



7th Critical Issues Workshop

CNG Cylinders & LNG Tanks: *Opportunities, Challenges & Innovations*

13-14 April 2014

Le Chatelain Hotel

Brussels

This is the 7th Clean Fuels Consulting Critical Issues Workshops

- **2008: CNG & H2 Cylinders:** *Opportunities, Challenges & Strategies*
- **2009: LNG is HOT:** *Opportunities, Challenges & Strategies as a Vehicle Fuel*
- **2010: Dual-Fuel:** *Opportunities, Challenges & Strategies to Expand the Market*
- **2011: Chickens & Eggs:** *Opportunities, Challenges & Strategies Building the Infrastructure for Natural Gas Vehicles*
- **2013: Poli-techs standards and regulations:** *Creating a Standards & Regulatory Roadmap for Gaseous Fuel Vehicles*
- **2014: CNG & LNG Safety:** *Perception & Reality*
- **2016: CNG Cylinders & LNG Tanks:** *Opportunities, Challenges & Innovations*

Thanks to the Participants

- Challenges in Brussels with terrorist attacks & subsequent transportation problems
 - A few participants dropped out
 - Some presenters have changed & a few presentations will be done remotely but the information is the same; *as intended!*
- Crowded conference and workshop calendar – NGVs and LNG increasingly popular
- But... our knowledgeable and experienced speakers & participants will make for an engaging workshop opportunity

