Contribution of Energy Crops in Displacing Fossil Fuels in the EU

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KEYWORDS Energy crops, biomass resources, competition for food ground.

SUMMARY

In the EU, fossil fuels account for about 79% of the total energy consumption and nuclear power for about 15%. In the transport sector, fossil fuels deliver 98% of total consumption. "Oil is the energy source that represents the most severe security of supply challenge for Europe". This presentation considers how a biomass based energy supply could significantly decrease energy depending.

Biomass production is limited and is dependent upon the availability of land and the yields that can be obtained. This paper assesses the current area under biomass production in the EU, the available land area and the potential to use that land for biomass production. There is also as assessment of the potential to produce biomass based on improvements in crop yield.

There is also an issue with the use of arable land to produce biomass instead of food. The figures presented here are therefore based on the potential of existing cropped areas to produce biomass. Permanent grassland, areas dedicated to agro-forestry and pasture have not been included in the figures.

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INTRODUCTION

Climate change is probably the greatest problem facing the human race in the 21st Century. As a result of industrialisation over the last 100 years and also because of the increases in population, human activities have created a situation where harmful emissions are threatening our future. The Kyoto agreement was an attempt to limit further increases in emissions. However on a world scale emissions continue to increase largely as a result of the consumption of fossil fuels.

Atmospheric concentrations of carbon dioxide have increased by 38% from 1850 to 2007. The concentrations of methane and nitrous oxide have also increased significantly. Activities such as agriculture, deforestation and waste production play a major role in anthropogenic green house gas emissions, accounting for almost 40% of the total atmospheric emission. Increased livestock production and the use of inorganic fertilisers have also lead to further environmental degradation with the production of ammonia, leading to acid rain. There are also other consequences such as the loss of biodiversity, which is harder to quantify.

Biomass is already contributing to 15% of the worlds primary energy demand. Within the EU some of the member states such as Austria, Finland and Sweden have considerable contribution from biomass as a result of natural resources, particularly from forestry and this paper assess the potential for energy crops to contribute to the overall energy balance.

The increase in the use of energy from biomass and in particular from energy crops has benefits other than those associated strictly with co2 emissions:

- Security of supply. One of the areas of increasing concern is the overdependence upon imported fossil fuels, from increasingly volatile political environments. Countries such as the UK and Ireland are heavily dependant upon imported fossil fuels, particularly oil and gas which come from Russia, Algeria and Khazakstan. The production of indigenous energy crops can help to elevate this problem.
- Social policy. It has been estimated that ten jobs are created per megawatt of installed biomass capacity. 20% additional contribution from energy crops within the EU would lead to 550,000 additional jobs. There is also an argument to be made for the economic desirability of recycling money within the European economy from using home grown energy crops.
- Regional Policy. Biomass can be used as a decentralised energy source where conversion plants are located close to the source of biomass.

On the downside there has been considerable criticism recently where food crops have been redirected into the energy supply chain. There has been a significant increase in the price of cereals and particularly corn and maze since the US begin large scale bioenathal production. This has arisen largely because this type of conversion into bioethanol is probably one of the least efficient ways of using ground. It is relativity easy to quantify the energy returns from a hectare of ground both in terms of energy produced and of green house gas emissions resulting and bioethnal production does not score well on this chart.

This paper will assess the potential to develop energy crops across the EU. It will also consider the impact that this increase may have on food production if it is carried out in an inappropriate way. The paper argues that we should focus on land which is not already being using for intensive food production and it also considers the economy's that can be gained from large scale production. There is already considerable wastage within the existing biomass production chain and it has been estimated that approximately 70% of the biomass which is currently used for food feed and traditional wood fuel is lost somewhere along the processing chain. An increase in the efficiencies within this system should therefore be able to double the existing production without having an impact on the area already under cultivation.

