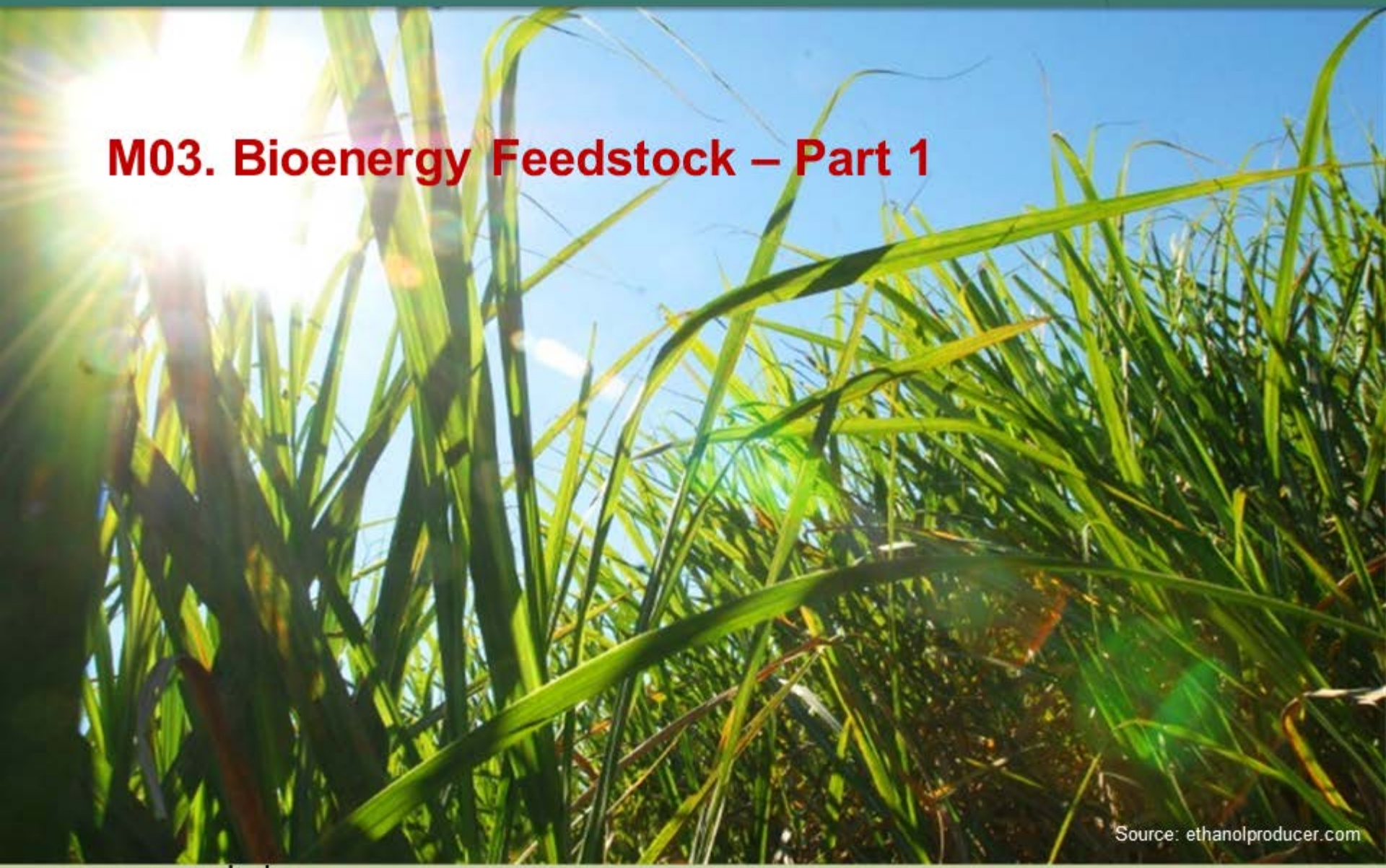
M03. Bioenergy Feedstock – Part 1



Source: ethanolproducer.com

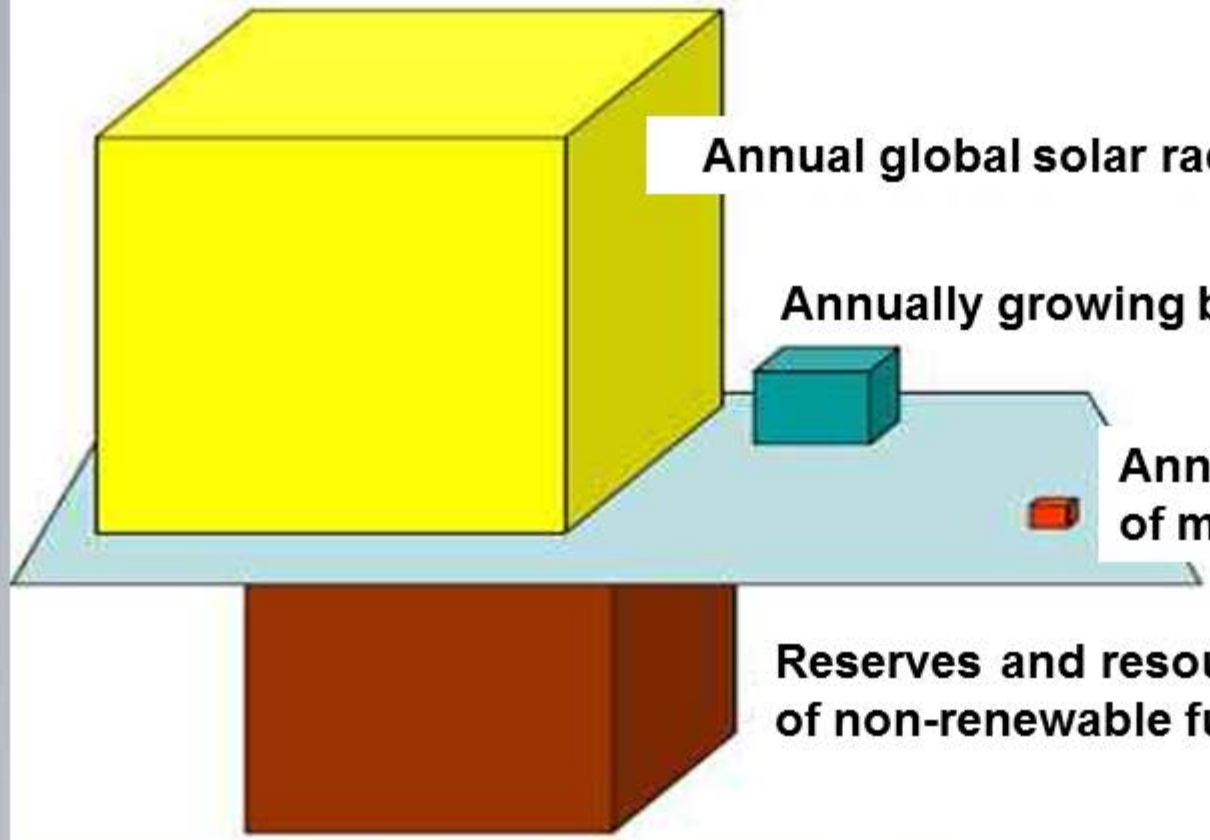
Bioenergy feedstock

- Introduction
- Trees and residues
- Ligno-cellulosic crops and residues
- Oil crops and residues
- Sugar and starch crops and residues
- Environmental aspects

Introduction

- Global biomass generation
- Definition and classification of biomass
- Bioenergy potentials
- Classification of energy crops

Selected energy sources and energy consumption worldwide



Annual global solar radiation: $26*10^5$ EJ

Annually growing biomass: $>3*10^3$ EJ

Annual energy consumption of mankind: $5\text{-}6*10^2$ EJ

Reserves and resources of non-renewable fuels: $6*10^5$ EJ

http://www.aktuelle-wochenschau.de/images/w3/abb2.jpg&imgrefurl=http://www.aktuelle-Wochenschau.de

Biomass

Bioenergy Feedstock

Future source: Algae!

Biomass
is material derived from **recently** living **organisms**, which includes **plants**, **animals** and their **byproducts**.

