residues for bioenergy:

Cereal straw

ROTHAMSTED RESEARCH

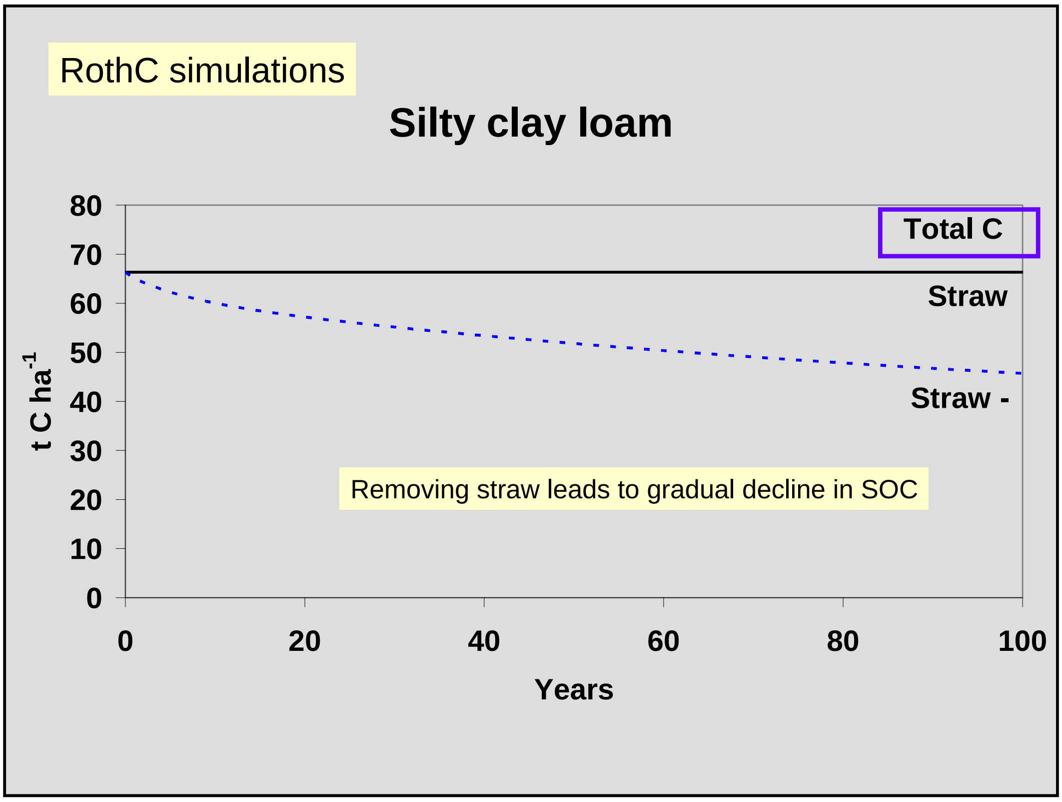
Fate of straw:

- Burn in the field
- Incorporate into soil
- Animal bedding
- Surface mulching in horticulture
- Industrial uses, e.g. fibreboard
- Energy

Some organic C returned to soil

Straw -

- Convenient for bioenergy. ***But …***
- One of few options for maintaining OM content of arable soils
- EU Commission identifies OM decline as a threat to soils in Europe
- Nutrient removal - K



Caution!

Soil organic matter (SOM) matters !

- Influences virtually all soil properties

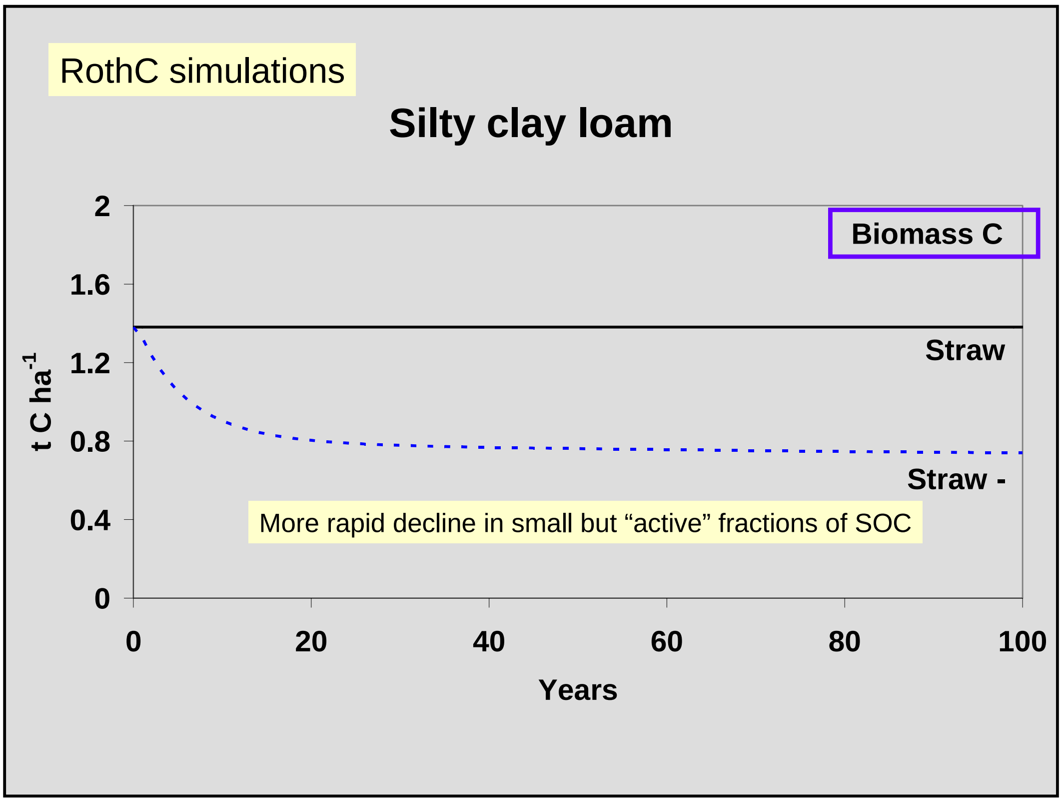
  eg, physical structure, ease of cultivation, ease of root growth, erosion, nutrients, biodiversity ("soil quality")
- Generally, more is better !
- Additional environmental benefit

  locking up (sequestering) C from atmosphere

But not so simple…..!

- **TOTAL** soil organic matter content changes *slowly* in response to straw or other organic additions (years – decades).

- But individual **FRACTIONS** and soil **FUNCTIONS** associated with OM change *faster* and *proportionately more* than total.



- Evidence that small change in total C has larger proportional influence on soil physical properties
  - Energy for tillage
  - Aggregate stability
  - Water infiltration rate
- Evidence from
  - Farmer assessments
  - Research - Broadbalk long-term experiment

ROTHAMSTED RESEARCH

UK Defra project

Objectives included:

- Record farmer's assessment of management benefits from increased SOM (often resulting from straw incorporation)
  – interviewed 110 farmers.
- Estimate financial of value on SOM based on farmer's estimates of management benefits.

Cranfield UNIVERSITY Silsoe

ROTHAMSTED RESEARCH

g y a
www.gya.co.uk

Farmer measurements/observations on SOM impacts

Some evidence that farmers could detect changes caused by increased SOM sooner than by traditional "scientific" measurements

Main benefits:

- **Cultivation, soil structure, crop establishment, drought resistance, earthworms, less fertilizer**

Some negatives:

- **Diseases**

What determines SOM economic value?

Most important factors:

- Soil type
- Value of crops benefiting from SOM
- Costs of animal manure application
- Price of straw if sold (animal bedding, energy)

Net value of SOM management : €8-80/ha/yr

Considerable assumptions and uncertainties !

- Highly dependant on nature of enterprise
- Intangibles (e.g. timeliness, flexibility) may be more significant

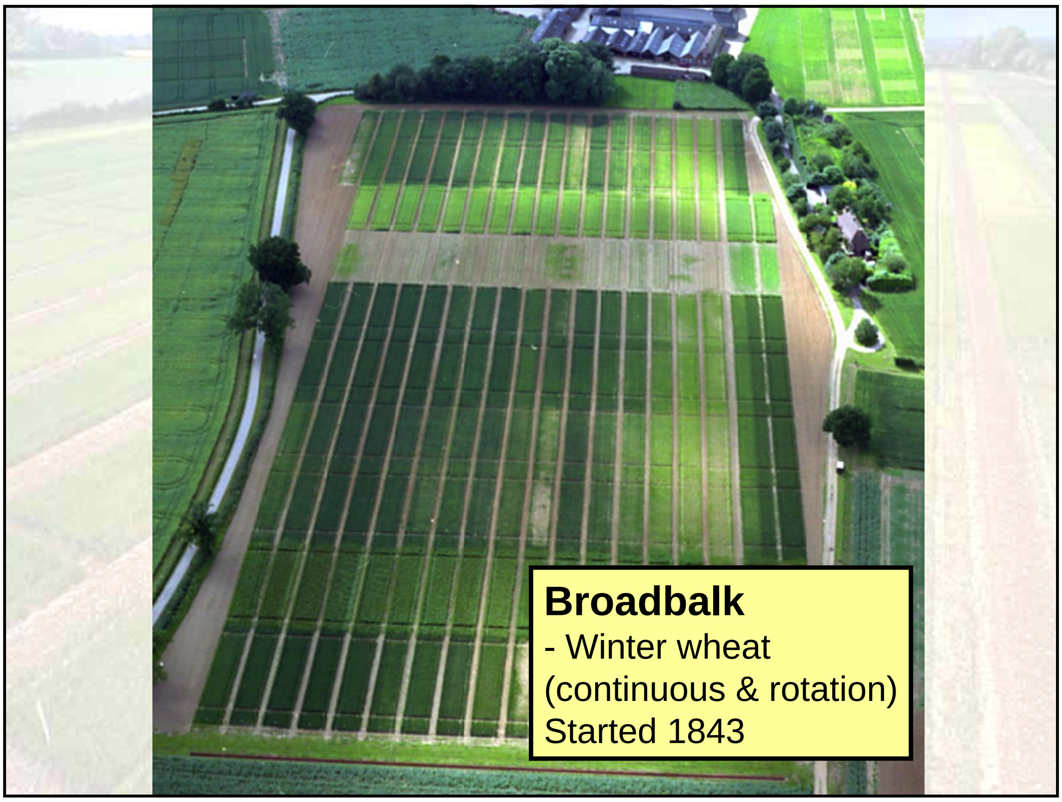
http://www.defra.gov.uk/science/Project_Data/DocumentLibrary/SP0310/SP03102471_FRP.doc

Plough draught

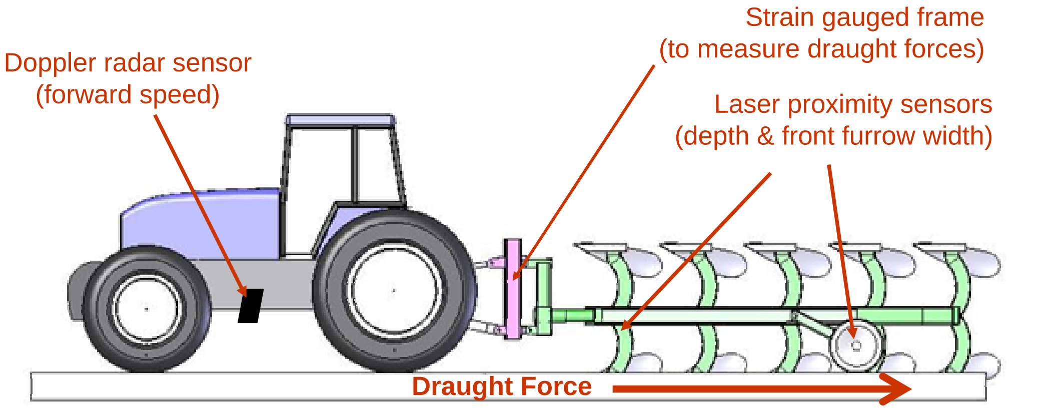
- Small increases in SOM led to decrease in energy required for cultivation
- SOM favoured by increased crop residues (N fertilizer and straw incorporation)

Watts, Clark, Poulton, Powlson, Whitmore (2006) *Soil Use and Management* **22**, 334-341

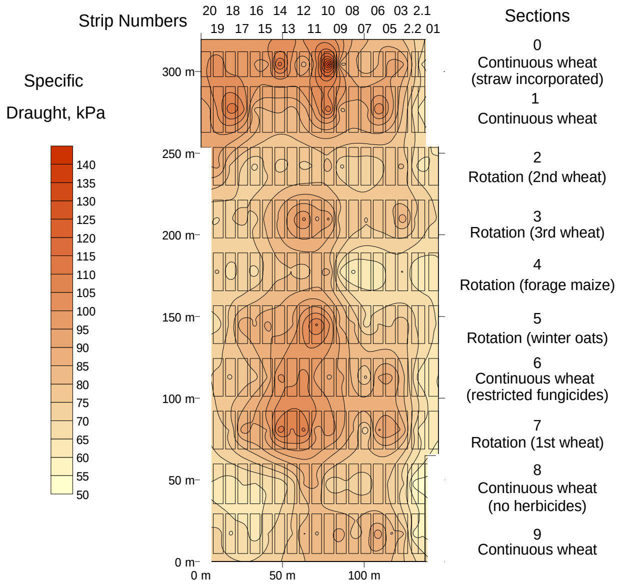
ROTHAMSTED RESEARCH



Draught Forces & Energy



Specific draught measurements; Broadbalk Experiment, Rothamsted



Watts, Clark, Poulton, Powlson, Whitmore.
Soil Use and Management **22**,*334-341* (2006)

Broadbalk – SOC and specific draught

Treatment	SOC %	Specific draught, S kPa
Nil	0.84	88
FYM	2.80 (↑233%)	75 (↓15%)
NPK	1.08 (↑29%)	77 (↓12%)

Watts, Clark, Poulton, Powlson, Whitmore.
Soil Use and Management **22**,*334-341* (2006)

"Labile C" – easily oxidisable – about 10% of total C (microbial biomass + metabolites)

- Increased by straw incorporation and N fertilizer application (larger yields, larger residue returns)
- "Labile C" – correlated with:
  - –**Increased aggregate stability**
  - –**Increased water infiltration rate**

Blair, Faulkner, Till, Poulton. *Soil & Tillage Research* **91**, 30-38 (2006)

Rothamsted, Broadbalk Experiment

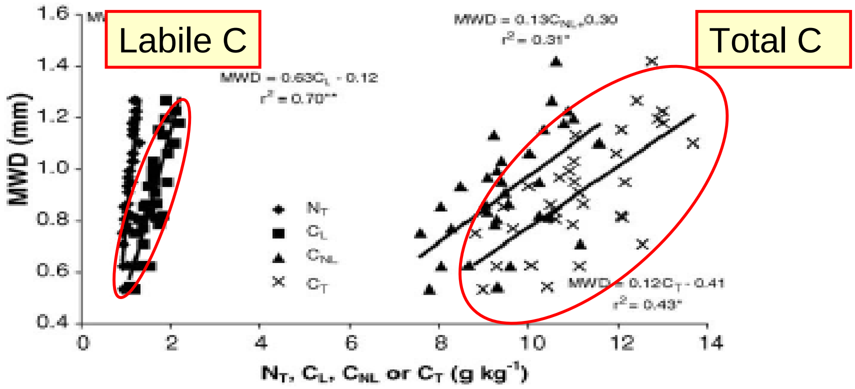


Fig. 2. Linear relationships of total N (N_T), labile C (C_L), non-labile C (C_{NL}) and total organic C (C_T) with mean weight diameter (MWD) for the Broadbalk Wheat Experiment for the low C treatments. ($^{**}P < 0.01$; $^{*}P < 0.05$.)

Aggregate stability related to "labile C"
– increased by straw and N fertilizer

Blair, Faulkner, Till, Poulton. *Soil & Tillage Research* **91**, 30-38 (2006)

Rothamsted, Broadbalk Experiment

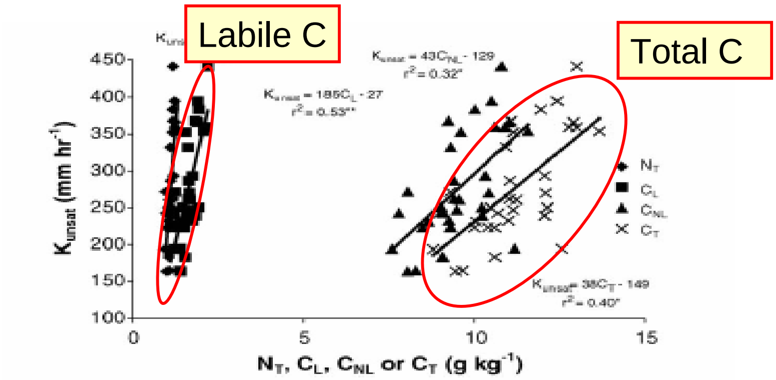


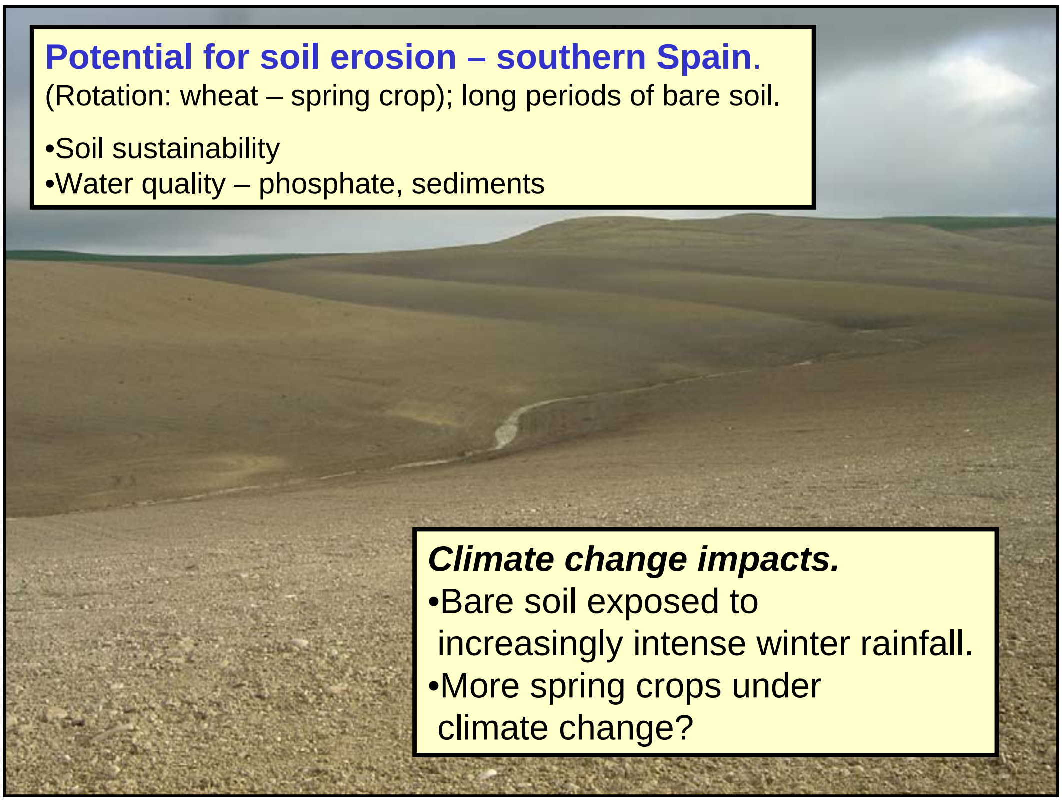
Fig. 3. Linear relationships between unsaturated hydraulic conductivity (K_{unsat}) (10 mm) and total N (N_T), labile C (C_L), non-labile C (C_{NL}) and total organic C (C_T) for the Broadbalk Wheat Experiment for the low C treatments. ($^{**}P < 0.01$; $^{*}P < 0.05$.)

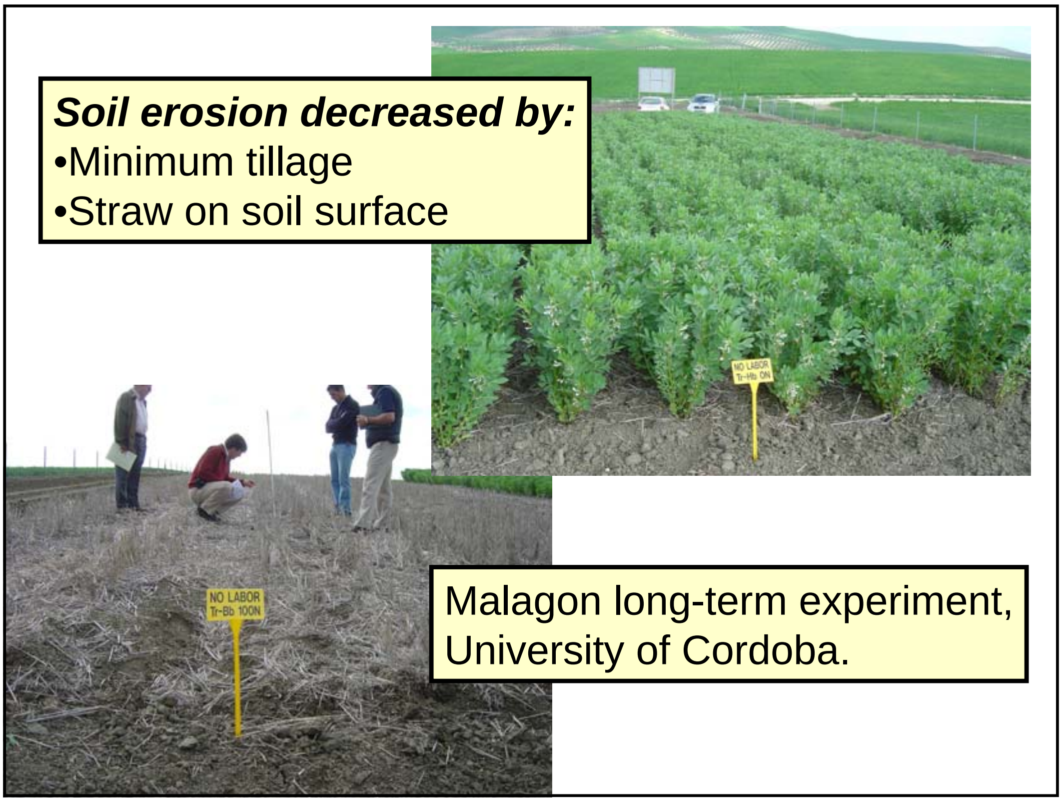
Water infiltration rate related to "labile C"
– increased by straw and N fertilizer

Blair, Faulkner, Till, Poulton. *Soil & Tillage Research* **91**, 30-38 (2006)

Other benefits from straw addition to soil

- Source of organic N (very slowly available)
- Immobilisation of N in short term:
  - would expect some decrease in nitrate leaching
  - but very limited direct evidence of significant effect
- Source of K
- Potential to decrease soil erosion


Potential for soil erosion – southern Spain.
(Rotation: wheat – spring crop); long periods of bare soil.
•Soil sustainability
•Water quality – phosphate, sediments
Climate change impacts.
•Bare soil exposed to increasingly intense winter rainfall.
•More spring crops under climate change?


Soil erosion decreased by:
•Minimum tillage
•Straw on soil surface
Malagon long-term experiment, University of Cordoba.

Use straw for bioenergy?

- Assess number of years when straw could be removed whilst maintaining SOM
  - Affects area required to supply power plant
- Remember nutrient removal – K
- Consider implications for soil physical properties, on- and off-site
  - tillage, surface capping, seedling emergence, water storage, soil biology, erosion risk
- Straw burning power plants – may permit development of **biomass crops** – increasing security and continuity of biomass supply
- Consider **mix of straw and biomass crops** for energy – rather than straw alone

ROTHAMSTED RESEARCH

Cereal/Soybean Straw and other Crop Residues Utilization as Fuel in Serbia – Status and Prospects –

Prof. Dr. Milan Martinov, Prof. Dr. Milos Tesic

Faculty of Technical Sciences, Novi Sad

1. **Introduction**
2. **Crop residues, arts and potentials**
3. **Soil amelioration**
4. **Current utilization**
5. **Visions and prospectus**

1. INTRODUCTION

Fossil fuels consumption in Serbia, 11.8 mil. toe* of primary energy per annum.

Biomass total potential – 2.7 million toe.

Crop residues biomass – 1.4 million toe.

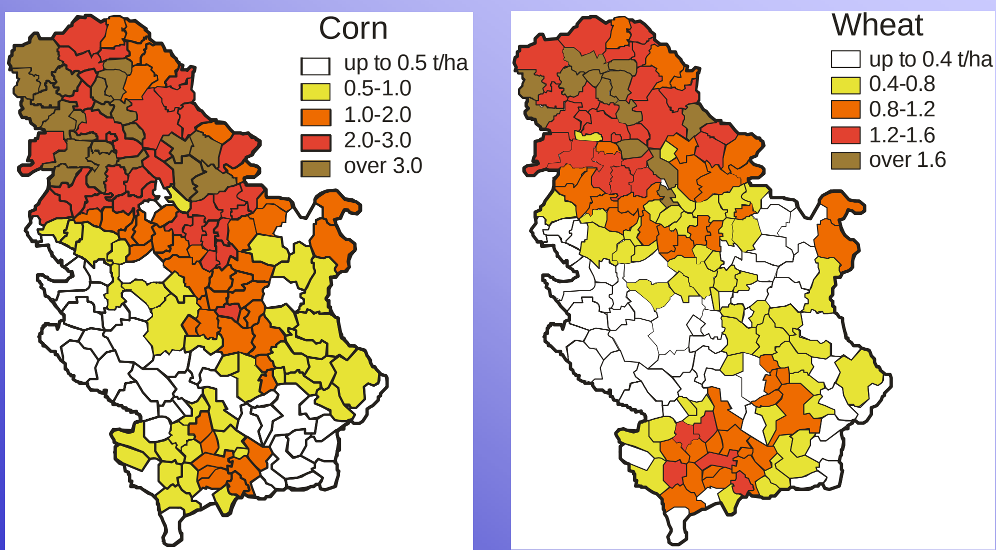
About 4.5 million ha of agricultural land, and about 3.5 million ha of sowing land.

Field production about 2.6 million ha, 20% big farms.

Two groups of farms, big, over 200 ha, small (up to 50 ha), and medium (50 to 200 ha) – S&M. Different production technology, different energy needs and approach to energy production and utilization.

***) 1 toe – ton of oil equivalent = 41 860 MJ**

Production density of corn and wheat in Serbia (Ilic et al, 2003)



2. CROP RESIDUES, STATUS AND POTENTIALS

Significant agricultural residues of field production in Serbia:

- **cereal straw**
- **maize stover and cobs**
- **soybean straw**
- **oil rape straw**

Crop residues yields

The production technology and grain yield of big and small and medium (S&M) farms is different, i.e. higher at big farms.

Harvestable straw for all cereals is approximately the same, according to farmers data about 3 t/ha for big farms, and 2.5 t/ha at S&M farms. The same holds for soybean, and slightly higher for oil rape.

Sunflower crop residues harvestable yield is approximately twice higher than the grain yield, i.e. about 5 t/ha (Martinov, 1982).

Maize stover harvestable yield is about 60% of the grain yield. Average 5 t/ha for big and 4 t/ha for S&M farms.

The maize cobs yield is in the range 15 to 18% of the grain yield (Martinov and Topalov, 1984). This is on average approximately 1 t/ha, for most big and S&M farms (big farms have higher yield but only seed production was considered, and this yield is comparable with that of S&M farms).

Restrictions

Both big and S&M farms apply the so called conservation tillage, whereby all crop residues remain in soil. Conservation tillage is applied on about 30% of fields, and this share shows growing tendency.

Maize stover can be harvested only until the second half of October, i.e. Later on, it is too soiled and too wet. That means, only early hybrids can be harvested. Their share is estimated to be about 20% for big and 15% for S&M farms. There is no mature technique for stover harvesting.

Dominate maize harvesting procedure for S&M farms is picking/husking of maize ears, and natural drying. Maize cobs are available in the farmers' yard after drying and shelling, end of February. The share of this technology is assessed to be 70%. Big farms use same technology for seed production. This is about 10% of the total. Maize cobs are available already in October, November, and can be used for drying of maize ears.

