



Πανεπιστήμιο Δυτικής Μακεδονίας
Τμήμα Μηχανολόγων Μηχανικών

Ειδικά κεφάλαια παραγωγής ενέργειας

Ενότητα 4(δ): ENERGY CROPS POTENTIAL IN GREECE –
an estimation based on land availability and agricultural economics.

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ΥΠΟΥΡΓΕΙΟ ΠΑΙΔΕΙΑΣ ΚΑΙ ΘΡΗΣΚΕΥΜΑΤΩΝ
ΕΙΔΙΚΗ ΥΠΗΡΕΣΙΑ ΔΙΑΧΕΙΡΙΣΗΣ

Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης



ΕΥΡΩΠΑΪΚΟ ΚΟΙΝΩΝΙΚΟ ΤΑΜΕΙΟ



BIOMASS IN EUROPE

Biomass use in EU-27 (2007 data)				
	(Mtoe)			
gross consumption	98,6			
cogeneration	33,3			
biofuels	7,9			
industrial heating	18,6			
domestic heating	35,0			
"European Biomass Statistics 2009" European Biomass Association, Brussels, 2009				
Biomass technical potential in EU-27 (2010 data)				
	EU-27		Greece	
	Mtn (dry)	Mtoe	Mtn (dry)	Mtoe
agricultural				
residues	76,128	36,153	3,833	1,820
manure	76,438	18,082	0,516	0,179
forest	97,892	46,489	1,199	0,569
industrial	74,268	25,975	0,590	0,28
sewage sludge	9,945	2,362		0,020
municipal				
biodegradable		23,685		0,643
lignocellulosic	13,585	6,452		
TOTAL		159,198		3,511
C. Panoutsou et al "Biomass supply in EU27 from 2010 to 2030" Energy Policy (2009)				