Solid Biofuels | **Liquid Biofuels** | **Gaseous Biofuels**

Heat | **Mech. Power** | **El. Power**

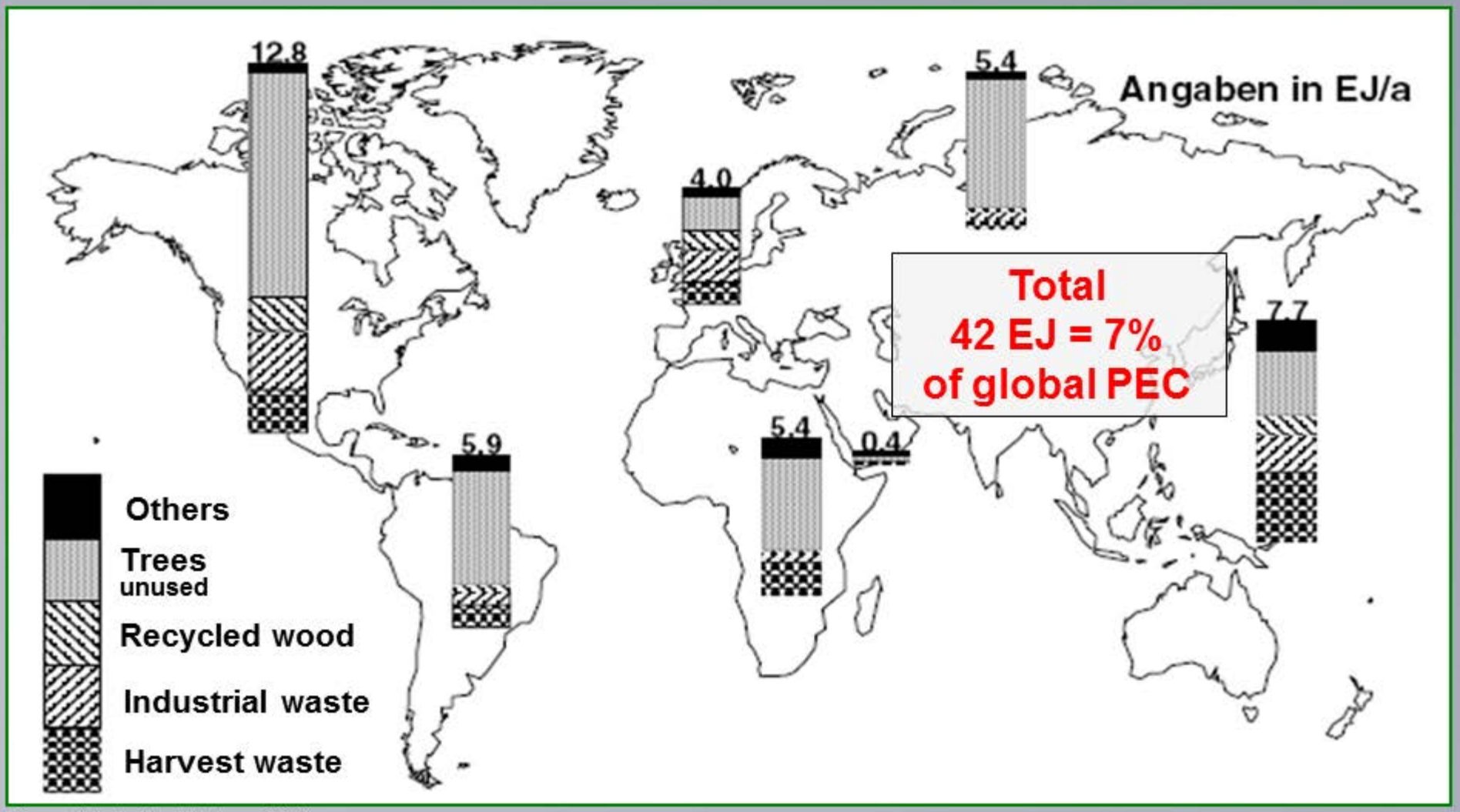
Examples:

Whole trees, Short rotation coppice, Prunnings, Bark, Sawdust, Waste wood, Grass, Sugar cane, Palm seeds, Corn, Straw, Shells, Bagasse, Garden residues, Banana peels, Food waste, Excrements, Organic industrial waste, Used organic materials etc.

Energy potential
of wood

go green ltd.

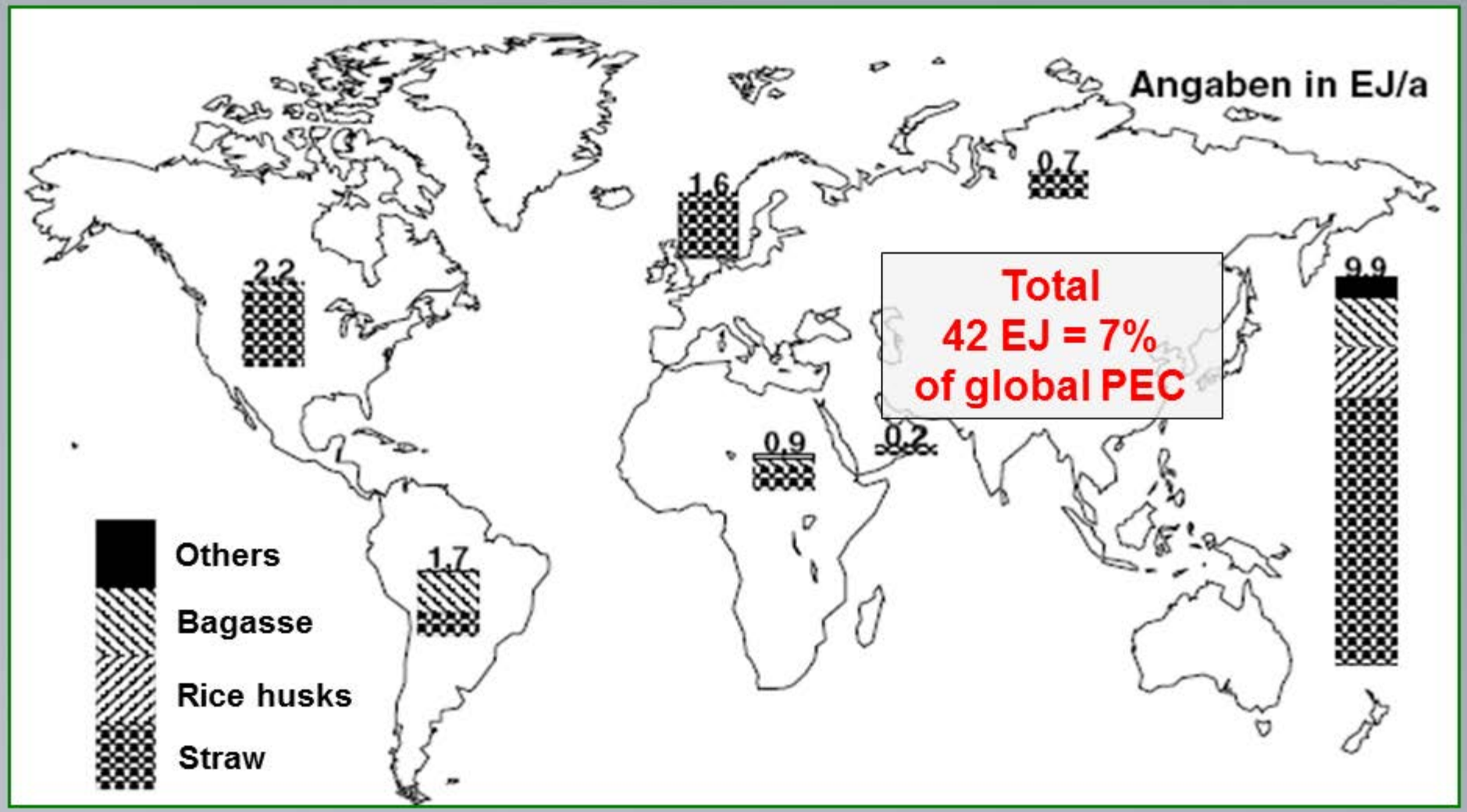
worldwide by regions



Source: Kaltschmitt und Hartmann 2001

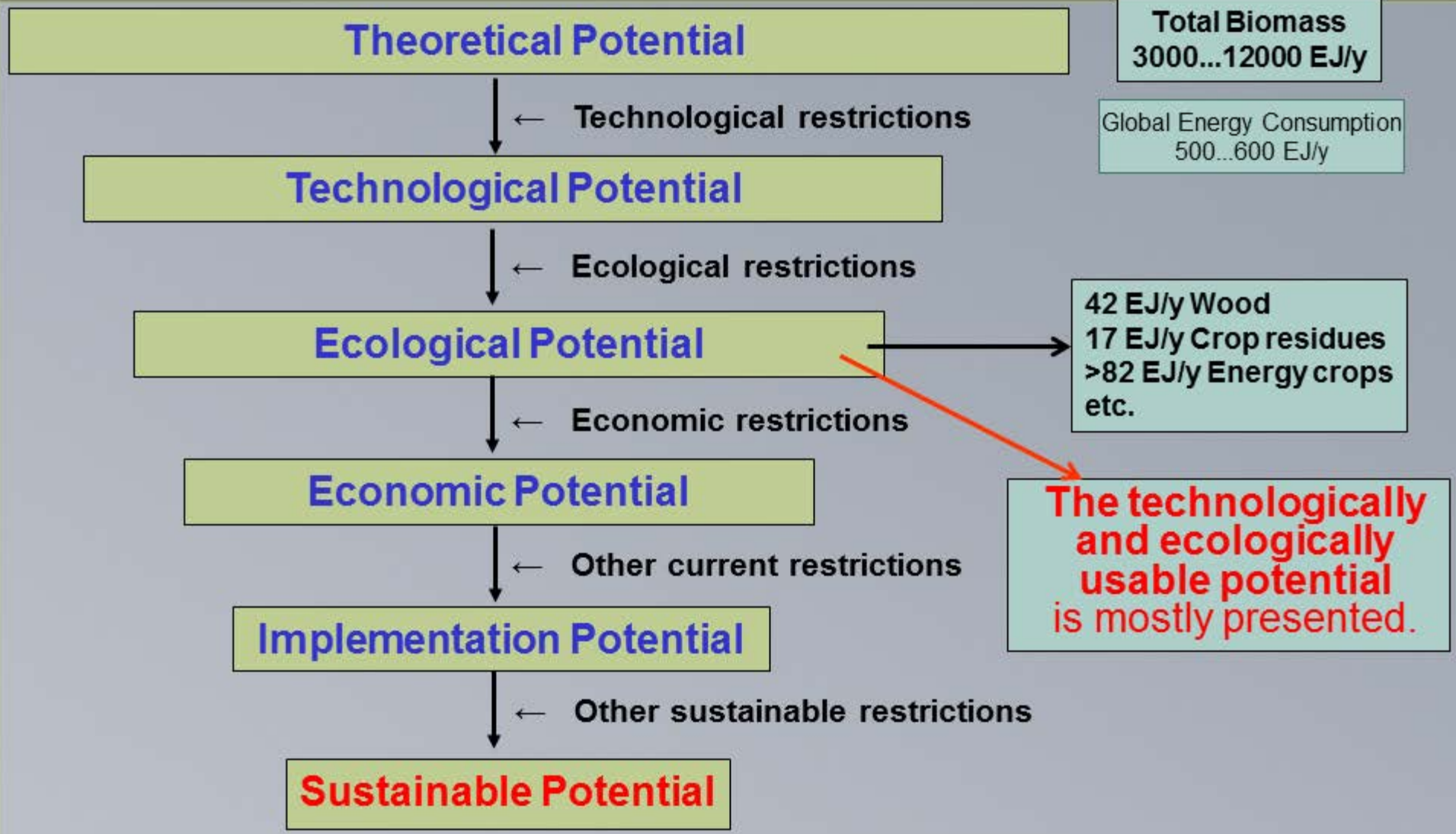
Energy potential
of solid crop residues and by-products

