
# Cryogenic LNG Expanders Reduce Natural Gas Liquefaction Costs

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# EBARA International Corporation
# Cryodynamics Division

## Company Profile

- Established in 1973
- Manufacturer of custom engineered liquefied gas pumps and expanders
- Located in Sparks, Nevada, USA
- Division of Ebara Corporation of Japan
- 5000 M2 factory with a modern, dedicated liquefied gas test facility

Ebara LNG Test Facility in Nevada

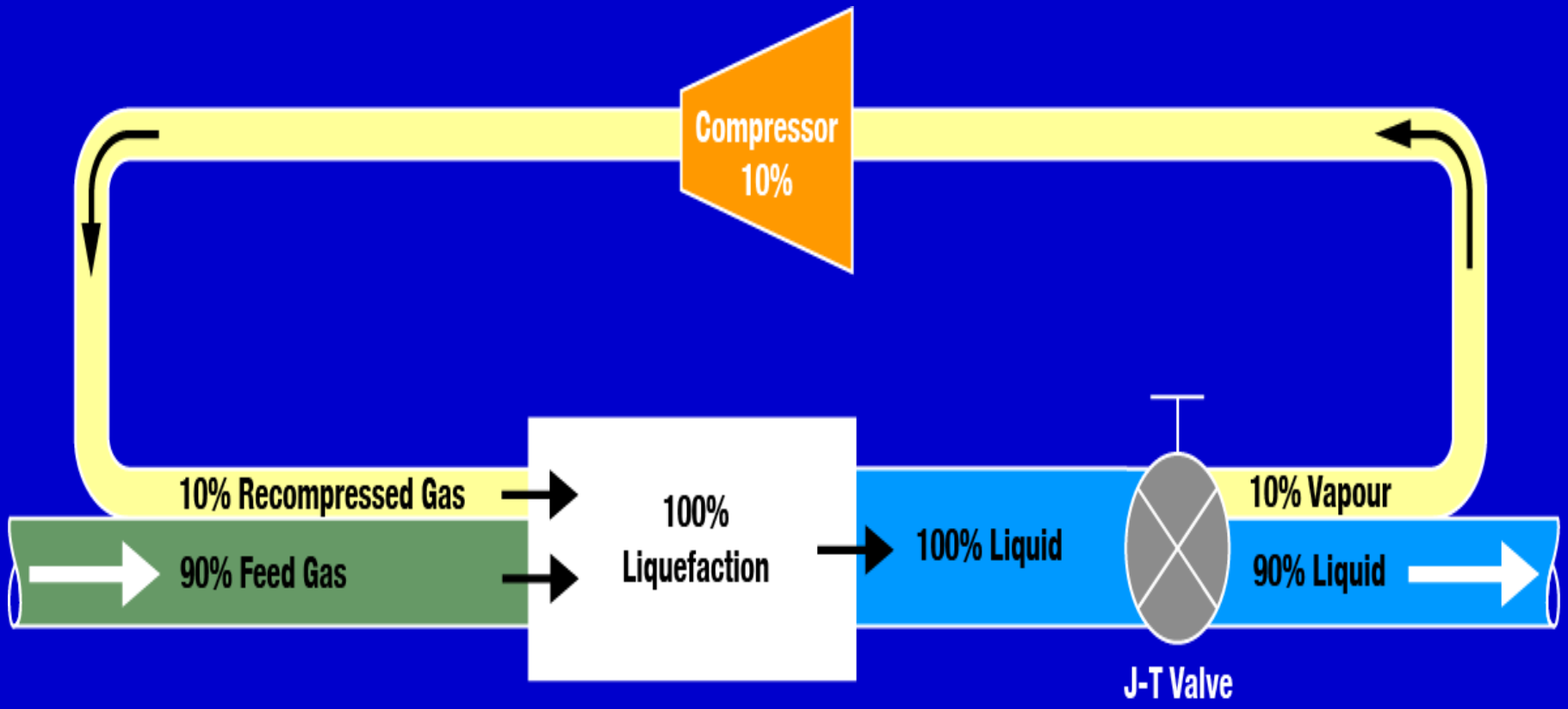
The liquefaction of Natural Gas requires a significant amount of energy for the refrigeration process

Cryogenic LNG Expanders reduce this amount of energy by replacing the throttling Joule-Thomson Valve with a power generating Expansion Turbine.

