



An argument for using grass biomethane as RES-H & RES-T

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IEA Task 37
Copenhagen 26 May 2010



UCC

Coláiste na hOllscoile Corcaigh, Éire
University College Cork, Ireland



Research

Research areas

- Life cycle analysis of bioenergy systems
- Liquid and gaseous biofuels
- Basic research in biogas production

Research Team

- One PI, two Postdoc's, three PhD's, 4 Masters students.

Publications since 2004

- 30 peer review journal papers since 2004 (5 under review)
- 22 peer review conference papers

Backlash against biofuels

Biofuels Are Bad for Feeding People and Combating Climate Change

Scientific America, 7th February 2008

Biofuels worse than fossil fuels for environment, say activists

The Irish Independent, 15th April 2009

Ethanol Production Could Be Eco-Disaster, Brazil's Critics Say

National Geographic News, 8th February 2007

When Renewable Energy Is Bad For The Environment

Spiegel, 28th September 2006

Bi ofuel s menace rai nforests

The Guardian, 17th August 2007

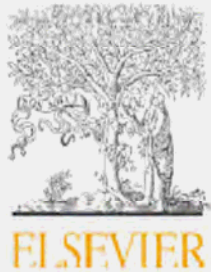
Biofuels make climate change worse, scientific study concludes

The Independent, 8th February 2008



Rape seed biodiesel

Applied Energy 86 (2009) 595–604



Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy



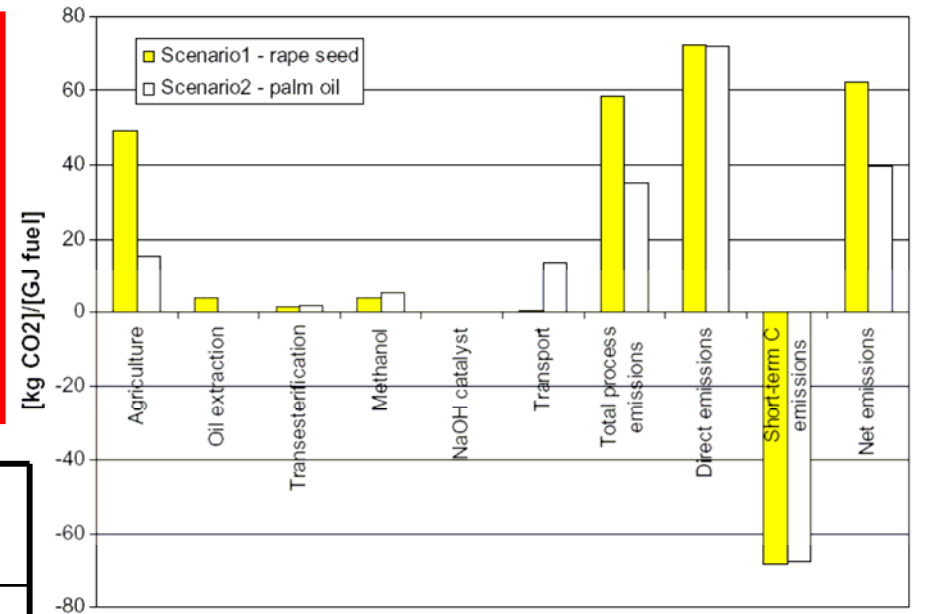
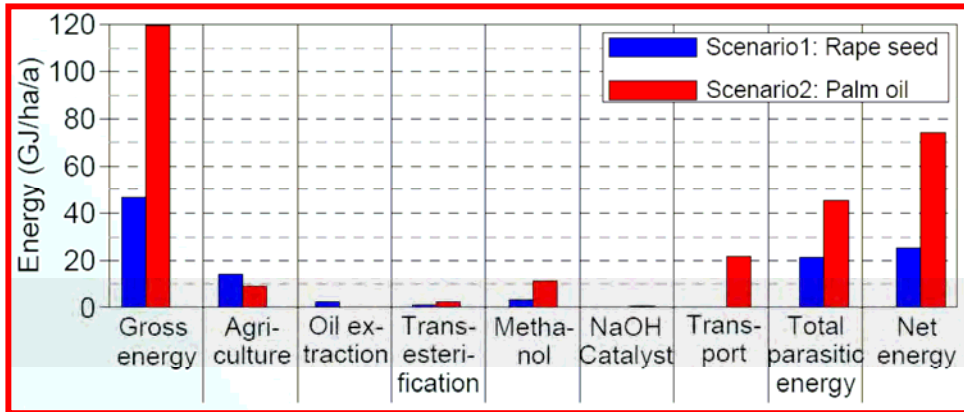
Is it better to import palm oil from Thailand to produce biodiesel in Ireland than to produce biodiesel from indigenous Irish rape seed?