worldwide by regions



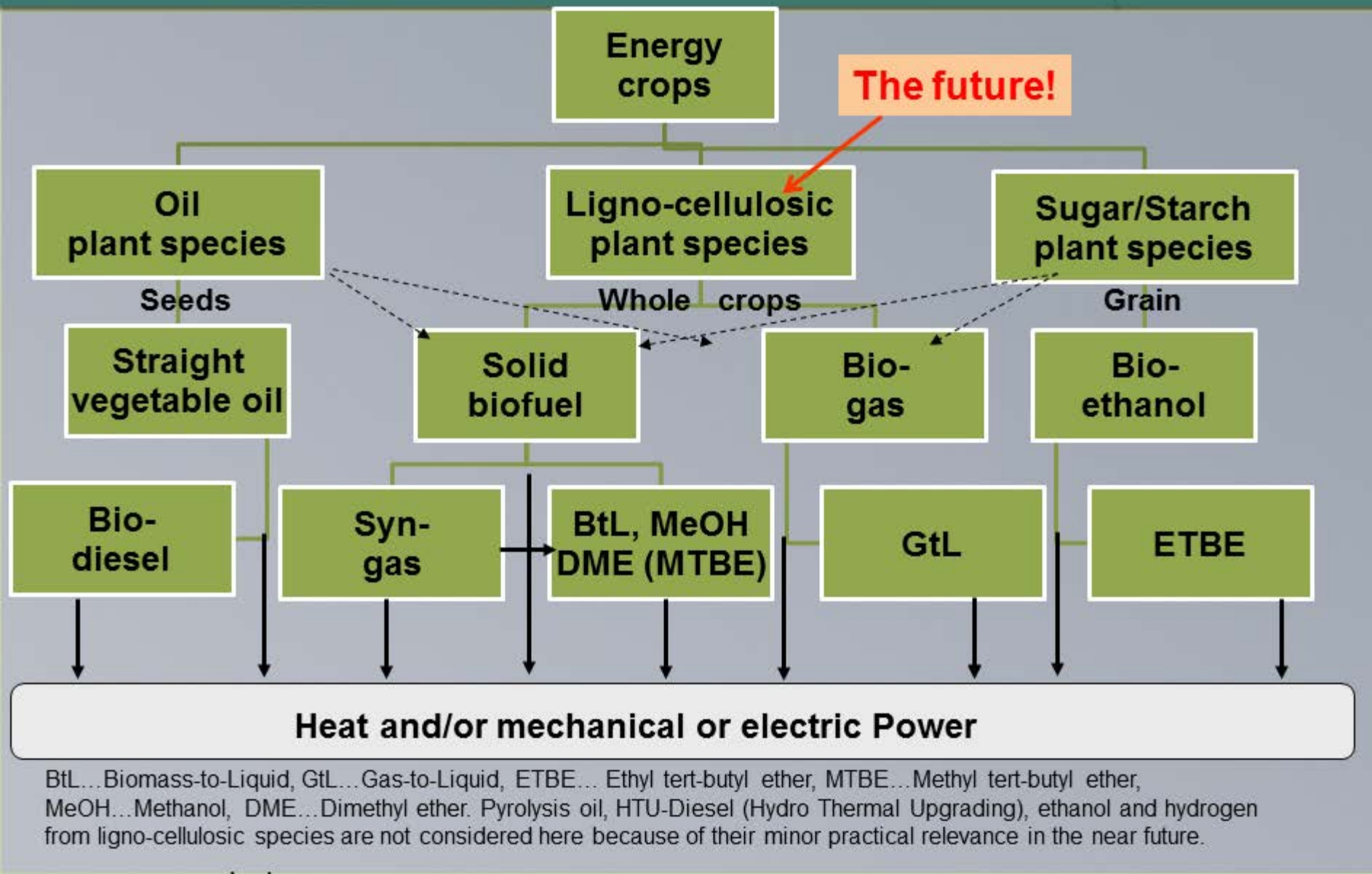
FNR, 2005 Abb. 2-5 Source: Kaltschmitt und Hartmann 2001

Categories of potential
of renewable energy sources



All potential fractions need a temporal and regional description!

Energy crops
Classification



BtL…Biomass-to-Liquid, GtL…Gas-to-Liquid, ETBE… Ethyl tert-butyl ether, MTBE…Methyl tert-butyl ether, MeOH…Methanol, DME…Dimethyl ether. Pyrolysis oil, HTU-Diesel (Hydro Thermal Upgrading), ethanol and hydrogen from ligno-cellulosic species are not considered here because of their minor practical relevance in the near future.

Energy crops
Species and cultivation conditions

Common name	Botanical name	Use	Elevation (m)		Temperature (°C)			Rainfall (mm y^{-1})	
			min	max	months	min	max	min	max
Oilseed rape	*Brassica napus*	O	0	800	04-07	6	40	400	1500
Linseed	*Linum usitatissimum*	O	0	900	03-09	4	32	250	1300
Field mustard	*Sinapis alba*	O	0	950	04-08	7	27	600	1200
Hemp	*Canabis sativa*	O/L	0	950	04-09	5	28	600	1500
Sunflower	*Helianthus annuus*	O	0	950	04-09	15	39	350	1500
Safflower	*Carthamus tinctorius*	O	0	900	04-09	20	45	400	1300
Castor	*Ricinus communis*	O	100	1800	04-08	17	38	500	2000
Olive	*Olea europaea*	O	0	2000	03-11	-7	42	200	1300
Groundnut	*Arachis hypogaea*	O	0	1500	04-08	19	45	450	2000
Barley	*Hordeum vulgare*	S/L	0	900	05-09	8	35	250	2000
Wheat	*Triticum aestivum*	S/L	0	950	05-09	11	32	400	1600
Oats	*Avena sativa*	S/L	0	1000	04-08	6	25	400	1200
Rye	*Secale cereale*	S/L	0	950	05-09	11	32	400	1600

O…Oil; S…Sugar/Starch; L…Lignocellulose

In total there are more than 60 crop species
usable for energy purposes

Energy crops
Species and cultivation conditions

Common name	Botanical name	Use	Elevation (m)		Temperature (°C)			Rainfall (mm y^{-1})	
			min	max	months	min	max	min	max
Potato	*Solanum tuberosum*	S	0	1000	04-09	5	25	500	1500
Sugar beet	*Beta vulgaris*	S	0	1000	04-09	5	25	500	1500
Jerus. Artichoke	*Helianthus tuberosus*	S	100	750	05-09	8	25	500	1600
Sugarcane	*Saccharum officinarum*	S	0	1200	03-09	16	41	1000	-
Cardoon	*Cynara cardunulus*	L	0	500	11-08	-3	37	400	900
Sorghum	*Sorghum bicolor*	L/S	0	1100	04-08	16	40	300	700
Kenaf	*Hibiscus cannabinus*	L	0	600	02-11	-2	33	500	1100
Prickly pear	*Opuntia fiscus-indica*	L	0	1500	12-02	6	-	350	1500
Maize (whole)	*Zea mays*	L/S	0	950	05-09	9	40	450	1500
Reed canary	*Phalaris arundinacea*	L	0	1100	04-10	1	38	600	2000
Miscanthus	*Miscanthus* spp.	L	0	950	04-09	11	40	600	1500
SRC	*Salix* spp.	L	0	1100	04-10	1	38	600	2000
	Populus spp.		0	1100	05-09	3	38	600	2000
Eucalyptus ssp.	*Eucalyptus globulus*	L/O	0	1500	10-03	-6	36	400	2500
	E. camaldulensis		0	1500	04	7	36	400	2500
	E. grandis, E. terticonis		0	1500	05-09	10	36	400	2500

O…Oil; S…Sugar/Starch; L…Lignocellulose

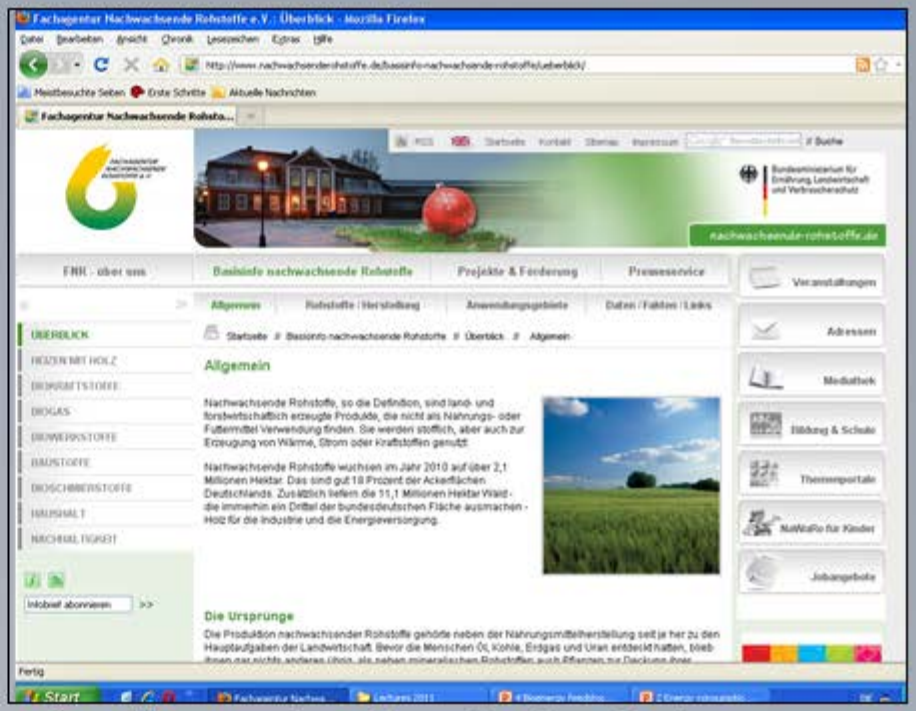
Typical solid crop residues
and by-products