There is no procedure and machinery for harvesting of sunflower crop residues.

Other utilization

Most significant use of diverse straws is for animal bedding. The share of the so used straw is calculated to be approximately 5% for big and 10% for S&M farms. Soybean and oil rape straw is exceptionally used for this purpose.

Maize stover is used as cattle fodder. It is not used on big farms and part used at S&M farms is assessed at 10%.

In some cases storage and transportation losses have been calculated, as well as the other minor non-energy utilizations.

Tab. 1 Crop residues for use as energy source in Serbia

Crop	T[3]	Area, 1,000 ha	Big farms, 1,000 t	S&M farms, 1,000 t	Total harvestable crop residues, 1,000 t		Energy available crop residues, 1,000 t	
					Big farms	S&M farms	Big farms	S&M farms
Wheat	↓	797	178	619	374	1,080	355	970
Rye	–	8.6	0.8	7.8	2	14	2	14
Barley	–	135	46.6	88.4	80	154	80	138
Maize	↑	1,358	133	1,225	s[1] 130	s 735	s 130	s 660
					c[2] 15	c 1,200	c 15	c 1,200
Sunflower	–	160	74.9	85.1	0	0	0	0
Soybean	↑	83	54.8	28,2	105	50	105	50
Oil rape	↑↑	1.4	0.7	0.7	2	2	2	2
Total					708	3,235	689	3,034
					3,943		**3,723**	

[1] maize stover
[2] maize cobs
[3] trend of the change of growing area

Comments and perspectives

Total amount of biomass usable for energy purposes is more than 3,7 million tons. Calculating 3 kg of biomass for 1 kg of oil of primary energy, the equivalent is 1.23 million toe. Together with pruning and other agricultural residues this is about 1.4 million TOE, as calculated in previous studies of biomass potentials, or 11.8% of total fossil fuel primary energy used per annum.

Trends of production are also given in the table. Considerable rise is expected for rape oil, due to new factory of biodiesel. The rise of maize and soybean production is also expected due to better prices, production of bio ethanol.

Over 80% is located at S&M farms. This category should be more targeted in the future.

3. SOIL AMELIORATION

Agronomists do not support removal of crop residues from the fields, in Serbia as in the other countries (Kastori and Tesic, 2005). On the other hand there are no experimental data on the effects of biomass removal on soil fertility reduction. Through roots, stubble and harvesting residues more than two thirds of residual biomass remind in the soil. The current practice in the country is also burning of crop residues. This is prohibited by law, but widely applied.

The removal of nutrients has also been evaluated as negative, but most of them can be brought back by spreading of coarse combustion ash of biomass.

Influence of biomass removal in big scale should be further investigated, but it seems that the presented amount should not have negative effects on soil and ecology. This is especially the case for maize, as the most popular crop,.

4. CURRENT UTILIZATION

Tab. 2 Assessment of currently used crop residues in Serbia

Crop residue	Big farms, 1,000 t	S&M farms, 1,000 t
Cereal straw	150	200
Maize stover	–	60
Maize cobs	10	900
Soybean straw	20	10
Total	180	1,170
	1,350	

Only about 36% of available crop residues used, 87% by S&M farms owners and other users in their vicinity

Tab. 3 Example of straw use as a fuel in one big farm with 7,000 ha

Unit	Heating area, m^2	Required boiler power, kW	Installed boiler power, kW	Manufacturer	Fuel
Martinci	2.528	500	250+150	Ekoprodukt	Straw
Laćarak	972	194	300	Ekoprodukt	Straw
Veliki Radinci	1.425	285	400	Terming	Straw
Sr. Mitrovica	1.637	327	300	Terming	Straw
Svinjogojska farma	7.827	1564	750 250	Nigal Ekoprodukt	Straw
Bosut	210+316	42+36	120 50	Ekoprodukt Terming	Straw
Divoš	817	163	80	Terming	Straw
Sremska Rača			35	Stadler	Wood, coal
Total	15.714	3.112	2.685		

The list of major domestic producers of biomass facilities

No	Manufacturer	Web	Products
1	TERMING D.O.O.	www.termingkula.co.yu	Straw and maize cobs boilers 40-1000 kW
2	ŠUKOM D.O.O.	www.sukom. co.yu	Straw boilers 100–1000 kW
3	PODVIS-TERM A.D.	www.podvisterm.co.yu	Straw boilers 30–1800 kW
4	METALAC A.D.	www.inter-mehanika.com	Straw boilers 20–80 kW
5	KIRKA-SURI D.O.O.	www.kirka.co.yu	Straw boilers, medium and big, over 1 MW
6	TEHNOSERV	–	Straw boilers 25–120 kW
8	NIGAL D.O.O.	–	Big straw boilers and hot air generators, over 500 kW
9	EKO PRODUKT	–	Straw boilers 120–400 kW
10	TERMOMONT	www. termomont. co.yu	Small and medium straw boilers
11	ALFA PLAM	www.alfaplam.co.yu	Biomass stoves
12	RAZVOJ	–	Biomass boilers 40 kW to 1 MW
13	TERMOPLIN D.O.O.	www.termoplin.co.yu	Biomass boilers and hot air generators (driers)
14	RADIJATOR INŽENJERING	www. radijator.co.yu	Biomass boilers 18–250 kW
15	ZIVANKO ARNAUTOVIĆ	–	Biomass hot air generators 20–55 kW
16	INOMAG	–	Biomass boilers
17	RADIJATOR	–	Biomass boilers, small and medium
18	DP ZASTAVA-METAL	–	Biomass boilers 32–63 kW
19	MEGAL A.D.	www.megal.co.yu	Biomass boilers and stoves 18–140 kW
20	MILAN BLAGOJEVIĆ A.D.	www.mbs.co.yu	Biomass stoves
21	ABC Proizvod	www.abcproizvod.co.yu	Biomass boilers 25–130 kW

Problem: Low efficiency and high pollutant emission

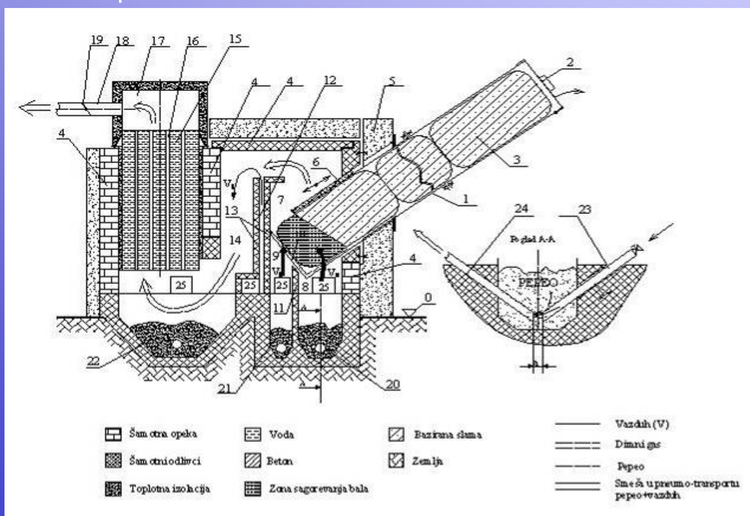
Tab. 4 Example of boiler testing results (Brkic and Martinov, 2006)

Manufacturer	Declared power, kW	Measured power, kW	η, %	λ	CO_2, %	CO, mg/Nm^3	NO_2, mg/Nm^3
Bratstvo I	40	41.9	54	2.8 1.7-3.6	5.7-11.6	2.28- 5.91	–
Bratstvo II	360	145-317	64-72	1.3-2.7	2.5-15.5	2.8* 0–4.8*	–
Nigal	750	299-530	43-69	2.8-7.9	2.4-6.5	1,8- 2,8	1.7-2.43
Razvoj	400 500	249-369 340-685	63 66	2.1-4.8 1.5-5.9	3.1-15.3	2.0- 5.2	21-36
Šukom	250	171-232	31-67	1.8-8.8	3.1- 11.0	1.6- 9.0	34-97
Terming	500	59-170	50-73	1.3-3.5	5.5-14.4	4.0-6.4	1-7

η– energy efficiency, λ– air excess ratio, (*) in %

Domestic developments

Scheme of developed small straw conventional bales boiler



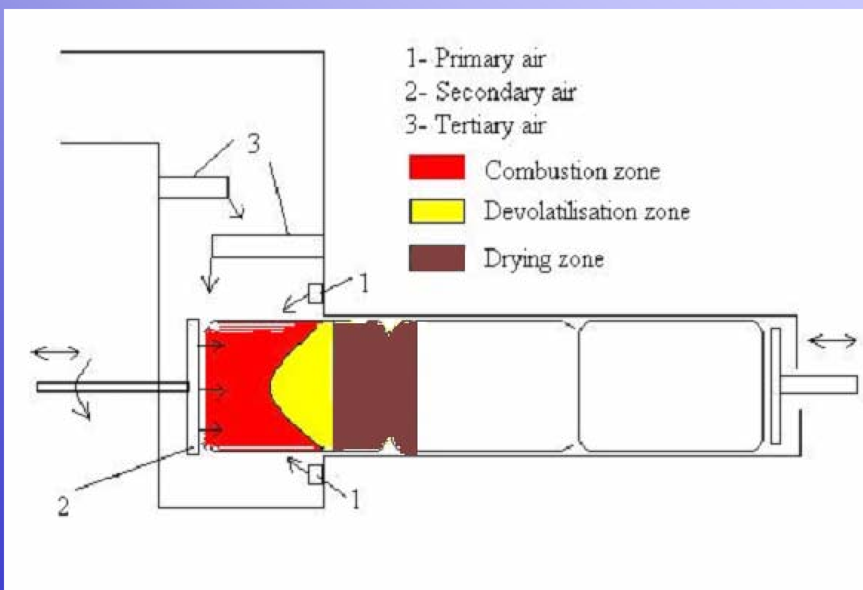
Example of replacement of fossil fuel boiler with biomass ones in one household

Demerits of oil boiler:
- high emission of pollution
- difficult to handle
- high fuel costs

Merits of biomass boiler:
- high efficiency
- low emission
- easy to handle

Biomass competitive in comparison with heating oil!

Schema of combustion chamber for soybean straw round bales



Pilot plant, about 1 MW thermal power boiler, for soybean straw round bales

New boiler of this type, for big rectangular bales of soybean straw, 1.2 MW, under construction. It should serve as demonstration plant used for heating of greenhouse.

5. VISIONS AND PROSPECTS

Wider use of crop residues can be expected first after introduction of subsidies and other financial supports

Simultaneous development of rural areas –societal, economic and demographic effects

CHP and tree-generation

Co-firing

Biodiesel

Bio-ethanol

Small and medium farms produce over 70% of total agricultural residues. They already use crop residues as a fuel for household heating. The facilities should be more efficient and have lower emission of pollutants.

In this sector utilization of crop residues is traditional, but the is very low. Profitable use is possible in many cases, also without subsidies.

Most dominant fuel are maize cobs.

Contemporary facilities are urgently needed.

It is unrealistic to expect merger of few households to use district heating.

Development of local specific low-cost facilities is needed.

Typical project can be

Energetically and environmentally improved maize harvesting and drying technology in SEE

Big farms already now use crop residues as energy source for different purposes; further growth is expected, especially if the subsidies are to be introduced. They are also capable to invest in CHP. The problem is inhomogeneous form of bales (conventional, round and big rectangular bales of different dimensions), and unstable prices of crop residues.

Big farms are suitable for demonstration plants.

Good future for soybean and rape straw.

Technology from EU applicable in the future.

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Czech Republic,
Crop Research Institute,
Division of Agroecology

Sergej Usťak:

Biomass as a renewable source of energy in the Czech Republic

The map of the Czech Republic

The targets of the current Czech National Programme for Energy Efficiency and Renewable and Secondary Energy Sources for the year 2010 are:

1) Production of electricity from renewable sources in the amount 8 % (EU-21 %) of the gross electricity consumption;

2) Share of renewable energy sources in the total primary energy consumption at the level 6 % (EU-12%) of the total primary energy consumption ;

Shares of different energy sources of power industry in the Czech Republic (2006)

Source of energy	Share of total primary energy sources, %	Share of total electricity production, %
Coal	48,3	59,3
Oil *	19	0,03
Natural gas *	19	4,63
Nuclear	9,3	30,1
Renewable sources of energy (RES)	4,31	4,17
others	0,09	1,77

* - imported sources

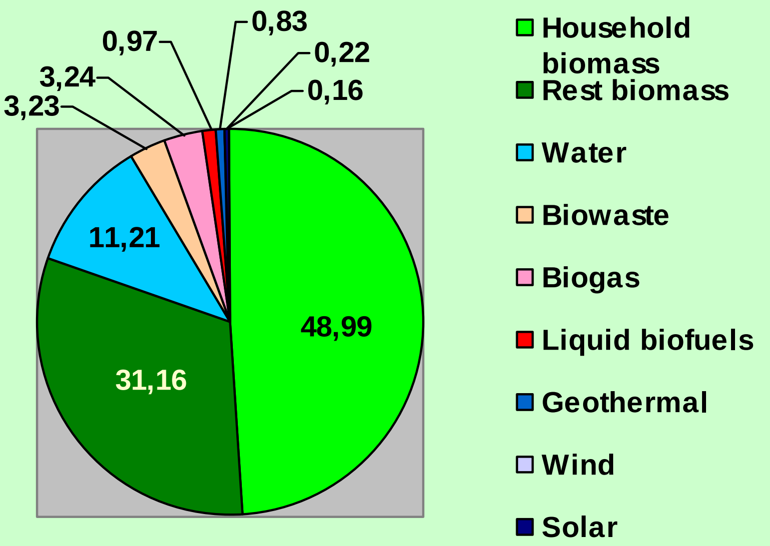
** - share of gross electricity consumption - 4,91 %

2006: Renewable energy share of gross electricity consumption (GEC - approx. 71,7 TWh per year): 4,91 % or 3,52 TWh;

Renewable energy share of total electricity production (TEP - approx. 84,4 TWh per year): 4,17 % or 3,52 TWh;

Renewable energy share of primary energy sources (PES - approx. 1 903 PJ per year): 4,31 % or 82 PJ;

Structure of renewable energy sources RES (4,31 % of total PES in 2006) in the Czech Republic (% of RES)



Currently biomass is the most important source of renewable energy in the Czech Republic !!!

In the Czech Republic households are the main consumer of RES - renewable energy sources (about a half of total renewable energy). The main source of household energy is **solid biomass** for the purposes of heat generation, first of all **firewood and wood residues**, which are obtained by **purchase** by the sellers of fuels or **self collection** or by the **businesses handling** with this resource originated from forest, from the maintenance of city and village green etc.

Number of domestic installations burning or co-burning biomass fuel in Czech Republic (MPI-2005)

Installations	Total amount	For biomass	For coal and biomass
Kitchen-stoves	75 500	56 500	19 000
Heating boilers	284 000	105 900	178 100
Heating and hot water boilers	116 500	47 100	69 400
Local heaters	126 200	66 200	60 000
Hot water boilers	21 600	17 300	4 300
Hearthstones	66 900	66 900	--
Total	690 700	359 900	330 800

Development of household biomass consumption in CZ during 2003-2006

Year	Solid biomass, millions t	Energy of biomass, PJ	Achieved heat, PJ
2003	2,65	34,5	21,8
2004	2,83	36,8	23,3
2005	2,85	37,1	23,5
2006	3,09	40,1	25,4

Czech Republic has relatively good condition for wood biomass production due to the large areas of forest:

Total area, millions ha	forests, millions ha	Forest on total area, %	Coniferous, millions ha	Deciduous, millions ha	Average age of trees
7,89	2,58	32,8 %	1,98	0,58	63

Development of wood exploitation and fire wood deliveries in CZ during 2001-2006

Year	Wood, millions m^{3*}	Fire wood, millions m^{3*}	Wood, millions t	Fire wood, millions t	Forest waste, millions t
2001	14,4	--	8,62	--	1,29
2002	14,5	--	8,72	--	1,31
2003	15,1	1,09	9,08	0,65	1,36
2004	15,6	1,19	9,36	0,71	1,40
2005	15,5	1,23	9,31	0,74	1,40
2006	17,7	1,35	10,61	0,81	1,59

* - without bark

The potential of forest biomass of Czech Republic consists of wood residues from the wood-processing industry, thinning, pruning and firewood

Potential	energy (PJ)
Technical	77,6
Available	44,8
Real consumption of biomass by households in 2006	40,1

The potential for increase of forest biomass consumption by households in CZ is very low!

Three options available:

1) export of wood biomass;
2) extension of production and use of short rotation coppice woods;
3) extension of production and use of standardised biofuels (pellets and briquettes) with use of agricultural biomass (i.e. energy crops and agricultural residues)

Balance of briquettes and pellets in CZ in 2005-2006 (in tons) and price

	Briquettes 2005	Briquettes 2006	Pellets 2005	Pellets 2006
Capacity	144 415	149 448	49 016	118 250
Production in CZ	102 303	113 969	20 875	53 283
Import	975	3052	0	188
Export	81 335	81 910	11 686	24 382
Delivered on the home market	46 155	32 763	13 912	28 872
From large consumers	23 599	5 784	9 223	21 017
From small consumers	2 426	26 979	3 617	7 855
Price (incl. 19% VAT), EUR/t	155 average	(107-225) min-max	150 average	(125-190) min-max

Balance of energy biomass utilisation in CZ in 2006

Fuel - kind of biomass	Fuel for electr., **kt**	Fuel for heat, kt	Fuel in total, kt	Fuel in total, %
Wood chips or wastes	250	881	1 131	19,0
Cellulose leach	185	884	1 069	17,9
Fire-wood	0	54	54	0,9
Agricultural crops	62	12	74	1,2
Briquettes and pellets	16	8	24	0,4
Total	513	1 840	2 353	39,5
Energy biomass use in households			3 088	51,8
Export of wood fuel			517	8,7
Total biomass fuel			5 958	100

Heat generation from different types of biomass without households in the year 2006 *

Fuel - kind of biomass	Total fuel consum-ption (kt)	Aver. energy content in fuel, GJ/t	Gross heat generation (TJ)	Net heat consum-ption (TJ)	Sale of heat (TJ)	Ratio of sale: total
Wood chips or wastes	881	9,0	7 918	7 032	886	11,2
Cellulose leach	884	8,7	7 656	7 100	556	7,3
Fire-wood	54	10,3	556	556	0	0,0
Agricultural crops	12	10,0	123	64	59	47,8
Briquettes and pellets	8	14,3	117	72	44	38,0
Total	1 840	8,9	16 370	14 825	1 545	9,4

Power generation from different types of biomass without households in the year 2006 *

Fuel - kind of biomass	Fuel consump tion (kt)	Fuel energy (TJ)	Power generation (MWh)	Net consum-ption. (MWh)	Delivery to electricity network (MWh)	Direct deliveries (MWh)	Ratio of delivery : total
Wood chips or wastes	250	2 247	272 725	78 257	190 673	3 794	71,3
Cellulose leach	185	1 600	350 028	331 976	0	18 051	5,2
Agricultural crops	62	619	84 465	7 822	76 040	603	90,7
Briquettes and pellets	16	222	23 850	1 599	19 033	3 217	93,3
Total	513	4 560	731 068	419 654	285 746	25 665	42,6

Average market price (incl. 19 %VAT and 10 % profit) in Czech Republic:
- of cereal and rape straws packed into huge bags - 40-55 EUR/t or 2,7-3,7 EUR/GJ
- of wood chips - 50-70 EUR/t or 3,8-4,7 EUR/GJ;
- of briquettes and pellets - 120-180 EUR/t or 6,7-10 EUR/GJ

Key consumers of different types of biomass in CZ

Fuel - kind of biomass	Fuel in total, kt	Fuel in total, %	Key consumers - Czech energy producers
Wood chips or wastes	1 131	48,1	1) CEZ, (4 power plants: Hodonín, Tisová I., Poříčí II., Dvůr Králové); 2) 4 companies: Plzenska teplarenska, Dalkia CR, TEDOM and IROMEZ. The share of all others is less than 30 %.
Cellulose leach	1 069	45,4	Excl. group of paper and cellulose producers: two the biggest are 1) Mondi Packaging Paper CR Steti, and 2) Biocel Paskov.
Total	2 353	100,0	

Key consumers of different types of biomass in CZ

Fuel - kind of biomass	Fuel in total, kt	Fuel in total, %	Key consumers - Czech energy producers
Fire-wood	54	2,3	Only small heat producers
Agricultural crops	74	3,2	The heat producers are medium public boilers (use near 16 % of biomass) and the power producers are big power plants (CEZ, Dalkia, IROMEZ, TEDOM) - use together 84 % of biomass.
Briquettes and pellets	24	1,0	Near 70 % is used by bigger consumers (co-generation of power and heat) and 30 % by small heat producers.
Total	2 353	100,0	

Crops	Area (ha)	% of total arable land*	Yields (t/ha) grain	straw or residues	whole crop	ratio of straw/resid : grain
Winter wheat	779 241	25,39	4,81	3,75	8,55	0,780
Spring wheat	71 569	2,33	3,46	2,77	6,24	0,801
Winter barley	131 099	4,27	4,04	3,64	7,68	0,901
Spring barley	368 278	12	3,86	2,32	6,18	0,601
Oats	58 978	1,92	3,04	3,65	6,69	1,201
Triticale	49 668	1,62	3,95	3,56	7,51	0,901
Rye (winter and spring)	44 093	1,44	3,92	3,8	7,72	0,969
Basic cereals in total	1 502 926	49,0	3,87	3,36	7,22	
Rape	298 058	9,71	2,56	3,47	6,04	1,355
Mustard	41 066	1,34	0,95	2,18	3,12	2,295
Maize for grain	71 027	2,31	6,69	6,57	13,27	0,982
Sunflower for grain	34 284	1,12	2,18	6,1	8,27	2,798
Other crops in total	444 435	14,5	3,10	4,58	7,68	1,48
Fodder crops at arable land - in hay	582 236	18,97			5,76	
Hay from grasslands	883 296	28,78			2,89	
All crops in total	3 412 893	82,4	3,57	3,83	6,99	1,07

*-the official area of total arable land in the Czech Republic is 3,06 mil. ha

Crops	Area (ha)	% of arable land*	Biomass output (kt) grain	straw or residues	whole crop	Total energy output, PJ straw or residues	whole crop
Winter wheat	779 241	25,39	3 774	2 921	6 695	43,82	100
Spring wheat	71 569	2,33	248	198	446	2,98	6,69
Winter barley	131 099	4,27	533	477	1 010	7,15	15,2
Spring barley	368 278	12	1 424	854	2 278	12,80	34,2
Oats	58 978	1,92	180	215	395	3,23	5,93
Triticale	49 668	1,62	199	177	376	2,65	5,64
Rye (winter and spring)	44 093	1,44	178	168	346	2,52	5,19
Basic cereals in total	1 502 926	49,0	6 537	5 009	11 546	75,1	173
Rape	298 058	9,71	770	1 035	1 805	15,53	27,1
Mustard	41 066	1,34	38	89	128	1,34	1,92
Maize for grain	71 027	2,31	471	467	938	7,00	14,1
Sunflower for grain	34 284	1,12	75	209	284	3,14	4,26
Other crops in total	444 435	14,5	1 355	1 800	3 155	27,0	47,3
Fodder crops at arable land - in hay	582 236	18,97			3 356		50,3
Hay from grasslands	883 296	28,78			2 544		38,2
All crops in total	3 412 893	82,4	7 892	6 810	20 602	102	309

Different types of potential for the use of straw and residual biomass in CZ

Source of agricultural biomass	Total biomass output, kt	Total energy output, PJ	Max. enviro-suitable, %	Avail-able, %	Max. enviro-suitable, PJ	Avail-able, PJ	Real (2006), PJ
Straw of cereals	5 009	75,1	40	20	30,1	15,0	0,80
Straw of rape and mustard	1 124	16,9	100	50	16,9	8,4	0,20
Residues of maize and sunflower	676	10,1	60	30	6,1	3,0	0,05
Hay of fodder crops at arable land	3 356	50,3	80	40	40,3	20,1	0,05
Hay from permanent grasslands	2 544	38,2	100	50	38,2	19,1	0,01
All crops in total	12 711	191			131	65,7	1,11

Conclusions:

1) For generation of heat and power with energy biomass burning and co-combustion, the most suitable is utilisation of straw of cereals and straw of rape and mustard. The total available potential for basic cereal straw is 1 million t of biomass or 15 PJ of energy and for rape and mustard straw is 0,56 million t or 8,4 PJ (in sum 23,4 PJ of energy).

2) The other types of agricultural energy biomass (hay of grasslands, hay of fodder crops from arable land, residues of maize and sunflower) are not suitable for direct burning, but they are suitable for biogas production.

Conclusions:

3) Current intensive development of biogas production in the Czech Republic, which started two years ago due to the new Czech law for support of renewable electricity production, allows the extension of agricultural energy biomass production and utilisation.

4) The available potential of residues of maize and sunflower and fodder crops (from grasslands and arable land) is very significant. In total it is 6,6 million t of energy biomass or 42,2 PJ.

5) Moreover, much higher is the potential of biomass for biogas production (first of all maize for silage, which is cultivated in CZ on area of about 220 thousand ha with a production of about 6,6 million t).

Potential use of straw and agricultural residues for bioenergy in Slovenia

www.uni-mb.si/fk

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WORKSHOP
Novi Sad, 2nd-3rd October 2007

Potentials of cereal straw and crop residues in SLOVENIA

Resources cereal straw and crop residues?

POTENTIAL PRODUCTION

- Potentials: 95.000 ha of cereals (incl. 35.000 ha wheat, 13.300 ha barley and 42.700 ha grain maize, (EUROSTAT, 2003).
- According to the SI Yearbook 2006 (data for 2005) wheat production covered 30,095 ha, barley covered 15,451 ha, grain maize covered 42,396 ha, while rape production for bioenergy increased to 7,000 ha in 2007.
- Very problematic and maybe important crop residues are hops straw (well concentrated on 1,453 ha) and residues from wine production (16,428 ha concentrated mainly in three regions).

STRAW + RESIDUES PRODUCTION

Total straw production
- from wheat is 140,000 t,
- from barley 50,000 t and
- from grain maize 350,000 t

Total 540,000 t

- straw residues from hops about 22,500 t and
- about 70,000 t of residues from wine production (all data are presented on dry basis). Residues from industry are not included because until now they were used mostly for compost.

For wheat and maize, we calculated harvest index from 0.50 to 0.55 with regard to differences among varieties (low – early mature to high – late mature plants) and dry basis of yield.

USED STRAW

- Total 0.6 million livestock units (LSU), cattle 0.3 LSU, sheeps 0.01 LSU.
  - Cattle population: No. 452,517 in 2005 (1/4 use straw, 1 kg per day = 42,000 t)
  - Pigs: No. 457,432 in 2005 (1/8 use straw, 0.5 kg per day = 10.000 t)
  - Horses: 16,879 in 2003 i.e. 9.000 t straw (1.5 kg per day)
  - Sheeps: 7,700 t (0.1 kg per day)
  - Horticulture / mushrooms production: 500 t
- Total use of straw is 61,100 t per year.

Status or present utilization of cereal straw and crop residues in Slovenia

- **Status or present utilization of cereal straw and crop residues**
- No existing uses for energy

- What are the competitive use
  Left in the field: 156,000 t straw
  Cattle production - used as litter (61,000 t), straw is incorporated into organic matter with pig slurry and cattle liquid manures.

- Available for energy: 323,000 t straw

Environmental issues related to cereal straw and crop residues utilisation (i)

Local sustainability of straw removal

- Local community – draft based on Law of Environment and Aarhus Convention made by Environmental Societies includes very strict rules about use of energy and especially management of the projects. For example, the biogas stations were object to extensive public discussions.

- The second problem are small farms (61.000 holders, with an average of 7.3 ha per holding, 5% of farms have a size under 5 ha, 47% farms between 6-20 ha, and just 4% farms are larger than 31 ha).

How frequently one may take straw instead of incorporating it?

Rules exist in case of Integrated Crop Management (ICM), and additional rules are necessary.

