Bio-LNG :a clean and cool biofuel for ships

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- LNG as a transport fuel : cases and pilots – Why not using bio-LNG?
- Benefits: not only reducing the emissions
- Examples of LNG use (in the shipping sector)
- Are there differences in use of bio-LNG instead of LNG?
- Projects and pilots
- Are you interested?

Bio-LNG: a clean and cool biofuel for ships

What is bio-LNG?

Bio-LNG has the same chemical formula as liquefied natural gas (LNG).
It is almost 100% of CH_4; it is also called liquefied bio-methane: LBM

The differences between fossil LNG and bio-LNG

Bio-LNG is a 100% renewable bio fuel, LNG is a fossil fuel
The production process of Bio-LNG is cleaner than that of LNG
Bio-LNG can be made from biogas at any spot where anaerobic digestion is possible

The difference between bio-LNG and other biofuels

Bio-LNG can be produced without competition with the food chain
Bio-LNG does not need blending in fossil fuels

Bio-LNG: a clean and cool biofuel for ships

An obvious difference between bio-LNG and most other fuels

The convenient truth is that:

"There is no need for any interference in the bio-LNG chain of one of the oil companies"

Any farmer, village and city can make their own clean and cool liquid transportation fuel which bio-LNG is, by simply digesting its waste, with help of dedicated partners (sufficient volume) to create and optimize the chain from production to (end) users.

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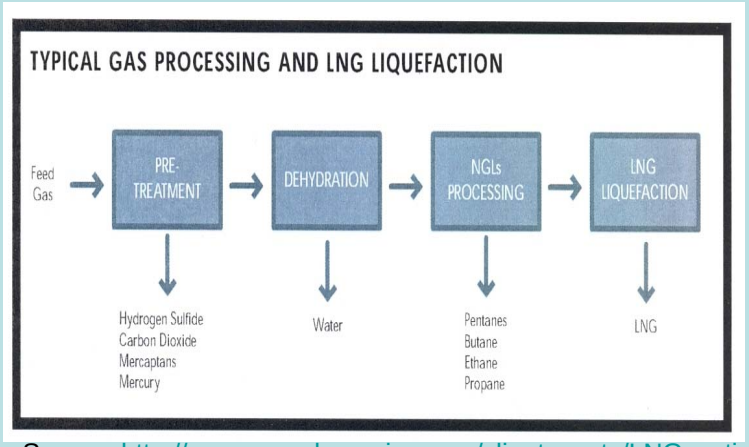
How to make LNG:

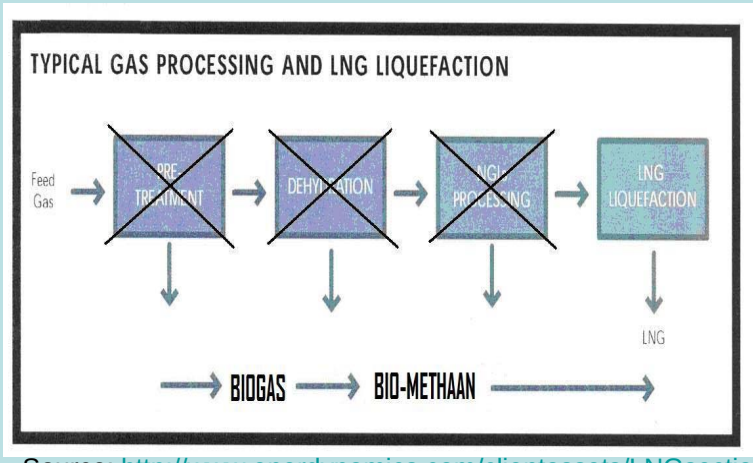
Cleaning of heavy gasses
Nitrogen, water,
Carbon dioxide
Liquefaction



Source: http://www.enerdynamics.com/clientassets/LNGsection3.pdf

How to make bio-LNG:

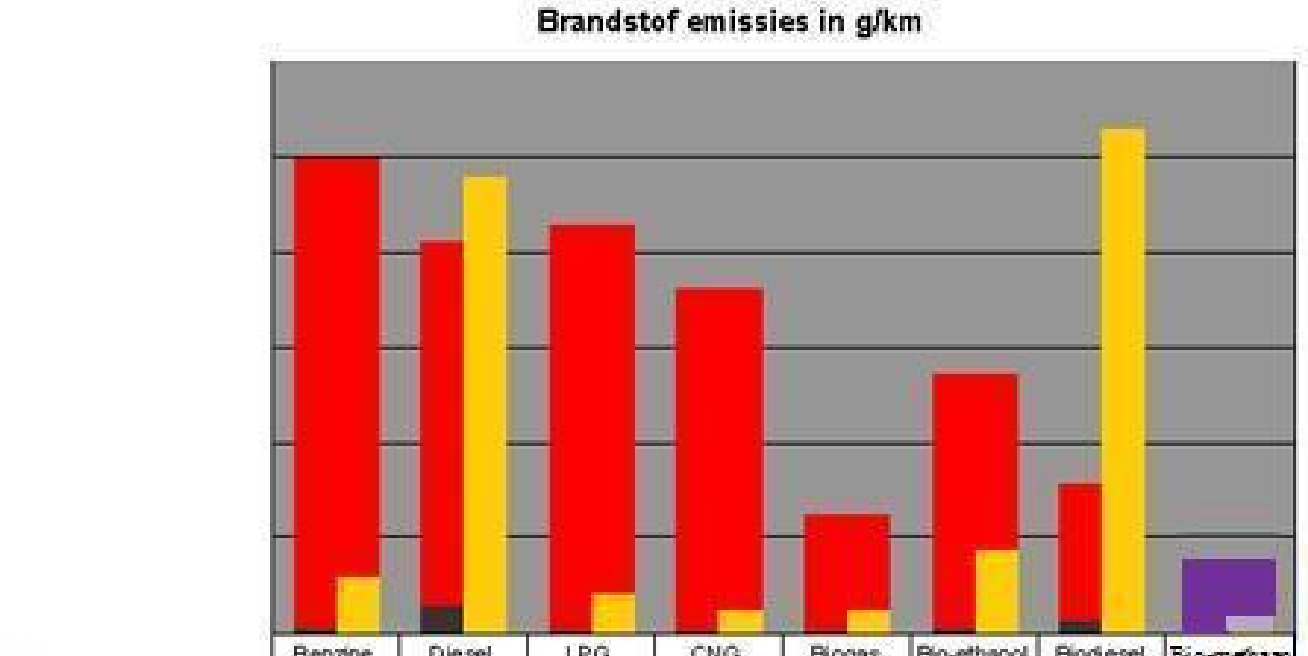
Upgrading of biogas
Liquefaction
No ethane, propane, N2 etc



Source: http://www.enerdynamics.com/clientassets/LNGsection3.pdf
(modified by HIT)

Bio-LNG : a clean and cool biofuel

Comparison of emissions of bio-methane (= bio-LNG) with other biofuels, LPG and CNG