Crop	Field (standing)	Field (cut)	House	Factory
Subsistence/cash				
Cereals				
Maize	Stover and leaf	Cob leaves	Cob	Parchment
Deep water paddy	Straw (nara)	Straw (kher)	Kher	Husk
Normal rice paddy	Stubble	Straw	Straw	Husk
Millet; sorghum	Straw	-	Chaff	-
Wheat, etc.	Stubble	Straw	-	-
Cassava	-	Stem	-	Waste
Pulses	Stern	-	-	-
Plantain, banana	-	Stem	Fruit stem	-
Papyrus	Stern	-	-	-
Heather, etc.	Whole plant[a]			
Cash crops				
Coffee (dry proc.)	(Woody biomass)		Cherries[b]	Cherry, husk
Coffee (wet proc.)	(Woody biomass)		-	Cherry, husk
Cotton	-	Roots and stems[c]	-	(Tow)
Coconut; palm nut	(Wood)	Fronds	Husk + Shell	Husk + Shell
Nut trees	(Woody biomass)		Shell	Shell
Groundnut	-	Stems		Shell
Sugar cane	-	-	-	Bagasse
Sisal	-	Old plants	-	Waste
Jute; kenaf; flax	-	Waste	-	Waste
Pineapple	-	Old plants	-	Waste
Indirect use				
Grasses[d]	(Grass)	(Hay)		

Which has local importance?

Further information
on bioenergy feedstock

http://bioenergy.ornl.gov/main.aspx



http://www.nachwachsenderohstoffe.de

<u>in English:</u>

(BFIN) Bioenergy Feedstock Information Network

<u>in German and English:</u>

(FNR) Fachagentur Nachwachsende Rohstoffe

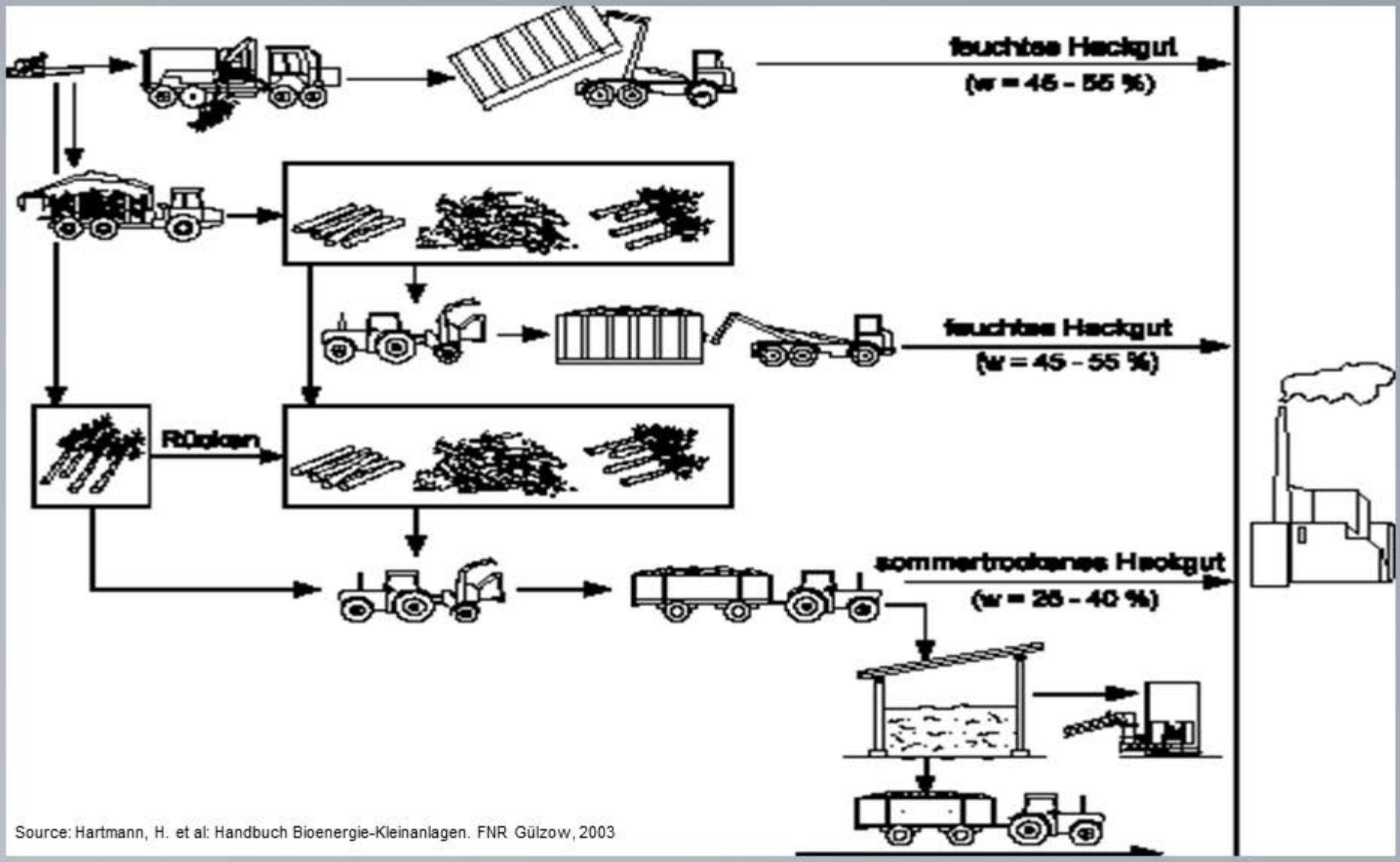
Agency for Renewable Resources

Trees and residues

- Energy wood from forest
- Energy wood form farmland
- Wood residues and waste

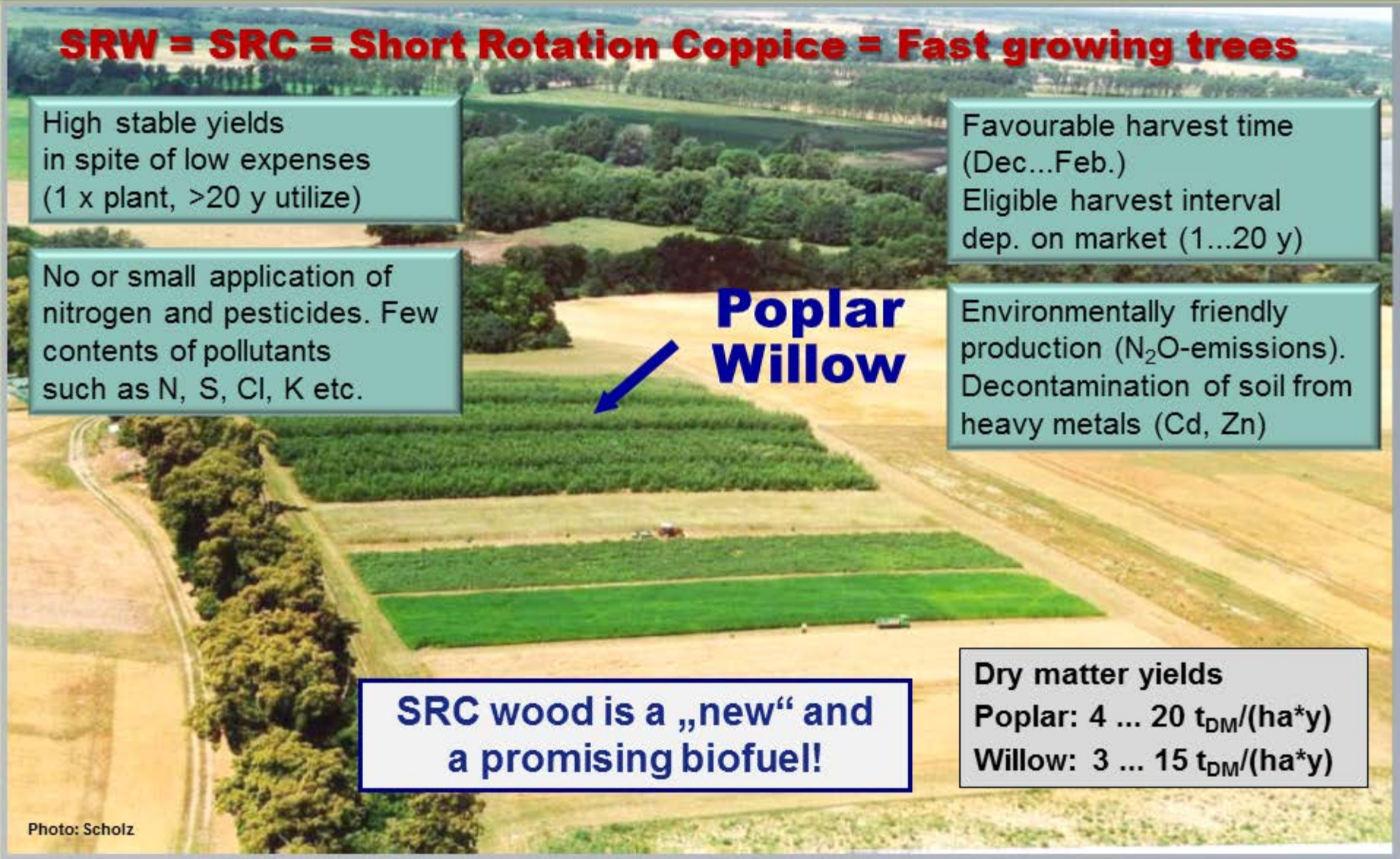
Conventional forest technologies and (increasingly) chip lines