Environmental issues related to cereal straw and crop residues utilisation (ii)

formula based on soil, climate, technologies

- In Slovenia more than 35 types and sub-types of soils with different, mainly bad, structure.
- According to the Guidelines for Integrated Crop Management (ICM, part of Slovenian Environmental Programme in Agriculture) in case of content of the humus in the soil lower than 1,5% there exists a strong prohibition to take away the straw. Percentage of the fields with low level of humus is very high. On the other hand also burning the straw is strongly prohibited.

effect on subsequent yields and fertiliser requirements

- In Slovenia are often used fertilizers such as pig slurry and cattle liquid manures incorporated on the fields with cereal straw. Due to better C:N ratio is that the main way for increasing content of the humus in the soil and influence the soil structure. The straw in combination with liquid manure has a great effect on subsequent yields.

other effects of incorporating straw

- Increase of soil biodiversity.

Ongoing projects in Slovenia

On going projects

Bioenergy is based mainly on forest resources and production of rape seed. Three bio-power stations produce energy from pig slurry and maize silage, but not yet from straw and other crop residues.

Practical problems in terms of resources, logistics, technology and economics: small farms; technology, logistics and economics unknown.

NEW PLANS

for bioenergy projects

- Research of utilization of different crops for bioenergy (incl. different oil crops, hemp ...), use of N-containing organic matter and C-organic compounds including straw

for biofuels plants

- Bio oil and biodiesel production from rape seed and other oil crops.

Production of straw and other agricultural residues in Republic of Macedonia and possibilities for use as bio fuel

Ordan Cukaliev

Faculty for Agricultural Sciences and Food-Skopje

Workshop "Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries",

2-3 October 2007, Novi Sad, Serbia

Republic of Macedonia – general data

- Total area 25,713 km^2
- Population 2 million
- Precipitation 609 mm/year
- Runoff coeff. 0.29
- Catchments:
  - Aegean (Vardar r. and tributaries) 22,319 km^2
  - Adriatic (C. Drim & Ohrid, Prespa) 3,350 km^2
  - Black Sea (Strumica) 44 km^2

Republic of Macedonia -Relief structure

The Republic of Macedonia is a mountainous country with many lowlands. The average altitude of the whole territory is 850 meters. According to the Spatial Plan of the Country, 1.9% of the territory is covered by water (lakes), 19.1% are Plains and valleys, and the biggest part of 79% are hills and mountains.

Plains and valleys in Macedonia occupies a total area of 4,900 km^2 scattered throughout the country.

Hypsometric characteristics of Macedonia

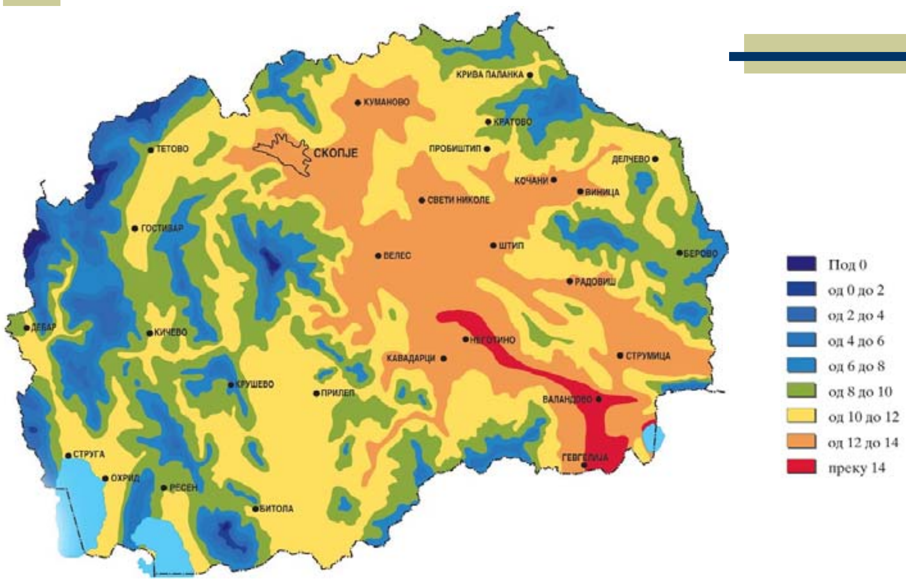
Level of elevation	Area km^2	%
Up to 200 m	744.10	2.89
200-500 m	5769.10	22.44
500-1000 m	11317.32	44.01
1000-1500 m	5741.68	22.33
1500-2000 m	1786.54	6.95
Over 2000 m	354.26	1.38
Total 44-2764 m	25713.00	100.00

Climate

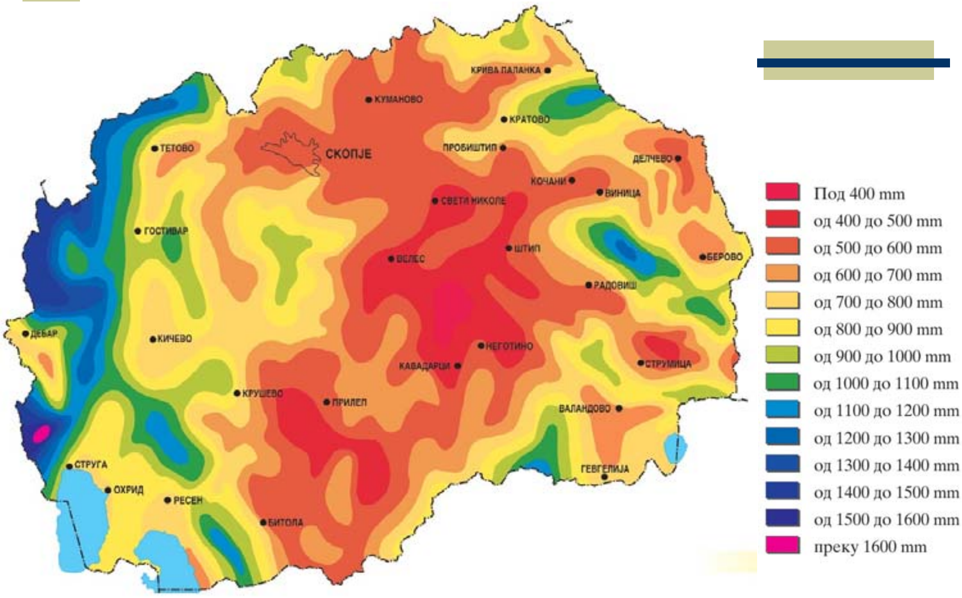
Key Climatic Indicators at Major Meteorological Stations

River Basin	Station	Rainfall (mm/year)	Temp. (°C)	Wind (m/sec)	Sunshine (hours/day)	Cloudiness (0-10)	Air Humidity
Vardar	Gevgelija	667	14.0	1.8	6.5	4.4	70.8
Treska	Sol.Glava	640	9.0	5.6	5.6	5.6	83.3
Pchinja	K.Palanka	617	10.0	2.3	6.3	5.3	68.2
Bregalnica	Shtip	467	12.6	2.1	6.4	5.0	66.9
Crna	Prilep	535	11.1	1.6	6.3	5.0	67.5
Crn Drim	Ohrid	694	11.1	1.8	6.2	5.0	70.4
Strumica	Strumica	547	12.7	1.1	6.2	4.2	74.3

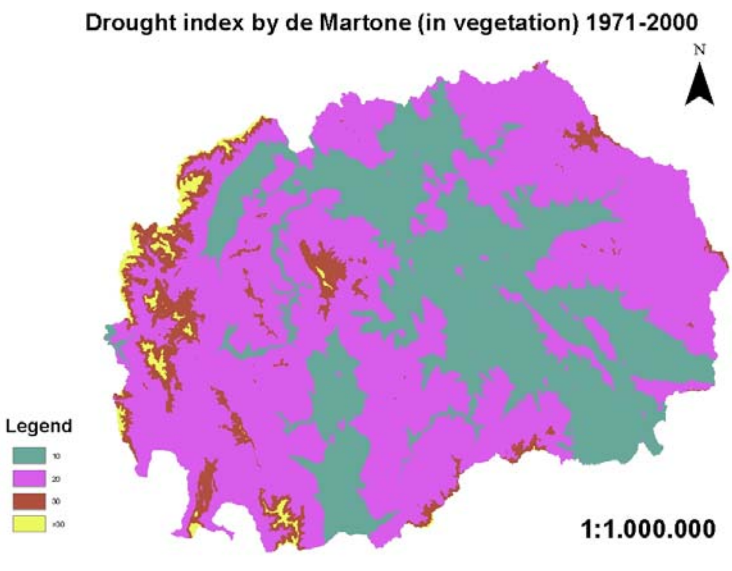
Average temperatures



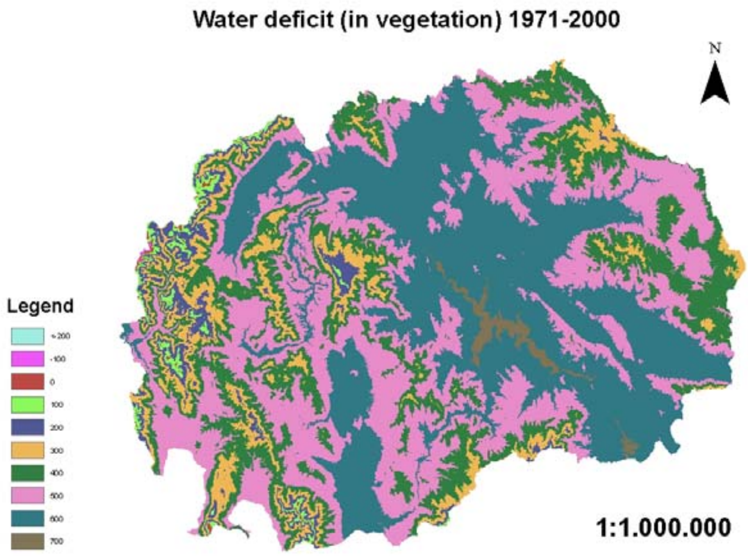
Precipitation



Agroecological Indices



Agroecological Indices



Macedonian Agriculture

- Macedonian Agriculture is accounted for 13-15% of the GDP (only in production sector).
- Annual trade of agricultural products corresponds to over 500 millions US$.
- Land equipped for irrigation equals 123,000 hectares (with 30,000 ha actually irrigated).
- Labor force in Agriculture 23-25%.
- Arable land: 650 000 ha (80% private property, 20% former large farms).

Agriculture – Land Use

Land use		1990 – 1999 (ha)	2000 – 2005 (ha)
Arable crop land		612,200	634,297
	Irrigated	60,153	31,755
	Rainfed	550,050	602,500
Pasture		630,000	707,263
Forest and woodland		997,374	934,128
Other land		331,926	191,349

Use of arable land

Year	Arable land and gardens	Sown Area					Nurseries	Fallow and uncultivated
		total	cereals	industrial crops	vegetable crops	fodder crops		
1998	533	358	222	42	58	36	1	174
1999	534	353	218	42	57	36	1	180
2000	498	350	221	34	60	35	2	146
2001	512	351	223	33	59	35	1	140
2002	480	321	196	31	56	38	1	158
2003	473	312	196	28	53	35	1	160
2004	481	304	191	27	52	34	1	156
2005	448	316	204	27	51	34	1	131

Use of fertilizers and agro chemicals

Year	Irrigated area in ha	Use of fertilizers in t	Use of Agro-chemicals in t	fertilizer use kg/ha	Agro-chemical use kg/ha
2000	45,095	16,416	308	27.45	0.52
2001	28,722	9,953	333	16.26	0.54
2002	21,448	10,593	245	18.36	0.42
2003	33,352	10,074	222	17.70	0.39
2004	15,075	9,931	273	17.73	0.49
2005	22,000	11,000	300	18.97	0.52

Cereal Production in ha

	wheat	rye	barley	oats	maize	rice	total
2000	121,669	5,845	49,988	2,374	37,488	3,871	221,235
2001	117,496	5,465	49,950	2,107	33,768	1,524	210,310
2002	102,774	3,945	49,883	2,589	34,873	1,868	195,932
2003	104,300	4,437	46,946	2,230	34,150	3,013	195,076
2004	101,607	4,546	44,975	2,408	32,913	2,888	189,337
2005	108,881	4,752	50,654	2,687	33,578	2,606	203,158
Average	109,455	4,832	48,733	2,399	34,462	2,628	202,508

Yield of Cereals in kg/ha

	wheat	rye	barley	oats	maize	rice
2000	2,472	1,412	2,213	1,095	3,382	4,773
2001	2,132	1,749	1,855	1,120	3,563	5,204
2002	2,641	1,809	2,658	1,525	4,124	4,739
2003	2,177	1,365	1,789	1,085	4,051	4,293
2004	3,522	2,295	3,328	1,715	4,364	5,168
2005	3.081	2,005	2,719	1,553	4,491	5,270
Average	2,671	1,773	2,427	1,349	3,996	4,908

Conversion factors grain: straw

Engel R., Long F., Carlson G., Wallander R. (2005) *Estimating Straw Production of Spring and Winter Wheat*, Fertilizers Facts, No 33, Montana Extension Service, Bozeman

Spring wheat 1,33

Winter wheat 1,64.

James A. Duke. 1983. *Handbook of Energy Crops*, unpublished

Rice 2

wheat is 1.23

barley is 1.45

oats is 1.16

rye is 0.70

other cereals are 1.10.

Conversion factors grain: straw

Edwards R.A.H., Suri M., Huld T., Dallemand J.F., (2005) *GIS-Based Assessment of Cereals Straw Energy Resource in the European Union*, Proceedings of the 14th European Biomass Conference and Exhibition Biomass for Energy, Industry and Climate protection, 17-21 October 2005, Paris.

Winter wheat and barley

straw=grain*0,769-0,129*arctan((grain-6,7)/1,5)

for Macedonian yield ratio grain: straw is 1,21.

for barley fits in low yield, high straw ratio end of the curve

for Macedonia result is 1,19.

this relation gives grain straw ratio from 1,06 to 1,61 (increase with yield increasing.

Conversion factors grain: straw

Ratio biological yield : grain yield (own results).

Winter wheat 3,00 – 3,21 (depend on fertilizer rate).

Straw production in Macedonia

	wheat	rye	barley	oats	rice	total
area	109,455	4,832	48,733	2,399	2,628	168,047
yield t/ha	2,671	1,773	2,427	1,349	4,908	
grain: straw ratio	1.21	0.70	1.20	1.16	2.00	
straw yield in t/ha	3.23	1.24	2.91	1.56	9.82	
grain production in t	292,354	8,567	118,275	3,236	12,898	435,331
straw production in t	353,749	5,997	141,930	3,754	25,796	531,226

Straw production in Macedonia

Straw production in Republic of Macedonia is 531,226 t , mainly from winter wheat (66.6 %) and barley (26.7%).

Straw use in Macedonia

Straw is most common bedding material for cattle in the country.

Number of cattle is 248,185 (2005).

Average straw used for bedding (estimated at 1.5 t/head/year) is 372,277 t/year.

Surplus of straw is 158,949 t /year.

Straw can be a valuable energy source in the country.

Vineyard area in ha

Year	Total vineyard area in ha
2000	26,530
2001	27,111
2002	26,194
2003	25,692
2004	24,777
2005	25,044
Average	**25,891**

Biomass from vineyard

Average vineyard area is 25,891 ha.

According Ilic, M, Grubor B., Tesic M., (2004) The state of biomass Energy in Serbia, Thermal Sciences, Vol. 8, No. 2, pp 5-19.

Pruning residues from vineyard are 4-8 t/ha.

Using average 6 t/ha pruning residues from vineyards are 155,346 (almost equal as straw surplus).

This biomass is almost not used.

Fruit production – number of trees in '000

	Apples	Pears	Plums	Cherries	Sour cherries	Apricots	Peaches
2001	3482	700	1707	168	1169	202	562
2002	3401	691	1617	167	1176	198	594
2003	3507	485	1467	161	1157	172	598
2004	4040	498	1463	170	1346	168	518
2005	4052	486	1436	176	955	161	522
Average	**3696**	**572**	**1538**	**168**	**1161**	**180**	**559**

Biomass from fruit production

According Ilic, M, Grubor B., Tesic M., (2004) The state of biomass Energy in Serbia, Thermal Sciences, Vol. 8, No. 2, pp 5-19.

Pruning residues in fruit trees vary from 1 kg/tree for some apple varieties up to 7 kg/tree for some plums and peaches.

Similar coefficient are used in calculation of biomass production fro orchards (next slide).

Biomass production from orchards

	Apple	Pear	Plum	Cherry	Sour cherry	Apricot	Peach	Total
No. trees	3696	572	1538	168	1161	180	559	
kg/tree	2	2	7	4,5	4,5	8	7	
Biomass production in t	7392	1144	10766	756	5224	1440	3913	30635

Exploitation of Agricultural Residues in Turkey

Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries

UTILIZATION OF AGRICULTURAL RESIDUES FOR BIOENERGY IN TURKEY

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Exploitation of Agricultural Residues in Turkey

Importance of Biomass

Biomass comprises all the living matter present on earth.

It is derived from growing plants including algae, trees and crops or from animal manure.

The biomass resources are the organic matters in which the solar energy is stored in chemical bonds.

Biomass has always been a major source of energy for mankind from ancient times. Presently, it contributes around 10–14% of the world's energy supply.

Biomass is a carbon neutral resource in its life cycle and the primary contributor of greenhouse effect. Renewable biomass is being considered as an important energy resource all over the world. Biomass is used to meet a variety of energy needs, including generating electricity, fuelling vehicles and providing process heat for industries

Exploitation of Agricultural Residues in Turkey

Importance of Biomass

Biomass usage as a source of energy is of interest due to the following benefits:

✓ Biomass is a renewable, potentially sustainable and relatively environmentally friendly source of energy.

✓ A huge array of diverse materials are available from the biomass giving the user many new structural features to exploit.

✓ Increased use of biomass would extend the lifetime of diminishing crude oil supplies.

✓ Biomass fuels have negligible sulphur content and, therefore, do not contribute to sulphur dioxide emissions that cause acid rain.

✓ The combustion of biomass produces less ash than coal and the ash produced can be used as a soil additive on farms, etc.

✓ The combustion of agricultural and forestry residues and municipal solid wastes for energy production is an effective use of waste products

✓ Biomass is a domestic resource which is not subject to world price fluctuations or the supply uncertainties as of imported fuels.

✓ Biomass provides a clean, renewable energy source that could improve our environment, economy and energy securities.

✓ Biomass usage could be a way to prevent more CO_2 production in the atmosphere as it does not increase the atmospheric CO_2 level.

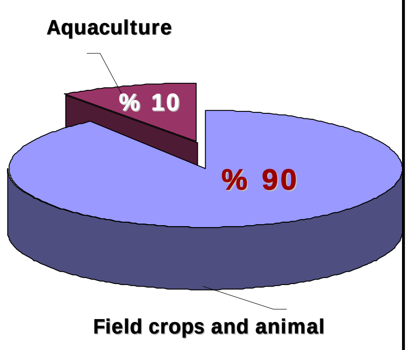
Exploitation of Agricultural Residues in Turkey

Agricultural sector in Turkey

Historically, the agricultural sector has been Turkey's largest employer and a major contributor to the country's GDP, exports and industrial growth.

As the country develops, agriculture declines in importance, however it still accounts for a relatively larger share of total output and employment than in many other countries.

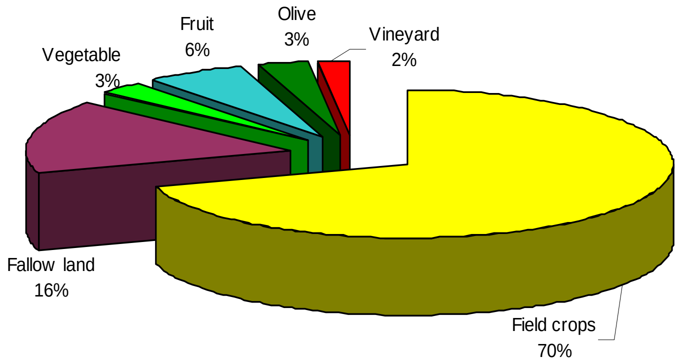
Crops and livestock represent almost 90% of the agricultural sector in Turkey, with aquaculture contributing the rest.



Exploitation of Agricultural Residues in Turkey

Agricultural land in Turkey

The total agricultural land = 26.4 million ha



Agricultural land distribution in Turkey

Exploitation of Agricultural Residues in Turkey

Agricultural crops in Turkey

Cereals, oily seeds and tuber crops are among the most widespread in Turkey.

Cereals are extensively grown in the central, eastern and southern parts of Turkey, whereas sunflower is prevalent in the region of Thrace (N-W Turkey).

Cotton and maize are the dominant crops in the south (the Cukurova and SE Anatolian regions), and the west (the Aegean region).

Tubers are widely produced in the Marmara (potatoes) and Central Anatolian (potatoes and sugar beet) regions.

Exploitation of Agricultural Residues in Turkey

Agricultural residues

The type and quantity of crops that form the basis of the agricultural sector in Turkey (wheat, barley, tobacco, cotton, rice, etc.) give rise to huge amounts of agricultural residues. The highest estimated amounts of residues are of wheat and barley followed by maize and cotton.

Residues left over the field after agricultural production. Cereal straw is used for various purposes such as animal feeding and animal bedding. Mainly residues from the production of industrial agricultural products are left over the field. The species are cotton stalk, corn stalk, sunflower stalk, straw and tobacco stalk etc.

Exploitation of Agricultural Residues in Turkey

Problems of agricultural residues

These residues are treated in an uncontrolled manner;

- either burnt in open-air fires or
- disposed of to decay.

Either case, they give rise to significant environmental impacts while at the same time useful resources are wasted in the expense of imported fuels.

Agricultural residues have been considered in three categories:

1) Annual crop residues that remain in the field after the crops are harvested. The main annual crops in Turkey are cereals, maize, cotton, rice, tobacco, sunflower, groundnuts, soybeans,
2) Perennial residues in Turkey that remain in the field after pruning of trees, shells, kernels etc.
3) Agro-industrial residues such as; cotton-ginning, seed oil industries, olive oil industries, rice industries, corn industries, wine and kernel factories.

Exploitation of Agricultural Residues in Turkey

Energy Resources of Turkey

Turkey is an energy importing country. More than about 60% of energy consumption in the country is met by imports. The share of imports continues to grow each year.

Therefore, it is critical to supply its energy demand by using domestic non-renewable resources and renewable resources.

Coal is a major fossil fuel source for Turkey. Domestically produced coal accounted for about 24% of the country's total energy consumption, used primarily for power generation, steel manufacturing and cement production.

Turkey's geographic location has several advantages for extensive use of most of the renewable energy sources. Turkey has substantial reserves of renewable energy resources. Renewable energy production represented about 14.4% of total primary energy supply (TPES). Main renewable energy resources in Turkey are: hydro, biomass, wind, geothermal and solar.

Exploitation of Agricultural Residues in Turkey

Agricultural Biomass Potential in Turkey

The project objective are:

- Mapping of the potential of agricultural waste
- Identification and assessment of legislative, institutional and administrative barriers to agricultural waste exploitation
- Technology review and assessment, in order to assess the different technological solutions available in the EU
- Preparation of an Action Plan
- Create an effective training infrastructure
- Setup investment support infrastructure
- Disseminate the results to a wide range of stakeholders using a variety of dissemination media.

Project team:

University of Cukurova (leader, Turkey)
TUBITAK (Turkey),
EXERGIA (Greece),
CRE (UK)
VTT (Finland)

Exploitation of Agricultural Residues in Turkey

Calculation of Energy Value of Agricultural Biomass in Turkey

The quantities of residues from the annual and perennial crops cultivated in Turkey, in tons of dry matter per year, were calculated and estimated using data from local authorities of Ministry of Agriculture and Rural Affairs.

The total amount of crop residues was divided into theoretic and actual values.

Exploitation of Agricultural Residues in Turkey

Total Annual Field Crops Production, Residues and Energy Values

Crops	Residues	Production (tons)	Area (ha)	Total residues (tons)		Available residues (tons)	Availability (%)	Calorific value (MJ/kg)	Total calorific value (GJ)
				Theooritic	Actual				
Wheat	Straw	3 538 329	1 111 429	4 599 828	2 631 316	394 697	15	17.9	7 065 084
Barley	Straw	505 033	208 873	606 040	326 762	49 014	15	17.5	857 750
Rye	Straw	9 392	3 923	15 027	6 944	1 042	15	17.5	18 229
Oats	Straw	23 080	10 846	30 004	24 347	3 652	15	17.4	63 545
Maize	Stalk	758 458	205 058	3 009 616	2 299 980	1 379 988	60	18.5	25 529 777
	Cop			204 784	963 077	577 846	60	18.4	10 632 371
Millet	Straw	294	245	517	576	346	60	16.7	5 773
	Husks			78	236	189	80	12.98	2 448
Tobacco	Stalls	6 894	7 252	13 788	15 718	9 431	60	16.1	151 839
Cotton	Stalks	440 354	161 547	1 213 175	809 365	485 619	60	18.2	8 838 269
	Ginning			92 474	176 430	141 144	80	15.65	2 208 900
Sunflower	Stalks	28 851	16 532	80 783	79 525	47 715	60	14.2	677 549
Goundnut	Straws	47 684	22 388	109 673	0	0			0
	Shell			23 842	25 615	20 492	80	20.74	425 001
Soybean	Straw	18 693	11 019	39 255	14 303	8 582	60	19.4	166 484

Exploitation of Agricultural Residues in Turkey

Total Annual Fruits Production, Residues and Energy Values

Crops	Residues	Production (tons)	Number of trees	Total Residues (tons)		Available Residues (tons)	Availability (%)	Calorific Value (MJ/kg)	Total Calorific Value (GJ)
				Theoretic	Actual				
Apricots	Shells	467.903	11.288.357		154.573				
	Tree pruning			1.328.846	86.964	69.571	80	19,3	1.342.719
Sour cherries	Shells	114.466	4.446.680		39.916			21,75	
	Tree pruning			137.359	21.400	17.120	80	19	325.279
Olive	Cake	1.496.630	90.208.994	673.484	829.816	746.834	90	20,69	15.451.997
	Tree pruning				441.254	220.627	50	18,1	3.993.345
Pistachios	Shells	42.926	29.600.005		14.007	4.202	30	19,26	80.932
	Tree pruning				209.611	167.688	80	19	3.186.080
Walnuts	Shells	115.698	3.737.868	173.546	75.792	60.633	80	20,18	1.223.584
	Tree pruning				50.480	25.240	50	19	479.563
Almonds	Shells	46.701	3.631.622	44.366	25.784	23.205	90	19,38	449.716
	Tree pruning			13.076	28.500	22.800	80	18,4	419.521
Hazelnuts	Shells	652.803	286.697.887	698.499	566.437	453.150	80	19,3	8.745.790
	Tree pruning				2.177.986	1.742.389	80	19	33.105.388

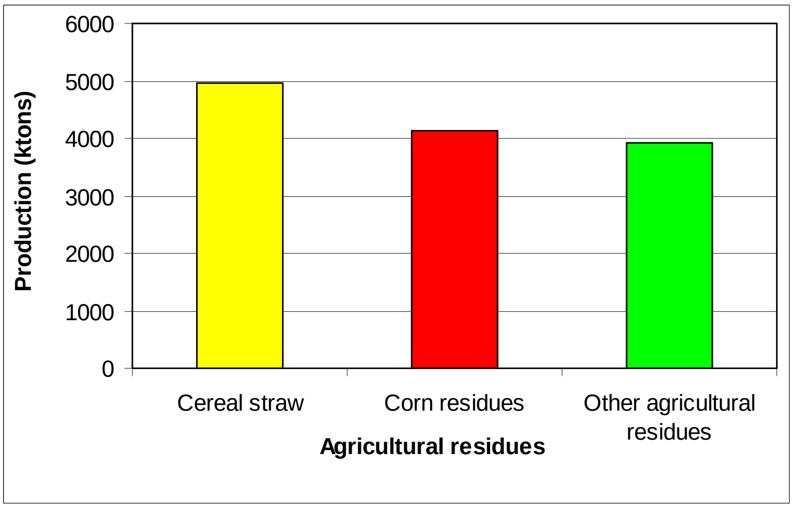
Exploitation of Agricultural Residues in Turkey