T. Thamsiroj, J.D. Murphy *

*Department of Civil and Environmental Engineering, University College Cork, Cork, Ireland
Environmental Research Institute, University College Cork, Cork, Ireland*



Rape seed biodiesel



	Rapeseed biodiesel	Palm oil biodiesel
Net energy	25.3 GJ/ha/a	74.2 GJ/ha/a
GHG emiss.	62.2 kg CO ₂ /GJ	39.2 kg CO ₂ /GJ
GHG saving	28.8%	55.1%



Rape seed biodiesel

Energy Fuels **2010**, 24, 1720–1730 · DOI:10.1021/ef901432g
Published on Web 02/24/2010

energy&fuels
article

Can Rape Seed Biodiesel Meet the European Union Sustainability Criteria for Biofuels?

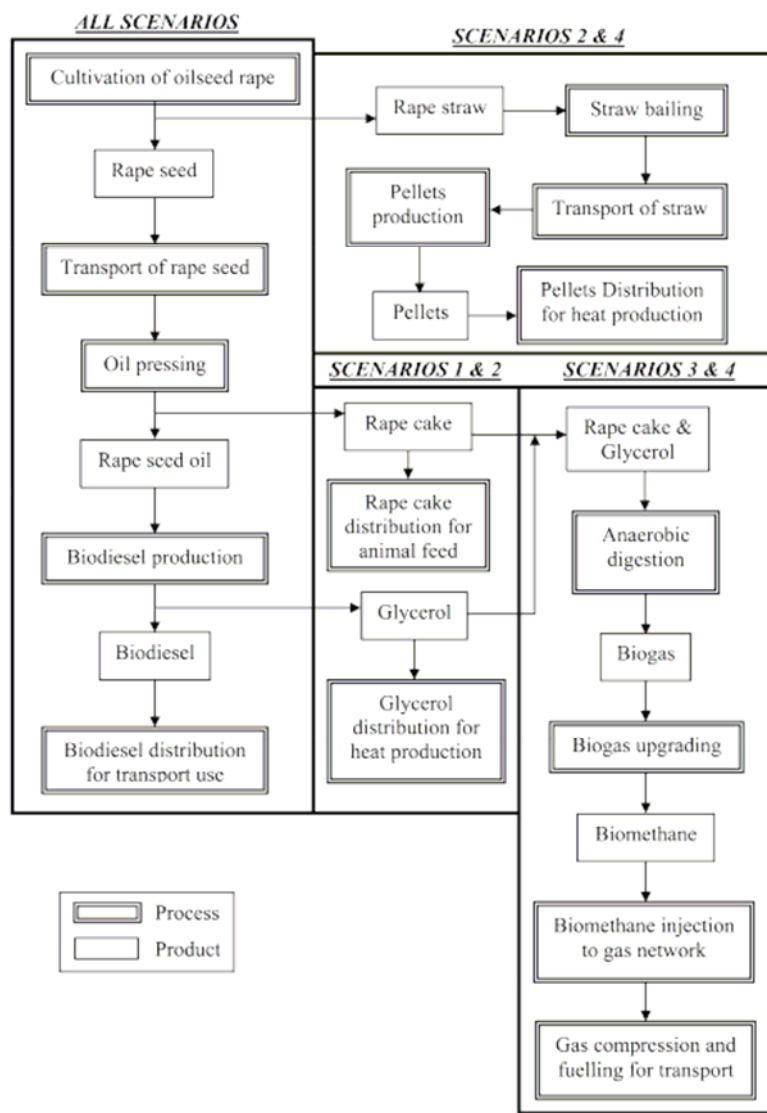
T. Thamsiriroj^{†,‡} and J. D. Murphy^{*,†,‡}

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Received November 24, 2009. Revised Manuscript Received February 8, 2010

Rape seed biodiesel



Thamsiroj and Murphy

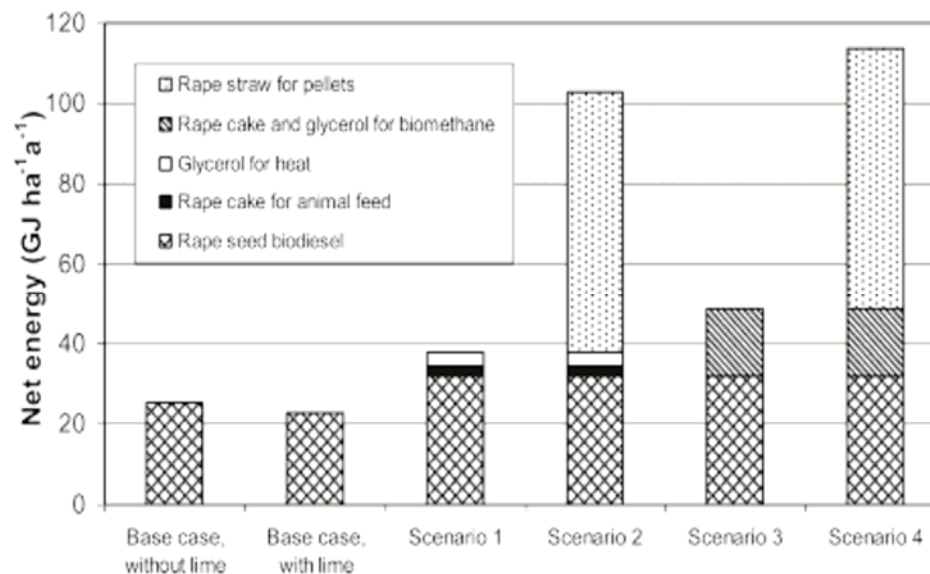


Figure 3. Net energy result of different scenarios.

