LNG bunkering demand and bunkering infrastructure
DNV fully understand your concerns and have the right capabilities to be your partner …

- Which bunkering operations fit your needs?
- What kind of small-scaled LNG distribution fits your needs?
- What are the hazards during bunkering operations?
- How to overcome the price gap between LNG & other fuel type?
- What will be the price of LNG in the future?
- What kind of incentives available for the players?
- Will regulations & standards be ready in time?
- How to convince public that LNG is safe?
- How much investment to be made to retrofit?
- What are hazard & risks during ship design & development?
- Is bunkering facility available outside ECA zones?
- How to identify the right locations for bunkering?

- Will demand be big enough in the future?
- Will funding be available?

• LNG bunker station-to-ship
• Ship-to-ship LNG bunker
• Small LNG carrier at large scaled LNG terminal
• What type of intermediate solutions needed?

LNG bunkering station-to-ship

• LNG supplier
• Port authority
• Ship owner
• Financial institution
• Engine manufacturer

- How to solve situation of supplying LNG from large scaled LNG terminals?
- How to ensure reliability of infrastructure, equipment?

- What is the best strategic investment – newbuild or retrofit?

LNG price gap globally

- 2-6 USD/mmbtu
- 10-11 USD/mmbtu
- 15-17 USD/mmbtu

Bit Biking retrofit
DNV’s motivation conducting the study

- **Further strengthen** DNV leading position in LNG as fuel for shipping
- **Response** to the prediction of 1000 LNG-fuelled vessels by 2020 on meeting the future LNG as fuel for shipping
- **By assessing global LNG bunkering infrastructure to meet the LNG bunker demand by 2020**
- **By estimating LNG bunker demand** to accommodate the 1000 LNG-fuelled vessels by 2020
- **Guide** our customers in subsequent strategic decisions related to what the future for LNG as fuel for shipping
The study shows that 4-7 million tons of LNG p.a is required by 2020 corresponds to 0.2-0.3% of global LNG production 2010

**Demand**

2020

- 1000 LNG fuelled ships

2012

- 28 ships in operation & 29 ships on order

**Supply**

- 4-7 Million tons p.a of LNG as fuel for shipping

- Limited volume of LNG as fuel for shipping
Approx. 1000 vessels will be fuelled by LNG and sailing within regions, primarily in the ECA zones

- Combined with stricter emissions control regulations, Europe and North America will experience a growth in LNG fuelled offshore ships

- Asia will play an important role, after 2020, driven by stricter regulations nations such as Singapore and Hong Kong

- Under high economic development and high environmental awareness scenario, the number of ships has been estimated to be around 1000 by 2020

- Offshore vessels and ferries dominate the LNG fuelled fleet and order book today, but there are on-going projects to develop concepts and designs for most ship types
LNG bunker demand is expected to experience a significant increase in volume due to stricter emission requirements.

By 2020, there will be more regions with increasing stricter emission controls come into the picture.

Demand of LNG bunker will increase in regions with high shipping traffic such as South East Asia and China.
Global LNG bunker demand by 2020

- **Europe & the Baltic Sea**: 1.4 – 2.2 million
- **China**: 0.3 – 0.8 million
- **Japan & Korea**: 0.3 – 0.5 million
- **Middle East & India**: 0.3 – 0.7 million
- **SEA**: 0.4 – 0.7 million
- **Australia & NZ**: 0.1 – 0.2 million
- **North America**: 0.9 – 1.4 million
- **South America**: 0.3 – 0.4 million
Current and forecast of global LNG bunkering infrastructure by 2020
LNG Bunkering grid in Europe by 2020

Existing
1. Florø
2. CCB
3. Halhjem
4. Snurrevarden
5. Risavika

Proposed
22. Gothenborg
23. Pori
24. Turku
25. Sillamäe
26. Helsinki
27. Paldiski
28. Riga
29. Swinoujscie
30. Lubeck
31. Rostock
32. Helsingborg
33. Copenhagen
34. Aarhus
35. Aberdeen
36. Dunkerque
37. Marseilles
38. Barcelona
39. Algeciras

Planned
6. Bodo
7. Mongstad
8. Øra
9. Lysekil
10. Porvoo
11. Stockholm
12. Tallin
13. Klaipėda
14. Hirtshals
15. Brunsbüttel
16. Hamburg
17. Rotterdam
18. Antwerp
19. Zeebrugge
20. Ghent
21. Vestbase

Existing  Planned (Feasibility study, risk study, proposed locations, pending approval)  Proposed (currently being discussed)
... because we offer comprehensive Advisory services, from strategy to operational level

<table>
<thead>
<tr>
<th>Strategic advice</th>
<th>Market &amp; Feasibility study</th>
<th>Planning &amp; Design</th>
<th>Operation &amp; Risk study</th>
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Service:
Strategic advice / Feasibility studies

Assess the feasibility of LNG bunkering, from a

- Safety,
- Environment,
- Regulatory,
- Logistics,
- Technical,
- Operational
- Financial,
- Business,
perspective.