Thank You Sponsors

Principal Sponsor



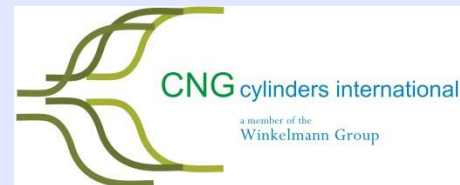
Event Sponsor



Supporting Sponsors

Westport™

xperion
ENERGY & ENVIRONMENT



Media Partners

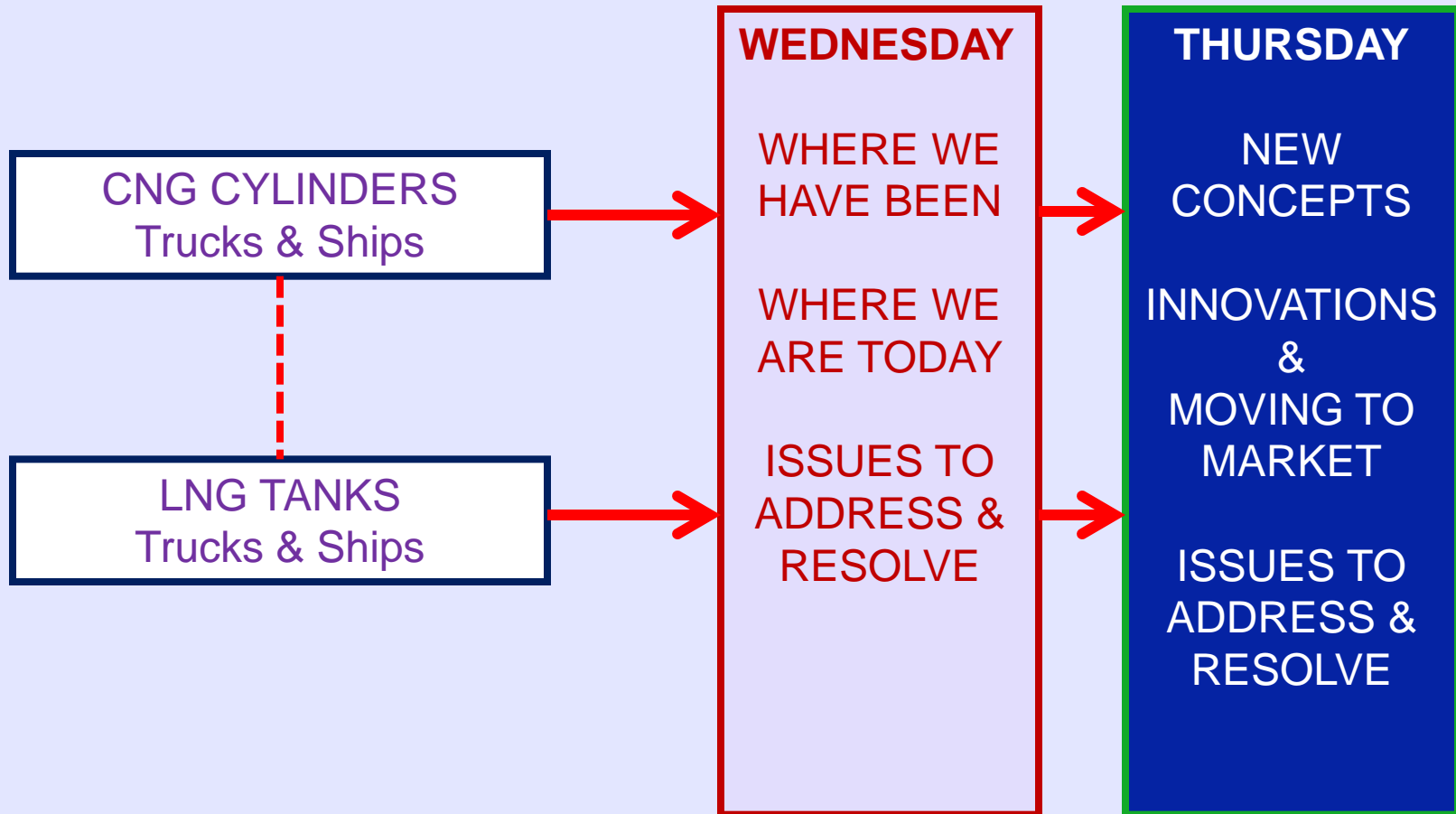
the
GVR

FLEETS & FUELS

time for gas!
International LPG & CNG & LNG magazine

gazeo.com
global LPG & CNG portal

Structure of the Workshop



Motivations for this Workshop

- **Critical Issues are facing the industry that need to be addressed.**
 - Harmonization of standards and regulations is needed
 - New standards/regulations needed in the marine market, in particular
 - Concerns about over-pressurization
 - Concerns about relief devices and related system hardware
 - Continued issues about safety from cradle to grave for CNG & LNG

Motivations for this Workshop

- **Innovations coming into the market for CNG and LNG**
 - The U.S. & Europe are funding new gas storage technologies, but...
 - Standards and regulations likely must be adapted and amended



MOVE Program Portfolio (U.S. DOE)

Methane Opportunities for Vehicular Energy

Investment: \$30M – 13 projects

Program Goal

Payback less than 5 years for light duty NGVs with conformable tanks and at-home refueling

Compressors

- Liquid piston
- Multi-stage linear piston
- Cryocooled-sorbent
- Dual engine-compressor



Sorbents

- Metal organic frameworks
- Nanovalved
- Containerless tank



Tanks

- Superplastic forming
- 3-D squeeze cast
- Cellular module
- Intestine storage



TEN-T NETWORKS (plan to 2020/25/30)

