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THIRD PROJECT WORKSHOP

LAMNET - LATIN AMERICA THEMATIC NETWORK ON BIOENERGY

CAN RENEWABLE ENERGY MAKE IMPORTANT CONTRIBUTION TO GHG ATMOSPHERIC STABILIZATION?

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BRASILIA, BRAZIL

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MOTIVATION FOR THIS PRESENTATION

- CRITICISM ABOUT SOME IPCC- THIRD ASSESSMENT REPORT RESULTS
- BIOMASS BASED ENERGY POTENTIAL OFTEN UNDER EVALUATED

•“**To stabilize the level of carbon dioxide in the atmosphere at 550ppmv in 2100 requires that 37-38 TW (1,188 EJ/yr) of the 1,453 EJ/yr of world energy demand be carbon-emissions-free primary energy. To fill the 830 EJ/yr (26 TW) gap between 1,188 EJ/yr and the maximum contribution of 467 EJ/yr of renewable energies requires new carbon-emissions-free energy technologies not now in existence**.”

•“The results of our research do not support the statement on page 8 of Climate Change 2001: Mitigation that, **“…known technological options could achieve a broad range of atmospheric carbon dioxide stabilization levels, such as 550ppmv, 450ppmv or below over the next 100 years or more...".**

•“**Renewable energies make a small**, but important, **contribution to world energy supply**. **Solar and wind electricity** contribute as stand alone operations in small niche applications.”

• “Hydroelectricity is the most valuable of the renewable energies but is relatively small compared to world energy consumption. Geothermal electricity will continue to be small unless heat from the centre of the earth can be tapped on a large scale.”

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"The amount of solar electricity available from 1% of unused land in various world regions is considered**. In practical terms, these amounts are much higher than can actually be used because much of this land is too far from regions of substantial electricity demand.** Almost 60% of solar land is in Africa and the Middle East. **WG III suggests that 10% of unused land is the maximum available,** but even if the increase to 10% of unused land were possible, the remoteness problem will not change and the amount of solar electricity potential is not likely to increase. Nor, would it change the number of systems that operate independently of a grid."

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Presentation Page 1

TECHNOLOGICAL AND BIOLOGICAL MITIGATION POTENTIALS AND OPPORTUNITIES

major findings from the IPCC WG III contribution to the Third Assessment Report

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CLA Chapter 3 WG III

July 18, 2001

Long-term technical potential renewable and nuclear energy supply

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	Long-term Technical Potential (EJ/yr)
Hydro	>130
Geothermal	>20
Wind	>130
Ocean	>20
Solar	>2600
Biomass	>1300
Total Renewable	>4200

2100 Total Energy Demand for SRES scenario range: 515-2737 EJ/yr

Nuclear total:7700- 462000 EJ
>> average 77-4620 EJ/yr over next 100 years

Source: Nakicenovics et al, IPCC,2000

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CONCLUSIONS

- Technologies are available in the short term to stop the growth of global GHG emissions
- Technologies are available today to mitigate climate change in the long term
- The real problem of controlling emissions is to overcome the many political, economic, social and behavioural barriers to implementing mitigation options

	Wind				
7	Average wind velocity, m/sec (10 metres above ground)	5.6 – 6.0	6	5.1	-
8	Area per EJ of electricity delivered	20,000	25,079	16,670	-
9	Area per EJ of electricity delivered	-	-	See p39	-
	Biomass				
10	woody biomass	-	-	33,333	
11	short rotation trees - max.	46,000	47,642	-	
12	short rotation trees – min.	19,000	28,802	-	
13	methanol - max.	120,000	-	66,666	
14	methanol - min.	50,000	-	66,666	
15	Ethanol from sugar cane	32,000	-	-	
16	Sorghum - max.	-	46,882	-	
17	Sorghum - min.	-	20,076	-	

Line 13:

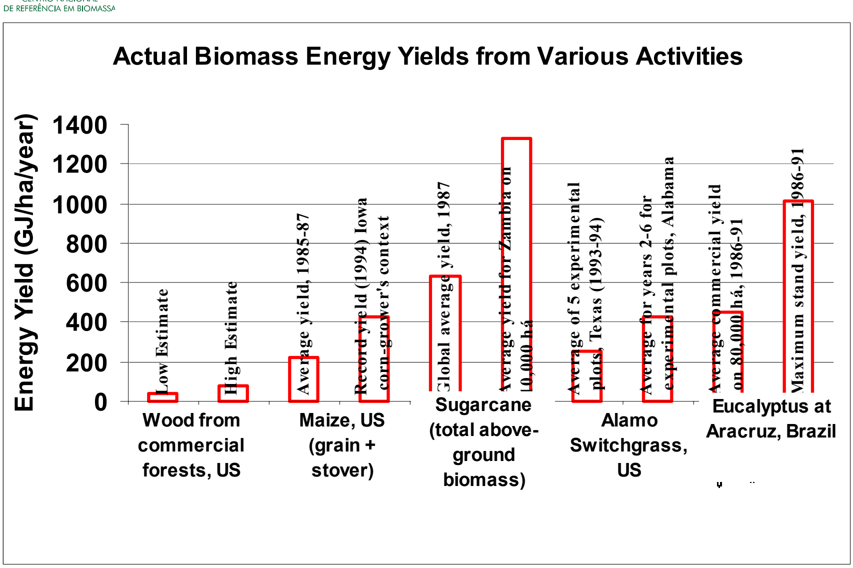
C Lightfoot & Green: Methanol: minimum area is 120,000 km²/EJ. This is more than twice the area to grow solid biomass because it takes more than one half of the energy in the wood to convert the wood to a liquid fuel, i.e., methanol.

D Eliasson has no equivalent.

E WG III: Area = 66,666 km²/EJ based on the following comment which appears on page 245 (Col. 2, line 10) - "Research into methanol from woody biomass continues with successful conversion of around 50% of the energy content of the biomass at a cost estimate of around US$0.90/litre." For purposes of this table, the assumption is exactly 50%. In the body of our report we have adjusted the 50% by multiplying by 0.7 to compensate for the energy to plant, grow and harvest the biomass. **The final result is 35% efficiency of conversion, or 94 EJ/yr of liquids from 268 EJ/yr of solid biomass.**

From the highlighted sentences above it is very clear the authors ignore the possibility of co-production of alcohol and electricity. This is a very important consideration. It is applicable to few energy crops only. May not be applicable to methanol from woody materials. We will return to this point when commenting line 15.

Alcohol from sugarcane is obtained from the primary energy contend of sugars, through the use of mechanical and electric energy, and heat.. All the mechanical, electric, and heat requirements are obtained from sugarcane bagasse that is, burned in boilers for steam production and may be gasified in the near future to drive gas and steam turbines cogeneration plants, The amount of bagasse is more than enough to fulfill all energy requirements for ethanol production and the surplus is sold to the grid in many countries. With the use of residues the amount of electricity will increase more than proportional to the amount of biomass. This allows a significant increase in the conversion efficiency of primary energy to secondary energies and overall process efficiency is higher than 50%.



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Energy Sources	Primary energy (EJ/yr) A			Best performane/2002 Steam turbine Secondary energy (EJ/yr) B			
	Current	60% barbojo	Total	Current	60% barbojo	Total	Efficiency (%)
	1	2	3	1	2	3	4
Electricity	0,0105	0,0063	0,0168	0,0018	0,0016	0,0034	20,23809524
Self-consumptio			0	0,00025	0	0,00025	
Surplus			0	0,00155	0,0016	0,00315	
Alcohol	0,0092	0	0,0092	0,0092	0	0,0092	100
Total	0,0197	0,0063	0,026	0,011	0,0016	0,0126	48,46153846
Total for sale				0,01075	0,0016	0,01235	47,5

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Energy Sources	Primary energy (EJ/yr) A			Best performane/2002 BIG/GT Secondary energy (EJ/yr)				40% MoreYield Secondary energy (EJ/yr)	
	Current	60% barbojo	Total	Current	60% barbojo	Total	Effic. (%)	Total	Effic. (%)
	1	2	3	1	2	3	4	3	4
Electricity	0,0105	0,0063	0,0168	0,00315	0,00252	0,00567	33,75	0,00794	33,75
Self-cons.			0	0,00025	0	0,00025		0,00035	
Surplus			0	0,0029	0,00252	0,00542		0,00759	
Alcohol	0,0092	0	0,0092	0,0092	0	0,0092	100	0,01288	100
Total	0,0197	0,0063	0,026	0,01235	0,00252	0,01487	57,19	0,02082	57,19
Total for sale				0,0121	0,0025	0,01462	56,23	0,02047	56,23

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Energy Sources	Primary energy (EJ/yr)			Best performane/2002 Steam turbine Secondary energy (EJ/yr)			
	A*			B*			
	1	2	3	1	2	3	4
				TWh/yr	TWh/yr	TWh/yr	
				Mboe/day	Mboe/day	Mboe/day	
				Mboe/yr	Mboe/yr	Mboe/yr	Effic.
	Current	60% barbojo	Total	Current	60% barbojo	Total	(%)
	1	2	3	1	2	3	4
Electricity	0,0105	0,0063	0,0168	0,499	0,443	0,942	20,24
Self-cons.			0	0,069	0,000	0,069	
Surplus			0	0,429	0,443	0,873	
Alcohol	0,0092	0	0,0092	0,005	0,000	0,005	100,00
Total	0,0197	0,0063	0,026	2,731	0,652	3,382	48,46