Similarly the paper briefly considers the gains which can be made from superior yields from improved genotypes. A considerable amount of work is currently being carried on issued such as short day genes, disease resistance, cold growth varieties and nutrient efficiencies. It is not yet conclusive whether the climatic change which we are experiencing will have a positive or a negative impact on overall yield production within the EU. One of the most difficult areas to manage under the new energy scenario is the production of liquid biofuels from biomass. In terms of pure conversion efficiency it is more cost effective to use biomass in combustion processes than it is to convert it either to liquid biofuels or to electricity. However both electricity and liquid biofuels have higher values than heat. There may therefore be instances where it is more cost effective to produce the higher value product even though it has a poor rating in terms of conversion efficiencies and in terms of energy balance.

ENERGY CROP POTENTIAL

The data in the following tables is taken from the FAO Database (2003). The quantification of potential from energy crops assumes that there is 100% conversion at a heating value of 1kg of oven dry material equalling 18 mega joules of thermal heat. For more detailed calculations it is necessary to consider the conversion efficiencies and the actual caloric value of that crop.

Table 1

Data of total area and areas of interest for biomass production for each member of EU-27; area data in millions of hectares

	Total area (10^6Ha)	Agricultural area (10^6Ha)	Arable land (10^6Ha)(% of total area)		Hectares of agricultural land per capita
Austria	8.4	3.4	1.4	17	0.42
Belgium	3.1	1.4	0.8	27	0.13
Bulgaria	11.1	5.3	3.3	30	0.68
Cyprus	0.9	0.1	0.1	11	0.18
Czech Republic	7.9	4.3	3.1	39	0.42
Denmark	4.3	2.7	2.3	53	0.49
Estonia	4.5	0.8	0.5	12	0.63
Finland	33.8	2.2	2.2	7	0.43
France	55.2	29.7	18.5	33	0.49
Germany	35.7	17.0	11.8	33	0.21
Greece	13.2	8.4	2.7	20	0.77
Hungary	9.3	5.9	4.6	50	0.6
Ireland	7.0	4.4	1.2	17	1.09
Italy	30.1	15.1	8.0	26	0.26
Latvia	6.5	2.5	1.8	28	1.08
Lithuania	6.5	3.5	2.9	45	1.02
Luxemburg	0.3	0.1	0.06	24	0.28
Malta	0.03	0.01	0.01	31	0.03
Netherlands	4.2	1.9	0.9	22	0.12
Poland	31.3	16.2	12.6	40	0.42
Portugal	9.2	3.7	1.6	17	0.37
Romania	23.8	14.7	9.4	39	0.66
Slovakia	4.9	2.4	1.4	29	0.45
Slovenia	2.0	0.5	0.2	9	0.26
Spain	50.5	30.2	13.7	27	0.73
Sweden	45.0	3.2	2.7	6	0.36
U.K.	24.4	17.0	5.7	23	0.28
EU-27	**433.1**	**196.6**	**113.5**	**26**	**0.41**

Table 1 contains the areas of land within each of the EU 27 countries, the identified agricultural area within those countries, the arable land currently under production and the hectares of agriculture land per capita. There is obviously a very large variation in the percentage of arable land available, e.g. Sweden at 6% of total area and Denmark at 53%. However it is important to have an overall view of the total area available and the percentage of that land which is currently used for arable production. Remember that table 1 does not consider lands currently under afforestation.

Table 2

Energy crop potential in EU-27, depending on percentage of utilised arable land and achieved crop yield

Yield	10% arable land in EU-27		20% arable land in EU-27		30% arable land in EU-27	
10t TS/ha	2,042 PJ	46Mtoe	4,084 PJ	91Mtoe	6,127 PJ	137Mtoe
20t TS/ha	4,084 PJ	91Mtoe	8,169 PJ	182Mtoe	12,253 PJ	274Mtoe
30t TS/ha	6,127 PJ	137Mtoe	12,253 PJ	274Mtoe	18,380 PJ	410Mtoe

Table 2 is an assessment of the total energy crop potential in the EU 27. It has been prepared using three possible areas and three possible average yields. It is important to note that most energy crops are currently in the 10-14 oven dried tonnes per hectare per annum range, including average yields of willow around 10 oven dried tonnes and miscanthus averaging 13 oven dried tonnes. It is possible to get some higher yields with crops such as Sorghum but these are relatively insignificant in overall terms at present.