Total Annual Fruits Production, Residues and Energy Values

Crops	Residues	Production (tons)	Number of trees	Total Residues (tons)		Available Residues (tons)	Availability (%)	Calorific Value (MJ/kg)	Total Calorific Value (GJ)
				Theoretic	Actual				
Peach	Kernel	360.263	8.942.097	14.411				20,82	
	Tree pruning			904.260			80	19,4	
Lemons	Peel	475.159	5.529.038						
	Tree pruning			236.852	88.465	70.772	80	17,6	1.245.582
Oranges	Peel	1.180.851	11.884.275						
	Tree pruning			3.424.439	237.686	190.148	80	17,6	3.346.612
Mandarins	Peel	592.884	8.619.163						
	Tree pruning			918.970	103.430	82.744	80	17,6	1.456.294
Grapefruits	Peel	126.285	894.293						
	Tree pruning				14.309	11.447	80	17,6	201.466

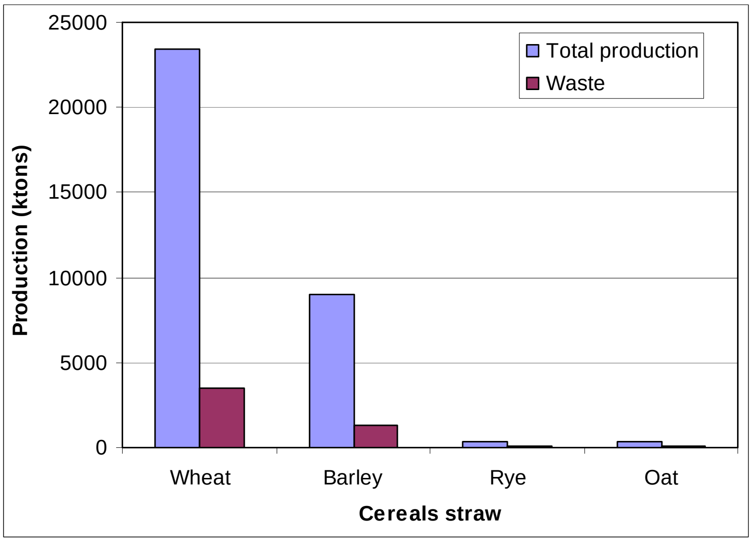
Exploitation of Agricultural Residues in Turkey

Agricultural residues for bioenergy production in Turkey



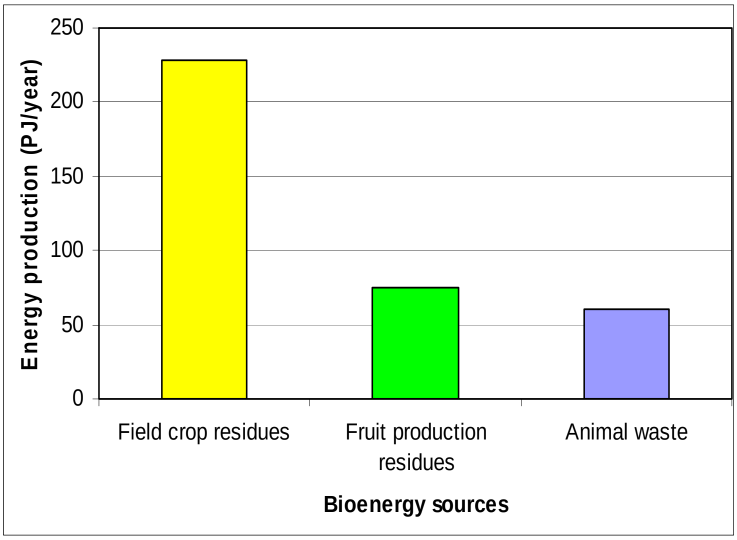
Exploitation of Agricultural Residues in Turkey

Cereal straw production in Turkey



Exploitation of Agricultural Residues in Turkey

Possible Bioenergy Production from Agricultural Residues in Turkey



Exploitation of Agricultural Residues in Turkey

Regional Distribution of Agricultural Biomass Potential in Turkey

Exploitation of Agricultural Residues in Turkey

Mediterranean Region

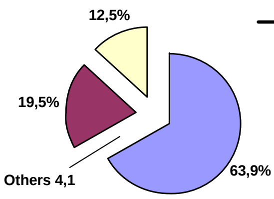
Field Crop Production

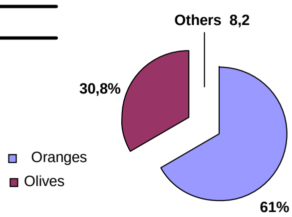
Crops	Production (tons)	Area (ha)
Wheat	3,538,329	1,111,429
Maize	758,458	205,058
Barley	505,033	208,873
Cotton	440,354	161,547

Fruits Production

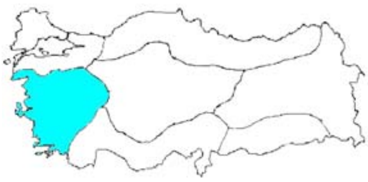
Fruits	Production (tons)	Fruit Trees
Olive	252,597	9,638,816
Orange	1,109,142	10,068,210
Lemon	4,486,934	4,844,293
Mandarin	431,161	4,765,416
Grey hurt	125,149	877,183

Field crops (PJ)	Fruits (PJ)
57,0	8,0





Exploitation of Agricultural Residues in Turkey



Aegean Region

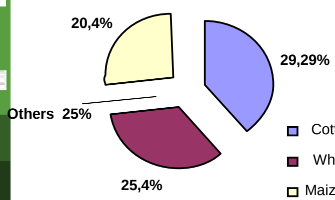
Field Crop Production

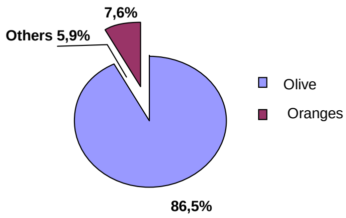
Crops	Production (tons)	Area (ha)
Wheat	2,141,149	792,251
Barley	1,067,307	409,017
Cotton	686,260	227,737
Maize	162,009	40,331
Tobacco	101,207	136,264

Fruits Production

Fruits	Production (ton)	Fruit Trees
Olive	990,787	51,723,577
Orange	142,239	3,067,707
Lemon	70,373	1,728,990

Field Crops (PJ)	Fruits (PJ)
24,2	15,3





Exploitation of Agricultural Residues in Turkey

Marmara Region

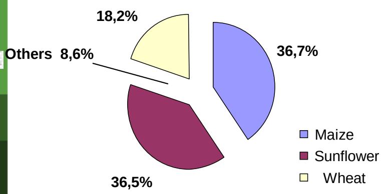
Field Crop Production

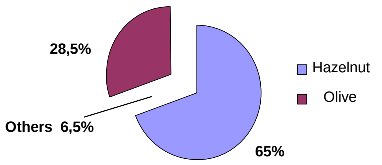
Crops	Production (tons)	Area (ha)
Wheat	3,812,029	1,121,30
Sunflower	670,605	413,777
Maize	566,275	85,225
Barley	495,996	160,043
Millet	209,094	37,459
Oats	126,233	53,254

Fruits Production

Fruits	Production (ton)	Fruit Trees
Olive	170,667	24,300,490
Hazelnut	115,156	39,134,379

Field crops (PJ)	Fruits (PJ)
41	9,5





Exploitation of Agricultural Residues in Turkey

Central Anatolian Region

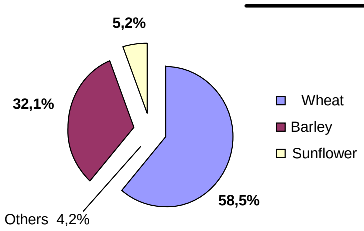
Field Crop Production

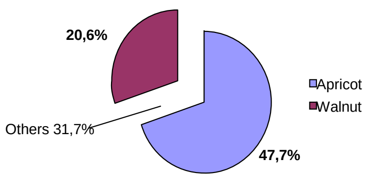
Crops	Production (tons)	Area (ha)
Wheat	6,263, 294	3,124,326
Barley	3,592,381	1,610,071
Rye	188,594	108,342
Sunflower	61,013	60,686

Fruits Production

Fruits	Production (tons)	Fruit Trees
Apricot	50,527	1,451,185
Cherries	35,927	1,300,953
Walnut	15,864	449,235

Field crops (PJ)	Fruits (PJ)
31,3	1





Exploitation of Agricultural Residues in Turkey

Eastern Anatolian Region

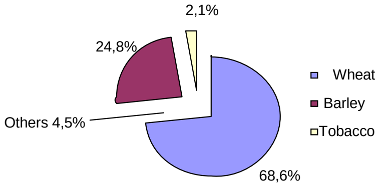
Field Crop Production

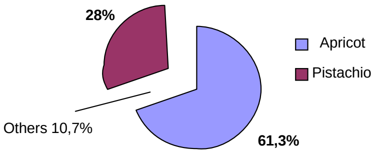
Crops	Production (tons)	Area (ha)
Wheat	1,525,730	1,037,619
Barley	627,665	404,789
Rye	20,896	13,464

Fruits Production

Fruits	Production (tons)	Fruit Trees
Apricot	324,888	7,020,689
Pistachio	20,453	618,430

Field crops (PJ)	Fruits (PJ)
8,2	0,4





Exploitation of Agricultural Residues in Turkey

South-eastern Anatolian Region

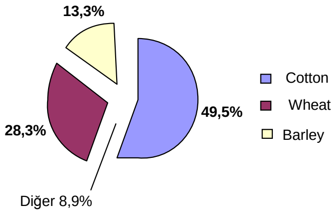
Field Crop Production

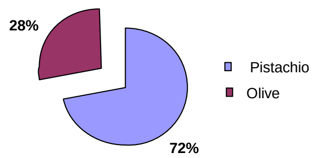
Crops	Production (tons)	Area (ha)
Wheat	2,829,060	1,222,933
Cotton	1,157,940	287,376
Barley	1,432,614	659,534
Maize	84,804	11,115

Fruits Production

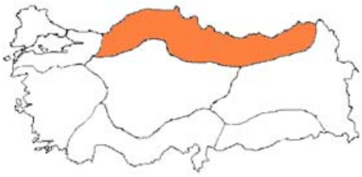
Fruits	Production (tons)	Fruit Trees
Olive	75,962	4,115,687
Pistachio	34,213	26,633,575
Walnut	5,510	238,703
Almond	3,590	369,766

Field crops (PJ)	Fruits (PJ)
37,1	4





Exploitation of Agricultural Residues in Turkey



Black Sea Region

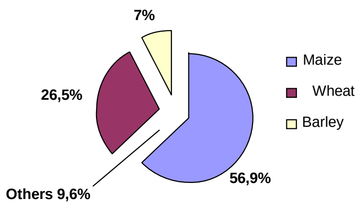
Field Crop Production

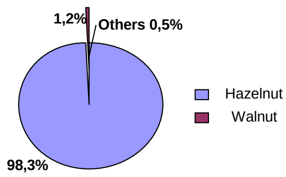
Crops	Production (ton)	Area (ha)
Wheat	2,323, 452	1,014,920
Maize	618,981	218,582
Barley	606,462	280,665
Ceviz	29,461	1,06, 690

Fruits Production

Fruits	Production (tons)	Fruit Trees
Hazelnut	537,111	247,423,170
Walnut	29,461	1,067,690
Cherries	11,458	501,828

Field crops (PJ)	Fruits (PJ)
29,6	36,1





Exploitation of Agricultural Residues in Turkey

Regional Distribution of Animals in Turkey

Mediterranean

Animal	Number
Cow	890,600
Sheep	1,858,400
Poultry	29,361,700

Aegean

Animal	Number
Cow	1,271,200
Sheep	2,906,500
Poultry	28,998,300

Marmara

Animal	Number
Cow	1,077,00
Sheep	2,211,200
Poultry	57,703,000

Central Anatolian

Animal	Number
Cow	1,840,600
Sheep	6,400,800
Poultry	37,442,400

East Anatolian

Animal	Number
Cow	2,472,900
Sheep	10,295,000
Poultry	14,018,400

South-eastern Anatolian

Animal	Number
Cow	664,500
Sheep	3,984,100
Poultry	5,226,500

Black Sea

Animal	Number
Cow	4,621,485
Sheep	2,247,590
Poultry	92,033,750

Exploitation of Agricultural Residues in Turkey

Total Energy Value of Agricultural Residues in Turkey

Regions	Field Crops (PJ)	%	Fruits (PJ)	%	Animals (PJ/Year)	%
Mediterranean	57,0	25	8,0	11	4,5	7
Aegean	24,2	11	15,3	20	6,0	10
Marmara	41,0	18	9,5	13	6,2	10
Central Anatolian	31,3	14	1,0	1	8,9	15
East Anatolian	8,2	4	0,9	1	10,9	18
South-eastern Anatolian	37,1	16	4,0	5	3,1	5
Black Sea	29,6	13	36,1	48	20,5	34
TOTAL	228,4	100	74,8	100	60,1	100

Maize % 33.4,
Wheat % 27.6
Cotton % 18.1

Hazelnut % 55.8
Olive % 25.9

Exploitation of Agricultural Residues in Turkey

http://www.agrowaste-tr.org

Agricultural Biomass Potential of Turkey

Click Regions for Regional Data

Agricultural Productions, Residues and Total Heating Values of TURKEY

Field Crops	Residues	Productions (tons)	Area (ha)	Total Residues(tons) Theoretic	Total Residues(tons) Actual	Available Residues(tons)	Total Heating Value (GJ)
Wheat	Straw	22.439.043	9.265.785	29.170.760	23.433.811	3.515.075	62.919.847
Maize	Stalks	2.952.394	565.109	5.904.788	4.964.802	2.978.883	55.109.349
	Cob			797.145	1.905.027	1.143.017	19.888.497
Barley	Straw	7.921.456	3.549.858	9.505.747	8.394.564	1.259.185	22.035.757
Rye	Straw	253.243	145.907	405.189	358.221	53.734	940.356
Oats	Straw	322.830	146.020	419.684	321.938	48.293	840.300
Millet	Stalks	7.283	3.605	10.196	0	0	0
Rice	Straw	332.142	67.161	584.570	209.534	125.722	2.099.561
	Husk			89.679	77.749	62.200	807.357
Tobacco	Stalks	181.320	222.515	362.640	410.487	246.292	3.965.306
Cotton	Stalks	2.474.868	687.787	6.830.637	2.554.418	1.532.649	27.894.213
	Ginning residue			519.721	742.463	593.972	9.295.662
Sunflower	Stalks	839.066	545.914	2.349.387	2.280.098	1.368.058	19.426.425
Groundnuts	Straw	71.594	25.167	164.666	0	0	0
	Shells			35.798	28.638	22.910	475.153

Animals	Residues	Animal Number	Waste Quantity (tons/year)	Available Dry Manure (tons/year)	Available Biogas (m3/year)	Total Heating Value (GJ/year)
Cow	Manure	12.934.485	128.602.413	10.616.129	2.123.225.839	48.197.227
Sheep	Manure	30.035.590	24.666.733	801.669	160.333.765	3.639.576
Poultry	Manure	265.606.950	7.755.723	1.919.541	383.908.289	8.714.718

Exploitation of Agricultural Residues in Turkey

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<< Home

CENTRAL ANATOLIAN REGION

Click Provinces for Data

AKSARAY ANKARA ÇANKIRI ESKİŞEHİR KARAMAN KAYSERİ KIRIKKALE KIRŞEHİR KONYA NEVŞEHİR NİĞDE SİVAS YOZGAT

Agricultural Productions, Residues and Total Heating Values of CENTRAL ANATOLIAN REGION

Field Crops	Residues	Productions (tons)	Area (ha)	Total Residues(tons)		Available Residues (tons)	Total Heating Value (GJ)
				Theoretic	Actual		
Wheat	Straw	6.269.294	3.124.326	8.150.082	6.818.554	1.022.783	18.307.817
Maize	Stalks	15.816	3.117	31.632	20.821	12.493	231.121
	Cob			4.271	10.123	6.074	105.689
Barley	Straw	3.592.381	1.610.071	4.310.859	3.828.284	574.242	10.049.238
Rye	Straw	188.594	108.342	301.751	254.012	38.102	666.787
Oats	Straw	73.441	49.929	95.473	85.466	12.821	223.086
Millet	Stalks	0	0	0	0	0	0
Rice	Straw	12.245	2.522	21.551	6.613	3.968	66.266
	Husk			3.306	3.306	2.645	34.332
Tobacco	Stalks	0	0	0	0	0	0
Cotton	Stalks	0	0	0	0	0	0
	Ginning residue			0	0	0	0
Sunflower	Stalks	61.013	60.686	170.837	212.500	127.499	1.810.486
Groundnuts	Straw	0	0	0	0	0	0
	Shells			0	0	0	0
Soybeans	Straw	0	0	0	0	0	0

Exploitation of Agricultural Residues in Turkey

Conclusions on Exploitation of Agricultural Residues

- Although there are sufficient quantities of residues in the country, certain parameters should be taken into account before making a strategy for their energy exploitation.
  - Small farming size depends on the region (increases harvesting and transportation costs).
  - Environmental risks caused by the removal of the residues from the field (erosion in sloping and low fertility areas, etc.).
  - Opportunity cost of the residue (e.g. cereals straw has already a market price as it is sold for animal feeding purposes and paper industry)
  - Lack of commercial harvesting machinery for certain residue types (e.g. higher cutting stalks of maize and cereals, cotton residues).

Agricultural residues in Estonia - resources and possibilities

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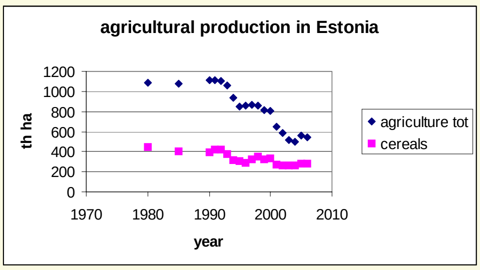
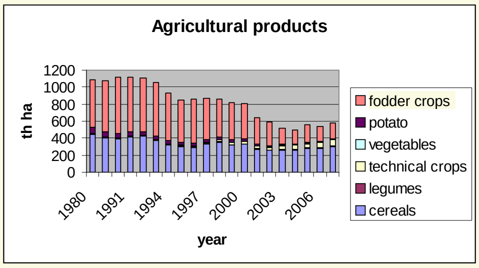
Background

- Half of the agricultural land has not being used in recent years (since 1990s)



Background

- After recession, small increase in agriculture
- More attention to technical crops (rape) presently



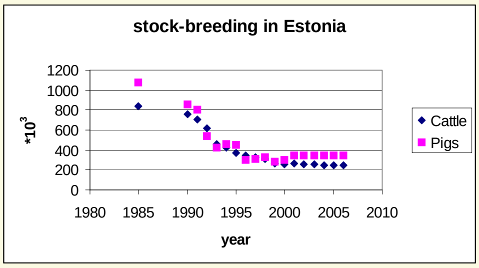
Background

Agricultural production thousands tons

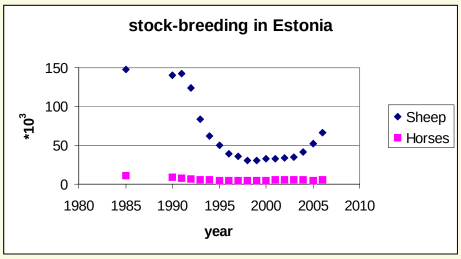
	2000	2001	2002	2003	2004	2005	2006
Total	809.8	644.2	588.1	517.3	495.6	560.7	539
Cereals	329.3	274.1	259.2	263.2	261	282.1	280.3
….rye	28.9	20.9	17.9	15.2	8.1	7.4	7.3
….winter wheat	21.7	25.5	27.8	25.5	23.2	19.6	23.6
….winter barley	..	..	..	0.1	0.2	0.5	0.5
….triticale	..	4.2	5.3	7.2	6.5	6.2	2.5
….summer wheat	47.2	34.1	36.7	41.7	55.2	65.8	67.3
….summer barley	165.1	134.3	129.9	131.3	127	143.7	141.5
….oats	53.3	48.1	35.2	36.5	35.4	33.7	32.6
….mixture	12.6	6.3	6.3	5.6	5.1	4.5	4.9
….buckwheat	0.5	0.7	0.1	0.1	0.3	0.7	0.1
Legumes	3.9	3.7	2.4	4.4	4.3	4.4	4.6
Technical crops	29.1	28.3	33.2	46.7	50.6	47.1	62.9
Vegetables	3.8	3.3	3	3.4	3.5	3	2.8
Potato	30.9	22.1	16	17	16.1	14	11.5
Fodder crops	412.8	312.7	274.3	182.6	160.1	210.1	176.9

Background

- Number of livestock also decreased threefold



- The only increase is in sheep number



Competition between uses

- plant growing residues: feed - biogas
- straw: building material - fertiliser - biogas - burning
- manure: fertiliser - biogas - burning

Sources evaluation:

- Agricultural residues from vegetables are large in ratio, but small in total amount
- Straw production 1 t dry matter per ha varies among crops and agro-techniques
- 10 % of straw needed for animals, 25…75 % of straw needed for field fertilisation

Case studies. Biogas

Jööri Biogas plant:

- opened in 2005
- raw material pig slurry and sewage sludge
- capacity 350 kW

Case studies. Biogas

Problems with Jööri Biogas plant

- lack of technical malfunction backup system
- system corrosion
- poor residue usage

Case studies. Straw boilers

Lutter, 2006

Tamsalu straw boiler

- energy supply for the distant heating plant
- capacity 850 kW
- established in 2006

Case studies. Straw boilers

Problematic:

- supply system with straw
- influence on local soil
- subsidy policy

Poorly studied resources

Influence of agricultural residues as fertilisers for energy crops?

- Pig slurry biogas digestate to SRF

Poorly studied resources

Resource of Natura 2000 semi-natural communities for biomass production?

- Amount and quality of hay in mandatory set aside areas (resource 20,000 ha)

Sources of biomass , energy potential and collection of statistical data concerning availability and utilization of biomass in Slovakia

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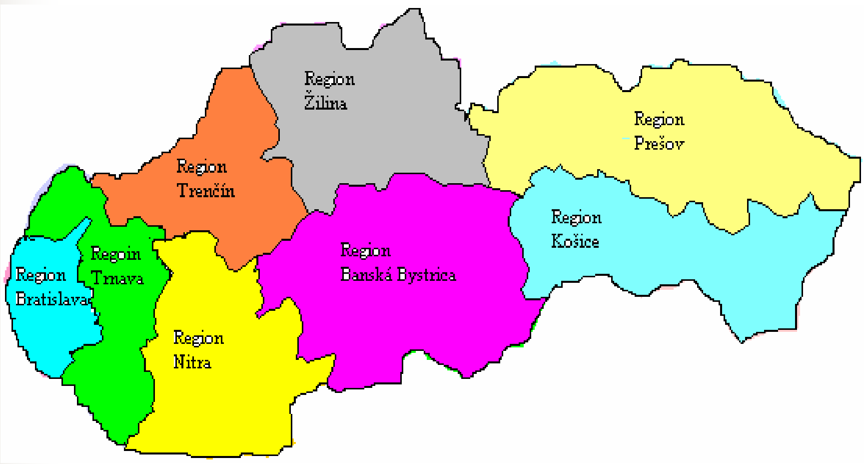
Map of Slovak regions



Characteristics of the regions of Slovakia

Region

Region	Number of inhabitants	Area in km^2	Number of inhabitants per km^2	The number of villages
Bratislava	599 042	2 052	292	73
Trnava	550 918	4 147	133	251
Trenčín	604 917	4 502	134	276
Nitra	712 312	6 344	112	354
Žilina	692 434	6 801	102	315
Banská Bystrica	661 343	9 455	70	516
Prešov	791 335	8 981	88	666
Košice	766 650	6 752	114	440
Slovakia	**5 378 951**	**49 034**	**110**	**2 898**

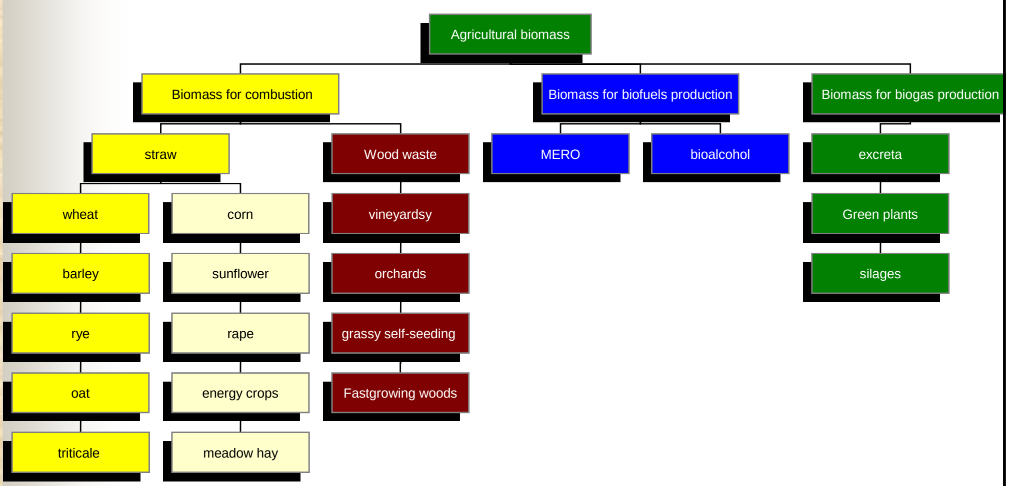
Structure of regions in Slovakia (ha)

Region	Arable land	Agricultural land	Forest land	Water areas	Built-up areas	Other area
Bratislava	46 141	66 012	75 429	5 582	14 230	19 683
Trnava	264 323	294 322	65 205	14 363	26 546	28 650
Trenčín	100 097	186 891	220 537	6 296	22 601	20 164
Nitra	407 032	469 763	96 094	15 653	37 088	31 428
Žilina	64 437	248 067	376 191	12 814	24 591	31 210
Banská Bystrica	168 621	419 634	462 113	7 861	32 660	31 117
Prešov	154 921	218 055	440 504	14 131	30 861	40 459
Košice	205 591	338 469	266 056	16 231	33 898	36 715
Slovakia	**1 411 163**	**2 439 408**	**2 002 129**	**92 932**	**222 475**	**146 404**

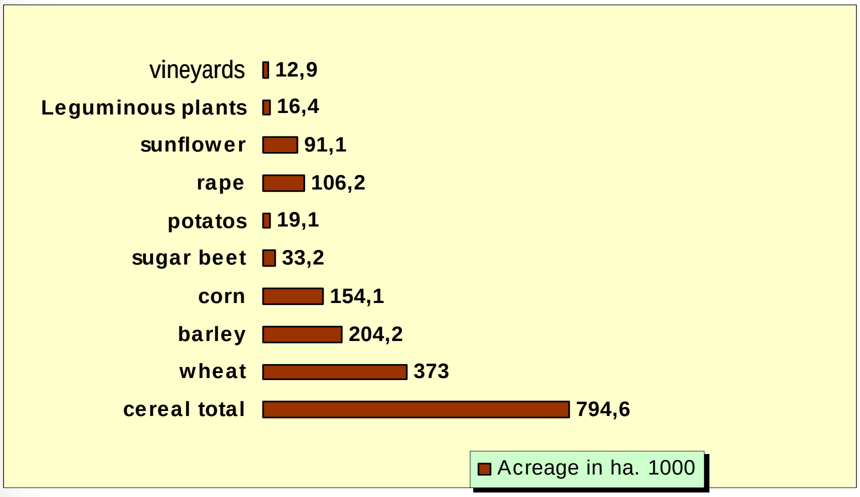
Acreage of agricultural land in Slovakia (ha)

Indicator Year	2003	2004	2005
Used agricultural land	2 236 036	1 934 659	1 941 380
From that: arable lands	1 379 379	1 360 893	1 357 201
permanent grasslands	794 733	514 478	524 110