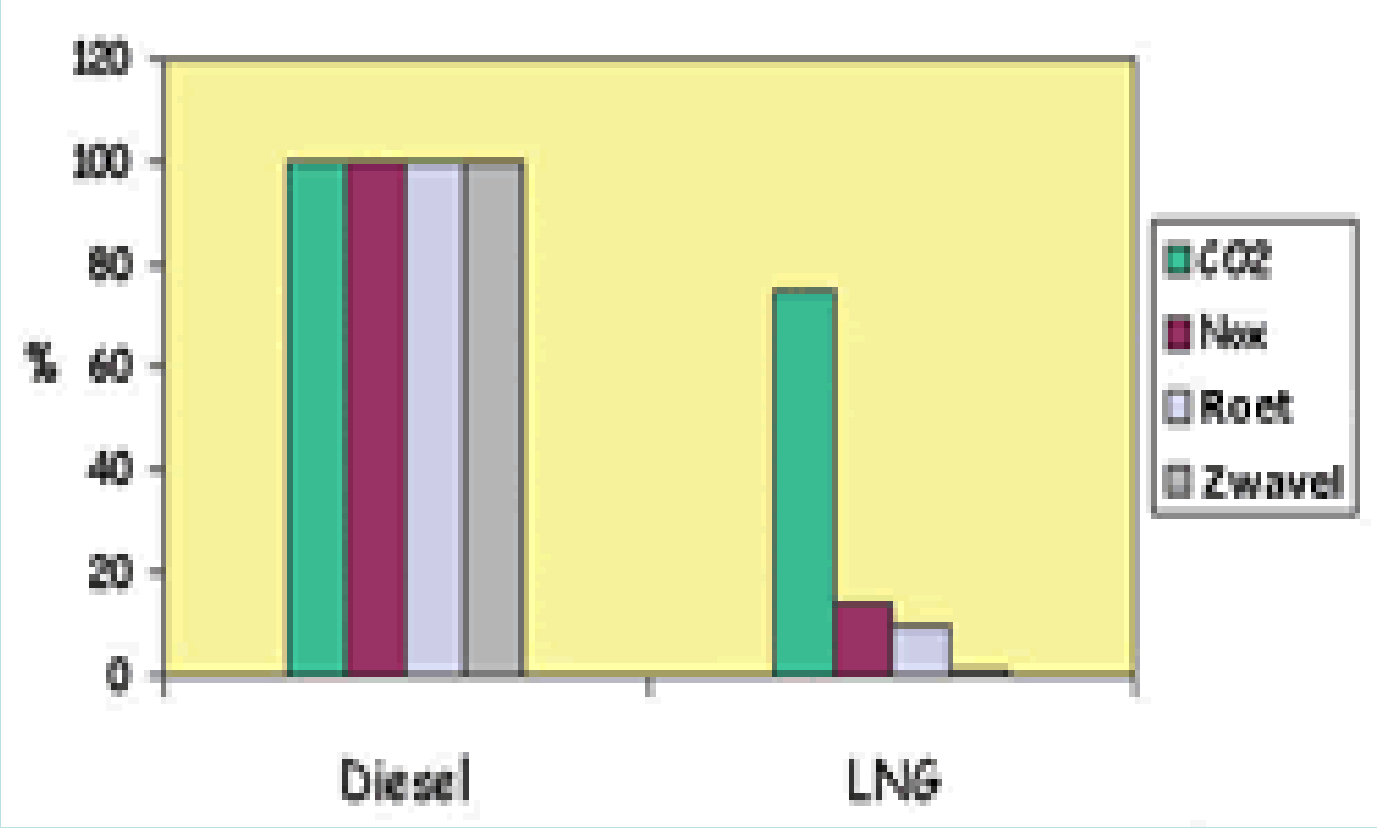


	Benzine	Diesel	LPG	CNG	Biogas	Bio-ethanol	Biodiesel	Bio-methaan
CO2 emissie (g/km)	249	206	214	181	62	136	79	44
Fijnstof emissie (g/km)	0,006	0,046	0,005	0,002	0,002	0,006	0,023	0,0014
NOx emissie (g/km)	0,1	0,8	0,07	0,04	0,04	0,145	0,88	0,028

Source: www.fuelswitch.nl and Holland Innovation Team

Bio-LNG: a clean and cool biofuel

Comparison of emissions between Marine Diesel and LNG



Source: www.energieprojecten.nl/pr_lngfjorden.html

Bio-LNG: a clean and cool biofuel

How can we produce the first step in the process: biogas?

Start with anaerobic fermentation, i.e. fermentation with a lack of oxygen and produce **biogas**

Biogas is 55-65% CH_4 ; 35%-45% CO_2 ; some H_2S and other gasses

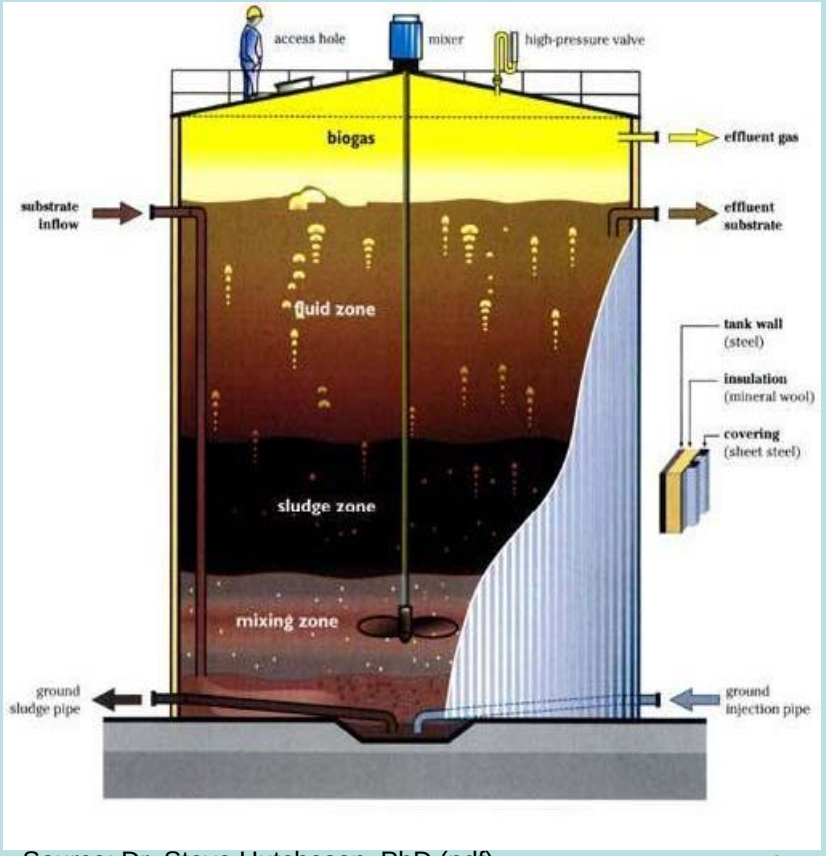
Biogas is nothing more than young swamp gas or extra young natural gas

Biogas can be produced from a large variety of streams:

Bio-LNG: a clean and cool biofuel!