What this table does attempt to quantify is the potential assuming an increase in the area given over to energy crops and the possible increase that could accrue from improved genotypes. It is interesting to note that the countries with higher hectare per capita figures such as Bulgaria and Romania which also have relatively large areas of ground are those which have the greatest potential to produce biomass in the future.

It is unlikely that we will see the yields improving in line with the higher potential yields. This is because the new genotypes will probably be climate specific and one improved type will not benefit all production areas. There will also be an issue with Genetically Modified (GM) crops which are currently not acceptable in the EU. Some of the increase yields will only be possible using GM crops and unless there is a considerable shift in opinion/attitude they are like to remain unacceptable in the European context.

Table 3

Gross inland consumption RES per member state and contribution of biomass in 2004* (Mtoe)

	Gross inland consumptio n Mtoe	Renewable s	Biomas s	Shar e of RES of GIC (%)	Share of Biomas s related to GIC (%)
		Mtoe	Mtoe		
Austria	32.7	6.77	3.45	20.7	10.55
Belgium	54.8	1.16	1.12	2.11	2.04
Bulgaria	-	-	-	-	-
Cyprus	2.5	0.09	0.005	3.6	0.2
Czech Republic	43.6	1.36	1.19	3.12	2.72
Denmark	20	2.93	2.37	14.6	11.85
Estonia	5.6	0.61	0.60	10.89	10.7
Finland	37.7	8.80	7.49	23.34	19.86
France	273.7	17.30	11.92	6.32	4.35
Germany	347.7	13.76	9.37	3.95	2.69
Greece	30.6	1.56	0.95	5.09	3.1
Hungary	26.2	0.97	0.86	3.7	3.28
Ireland	15.7	0.32	0.21	2.03	1.33
Italy	184.8	12.53	3.79	6.78	2.05
Latvia	4.6	1.65	1.37	35.86	29.78
Lithuania	9.2	0.73	0.69	7.93	7.5
Luxemburg	4.7	0.07	0.05	1.48	1.06
Malta	0.9	-	-	-	-
Netherlands	82.3	2.36	2.17	2.86	2.63
Poland	92.5	4.32	4.12	4.67	4.45
Portugal	26.2	3.89	2.87	14.84	10.95
Romania	-	-	-	-	-
Slovak Rep.	18.6	0.74	0.38	3.97	2.04
Slovenia	7.1	0.82	0.47	11.54	6.61
Spain	140.2	8.98	4.85	6.4	3.45
Sweden	53.1	14.13	8.88	26.61	16.72
U.K.	232.1	3.67	3.05	1.58	1.31
EU25**	**1747.2**	**109.53**	**72.274**	**6.26**	**4.13**
** Data from Romania and Bulgaria missing					

Table 3 is the gross inland consumption of renewable energy per member state. This also shows the share of biomass within this figure. This takes into consideration the existing production of energy from all biomass within each country including that from forestry. It is immediately evident that countries such as Finland with 20% and Sweden at 17% are already sourcing a considerable amount of their total energy from indigenous biomass. Other countries such as the UK and Ireland are currently only sourcing 1% from biomass, however if you put these figures together with those in the last column of table 1 it can be seen that countries such as Ireland with a very low level of current biomass production and a relatively low level of biomass contribution to overall energy probably have the greatest potential to show significant increases (in terms of percentage) in biomass consumption in the future.

Table 4
Agriculture basic data in the EU 27 in 2005* (kha)