Ethanol



ELSEVIER

Available online at www.sciencedirect.com



Fuel 87 (2008) 1799–1806



www.fuelfirst.com

How can we improve the energy balance of ethanol production from wheat?

Jerry D. Murphy^{a,*}, Niamh M. Power^b

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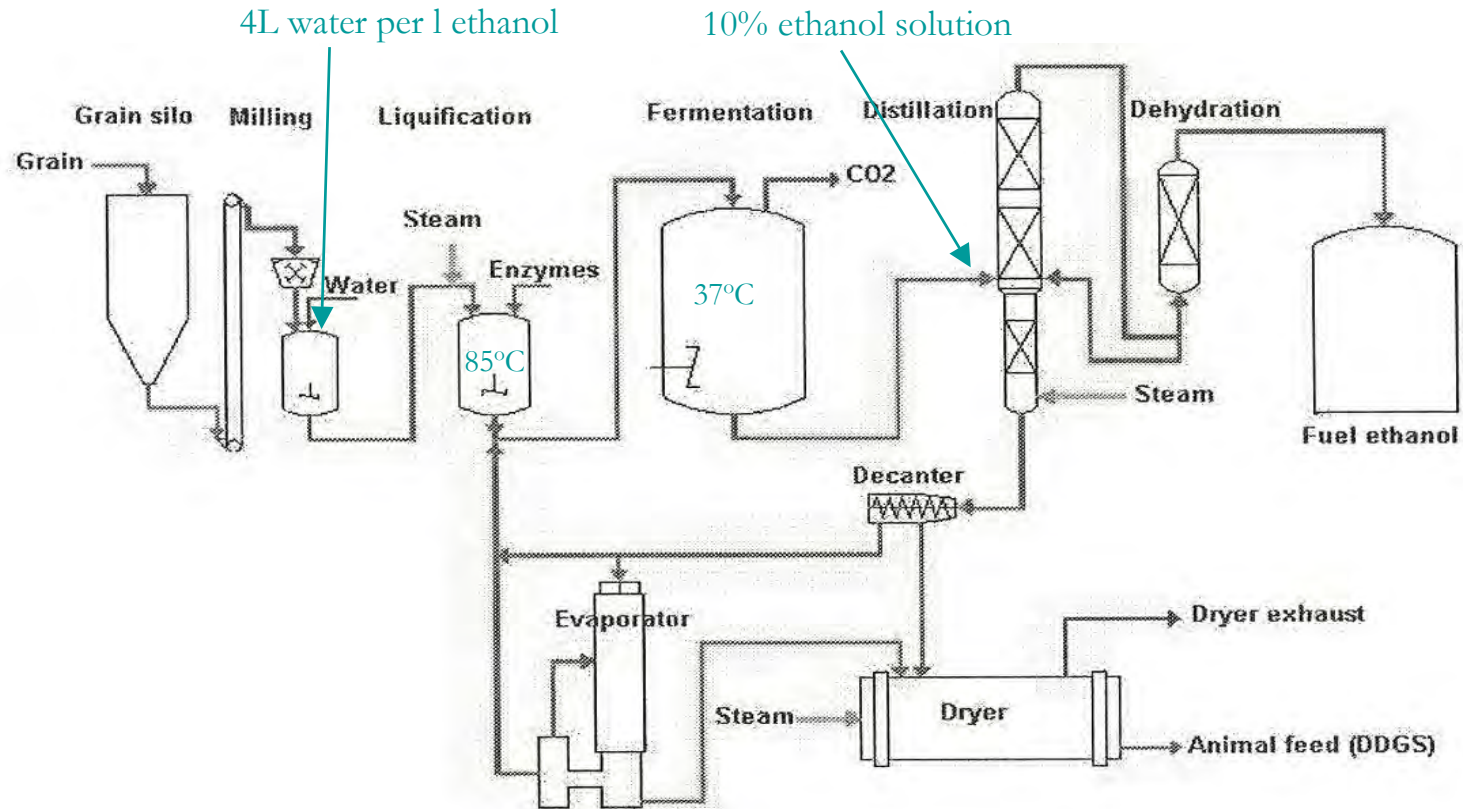
^b *Department of Civil, Structural and Environmental Engineering, Cork Institute of Technology, Cork, Ireland*

Received 28 September 2007; received in revised form 14 December 2007; accepted 19 December 2007

Available online 15 January 2008



Ethanol



Thermal parasitic demand is substantial: Cook at 85°C; triple distillation (78°C); Evaporate water off mash to produce dried distillers grains and solubles (DDGS).



