

Production and Usage of Biomass in Agriculture

Using biomass Residues from Agricultural Production
and Quality of Soil – Business Case Food Industry





Austrian Agricultural Cluster
Integrated solutions for agriculture, food processing and renewable energy



AAC-members





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Mission – integrated solutions for



agriculture



food processing



renewable energy

Main topics



- **Characteristics of main crop residues**










- **Impacts of straw removal from fields for soil quality**



- **Business Case: Agro-biomass project in Food Industry - Replacement of fossil fuel (mazut) with straw**

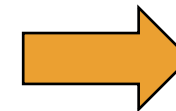
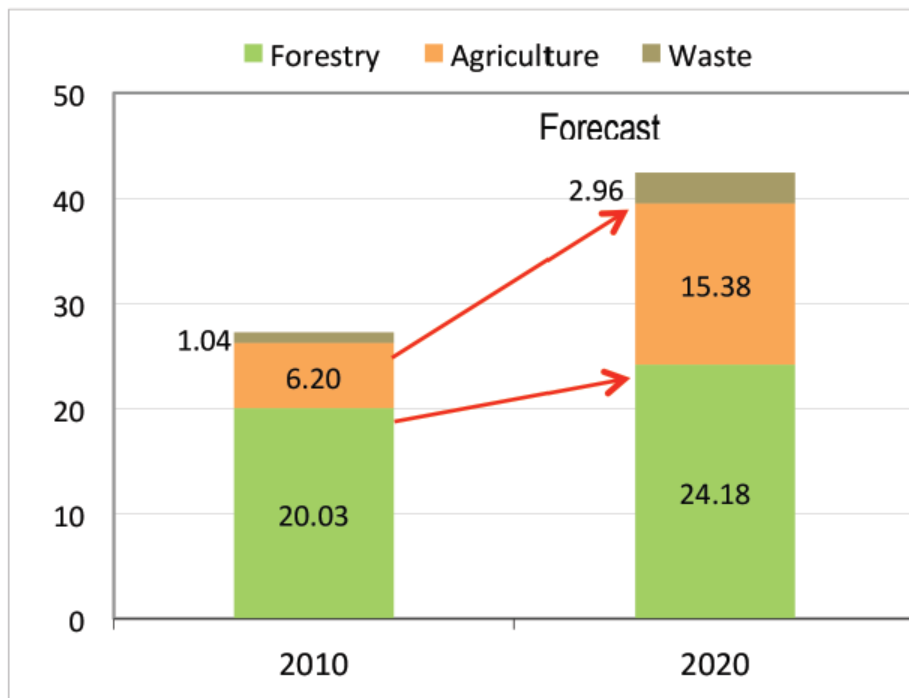
Increasing demand of agro-biomass – why?

-  **EU climate & energy targets 2030: -40% CO₂(level 1990) + 27% RES, +27% EE**
-  **European Union and National subsidies support investment in biomass projects**
-  **Introduction of “feed-in tariffs” for green electricity**
-  **Volatility of oil and gas prices**
-  **Companies are looking for cost-effective solutions for heat and steam production (Reduction of energy bill!)**
-  **Limited development potential in forestry (e.g. some Regions in Austria) – in some regions already overexploitation of forest resources**
-  **In Southeast Europe and especially in Vojvodina the biomass resources from agriculture dominates wood biomass**



Biomass supply in Danube Region 2010 and forecast 2020


Graph No. 32: Biomass supply by source [Mtoe]



**+150% increase
of agro-biomass**

Source: Danube Region Biomass Action Plan within Danube Region Strategy Energy; Countries Austria, Bulgaria, Croatia, Czech Republic, Germany (Bavaria, Baden-Württemberg), Hungary, Romania, Serbia, Slovakia and Slovenia