Directive 2014/04

Deployment of the
*Alternative Fuels
Infrastructure*

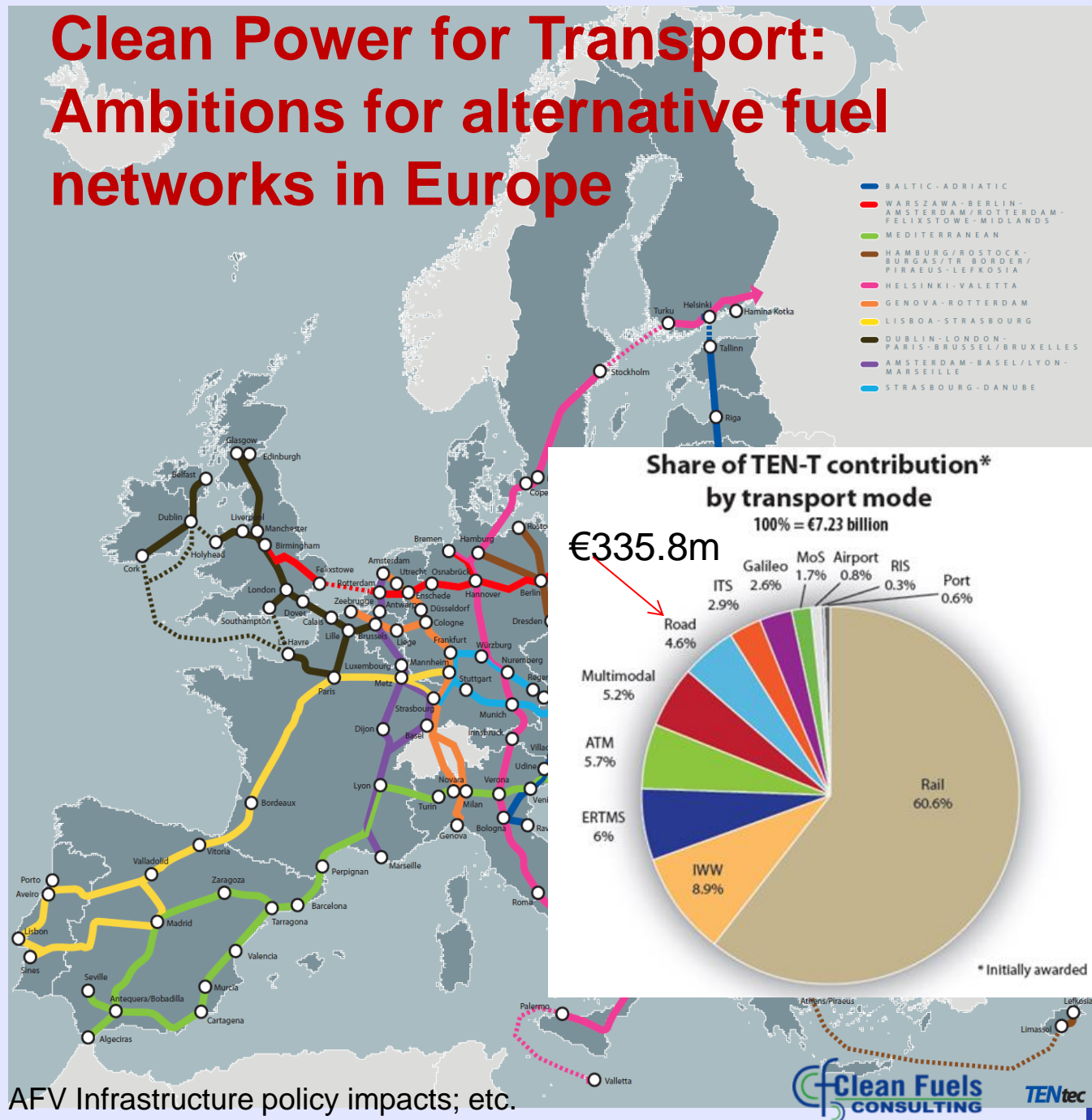
originally specified
development of CNG
& LNG stations for
road and ports; also
EV charging points.

The specific targets
were removed in the
final version.

Still the mandate
exists to 2020, 2025
and 2030 to install
'appropriate (or
sufficient) numbers' of
fuelling stations.

Sources: EU documents Ten-T; AFV Infrastructure policy impacts; etc.