Production lines of wood chips
Logistics of forestal wood



Source: Hartmann, H. et al: Handbuch Bioenergie-Kleinanlagen. FNR Gülzow, 2003

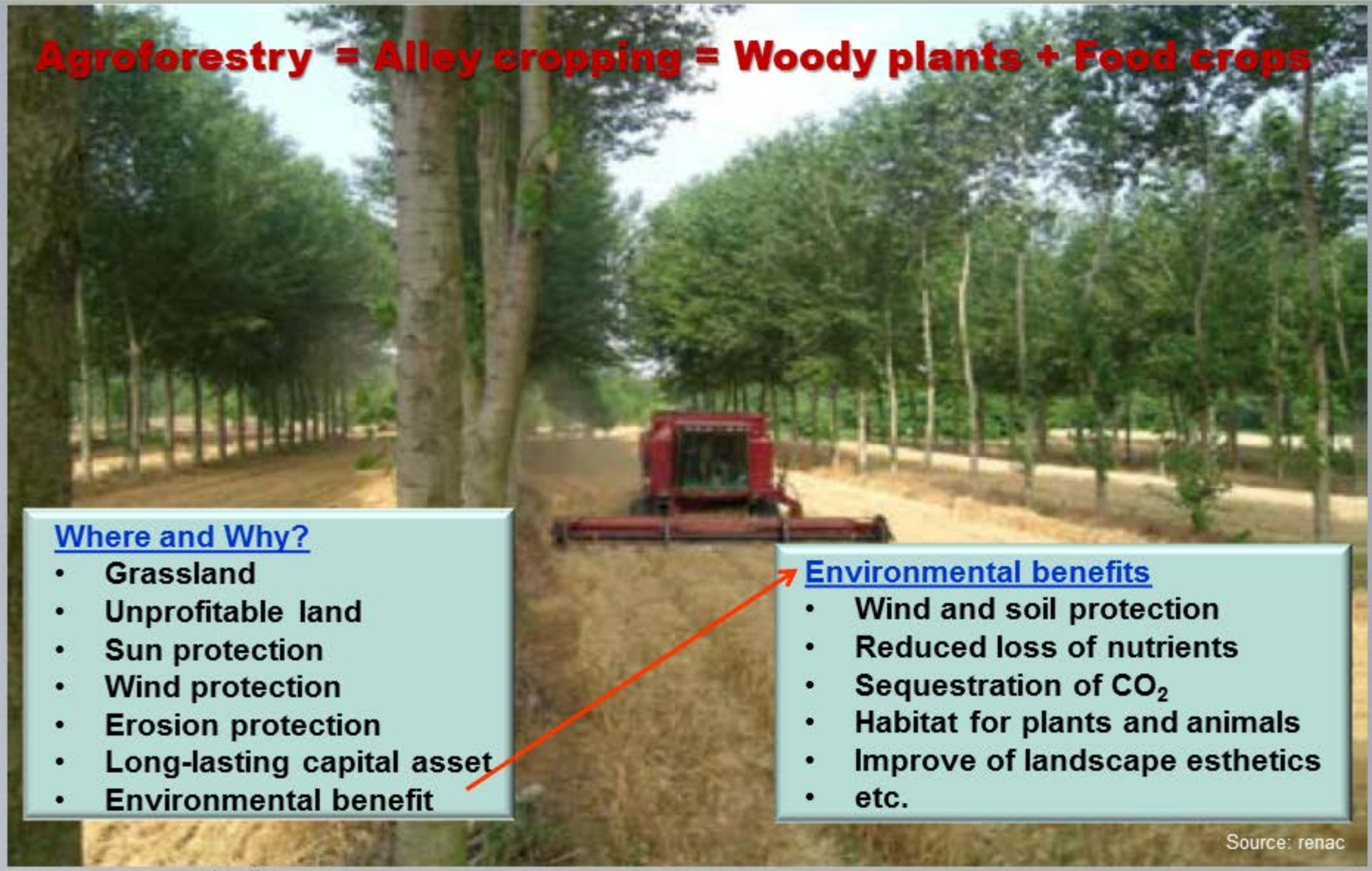
Energy wood from farmland
in temperate climates



Production lines
of short rotation coppice

go green ltd.

Agroforestry systems
Example: Poplar + Rye



Energy wood from forest or farmland
in the tropics

Example: Eucalyptus

Logs and chips

Rotation intervall: 6 - 7 years

Wood density: 200-1000 kg_{FM}/m^3

Logs for charcoal production

Dry matter yield

10 ... 30 $t_{DM}/(ha*y)$

Yields of selected tree species
in temperate climate and tropical zones

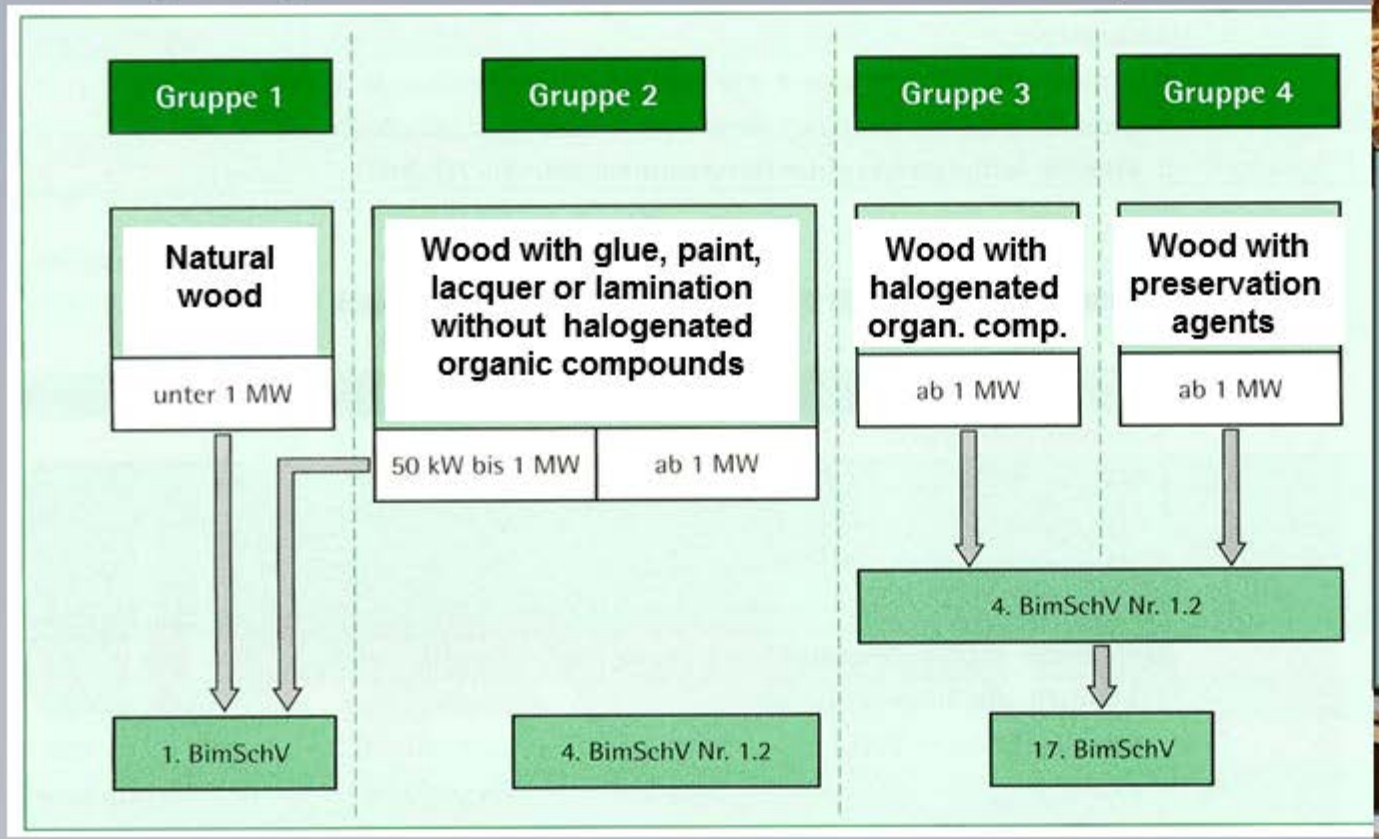
In Central Europe	Average	Range
	without bark and small branches	
Deciduous trees from forest		
Oak	3,7	3,5 - 5,2 m³/(ha*y)
Beech	5,4	4,4 - 6,6
Others	3,7	3,2 - 5,2
Conifers trees from forest		
Pine	8,2	6,9 - 9,4 m³/(ha*y)
Spruce	7,9	6,2 - 14,1
Pine, wild	4,7	4,0 - 6,4
Others	5,7	4,3 - 8,1
Short rotation coppice (SRC) from farmland	with bark and branches	
Poplar	10 t_{DM}/(ha*y)	4 - 20 t_{DM}/(ha*y)
Willow	8 t_{DM}/(ha*y)	3 - 15 t_{DM}/(ha*y)
In the Tropics		
Eucalyptus on plantation	20 t_{DM}/(ha*y)	10 - 30 t_{DM}/(ha*y)
Madero negro on plantation	15 t_{DM}/(ha*y)	5 - 20 t_{DM}/(ha*y)

$$m = \rho V$$

Sources: Kaltschmitt & Wiese (1993); KTBL (2010); Scholz (2014)

Wooden residues and waste for energetic use

Classification of wood waste (treated wood, used furniture, demolition wood, chipboard residues, railway sleepers etc.) **and legal regulations for combustion in Germany**



BImSchV…Federal Immission Control Act

Source: Energie aus Biomasse. Ein Lehrmaterial

Natural untreated wood residues from agriculture and forest (thinnings, branches, prunings etc.) or from industries (bark, sawdust, palettes etc.) can energetically be used **without any legal restrictions**.