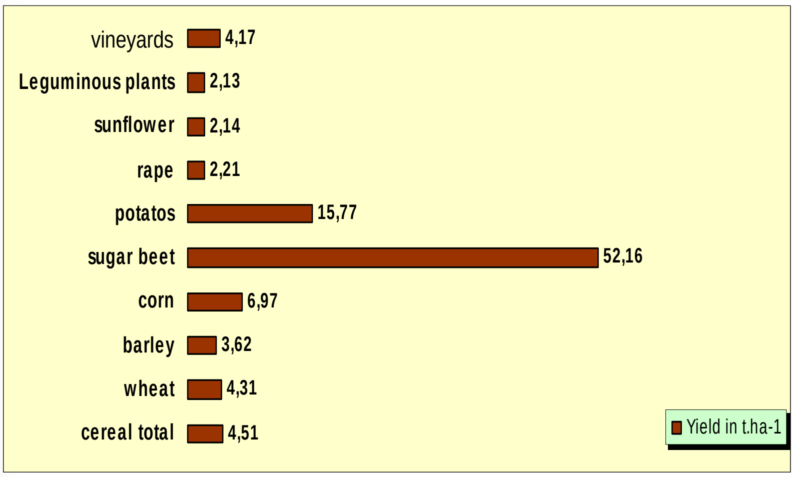
CLASSIFICATION OF AGRICULTURAL BIOMASS



Harvested areas for main crops (2005)



Yields of the main crops (2005)



Number of farm animals until 1.12.2005

Region	Cattle total	Cows from that	Pigs total	Sow from that
SR	527 889	229 607	1 108 265	79 529
BA	16 756	7 740	25 890	2 601
TT	87 240	34 266	278 275	22 328
TN	53 285	22 497	120 808	8 607
NR	83 539	33 234	317 470	22 432
ZA	72 516	33 132	36 700	1 591
BB	81 510	36 583	139 109	11 062
PO	81 139	39 621	83 724	4 420
KE	51 904	22 534	106 289	6 488

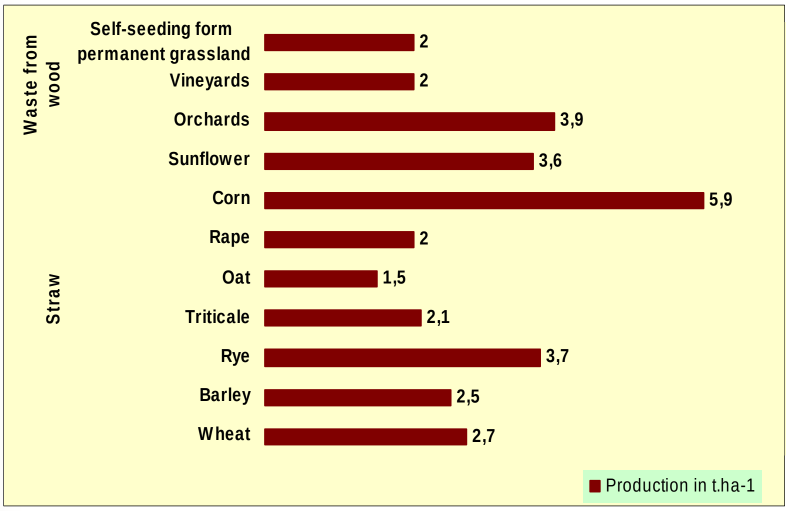
Region	Sheep total	Poultry total	Hens from that
SR	320 487	14 084 079	5 591 218
BA	815	487 259	254 490
TT	1 873	2 101 932	564 058
TN	23 925	2 332 641	605 931
NR	10 064	3 738 784	1 593 775
ZA	74 488	1 242 994	391 892
BB	101 839	1 451 716	656 014
PO	67 710	1 183 055	554 918
KE	39 773	1 545 698	970 140

Structure of forests according to utilization and ownership until 31.12.2005 and evolution of wood cuts

Ownership	**Acreage of stands (ha)**	
	ownership	**utilization**
State	807 753	1 130 786
Non-state	1 011 096	800 859
Unknown	112 796	-
Total	**1 931 645**	**1 931 645**

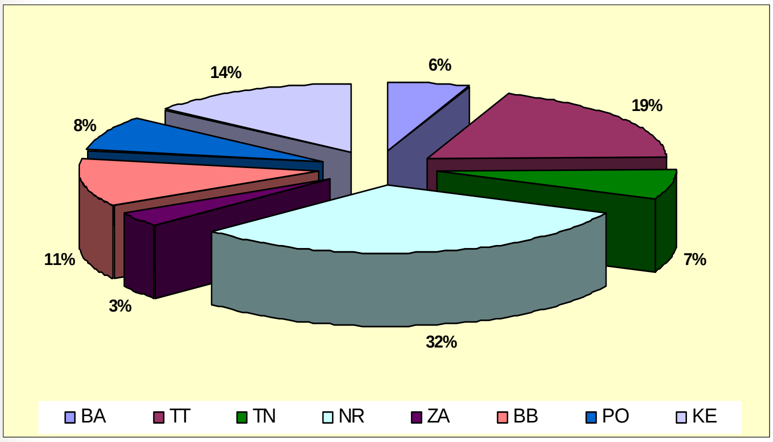
Wood cutting	**Year**											
	1990			**2000**			**2004**			**2005**		
	Realized wood cuts **in 10^3 m^3 (1)**			of which accidental cuts **in 10^3 m^3 (2)**			share of accidental cuts **% (3)**					
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Coniferous	2777	1838	66,2	3245	2012	62	4000,7	2550	63,9	6927	6152	88,8
Foliaceous	2499	766	30,7	2973	1010	34	3267,4	361	11	3263	380,3	11,7
Total	5276	2604	49,3	6218	3021	48	7268,1	2916	40,1	10190	6533	64,1

Average hectare production of biomass in 2004

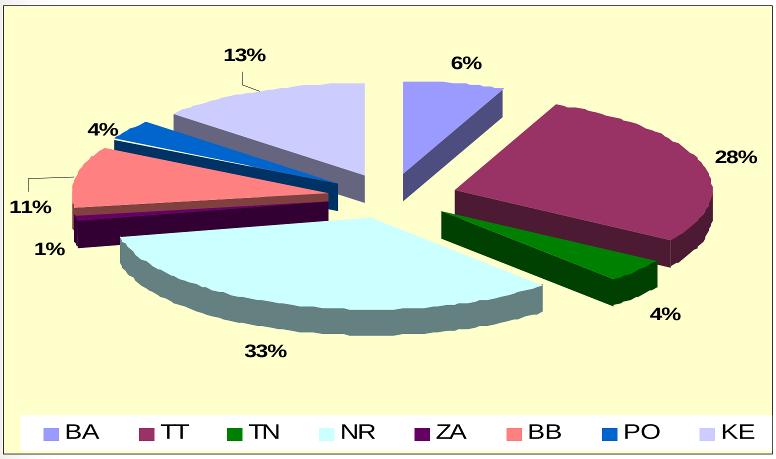


Total production of biomass in the year 2005

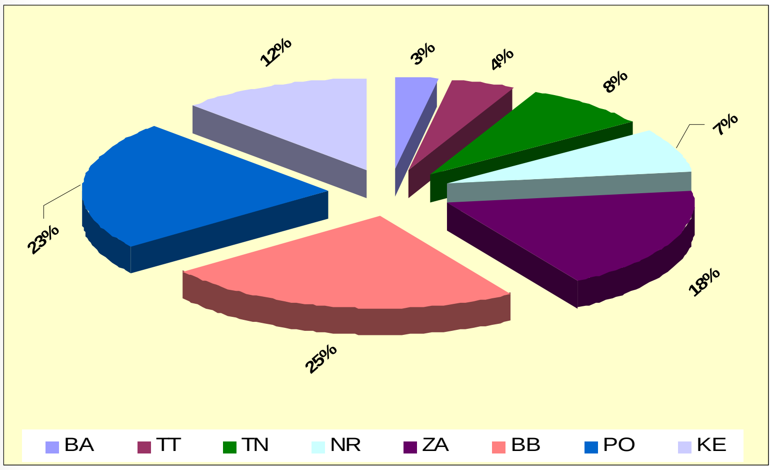
Share of cereal straw (regions / total Slovak production, 2005)



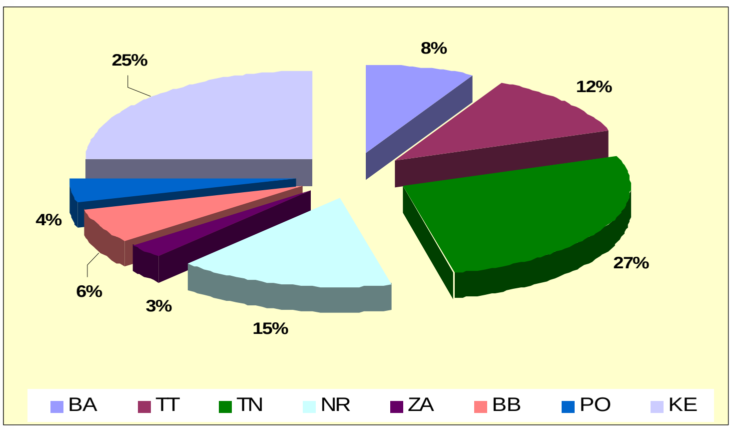
Share of others types of straw (regions / total Slovak production, 2005)



Share of wood waste (regions / total Slovak production, 2005)



Share of manure from livestock production (regions / total Slovak production, 2005)



Forest biomass

- The total cutting of wood was 10,190,000 m^3 in 2005
  - of which 6,927,000 m^3 of coniferous wood
  - 3,263,000 m^3 of foliaceous wood
- The total production of wood residues was 1,810,000 tons
- The total production of wood residues from wood-processing industry is 1,410,000 tons

Biomass for biofuels production

Supplies of crude materials for the production of esters till 2010

Year	Esters (t)	Rape (t)	Required harvest area of rape (ha)	Total acreage of rape (ha)	Ratio of area to esters, %
2005	18 376	55 128	24 944	106 204	23,48
2010	63 151	189 453	63 151	160 000	39,5

Variant 1 – Production of corn-based bioethanol

Year	Bioehtanol (t)	Corn(t)	Required area of corn (ha)	Total acreage of corn (ha)	Ratio of area to bioethanol, %
2005	15 935	39 837	6 639	154 085	4,3
2010	47 122	117 805	16 829	140 000	12,0

Variant 2 – Bioethanol production on the base of high-density sown cereals

Year	Bioethanol (t)	Cereals (t)	Required area of cereals (ha)	Total acreage of cereals (ha)	Ratio of area to bioethanol, %
2005	15 935	52 585	10 517	372 962	2,8
2010	47 122	155 500	25 918	450 000	5,8

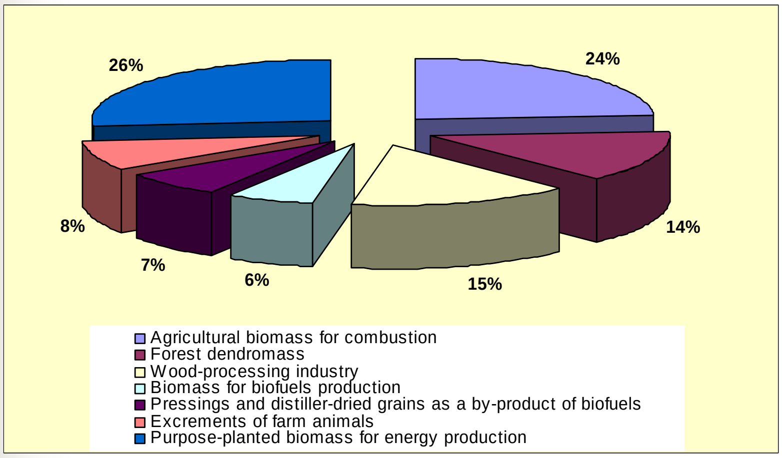
Production of Municipal Waste (MW) and Biodegradable Waste (BDW)

Waste in t	Year 2004	Year 2005
Municipal waste (MW), from that	1 475 123,7	1 558 262,9
Biodegradable waste (BDW)	86 547	95 864

Total energetic potential of agricultural biomass

Sort of biomass	Amount/volume	Energetic potential in PJ
Agr. Biomass for incineration/combustion	2 031 000 t	28,6
Forest dendromass	1 810 000 t	16,9
Wood-processing industry	1 410 000 t	18,1
Biomass for production of bio fuels	200 000 t	7,0
Pressings and distiller-dried grains as a by-product of bio fuels	400 000	8,4
Manure from farm animals	13 700 000	9,3
Biomass planted for energy production	300 000 ha	32,0
Total		**120,3**

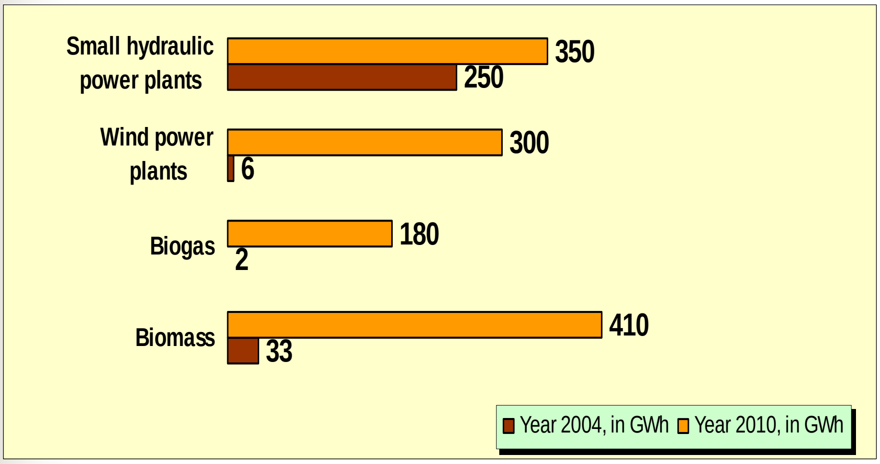
Energetic potential of agricultural biomass categories



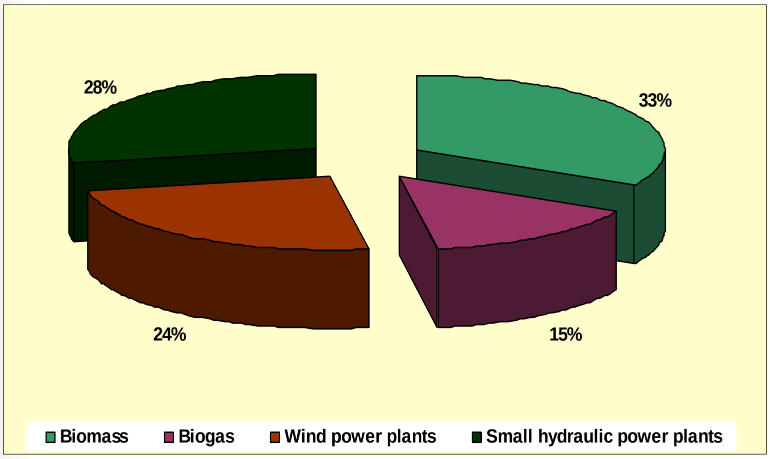
Forecast of energy production in 2010

Source	Year 2004, in GWh	Year 2010, in GWh
Biomass	33	410
Biogas	2	180
Wind-power plant	6	300
Small hydraulic power plant	250	350
Total	**291**	**1240**

Forecast of electricity production in 2010



Assumed share of several RES in power production in 2010



Risk related to the development of the use of biomass and RES in Slovakia

- lack of available capital,
- lack of scientific research,
- slow restructuring and modernization of energy technologies,
- slow change of inefficient technologies increasing production costs,
- limited financial governmental support for applied research.

Recommendations on the use of biomass in Slovakia

- issue appropriate legislative regulation to support biomass utilization most optimal solution - act supporting heat and electricity production from RES,
- develop local concept of support to biomass for energy,
- create consultation centre for biomass,
- disseminate knowledge among biomass producers,
- introduce education specialists for biomass and RES in the schools,
- support gasification and tri-generation,
- evaluate biomass in combined heat and electricity production,
- establishment and development pilot project of utilization agricultural biomass for space heating, water heating, drying agricultural biomass and electricity production.

Workshop
Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries

Novi Sad, Serbia, October 2-3, 2007

Potentials and Limits of the use Agricultural Residues for Bioenergy in Lithuania

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LITHUANIA

- Population - 3,4 mil
- Total area – 65000 sq km
- Agricultural land – 3.5 mil ha,
- Forests – 2.0 mil ha
- Total arable land – 2.9 mil ha,
- Meadows and natural pastures – 0.5 mil ha.

K. Navickas Lithuania 2

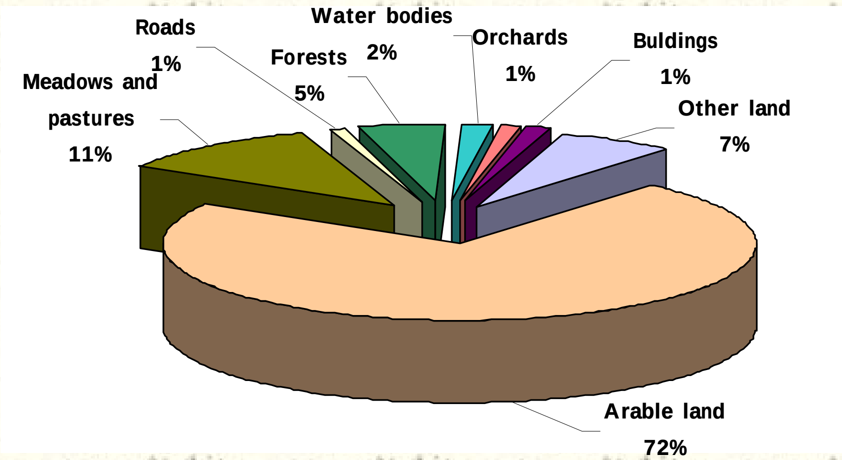
Lithuania's climate conditions

- Lithuanian's climate temperate between maritime and continental. The average annual precipitation level is 630 mm, which is higher in the western and lower in the eastern part of the country. 82% of agricultural land is drained.

- The average annual temperature is 6 ºC (the lowest –4.8 ºC in January and the highest 17.2 ºC in July). The length of active growth season, with temperatures above 10 ºC, is 135-150 days.

- Low fertility acid soils account for 63% of the country. Fertile soils account for 26% and prevail the central part of Lithuania.

Structure of land use for agricultural activities in 2005



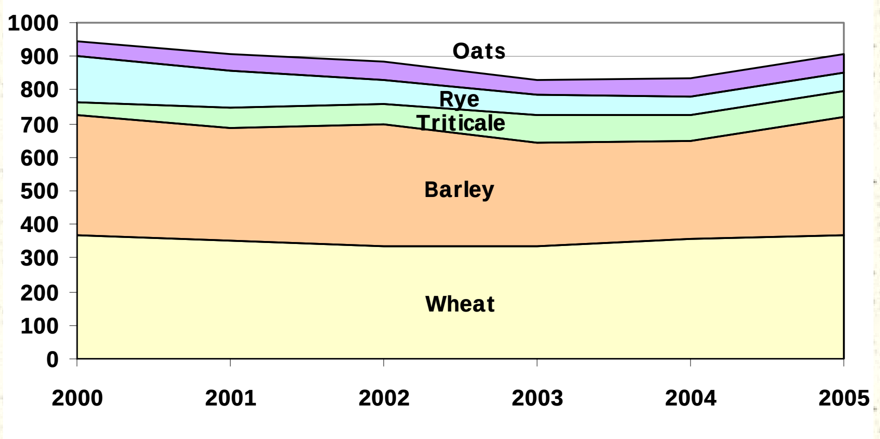
Main cereals

Traditionally cereals have been one of Lithuania's most important agricultural sectors. Cereals are grown for domestic feed and food needs. Cereals cover about 60% of the total crop area and are grown on almost every farm.

After EU Accession cereal crop area increased by 10% and reached 950000 ha in 2005. It was influenced by prospects of higher prices, direct payments and changes in the market. In 2005 81% of grain plants were sown by farmers and residents private farms. The remaining part was sown by agricultural companies.

Most popular cereals are wheat and barley. In 2005 wheat was grown on 370,000 ha, barley – 350,000 ha. Area of rye decreased due slip of prices and demand in the market.

Area of main cereals, 1000 ha



Department of Statistics of the Government of the Republic of Lithuania

Yields of cereals

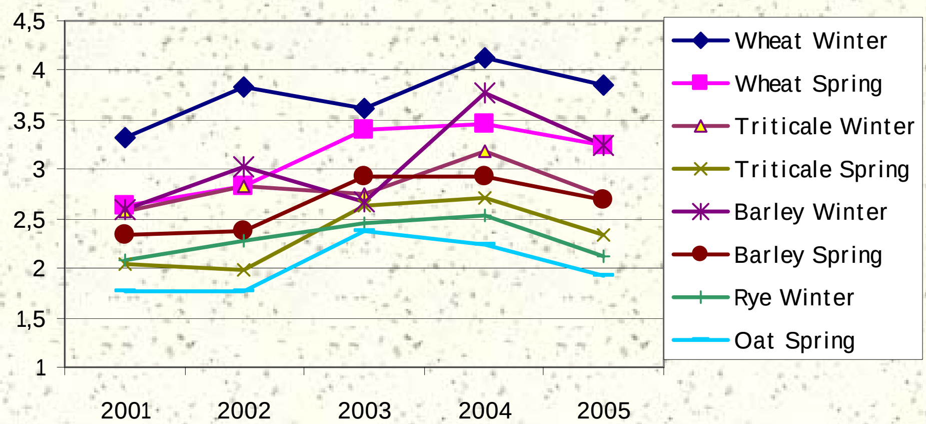
Yields of cereals are lower than in other EU countries. In the 2005 average yield from cereals was 2.9 ton/ha. Less use of fertilizers and pesticides, small scale farms, insufficient machinery and unfavorable climate influence this difference.

There are differences of the yield on some regions, influenced by climate conditions.

Stronger competition in the EU threatens grain growers' profitability; they need to increase cereal yields, improve grain quality, reduce costs and develop growing technologies.

Production of grain in the period 2000-2005 increased by 200 thousand tones – from 2,7 mil. tones in 2000 to 2,9 in 2005.

Yields of main cereals, ton/ha



National legal basis on Renewable Energy

The use of RES is one of the main objectives of the Lithuanian energy policy set out in the Law on Energy and the National Energy Strategy approved by Resolution of the Parliament aiming at a 12% share of renewable energy sources in the total energy consumption by 2010.

The promotion of the production and use of biofuel is foreseen in the Law on Biofuel, Biofuels for Transport and Bio-oils providing for the competence of institutions. The Law obligates to prepare measures to ensure that by 31 December 2010 the share of biofuels for transport shall amount to at least 5.75 % of the total energy content of all petrol and diesel for transport purposes placed on the national market. The production of biofuel is attributed to new, environment-friendly technologies.

The Law on Electricity provides for certain priorities of electricity produced from renewable, waste or local energy sources. Electricity, produced on biomass plants, has a special price of 0.06 Euro/kWh.

National legal basis on Renewable Energy

The Law on Environmental Protection promotes waste recycling for energy purposes.

The Law on Pollution Tax provides that natural and legal persons implementing measures intended to reduce pollutant emissions from stationary pollution sources at least by 10%, shall be exempt from the pollution tax.

The Rules for financing the production of biofuels for transport are approved annually by the Minister for Agriculture, providing for promotion biofuel production facilitating the use of agricultural produce for non-food applications. Farmers receive the EU subsidies of 45 Euro per hectare for selling crops for energy production.

The Government approved the updated Description of the procedure including general criteria, conditions and requirements for the promotion of generation and purchasing of electric power produced using RES: it promotes electric power generation in wind, biomass and solar hydro plants of a capacity of less than 10 MW.

Implementation of RES in Lithuania

RE sources	Energy production, TWh		
	2005	2010	2020
Wood	**8.24**	**9.50**	**9.80**
Straw	0.03	0.50	1.50
Liquid biofuel	0.04	0.72	2.25
Municipal waste	0.00	0.00	0.46
Biogas Landfill gas	0.02	0.14	0.28
Geothermal	0.017	0.11	0.11
Hydro	0.45	0.46	0.58
Solar	0.00	0.00	0.00
Wind	0.00	0.29	0.85
Total	**8.80**	**11.7**	**14.3**

Biomass energy

In 2006, Lithuania had:

- two cogeneration plants using wood waste, with a total installed capacity of 13.5 MW;

- seven biogas power plants, including five cogeneration plants (able to generate both heat and power) and two heat-only generation plants. The total installed capacity of biogas power plants is about 17.1 MW (heat generation plant - about 15.0 MW, power plant - about 2.1 MW).

At present, there are 200 boiler-houses (of over 0.3 MW capacity) using biofuel (wood, wood waste and straw). The total installed capacity of the boiler-houses is about 500 MW.

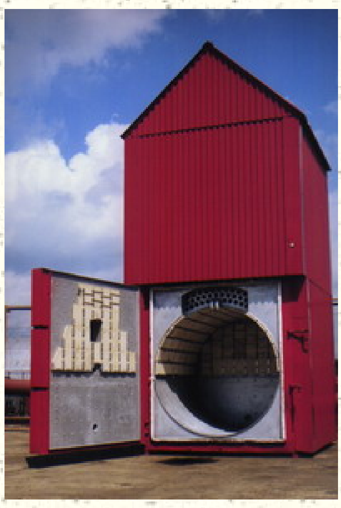
In the updated National Energy Strategy the plans are 50 % of Lithuania's central heating to be provided by biomass by 2025. Lithuania plans to double use of biomass for heat and power using wood, straw, municipal waste, as well as fast growing trees and crops.

Straw

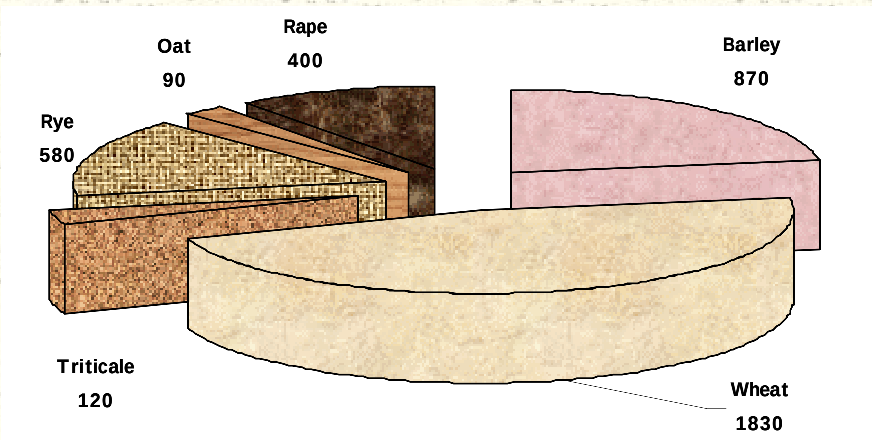
Estimation shows that total yield of straw in Lithuania amounts to 3,5-4,0 mill tones per year. This includes rye, winter and spring wheat, triticale, barley, oats and rape straw. Traditionally straw is used for fodder, bedding, gardening and mushrooms. Part is left in the fields. It can be assumed that about 10-12% of the total amount of straw or 400-500,000tonnes could be used as a fuel.

Straw for the fuel started to be used in Lithuania in 1996. Recently the total installed capacity of straw-fired boilers make up 5 MW. Capacities of these boilers varies from 15 to 340 kW. About 7500 tones of straw is used for fuel.