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Energy Sources	Primary energy (EJ/yr)			Best performane/2002 BIG/GT Secondary energy (EJ/yr				40% MoreYield econdary energy (EJ/y	
	A*			C*				D*	
	1	2	3	1	2	3	4	3	
				TWh/yr	TWh/yr	TWh/yr		TWh/yr	
				Mboe/day	Mboe/day	Mboe/day		Mboe/day	
				Mboe/yr	Mboe/yr	Mboe/yr	Effic.	Mboe/yr	Effic.
	Current	60% barbojo	Total	Current	60% barbojo	Total	(%)	Total	(%)
	1	2	3	1	2	3	4	3	4
Electricity	0,0105	0,0063	0,0168	0,873	0,698	1,571	33,8	2,1988	33,8
Self-cons.			0	0,069	0,000	0,069		0,0970	
Surplus			0	0,803	0,698	1,501		2,1019	
Alcohol	0,0092	0	0,0092	0,005	0,000	0,005	100,0	0,0077	100,0
Total	0,0197	0,0063	0,026	3,281	1,026	4,307	57,2	6,0295	57,2
Total for sale				3,211	1,026	4,238	56,2	5,9325	56,2

Energy Source	A	B	C	D	E	F	G	H	I
	Lightfoot	THIS PAPER	THIS PAPER	Lightfoot	THIS PAPER	Lightfoot	IPCC	THIS PAPE	THIS PAPER
	et al.	4800 units	37,800 units	et al.		et al.	TAR	4800 units	37,800 units
	Secondary	Secondary	Secondary	Convertion	Convertion	Primary	Primary	Primary	Primary
	Energy	Energy	Energy	Factor	Factor	Energy	Energy	Energy	Energy
	EJ/yr	EJ/yr	EJ/yr	EJ/yr	EJ/yr	EJ/yr	EJ/yr	EJ/yr	EJ/yr
						F=A*D		H=B*E	I=C*E
Land Area (Mkm2)	12,8	1,71	13,5			12,8	12,8	1,71	13,5
Solid Biomass						268	400	175	1378
Liquid Biomas	94	38	300	2,85	1			113	890
Electricity		62	488		2,97			62	488
Total	94	100	788						

Table 2

Amount of secondary energy produced from sugar/alcohol mills distributed over world agricultural land area at a density of 1 every 5,208km²

Total number of renewable energy producing units is 4,800

SECONDARY ENERGY CATEGORY	PRIMARY ENERGY (EJ/yr)	SECONDARY ENERGY (EJ/yr)	TOTAL LAND AREA USED FOR CROPS
ELECTRICITY	113	38	
LIQUID FUEL	62	62	
TOTAL	175	100	1.71×10^6 km²

Amount of secondary energy produced from sugar/alcohol mills distributed over world agricultural land area at a density of 1 every 661 km^2

Total number of renewable energy units is 37,800

SECONDARY ENERGY CATEGORY	PRIMARY ENERGY (EJ/yr)	SECONDARY ENERGY (EJ/yr)	TOTAL LAND AREA USED FOR CROPS
ELECTRICITY	890	300	
LIQUID FUEL	488	488	
TOTAL	1378	788	13.5X 10^6 km^2

We recognize that 37,800 units is really a huge figure, but the amount of secondary energy is also unthinkable:

300 EJ/yr of electricity (or 83,200 TWh/yr)
487 EJ/yr of liquid fuel (290 million barrel/day)

Also, if we would like to produce such amount of electricity using nuclear plants with 1,000MW each (operating factor of 70%, 6.1 TWh/yr) we would need 13,640 nuclear plants in operation at the year 2100 or the installation of a new plant every 2,5 days from now on.

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We also agree that no single solution will be able to solve the problem. IPCC/TAR presents a series of technological solutions, essentially:

- **1. Energy efficiency improvement**
- **2. Renewable energy**
- **3. Shift to low-C fossil fuels**
- **4. Biological C sequestration**
- **5. Physical C sequestration**

And, in the category "Renewable Energy" we shall rely on several possibilities, mainly, Solar PV, Wind and Biomass

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As listed in Lightfoot and Green document 40% of the usable land would be in Latin American and the Caribbean. Thus, 40% of the plants would be installed there (15,120 units) with a production of 33,300 TWh/yr and 116 million barrels of liquid fuel per day. Transportation of the liquid fuel should not be a problem. Today we already transport 40 million barrels of oil per day. Transportation of electricity may be an issue. Probably, all electricity consumption of Latin American and Caribbean would be less than 10,000TWh/yr even at 2100. The large surplus (23,000 TWh/yr) could not be transferred to other continents. One possible solution is to concentrate major energy intensive activities in the region.