Ligno-cellulosic crops and residues

- Cereals
- Grass and cane
- Crop and energy yield

Ligno-cellulosic crops and residues

A wide spectrum of bioenergy feedstock

Wheat/Corn/Jowar Bajara Husk

Napier Grass

Wood Waste

Corn Cob

Ground Nut Sheels

Sunflower/ Soybean Husk

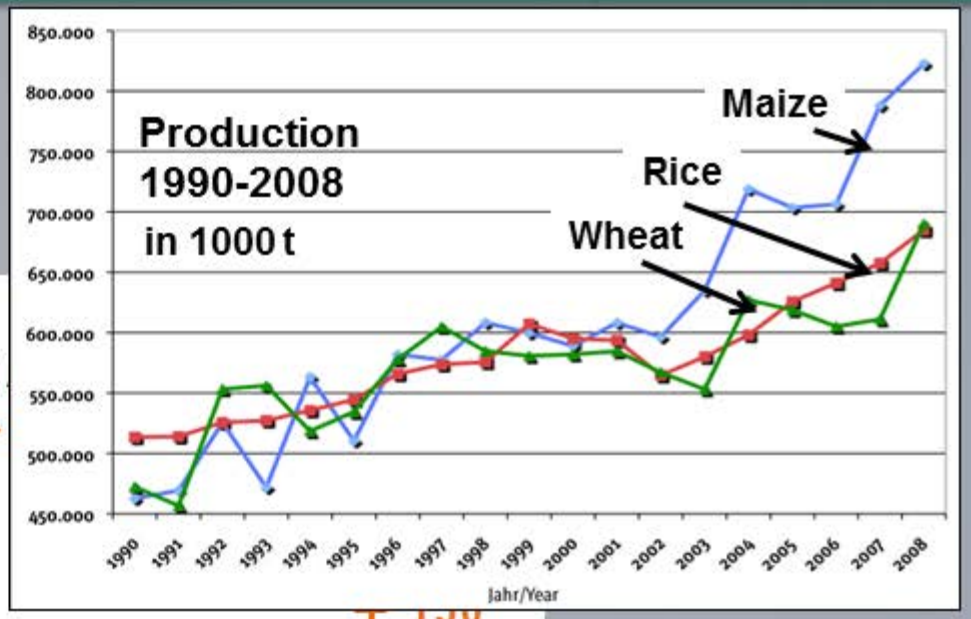
Bagasse Waste

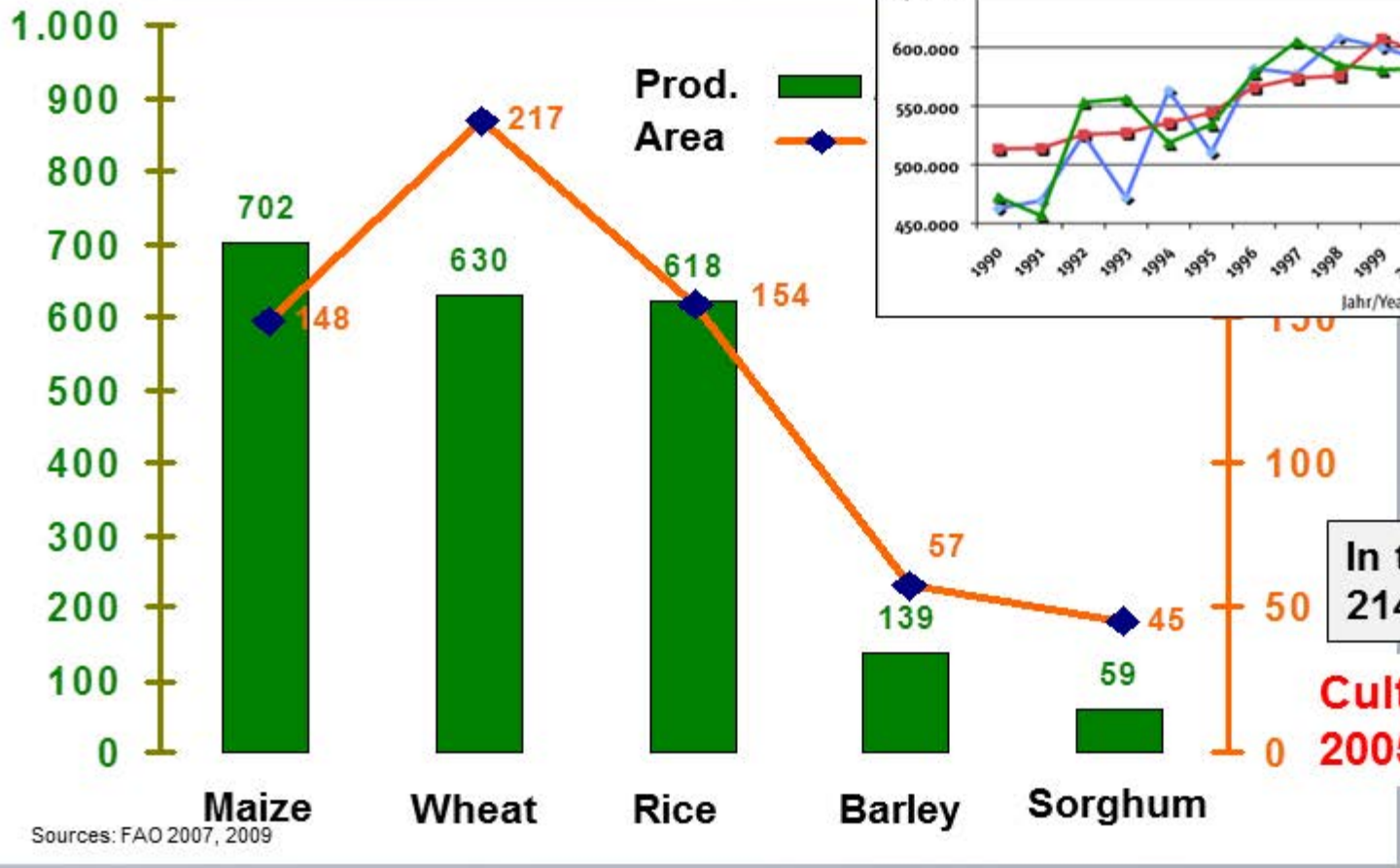
Cotton Stalk

Cereal production
worldwide according to FAO

go green ltd.

Production 2005 (Mt)





In total:
2148 Mt on 621 Mha

Sources: FAO 2007, 2009

Sorghum
A potential energy crop species

Native to Africa but also cultivated in Central Europe

Dry matter yield of the whole crop
2 - 20 t_{DM}/(ha*y)

Sorghum bicolor
Sorghum sudanense
Sorghum bicolor x Sorghum sudanense

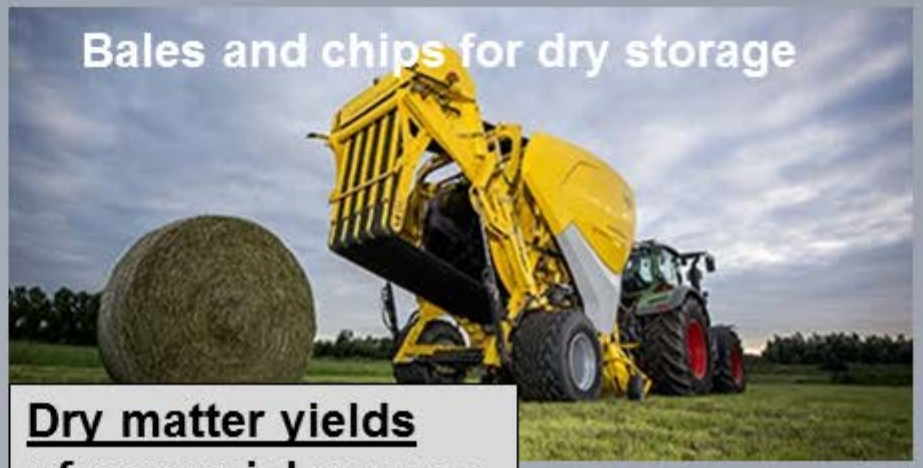
Geografical distribution:

Africa
Araby
Burma
India
East Asia
Australia
America
South Europe
Central Europe

First domestication:

Sudan
Chad

Energy grass or cane
Potential energy crop species



Dry matter yields of perennial grasses

In temperate climates:

10 … 25 t_{DM}/(ha y

In the tropics:

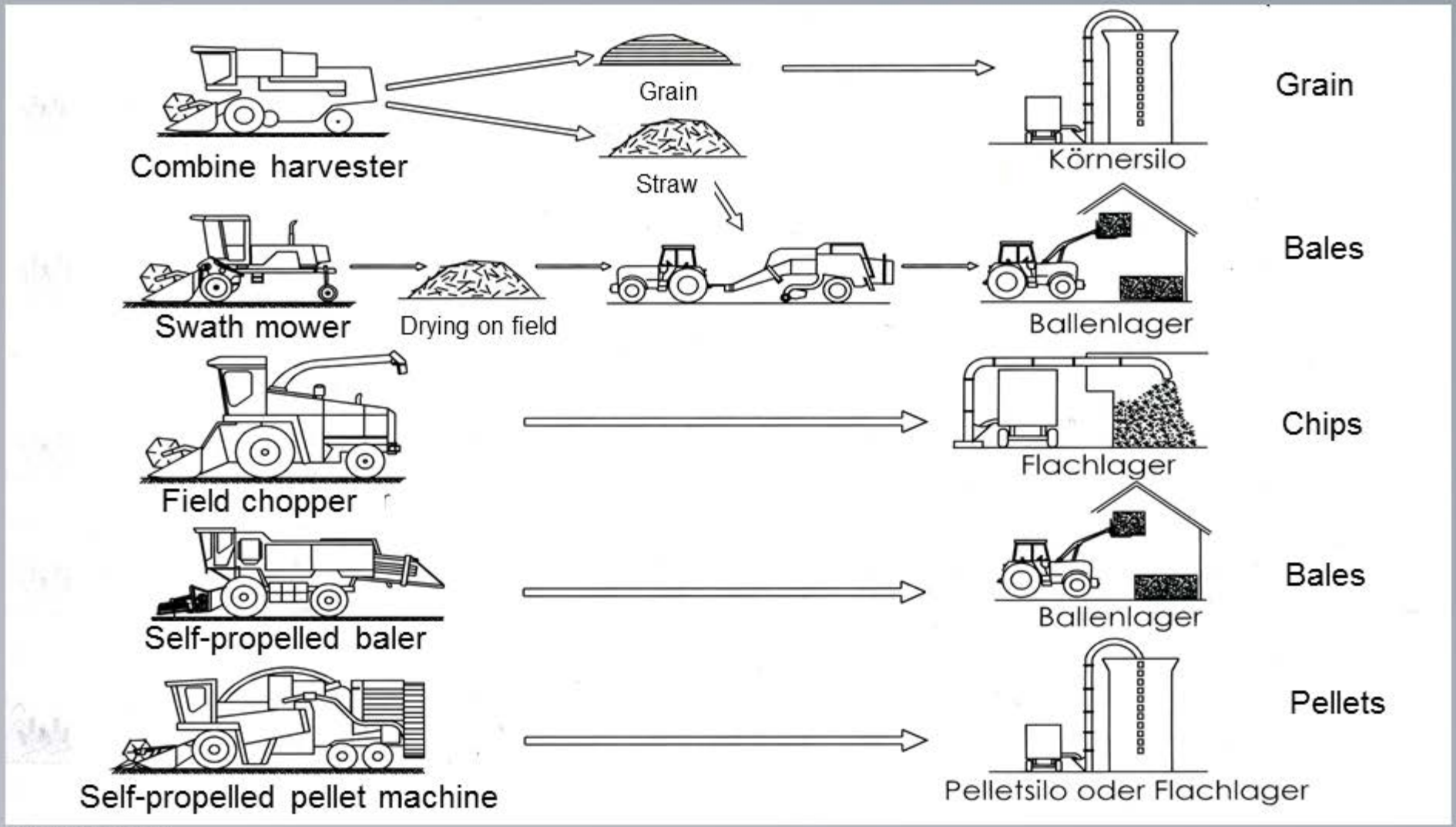
15 … 50 t_{DM}/(ha y)

Various species:

- **Chinese silver grass** (*Miscanthus sinensis*)
- **Giant miscanthus** (*Miscanthus × giganteus*)
- **Giant cane** (*Arundo donax*)
- **Elephant grass** (*Pennisetum purpureum*)
- **Ravenna grass/Erianthus** *(Saccharum ravennae)*
- **Sugarcane** *(Saccharum spp)*
- **Sugarcane** *(Saccharum X officinarum)* etc.

Further Information in: P. MISLEVY, F. G. MARTIN, M. B. ADJEI and J. D. MILLER, ENERGYCANE FOR BIOMASS. Biomass and l&energy Vol. 9, No. 6. pp. 449451. 1995

Processes and machines for harvesting
of cereal, straw and grass



Source: FNR Gülzow

Baler types
for cereal, straw and grass

trailed baler

conventional baler

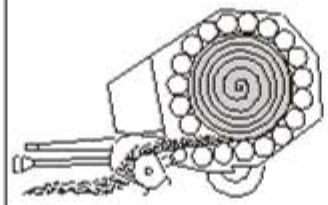
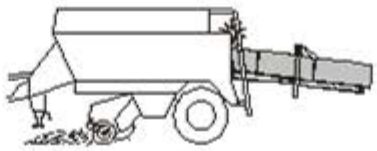
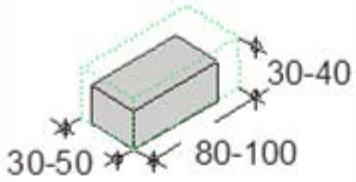
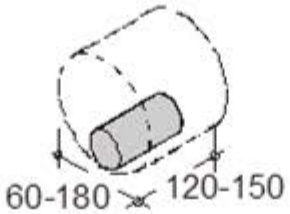
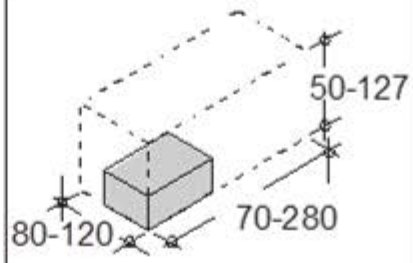
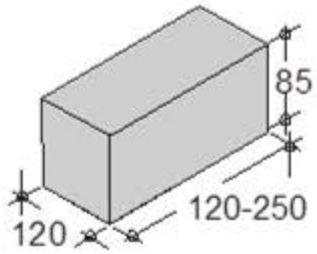
big baler

round bales

square bales

self propelled big baler

Dry line
< 15% water

Typ of baler				
Bale form (dimensions in cm)				
Density-straw, kg/m³	< 130	< 120	< 160	< 160

Source: FNR Gülzow, 2000

Yields of ligno-cellulosic crops
and their residues

Crop Species	Reference region	Grain yield $t_{FM}/(ha\ y)$	Residue type	Grain-to-residue ratio
Wheat	Germany	4 - 11	Straw	0.7 - 1.0
Rye	Germany	3 - 9	Straw	0.7 - 1.6
Barley	Germany	4 - 10	Straw	0.9 - 1.1
Corn	Global	4 - 10	Straw(90%)+ Cobs (10%)	0.5 - 1.3
Rice	Global	3 - 9	Straw(80%)+ Husks(20%)	0.5 - 2.0
Sorghum	Global	1 - 10	Straw	0.6 - 1.0
Cotton	Egypt	2.0 (fibres) 1.0 (seeds)	Stalks	0.5 0.25
Grass	Germany	50 - 125	-----	-----
Cane	Tropics	50 - 200	-----	-----
Sugar cane	Tropics	50-100(cane)	Bagasse	3 - 5

From various sources. Further Information in: Jekayinfa & Scholz: Potential Availability of Energetically Usable Crop Residues in Nigeria. Energy Sources, 31:687–697 (2009)

Characteristics of wood and crops

Basic data for calculation the energy yield

	Water content [%]	Higher heating value HHV_{DM} [kWh/kg_{DM}]	Lower heating value LHV_{FM} [kWh/kg_{FM}]	Bulk density [kg_{FM}/m^3]	Energy density [kWh/m^3_{FM}]
Wood pellets	10,00	5,50	4,60	600	2.756
Wood chips – hardwood – pre-dried	30,00	5,50	3,40	320	1.094
Wood chips – hardwood	50,00	5,50	2,20	450	1.009
Wood chips – softwood – pre-dried	30,00	5,50	3,40	250	855
Wood chips – softwood	50,00	5,50	2,20	350	785
Grass – high-pressure bales	18,00	5,10	3,80	200	750
Bark	50,00	5,60	2,30	320	727
Triticale (cereals) – high-pressure bales	15,00	5,20	4,00	175	703
Sawdust	50,00	5,50	2,20	240	538
Straw (winter wheat) – high-pressure bales	15,00	5,20	4,00	120	482

$$\text{Energy } E = m_{FM} \times LHV_{FM}$$

DM...Dry Matter
FM...Fresh Matter

Oil crops and residues

Selected tropical species

- Soybean
- Sunflower
- Castor
- Jatropha
- Oil palm

Tropical oil plant species

- √ Soybean*;
- √ Sunflower*;
- √ Castor bean(*);
- √ Oil palm;
- √ Rapeseed*;
- √ Palm cabbage;
- √ Babassu;
- √ Peanut;
- √ Tucumã;
- √ Cotton seed;
- √ Pequi;
- √ Sesame;
- √ Jatropha;
- √ Buriti;
- √ Nabo forrageiro;
- √ Jotobá;
- √ Flaxseed*;

Source: José Geraldo Eugênio de França, João Pessoa, 2006

* Also in temperate climates

Seed yield and oil content
of selected oil crops (1)

Common Name	Scientific Name	Indicative Yield t/ha	Oil Content %
Almond	Prunus dulcis	3.0	25-50
Bean, African locust	*Parkia filicoidea*	5.0	16-18
Bean, broad	*Vicia faba*	6.6	1-2
Bean, lablab	*Dolichos lablab*	1.4	
Bigseed falseflax	*Camelina sativa*	1.0	40
Canicha	*Sesbania bispinosa*	1.0	
Cashew	*Anacardium occidentale*	1.0	38-46
Castor bean	*Ricinus communis*	5.0	35-55
Chickpea	*Cicer arietinum*	2.0	5-6
Cocoa	*Theobroma cacao*	3.3	50
Coconut	*Cocos nucifera*	6000[a]	0.63[b]
Coloynth	*Citrullus colocynthis*	6.7	19-20
Cotton	*Gossypium spp.*	1.5	20
Crambe	*Crambe abyssinica*	5.0	36
Croton, purging	*Croton tiglium*	0.9	50-60
Crownvetch	*Coronilla varia*	0.5	
Fenugreek	*Trigonella foenum-graecum*	3.0	6-7
Flax	*Linum usitatissimum*	1.3	38
Gourd, buffalo	*Cucurbita foetidissima*	3.0	24-30
Groundnut, Bambarra	*Voandzeia subterranea*	4.2	
Guar	*Cyamopsis tetragonoloba*	2.0	
Jatropha	*Jatropha curcas*	8.0	50
Jojoba	*Simmondsia chinensis*	2.2	48-52
Lablab	*Dolichos lablab*	1.4	

See also lesson "Liquid Biofuels".