Classification of biomass resources

Sector	Type	Example
 Agriculture	Agricultural residues	Straw from wheat, corn, rape, sunflower, corn-cobs, etc.
	Livestock waste	Wet and dry manure (cows, pigs, especially poultry litter)
	Dry ligno-cellulosic energy crops	Herbaceous crops e.g. willow (salix), poplar , miscanthus, giant reed
	Oil sugar and starch energy crops	Oil seeds for methylester (e.g. rape seed, sunflower) Sugar crops for ethanol (e.g. sugar cane, sweet sorghum) Starch crops for ethanol (e.g. maize, wheat)
Forestry	Forestry by-products Dedicated forestry	Wood blocks, wood chips from thinnings Short rotation plantations (e.g. willow, poplar eucalyptus)
Industry	Industrial residues	Industrial waste wood, sawdust from sawmills Fibrous vegetable waste from pulp and paper industry
Waste	Dry ligno-cellulosic Contaminated waste	Residues from parks and gardens (e.g. prunings, grass) Demolition wood, organic fraction of municipal solid waste, biodegradable landfilled waste, landfill gas, sewage sludge

Properties of agro-biomass



Rectangular straw bale

- Dimension: 1,2 x 1,2 (0,9) x 2,5 m
- Weight: ~ 400 kg (high density up to 800 kg)
- Heating value: ~ 3.900 Kwh/ton
- Energy quantity: ~ 1.500 – 2.000 KWh per straw bale
- **Equivalent: ~ 200 l heating oil or 300 kg coal**



