



25th world gas conference

“Gas: Sustaining Future Global Growth”

# Jet-LNG is the sustainable fuel for Aviation

Research work on liquid bio-methane: the only option available to sustain the aviation industry growth of the 21<sup>st</sup> Century in a balanced environment and economy

***Dr. Antonio Nicotra***

*General Manager, Gasfin Investment SA  
Managing Director, AIR-LNG GmbH*

**CS 5.3 WOC 5 - 06 June 2012**

*NGV: the solution for a low carbon society*

Patron



Host



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# ... the “drop-in” synthetic-kerosene options...

(mixable with Jet-kerosene)



from coal ...



from gas ...



from biomass fibres ...



oil, fat, sugars ...



## 09.04.2008- Sasol gets approval for 100% synthetic jet fuel

- 100% Synthetic Fuel Wins First-Time approval for International use in Commercial Aviation.
- Pioneering Fuel produced by Sasol Ltd, meets stringent performance standards and burns more cleanly than conventional jet fuel
- Johannesburg, South Africa—Sasol, the world's leading producer of synthetic fuels from coal and natural gas, today announced that it has become the first company worldwide to receive international approval for its 100% synthetic jet fuel produced by its proprietary Coal to Liquids (CTL)

## 29.09.2009 - GTL Jet Fuel approved for use in civil aviation

- Shell today welcomed the release by ASTM International of a new specification that fully and unconditionally approves the use of Gas-to-Liquids Kerosene blends for powering commercial aircraft.
- The new specification, ASTM D7566 “Aviation Turbine Fuel Containing Synthesized Hydrocarbons”, approves jet fuel containing up to 50% GTL Kerosene for use in civil aviation.
- The blends will be known as **GTL Jet Fuel**.
- **12 Oct. 2009 - Qatar Airways Makes Historic Journey From**

## 16.02.2010 - BA & Solena announce partnership to establish EU 1<sup>st</sup> sustainable jet-fuel plant converting trash into jet fuel.

- The new fuel is derived from waste biomass and made in a new facility that can convert several types of landfill waste into aviation fuel.
- The airline said it plans to use the low-carbon fuel to power part of its fleet beginning 2014
- The self-contained plant will likely be built in east London. It's expected to convert 551,000 tons of waste into 16 million gallons of green jet fuel each year.

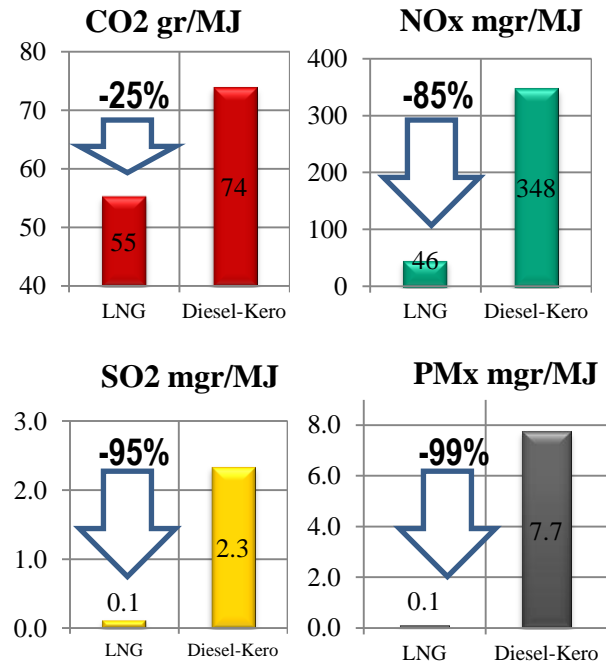
## 29.11.2010 - Lufthansa to begin flights in the spring powered by renewable fuel from Neste Oil

