ERA ARD
The Agricultural Research for Development (ARD) Dimension of the European Research Area (ERA)

Reduction of Impact of Biofuel Production to Food Stock

(Biodieselfeed)

Bioenergy Special Event, 16 December 2009
Brussels

PROJECT PARTNERS

Project coordinator

Lithuanian University of Agriculture

Coordinator prof. Prutenis Janulis

(Valdas Paulauskas)

Partners

Institute of Fuels and Renewable Energy

(Poland)

dr. Krzysztof Kolodziejczyk

National University of Life and Environmental Sciences of Ukraine

prof. Svitlana Kalenskaya

PROJECT OBJECTIVE
reduction of negative impact of biodiesel fuel production on food production and food industries

- Biodiesel is mainly produced from rapeseed oil
- Rapeseed oil is food product
- Growing of rape - means less land for other food products
- Biodiesel production can have negative impact on food production

MAIN IDEA

Oil-seed plants

▼

Fatty acid methyl esters (FAME)

▼

Biodiesel fuel mixtures

▼

Waste utilisation

▼

Impact

First year tasks (2009)

- Investigation and selection of **oil-seed plants**, which could be grown in the soil of poor quality and with less inputs of fertilisers, also which could be grown as under sowing for food crops seeking to reduce usage of herbicides
- Evaluation of their growing possibilities under different **climatic conditions** (also year 2)
- Investigation of optimal **mixture composition of esters**, made from oil of the selected plant seeds and fatty waste of animal origin (also year 2)
- Investigation of the role of regional, national and public **policies for bioenergy on food security** (also year 2 and 3)

1ST YEAR RESULTS

(Ukraine partner)

Investigation and selection of oil-bearing plants **suitable for biodiesel fuel production**

- field experiments carried out in Ukraine with 10 different species and at 3 different locations during 2009
- duration of organogenesis stages for oilseed crops in conditions of Forest-steppe determined
- oilseed plant height evaluated according to growing stages
- potential productivity of oil crops under different climatic and soil conditions determined
- oil output from oilseed assessed
- 3 plant species selected for further investigations

Duration of organogenesis stages for oilseed crops in conditions of Forest-steppe of Ukraine, days (2009)

Crop	Sowing-emergence	Emergence-first true leaf	First true leaf-rosette	Rosette-stem elongation	Stem elongation-branching	Branching-flowering	Flowering-fruit formation	Fruit formation-full maturity	Vegetation period, total
Spring rapeseed (Brassica napus)	10	9	17	11	12	13	17	22	100
Brassica campestris	8	7	10	9	8	9	8	20	71
White mustard (Sinapis alba)	9	7	11	11	12	11	14	24	91
Indian mustard (B. juncea)	9	7	10	9	9	11	9	18	74
Oil raddish (Rhaphanus sativa)	6	6	14	13	12	16	11	25	98
Camelina (Camelina sativa)	9	8	8	8	9	11	9	18	70
Safflower (Carthamua tinctorius)	16	5	7	10	20	26	14	36	118
Oil flax (Linum usitatissimum)	10	6	21 (spruce)			15	13	27	82

Oilseed plant height according to growing stages, cm (2009)