**One truck with average 20 tons
equivalent to 8.000 litres heating oil**

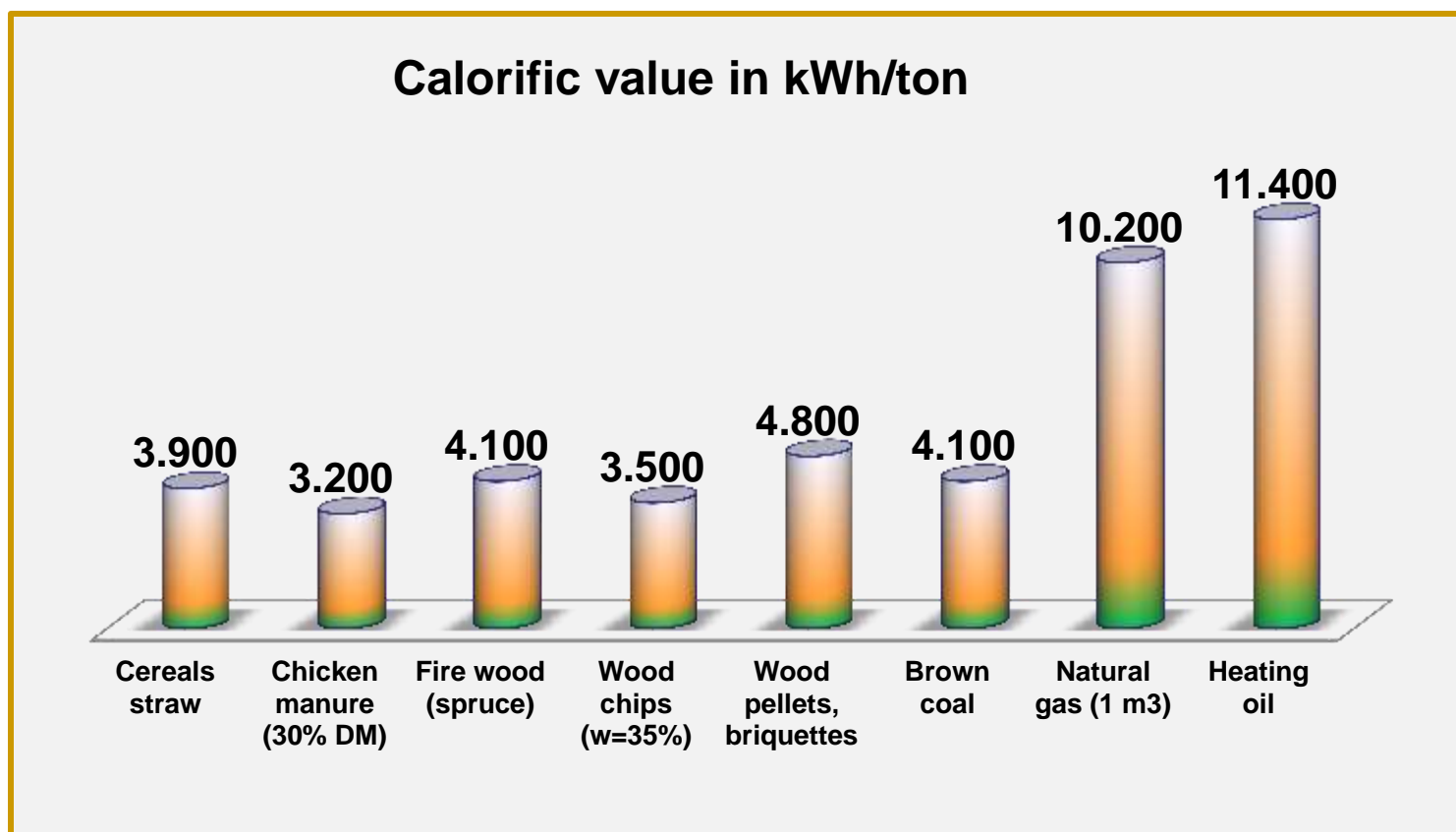


Intermediate storage on field

(Tight stacking, covered with foil)

On demand delivery to straw-biomass plant

Calorific values of different energy carriers



**) average heating values of agro-biomass in natural condition*

Properties of wheat straw



Average grain yield	6,5 t/ha
Average straw yield	5,2 t/ha
Average yield Vojvodina	2,5 t/ha
Grain-straw proportion	1:0,8
Heating value	3.900 kWh/t



- Mostly baled field crop in Europe
- Advanced harvesting technology and experience available
- Experience for energetic use due to clear biomass directives in Denmark, Great Britain and Spain
- Energetic use in Germany, Austria and Southeast Europe at beginning

Properties of corn straw



Average grain yield	6,8 t/ha
Average straw yield	8,9 t/ha
Average yield in Vojvodina	6,5 t/ha
Grain-straw proportion	1:1,3
Heating value	3.900 kWh/t



- Second mostly used field crop for energetic use mostly in southern Europe
- Harvesting technologies: bale press and collecting with self loading wagons
- Higher water content of corn straw at harvest but this depends on climate conditions
- Also used for production of agro-pellets

Properties of corn-cobs



Average grain yield	6,8 t/ha
Average corn-cobs yield	1,8 t/ha
Grain-cob proportion	1:0,26
Heating value	3.900 kWh/t



- Fuel with promising future
- Innovative and approved harvesting technology available
- Harvesting of corn kernels and cobs in one operation cycle - nearly cost neutral production as by-product
- Storage on field with foil cover
- Excellent fuel properties (bulk density and crude ash content comparable with wood chips)
- Optimal use in combination with other utilization (bedding material for poultry production, use in pharmaceutical industry, etc.)

Properties of soya straw



Average grain yield	3,5 t/ha
Average straw yield Vojvodina	2,3 t/ha
Grain-straw proportion	1:0,6
Heating value	3,8 kWh/kg



- Increasing demand for growing of soya in Danube region
- Baling similar to wheat straw with usually bale presses
- Experiences of soya straw baling in Vojvodina
- Storage on field with foil cover
- Minor heating value than other field crops

Properties of short-rotation forest (energy wood)



- Usual species Poplar and Salix
- Grown in short-rotation 2 - 3 years
- Alternative to crop production on marginal agricultural land
- Low annual production cost and minimal work input after first 2 years
- Alternative fuel due to increasing demand of wood based biomass (wood chips)



- Different harvesting methods in practise
- Manual with motor saw (for thick logs)
- Forestry harvesting methods like wood harvester for SRF > 7 years
- Modified combine - most cost-efficient an used in practise

Yields of short-rotation forest (energy wood)

Species	Good locations	Optimum locations
Poplar	10 – 15 t/ha/y atro	16 – 25 t/ha/y atro
Salix	10 – 14 t/ha/y atro	15 – 20 t/ha/y atro
Volume fresh harvest	60 – 90 loose m ³ /ha	90 – 120 loose m ³ /ha















Properties of animal substrates

	Cows	Pigs	Hens
Availability	18 m ³ /(LU a)	15 m ³ /(LU a)	6,5t/(LU a)
Dry matter content (DM)	11 – 12%	7 – 8%	22 – 23%
Organic substances (OS)	1.760 kg/(LU a)	840 kg/(LU a)	1.070 kg/(LU a)