Large 2.6 MW
Cryogenic
LNG Expander
for
Algeria, Skikda,
at the
Ebara Test Stand
in Sparks,
Nevada, USA

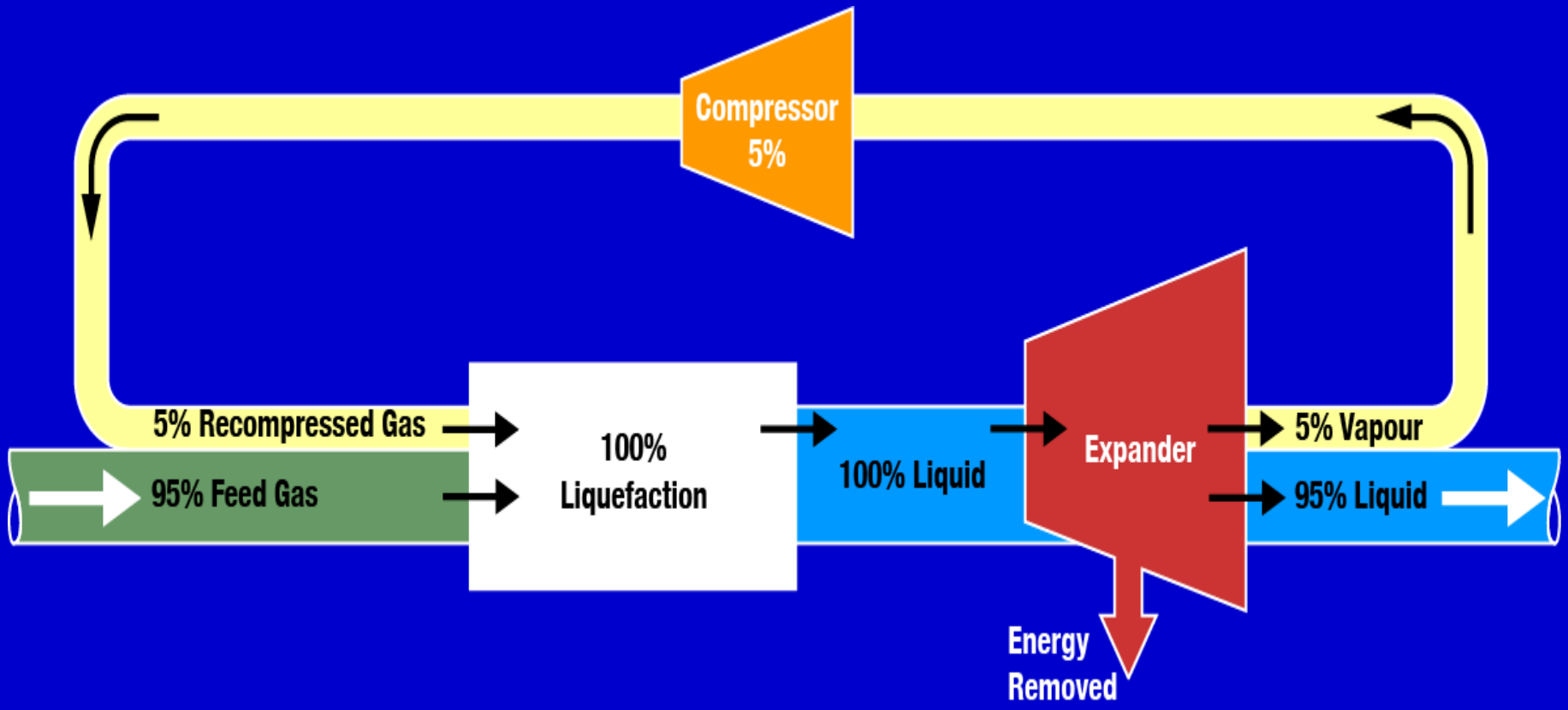
In existing older LNG plants with a liquefaction capacity of 100% the pressurized condensed LNG is passed across a Joule-Thomson Valve reducing the pressure to storage conditions