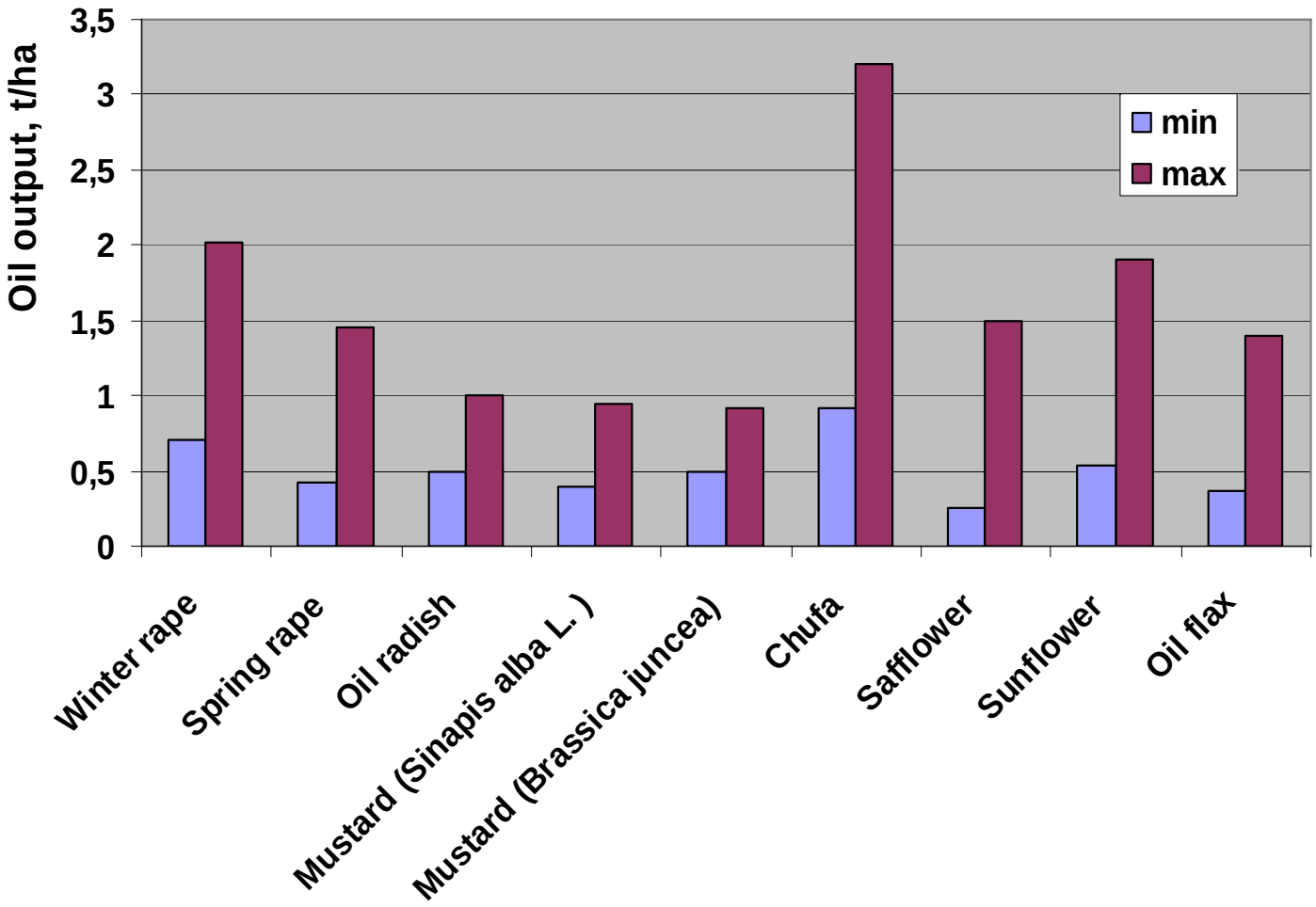
Stage	Brassica napus	B. campestris	Sinapis alba	B. juncea	Rhaphanus sativa	Camelina sativa	Carthamua tinctorius	Linum usitatissimum
Rosette	4.4	2.0	4.3	3.9	3.6	2.5	3.2	27.6*
Stem elongation	24.6	18.8	29.3	22.3	19.7	18.7	24.8	
Branching	102.3	44.0	89.0	49.9	40.5	34.9	60.4	47.7
Flowering	122.7	68.4	127.3	89.2	73.7	52.3	80.4	59.7
Fruit formation	131.3	82.0	136.7	109.3	101.7	66.1	91.8	67.1
Maturing	135.2	90.1	137.7	121.5	119.2	69.9	96.9	70.1

Potential productivity of oil crops suitable for biodiesel fuel production

Cultivars	Seed yield, t/ha	Oil content, %
Winter rape	**1.5-4.5**	**45-50**
Spring rape	1.3-3.5	41-49
Oil radish	1.2-2.1	31-50
White mustard	1.0-2.2	35-47
Indian mustard	1.2-2.1	32-49
Chufa	**4.5-12.0**	**23-40**
Safflower	1.0-3.5	25-50
Sunflower	1.3-3.9	41-52
Oil flax	**1.2-3.0**	**30-47**

3 plant species selected for further investigations

Oil output from oilseed, t/ha



Winter rape

Winter cress

Oil radish

Chufa
(Cyperus esculentus L.)