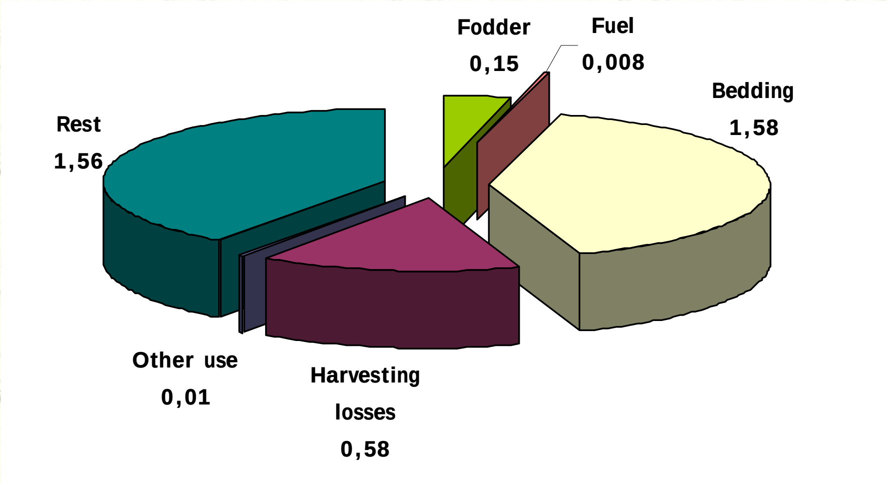
Small scale boilers are installed at individual farmhouses. Larger boilers are designated for district heating systems.



Straw yield, 1000 t.



Straw use, mill. t.



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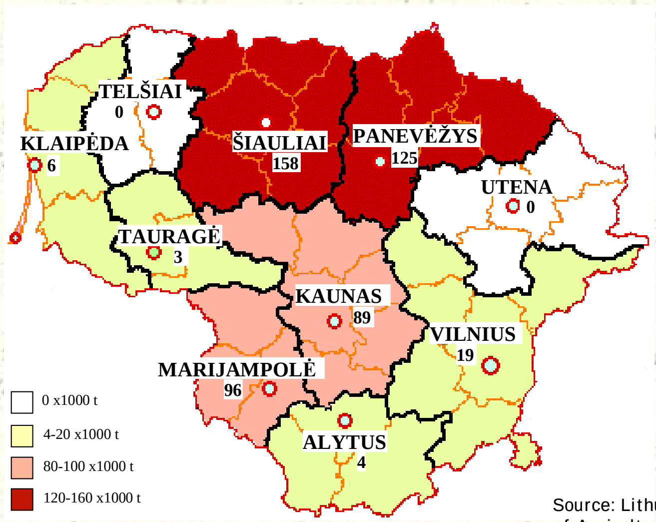
Regional distribution of possible use of straw for energy, 1000 t DM



Source: Lithuanian Institute of Agricultural Engineering

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Estimation of straw based plants

The installation costs of straw-burning plants vary significantly from 583 to 2029 Lt/kW. Such large variation of installation costs are because different infrastructure (new boiler-house buildings, fuel storage buildings etc.) are included in the project costs. Investments are lower when boilers are placed in the existent boiler houses.

Price of straw fuel varies from 3,79 to 5,36 Lt/GJ (according to calorific value) and it depends on the way of acquisition. Three different cases in provision of straw are observed. The cheapest one is when the owner of boiler is agricultural institution or similar and has its own straw resources. The second case is when straw is purchased from farmers or agricultural companies. The third case is when owner of boiler rents field of cereals after harvesting aiming to collect straw for fuel purposes.

Average energy production cost for straw based plants is app. 18 Lt/GJ, it includes operation and maintenance cost of app. 6 Lt/GJ. Average energy price is 38 Lt/GJ (based on calorific value).

K. Navickas Lithuania

Source: Lithuanian Energy Institute

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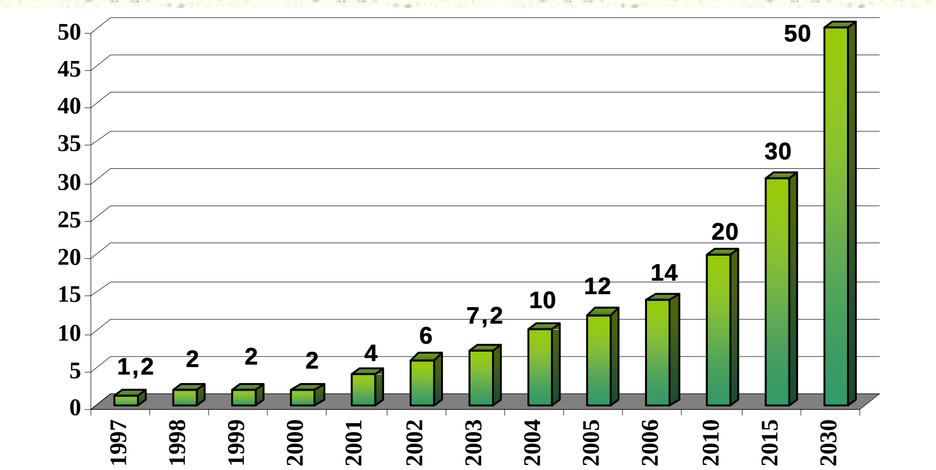
Solid biofuel (wood, straw) in district heating (%)



Source: LITBIOMA

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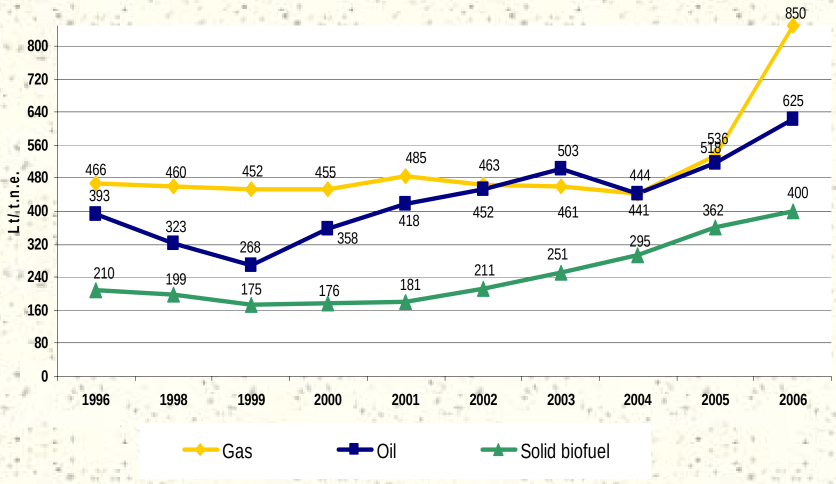
18

Average costs of main fuels



Liquid biofuel perspectives

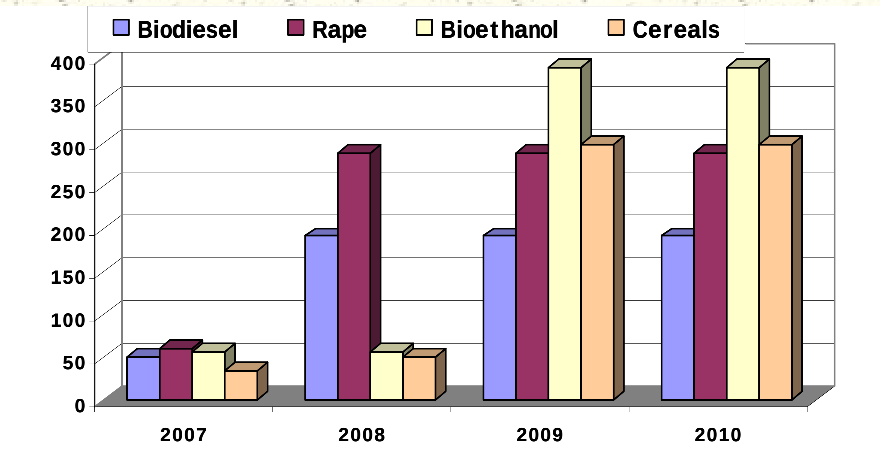
In 2007 Lithuanian biofuel production should reach 60,000 t. Ethanol production will increase to 20,000 t, production of biodiesel will increase to 40,000 t.

The Lithuanian Ministry of Agriculture has set production targets of 190 thousand tons of biodiesel and 190 thousand tons of ethanol for 2010. Even at those levels, Lithuania believes it can produce enough raw materials domestically for biofuel production, but above 380 thousand t, it would need to import grain. The government believes that these ambitious projections are possible to meet based on the new biofuel plants under construction and the plans to increase acreage of biofuel crops.

About 10-15% of the country's agricultural crop areas could be used for the cultivation of plants intended for energy purposes. By 2010, oilseed rape (raw material for the production of biodiesel) crop areas are expected to cover about 290 000 ha, with those of cereal grains (raw material for the production of bioethanol) to cover about 250 000 ha.

Expansion area for energy cereals will make additional straw production. It can be basis for further development of new straw based energy plants.

Production of biofuel and required area of cereals



K. Navickas Lithuania 21

Conclusions

Cereals cover about 60% (950.000 ha) of the total crop area and are grown on almost every farm. Most popular are wheat and barley.

Total yield of straw in Lithuania amounts to 3,5-4,0 mill tones per year. Traditionally straw is used for fodder, bedding, gardening and mushrooms. Present straw use for fuel is 7500 tones per year. It can be assumed that about 10-12% of the total amount of straw or 400-500,000 tones could be used as a fuel.

The straw use as fuel increases slightly, due to the relatively expensive straw combustion equipments, big investments to infrastructure (straw collection, pressing and transportation), lack of traditions.

Growing interest of liquid biofuel production will increase area biofuel crops and straw production as well. It can influence interest of straw energy use.

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CEREALS STRAW AND AGRICULTURAL RESIDUES FOR BIOENERGY IN ROMANIA

Ion Antohe

NATIONAL AGRICULTURAL RESEARCH and DEVELOPMENT INSTITUTE FUNDULEA - ROMANIA

WORKSHOP “Cereal Straw and Agricultural Residues for Bioenergy in New Member States and Candidate Countries.
NOVI-SAD – October 2-3, 2007

INDUSTRY REVOLUTION OF XXI CENTURY WIL BE MARKED AMONG OTHERS BY BIO-ECONOMY

CEREAL STRAW YIELD AND ENERGY POTENTIAL
ROMANIA (2000 – 2006)

	YEAR						X
	2000	2001	2002	2003	2004	2005	
Wheat crop area (million ha)	1,940	2,559	2,310	1,748	2,296	2,476	2,221
Total straw yield (million t dry matter)	2,864	4,449	2,991	1,582	4,486	4,392	3,461
Collectable straw/grain ratio	0,6	0,5	0,6	0,5	0,8	0,8	0,63
Energy potential: (million. toe)	0,9738	1,4831	0,9971	0,5273	1,4954	1,4641	1,1568
(10^3Gj)	40,914	68,965	46,363	24,520	71,087	68,081	52,322
Biogas = 10^3Gj	57,290	89,784	59,813	31,639	62,593	110,584	100,3

Crop area data Ministry of Agriculture - 2006
Romania's Institute of statistic
Energy equiv. E.Matei, 1995

MAIZE STOVER YIELD POTENTIAL AND ITS ENERGY POTENTIAL ROMANIA 2000-2005

	YEAR						X
	2000	2001	2002	2003	2004	2005	
Maize crop area (mil. ha)	3,049	2,974	2,894	3,199	3,274	2,628	3,003
Total stover yield (million t dry matter)	7,113	14,043	12,305	13,746	21,278	14,520	13,834
stover/grain ratio	1.2	1.2	1.3	1.1	1.5	1.5	1.3
Energy potential: (million toe)	2,354	4,648	4,073	4,550	7,043	4,806	4,579
(10^3Gj)	91,192	180,04	157,756	176,23	272,790	207,428	177,356
Energy via Biogas 10^3Gj	102,211	201,283	176,372	274,920	425,558	290,379	245,120

Crop area data Ministry of Agriculture 2006
Romania's Year of Statistic. doc. 2005
Energy potential E.Matei, 1995

POTENTIAL AGRICULTURAL BIOMASS YIELD AND ITS ENERGY POTENTIAL - ROMANIA – 1995 – 2000

		extensive cropping	intensive cropping
Non irrigated land	1) Straw (wheat, barley, rye) yield - million t dry matter/yr	6.9	10.5
	Energy potential (PJ/yr)	119	183.7
	≈ 80 % efficiency	95.2	147.8
	energy density (GJ/ha)	2.7	18.4
	2) Straw (wheat, barley, rye) and agricultural residues (maize, sunflower) yield - dm t/yr	13.4	37.4
	energy potential (PJ/yr)	266.5	764.2
	≈ 80 % efficiency	212.8	611.4
	energy density (GJ/ha)	6.3	24.2
Irrigated land	Straw (wheat, barley, rye) and agricultural residues (maize, sunflower) yield (dm t/yr)	26.1	72.9
	energy potential PJ/yr	520	1,400
	≈ 80 % PJ/yr	416	1,120
	energy density (GJ/ha)	10.8	45.6

BIOENERGY OBTAINABLE FROM ENERGY CROPS IN ROMANIA DURING 2007 -2010

	Wheat straw yield (dry matter t) and its energy potential		
	2005	2007	2010
Crop area (million ha)	2.428	1.800	1.500
Straw yield (million t)	3.399	2.520	2.100
Energy potential (million toe)	1.133	0.845	0.720
10^3Gj	43.894	32.735	27.892
	Maize stover yield (dry matter t) and its energy potential during 2005-2020 years		
Crop area (million ha)	2.634	2.850	1.500
Stover yield (million t)	14.520	2.850	10.050
Energy potential (million toe)	4.806	4.948	3.141
10^3Gj	184.557	191.685	121.682
	Sunflower stalk yield (dry matter t)		
Crop area (million ha)	0.7651	0.8000	1.000
Stalk yield (million t)	0.9946	1.0415	1.3254
Energy potential (million toe)	0.3441	0.3542	0.4679
10^3Gj	16.808	17.601	22.399

FAILLING TO PLANNING IS .....PLANNING TO FAIL SUSTAINABILITY CRITERIA FOR ENERGY CROP BIOMASS IN ROMANIA

	Cereals	Maize	Sunflower	Broocorn x Sweet Sorghum-Sudanense Sudanense x Sudanense	Helianthus tuberosus
High energy ratio	≤ 1	2 - 5		3,4 - 12,5	-
High resource availability	over 1,2 million ha	over 1,5 million ha	≈ 0,8 million ha	≈0,1- 0,5 million ha after 2008	≈0,1 million ha
High non food biomass yield (mt/ha)	2,0 – 6,0	3,5 - 9	≈ 2,5 – 3,5	≈ 15 - 35	≥15 - 25
Suitability to sustainable crop sequence	common	common	special sequence	common	special sequence
Suitability to bio-refinery profitable processing	fibber, feed, fuel	feed, fuel, fibber	fuel, feed, fibber,	fibber, feed, fuel, fertiliser	fibber, fuel, fertiliser
Energy consumption saving on biomass supply chain	> 20 % water	-	> 20 % water, seed	> 40 % water, seed, fertiliser	water
Re-growing ability after climate disaster	-	-	-	good re-growing capacity	good re-growing capacity
Environmental risk	A	C	C	B/A	B
Preventing desertification and abandonment of land, capacity	small	small	intermediate	high	intermediate
Biodiversity maintaining enlarging by diversifying energy crop species	I	I	I	I	II
Soil erosion preventing capacity	high	small	small	high	medium high
Protection of human, animal and plant life or health even on	1 a	1 c	1 b	1 c	1b
Resource	straw-DDG	Stover-DDG	Stalk, roots	entire plant (bagasse panicles, leaves)	entire plant (stalk leaves)

1- assure food, feed, and even pharmaceuticals by refinery processing of entire crop.
1 a – need insecticide treatment during vegetation
1 b – usually without insecticide treatments
1 c – some years or places suited to insecticide treatments at the beginning of growing durations
I – acceptable crop sequence for farmers and ready to use technology knowledge
II – difficulties in stubble eradicating.
Cereals, maize, sorghum and Helianthus tuberosus – ethanol + higher potential reducing pollutant emissions than biodiesel.

SOIL FERTILITY CLASSES* OF ROMANIA AND LAND AREA DESTINED TO ENERGY PURPOSES

	1*	2*	3	4	5	Total
Land area (ha), of which:	124,363	2,076,873	3,350,379	236,2918	1,495,539	9,410,072
For food purposes	124,363	2,076,873	3,350,379	1,162,918	605,639	5,551,615
For non food purposes						3,858,457 of which
for RES				≈1,200,000	800,000	≈ 2,000,000
% from total arable land				9 %	6 %	15 %
EU regulations						10 - 15 %

The government paid attention to food security even in the frame work of bioenergy system. About 5,5 mil. ha are reserved for food security and that include the best I-IV soil fertility classes.

1* = ≥100 kg grain/unit of suitability class

Of 9,410,072 ha, about 3,968,126 ha under desertification process and about 930,000 ha susceptible to nitrate percolation under heavy (> 100 kg N/ha) nitrate fertilisation

ECOLOGY THE MAJOR RELIGION OF XXI CENTURY
ENVIRONMENTAL IMPACTS OF THE ENERGY CROP BIOMASS PRODUCTION

	Soil quality				Water quantity and quality		Emissions	Bio-diversity
	erosion	soil compaction	moisture retention	nutrient input	ground water	surface water	CO_2 release	
Cereals wheat	A	C	A	C	B	C	A	A
Maize	C	A	C	C	B	C	C	B
Sunflower	C	A	C	B	A	B	C	B
Sweet sorghum	B	A	B	A	A	B	C	A-B
Helianthus tuberosus	A - B	C	B	B	A	B	A	A

A = slow - poor intensity
B = medium intensity
C = strong intensity

ENERGETICAL POTENTIAL OF RES IN ROMANIA

Energy source	Potential/yr	10^3TOE	Use (intentional)
Solar	6 x10^3Gj	143,3	thermal
	1x200Gwh	103,2	electric
Wind	23.000 Gwh	1,978	electric
Hydro	40.000 Gwh	516,0	electric
Biomass	318 x 10^6 Gj	7,597	thermal and transport
Geothermal	7 x 10^6 Gj	167,0	thermal
TOTAL		10,504 x 10^3 Toe	

Evaluations of RAES; ICEMENERG; ICPE; INL; ISPH; ENERO – from Romania
GD 1335/2003

Agri forestry biomass represent one of the most important sources of RSE in Romania. Energy crops biomass could make a real contribution for rising total agricultural biomass. From 5,2 Mtoe to 7,597 toe – other biomass sources (forestry and so.on).Energy crops could enhance to 10 Mtoe/yr.

BIOMASS USED IN ROMANIA (2000)

Biomass type	Energetic potential Pj	
Firewood	40,03	
Wood residues	10,3	
Agricultural residues	35,04	
Biogas	6,02	
Others	≈24,00	
Total	116,0 → 0,81 % from a total of 1689 Pj at national level of biomas resources	

FOOD, FEED, ENERGY
- FORECAST FOR ROMANIAN AGRICULTURAL DEVELOPMENT 2025 - 2030 -

BIOMASS Processing	OBJECTIVES	FOOD	FEED	ENERGY	ENVIRONMENT RISK	NEW JOBS
BIOGAS	5 - 6,5 million cattle	≈ 18-24 million t milk	-	≈215-279 GJ	A	≈ 2-3.5 million
BIOETHANOL	liquid biofuel 2 x 10^6 m^3	-	1.5 – 1.8 x 10^3 million t	1.3 – 1.4 million toe	A – B	0.12–0.15 million
BIODIESEL	liquid biofuel 6 -7 x 10^5 t	-	1 x 10^6 million t	0.50 – 0.55 million toe	A	0.1 million
PYROLYSE OIL	liquid biofuel ≈3 x 10^3	-		0.,4 million toe	A	0.1 million

Bioethanol and biodiesel from energy crops could be preferred solutions
Biogas is suitable for cattle manure processing. The cereals straw used as cattle bedding (about 9 million) is by far the best uses for obtaining, food, energy and fertiliser (humus forerunners) at the same time with a larger offer for new job (animal growing).
Pyrolysis technology is a tool for incinerating agricultural residues containing contaminant pathogens and pests
Biodiesel obtained from non traditional food oil (Rape, Camelina, etc.) could be a good solution for sustaining biodiversity, biomass chain supply and feed quantity, quality and diversity.

ONGOING PROJECTS FOR BIOFUEL PLANTS IN ROMANIA

Ethanol plants $\geq 10^4$ t/yr	Biodiesel plants $\geq 10^4$ t/yr	Biogas plants	Fast pyrolysis plants	Pellet plants
> 10	> 7	> 5	1	8 - 10
of which				
- 3 plants of 10^3 t/yr - 2 plants of 10^5 t/yr - one plants lignocellulosic raw material which probably will start during 2009-2010 Estimated production 1000 x 10^3 t/yr	six of them being established to start operating during 2007-2008 estimated production 600 x 10^3 t/yr	- 3 plants on sewage sludge of bioethanol plants - one plant is operating from 2006	- one plant starting during 2008 at pilot scale and during 2009 at commercial scale	- 3 plants on straw, agricultural residues and landfill - export of agro-forestry pellets about 50 x 10^3 t/yr

LIGNOCELLULOSE CONTENT OF CEREALS

(percentage by weight)

Agricultural biomass	Cellulose* K-H	Lignine	Penthosans	Ash
Sweet sorghum stalks	28 - 32	15 - 17	19 - 23	2.3 – 3.7
Sweet sorghum (bagasse)	35	14	20.0	2.6
Sorghum x Sudanense – hybrids	42 - 52	13 - 17	19 – 22.5	2.5 – 3.5
Sudanense x Sorghum	56.4	13	20.0	4.5
Broomcorn (Sorghum var.technichum)	35 - 50	17 - 19	19 - 24	4.9
Rice straw		15.9	21.1	14.4
Wheat straw	45.8	20.0	24.9	4.0
Agricultural residues	30 - 42	11 - 29	-	2 - 18
Jerusalem artichoke (Helianthus tuberosus (L))	32	9	-	39

K-H = Kürschner-Hoffer

CHEMICAL COMPOSITION OF STRAW AND OTHER AGRICULTURAL RESIDUES FOR GASIFICATION PURPOSE

Biomass	Percentage (by weight)					
	Humid (%)	Ash	C	H	S	O_2 (+N)
Reed	12.24	5.17	40.05	5.32	trail	37.22
Rice barks	13.55	13.34	33.79	4.38	“”	32.94
Sunflower barks	12.82	1.89	37.86	5.26	“”	42.17
Cereal straw	6.82	6.52	43.27	5.35	“”	38.04

PHYSICAL CHARACTERISTICS OF AGRICULTURAL BIOMASS

Biomass	Volatile materials dm	Calorific value Kcal/kg	
		max.	min.
Reed	65.24	3,846	3,486
Rice barks	43.51	3,470	3,153
Sunflower barks	61.57	3,795	3,465
Cereal straw	71.83	4,070	3,740

LEGISLATION DRAFT FOR BIOENERGY PROMOTION IN ROMANIA

Law 199/2000 - on Efficiently use of energy in Romania
Law 443/2003 - Electrical energy producing from RES – In Romania
GD 1335/2003 - RES using strategy in Romania (Energy saving)
Law 571/2003} ___on exemption of excise fee for biofuels
343/2006}
Law 1835 – 2004
GD 1844 – 2005 – adoption of 2003/30/CE directive
GD 44 -2006 – Biodiesel consumers and biofuels investments subsidies
Ministry agricultural order 607/aug.2006 – energy crop subsidies for 2007-2009.
GD = government decision.

ENERGY BIOMASS RATE (% OF TOTAL ENERGY CONSUMPTION) USED FOR ELECTRICITY, HEAT AND TRANSPORT

	Year	RES	Electricity	Heat	Transport
EU	2005	6 %	14 %	≈10 %	1 %
	2010	12 %	22 %	16%	5.75 %
	2020	20 %	33 %		10 %
ROMANIA	2005	10.01 %	27 %		20 %
	2010	11%	29.9 %		5.75%
	2015	15%	33.5 %		≈ 10 %
	2020	20%	≈ 50 %		≥ 20 %

Balance of straw in Poland

Jan Kuś, Mariusz Matyka

Department of Systems and Economics of Crop Production

Novi Sad, 2-3 October 2007

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150 years of tradition in agricultural science in Pulawy

1862 – Technical Institute of Technology Agriculture and Forestry

1917 – National Research Institute of Rural Husbandry (PINGW)

1950 – Institute of Soil Science and Plant Cultivation (IUNG)

2005 – Institute of Soil Science and Plant Cultivation – National Research Institute (IUNG-PIB)

- **the oldest agricultural centre in Poland**
- **the second oldest agricultural centre in Europe (after Rothamsted)**

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Director General — **Scientific Council**

- Department of Agrometeorology and Applied Informatics
- Department of Soil Science, Erosion and Land Conservation
- Department of Systems and Economics of Crop Production
- Department of Soil Tillage and Fertilization
- Department of Plant Nutrition and Fertilization
- Department of Agricultural Microbiology
- Department of Biochemistry and Crop Quality
- Department of Ecology and Weed Control
- Department of Breeding and Production of Special Crops
- Department of Forage Crop Production
- Department of Cereal Crop Production
- Experimental Stations

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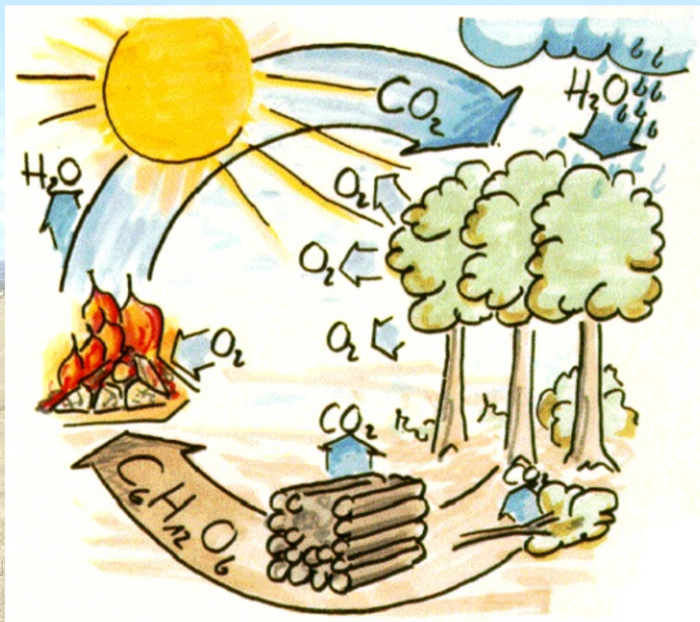
the evaluation criteria of solutions offered by the science and advisory service

Earlier:	**maximization of production and profits**
Now:	**the quality of products**
	economic effectiveness
	safety for natural environment and human health
	optimisation of use of production factors

Biomass – renewable energy sources



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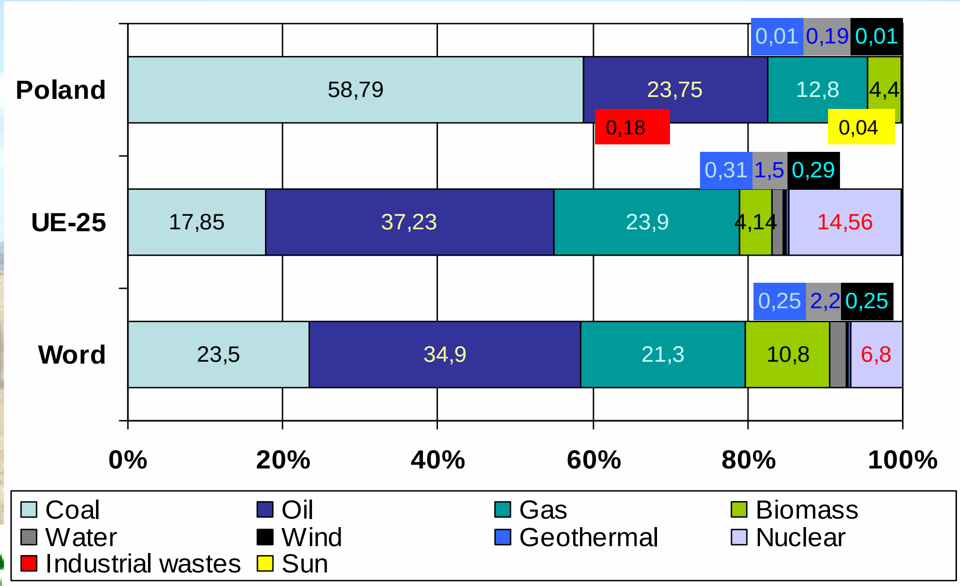
Consumption of energy carriers



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Targets in the area of utilization of renewable energy sources - % in balance of primary energy:

Specification	2001	2010	2020
Poland*	1,0-1,5	7,5	14
UE	6	12	over 20

**/ Strategy for development accepted by government (5. 09. 2000) and approve by Sejm Republic of Poland (23. 08. 2001).*

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Possibility for utilization of straw

PROCESS		PRODUCTS
Pyrolysis	➢	Gas of low calorie content
Gasification	➢	Gas
Fermentation	➢	Biogas
Liquefaction	➢	Liquid fuel
Combustion	➢	Heat energy

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Benefits from utilization of straw for energy purposes in Poland

1. **For agriculture**

- **increase of the employment in the agricultural sector**
- **increase the agricultural incomes,**
- **reduction of the prices fluctuations of agricultural products ,**
- **stabilization of the agricultural production size,**
- **stimulation of the local industry and development of the rural area .**

2. **For country**

- **protection of the environment through limitation of emission NO_x and closed circulation of CO_2**
- **increase of the energy security of Poland.**

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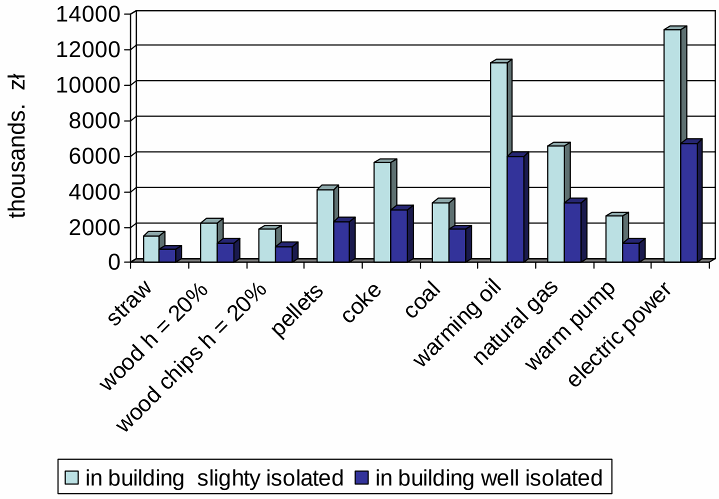
Economics

Cost of heating for a 150 m² surface



Source: Wach 2006

What is the reason of the surplus of straw ?