**Case: Belgian (Flemish) LNG study**

<table>
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<th>Project scope</th>
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<td>• Market study: forecast LNG bunkering demand for 3 Belgian ports based on shipping forecasts &amp; world energy market forecast</td>
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<tr>
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<td>• Risk analysis</td>
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# Feasibility study for the supply of LNG as shipping fuel in Belgian ports

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<th>LNG bunkering / strategic feasibility study</th>
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### Project Challenge/Scope

- Market study: forecast LNG bunkering demand for 3 Belgian ports based on shipping forecasts & world energy market forecast
- Logistics model: model & compare different supply chain options to provide LNG as bunker fuel
- Legal & Regulatory: provide a comprehensive overview & gap analysis of current regulatory framework
- Risk analysis (not executed by DNV)

### DNV's approach

- Brought together and built on multi-disciplinary in-house expertise wrt LNG bunkering / LNG as shipping fuel
- Overview & review of relevant national & international standards & industry Best Practices

### Value to the client

- An integrated report addressing all aspects of providing LNG as bunker fuel
- A list of concrete recommendations to close the gaps in the regulatory framework
- An excel model allowing the ports to simulate, compare and calculate costs of future LNG supply chains
Frame agreement with the port of Brunsbüttel

Service Area  
LNG bunkering / operational study

Project Challenge/ Scope

- **Scope:** to develop bunkering procedures for truck-to-ship LNG bunkering in the port of Brunsbüttel
- **Challenge:** First port in Germany to move forward, no existing framework for bunkering procedures available, (international) standards still under development, existing legal frame explicitly prohibiting bunkering of fuels with a flashpoint < 55°C

DNV’s approach

- DNV’s unique position in the maritime LNG business allows to deliver building on internal expertise & industry Best Practices
- Bunkering procedures developed based on DNV’s vast general risk assessment and risk management experience, including over 30 years’ experience of carrying out risk assessments of onshore and offshore installations for operators, engineering contractors and statutory authorities worldwide. DNV’s involvement in ISOTC67WG10 ensuring that developments in the field are fed into standard development and vice versa.

Value to the client
Consultancy services for Gasnor Brunsbüttel LNG Terminal

Service Area
LNG bunkering / risk & facility siting study, support throughout permitting process & all project phases

Project Challenge/Scope

- Safety screening of possible locations for the terminal
- Safety analysis for the chosen location for the terminal
- Safety analysis for the seaside operation including bunker operation
- Preparing of the application for the authorities (LLUR)
- Contact with the "Sachverständigen" regarding application process

DNV's approach

- DNV has a great deal of experience in LNG-specific safety and environmental studies conducted in support of feasibility studies, planning applications, public hearing and the design process.
- DNV has extensive relevant experience in onshore and offshore QRA for LNG terminals & storage facilities

Value to the client

- A trusted and experienced partner throughout the whole process
- Concrete guidance & recommendations
- Quick response when needed
Environmental Impact Assessment for Eckelmann’s power barge

**Service Area**
LNG fuelled power barge / Environmental study

**Project Challenge/Scope**

- Evaluation of typical cruise vessel at berth (ship self-reliant for power)
- Evaluation of LNG fuelled power barge (barge provides cleaner energy for ship)
- Comparison of environmental impact of both options
- Identification of the project showstoppers

**DNV’s approach**

- DNV has a great deal of experience in characteristics of LNG fueled engines of the different makers
- DNV has a clear picture of the emission profile – SOx, NOx, CO2 – of the different engine technologies
- DNV has extensive relevant experience in LNG powered vessels

**Value to the client**

- A trusted and experienced partner throughout the whole process (step approach)
- Conclusive results of the environmental impact of both options
- Elimination of environmental impact as showstopper
- Identification of potential showstoppers with reference to business viability, regulations, operations, …
Assistance on implementation of Seveso regulation of Gate LNG terminal

**Service Area**

LNG terminal / Assistance for legal compliance

**Project Challenge/Scope**

- Ensure legal compliance of new built terminal
- Safety report of LNG terminal including QRA
- Develop safety management system
- Develop emergency response system
- Identify security risks

**DNV’s approach**

- DNV’s unique position in the maritime LNG business allows to deliver building on internal expertise & industry Best Practices
- DNV has extensive relevant experience in safety studies and QRAs for onshore and offshore LNG facilities
- Integrated systems for safety management

**Value to the client**

- A trusted and experienced partner throughout the whole process
- Recommendations to improve the safety of the terminal
- Regulatory compliance
Harbour toolkit for the Port of Rotterdam

Service Area: Port authorities / Toolkit

Project Challenge/Scope:
- Port of Rotterdam is preparing for the arrival of LNG as fuel
- Determine safety distances for activities related to LNG bunkering
- Provide risk based insight in the magnitude of the hazards related to LNG bunkering

Value to the client:
- Analysis based on the local legislation
- Practical toolkit for (first) screening of bunkering locations
Feasibility study for mobile LNG fuel tanks

**Service Area**
LNG bunkering / feasibility study

**Project Challenge/Scope**
- Evaluation of the risk for safety and environment related to mobile LNG fuel tanks
- Identify the feasibility for safety and environment
- Screening of show stoppers based on legal requirements

**DNV’s approach**
- DNV has specific knowledge of the local legislation and situation
- DNV has extensive relevant experience in LNG fuelled ships & class requirements
QRA for LNG terminal of Vopak

Service Area: LNG terminal / Quantitative risk study

- Identify the external risk of planned LNG terminal
- Evaluate the acceptability of the risk towards the environment
- Sensitivity analysis of the LNG terminal installation towards the external risk

Project Challenge/Scope:

- DNV has specific knowledge of the local legislation and situation
- DNV has extensive relevant experience in onshore and offshore QRA for LNG facilities

DNV’s approach:

- Identification of criticality of installations for external risk
- Identification of the focus points to increase the safety of the terminal

Value to the client:
FASE DI RIFORNIMENTO SU NAVI CON PROPULSIONI LNG

UNITA' NAVALE CON PROPULSIONE AD LNG

DEPOSITO COSTIERO LNG GALLEGGIANTE CON SERBATOI CRIOGENICI

AUTOCISTerna LNG CON SERBATOIO CRIOGENICO PER LA DISTRIBUZIONE STAZIONI DI RIFORNIMENTO

EP/83/REV.C/ LNG Mediterraneo/ 18 Luglio 2012
Safeguarding life, property and the environment

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