Oil flax

No	Oilseed	Oil content, %
1	Rapeseed	46.7
2	Chufa (Cyperus esculentus L.)	28.3
3	Oil flax	37.2

Next steps

- Field experiments will be continued in 2010 with 3 selected oil-bearing plants to improve cultivation technology (also year 3)

- Field experiments in Poland and Lithuania???

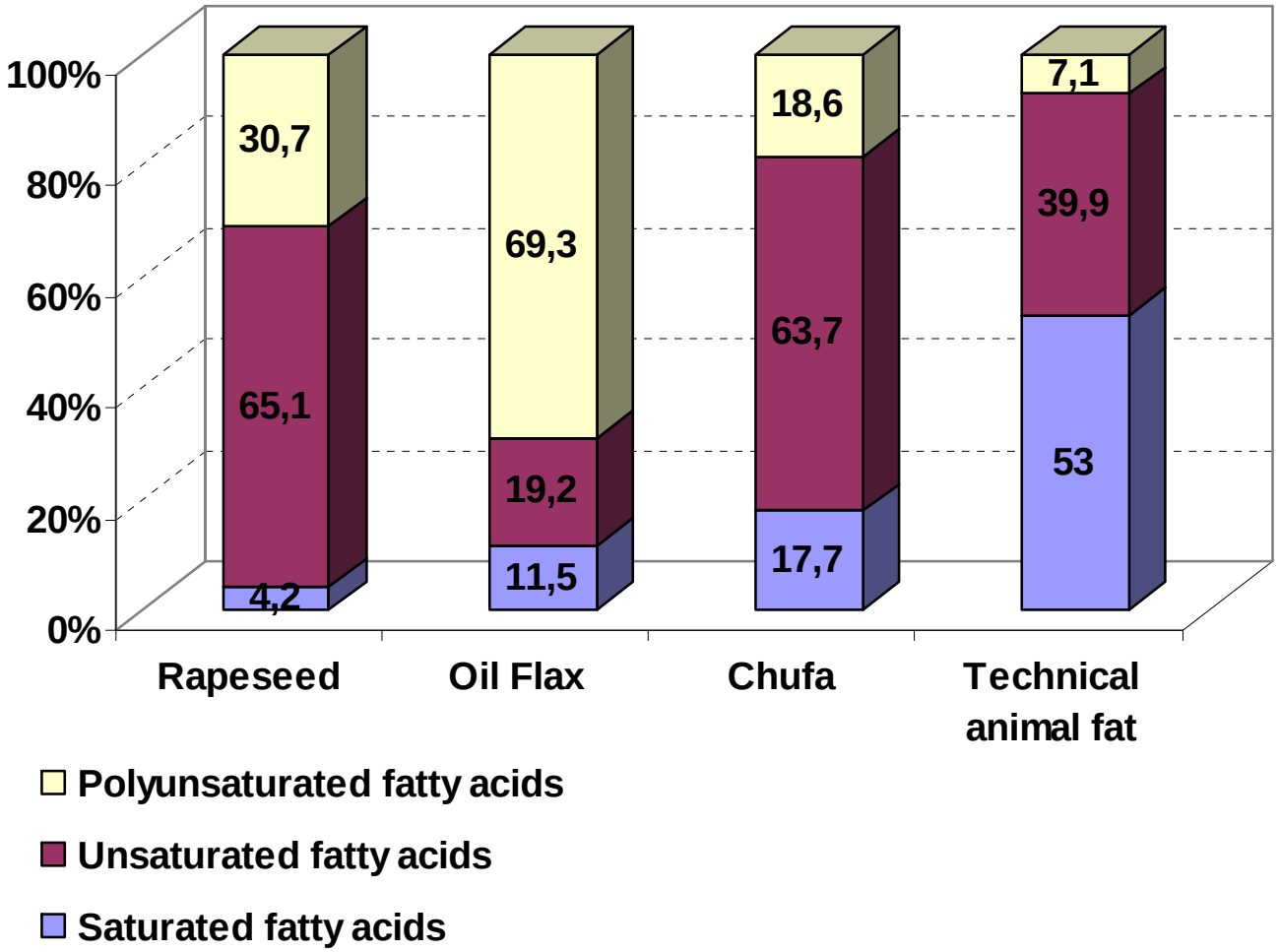
1ST YEAR RESULTS

(Lithuanian partner)