	UAA as a share of total land area (%)	Arable land	Permanent grassland	Permanent crops	Set aside** land in kha	Set aside land in % (related to arable land)
Austria	39.4	1379	1810	66	107	7.75
Belgium	45.8	843	519	21	24	2.84
Bulgaria	49.0	3297	1801	216	293	8.88
Cyprus	-	87	1	37	-	-
Czech Republic	46.7	2703	853	42	70	2.58
Denmark	62.8	2470	228	10	213	8.62
Estonia	18.2	517	236	2	-	-
Finland	7.4	2234	26	4	177	7.92
France	54.6	18305	10039	1123	1489	8.13
Germany	-	11903	4929	198	1137	9.55
Greece	-	2619	-	1133	30	1.14
Hungary	65.4	4502	1057	207	215	4.77
Ireland	62.5	1205	3098	2	29	2.40
Italy	49.9	7713	4411	2463	231	2.99
Latvia	27.8	1092	629	13	-	-
Lithuania	45.3	1877	891	40	300	15.98
Luxemburg	50.4	60	68	2	-	-
Malta	32.4	9	-	1	-	-
Netherlands	57.0	1117	763	32	16	1.43
Poland	52.3	12085	3388	351	130	10.7
Portugal	40.5	1418	1507	773	80	5.64
Romania	62.3	9017	4665	413	500	5.54
Slovak Rep.	40.4	1357	524	26	29	2.13
Slovenia	25.3	176	305	28	10	5.68
Spain	51.4	12608	7264	5659	1329	10.54
Sweden	7.9	2668	555	3	264	9.89
U.K.	69.6	5484	5711	32	567	10.33
EU25**	**-**	**108745**	**55278**	**12897**	**7240**	**6.66**

* Key figures on Europe Statistical Pocketbook 2006, Euro stat

** Bio-Energy's role in the EU Energy Market, a view of developments until 2020 Report to the European Commission

Table 4 is the agriculture basic data for the EU 27 in 2005. It gives a more detailed break down of the total area under agricultural production. However the permanent crop land figures which are recorded in this table do not include energy crops, but include all other permanent crop land including fruit, grain and grape. It also identifies that there was 7.24 million hectares of set aside in 2005, though this figure may have reduced by 2008. Again there is considerable potential to use the set aside in a more productive way. Countries such as Spain and the UK were both sitting with 10% set aside in 2005.

Table 5

Crop yields in the EU 27 for wheat, rapeseed, sunflower, sugar beet and maize in t/ha in the year 2005*

	Wheat	Rapeseed	Sunflower	Sugar beet	Maize
Austria	5.08	2.96	2.67	70.85	10.31
Belgium	8.42	4.25		69.95	11.69
Bulgaria	3.14	1.98	1.47	19.11	5.31
Cyprus					
Czech Republic	5.05	2.88	2.39	53.31	7.17
Denmark	7.23	3.06		58.75	
Estonia	3.08	1.78			
Finland	3.72	1.37		37.74	
France	7.18	3.68	2.33	82.32	8.37
Germany	7.47	3.76	2.47	60.18	9.21
Greece	2.70		1.25	65.88	9.0
Hungary	4.49	1.0	2.16	57.03	7.56
Ireland	8.43	3.15		45.00	
Italy	5.45	1.72	2.22	55.94	9.39
Latvia	3.61	2.04		38.51	3.06
Lithuania	3.73	1.84		38.02	
Luxemburg	6.02	3.62			9.58
Malta					
Poland	3.95	2.64	1.71	41.62	5.73
Portugal	6.7		0.34	70.14	4.66
Romania	2.97	1.68	1.38	28.93	4.01
Slovak Rep.	4.28	2.19	2.12	52.42	7.04
Slovenia	4.7	2.37	2.22	51.43	8.29
Spain	2.21	1.13	0.69	71.33	9.68
Sweden	6.34	2.42		48.41	
Netherlands	8.66	3.69		64.95	12.2
U.K.	7.96	3.29	2.0	57.31	
EU 27	**5.99**	**3.22**		**60.37**	**8.4**

* Average yield figures obtained from Euro stat

Table 5 is a statement of the of the average yield figures for different crops across the EU 27. The variation in yield between the highest and lowest is significant. Even taking into consideration that there will be considerable variations in soil quality, climate, suitability and rain fall, there is still a yield variance that would indicate that some of the discrepancies may be due to inefficient farming techniques rather than purely environmental. It would be reasonable to expect climatic conditions to have an effect on crops such as maze and this is noticeable when comparing crop yields from Latvia with say Spain. However some of the variations are obviously due to farming techniques, for instance where the Netherlands has average yields three times those of Bulgaria. In arguing for recognition of the potential that energy crops can contribute within the EU it is important to bear in mind the suitability of crops for different climatic conditions, local conditions and the improved yields that can obviously be achieved from better farming practice.