Ethanol energy balance



Wheat	8.4 t/ha	375 l/t	3150 l/ha	66.5 GJ/ha/a
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Less energy used in process
Less energy in agriculture

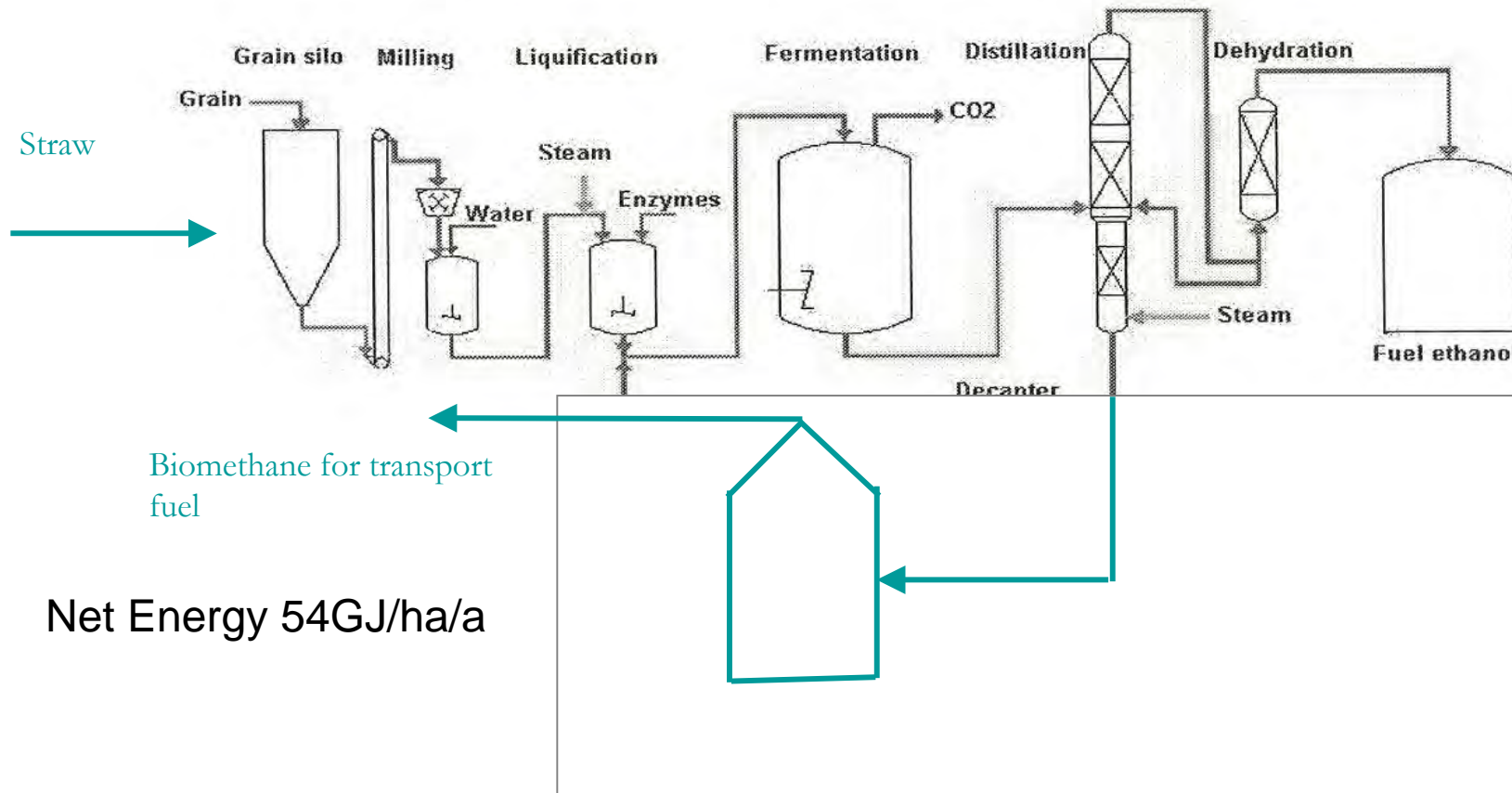
Net energy

41.5GJ/ha/a.
21 GJ/ha/a.