Composition of raw materials and **transesterification** of fatty wastes of animal origin

- Fatty acid composition of vegetable oil and animal fat
- Physico-chemical parameters of oil of the selected oil-bearing plants
- Physico-chemical parameters of technical animal fat
- Production of fatty acid methylesters from technical fat

Fatty acid composition of oil and fat



Problems of usage of new kinds of oil for biodiesel fuel production

Flax oil **Chufa (Cyperus esculentus L.) oil**

High content of mono and polyunsaturated fatty acids !!!!!

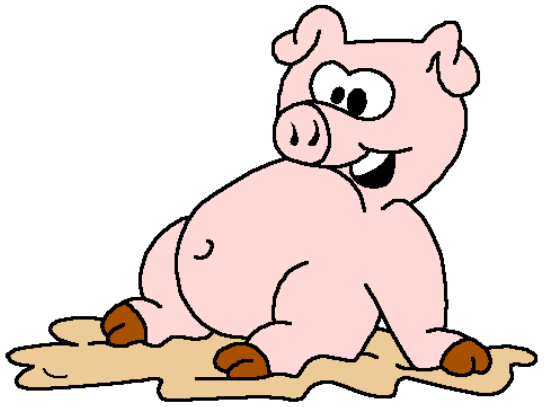
Low oxidation stability
High iodine value
High content of linolenic acid

Possible solutions:

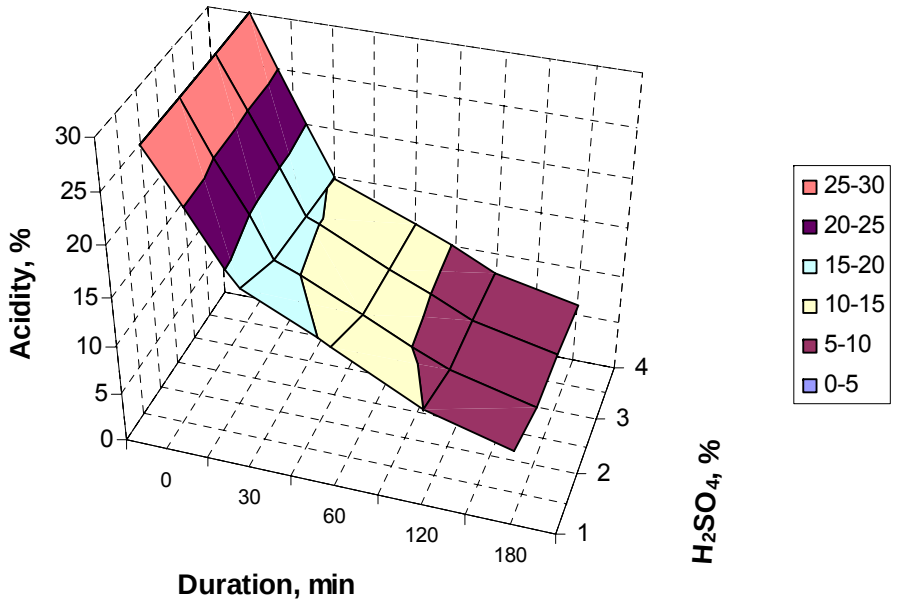
Production of FAME mixtures (with esters of animal origin)
Selection of suitable additives (antioxidants, depressants)

Physico-chemical parameters of technical animal fat

Parameter	Value
Density at 15°C, kg/m^3	910
Viscosity at 70°C, Pa*s	0.023
Acidity %	23
Acid value, mg KOH/g	46
Melting point, °C	+36
Iodine value, g/100g	46.5
Moisture, %	1.6