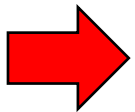
The table above shows the fresh manure (dung and urine) from animal production in livestock units (LU) (one LU is equivalent to 500 kg living weight; ~ one cow, ~ six pigs fattening places, ~ 294 laying hens places)

Agro-Biomass: Strength-Weakness Analysis

Strength	Weakness
<ul style="list-style-type: none">  Sustainable production  CO₂-neutral fuel  Cost-efficient (lower price than fossils)  Regional production – local use “Principal of short ways/logistics”  Structure of Serbian agriculture offers high potential of availability  Agricultural residues do not compete with food and feed  “Food is for people – waste for energy” 	<ul style="list-style-type: none">  Lack of standardisation of agro-biomass  Legal framework conditions needs to be improved and adapted  Investments in harvesting, logistic and conditioning necessary  Fuel properties different to wood-biomass but innovative and approved combustion technology available  Up to now minor activities in research and development

Impacts of straw removal from fields for soil quality








-  **Lack of availability of reliable scientific research analysis**
-  **Controversial discussion among experts** depending mainly on their priority of agricultural production (crop farming, animal production,...)
-  **Therefore only general statements can be made**
-  **Rule of thumb:**



40% of residual biomass could be taken from the fields without damaging the soil quality / nutrition value sustainably



Impacts of straw removal from fields for soil quality

-  **Decision of how much residual biomass can be taken from the fields can only be decided locally and depends on following main issues:**
-  **Soil conditions and quality**
-  **Climate conditions** (rainfalls, drought resistance,...)
-  **Crop rotation plan**
-  **Fertilizer management**
-  **Harvesting technology** (e.g. adjustment of harvester in terms of heights, collection losses,...)
-  **Practical experience!**



Impacts of straw removal from fields for soil quality – Harvesting technology

 Example: Residues on corn field before baling



Without chopping (after corn-head)

- Less material available for baling
- Higher wear on baler pickup from high stubble



With chopping (after corn-head)

- More material available
- Perfect windrow
- Less pickup wear



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The farmer as renewable energy producer

-  **New perspectives** for farmers and **adding value** to agricultural production
-  Diversification and **additional income** by sustainable use of residues and energy crops
-  Cultivation of **marginal agricultural land** (especially for **energy wood**)
-  **Contribution to local economy** by creating new jobs and supporting local investments
-  Agreement on long-term **supply contracts** (12 – 15 years) with agro-biomass plants contribute to improve the **balance of risks** in production
-  Favourable **investment opportunities** in agro-biomass plants due to profitable green electricity tariffs for agro-biomass and energy wood (minor or even major shareholder)



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 -  Minor or even major shareholder of biomass plants










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Business proposal: Farmers agro-biomass logistic company

-  **Regional farmers** join together for foundation of biomass logistic company or use legal form of association
-  Buying **agricultural machinery** for logistics (tractors, balers, staplers,...)
-  Making use of **EU-Funds** (IPARD-Programme) and **National/Regional support schemes**
-  **Provide unused buildings for storage** of straw bales beside storage on-field
-  Agreement of **long-term supply contracts** with agro-biomass plant operators (Toplanas, Public buildings, PPP, Neighbour-heating, Industrial plants,...)
-  Participation as **shareholder** in **agro-biomass plant companies**



Primary energy cost of different energy carriers in Serbia

Energy carrier	Unit	Calorific value in per unit	Price per unit EUR	Price per kWh in Eurocent
Straw in bales	ton	3.900	45,00	1,2
Electricity	kWh	1	0,055	5,5
Natural gas	m3	10	0,37	3,7
LPG	litre	10	0,906	9,1
Diesel	litre	9,8	1.159	5,2
Fuel oil (Mazut)	kg	11	0,50	4,5
Wood chips (mc=35%)	ton	3.500	65,00	1,86
Pellets, briquettes	ton	4.800	180,00	3,75
Coal Kovin mine	ton	2.920	27,00	0,93
Coal Vreoci mine	ton	5.210	75,00	1,43
Coal Banovici mine (BiH)	ton	5.810	75,00	1,30