- In 1985-2004, the cereals area increased in Poland from 7.8 to 8.6 million ha.
- In this period the share of cereals in the cropping pattern increased from 54 to 75%.
- In 1995-2004, cattle population decreased by 31%, sheep by 60% and horses by 50%.
- There were farms without livestock, 878,000 in 2002, (45% of total).

Sources of straw

- Cereals
- Maize
- Rape
- Pulses

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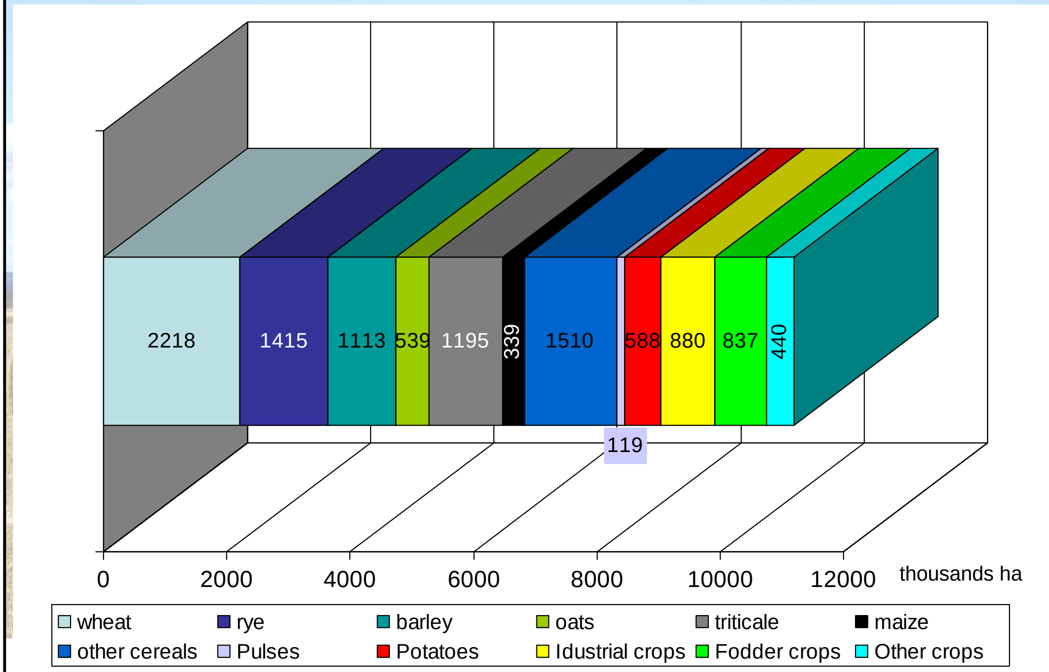
Sown area in Poland in 2005 year



Ratio of grain : straw for cereals in Poland

Winter Wheat – 0.91
Spring Wheat – 0.94
Winter Triticale – 1.13
Winter Rye – 1.44
Winter Barley – 0.87
Spring Barley – 0.86
Oats – 1.08

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Ways of straw utilization

- Fodder
- Litter
- Incorporation to soil
- Surplus for energy use

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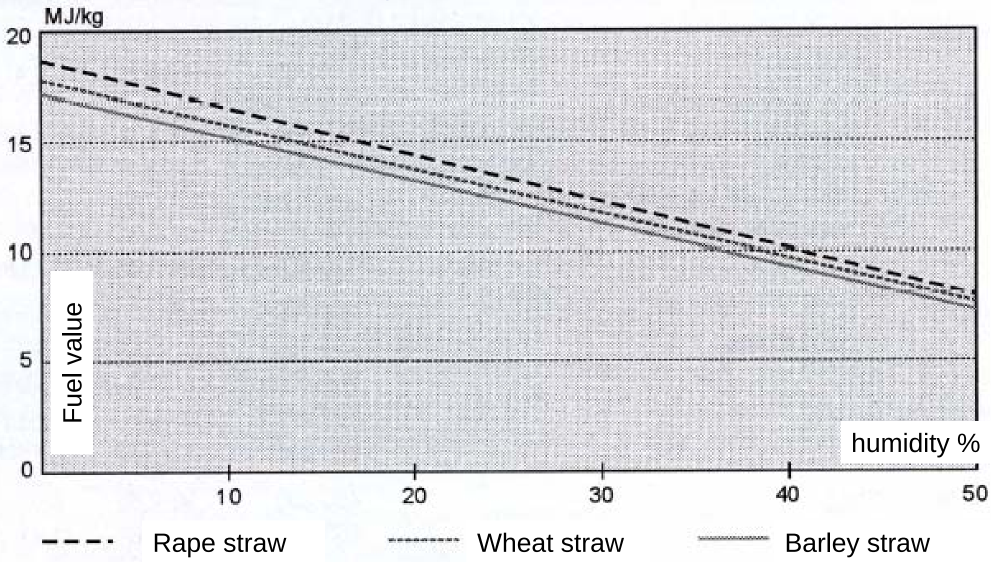
Quality of straw

Dependence of energy value upon the humidity of straw



Source: Gradziuk, 2006

Production of straw (average, 2002-2005)

Crops	Harvest (thousands tons)
Winter cereals	14,369
Spring cereals	8,821
Rape	1,206
Maize	2,033
Pulse crops	223
Total	26,652

Utilization of straw in Poland

Utilization	thousand tons
Litter	12,080
Fodder	4,059
Incorporation to soil	3,038
Total	19,177

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How was calculated quantity of straw for incorporation

Specification	**Poland**
Ratio of degradation of soil organic matter	-0.53
Dose of manure ($t•ha^{-1}•year^{-1}$)	7.3
Dry mass of manure ($t•ha^{-1}•year^{-1}$)	1.82
Reproduction of soil organic matter ($t•ha^{-1}$)	0.64
Balance ($t•ha^{-1}$)	0.10
Straw for incorporation ($t•ha^{-1}$)	0.27
Sown area (thousands ha)	11,033
Total straw for incorporation (thousands t)	3,039

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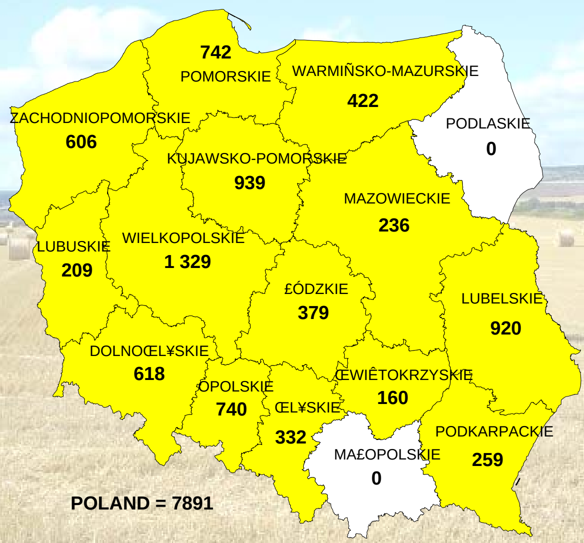
Balance of straw in Poland

Region	Harvest of straw	Utilization of straw:				Balance	
		litter	fodder	incorporation on soil	total	deficit	surplus
Dolnośląskie	2,382	323	99	1,342	1,764	0	618
Kujawsko-pomorskie	2,280	1,047	294	0	1,341	0	939
Lubelskie	2,429	916	325	268	1,509	0	920
Lubuskie	674	181	52	232	465	0	209
Łódzkie	1,664	961	324	0	1,285	0	379
Małopolskie	770	564	223	0	787	-17	0
Mazowieckie	2,739	1,808	695	0	2,503	0	236
Opolskie	1,613	346	91	436	873	0	740
Podkarpackie	806	392	152	3	547	0	259
Podlaskie	1,268	1,160	507	0	1,667	-399	0
Pomorskie	1,402	519	141	0	660	0	742
Śląskie	773	332	109	0	441	0	332
Świętokrzyskie	713	399	154	0	553	0	160
Warmińsko-mazurskie	1,463	750	291	0	1,041	0	422
Wielkopolskie	3,909	2,061	519	0	2,580	0	1,329
Zachodniopomorskie	1,767	321	83	757	1,161	0	606
Poland	**26,652**	**12,080**	**4,059**	**3,038**	**19,177**	**-416**	**7,891**

Regional differentiation in surplus of straw



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What about the future ?

Straw production for energy utilization in future will grow, because:

- Cereals area will be in the same level, and it can even grow to 9 millions ha.
- Area of rape will grow from 0.5 to 1 million ha, because of biofuel production and implementation of EU Biofuels Directive (2003/30).
- Utilisation for fodder and litter will probably drop, because economic factors promote growth of individual production capacity at decrease of livestock.

Recapitulation

1. In regions with crumbled agrarian structure, despite a straw surplus, harvest and transport of straw for energy purposes will be unprofitable.
2. The yields of cereals and straw undergo seasonal fluctuation and therefore regarding for utilization of productive force. Surplus of straw for energy purposes should be estimated at 4-5 million ton.
3. Large amounts of straws can be assigned for energy utilization in regions with large farms. (low level of livestock, high share of cereals and rape in sown area).
4. Precise estimation of straw surplus for country or regions is difficult. Higher precision is possible for smallest administrative units, like administrative district or commune.

INSTITUTE OF SOIL SCIENCE AND PLANT CULTIVATION – NATIONAL RESEARCH INSTITUTE

"Cereals straw and agricultural residues for bioenergy Situation in Bosnia and Herzegovina"

HYDRO-ENGINEERING INSTITUTE SARAJEVO

Semra Fejzibegović, B.Sc in Mech. Eng.

Agricultural land in B&H

- In accordance with the National Spatial Plan of B&H for period of 1981-2000 (it is still in use until the new Plan is prepared) it has been confirmed that:
  - Agricultural land in B&H is about half (50.3 %) of the total land area of B&H, which amounts to 2,573,000 ha.
  - only 31.35 % of agricultural land of sustainability class I to IV.

Relevant documents for data gathering

- Working material for the Preparation of Strategy of Environment Protection of FB&H (2008-2018)
- Strategy of mid term development of agricultural sector in FB&H (2006-2010)
- Strategy of mid term development of agriculture and rural regions in Republic Srpska (2006-2015)

Federation of B&H

- Total area – 26,110.5 km^2 i.e., 2.6 mil ha
- 1,140,000 ha of total agricultural land, of which 63% is cultivated, i.e. 719,000 ha (0.25 ha/inhabitant)
- 411,000 ha tillage (57.2% of cultivated land)
- 42,000 ha orchards (5.8%)
- 4,000 ha vineyards (0.6 %)
- 262,000 ha natural meadow (36.4%).

Republic of Srpska Entity in B&H

- 1,241,000 ha of agricultural land,of which
- 908,000 ha of cultivated land,of which
- 590,000 ha are tillage and gardens.

Land characteristics in B&H

- 60 % of cultivated land is at least 500 m above sea level
- Five sixth of the territory with slope above 12%, which limits mechanical cultivation

Land characteristics in B&H

- 70 % of land surface in B&H with erosion risk
- and about 200,000 ha with flood risk.

Site conditions

- Climate and precipitation pattern are not favourable for agriculture
- Water shortage in summer period is main limiting factor for agriculture development in Mediterranean part of the country, where agriculture is impossible without irrigation.

Agricultural practice

- Currently, the irrigated area is 4,630 ha, and potential area that should be irrigated is 74,000 ha
- The existing irrigation systems are damaged due to the war and neglect.
- Most of the land in North part of B&H which is used as cultivated land should be drained.

Cereal straw resources

- In FB&H for 2006 there are:
- 33,493 ha of harvested cereals (wheat, rye, barley, oat)
- Ratio of mass of seed/ha and mass of straw is approx. 1:1
- 0.359 t/ha of stubble ploughed in

Production of agricultural waste (FB&H, 2006)

- Cereals straw amounts to approximately 12,000 t/year
- Silage and hay is approximately 70,000 t/year

Agricultural practice

- Organic production- 116 ha of land (0.016% in relation to total cultivated land)
- 259.9 ha of land for integrated fruit production (0.62% in relation to total land under the orchards)
- There are no institutions and economic instruments for agricultural waste management

Cattle raising in B&H

- Good natural conditions for development, especially in North-West Region of B&H where it has been estimated that current number of livestock is only 35 % of the pre war number
- According to the Statistical Yearbook, largest livestock in Tuzla Canton (the largest production of manure)

Current research

- Feasibility Study- Animal waste - Integrated problem solving of farm and slaughterhouse waste in North West region of B&H - EU CARDS Program for B&H - May 2005
- North-West Region covers 13 municipalities from FB&H and 21 municipalities from RS

Production of manure in north west region

- Questionnaire sent to 300 farms
- The total quantity of manure produced in Federation of B&H for 2006 has been calculated on the basis of daily and annual manure for each type of livestock
- The produced manure is approximately 4,550,000 t/year
- The most part of this amount (80%) has been spread over the cultivated land

Production of manure

Type of livestock	Number of head	Fresh manure per head (t/year)	Total production of manure (t/year)
Total cattle	233,289	15.33	3,576,320
Total sheep	541,606	0.661	358,002
Total pigs	94,196	2.92	275,052
Total horses	9,690	8	77,520
Total goats	44,849	0.679	30,452
Total poultry	6,786,100	0.034	230,727
Total			4,548,073

Production of waste from cattle breeding

- Approx. 4,550,000 t/year of manure
- Approx. 4,700 t/year of waste animal tissue

Waste management

- Fertilizing of the agricultural land is a common use in B&H
- Currently, there are no systems for biogas production from agricultural waste
- No incineration plants

According to Solid Waste Management Strategy in B&H (August 2000):

- Due to high costs of building and operation of incineration plants for hazardous waste, it has been considered that no incineration plant would be cost effective in next 10 years
- If the volume of waste is going to increase and economic situation is going to improve, such solution can be feasible.

Agricultural Cooperative “Vrtoče” Bosanski Petrovac

- System for gasification and incineration of biomass waste from poultry slaughterhouse with capacity of incineration of about 500 kg/day of such material.
- Operation hours of this plant is 10 to 12 hours/day.
- Power: 300 kW.
- Basic fuel:
  - Animal waste from poultry slaughterhouse
- Support fuel:
  - Wood waste,
  - Agricultural waste,

Environmental aspects

- Emissions in accordance with EU standards and existing bylaws in RS and FB&H.
- Residence time of flue gases in secondary chamber is 2-4 sec, at temperature up to 1300^{o}C are sufficient for elimination of possible halogenated organic substances.
- NOx reduction is possible with use of staged incineration concept.

CONCLUSION

- Land suitable for agriculture is scarce.
- The situation is worsened by minefields that prevent substantial areas of the land from being used for agriculture.
- Most of the land is not suitable for agriculture without irrigation.

Cereals straw and agricultural residues for energy production in Latvia

Imants Plume,
Dainis Viesturs,
Latvia University of Agriculture,
Latvia

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Latvia

- Habitants 2,3 mil.
- Area 64 600 km^2
- Forests 45 %
- Highest point above sea level – 326 m
- Precipitation ~ 550...650 mm/year
- Evaporation ~ 400...450 mm/year
- Primary energy consumption – 199 PJ/year
- Share of renewable energy in primary energy consumption 34,5 %

Renewable energy structure in Latvia (2004)

- **Wood, straw - 82.9%**
- **Hydropower - 16.4%**
- **Biogas - 0.42%**
- **Wind – 0,28%**

Wood biomass for energy in Latvia (2004)

- Share of wood biomass in primary energy consumption – 28,8 %
- Share of wood biomass for district heating – 24,2 %
- Share of wood biomass for local and household heating – 56,2 %
- Utilized forest biomass (for different purposes) – 10,75 mil. m^3 (78 PJ)
- Exported wood biomass – 1,4 mil. t (25,2 PJ)
- Yearly growth of forest biomass -16,5 mil. m^3 (120 PJ)
- Potential for increase of wood biomass harvest for energy production – 5,8 mil. m^3/year (41,8 PJ)

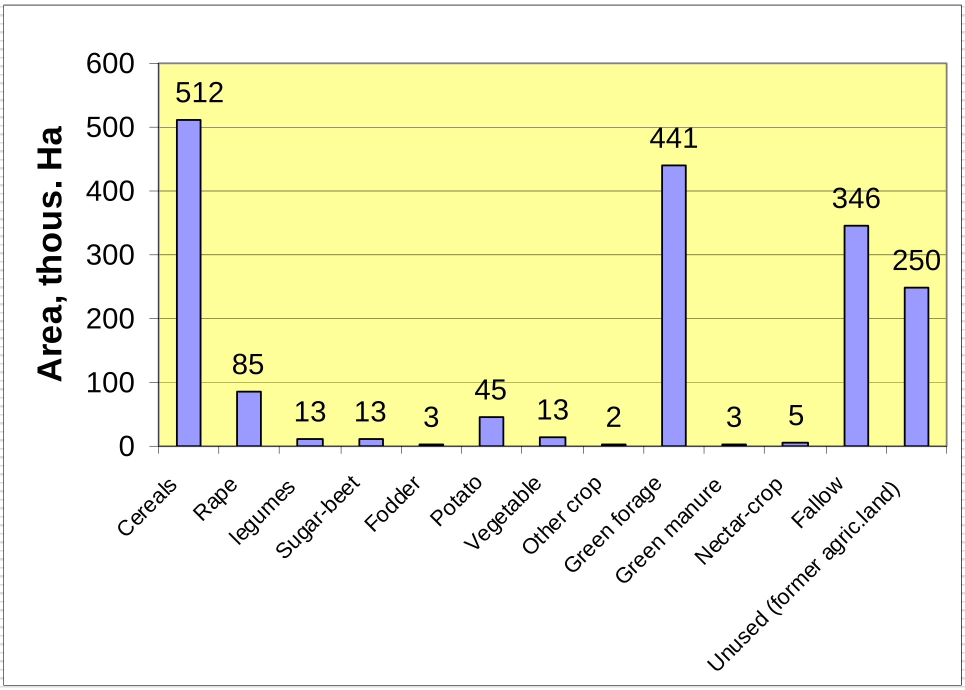
Biofuel production for transport in Latvia

- Share of biodiesel and bioethanol in total fuel consumption for transport was 0,33 % in year 2005 (target of 5.75% for Latvia in 2010).
- Biodiesel produced from 62,000 tons of rapeseed (51 % of all rapeseed production) in 3 plants and bio-oil produced in 1 plant in 2006.
- Bioethanol produced from grain (wheat, rye, triticale) – 9,000 tons in 2006 (full capacity of 2 plants for bioethanol production was 19,500 t in 2006).

Plants for electric energy production from renewable sources (2005)

- Hydropower plants produces 97.7% of all renewable electricity
- Cogeneration using wood – 4 plants (2.5 MW)
- Cogeneration using biogas – 3 plants (7.5 MW)
- The task for Latvia in electricity production from renewable sources is 49.3% of total electric energy consumption in 2010.

Agricultural land in Latvia (2006)



Straw and grass production in 2002-2005

Cereals and rape	Area, thousand ha (aver. 2002 06)	Grain yield (aver. 2002 06), t/ha	Grain: straw ratio	Straw, grass, thousand t	Straw, grass, available for energy, thousand t
Wheat	215	3,1	~ 1:0,9	600	
Barley	136	2,1	~ 1:1	285	
Rye	43	2,3	~ 1:1,2	118	
Oats	53	1,7	~ 1:1,1	105	
Rape	51	1,7	~ 1:1,3	114	
Sum, straw	545			1216	174 (14 %)
Fallow grass	341	1,9		649	325 (50% area)

Energy potential from agricultural biomass residues in Latvia (2006)

Name of residues	Biomass	Energy from burning	Biogas available	Biogas energy	Energy from technically most feasible utilisation
	Th. t	PJ	Mil. m^3	PJ	PJ
Straw	174 (18% moisture)	2,5			2,5
Energy crop (maize, 2% of agr. land)	160 (DM)	2,1 (pellets)	22,4 (from maize juice)	0,5	2,6 (2,1+0,5)
Grass, fallow land	325 (DM)	4,5 (pellets)	48 (from grass juice)	1,1	5,6 (4,5+1,1)
Livestock wastes	6100 (natural)		290	6,5	2
Degradable household wastes	400 (natural)				
Wastewater sludge	180 (natural)				

Plant for straw burning in Saulaine, Latvia

Plant for heat production from straw in Saulaine, Latvia

- Power of plant for burning of– 1,36 MW
- Efficiency of straw boiler 87%
- Efficiency of boiler together with distribution net – 70%
- Heat energy produced – 20 TJ/year
- Utilised biomass - wheat straw, 1300 tons/year
- Area for straw production ≈ 500 ha
- Average transport distance ≈ 6 km
- Density of square bales – 0,11...0,12 t/m^3
- Weight of bale ≈ 500 kg
- Straw price (transport costs included) – 23,8 €/t
- Investments 425 000 €/MW
- Time of service of – 20 years

Running expenses, per year:

- Salary (for 4 persons) – 47 000 €/MW
- Refund of investments - 2150 €/MW
- Purchase of straw - 23800 €/MW
- Rate of interest 6% - 5750 €/MW
- Electricity and materials – 1550 €/MW
- Overhead expenses-7000 €/MW
- Total cost for 1 GJ energy production by straw boiler: 4,4 €/GJ

Calculation of amount of cereals and rape straw for energy in Latvia (2002-06)

- Cereals and rape straw available for energy calculates:

$$\mathbf{S_e = Y_g - S_m\ A_s - L - M\ [t]}$$

where,

S_e – straw available for energy, t;
Y_g – straw yield, t; A_s - area of cereals and rape, ha;
S_m– straw not removed from field to keep organic matter content at the same level for Latvia conditions, t, S_m=1,6 t/ha;
L – straw for litter, t,
I – straw for chemical industry, t

Amount of cereals and rape straw can be utilised for energy production (calculation was provided for 5-year period 2002-2006):

$$\mathbf{S_e = 1216 - 545 \times 1{,}6 - 160 - 10 = 174\ [thousand\ t]}$$

Constraints and recommendations for straw burning for energy

- Straw have a significant content of Cl (Cl=0,17...0,6%), which may cause formation of dioxines at combustion temperatures around 600°C at normal residence time in the furnace.
- Straw contains significant content of N (N=0,5....1,2%), that can be a source of nitrogen oxides emissions at temperatures above 750°C.
- Straw contains significant content of potassium, that facilitates ash melting at temperatures above 800°C.

Recommendations

- **Optimal combustion temperatures of straw are within the range of 700-750 °C.**
- **Continuous material feed is preferable, which decreases the residence time of straw at temperature 600°C, which prevent dioxins formation.**

Conclusions

- Potential of unharvested wood biomass energy in Latvia is 5,8 million m^3/year (41,8 PJ/year).
- Potential of cereals and rape straw for energy production is 14% of total straw available, or 174 thousands t/year (2,5 PJ).
- Potential of energy crop (maize) from 2% of agricultural land (5,7 t dry matter/ha) for energy production is (2,6 PJ), that can be obtained by maize juice anaerobic treatment (0,5 PJ) and from pellets (2,1 PJ) produced from residues.
- Potential of fallow grass (1,9 t DM/ha) by grass juice anaerobic treatment (1,1 PJ) and from pellets (4,5 PJ).
- Feasible biogas production potential is 30% of theoretical biogas energy obtainable from animal wastes, degradable household wastes and wastewater sludge, or 2 PJ .
- Straw burning plant in Saulaine (Latvia) produces heat energy at a price of 4,34 €/GJ.
- It is recommended to feed boilers with straw in continuous flow and to keep process temperature in range **700-750 °**C to minimise excessive **dioxins** or **nitrite oxides** formation as well as to prevent ash **melting**.