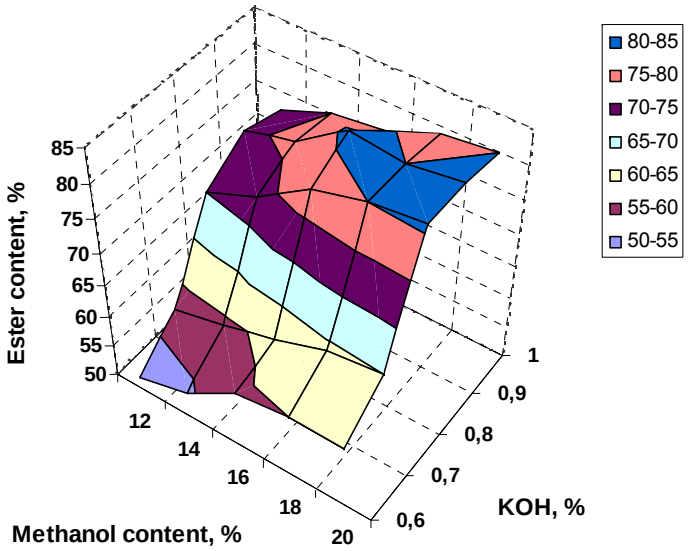
Esterification of technical fat with methanol

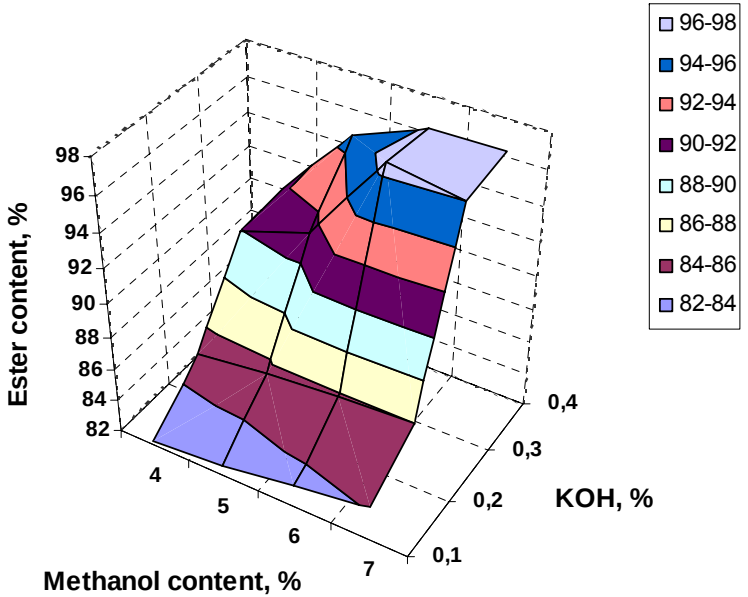


Optimal conditions of esterification:

Methanol excess - 5 times higher from stechiometric
Concentration of catalyst (H_2SO_4) - 1.04 %
Duration - 2 h
Temperature - 60 °C
Mixing speed - 250 min^{-1}.

Transesterification of technical fat with methanol





Optimal conditions of transesterification:

2 stage

Methanol content – 16-18%
KOH content – 0.8-0.9%

3 stage

Methanol content – 7%
KOH content – 0.3%

Duration - 1 h
Temperature - 60 °C
Mixing speed - 250 min^{-1}.

Some quality parameters of fatty acid methyl esters produced from technical fat

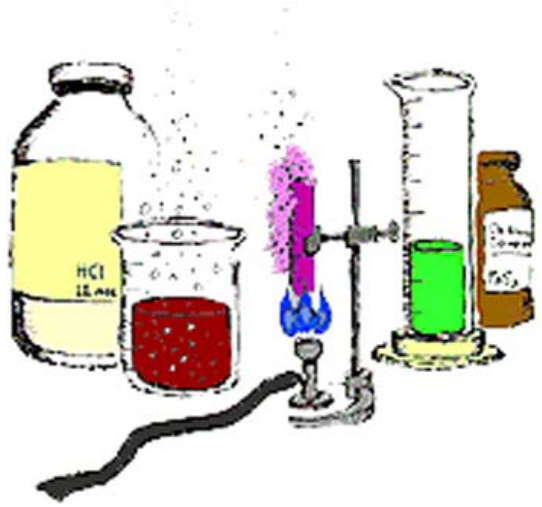
Parameter	Unit	Value	Requirements		Method
			min	max	
Ester content	% (mass)	96.6	96.5		EN 14103
Density at 15°C	kg/m³	881.9	860	900	EN ISO 3675
Viscosity at 40°C	mm²/s	4.7	3.50	5.00	EN ISO 3104
Sulfur content	mg/kg	21.2	-	10.0	Pr EN ISO 20846
Total impurities	mg/kg	32.4	-	24	EN 12662
Oxidation stability (110°C)	h	1.6	6.0	-	EN 14112
Acid value	mg KOH/g	0.90		0.50	EN 14104
Iodine value	g J_2/100 g	58		120	EN 14111
Total glycerol	% (mass)	0.10		0.25	EN 14105
Alkali metals	mg/kg	3.29		5.0	EN 14108
Phosphorus content	mg/kg	9.5		10.0	EN 14107
Cold filter plugging point (CFPP) (summer period)	°C	15	-5		EN 116