- Neste Oil and Lufthansa signed a cooperative arrangement that will see Lufthansa begin commercial flights using Neste Oil's NExBTL renewable jet fuel The agreement represents a major step forward for both companies, as this is the first time that renewable fuel is announced to be used on normal scheduled flights.
- Flights will begin in 2011 after official approval has been received from the ASTM allowing the use of jet fuel produced using Neste Oil's NExBTL technology. This is expected to take place in

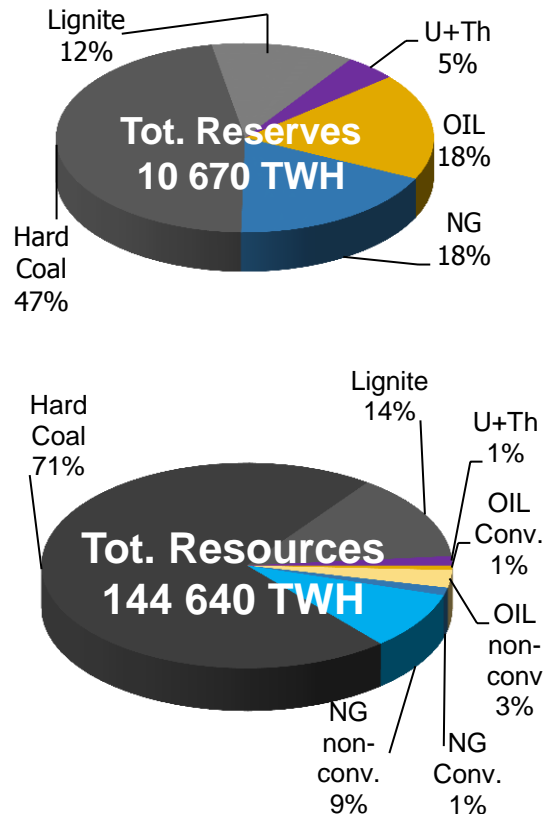
**HIGH ENERGY DEMAND = HIGH PRICES & HIGH POLLUTION**

# ... the "non-drop-in" jet-LNG option... (non-mixable with Jet-kerosene)

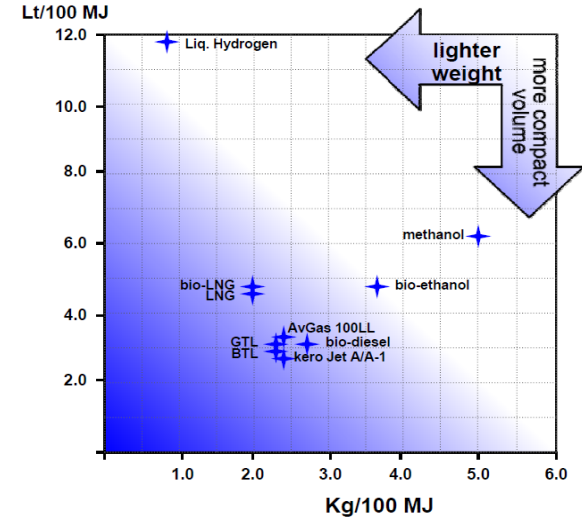
## ... CLEAN ...



## ... AVAILABLE ...



## ... EFFICIENT ...



✓ Gas 15% higher energy density than Oil (by weight)