5,45 % of 1.806 Mtoe

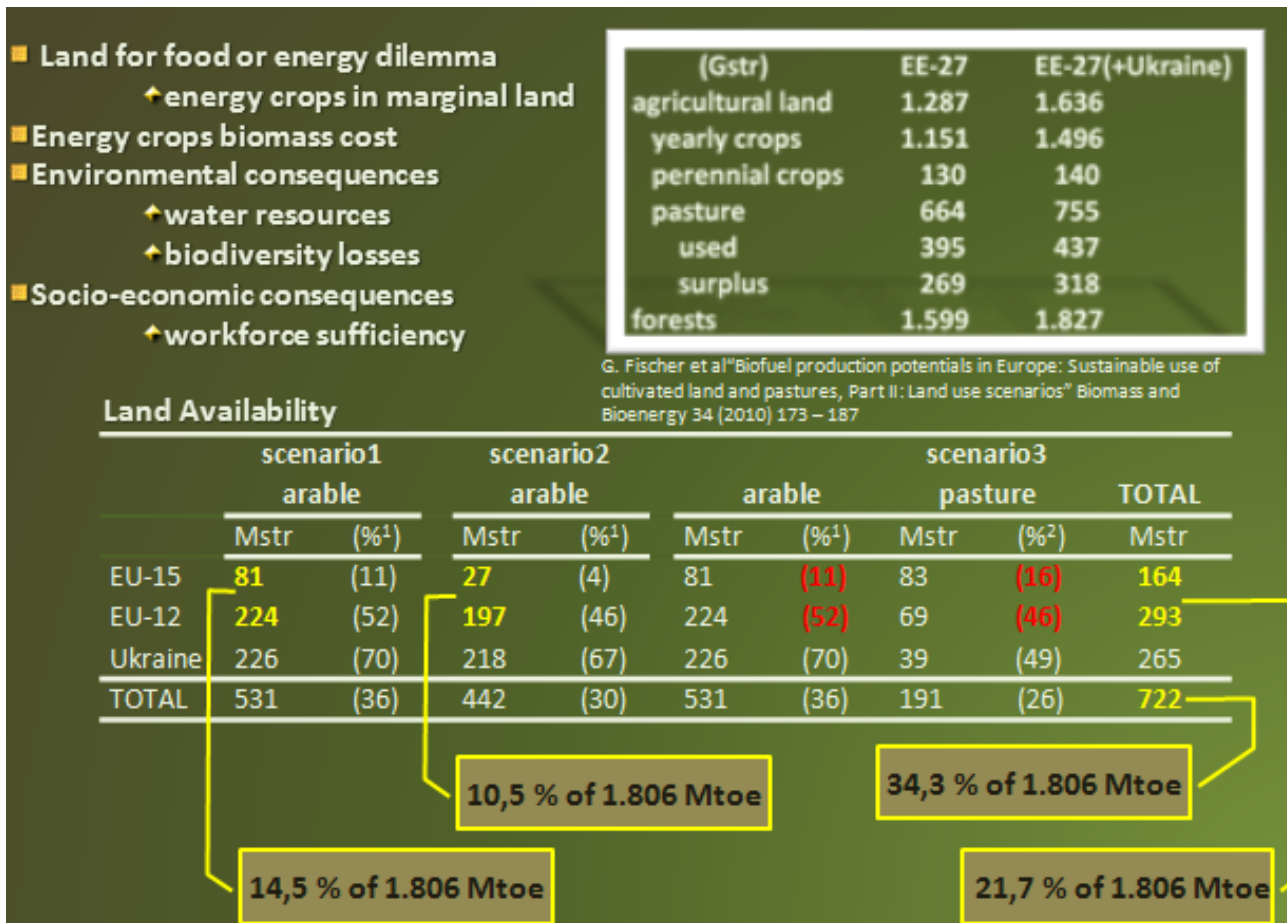
10,5 % of 33,5 Mtoe

8,80 % of 1.806 Mtoe



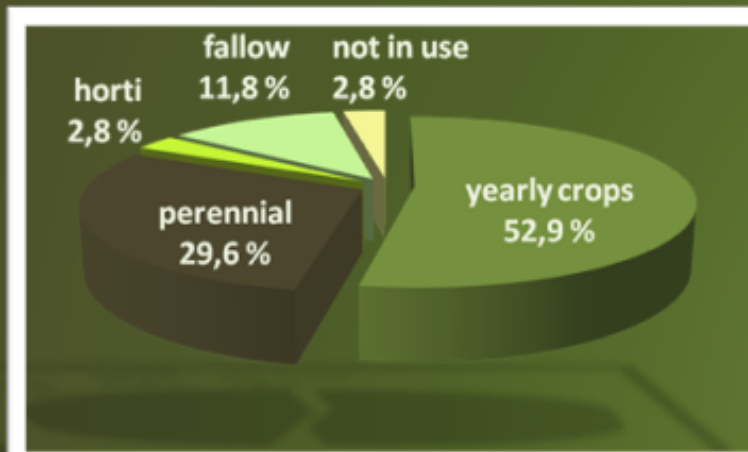
ENERGY

CROPS PROSPECTS IN EUROPE



CURRENT STATUS OF GREEK AGRICULTURE

(Mstr)	(1999)	2002	2003	2004	2005	2006
Agricultural land		39,7	39,4	39,0	38,7	38,5
In use	(35,8)	38,5	38,2	37,8	37,6	37,4
Yearly crops	(19,7)	21,8	21,4	21,1	21,0	20,4
(of those pasture)		(0,8)	(0,8)	(0,8)	(0,8)	(0,8)
Perennial crops	(10,0)	11,4	11,3	11,3	11,4	11,4
Horticulture	(0,1)	1,2	1,2	1,2	1,1	1,1
Fallow		4,2	4,3	4,2	4,0	4,5
Permanent Pasture	(6,1)					
Not in use		1,2	1,2	1,2	1,1	1,1



- ◆ a decline in land for yearly crops of about 1,5 Mstr in 5 years
- ◆ almost ½ of the fallow was excessive
- ◆ more than 1 Mstr is not in use
- ◆ **almost 5 Mstr may be available for energy crops, from these land sources, in case energy crops economics are favorable**