Next steps

- Production of vegetable oil (Flax, Chufa) methyl esters, evaluation of their quality parameters

- Selection of mixture compositions containing animal fat and vegetable oil meeting the requirements of biodiesel standard EN 14214

- Investigation and selection of additives for improvement of biodiesel cold flow properties and oxidation stability



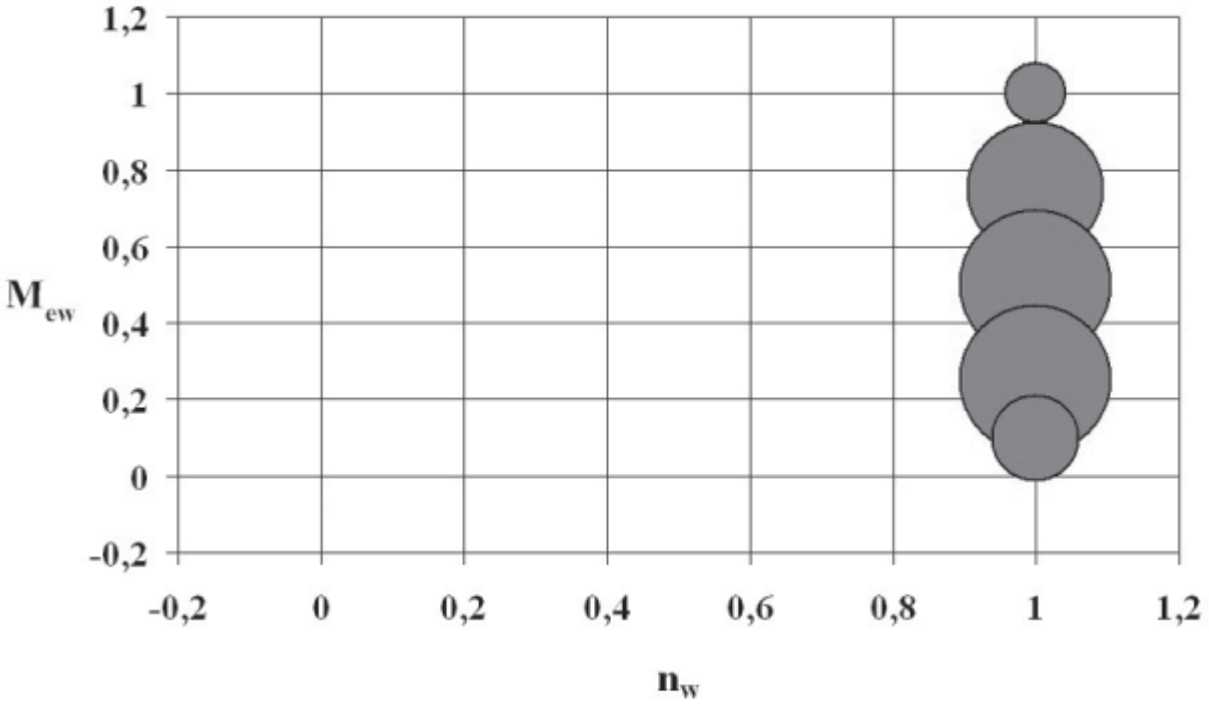
1ST YEAR RESULTS

(Poland partners)