4GJ/ha/a



Methods of improving ethanol facility



Sustainable Biofuels

DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 23 April 2009
on the promotion of the use of energy from renewable sources and amending and
subsequently repealing Directives 2001/77/EC and 2003/30/EC

- Article 17 (2):
 - From Jan 1 2018 the greenhouse gas emissions of new biofuel facilities are reduced by **60%** compared to the alternative fossil fuel use;
- Article 17 (3):
 - No damage is done to sensitive or important ecosystems.
- Article 17 (4)
 - May not convert wetland, forestry or grassland to energy crop production
- Article 21 (2)
 - Biofuels from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels



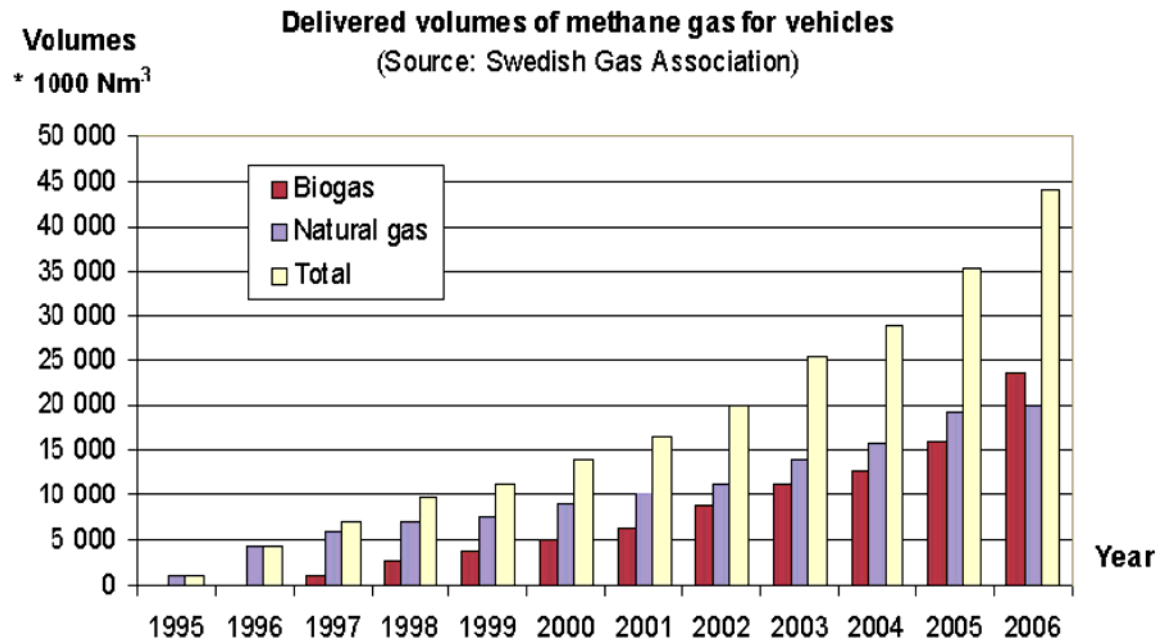
Annex 5 of Renewable Directive

Biofuel	Typical GHG savings	Default GHG savings
Wheat ethanol	32%	16%
Rape seed biodiesel	45%	38%
Sugar beet ethanol	61%	52%
Corn ethanol	56%	49%
Sugar cane ethanol	71%	71%
Waste oil biodiesel	88%	83%
OFMSW biomethane	80%	73%
Slurry biomethane	84%	81%



GNG Vehicles

- 10 million vehicles worldwide
 - 1.75 million in Argentina
 - 580,000 in Italy
 - 70,000 in Germany



Sweden: biomethane/natural gas mix in vehicle fuel



Grass Biomethane Papers

BIOMASS AND BIOENERGY 33 (2009) 504–512



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<http://www.elsevier.com/locate/biombioe>



BIOMASS &
BIOENERGY

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An argument for using biomethane generated from grass as a biofuel in Ireland

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Grass Biomethane Papers

Renewable and Sustainable Energy Reviews 13 (2009) 2349–2360



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Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



What is the energy balance of grass biomethane in Ireland and other temperate northern European climates?

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^b Environmental Research Institute, University College Cork, Cork, Ireland



Grass Biomethane Papers

Environ. Sci. Technol. 2009, 43, 8496–8508

Review of the Integrated Process for the Production of Grass Biomethane

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*Received May 26, 2009. Revised manuscript received September 22, 2009. Accepted
September 30, 2009.*



Grass Biomethane Papers



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journal homepage: www.elsevier.com/locate/rser



What type of digester configurations should be employed to produce biomethane from grass silage?

Abdul-Sattar Nizami^{a,b}, Jerry D. Murphy^{a,b,*}

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^bEnvironmental Research Institute, University College Cork, Ireland



Grass Biomethane Papers

Modeling and Analysis



Is grass biomethane a sustainable transport biofuel?