Table H1 Comparison of primary and secondary renewable energies available

	A	B Our estimate of representative renewable secondary energy, Table 11 EJ/yr	C Conversion factors for renewable secondary energy to primary energy from Table 12	D Our estimate of representative renewable primary energy available B x C EJ/yr	E WG III estimate of renewable primary energy available EJ/yr
1	Hydro	19.3	1.18	22.8	50
2	Geothermal	1.5	6.2	9.3	20
3	Wind	72	3.33	240	630
4	Ocean	-	-	-	20
5	Solar	178	13.3	2,367	1,600
6	Sub-total: electricity	271	-	2,639	
7	Solid biomass	-	-	268	440
8	Liquid biomass	94	2.85	-	-
9	Totals	365	-	2,907	2,800

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1. • **IPCC/TAR/Chapter 3 did not quote explicitly the amount of secondary energy that can be obtained from the 400 EJ/yr of primary energy from biomass. Nevertheless, there are comments in the text where conversion efficiency around 25 to 30 % can be inferred, when transforming biomass in electricity.**

2. • **Regarding Primary Energy production the lowest value is from Lightfoot and Green With 268 EJ/yr, the middle one is the IPCC/TAR with 400 EJ/yr, and the highest one is from This Paper 37,800 units with 1,378 EJ/yr**.

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All scenarios except the ones under the label This Paper do not consider co-production of secondary energy when transforming biomass primary energy. Co-production is a very efficient way of conversion of primary to secondary energy forms, but can not be performed for all biomass sources. It is very appropriate for sugarcane, sweet sorghum, and ethanol/methanol production from woody materials. Nevertheless, such technology is presently practiced only for sugarcane. With co-production it is possible to increase conversion efficiency. In the scenario This Paper, conversion factor is 1.75 (see column E, in combination with results listed in column H and I) for the particular relative amounts of liquid fuel and electricity energy obtainable with the technologies used.

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- **The amount of secondary energy presented by the different evaluation using around the same land area (approx. 13 million km^2) is completely different due differences in primary energy and in the conversion efficiencies assumed. Lightfoot and Green Find 94 EJ as liquid biomass energy, while This Paper finds 788 EJ/yr from which 300 is as electricity and 488 as liquid biomass fuel. The factor of around 8 times between the results are due to differences in primary energy (4.88, already normalizing for the same land area, and 1.71 from the conversion factors).**

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•The amount of secondary energy in This Paper 37,800 units is equivalent to 83,200 TWh/yr of electricity production plus 291 million barrels of oil equivalent per day. This shall be compared with year 2000 energy production of 12,500 TWh and 70 million barrel of oil per day.

•The scenario This Paper 4,800 units has been added since it represents a density of sugarcane units similar to what is operational today in the state of São Paulo, brazil. Its result shows that it is possible to obtain more secondary energy (100 EJ/yr) using 1.75 million km^2, than has been identified in Lightfoot and Green using 12.8 million km^2 (94 EJ/yr). Also, the amount of electricity produced in this scenario is enough to supply the world electricity demand in 1990. Regarding liquid fuel its level of production is 37 million barrels of oil equivalent per day or half the 1990 consumption

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The main conclusion from this paper is that Lightfoot and Green statement that renewables can not limit CO_2 stabilization at levels as low as 350ppm and as such we must develop new energy alternatives to fossil fuels is incorrect. It is incorrect because:

- Biomass can provide a significant share of the secondary energy needed
- Solar energy alone can provide all the needed secondary energy.

Table 5 Summary of the contribution of renewables energies to world energy demand in 2100

		A WG III method of accounting for renewable electricity as primary energy. Figure 1	B Same as A with biomass energy from this paper	Same as B with solar energy from WG III 10%
1	Range of world energy demand in 2100. EJ/yr	514 – 2,737	514 – 2,737	514 – 2,737
2	Range of contribution of renewable energies to world energy demand. EJ/yr	251 – 467	845 – 1051	4,245 – 4,451
3	Contribution of renewable energies to world energy demand	9,2 – 81,4	30,7 – 38,4	155.1 – 162.6
4	Average primary energy of forty SRES scenarios in 2100	1,542	1,542	1,542
5	Average contribution of renewables energies	16% - 30%	16 – 30%	16 – 30%

Figure 1 The contribution of renewable energies in WG III format for accounting for renewable electricity compared with primary energy in 2100 in the SRES scenarios