- ✓ **Review of legal and normative documents related to the development of bioenergy as well as food security**
- ✓ **Methodology of conducting policy activities related to bioenergy identified**
- ✓ **Survey of sectors of the economy, whose activity is related to bioenergy**
- ✓ **Preparation of questionnaires for the project partners in order to obtain a wider and practical knowledge in the tasks**
- ✓ **Preparation of testing methodology of engine emissions**

Evaluation of on exploitation properties and gas emissions of produced biodiesel fuel

Preparation of test methodology



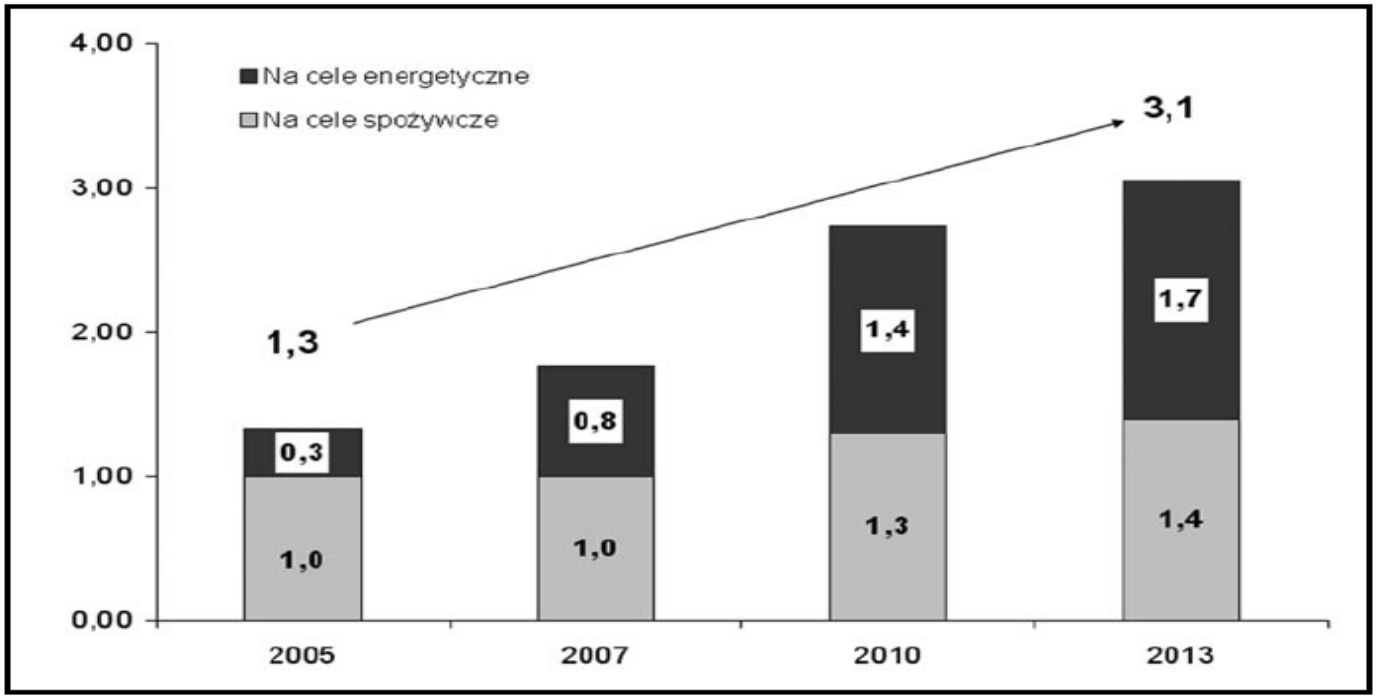
Scheme of engine loading with shares of the each phases in the total emissions in D2 – ISO 8178 test

Technical-economical grounding of the impact of the developed biodiesel fuel production technologies on the changes in production volumes in food industries

Factors influencing on the quantity of available raw materials for fuel and food industries:

- weather conditions (drought, ground frost, etc.)
- changes in demand and supply of raw material (the implementation of the National Index Target causes increasing production of biofuels, the variable profitability of plants cultivation (the raw material price changes)
- global trends (global environmental policy, emission reduction, etc.)
- State policies (subsidies for farmers)
- the use of genetically modified crops to increase yields while reducing the area of cultivation, cultivation of energy crops on poor soils (reducing the competitiveness of the cultivation surface for food crops)
- the use of oilseeds, which is not used in the food industry
- alternative technologies and second generation biofuels