Nicholas E. Korres, Anoop Singh, Abdul-Sattar Nizami and Jerry D. Murphy, ¹University College Cork, Ireland

Received December 15, 2009; revised version received February 8, 2010; accepted February 11, 2010

Published online in Wiley InterScience (www.interscience.wiley.com); DOI: 10.1002/bbb.228;

Biofuels, Bioprod, Bioref. 4: xxx-xxx (2010)

Argument for using grass biomethane

Regulations

- Cross compliance regulations state that the ratio of permanent grass land to arable land may not change by more than 10% based on 2003
- EU Renewable Energy Directive states that we may not convert wetland, forestry or grassland to energy crop production for biofuel production.

Ireland

- Ireland has 8% of EU cattle herd with less than 1% of EU human population
- 91% of Irish agricultural land is under grass; 9% arable
- Arable land fully employed..we import wheat.
- Sustainable indigenous employment in rural areas

Grass as a source of bioenergy

- Grass is a perennial low energy input crop that does not require rotation
- Digestion is a low energy input process.



Grass to biomethane process



harvest



silage storage



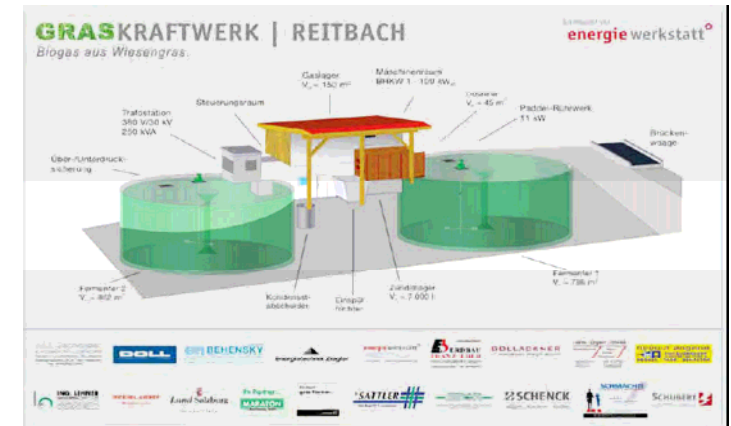
macerator



Service station



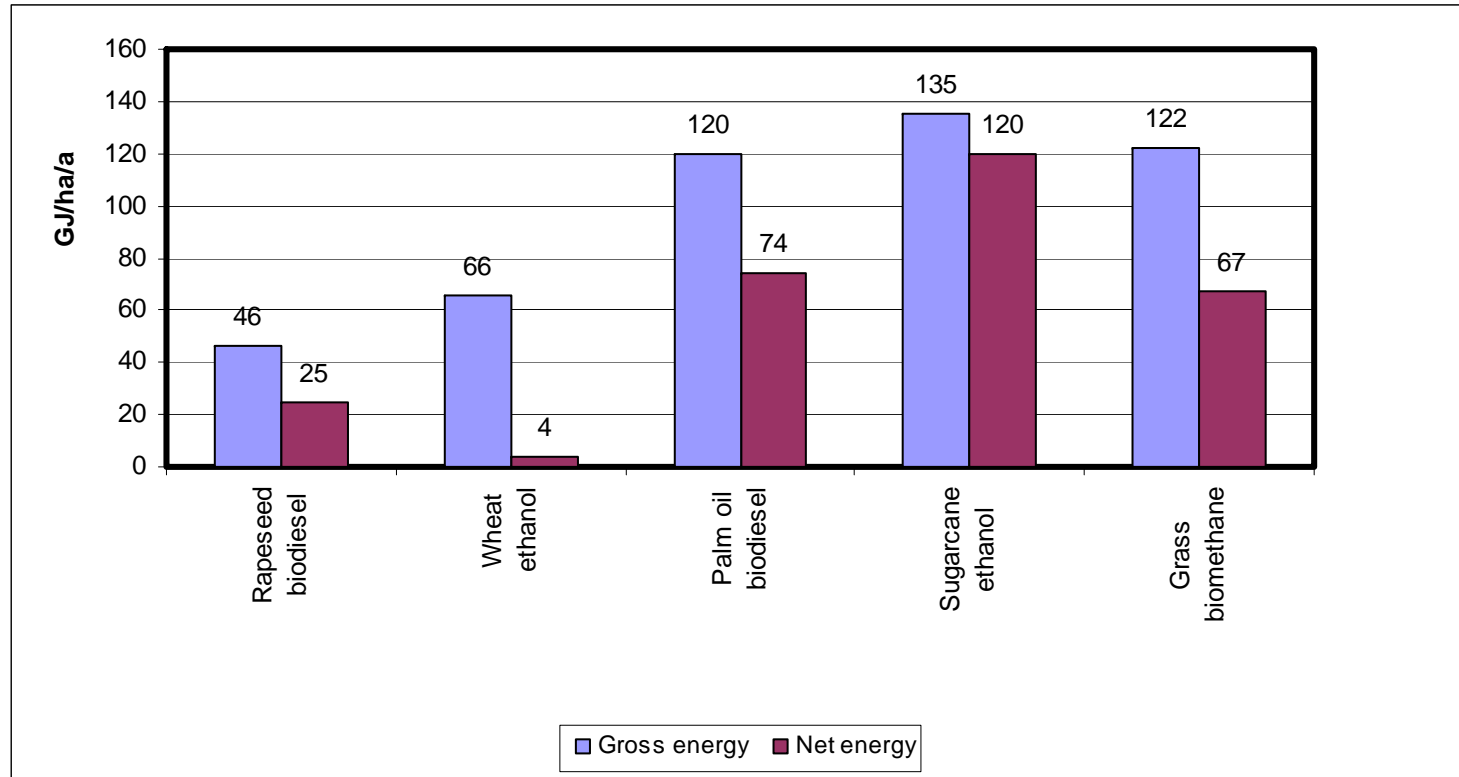
Biomethane upgrading



anaerobic digester



Relative Energy Balance of Grass Biomethane



Gross and net energy comparison of various crop systems



Land required to power one city bus



Table 7 – Biofuels, and associated land area required, to substitute for fuel used by a typical Dublin bus (28,000 l of diesel/a, 1008 GJ/a).