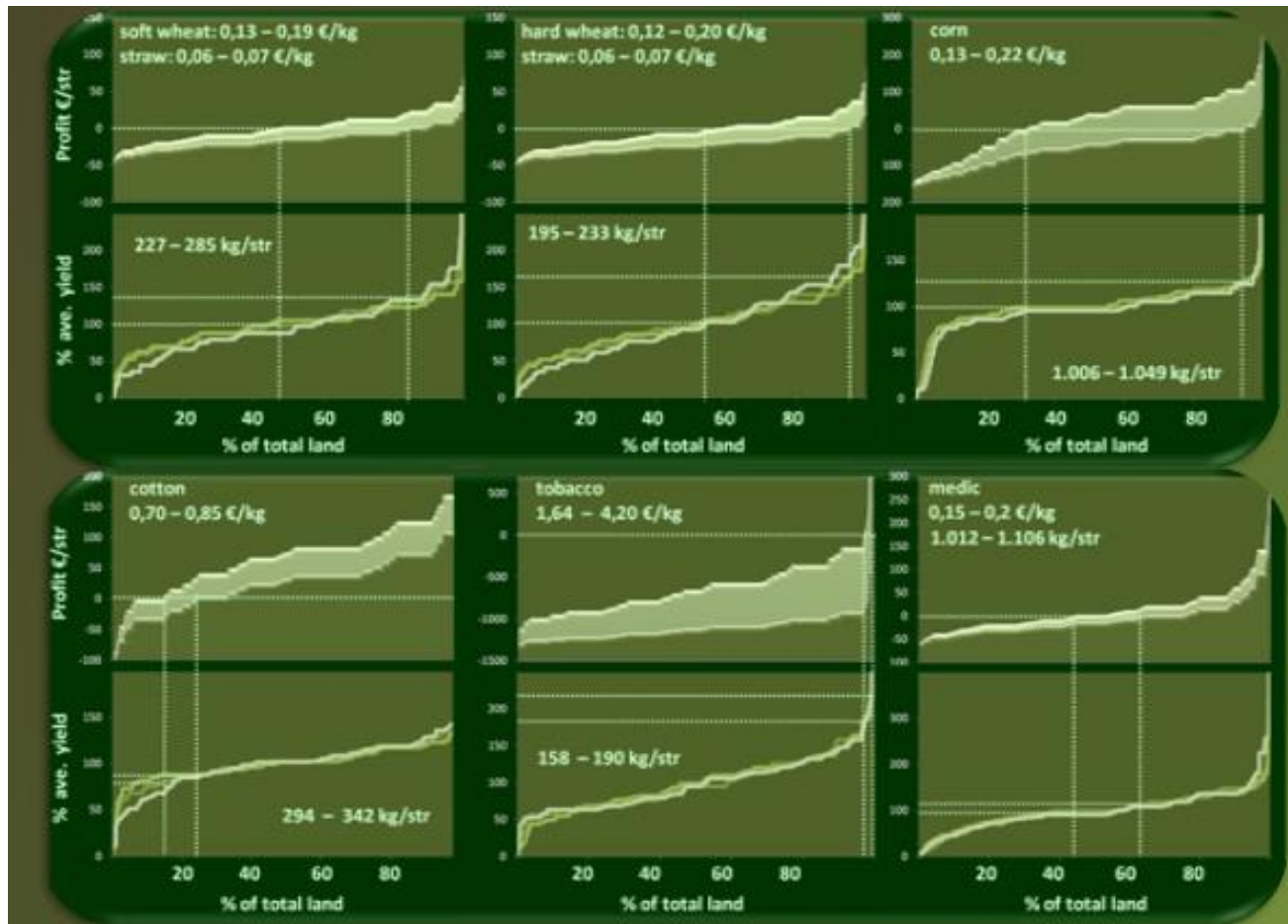


CURRENT STATUS OF DOMESTIC AGRICULTURE

(kstr)	2002	2003	2004	2005	2006	% arable	% ann. shift
cereals	12.666	12.520	12.387	12.324	11.736	57,6	-1,9
edible legume	157	150	148	153	161	0,8	0,7
melons & potatoes	729	729	725	704	702	3,4	-0,9
feed	2.145	2.135	2.113	2.123	2.226	11,0	1,4
feed legume	266	277	275	279	350	1,8	8,4
pasture	769	752	761	770	801	3,9	1,1
industrial	5.046	4.839	4.726	4.679	4.402	21,6	-3,3
rest	13	13	13	14	14	0,1	1,5
Dominant yearly crops							
(kstr)	2002	2003	2004	2005	2006	% arable	% ann. shift
hard wheat	7.129	7.037	7.191	7.193	6.326	31,0	-2,8
cotton	3.722	3.636	3.645	3.586	3.640	17,9	-0,5
corn	2.230	2.406	2.429	2.472	2.322	11,4	1,1
soft wheat	1.571	1.441	1.259	1.197	1.453	7,1	-1,1
medic	1.142	1.116	1.112	1.139	1.228	6,0	1,9
barley	1.130	1.040	940	895	1.017	5,0	-2,2
sugar beets	441	409	363	408	327	1,6	-6,5
tobacco	416	399	386	386	219	1,1	-12,7