Demand for rapeseed, mln tones (Poland, 2005-2013)



Black colour – planned demand for energy purposes
Grey colour – planned demand for food purposes

Area of cultivation, yields, and rapeseed harvest – trends (Poland, 2005-2013)

Description	Unit	2005	2007	2010	2013
Cultivation area	thousand ha	545	680	975	1052
- for food purposes	thousand ha	418	400	464	483
- for energy purposes*	thousand ha	127	304	511	569
Yield	t/ha	2,6	2,5	2,8	2,9
Harvest	mln ton	1,45	1,70	2,73	3,05
- for food purposes	mln ton	1,00	1,00	1,30	1,40
- for energy purposes*	mln ton	0,33	0,76	1,43	1,65

Planned demand for rapeseed oil for energy purposes (Poland, 2005-2013)

Description	Unit	2005	2007	2010	2013
Consumption of diesel fuel*	thousand ton	7110	7830	8980	10300
	thousand m^3	8464	9266	10627	12262
Ester content in diesel fuel**	%	2,12	3,71	6,10	6,10
Demand for esters	thousand m^3	179	344	648	750
	thousand ton	158	303	570	660
Demand for rapeseed oil	thousand ton	158	303	570	660

It is possible to increase the production of oilseed, by using lands with poor soils which size is estimated at over 1 million ha

Conclusions

- **Chufa (Cyperus esculentus L.) is the most promising to reduce negative impact of biodiesel production on food industries**
  Field experiments to be continued

- **Production of FAME from technical fat investigated**
  Optimal process parameters determined

- **FAME of animal origin has bad thermal properties**
  FAME of vegetable oil is expected to have low oxidation stability
  Problem solution – mixing if esters of different origin + additives

- **Impact evaluation started**

Project Coordination and Management

10 of June 2009
Kick-Off Meeting (Nowogród, Poland)

22 of November 2009
Second meeting (Kiev, Ukraine)

Third meeting of project Steering committee is planned in Lithuania during Baltic state conference covering problems of biofuel production, May, 2010.

All project life-time

- **Involvement of stakeholders / target groups (farmers-seedgrowers and biofuel producers)**
  - ✓ conferences
  - ✓ workshops-seminars
  - ✓ exhibitions
  - ✓ journal papers
  - ✓ articles, leaflets, recommendations

DIALOGUE WITH STAKEHOLDERS
DISCUSSIONS, FEED-BACK (QUESTIONEERS)
FIELD TESTING
EXPERIMENTAL BENCH SCALE BIODIESEL PRODUCTION

Dissemination

- Seminars for seed-growers and biofuel producers in Lithuania, Poland and Ukraine (LUA – Agrobalt-2010, annual expositions, etc.)
- International workshops and conferences every year in one of the selected partner country
  (Baltic state BIOFUEL conference, LT May, 2010)
- Publications in papers easily available for those dealing with agriculture (paper “Actuality of biofuel production development and new raw materials”. Author P. Janulis, Journal “Agriculture”, in Lithuanian)
- Publications in scientific journals (under preparation)
- Questionnaire for seed-growers, biofuel-producers, end-users (Poland)
- Recommendations for the seed growers and biodiesel fuel producers (3rd Year)

Financing of project partners

- **Lithuanian University of Agriculture is supported by Lithuanian Ministry of Agriculture**

  Planned budget – **76.840** EUR
  Financing for **2009 year – 17.391** EUR
  Financing for **2010 year – 28.985** EUR (under negotiation)

- **Institute for Fuels and Renewable Energy (Poland) is supported by Polish Ministry of Agriculture and Rural Development**

  Planned budget - **22.264** EUR including:
  20.240 EUR as a compensation for the task to pay by Ministry
  2.024 EUR as IPiEO's own recourses

- **National University of Life and Environmental Sciences of Ukraine - funding from own resources**

  Financing for **2009 year – 20.000** EUR

Thank you for attention!!!

Valdas Paulauskas
Lithuanian University of Agriculture
E-mail: valdas.paulauskas@lzuu.lt