	Crop t/ha ^a	Fuel/t	Fuel/ha/a	Gross ^d Energy GJ/ha/a	Land required ha/a	Rotation	Land to be contracted Ha
Biodiesel (rapeseed)	4	0.3 t	1.2 t oil	42	24	1 in 5	120
Ethanol (sugar beet)	50	100 l/t ^b	5000 l/ha	105	9.6	1 in 3	28.8
Ethanol (wheat)	8.4	375 l/t ^b	3150 l/ha	66	15.3	2 in 3	23
Biogas (sugar beet)	50	128 m ³ /t ^c	6400 m ^{3c}	134	7.5	1 in 3	22.4
Biogas (wheat)	8.4	420 m ³ /t ^c	3528 m ^{3c}	74	13.7	2 in 3	21
Biogas from silage	60	123 m ³ /t ^c	7380 m ^{3c}	155	6.5	3 in 3	6.5





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Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser



A biofuel strategy for Ireland with an emphasis on production of biomethane and minimization of land-take

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^a Department of Civil and Environmental Engineering, University College Cork, Cork, Ireland

^b Biofuels Research Group, Environmental Research Institute, University College Cork, Cork, Ireland

7.5 – 33% substitution of natural gas

Table 9

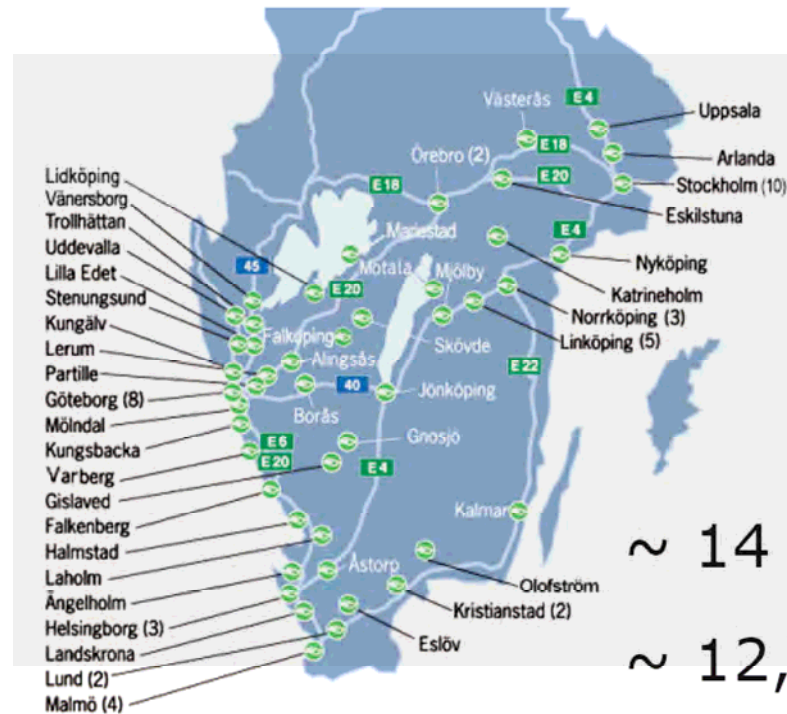
Digesters proposed for Ireland in 2020.

Digester type	Number	Feedstock treated	Total feedstock	Capital Investment (M€) ^a
Rural	183	50,000 t/a: 29,000 t/a grass (530 ha) 21,000 t/a slurry	9.15 Mt/a: 5.3 Mt/a grass (97 kha) 3.87 Mt/a slurry	183 × €7 = €1281
Slaughter	4	52,000 t/a	208,000 t/a	4 × €15 = €60
Municipal	4	54,500 t/a	218,000 t/a	4 × €20 = €80

^a Capital costs from Murphy and Power [41], case study of Linköping Digester, Murphy and McCarthy [73].