Biogas production is possible:

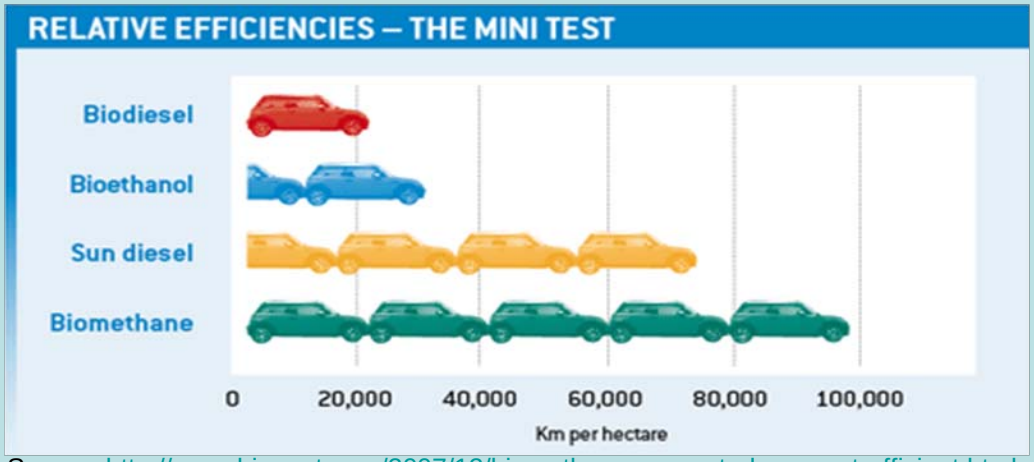
1) From sewage sludge
2) From bio fuels waste
3) From household and food waste
4) From agricultural streams
5) From manure
6) From landfills
7) From wood/paper industry
   all without competition with food
8) From crops (if prices are low)



Source: Dr. Steve Hutcheson, PhD (pdf)

Bio-LNG: a cool biofuel

Of course biogas can be made from crops; biogas yield per ha is much higher than the other biofuels in that case



Source: http://www.biopact.com/2007/12/biomethane-presented-as-most-efficient.html