Clean Power for Transport: Ambitions for alternative fuel networks in Europe



Innovation & Networks Executive Agency (INEA) replaced TEN-T EA as of 1 Jan 2014

- Created to manage the technical and financial implementation of the TEN-T program
- Budget 2014-2020 = € 34,1 billion (4 times the TEN-T budget)
- Expansion from 100 staff in TEN-T EA to about 300 staff in INEA managing around more than 2000 projects by 2020

Connecting Europe Facility (CEF) & Horizon 2020 can fund alternative fuel & NGV/LNG projects



CEF Transport



Projects involving LNG bunkering

Challenges Smart green and integrated transport

Secure, clean and efficient energy

Mobility for Growth

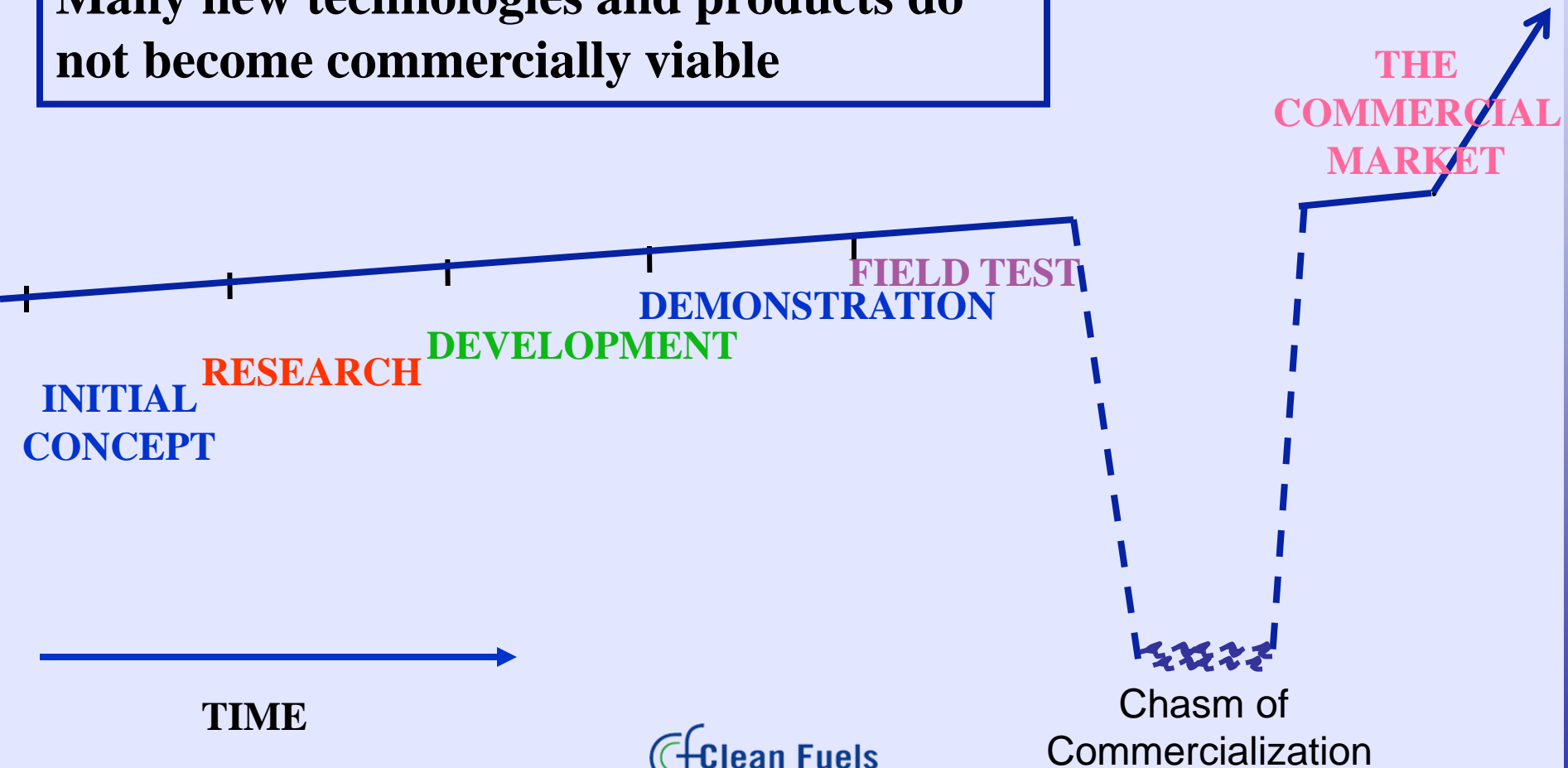
Green Vehicles

Smart Cities & communities

Competitive low carbon Energy

NGV innovative technologies should avoid falling into the Chasm of Commercialisation

Many new technologies and products do not become commercially viable



Growth in the demand for CNG Type 1 (all-metal) vessels will dominate, however, there will be increasing demand for vessels that incorporate composites (CNG Types II, III, IV and V)