Source: Different energy carriers in Serbia and their calorific value and prices (excluding transport cost); Desk research of different studies, expert talks and data from Rudarski Institut d.o.o., Beograd, Laboratorija za Cvrsta Goriva, November 2013



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Business Case A: Agro-biomass project in Food Industry

Replacement of mazut-boiler with straw-fired biomass boiler

INITIAL SITUATION

- Food processing company with constant demand of process energy
- Replacement of fossil fuel (MAZUT - heavy oil boiler)
- Implementation of 3 MW straw-fired steam boiler plant
- Economic strategy
- Technical proposal
- Profitability analysis





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Business Case: Framework conditions

- Established food processing company group
- Operation 52 weeks / 5 days per week / two-shift / 4.160 operation hours/year
- Actually mazut boiler in operation for production of
3 – 4 tons steam per hour
- Heat demand: 2,2 – 2,8 MW
- Mazut occurs high fuel cost (mazut 0,50 €/kg and 4,5 €cent/MWh – four times
higher than straw and coal, boiler at end of live time, low efficiency)
- **Immediate solution for reduction of heat cost
required in order to reduce energy cost!!!**



Economic strategy

- Immediate substitution of mazut boiler which occurs high energy cost
- Reduction of energy cost of actual 68 €/MWh or 46 €/t steam
- Additional income in new business sector and in farming activities

Actual cost of heat production with mazut boiler:

Heat production		10.400 MWh	
Oil price	45 €/MWh		668.000
Electricity	1,5%	50 €/MWh	7.800
Staff	15.000 €		15.000
Maintenance	12.000 €		12.000
Depreciation			0
Interest			0
Total	68 €/MWh		702.800
	46 €/t steam		