Conversion of crops to biogas is 70% instead of 40% in case of bio-ethanol

Low energy input needed in the process

Bio-LNG: a clean and cool biofuel

Upgrading of biogas to bio-methane is possible by several different techniques

Pressure Swing Adsorption

Membrane Separation Technology

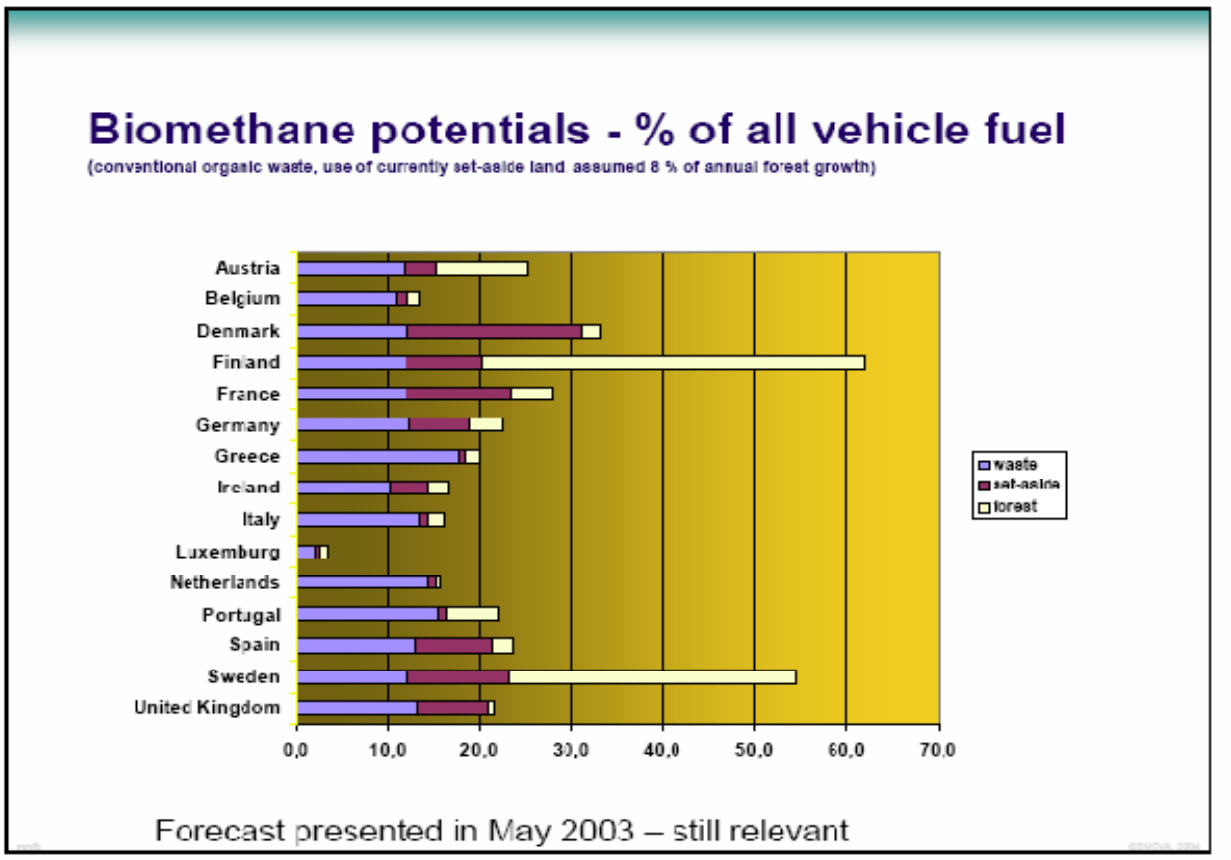
Cryogenic Separation

And others

Costs are less than 5% of the energy of the gas itself and with smart solutions only will cost a few cents per cubic meter of bio-methane produced

Bio-LNG: a clean and cool biofuel

Which are the potentials, how much is there?



Source: http://ecocomplex.rutgers.edu/PeterBoisen.pdf

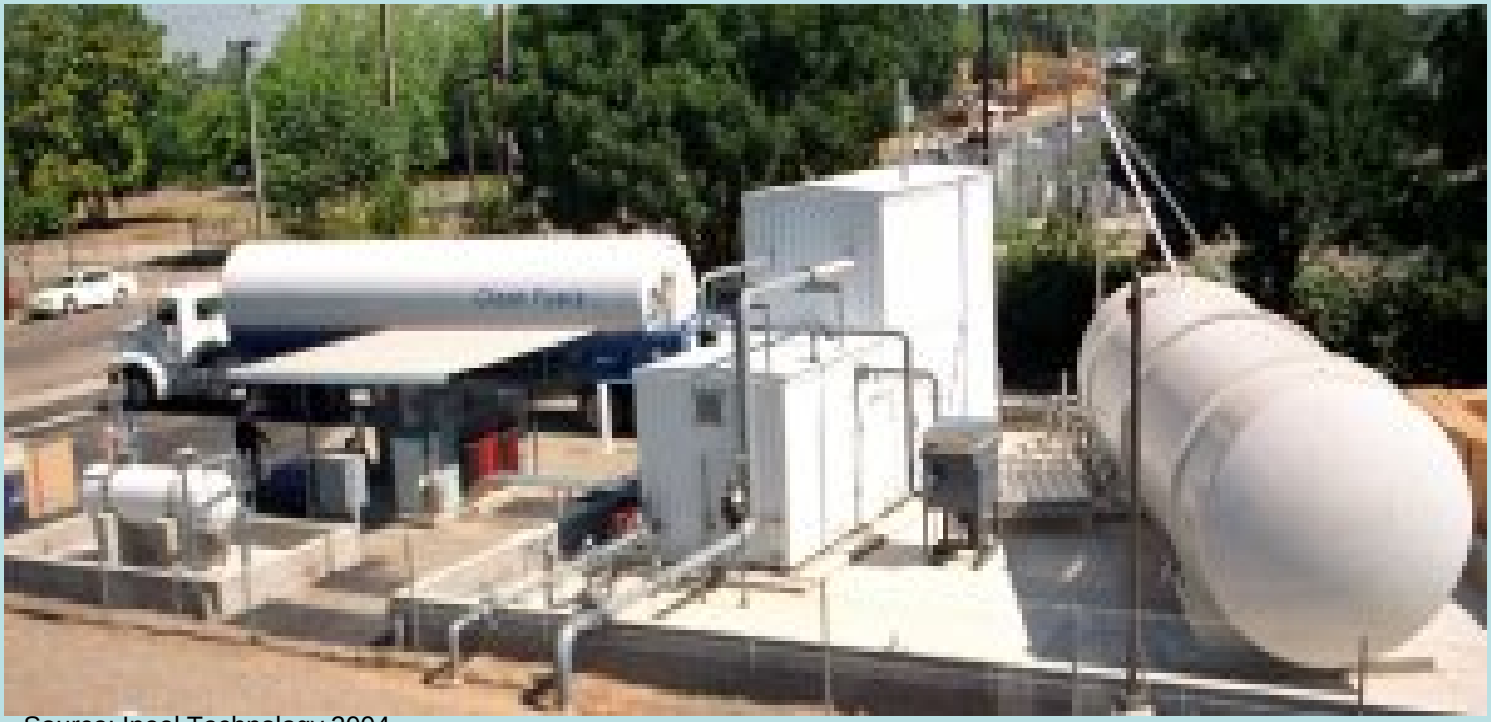
The Eu Agrobiogas project announces 40% higher yield after 1 year of study (2008)