## ... SAFE ...

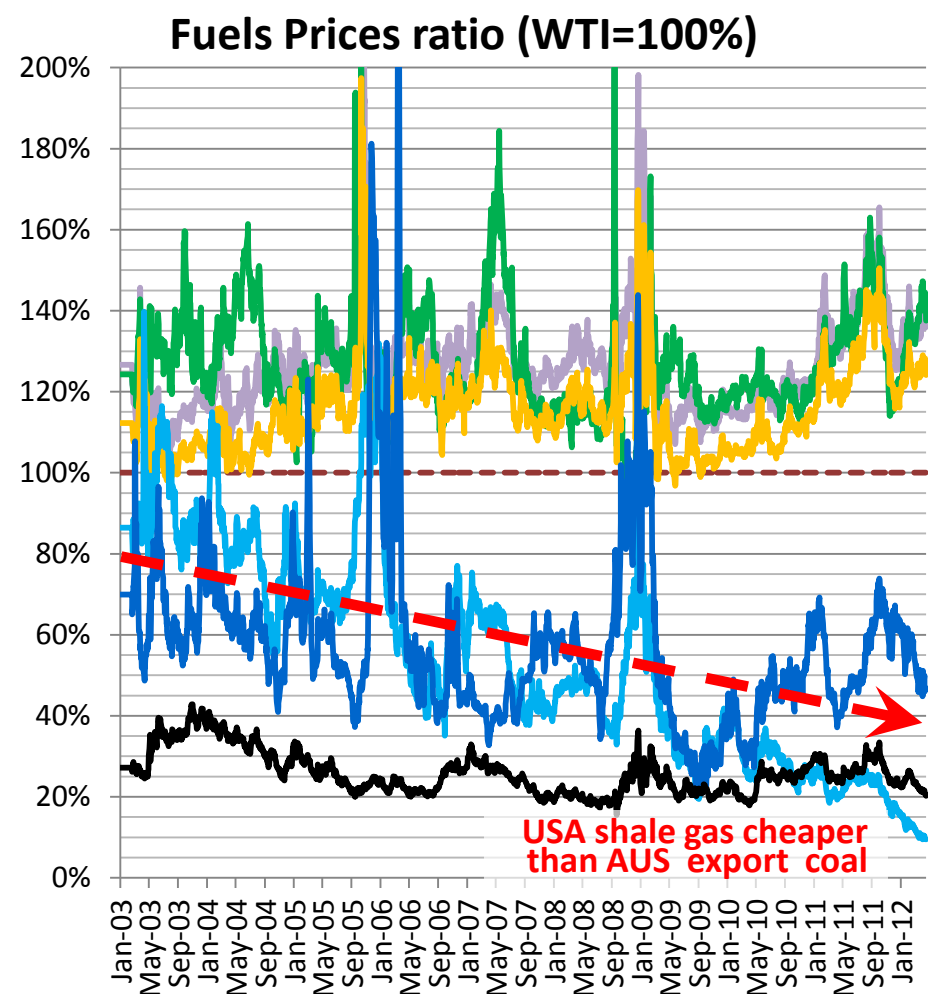
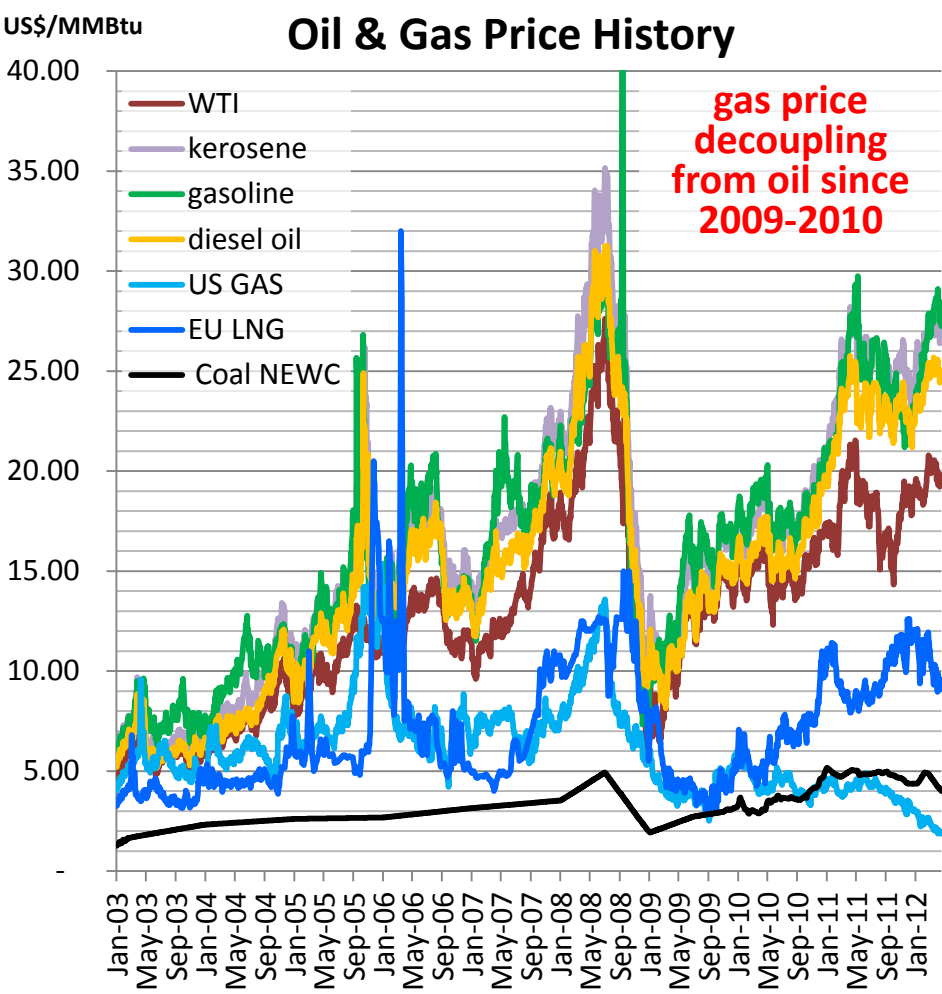
- ✓ Gas is not toxic
- ✓ Gas is less flammable
- ✓ Gas allowed in our homes