ENVIRONMENTAL CONSIDERATIONS

Table 6

Environmentally compatible bio energy potential in the member states of the EU 25* (Mtoe)

	2010	2020	2030
Austria	6.9	7.8	8.7
Belgium	2.3	2.3	2.3
Bulgaria	-	-	-
Cyprus	0.3	0.3	0.3
Czech Republic	3.8	4.5	5.0
Denmark	2.8	2.5	2.5
Estonia	1.5	2.2	2.6
Finland	9.6	9.8	9.4
France	31.4	37.2	47.4
Germany	26.2	33.8	43.2
Greece	1.6	3.4	3.8
Hungary	3.6	5.5	5.6
Ireland	1.1	1.2	1.3
Italy	16.2	18.7	24.8
Latvia	1.3	1.9	2.4
Lithuania	4.1	7.6	9.9
Luxemburg	-	-	-
Malta	0.05	0.05	0.04
Netherlands	2.6	2.2	2.4
Poland	23.8	33.0	39.3
Portugal	3.6	3.9	4.1
Romania	-	-	-
Slovak Republic	2.2	2.4	3.6
Slovenia	1.8	1.7	1.8
Spain	16.5	22.0	25.1
Sweden	11.7	13.0	13.5
U.K.	13.5	19.0	24.5
EU 25	**187.95**	**235.95**	**283.54**

* How much bio energy

Table 6 provides a comparison of the bio energy potential from the EU 25 based on environmental suitability.

The figures are based on the following assumption:

- Land currently identified as arable has been included as potential for energy crop development.
- Areas currently under set aside have been included as suitable for energy crop development.
- Removal of large quantities of residues from land which is normally cropped has to be done in such a way that it is not adversely affecting the sustainability of the land itself
- Residue removal should not lead to increased artificial fertiliser application
- Crops are not transposed in such a way as to require additional pesticide
- The method of cropping has to be done in such a way as to reduce soil erosion and soil compaction
- Crop substitution is based on environmental benefit so that perennial crops may be used in place of annual crops which have a high demand for artificial fertiliser and there is also the potential to increase biodiversity.

It is interesting to note that the figures contained in figure 6 do not take into consideration the increased yields that could be obtained from improved plant types, nor the efficiencies associated with the recovery of the large percentage of material which is wasted through the processing operation.

FOOD V ENERGY CROPS

It is generally recognised that cereal prices and consequently the price of staple food products such as maze, corn, wheat and rice have increased significantly within the last two years as a result of competition for ground between energy crops and food crops. This competition has largely been driven by the demand for bio-ethanol in the United States of America. Large areas of Brazil have also gone over to bio-ethanol production from sugar crops. If this model were to be repeated within the European Union it would have a further detrimental effect on food prices even though the areas under consideration are relatively small to the resource in North and South America. However in the interests of sustainability it is important to ensure that additional energy crops can be established in such a way as to not conflict with food production.

There is concern that the way in which the EU has already set targets for the consumption of liquid biofuels for transport, has created an imbalanced and unsustainable market. There are instances where the EU now imports biofuels from Brazil and the US, which have been subsidised at the point of production. However our system now effectively also subsidises at the point of consumption. Those biofuels are being grown in circumstances that show little respect for sustainability, nor for biodiversity. However, our target setting is driving this situation forwards. If the same paradigm is applied to the biomass from energy crops scenario we may replicate and exacerbate what is being done with liquid biofuels.

The EU has always been focussed on setting consumption targets and not production targets. If those target for biomass and liquid biofuels do not consider sustainability, carbon footprint, biodiversity and issues associated with the impact on the countries/areas where we have sourced the material, we will replace fossil fuel dependency with biomass dependency. All the more reason to develop an indigenous European energy crop supply.