Bio-LNG: a clean and cool biofuel

Small scale Liquefaction of bio-methane to bio-LNG

It is not true that liquefaction needs large plants and investments

Small Scale Liquefaction Plants: growing market; costs p/l are marginal



Source: Ineel Technology 2004

Bio-LNG: a clean and cool biofuel

Costs of the process

Costs of biogas production 10-30 Euro cts per Nm^3 (depends upon feedstock costs)
Costs of bio-methane upgrading < 5 cts per Nm^3 bio-methane
Costs of liquefaction < 5 cts for one liter bio- LNG. Cheaper than natural gas

Comparison of fuels

Calorific value of 1 liter of bio-LNG 21 MJoule
Calorific value of 1 liter of bio-ethanol 21 MJoule
Calorific value of 1 liter of diesel 35 MJoule

Comparison of fuel prices (no tax, no VAT, excluding logistics and fuelling stations, if necessary)

Costs of one liter of bio-ethanol 64 ct, 1 ton 800 Euro, Heating Value 26GJ.
Costs of one liter of bio-LNG 32 cts, 1 ton 760 Euro, Heating Value 50GJ

Bio-LNG: a clean and cool biofuel

Why is bio-LNG better than second generation biofuels?

There is natural gas, there is swamp gas and there is gas from cows, there is an enormous quantity of bacteria that can rot, and produce bio-methane.

There are only a few that can convert ligno cellulose into bio-ethanol which needs input of much energy with high emissions during the conversion process.

Biodiesel gives rise to much more emissions and pollution than bio-LNG

Even BTL (biomass to liquids) generates pollution in the production process

Bio-LNG: a clean and cool biofuel

LNG : more and more used as a transport fuel

Boron, CA Plant

Opens Fall 2008

$70 Million Investment

160,000 gal/day

Expanding to 240,000 gal/day at end of 2009

1.5 Million Gallons Storage

Bio-LNG: a clean and cool biofuel

LNG as a transport fuel:

Source: http://www.nonox-bv.com/products.php

Harbour trucks: Los Angelos
Taxi's: China
Trucks: UK, Australia, China
Brazil, Sweden and others

Benefits
Less noise, less pollution, more cargo possible

But there is more especially in Ports:

Cold ironing, aggregates
Forklift trucks in closed spaces, which all contribute to more sustainable transport

Bio-LNG: a clean and cool biofuel

Source: Photo Courtesy of PG&E

The first-ever mobile LNG cold ironing test was recently conducted with the APL China at the Port of Oakland. PG&E supplied the LNG equipment and technical expertise.

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LNG as a transport fuel for ships:

Gasnor (Norway) is leading in this European project,

Germany, Poland and Baltic states participate

The project Magolog declared in 2006:

Within 5-10 years all short sea shipping will use LNG as a fuel

Now 13 ships in Norway use LNG, most of them ferries

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LNG-fuelled off-shore supplier (Norway)