✓ Gas ≈ 50% less GHGs emissions than Oil

✓ Gas >3 times more abundant than Oil

... the “non-drop-in” jet-LNG option  
(non-mixable with Jet-kerosene)

... AND AFFORDABLE



... “drop-in” vs “non-drop-in” ...  
... “UP-STREAM” vs “DOWN-STREAM” ...

## SYN-KEROSENE

- Up-Stream Investments to implement synthetic kerosene technologies for “drop-in” fuels



- Up-Stream CAPEX is charged @ a premium for syn-kerosene compared to fossil-kerosene

## JET-LNG

- Down-Stream Investments to convert/adapt aviation industry to “non-drop-in” Jet-LNG



- Down-Stream CAPEX can be discounted from lower OPEX of jet-LNG compared to kerosene



... forecasting prices:

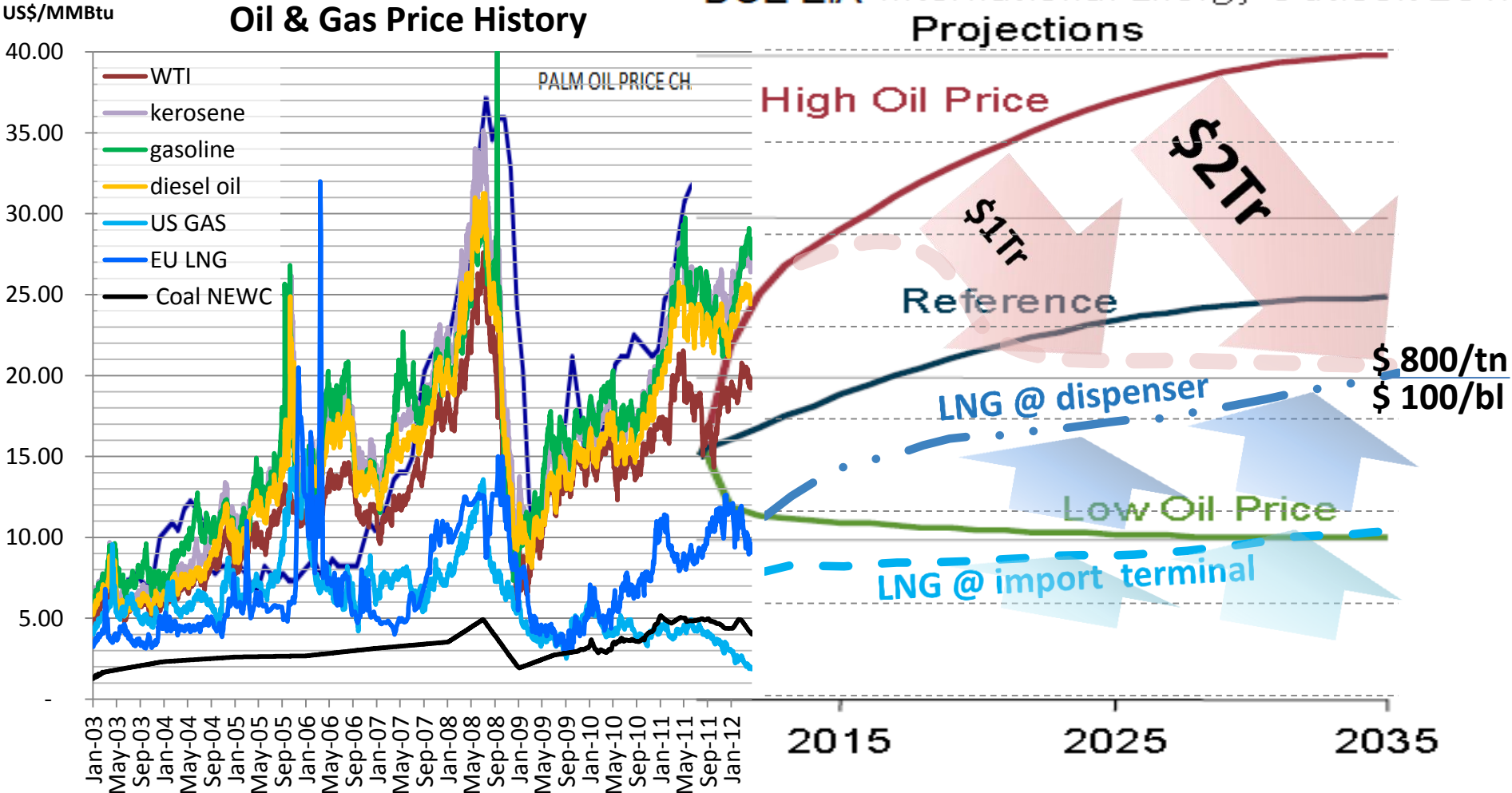
... gas @ 50% of oil ...