CURRENT STATUS OF DOMESTIC AGRICULTURE – ECONOMICS (1/2)



CURRENT STATUS OF DOMESTIC AGRICULTURE – ECONOMICS (2/2)

Used land with negative profits			
	kstr		% of land
Cereals	2.916	- 9.105	25 - 78
Legumes	5	- 13	3 - 9
Feed	346	- 753	15 - 32
Industrial	241	- 396	5 - 9
TOTAL	3.508	- 10.267	17 - 50

permanently
negative profits even
for the highest product
price
(not including
subsidies)

Land of dominant crops with negative profits				
	kstr		(%)	% of land
Cereals	2.916	- 9.105	(89)	25 - 78
hard wheat	1.878	- 4.861	(47)	30 - 77
corn	61	- 1.779	(17)	3 - 77
soft wheat	343	- 1.203	(12)	24 - 83
barley	356	- 781	(8)	35 - 77
oat	211	- 324	(3)	50 - 77
rye	68	- 141	(1)	42 - 88
Feed	346	- 753	(7)	15 - 32
medic	59	- 110	(1)	5 - 9
fodder	287	- 755	(2)	34 - 70
Industrial	241	- 396	(4)	5 - 9
cotton	26	- 62	(1)	1 - 2
sugar beet	7	- 64	(1)	2 - 20
tobacco	163	- 166	(2)	75 - 76



ENERGY CROPS – ANNUAL YIELDS OF DRY BIOMASS

(dry tn /str)	rain fed			irrigated			
	min	ave	max	min	ave	max	
sorghum				1,4		2,2	Europe
				2,4		3,2	Greece
kenaf	0,8					2,6	Greece
cardoon	0,8	1,5	2,5				Italy
	0,6	1,5	1,6	1,7		3,2	Greece
miscanthus	0,9	1,5	2,6		3,0	4,4	Europe
	0,8			1,6		4,4	Greece
reed	2,0		3,5				S. France
	0,5	1,3	1,9	0,7	1,5	3,2	Greece
switchgrass	0,8		1,6			3,5	USA
	0,5	1,6	2,3				Europe
	0,8		1,7	2,0		2,5	Greece
eucalyptus	0,9	1,6	2,5	2,5	2,8	5,0	Greece
acacia	0,5	1,0				2,4	Greece
poplar	1,1		1,7				Greece
	1,1	1,0	1,6				Europe

↗ 1,25 d.tn/str (0,6 – 1,5 d.tn/str) is a conservative estimation for the average yield in rain-fed land and 2,5 d.tn/str (2 – 3 d.tn/str) for the average yield in irrigated land



