POWER GENERATION USING ASSOCIATED GAS

GGFR STEERING COMMITTEE WORKSHOP
NOVEMBER 30 – DECEMBER 1, 2011

TOMAS RÖNN
DIRECTOR, OIL AND GAS BUSINESS
WÄRTSILÄ POWER PLANTS
• Company profile
• Technology comparison
Company profile

Solutions for

Energy

Marine/offshore

17,500 professionals

>30% of Ship sailing the oceans is powered by Wärtsilä

Our values

Capture opportunities and make things happen

Do things better than anyone else in our industry

Foster openness, respect and trust to create excitement

Our power plants produce 1% of the world’s electricity

- Listed in Helsinki
- 4.5 billion € turnover
- Solid financial standing

Ship Power 26% (34)

Power Plants 34% (31)

Services 40% (35)

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December 1, 2011  Power Generation using Associated Gas
2010 liquid fuel and gas fuel power plant orders

TOTAL MARKET: 56.6 GW

NB. Includes all gas and liquid-fuelled power plants with prime movers > 5 MW
NB. Includes estimated output of steam turbines of combined cycles (factor 0.5 for industrial turbines, 0.4 for aeros)
Solutions for the onshore Oil & Gas Industry

FIELD POWER
- Power Generation

PUMPING
- Oil Pipeline
- Water Pumping
- Re-injection

COMPRESSION
- Underground Gas Storage
- Injection
- Gas Pipeline
PetroAmazonas Power plant
- 4xW18V32LN, CRO fuel, start 2003
- 3xW18V34SG, AG fuel, start 2005
- Total output 40MW

Power plant Extension
- 2xW18V32, CRO fuel, start 2007
- 2xW18V32, CRO fuel, start 2009
- Total output 30MW

The first 4xW18V32LN has 2011 been converted to GD and is now running on associated gas with crude as backup, by that reducing flare
CRO & Gas Power Plant – Eden Yuturi, Ecuador

The first 4xW18V32LN has 2011 been converted to GD and is now running on associated gas with crude as backup.

Flare considerable reduced
References – Crude Oil Pumping

Baku -Tbilisi - Ceyhan (BTC) Crude oil pipeline, 1700 km

BTC pipeline
1,000,000 bpd crude oil pipeline across from Baku to Ceyhan

Station setup, Turkey
- Main stations: 4+1 (5 x 18V34SG), parallel
- Booster stations: 3+1 (4 x 12 & 18V34SG ), series
Totally 33 pump units, 18 units in Turkey
Szöreg-1 Safety Storage, MOL Hungary

- 5 x W9L34SG a 4050 kW
- 2 x 5500 kW electrical driven
- Reciprocating compressors for gas storage in depleted gas/oil field
- Delivery September 2008
- In operation August 2009
## Wärtsilä Gas Engines

### Gas plant ranges and fuels

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<th>Plant size MW</th>
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<th>W34DF</th>
<th>W32GD</th>
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NG = Natural Gas
AG = Associated Gas
LFO = Liquid Fuel Oil
HFO = Heavy Fuel Oil
CRO = Crude Oil
LBF = Liquid Bio Fuel
Wärtsilä GD Fuel Sharing Mode

WÄRTSILÄ 32GD FUEL SHARING WINDOW

Fuel Sharing

Transfer window

GD operation

Fuel oil operation

Engine load %
0 10 20 30 40 50 60 70 80 90 100

Diesel share %
0 10 20 30 40 50 60 70 80 90 100

Gas share %
Wärtsilä GD Technology

- No de-rating for low methane number
- Large fuel flexibility
- Tolerant to fuel quality
- High thermal efficiency
- Fast load response
- Good loading capacity
- Short start-up time
- Automatic transfer to back-up fuel
- Easy to maintain
PERFORMANCE COMPARISON
Varying gas composition

Fuel composition from Secoya power plant

Molecular fraction (%)

- **CO2**
- **N2**
- **C1**
- **C2**
- **C3**
- **i-C4**
- **n-C4**

Site specific conditions

Gas turbines and combustion engines both derate with high ambient temperature and altitude.

Combustion engines offer stable output and high performance in hot and dry conditions.

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Source: GE Ger-3567 Ger-3695; Wärtsilä perf

Source: Termoflow calculation program; Wärtsilä perf
GT degradation is caused by mechanical and thermal stresses on individual gas turbine components over time.

Source: GE GER-3965/GER-4208; Wärtsilä
Operational flexibility vs. electrical efficiency

- Diesel cycle
- Otto cycle
- Industrial GT's
- Aero-GT's
- Boiler

Fuel adaptability
Starting time
Ramp rate
Part load operation

Steam Power Plants
Simple Cycle GT
Simple Cycle Combustion Engines

December 1, 2011
Power Generation using Associated Gas
Diesel cycle technology is the most efficient and flexible solution and consequently the most environmentally friendly.