### World oil prices three cases, 2010-2035

DOE EIA International Energy Outlook 2011

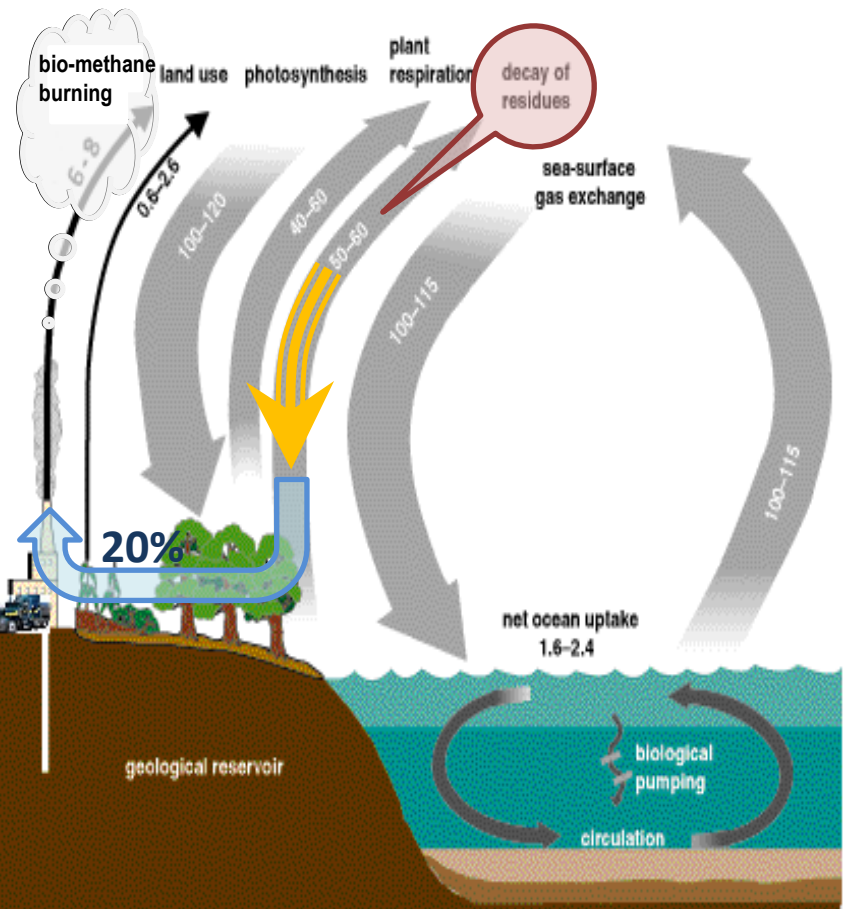
### Projections

### Oil & Gas Price History



**2010 FUEL DEMAND: All Transports 2.5 B.TOE – Aviation 250 M.TOE**

... forecasting availability: bio-gas inexhaustible reserves...  
and recoverable resources can fulfill world energy demand



IPCC Carbon Cycle – Gt<sub>carbon/year</sub>

**GLOBAL WORLD BIO-FUELS RESOURCES POTENTIALS FROM WASTE & RESIDUES**

**bio-gas/LNG : 20 G.TOE ≈ x2 world total energy use**

**B.T.L. : 4 G.TOE ≈ world liquid fuels**

**H.V.O. : 0.3 G.TOE ≈ world aviation fuels**

(recoverable quantities ≈ 20% depends on price)

**UN-CONTROLLED EMISSIONS OF METHANE (FROM ANTHROPOGENIC & NATURAL SOURCES)**  
**CH<sub>4</sub>/GHG effect = 21 times worse than CO<sub>2</sub>**  
**AVOIDED IF CONVERTED INTO ENERGY/CO<sub>2</sub>**

# AIRLNG Program on Jet-LNG for Aviation

a mixture of fossil-LNG with (initially) 20% bio-LNG



## A VISION FOR THE FUTURE

goals endorsed by aviation industry in joint industry submission to ICAO in September 2009:

- A cap on aviation CO2 emissions from 2020 (carbon-neutral growth)
- An average improvement in fuel efficiency of 1.5% per year from 2009 to 2020
- A reduction in CO2 emissions of 50% by 2050, relative to 2005 levels
- **Build a zero-emissions commercial aircraft within 50 years**