Source | Composites Forecasts & Consulting

| Change in Pressure Vessel Demand by Vessel Type | | | | | | | | | |
|---|------|------|------|------|------|------|------|------|------|
| CNG Vessel Type | 2007 | 2009 | 2011 | 2013 | 2015 | 2017 | 2019 | 2021 | 2023 |
| Type I | 89% | 88% | 84% | 82% | 72% | 67% | 65% | 56% | 54% |
| Type II | 9% | 11% | 14% | 16% | 25% | 26% | 24% | 30% | 31% |
| Type III | 2% | 1% | 1% | 1% | 2% | 5% | 5% | 7% | 8% |
| Type IV | 1% | 1% | 1% | <1% | 1% | 2% | 5% | 7% | 7% |
| Type V | - | - | - | - | <1% | <1% | <1% | <1% | <1% |

| Estimated Pressure Vessel Unit Production | | | | | | | | | |
|---|-------|-------|-------|-------|--------|--------|---------|---------|---------|
| Market Segment | 2007 | 2009 | 2011 | 2013 | 2015 | 2017 | 2019 | 2021 | 2023 |
| CNG Vehicles | 4.03M | 5.06M | 6,79M | 9.73M | 12.41M | 9.43M | 15.87M | 14.94M | 20.14M |
| H ₂ Vehicles | 1,000 | 5,000 | 4,000 | 5,500 | 32,000 | 73,200 | 125,000 | 219,800 | 412,000 |
| Gas Transport | 0 | 0 | 40 | 400 | 1,200 | 2,000 | 2,650 | 3,500 | 4,600 |