Source: CIGR Handbook of Agricultural Engineering, Vol. 5, 1999

Seed yield and oil content
of selected oil crops (2)

Common Name	Scientific Name	Indicative Yield t/ha	Oil Content %
Lesquerella	*Lesquerella spp.*	1.3	30
Lupine, European blue	*Lupinus angustifolisus*	1.0	5-6
Lupine, European yellow	*Lupinus luteus*	1.0	5-6
Lupine, white	*Lupinus albus*	1.0	6-9
Marijuana	*Cannabis sativa*	1.5	30-35, 23-26[c]
Meadowfoam, Baker`s	*Limnanthes bakeri*	0.4	24-30
Meadowfoam, Douglas`s	*Limnanthes douglasii*	1.9	24-30
Mu-oil tree	*Aleurites montana*	5.5	7-8
Mustard, blanck	*Brassica nigra*	1.1	27-35
Mustard, white	*Sinapis alba*	8.0	30-35
Niger seed	*Guizotia abyssinica*	0.6	31-41, 30-35[c]
Nut, macadamia	*Macadamia spp.*	1.0[d]	65-75
Oilvine, Zanzibar	*Telfairia pedata*	2.0	35-38
Palm, African oil	*Elaeis guineensis*		2.2[c]
Pea, cow	*Vigna unguiculata*	2.5	
Peanut	*Arachis hypogaea*	5.0	36-50
Perilla	*Perilla frutescens*	1.5	49-51, 26-33[c]
Poppy, opium	*Papaver somniferum*	0.9	40-50
Rape	*Brassica napus*	3.0	33-40
Safflower	*Carthamis tinctorius*	4.5	25-37, 17-25[c]
Sesame	*Sesamun indicum*	0.5	50
Soybean	*Glycine max*	3.1	17-26
Stylo, townsville	*Stylosanthes humilis*	1.2	
Sunflower	*Helianthus annus*	3.7	35-40
Tallow tree	*Sapium sebiferum*	14.0	55
Velverbean	*Mucuna deeringgiana*	2.0	
Walnut, black	*Juglans nigra*	7.5	60
Walnut, Persian	*Juglans regia*	7.5	60

[a] Nuts. [b] Oil (t/ha). [c] Mechanical extraction. [d] Kernels.

Source: CIGR Handbook of Agricultural Engineering, Vol. 5, 1999

See also lesson "Liquid Biofuels".

Soybean
General information

The **soybean** (U.S.) or **soya bean** (UK) (***Glycine max***) is a species of legume native to East Asia.

- Fat-free (defatted) soybean meal is a primary, low-cost, **source of protein** for animal feeds and most prepackaged meals.
- Soybeans can produce at least twice as **much protein per acre as any other major vegetable or grain crop**, 5 to 10 times more protein per acre than land set aside for grazing animals to make milk, and up to 15 times more protein per acre than land set aside for meat production.
- **Cultivation** is successful in climates with **hot summers**, with optimum growing conditions in mean temperatures of 20 to 30 °C; temperatures of below 20 °C and over 40 °C retard growth significantly. They can grow in a **wide range of soils**, with optimum growth in moist alluvial soils with a good organic content.
- The **main producers** of soy are the United States (32%), Brazil (28%) and Argentina (21%).

http://en.wikipedia.org/wiki/Soybean

Soybean
Technological data

Item	Data
Cycle	105 to 135 days (86 -162)
Oil content in the seed	20% (18-21)
Percentage of meal (cake)	72-79 %
Average productivity (seed)	2.800 kg/ha (1.800 – 4.000)
Yield in vegetable oil	560 kg/ha

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008

Sunflower
General information

The **sunflower** (***Helianthus annus L.)*** is native to the **Central Americas**. The evidence thus far is that it was first domesticated in present day Mexico, by at least 2600 BC.

- Sun flowers have a type of phototropic response called **heliotropism** (sun turning); the leaves and flower heads of young sunflowers follow the sun.
- To grow well, sunflowers need full sun. They have a **simple cultivation**, no need for sophisticated equipment and **good adaptation** to **soil conditions and climate.** They grow best in fertile, moist, well-drained soil with a lot of mulch. In commercial planting, seeds are planted 45 cm (1.5 ft) apart and 2.5 cm (1 in) deep.
- Sunflower oil, extracted from the seeds, is used for cooking, as a carrier oil and to produce margarine and **biodiesel**, as it is cheaper than olive oil. A range of sunflower varieties exist with differing fatty acid compositions; some 'high oleic' types contain a higher level of healthy monounsaturated fats in their oil than even olive oil.

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008

Sunflower
Technological data

Item	Summer	Period between crops
Cycle	90 to 140 days (65-165)	90 to 140 days (65-165)
Oil content in the seed	42 - 45% (40-47)	42 - 45% (40-47)
Percentage of meal	53-60%	53-60%
Average productivity (seed)	1.800 kg/ha (1.500-2.800)	1.300 kg/ha (1.000 – 1.800)
Yield in meal	990 kg/ha	715 kg/ha
Yield in vegetable oil	774 kg/ha	559 kg/ha

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008

Castor bean
General information

- The production of **castor bean** (***Ricinus communis L***), oilseed species occurs in most **tropical and subtropical areas** of the world. Originated to **Ethiopia** and cultivation has spread worldwide, with more present in developing countries , castor has a planted area of approx. 160000 hectares. But the yields are low up to now.
- In areas with a suitable climate, castor establishes itself easily as an apparently **"native" plant** and can often be found on wasteland. However, it can grow well outdoors in cooler climates.
- This oilseed still has **low productivity** due to poor technology and lack of inputs used in agriculture. From castor can be extracted the oil which is the main **industrial product**. As co-product has the **cake**, rich in nitrogen, phosphorus and potassium used in the recovery of land frayed. The **oil**, obtained from the castor seed, is the most noble and important (**extrem high viscosity!)** The application of oil is done in several segments of the **chemical industry** such as **cosmetics, lubricants** for engines of high rotation, the diesel engine fuel and hydraulic fluid in aircraft.
- The **toxicity** of raw castor beans due to the presence of **Ricin** is well-known. Although the lethal dose in adults is considered to be 4 to 8 seeds, reports of actual poisoning are relatively rare. According to the 2007 edition of the Guinness Book of World Records, this plant is the **most poisonous in the world**.

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008

Castor bean
Technological data

Item	Data
Cycle	150 to 250 days
Oil content in the drop (seeds)	47 to 48% (45-50)
Percentage of meal	50 – 55 %
Average productivity (drop)	1.000 kg/ha (700 – 2.000)
Yield in vegetable oil	470 kg/ha

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008

Problems:
- long harvest period
- mainly manual labor

Jatropha
General information

- The Jatropha (***Jatropha curcas L.),*** *also called* Purgier nut, of the family Euphorbiacea is native to **Central America** and is a small tree of 3 to 5 m in height.
- Cultivation is uncomplicated. *Jatropha curcas* grows in tropical and subtropical regions. The plant can grow in wastelands and on **almost any terrain**, even on gravelly, sandy and saline soils. It is a plant very **resistant to drought** and **suffering little** attack of **pests and diseases**, which makes it suitable for many different regions.
- While Jatropha starts yielding from 9–12 months time, the best yields are obtained only after 2–3 years time.
- The fruits of the Jatropha have dimensions similar to a golf ball. And **the bark** of pine nuts may be used as **vegetable oil** and serve as a component of the paper. And beyond the use in the form of oil, is also used in manufacturing of paints and varnishes.
- The Jatropha has advantages as: Ability to grow and survive in places of **low fertility**; Cake of **great value** as fertilizer and **organic fertilizer**, and **Rapid growth.**
- The seeds are also a source of the **highly poisonous** toxalbumin **Curcin**. (similar to Ricin in castor beans).

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008

Jatropha
Technological data

Item	Data
Cycle	30 years
Oil content in fruit	25-44%
Protein content in seed	35-40%
Productivity	5.000 kg/ha (400.000)
Oil yield	2.000 kg/ha (1.500-5.000) ?

Fertilization:
1 ton of seed needs
46 kg N + 21 kg P + 7 kg K
(Grass, Hohenheim 2008)

Problems:
- only few experiences
- different time to mature?
- manual labor

Oil palm
General information

The **oil palms** (***Elaeis***) comprise two species of the Arecaceae, or palm family. The African Oil Palm ***Elaeis guineensis*** is native to **West Africa**, while the American Oil Palm ***Elaeis oleifera*** is native to tropical **Central and South America**.
Mature trees are single-stemmed, and grow to 20 m tall.

- The palm fruit takes five to six months to mature from pollination to maturity. The palm fruit is reddish and grows in large **bunches** (40-50 kg) containing **800-4000 fruits**. Each fruit is made up of an oily, fleshy outer layer (**pericarp**), with a single seed (**palm kernel**). The fruits are perishable and have to be processed immediately (hot water).


Source:barnhouse.de

- Oil is extracted from both the **pulp** of the fruit (palm oil, an edible oil) and the **kernel** (palm kernel oil, used in foods and for soap manufacture). For every **100 kilograms of fruit bunches**, typically **22 kilograms of palm oil** and **1.6 kilograms of palm kernel oil** can be extracted.

- Since 2007, **Indonesia** emerged the world's largest producer of palm oil (approx. 50% of world production).


Source:umweltdialog.de

http://en.wikipedia.org/wiki/Oil_palm

Oil palm
Technological data

Item	Data
Cycle	25 years (max. 200)
Oil content of the total bunch	26%
Oil content of the fruits	40-50% (pericarp); 48-52% (kernel)
Average percentage of meal	22%
Average productivity (fruits)	10000-15000 kg/ha
Oil productivity	3000 kg/ha (pericarp) + 250 kg/ha (kernel)
Total yield in vegetable oil	4.000 kg/ha (3.000 – 7.000)

!!!

Source: Bioenergia – Brasil & Alemanha. Boletim Técnico 12, UFV 2008


Photos: Scholz 2009

Thank you

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