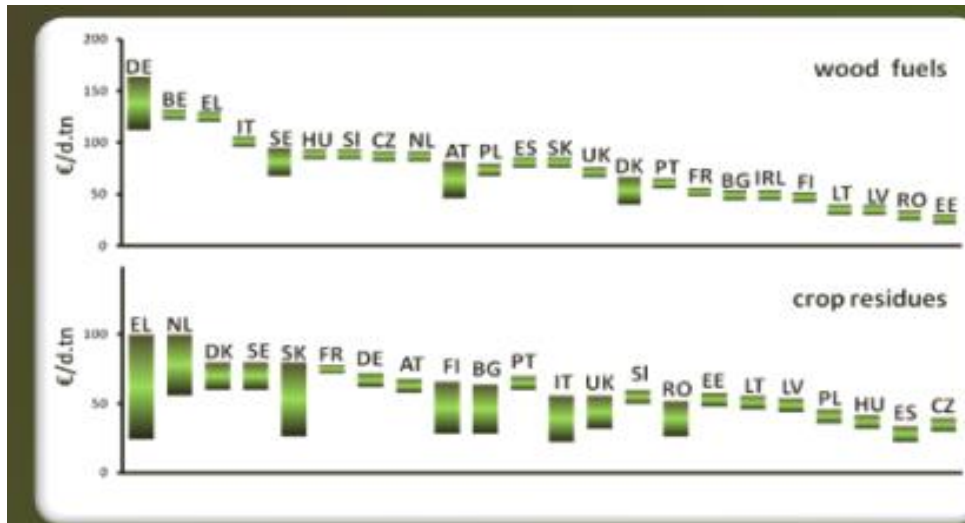
ENERGY CROPS – ANNUAL COSTS

(€/str/a)	amortization of plantation costs			annual costs			TOTAL ANNUAL COSTS		
	min	ave	max	min	ave	max	min	ave	max
sorghum							130	136	140
kenaf							160		170
cardoon		11,3			15,9		26,4	27,2	32,5
miscanthus	33,0		46,0	28,7	40,7	45,8	61,7	70,0	86,7
reed		18,7			18,5			37,2	
switchgrass	10,0		10,0	22,1		26,8	32,1	36,0	52,0
poplar		14,5			24,0		35,0	38,5	56,0
acacia							35,0	50,0	63,0
eucalyptus							35,0	43,0	56,0

† cardoon, studied extensively in Greece, seems to have annual cultivation costs (including a 10 year amortization of the initial investment) below 35 €/str, while other species, suitable for Greece, slightly overcome 40 €/str (the costs for the termination of the plantation rise the total cost for reed, slightly above 50 €/str)



ENERGY CROPS – DRY BIOMASS FARMGATE PRICE (1/2)

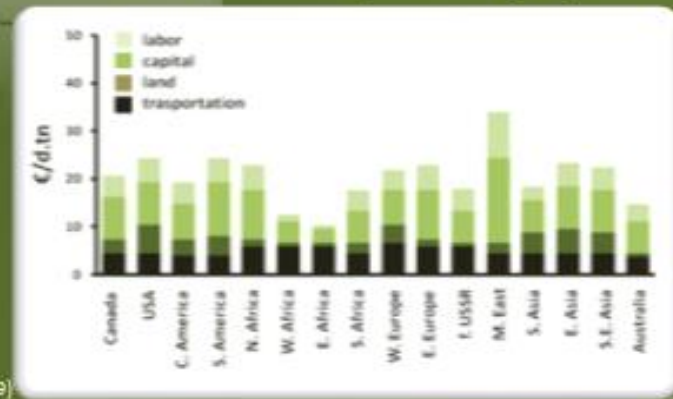


C. Panoutsou et al "Biomass supply in EU27 from 2010 to 2030" Energy Policy (2009)

total biomass costs, in Europe, are about 25 €/d.tn (retail price), with capital and transportation costs dominating (these costs do not include profit margins)

retail prices of crop residues (the closest in nature to energy crops biomass) vary between 30 – 100 €/d.tn (below 70 €/str in most countries)

M. Hoogwijk et al "Exploration of regional and global cost-supply curves of biomass energy from short-rotation crops at abandoned cropland and rest land under four IPCCRES land-use scenarios" Biomass and Bioenergy (2009)



ENERGY CROPS – DRY BIOMASS FARMGATE PRICE (2/2)

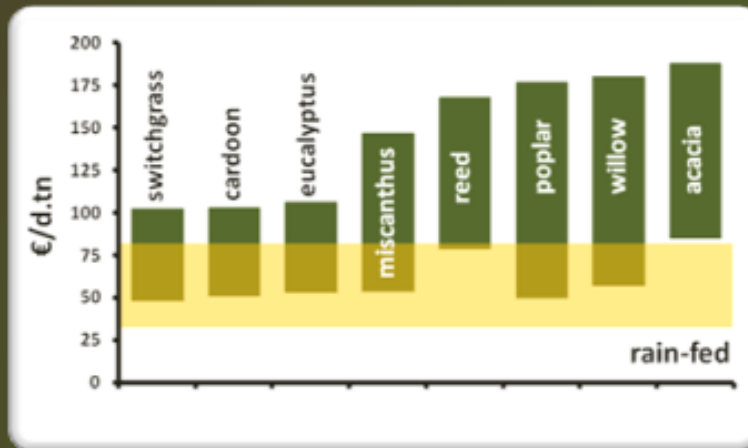
	break even point, €/d.tn	econ. feasibility €/d.tn	
(general estimation)		30 – 90	USA
		45 – 108	Europe
		42 – 86	Greece
sorghum	36 – 42		USA
	57		Greece
cardoos	24 – 54	57 – 80	Greece
switchgrass	38 – 48		USA
		25 – 40	Europe
		51 – 87	Greece
reed	43	57 – 80	Greece
acacia		32 – 54	USA
willow		30 – 80	USA