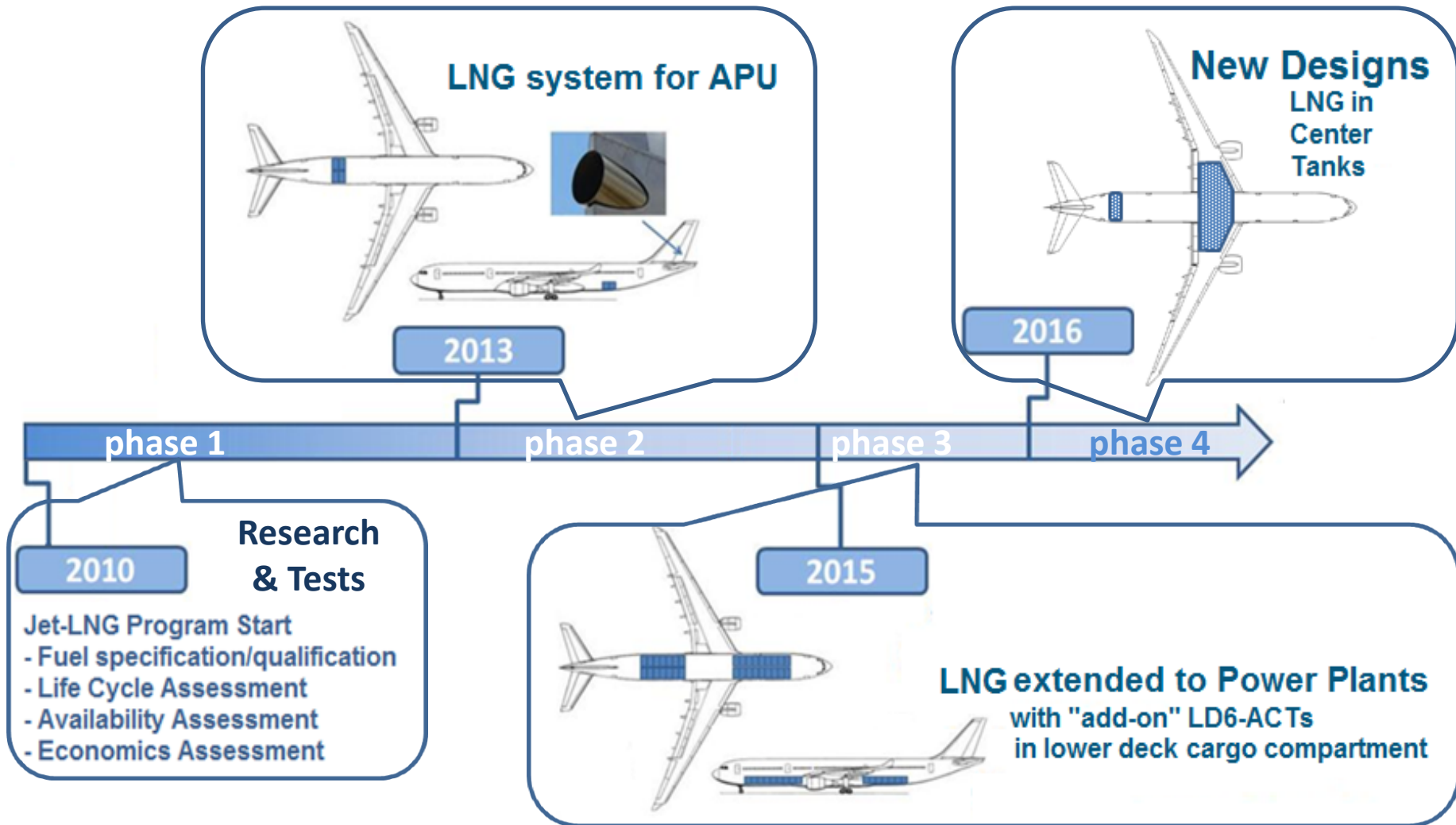
2010 - 2013 program sponsored by the German Ministry of Economics & Technology, under leadership of EADS/Airbus





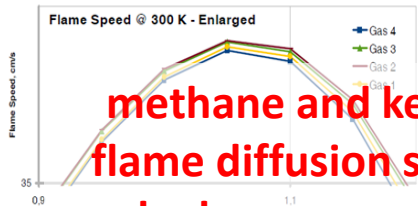
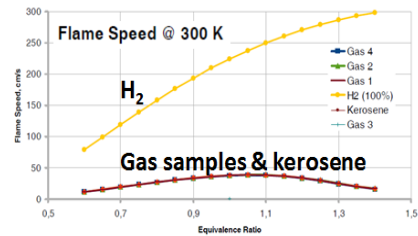
# AIR-LNG Program on Jet-LNG for Aviation