Source: http://www.ship-technology.com/projects/viking

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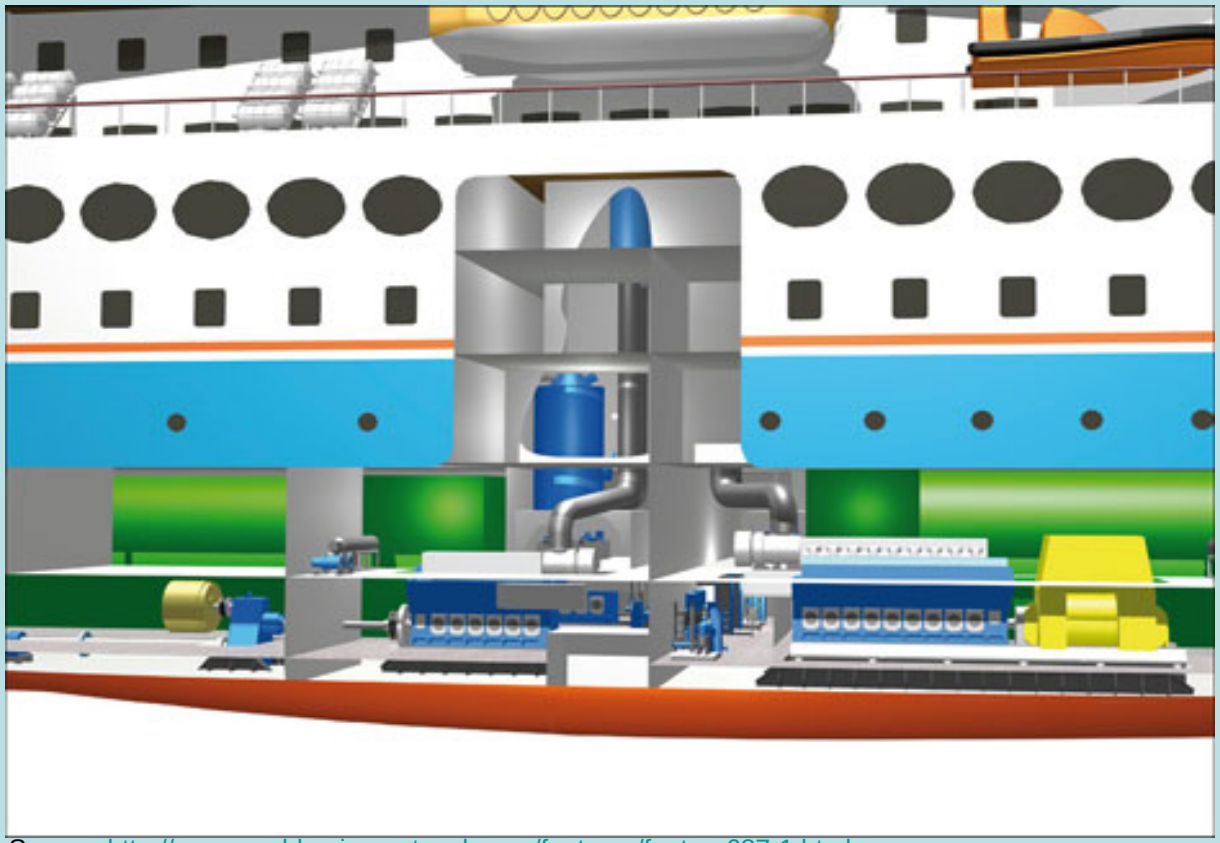
LNG as a transport fuel for ships: storage



Source: http://www.worldcruise-network.com/features/feature687-1.html

LNG is stored in cylindrical, double walled insulated stainless steel tanks.
Total weight Is approximately 1,5 times heavier than MDO with tanks.

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LNG as a transport fuel : engines

Wärtsila, Rolls Royce,
Mercedes, Westport Cummings
Caterpillar, Iveco and?

No difference in use/handling between LNG and bio-LNG:

Bio-LNG can be mixed with good quality LNG

Needs good storage optimization **as LNG:**

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Future plans with shipping

Norway:

All future ferries will use LNG

Small scale liquefaction plants are installed:

LNG tankers sail upon boil off of the LNG shipped

Netherlands:

The Rotterdam based company: Anthony Veder will use LNG as a fuel,

Likes to look at the possibility to use bio-LNG

Several projects will investigate inland navigation on bio-LNG

The Dutch power company Essent looks at SSL of bio-methane to bio-LNG, and takes care of logistics and contract with end users.

Bio-LNG: a clean and cool biofuel

When will it be economically viable to use bio-LNG?

Costs of one ton of MGO, R'dam,

Aug 2008: 700 €; Heating Value 44 GJ in bio-LNG equivalent € 790
Oct 2008: 550 € Heating Value 44 GJ in bio-LNG equivalent € 620

Calorific value of 1 liter of marine gas oil (MGO) 37-39 MJoule, bio-LNG 21 MJoule

1 ton bio-LNG will cost < € 760 (exclusive TAX and VAT)

Where will bio-LNG be available?

At large LNG terminals, where it can be mixed with good LNG

At individual bunker stations from landfills and digesters at close distance from Ports