✦ 30 – 80 €/d.tn is the conservative range for dry biomass farm-gate price, which is going to be used in the forthcoming analysis



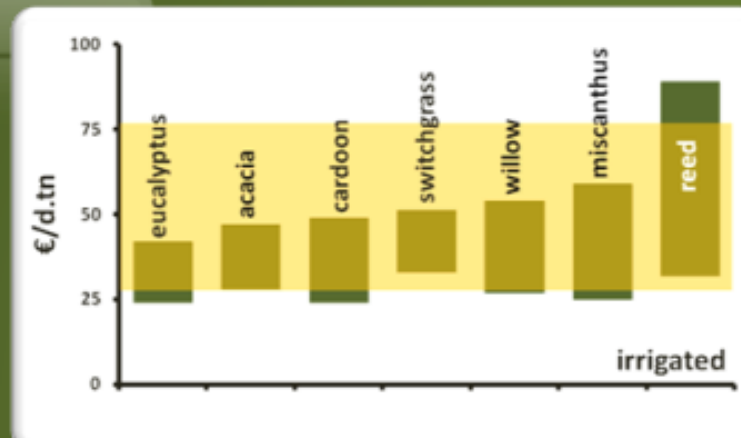
ENERGY CROPS – ECONOMICS (1/2)

Required farm-gate price for 50 €/str net annual profit (shaded area)