Swedish use of biomethane as a transport fuel

Biomethane as vehicle fuel in Sweden 30 June 2007



~ 13 500 gas-powered vehicles
(39 % increase)

~ 109 fuelling stations for
CBG/CNG

~ 14 mNm³ biogas (38 % increase)

~ 12,7 mNm³ naturgas (31 % increase)

(1st half year)



Renewable Energy Targets

- RES 16% – EU Target
- RES-E 40% – Irish Target (Equates to 7% RES)
- RES-H 12% – Irish Target
- RES-T 10% – EU & Irish Target



Biomethane for RES-H

- RES-H 12%
- How do we convert existing city houses to RES-H???
- How will Government Buildings meet targets???

- Sell blend of natural gas and biomethane
- Natural gas ca. 6 c/kWh
- Grass biomethane 11 c/kWh
- $0.88 (6) + 0.12(11)$ 6.6 c/kWh

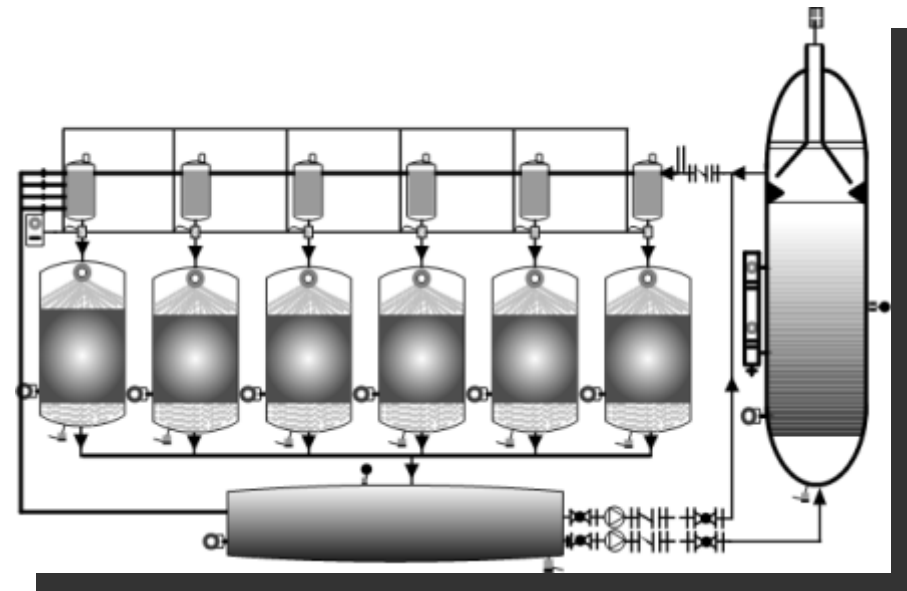
- Wood chips (inc annualised capital costs) 8-10 c/kWh



Basic research on grass digestion



Two stage wet continuous system (Continually Stirred Tank Reactors) with recirculation of leachate;



Sequencing fed Leach Bed Reactors coupled with Upflow Anaerobic Sludge Blanket, (SLBR-UASB);

Papers on grass digesters

- T Thamsiriroj, JD Murphy; “The difficulties associated with mono-digestion of grass as exemplified by commissioning a pilot scale digester” submitted to *Energy and Fuels*, March 2010.
 - Functional specific gravity of grass very different to maize: grass wants to float
 - 455 L CH₄/kg VS added @ 1 kg VS/m³ reactor/day for 1st cut perennial ryegrass
- Nizami AS, T Thamsiriroj, JD Murphy: “The role of leaching and hydrolysis in a two phase grass digestion system” submitted to *Environmental Science and Technology*, May 2010.
 - 70% destruction of volatile solids in 30 days sprinkling leachate onto bale silage (30% dry solids)
 - 61% destruction of volatile solids in 30 days sprinkling leachate onto pit silage (19% dry solids)

ERI@2GTi : Research informed Green Industry for Ireland

- €8.9 million proposed RD&D facility:
 - Injection to gas grid plus use as vehicular fuel
 - City Centre Site adjacent to P&R plus 300 Local Authority Vehicles
 - €4 million from Bord Gais Eireann
 - Dry and wet digestion facilities @ a scale of ca. 12000 t/a
- Build on existing expertise in Ireland in:
 - IT
 - Biotechnology
- Develop Green Industry in SMART Digesters, employing:
 - Wireless adaptive technology
 - Enzymatic pre-treatments
 - Process Engineering

Biofuels Research Group funded by:

- Environmental Protection Agency (EPA)
- Bord Gais Eireann (BGE)
- Higher Education Authority (HEA)
- Irish Research Council for Science Engineering and Technology (IRCSET)
- Sustainable Energy Authority Ireland (SEAI)
- Department Agriculture Food and Fisheries (DAFF)