From the waste of large biofuel plants operating in Ports

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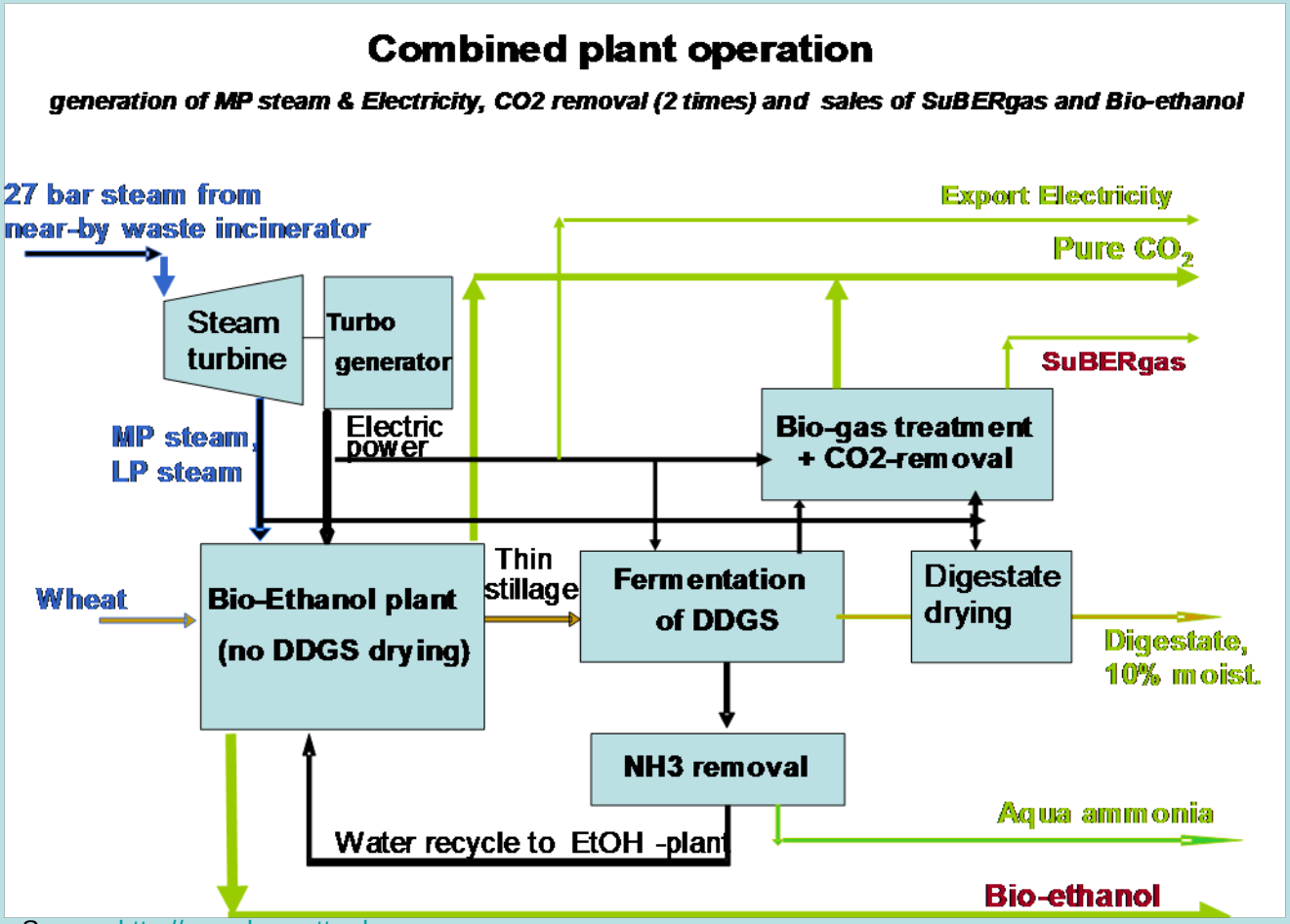
A possible project: bio-LNG from bio-ethanol waste



Source: http://www.ber-rotterdam.com

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Possible projects

Hamworthy Biogas - LNG

BER, Rotterdam, Holland – Models *based on 365 days/year

- Model 1: Birds view Snurrevarden, Norway

5
Update: May 2008

Hamworthy

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Bio-LNG from bio-ethanol waste

Bio-methane of BER (SuBERgas) can be converted into bio-LNG

50 million Nm^3 99% bio-methane can be converted into:

75 plus million liters of bio-LNG (over 30.000 tons) annually

Status:

Strongly opposed by current players: delayed?

Needs new innovative players

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How to continue?

Does it make sense to establish a consortium,

To start pilots and real projects, optimizing technology and logistics

To establish infrastructure with storage, fuel and bunkering stations,

Looking at automotive, inland navigation and short sea

To develop further technology, establish innovative combinations

We think it makes sense

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to develop a clean and 100% renewable independent fuel chain, which can compete in price with existing fuel chains, with no interference with food, with no emissions

Source: http://www.anthonyveder.com

during the production process, with even a carbon negative impact in the world, which will make transportation (also by ships) clean business, namely a chain of:

Bio-LNG

a clean

Source: http://www.anthonyveder.com

and cool bio fuel

Source: http://www.gasrec.com

Thank you for your attention

www.hollandinnovationteam.nl

Lloyd's maritime academy London: 12th of November 2008