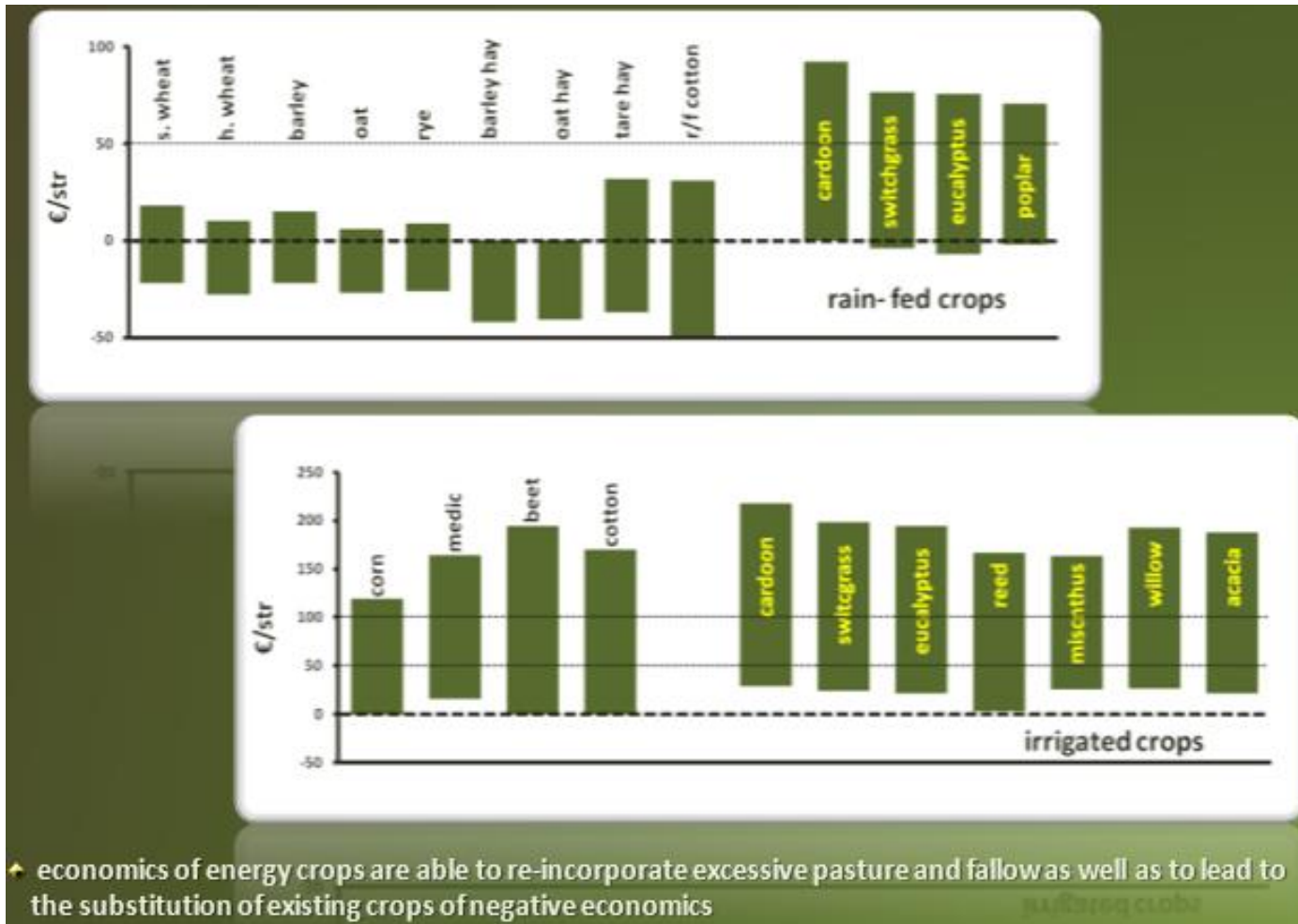


- rain-fed yield: 0,8 – 1,5 d.tn/str
- irrigated yield: 2 – 3 d.tn/str
- total annual costs as given previously

- rain-fed crops: switchgrass, cardoon and eucalyptus can obtain 50 €/str net profits, within the price range of 50 – 80 €/d.tn
- irrigated crops: eucalyptus, acacia, cardoon and switchgrass can obtain 50 €/str net profits within the price range of 30 – 50 €/d.tn



ENERGY CROPS – ECONOMICS (2/2)



↑ economics of energy crops are able to re-incorporate excessive pasture and fallow as well as to lead to the substitution of existing crops of negative economics



ESTIMATION OF THE NEAR FUTURE POTENTIAL OF DOMESTIC BIOMASS

	Greece			
	Mstr	Mtn (dry)	Mtoe	
agricultural res.		3,833	1,820	} technical potential 2010 3,5 Mtoe/a (C. Panoutsou et al "Biomass supply in EU27 from 2010 to 2030" Energy Policy (2009))
manure		0,516	0,179	
forest		1,199	0,569	
industrial		0,590	0,28	
sewage sludge			0,020	
municipal			0,643	
energy crops				} energy crops 5,5 – 9,5 Mtoe/a
on deserted land	1,2	1,500	0,700	
on fallow	4,5	5,625	2,670	
on marginal land	3,5 – 10,2	4,4 – 12,8	2,1 – 6,1	
TOTAL		17,7 – 26,1	8,3 – 12,3	

- ✦ energy crops can increase domestic biomass potential by 150 – 250 %
- ✦ today the technical biomass potential corresponds to 18 Mtn of lignite or 25 % of domestic lignite annual production
- ✦ extensive intrusion of energy crops can lead to an energy equivalent of 50 – 75 Mtn of lignite or 70 – 100 % of domestic lignite annual production



GEOGRAPHICAL ALLOCATION OF AVAILABLE LAND (1/2)

(kstr)	deserted	fallow	marginal land		total available land		(%)
Central Macedonia	180	435	1.076	- 3.105	1.691	- 3.720	(23)
East Macedonia and Thrace	90	461	456	- 1.886	1.007	- 2.437	(15)
Central Greece and Attica	246	634	331	- 1.064	1.211	- 1.944	(12)
West Macedonia	16	290	451	- 1.064	757	- 1.370	(9)
Thessaly	107	241	260	- 1.154	608	- 1.502	(9)
Western Greece	152	660	195	- 699	1.007	- 1.511	(9)
Crete	91	592	198	- 335	881	- 1.018	(6)
Peloponnese	131	567	89	- 238	787	- 936	(6)
Aegean	51	376	317	- 414	744	- 841	(5)
Epirus	30	183	79	- 224	292	- 437	(3)
Ionian	24	94	56	- 83	174	- 201	(1)
TOTAL	1.119	4.534	3.508	- 10.266	9.161	- 15.919	



GEOGRAPHICAL ALLOCATION OF AVAILABLE LAND (2/2)

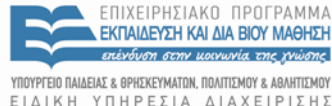
- **diameter: 6-8 mm**
- **length: 2-3 cm**
- **density: 1,15 kg/m³**
- **calorific value: 18 MJ/kg**
- **low ash content (0,5% - 1%)**
- **without binding agents**
- **high grade of homogeneity**



Τέλος Ενότητας



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Με τη συγχρηματοδότηση της Ελλάδας και της Ευρωπαϊκής Ένωσης