Bioverda
SUSTAINABLE ENERGY

Bioverda Activities For Energy Plants

2/3 October 2007, Novi Sad

Robert Halasz
Business Development Manager, CEE
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Paul Saunders
Bioenergy Development Director
Email: paul.saunders@bioverda.com

Group Overview

Total
05 Revenue
~ €468m

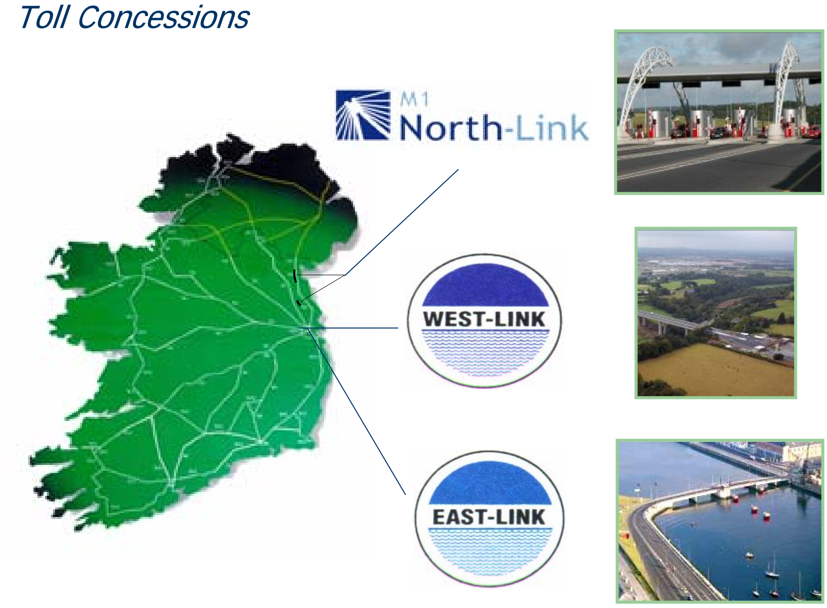
NTR

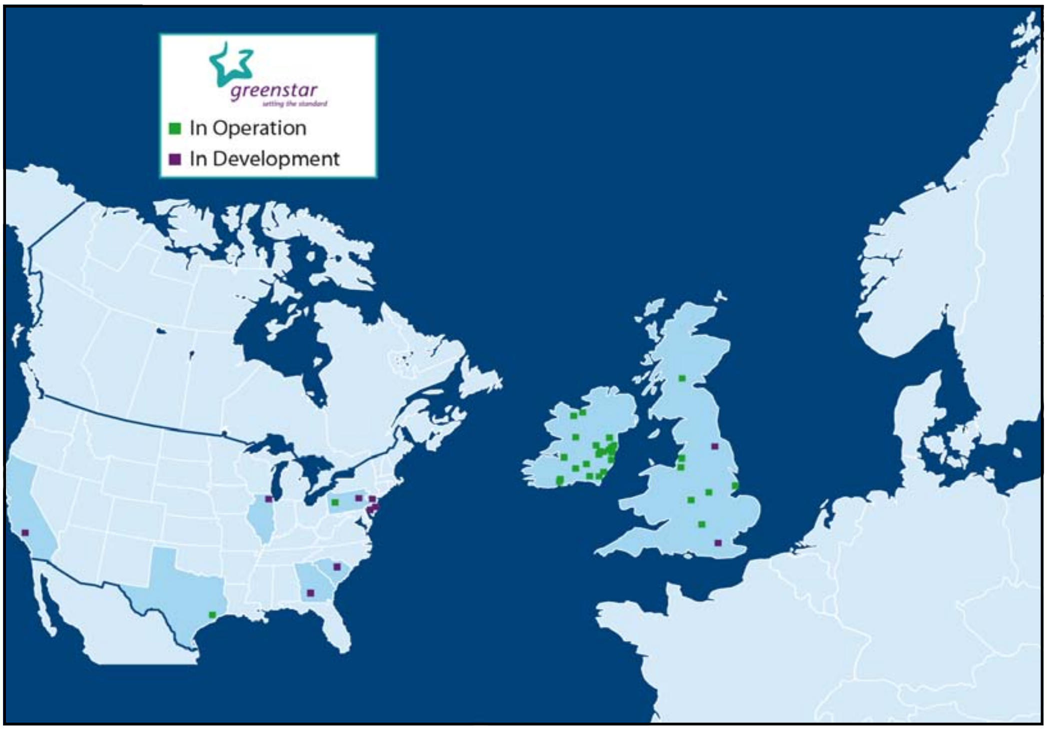
Market
Capitalisation
~ €1.3bn

- Roads
  - WEST-LINK
  - EAST-LINK
  - *C. R. G.* 33.3%
- Waste
  - greenstar
  - celtic anglian water
- Energy
  - Airtricity
  - Bioverda
- Telecoms
  - IRISH BROADBAND

Roads - Ireland

Toll Concessions

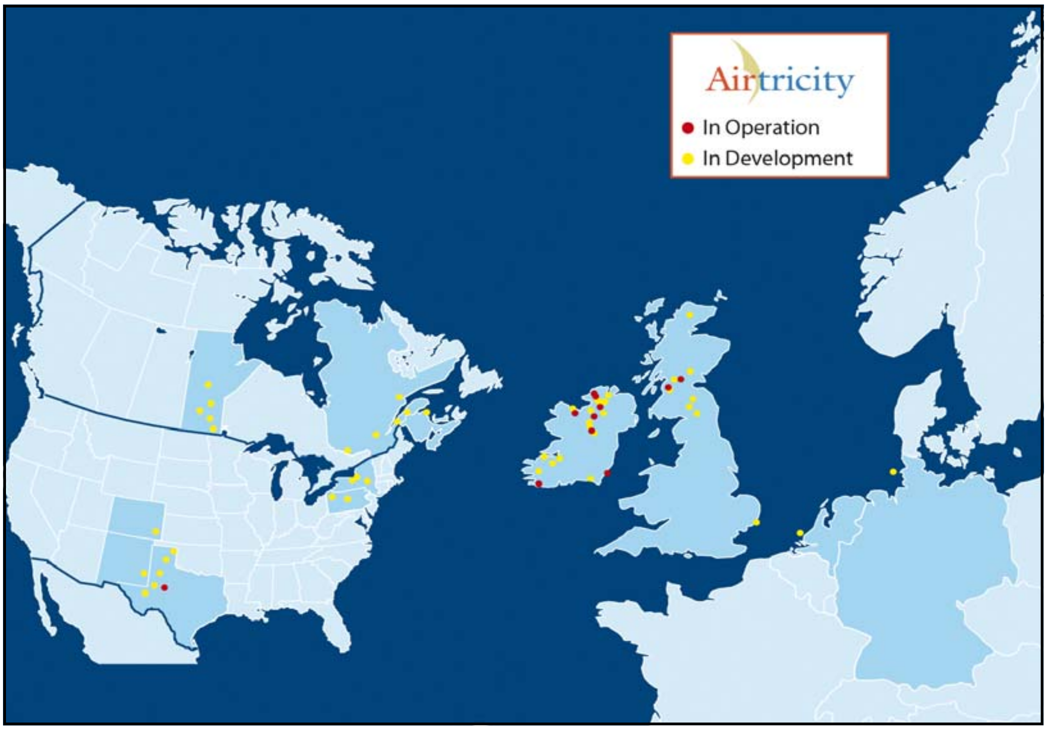




celtic anglian water

Dublin Bay Project is Ireland’s largest Anaerobic Digestion Plant - 4MW of power… and expanding

Airtricity
The Natural Progression



Growth Platform

Going Forward

Security of Energy Supply

Climate Change

Resource Depletion

Renewable Energy and Sustainable Waste Management

greenstar	Bioverda	Airtricity
IRL UK Other	IRL UK US Continental Europe	IRL UK US Continental Europe

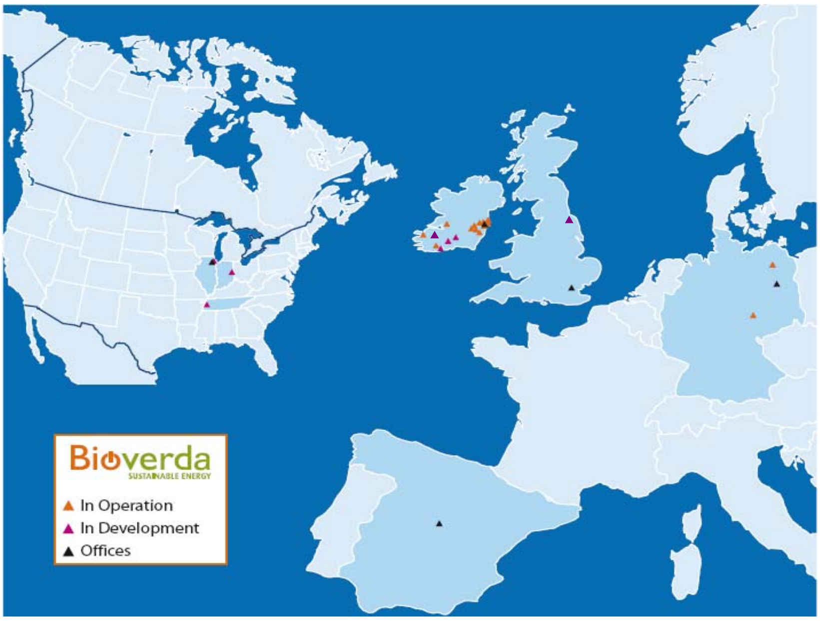
Who is Bioverda?

- Bioverda is the Bioenergy business subsidiary of NTR plc
- Bioverda is focused on two key areas:
  - **Biofuels** (Biodiesel, Bioethanol)
  - **Bioenergy** (Landfill Gas, Anaerobic Digestion & Biomass)
- Geographic asset focus in Europe and North America
- Pipeline being developed across all areas with significant potential for investment

**Goal is to be top 5 player –
"Be a Bioenergy Major"**

Bioverda Locations

Bioverda SUSTAINABLE ENERGY



Landfill Gas to Energy

Bioverda SUSTAINABLE ENERGY

25MW generated from 7 landfill sites - Producing 135,000 MWh p.a.

German Biodiesel Plants

Financed in 2006

Bioverda
SUSTAINABLE ENERGY

- Integrated seed crushing & biodiesel esterification plant in Neubrandenburg;
- Output of 45,000 t/p.a. biodiesel with 100kt expansion potential

- Integrated seed crushing & biodiesel esterification plant in Ebeleben;
- Initial output of 95,000 t/p.a. biodiesel

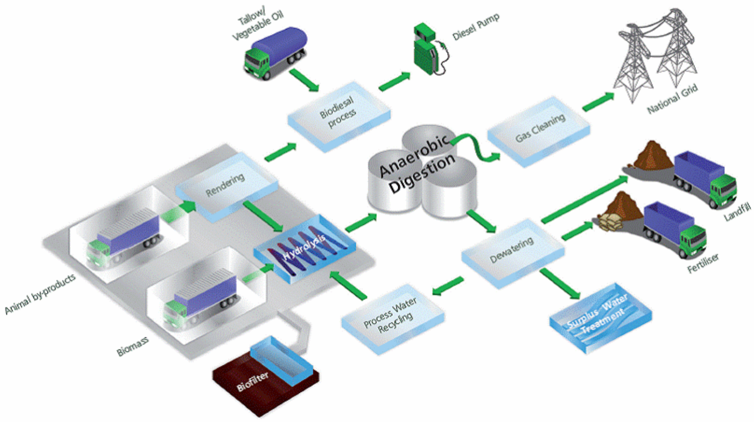
The Challenge & The Solution (Total investment approx. EUR 70 million)

- Market entry for foreign Sponsor & market risk due to changing Govt support
- Close & efficient collaboration with KfW IPEX-Bank & State Government

GOE Castleblake, Ireland

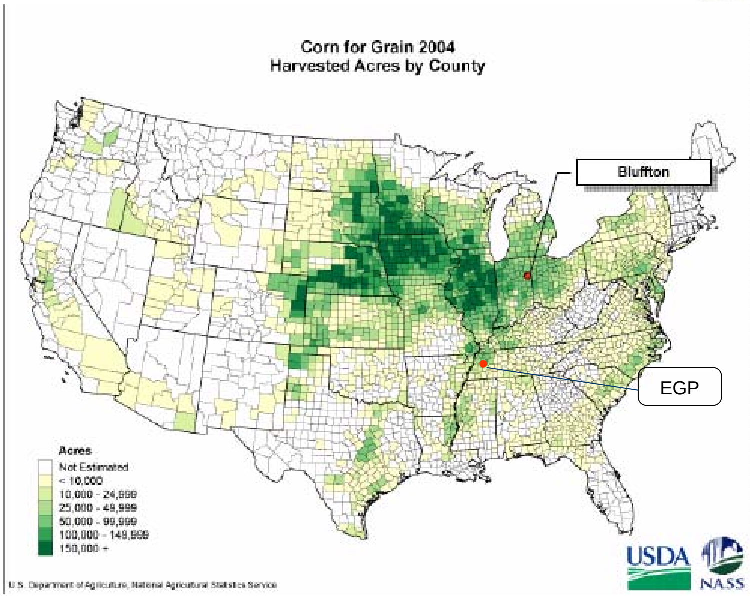
Bioverda
SUSTAINABLE ENERGY

PROPOSED BIOENERGY FACILITY
Process flow diagram



Planned 250kT AD plant (Animal by-products / biomass)
50kT Biodiesel Plant from Tallow

Bioverda US Ethanol Development



Virgin Bioverda JV – EGP, Tennessee

- 330 kt corn based Ethanol plant
- Based on ICM / Fagen technology

A Fully Constructed 330 kt Plant

Why Bioverda?

- Part of NTR plc, a leading renewable energy developer (€3bn)
- Strategic objective to be top player in target markets
- Global trading focus for inputs and off-takes
- Good people focused on building a world class business

Why Central-Eastern Europe

- Huge potential of biomass source
- „Untapped market“
- Attractive regulatory framework in most countries (adopting EU directives)
- Energy consumption of these countries grow fast
- Attractive green tariffs
- Fallow lands available for energy crops
- Growing yield

Practical difficulties of a bioenergy project from an investor´s point of view

General

- No/less experience in bioenergy project development
- Choosing the right Technology
  - Efficient and proven technology

Practical difficulties of a bioenergy project from an investor´s point of view

Economics

- Small land size of farmers
  - In some countries farmers have small lands which makes the security of feedstock more difficult
- Raw material price
  - Hedging
  - Crossholding
  - Indexation
  - Price formula
  - Renting land from farmers

Practical difficulties of a bioenergy project from an investor´s point of view

Economics

- Selling heat
  - it makes the project more efficient (economically and environmentally) and also it can be the margin in case raw material price is going up sharply in the future.

    Central heating systems
- Period of guaranteed power purchase

Practical difficulties of a bioenergy project from an investor´s point of view

Sustainable raw material source

- In some central and eastern European Countries straw is burnt on the field as it is the cheapest way to get rid of it (also good for the soil)
- Choosing the right energy crops (based on climate and quality of soil)

Practical difficulties of a bioenergy project from an investor´s point of view

Logistics

- economical radius (30-50 km) might be more if transportation is cheaper
- Storage
- Financial situations of farmers
  - Do farmers have the equipment to collect and bail the straw or to transport it?
    - Investor might have to pay for these equipment in order to bail and transport the straw
    - Available Funds for farmers to improve their equipment?

Workshop Motivation

"Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries"

Workshop

"Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries"

Place: Novi Sad, Serbia

Date: 2 - 3 October 2007.

Background

This Workshop is organised by the Institute for Environment and Sustainability (IES) of the Joint Research Centre (JRC) of the European Commission (http://www.jrc.ec.europa.eu) and the University of Novi Sad, Faculty of Technical Sciences, Department for Biosystems Engineering, and the Academy of Sciences and Arts of Vojvodina, Serbia. The Workshop is organised within the JRC-IES Action: Quality and Performance of Biofuels (http://re.jrc.ec.europa.eu/biof) of the Renewable Energies Unit.

It follows a previous joint seminar on Sustainable "Sustainable Bioenergy cropping systems for the Mediterranean" held in Madrid, Spain, on 9-10 February 2006 and a JRC Expert Consultation on the "Cereals Straw Resources for Bioenergy in the European Union" Pamplona, on 18-19 October 2006. It also follows the Workshop "Data Gathering for the New Member States and Candidate Countries on Renewable Energies", held in Cavtat-Dubrovnik, Croatia, on 15-16 November 2006 (http://re.jrc.ec.europa.eu/biof/html/Documents_Publications.htm).

The present Workshop addresses the use of agricultural residues (cereal straw, green tops, manure) and especially of cereals straw for bioenergy production in New Member States, Candidate Countries and Western Balkan Countries.

Motivation

The European Union has a target of 12 % of total energy consumption to be produced from renewable energy sources by 2010. In addition, in 2010, renewables should contribute by 21 % of gross inland electricity consumption. Biofuels and other renewable fuels for transport should also reach the target of 5.75 % of all petrol and diesel consumption for transport (on the basis of energy content) by 31december 2010.

In order to reach the mentioned targets, the European Commission has issued a Communication on a Biomass Action Plan and its corresponding Impact Assessment. The European Commission released a communication comprising an EU strategy for biofuels based on the Biomass Action Plan, aiming at biofuels promotion, preparation for large-scale use of biofuels by improving their cost-competitiveness, support of the research into second-generation biofuels and exploration of the opportunities for the production of biofuel feedstocks and biofuels.

The European Council (Brussels, 8/9 March 2007) endorsed a binding target of a 20 % share of renewable energies in overall EU energy consumption by 2020 (differentiated national overall targets) and a 10 % binding minimum target to be achieved by all Member States for the share of biofuels in overall EU transport consumption by 2020.

In addition to the existing European legislation on electricity from renewables and use of biofuels, a Directive on heating and cooling from renewables is in preparation. Consequently, the use of biomass in transport fuel, heat and electricity production will have to increase substantially in order to meet these targets.

Main Issues

Resources of cereal straw and agricultural residues

The question to answer is what are the cereal straw and agricultural resources at national/regional/local level that could be used for bioenergy production. This will provide information on best locations for a bioenergy plant site, but also on plant size.

Of importance is how much agricultural residues are generated in a certain region, the amount which is available and their physical and chemical characteristics. The amount of agricultural residues is directly related to crop production, which in turn depends on crop yield and cultivated area. The data of importance is agricultural practice (tillage/no tillage, straw shortness, organic farming, irrigation), cultivated area, yield and total production.

The agricultural residues removal rate and the quantity that must be left on land depends on climate conditions (wind patterns, rainfall patterns), and local site suitability (soil type, soil fertility, land slope, risk of soil erosion), farming practices (culture crop rotation, tillage practices).

An important issue is related to the competitive uses of cereal straw and agricultural residues: animal breading, mushrooms cultivation, horticulture, etc.

Environmental & agricultural constraints

The environmental benefits of using biomass resources is the most important driving force encouraging the use of biomass for energy production. One of the basic rules of sustainability requires that biomass use should be consistent with environmental quality requirements and produces green environmentally friendly bioenergy.

The existing agricultural resources, soil characteristics, sites conditions and different agricultural farming practices should to be taken into consideration when talking about straw removal for further use for bioenergy. Agricultural residues left on land provide the ecosystem with nutrients, reduce the risk of soil erosion and regulate water retention.

Therefore, the effect of biomass removal from the field on the organic matter content of the soils (soil carbon content and nutrients availability), CO_2 emissions, depletion of organic matter content, water retention capacity of soils, as well as increased sensitivity to erosion should be considered. Biomass removal should also not affect soil fertility and land productivity.

Implementation issues

Biomass could play an important role for sustainable energy production. Biomass is a local/regional resource, which could contribute to the rural regional development and security of energy supply. It could also contribute to the improvement of competitiveness and local/regional employment whilst creating environmental benefits in terms of greenhouse gas emissions reduction. Implementation of bioenergy technologies depends on the concepts for bioenergy technologies, availability and efficiency of conversion technologies, economic issues, environmental norms or regulations to be fulfilled, requirements of conversion plants, etc.

The biomass resources (quantity, harvesting period, multi-annual yield variation, collection distance), logistics (energy demand in the area, storage, security of supply), technological (available technologies), economical (costs of resources and cost of energy), social issues (perception and attitude of farmers) as well as policy support measures should be considered for the use of cereal straw and agricultural residues for bioenergy.

An objective of the workshop is to contribute to forming a cost-supply curve for straw and other agricultural residues in EU.

Goals

This Workshop aims at bringing together researchers and professionals in the energy field regarding the cereals straw and agricultural residues utilisation for bioenergy production in New Member States (NMS), Candidate Countries (CC) and Western Balkan Countries (WBC).

The Workshop addresses the cereal straw and agricultural residues availability, potential for bioenergy, implementation, present use and current experience in EU, demonstration projects, economics of bioenergy, etc. The Workshop aims specifically at technical discussions, in order to develop expertise, exchange information and knowledge and improve data collection on:

- resources of cereal straw and agricultural residues;
- environmental & agronomic constraints;
- implementation issues.

JRC has produced an estimate of straw resources (from wheat and barley) available for use in large-scale plants. It starts with statistical and GIS data for EU25+2 to assess the energy potential of straw. First the straw produced was calculated on from GIS cereals production taking into account variations in yield. Next, the major competitive uses were subtracted. This was done on the basis of correlations between straw, cattle population and human population. Costs were assigned based on collection and transport costs in Western Europe.

Clearly many of the assumptions and rules used in this preliminary assessment will differ for local conditions in NMS and candidate countries. From JRC point of view, the main Workshop objective is to see how these estimates should be adjusted for conditions in New Member States and Candidate Countries, as well as to generally improve them.

Critical Issues to be addressed

Basic Resources

- What is the ratio of straw: grain for wheat and barley. Can the ratio be correlated with yield? What other crops could contribute?

Environmental limits

- Can we make some rules for how frequently one may take straw instead of incorporating it?
  - formula based on soil, climate, technologies;
  - effect on subsequent yields and fertiliser requirements;
  - other effects of incorporating straw;
- What percentage reserve of supply in catchments' area to account for:
  - seasonal variations;
  - bargaining with farmers;
  - inaccessible fields.

Competitive uses

- What are the main competitive uses (percentage);
- Correlation with:
  - cattle population;
  - cattle housing;
  - horses;
  - horticulture / mushrooms.
- Existing uses for energy

Costs

- Costs for collection, transport, storage;
- Extra costs due to terrain etc.;
- Different conversion plants: cost vs. size; technical improvements;

- Optimized plant size;
- Logistical limits on plant size.

Expected outcome

The Workshop aims at collecting more information on the state of knowledge on the availability and possible use of cereal straw and agricultural residues, status, problems and barriers for implementation, and perspectives for development. The Workshop aims to carry out interactive technical discussions to share experience and draw conclusions that could be valuable for developing new projects using cereal straw and agricultural residues in New Member States, Candidate Countries and Western Candidate Countries.

The outcome of the Workshop will be summarized in proceedings, focussing on the three topics above and based on the contribution of the meeting participants.

Experts

This Workshop aims to include 20 participants from New Member States, Candidate Countries and Western Balkan Countries as well as from several European Union Member States or regions with valuable experience in the use of cereal straw and agricultural residues for bioenergy including 2nd generation biofuels. Experts will originate mainly from agricultural and environmental institutes, renewable energy institutes, research centres and energy companies. National experts are invited to prepare for the Workshop a presentation covering the critical issues to be addressed:

- cereals farming practices and soil characteristics;
- cereal straw and agricultural residues resources and competitive uses;
- present situation related to the use of cereal straw and agricultural residues for bioenergy;
- environmental issues related to cereal straw and agricultural residues utilisation;
- practical problems of bioenergy plants operation using cereal straw and other agricultural residues, in terms of resources, logistics, technology and economics;
- socio issues (perception and attitude of farmers);
- development or planning for bioenergy plants on cereal straw and agricultural residues;
- new developments in bioenergy policies and public support mechanisms.

Contacts

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Workshop Agenda

"Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries"

Tuesday 2nd October 2007

13.00 – 14.00 Welcome Lunch

14.00 Welcome address: Mr. Tomislav Papic, Provincial Deputy Secretary for Energy and Mineral Resources.

Welcome address: Prof. Dr. Milos Tesic, Secretary General of the Academy of Sciences and Arts of Vojvodina.

Session 1. Resources of cereal straw and agricultural residues

Chair: *Milos Tesic, Secretary General of the Academy of Sciences and Arts of Vojvodina.*

Rapporteur: *H. Huseyin Ozturk, University of Cukurova, Faculty of Agriculture, Adana, Turkey.*

14.00 – 14.30 *"Current activities, recent developments and trends for bioenergy and biofuels in EU"*, Nicolae Scarlat, European Commission, Joint Research Centre, Institute for Environment and Sustainability.

14.30 – 15.00 *"Cereal/soybean straw and other crop residues utilization as fin Serbia – status and prospects"*, Milan Martinov, Milos Tesic, Faculty of Technical Sciences, Novi Sad, Serbia.

15.00 – 15.30 *"Biomass as a renewable source of energy in the Czech Republic"*, Sergej Ustak, Crop Research Institute, Praha, Czech Republic.

15.30 – 16.00 *"Potential use of cereal straw and agricultural residues for bioenergy in Slovenia"*, Franc Bavec, Martina Bavec, University of Maribor, Faculty of Agriculture, Slovenia.

16.00 – 16.30 Coffee break

Session 2. Resources and competitive uses

Chair: *David S. Powlson, Rothamsted Research, Harpenden, UK.*

Rapporteur: *Semra Fejzibegovic, Hydro-Engineering Institute Sarajevo, Bosnia and Herzegovina.*

16.30 – 17.00 *"Production of straw and other agricultural residues in Republic of Macedonia and possibilities for use as biofuel"*, Ordan Cukaliev, Faculty of Agriculture and Food, Skopje, Macedonia.

17.00 – 17.30 *"Utilization of cereal straw and agricultural residues for bioenergy in Turkey"*, H. Huseyin Ozturk, University of Cukurova, Faculty of Agriculture, Adana, Turkey.

17.30 – 18.00 *"Agricultural residues in Estonia - resources and possibilities"*, Katrin Heinsoo, Estonian University of Life Sciences, Estonia.

18.00 – 18.30 *"Sources of biomass, energy potential and collection of statistical data concerning availability and utilization of biomass in Slovakia"*, Frantisek Zacharda, Stefan Pepich, Mariana Ceppanova, Technical and Testing Agricultural Institute, Slovakia.

20.00 Dinner

Wednesday 3rd October 2007

Session 3. Environmental & agricultural constraints

Chair: *Milan Martinov, Faculty of Technical Sciences, Novi Sad, Serbia.*

Rapporteur: *Nicolae Scarlat, Institute for Environment and Sustainability (IES), Joint Research Centre (JRC), European Commission.*

9.00 – 9.30 *"Using straw for energy - implications for soils and agriculture"*, David S. Powlson, Rothamsted Research, Harpenden, UK.

9.30 – 10.00 *"Potentials and limits of the use agricultural residues for bioenergy in Lithuania"*, Kestutis Navickas, Lithuanian University of Agriculture, Kaunas, Lithuania.

10:00 – 10.30 *"Cereal straw and agricultural residues usable for bioenergy producing – in Romania"*, I. Antohe, National Agricultural Research and Development Institute, Fundulea – Romania.

10.30 – 11:00 "*Straw availability end use for energy purpose in Poland*", Jan Kus, Mariusz Matyka, Institute of Soil Science and Plant Cultivation - National Research Institute, Poland.

10.30 – 11:00 Coffee break

Session 4. Implementation issues

Chair: *Kestutis Navickas, Lithuanian University of Agriculture, Kaunas, Lithuania*

Rapporteur: *Robert Halasz, Bioverda, Berlin, Germany.*

11.00 – 11.30 "Cereals straw and agricultural residues for bioenergy. Situation in Bosnia and Herzegovina", Semra Fejzibegovic, Hydro-Engineering Institute Sarajevo, Bosnia and Herzegovina.

11:30 – 12.00 *"Cereals straw and agricultural residues for bioenergy production in Latvia"*, Imants Plume, Dainis Viesturs, Institute of Agricultural Energetics, Latvia University of Agriculture, Latvia.

12.00 – 12.30 *"Bioverda activities for bioenergy plants"*, Robert Halasz, Bioverda, Berlin, Germany.

12:30 – 13.00 Final discussions

13.00 -14.00 Lunch

14.00 – 19.00 Technical visit Kula Plat for drying of seed maize, using maize cobs as fuel. Company “Terming” producing 10 kW to 500 kW straw boilers. Cereal straw plant in use.

List of Participants

Workshop
"Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries"

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List of Acronyms

CC - Candidate Countries

CHP – Combined Heat and Power

CONCAWE - The oil companies European Association for environment, health and safety in refining and distribution

DH – District Heating

EC – European Commission

EE – Energy Efficiency

EEA – European Environment Agency

EUCAR - European Council for Automotive R&D

GIS – Geographic Information System

GHG - GreenHouse Gases

GMO - Genetically Modified Organisms

IEA – International Energy Agency

IES - Institute for Environment and Sustainability

JRC – Joint Research Centre

LCA – Life Cycle Analysis

NMS – New Member States

PCC – Potential Candidate Countries

R&D – Research & Development

RES – Renewable Energy Sources

RES-E – Renewable Energy Sources – Electricity

RES-H – Renewable Energy Sources – Heat

SOM – Soil Organic Matter

TGC – Tradable Green Certificates

TPES – Total Primary Energy Sources

WTW – Well to Wheel Study of Joint Research Centre/EUCAR/CONCAWE

European Commission

EUR 23550 EN – Joint Research Centre – Institute for Environment and Sustainability
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Abstract
This document contains the Proceedings of the Workshop "Cereals straw and agricultural residues for bioenergy in New Member States and Candidate Countries" held in Novi Sad, Serbia on 2-3 October 2007. This Workshop was jointly organised by the Joint Research Centre, Institute for Environment and Sustainability and University of Novi Sad, Faculty of Technical Sciences, and Academy of Sciences and Arts of Vojvodina, Serbia. The workshop addressed the availability and possible use of agricultural crop residues and especially of cereals straw for bioenergy production, status, problems and barriers for implementation, and perspectives for development in New Member States (NMS), Candidate Countries (CC) and Potential Candidate Countries (PCC). A better understanding of the situation on cereal straw and crop residues production and competitive use in NMS, CC and PCC was needed to assess their availability and potential for the use for energy production. The main topics addressed to 1) resources of cereal straw and agricultural residues, 2) environmental & agronomic constraints and 3) implementation issues.

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