

Expert Session 1 – Workshop1
Commercialisation Roadmap
Perspectives and Gaps for Hydrogen Storage

**C-H2 Session: Vessel manufacturing & mass
production scale-up**
O. Hamre, RAGASCO



**STORHY
FINAL EVENT**

**June 3-4, 2008
Poissy, France**

RAGASCO AS

The World Leader In Composite LPG Cylinders.



STORHY



Date: 29.05.2008

Author: Ragasco AS

Hexagon Composites - Structure



Devold AMT AS

Multiaxial Reinforcement

Wind Mill Blades

Ships and Aircrafts

Ragasco AS

Composite LPG Cylinders

Composite CNG Cylinders

Lincoln Composites (USA)

Raufoss Fuel System AS

Composite High Pressure Cylinders (CNG + CHG)



Ragasco History



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Missil Structures

CNG Fuel Systems for Automotiv

LPG Cylinders

1.000 units/year

10.000 units/year

100.000 units/year

1.000.000 units/year

1980

1990

Start 2000

2007-

Ragasco AS – Company Information



- **Ragasco AS:** 100% owned by Hexagon Composites ASA (OSE:HEX)
- **Hexagon Composites ASA:** Norwegian Registered Public Company
- **Hexagon Composites ASA:** Registered with ticker HEX at the OSE (Oslo Stock Exchange)
- **Hexagon Composites ASA:** Market Capitalization: 70 Mill. Euro

• <u>Ragasco AS:</u>	Total Sales 2007:	250 MNOK	30 Mill Euro
	Result (EBIT) 2007:	25 MNOK	3 Mill Euro
	Employees:	LPG = 80	CNG = 10
	Plant Capacity:	1,0 Mill LPG Cyl.	0,1 Mill. CNG Cyl.

6-Shift Continuous Operation (24 h/day * 7 days/week * 51 weeks/year).

Export = 85-90%

PRODUCT DESCRIPTION



LINER

- Function: Gas Tight + Cold Impact Resistance
- Blow-Molded HDPE (Fuel Tank Quality)
- One Piece Permeability Layer
- Chemical Resistant
- Metal/Plastic Interface For Mounting The Valve

COMPOSITE

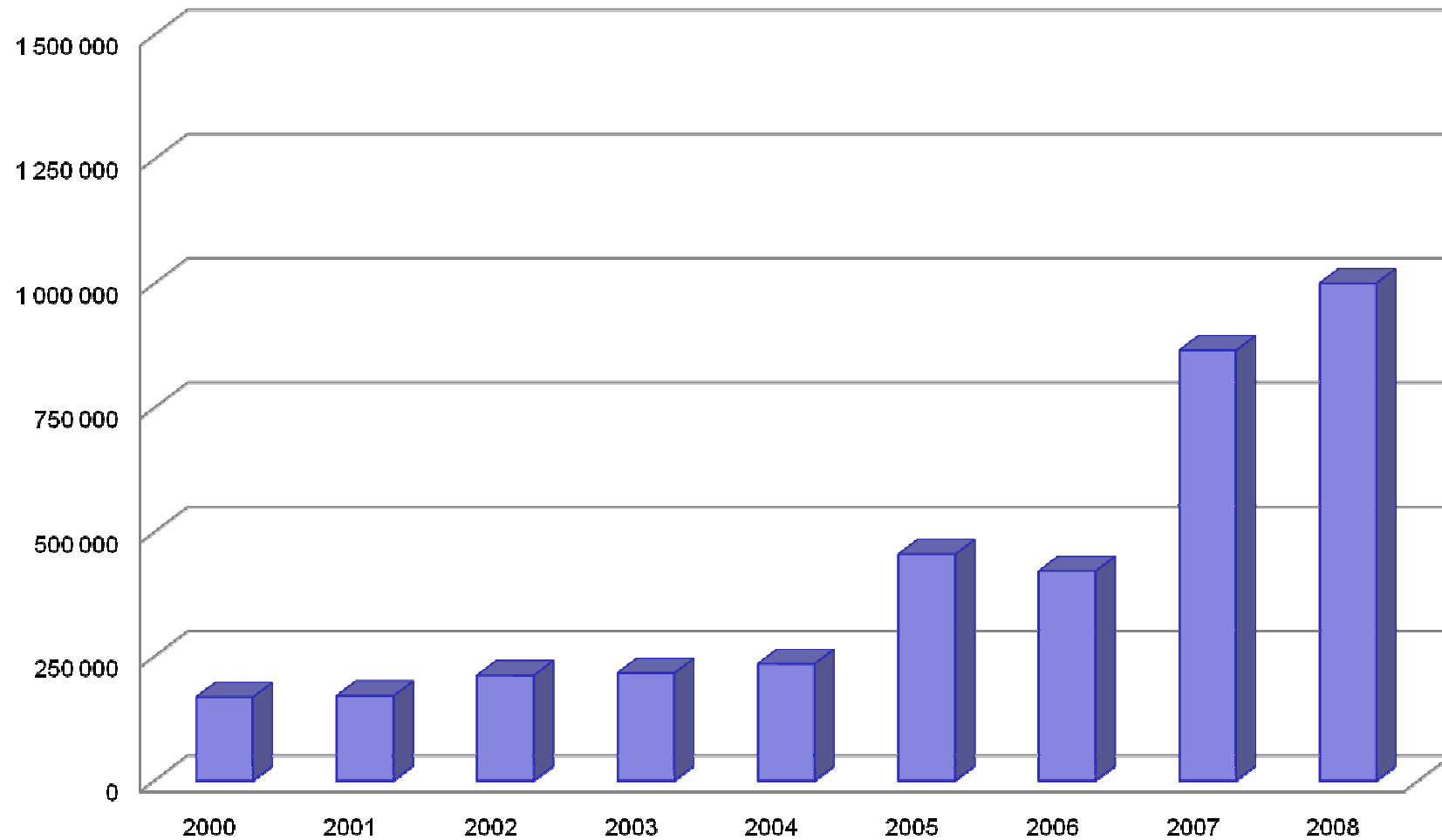
- Chemical Resistant E-Glass Fiber
- Fully Continuous Filament-Wound Structural Layer
- Translucent Wall – Gas Content Visible

OUTER CASING

- Attractive Design, Company Profile/Logo Possible
- Gas Level Visible
- Stackable
- Comfortable Handling
- Impact Protection Properties
- Parts are Snap Fitted Together



Ragasco Capacity Development



Ragasco - Automated Manufacturing



- All manufacturing steps are automated.
- Filament winding operation fully automated.
- All handling/Inspection steps are robotized.
- Significant use of Vision technology.
- Significant use of data acquisition and tracability.
- Significant use of built in logic for QA Control.
- Real time reporting of OEE reality.
- Constant focus on improving OEE.
- Constant focus on TPM work and training.
- Constant training of human skills and attitude.

Cost Reducing Issues for CGH₂ Cylinders



- **Cost of Carbon Fibre.**
- **Cylinders design with Impact, Fatigue and Creep Properties according to safety margin. (No margin on the margin)**
- **High degree of material strength utilization and reproducibility. (Robust Process)**
- **Improve material deposit rate in Filament Winding Process.**
- **T4 cylinder concept with low cost liner technology solving permeation requirements. (Monolayer / Coextrusion)**
- **Minimize cylinder opening size. (Less costly boss part)**
- **Utilization of dedicated mass production principles:**
- **Example:**
 - 30 L cylinder, WP = 700 Bar, Safety Margin = 2,35.
 - +200.000 Cylinders/Year.
 - Manufacturing Cost within range of 20% of total Cylinder Cost.