Table 7
Area under energy crops in the EU 25* (kha)

	Total	Energy crop scheme	Non food on set aside regime	Without spec. regime
Austria	19.63	7.91	9.37	2.36
Belgium	7.56	2.59	4.07	0.91
Bulgaria	-	-	-	-
Cyprus	-	-	-	-
Czech Republic	104.0	0.0	0.0	104.0
Denmark	47.90	17.34	24.81	5.75
Estonia	-	-	-	-
Finland	9.44	8.31	0.00	1.13
France	572.61	135.40	376.2	1.00
Germany	1356.61	235.60	341.00	780.00
Greece	-	-	-	-
Hungary	18.50	18.50	0.0	0.0
Ireland	2.36	1.61	0.47	0.28
Italy	9.80	0.29	8.34	1.18
Latvia	-	-	-	-
Lithuania	-	-	-	-
Luxemburg	-	-	-	-
Malta	-	-	-	-
Poland	60.2	3.67	0.0	56.53
Portugal	0.09	0.08	0.00	0.01
Romania	-	-	-	-
Slovak Republic	-	-	-	-
Slovenia	1.59	0.14	1.45	0.0
Spain	39.45	25.61	9.11	4.73
Sweden	37.45	29.34	3.61	4.49
The Netherlands	1.29	0.05	1.09	0.15
U.K.	191.17	88.59	79.58	23.0
EU 27	**2479.66**	**575.03**	**859.10**	**1045.53**

* Study On Implementing The Energy Crops Cap Measures and Bio-Energy Market, final report

Table 7 considers the current area under energy crops in the EU. One of the factors that we have to take into consideration is the relationship between land use and animal production. The production of food from animals and particularly the production of meat has a significant influence on the efficiency of the land. i.e. it is much more demanding to produce 1 kilo of food product from animals than it is from crops. This is likely to have a sociological impact on our diet in the future as we become increasing aware of the demand for land.

CONCLUSION

By 2030 it is possible to meet up to 20% of the EU 27 energy demand from biomass. This would require an increase in energy crop production of approximately 800%. This is achievable if the total land currently given over to energy crops is increased by a factor of 3 and there is a significant increase in the yield potential as a result of plant breeding. It is harder to quantify the additionally that can be added from improvements within the wastage associated with biomass processing.

Biomass and in particular energy crops is by no means the solution for our total energy shortfall. However there are additional benefits from using energy crops as a fuel other than those purely associated with carbon dioxide reduction. Those benefits are associated with environmental improvement and the social and economic aspects of using locally produced materials to satisfy our energy requirements. If the areas dedicated to energy crops are to be ramped up considerably, it should be done in a sustainable way, by regulation that identifies the true carbon dioxide savings based on whole life cycle costing.

One aspect that this paper has not considered is the higher value products that can be created from liquefaction, saccharificatiom, carbonisation and pyrolisis. These essentially involve creating higher value chemicals to supplant those which will be in shorter supply as traditional refining reduces in scale.

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BIOGRAPHICAL NOTES

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Michael is the Business Development Director with Rural Generation, a biomass company based in Derry. He graduated from the University of Salford in 1978 and began working life as a Quantity Surveyor. In 1982 he was a founding partner in Holmes and Doran, a multi-disciplinary practice, of Quantity Surveyors, Building Surveyors and Project Managers. Originally based in Northern Ireland, the practice expanded in 1995, to include an office in the Republic of Ireland. He left the practice in 1999 to work in the area of Business Development.

Michael has been involved in the RICS since 1992. He was an assessor for the APC in the Construction route, until 2002, and has been on the N.I Council of the RICS in several capacities. He is the current Chairman of the Northern Ireland Environment Faculty, and is the Chairman of the International Environment Faculty of the RICS.

He is also a Chartered Environmentalist, and has recently qualified as a member of the Institute of Directors. He was a founder member of the Irish Bioenergy Association, in 2000, and was their P.R. Officer until 2005. He also manages an E.U. Framework 6, R&D project, called Thermalnet, which is focussed on the combustion, gasification and pyrolysis of biomass.
Married with 4 children, Michael's interests include horse riding and motor boating. He is also a qualified basketball and swimming coach and has played basketball to international level, in the dim and distant past.

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