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Wheat straw



Corn straw



Soya straw

**3.600
tons/year**

**STRAW-FIRED
STEAM BOILER
PLANT
3 MW_{th}**



**TOTAL STEAM
PRODUCTION
~12.000 MWh/year
~8.000t steam/year**

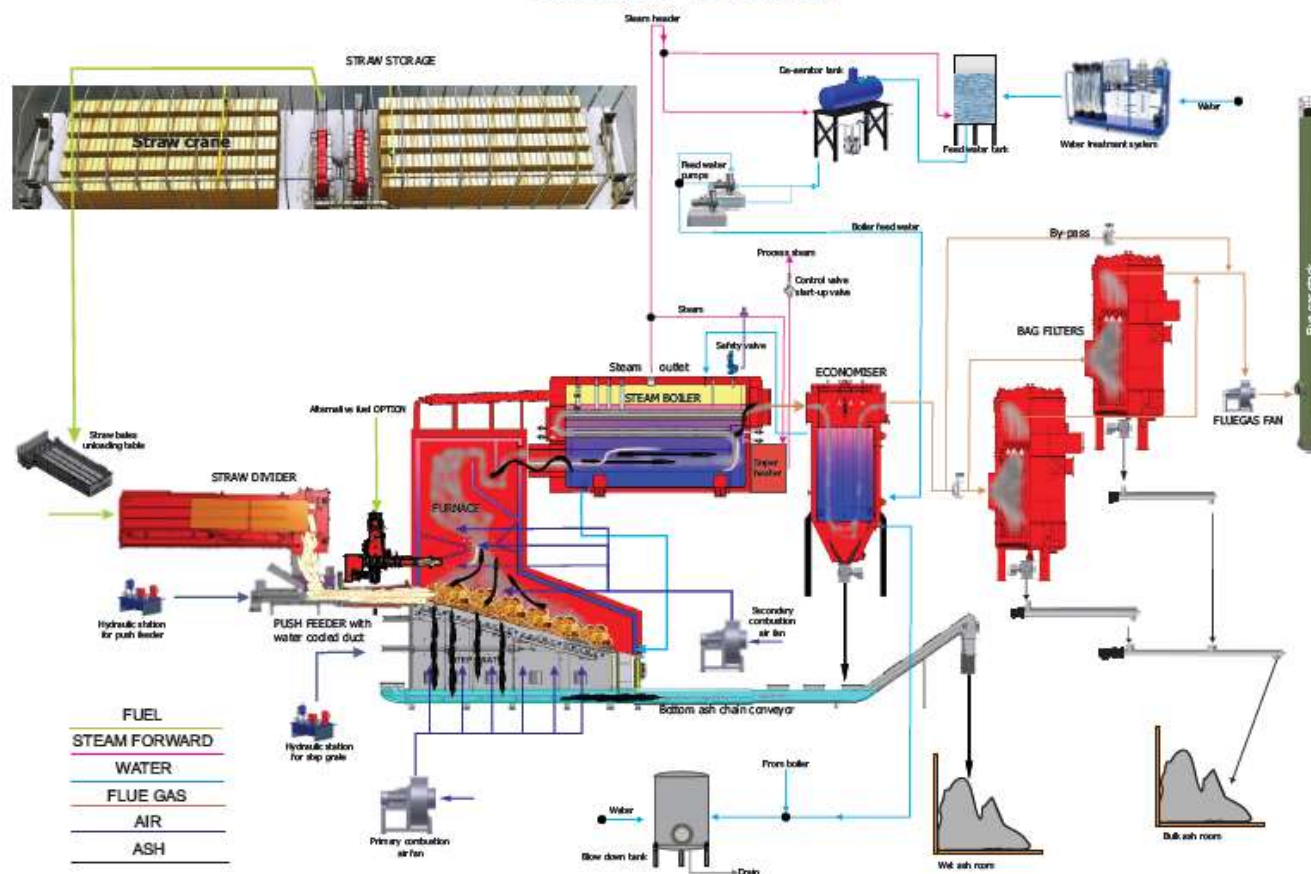
12.000 MWh

**Food processing
company**



BIOMASS BOILER PLANT 3-14 MW FUEL - STRAW

PROJECT PARAMETERS: Boiler size 3-14 MW / Steam output - 4,5-21 t/h / Pressure - 16 barg / Temperature - 204°C
Straw input - 900-4210 kg/h





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Fuel demand and on-site biomass storage capacity

- Fuel demand: 12.000 MWh/year
- 3.600 tons of straw (square bales)
- Agricultural land requirement: ~1.000 ha (~3,5 tons/ha)
- Storage capacity for one week maximum boiler load capacity during winter time recommended
- Fuel demand: ~0,9 ton/hour; 80 tons per week
- Required storage capacity for 200 bales (avg. bale weight 400 kg)





Evaluation of economic profitability

Investment	EUR	1.300.000
Equity	40%	520.000
Grant	0%	0
Loan	60%	780.000
Interest rate / period	7%	10 years
Persons employed / cost per year in €	4	15.000
Installed plant capacity (heat)	MW _{th}	3
Operation time	hours/year	4.160
Heat output per year	MWh	12.000
Heat price	EUR/MWh	68
Input materials (straw bales)	tons	3.600
Cost of straw bales	EUR/ton	45,00

Evaluation of economic profitability

- The project shows a very high profitability

ROI – Return on Investment	in %	39,0
Payback time	in years	2,4

- Comparison of production cost in MWh and per ton of steam

	Existing gas boilers	New agro-biomass steam boiler plant	Difference
Cost per MWh in €	68*	30**	-38
Cost per ton of steam in €	46*	21**	-25

**) Cost including expenses for fuel, production, operation, no depreciation and interest due to existing plant*

****) Cost including expenses for fuel, production, operation, depreciation and interest*



Economics before and after fuel change

	Before MAZUT	Fuel change STRAW-BALES	SAVINGS
Fuel	1.200.000 l	3.600 tons	-
Fuel cost in €	600.000	164.000	-436.000
Fuel cost in%	100%	27%	-73%
Cost in € per 1 MWh _{heat}	68/MWh	30/MWh	-38/MWh
Cost in € per 1 ton _{steam}	46/MWh	21/MWh	-25/MWh
CO ₂	3.120 tons	CO ₂ -neutral	3.120 t



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DOING BUSINESS WITH AGRO-BIOMASS

- ✓ Information & exchange of experience
- ✓ Cooperation
- ✓ Project development

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