## SCHEDULE

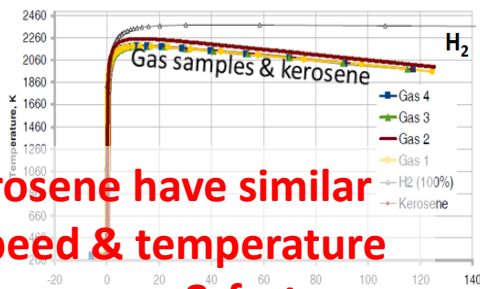


# AIR-LNG Program on Jet-LNG for Aviation TECHNOLOGY & SOLUTIONS

**Figure 21 - Flame diffusion tests at Cottbus University with 4 grades of LNG compared to hydrogen and kerosene**



AIR LNG Name	BioLNG / BioGas		Mischung / 70% Rich		Rich LNG / Qatar, Algerien		Lean LNG / Egypt, Alaska	
BTU Code	Gas 4		Gas 3		Gas 2		Gas 1	
Formula	Range	Real	Range	Real	Range	Real	Range	Real
CH <sub>4</sub>	>99.5%	100.00%	93.0-94.0%	93.00%	90.0-91.0%	90.00%	97.0-98.0%	97.50%
C <sub>2</sub> H <sub>6</sub>	-0.1%	0.00%	4.0-5.0%	4.00%	5.0-8.0%	6.00%	1.8-2.3%	2.00%
C <sub>3</sub> H <sub>8</sub>	-0.1%	0.00%	1.0-2.0%	1.50%	2.0-2.5%	2.00%	0.2-0.3%	0.30%
CH <sub>4</sub> O	0.00%	0.00%	0.5-1.0%	1.00%	0.5-1.5%	1.00%	0.1-0.2%	0.20%
CO <sub>2</sub>	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
CO	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
N <sub>2</sub>	0.0-0.1%	0.00%	0.4-0.5%	0.50%	0.2-1.0%	1.00%	0.0-0.1%	0.00%
H <sub>2</sub>	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%



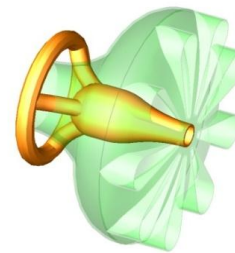
**methane and kerosene have similar flame diffusion speed & temperature  
hydrogen much warmer & faster**

**Multiple LNG tanks, fitting into LD6/ACT lower deck cargo space**



**allow up to 5,000 miles range with LNG**

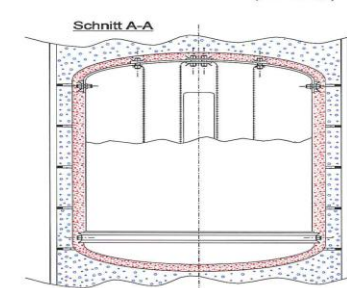
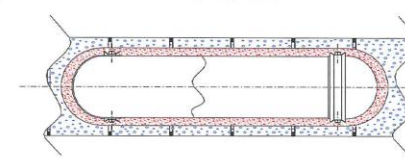
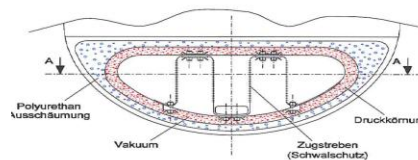
## Dual Fuel Nozzle



**cryogenic tank in LD6 container size**



**clean exhausts in airports**



**Concept for Innovative LNG central tank**

**Wing tanks stay on kerosene (weight balance)**

# Jet-LNG is the sustainable fuel for Aviation



- **COAL** was the driving force and fuel of the 19<sup>th</sup> century industrial revolutions
- **OIL** has been the leading fuel of the 20<sup>th</sup> century modern age mobility
- **GAS** is the key for sustainable growth of the 21<sup>st</sup> century global economy