Engine Technology for tomorrow's fuel
WinGD HQ in Switzerland (Winterthur) is the centre of excellence and a leading developer for low-speed 2-stroke marine diesel engines.

The company’s target is to set industry standards and to continue the long tradition of the Sulzer Diesel business which started in 1898.

Currently there are more than 350 people from 39 nations working in Winterthur and worldwide located subsidiaries.
Development of world LNG / gas price

Gas production per region

Source: BP Statistical Review of World Energy 06/2015

IMF: Natural Gas, $/m³

Source: IMF Commodity Price Forecasts, July 2015

Tomorrow’s merchant fuel will be GAS
Development path of gas fueled marine engines

1972
2-stroke low pressure
Dual-Fuel engine

1972
29 km³ LNGC ‘MV Venator’ 7RNMD90 Moss S/Y NOR

1980
2-stroke high pressure
Dual Fuel engine

1986
6RTA84 at IHI, Japan

1990
2-stroke low pressure
spark ignited engine

1992
4-stroke low pressure
Gas diesel engine

1995
Break through
4-stroke low pressure DF engine

2013
2-stroke low pressure
Dual-Fuel engine
Low pressure 2-stroke dual-fuel concept
Key technologies of low pressure concept

- **Micro-pilot system**
  - low pilot-fuel consumption < 1%
  - low NOX! common-rail

- **Pre-chamber technology**
  - low NOX and methane slip
  - good combustion stability!

- **Gas admission system**
  - safe and reliable gas admission
  - Simple sealing technology with low-pressure!

- **Engine Control & Automation system**
  - integrated engine control and safety!
Smoothest operation on gas or diesel

- Transfer to gas
  - Speed controlled transfer from Diesel to Gas on engine power up to 85%.
  - Fully automatic transfer, just by pressing the push button “gas mode” on the bridge
- Engine speed/load remains stable during transfer

- Trip to diesel
  - The switch from gas to diesel is instant ‘within 1 revolution’
  - At any load up to 100% to maximize safety
Emissions: Tier 3 w/o after treatment

Low-pressure concept vs. high pressure concept

Low pressure (Otto cycle) offers:

- Lowest possible NOx
- Almost zero SOx and particles
- 25% reduced CO₂

Tier III compliant without exhaust gas after treatment
Operation verification through test engines

- Engine converted to full scale in summer 2013:
  - Engine performance development
  - Control system development
  - Component reliability tests
  - >1000 running hours logged

- Engine testing continuing:
  - Future performance updates
  - Functionality enhancements

- Excellent cooperation with IHI/DU in design of the test engine

- 100% power reached with MN 65-67

- Gas storage and supply system projected by DU/IHI

- Engine started in January 2015 and demonstrated to customers in April
**Low pressure DF engines**

The industry standard

<table>
<thead>
<tr>
<th>Vessel type</th>
<th>Firm orders</th>
<th>Licensee</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>50DF</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14k DWT LNG Carrier</td>
<td>13 engines</td>
<td>YCMP</td>
</tr>
<tr>
<td>15k DWT Chemical Carrier</td>
<td></td>
<td>DU</td>
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<tr>
<td>1400 TEU container vessel</td>
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<td></td>
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<tr>
<td>15k DWT Asphalt tanker</td>
<td>110'880 kW</td>
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<tr>
<td><strong>X62DF</strong></td>
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<tr>
<td>175k DWT LNG carrier</td>
<td>10 engines</td>
<td>Doosan</td>
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<tr>
<td>143’100 kW</td>
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<td><strong>X72DF</strong></td>
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<tr>
<td>174k DWT LNG carrier</td>
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<td>HHI-EMD</td>
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<tr>
<td>161’250 kW</td>
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<td>Doosan</td>
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</table>

- **Power Plants**
  - DF Power plants
  - LNGC Multigas Carrier Conversion Ro-Ro
- **Merchant**
- **Offshore**
- **Cruise & Ferry**
  - LNG cruise ferry
  - LNG ferries
- **Navy**
- **Others**
  - Coastal patrol
  - Tug Guide ship
  - IWW Icebreaker

- as of August 2015

1300 low pressure dual fuel 4-stroke engines on order or operation
33 low pressure dual fuel 2-stroke engines on order

**More than 12 million cumulated running hours**
World-wide Wärtsilä 2-stroke Service

Hub North Europe
Hub Centre in Hamburg, workshop in Hamburg, training in Hamburg, Reman Centre in Kruiningen, In-Situ Gothenborg

Hub China
Hub Centre in Shanghai, workshop in Shanghai and Hong Kong

Hub East Asia
Hub Centre in Korea, workshop and training in Busan,

Hub South East Asia
Hub Centre in Singapore, workshop in Singapore, Technical competencies in Australia

Hub AMER
Hub Centre in Ft. Lauderdale, competences in several locations

Global Management in Switzerland
Hub SEAF
Hub centre in Winterthur, commercial and technical competences in several locations

Hub Middle East
Hub Centre in Dubai, workshop in Dubai, competences in several locations
Low Pressure dual Fuel: the industry standard

Low-pressure DF is the technology of choice and the industry standard!

- Operational experience from over 1000 4-s DF engines incorporated into 2-s DF engine design
- First 2-stroke engines passed successfully shop trials and will go into operation soonest
- The only technology being environmentally friendly during 100% of the trip, not only in ECA zone
### Wärtsilä Flow & Gas, Core Competences

<table>
<thead>
<tr>
<th>LPG marine</th>
<th>LNG &amp; Midstream</th>
<th>Gas Recovery</th>
<th>Separation Technology</th>
<th>Aftermarket</th>
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<tbody>
<tr>
<td>LPG cargo handling system</td>
<td>BOG reliquefaction plants</td>
<td>VOC recovery systems</td>
<td>Separator Design</td>
<td>Commissioning</td>
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<tr>
<td>Cargo heaters &amp; vaporizers</td>
<td>LNG regasification plants</td>
<td>Zero Flare solutions</td>
<td>VIEC /VIEC-LW Internals</td>
<td>Start–up support</td>
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<tr>
<td>Reliquefaction &amp; coling plants</td>
<td>Small scale LNG plants</td>
<td>HC Blanket Gas and Recovery</td>
<td>Interface level and Profilers</td>
<td>Project life time support</td>
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<tr>
<td>Ship- and Cargo Tank design</td>
<td>LNG Fuel gas systems</td>
<td>Flare Gas Recovery and ignition</td>
<td>Compact Separation</td>
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The LNGPac™ Classification acceptance

LNGPac compliance to:
Ultimate International Regulation (IGF Code etc.)

LNGPac approved by classification societies:

<table>
<thead>
<tr>
<th>Det Norske Veritas</th>
<th>Germanischer Lloyd</th>
<th>Lloyd’s Register</th>
<th>American Bureau of Shipping</th>
<th>United States Coast Guard</th>
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</table>

Wärtsilä participation in Hazid/Hazop

Wärtsilä FMEA of the LNGPac system components
Grazie e thank you

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