. Source: Composites Forecasts & Consulting

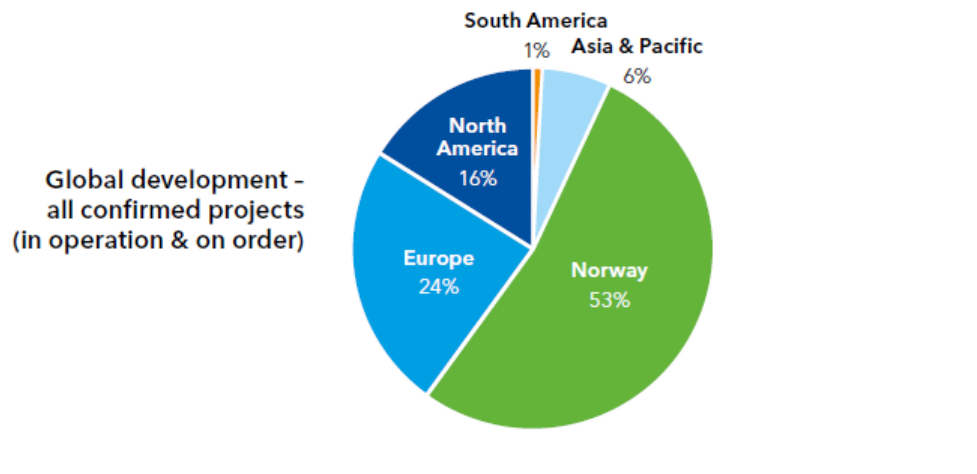
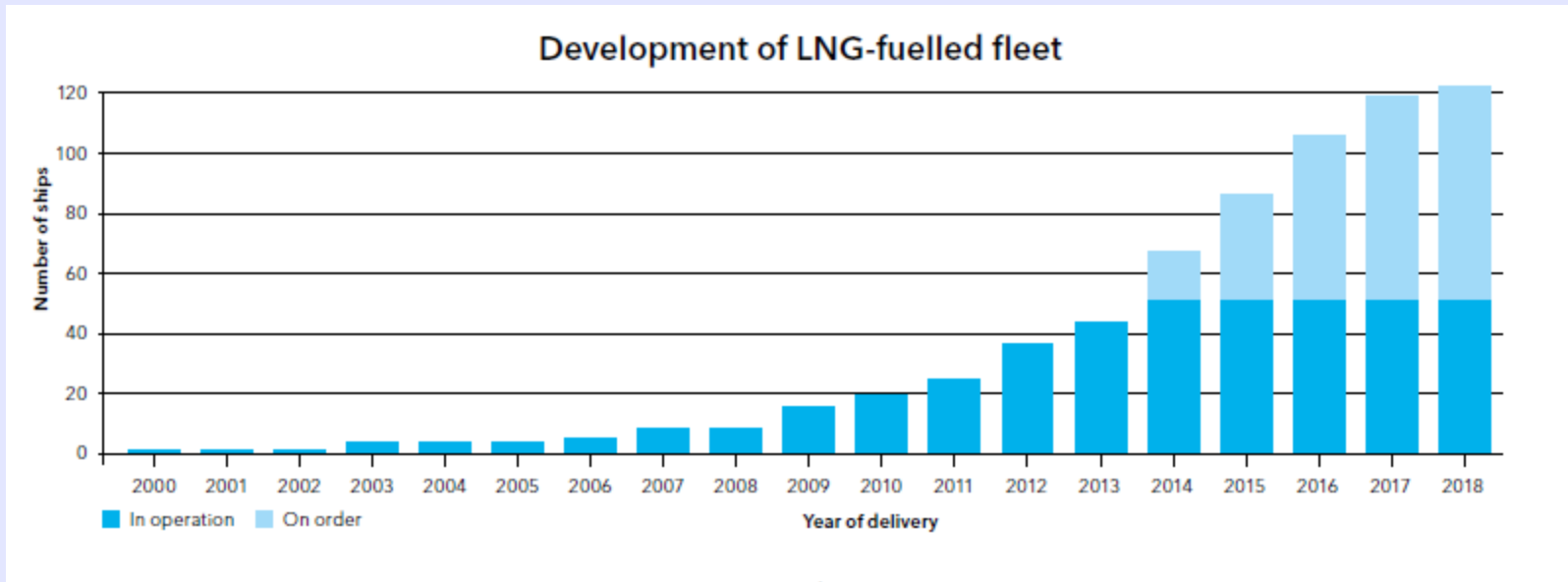
Demand for LNG trucks also will expand

- **China: Very strong growth**
 - 2008: 15 LNG stations
 - 2010: 6,800 LNG trucks
 - 2011: 211 LNG stations & 17,500 LNG trucks
 - 2012: 51,000 LNG trucks
 - 2013: 1800 LNG stations
 - 2014: 60,000 LNG trucks & 40,000 LNG buses
- **United States** 2013: 209 LNG stations & 6,000 LNG HDVs (est. 75% trucks; 25% buses)
- **Europe** 2014: approximately 50 LNG stations and 1,500 LNG trucks

x 2



The market for LNG shipping will grow steadily





7th Critical Issues Workshop

CNG Cylinders & LNG Tanks: *Opportunities, Challenges & Innovations*

13-14 April 2014

Le Chatelain Hotel

Brussels