The pressure reduction across the J-T valve produces 10% undesirable LNG vapour and only 90% of the liquid LNG is delivered to the storage tank

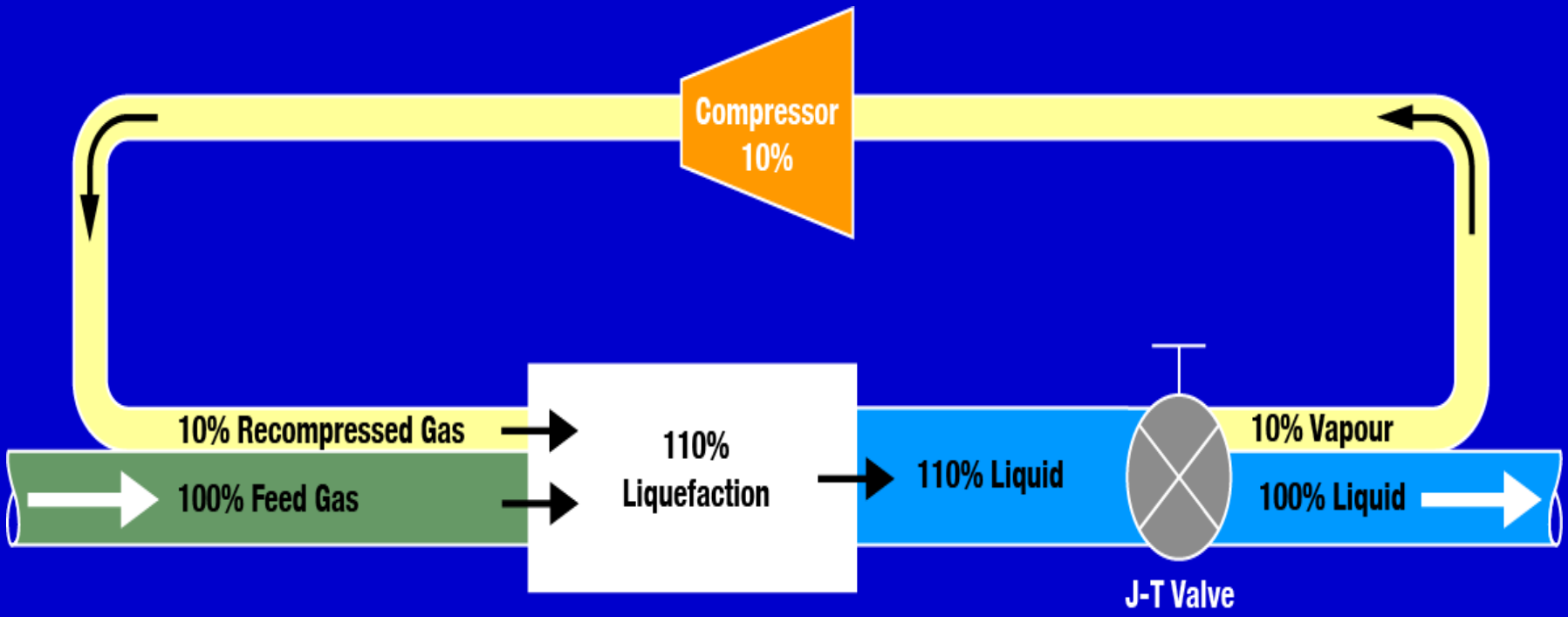



# Liquefaction Process without LNG Expander for Existing Older Plants

By replacing the J-T valve with a cryogenic LNG expander the amount of undesirable LNG vapour is reduced from 10% to only 5%, and in existing older plants 95% of the liquid LNG is delivered to the storage tank

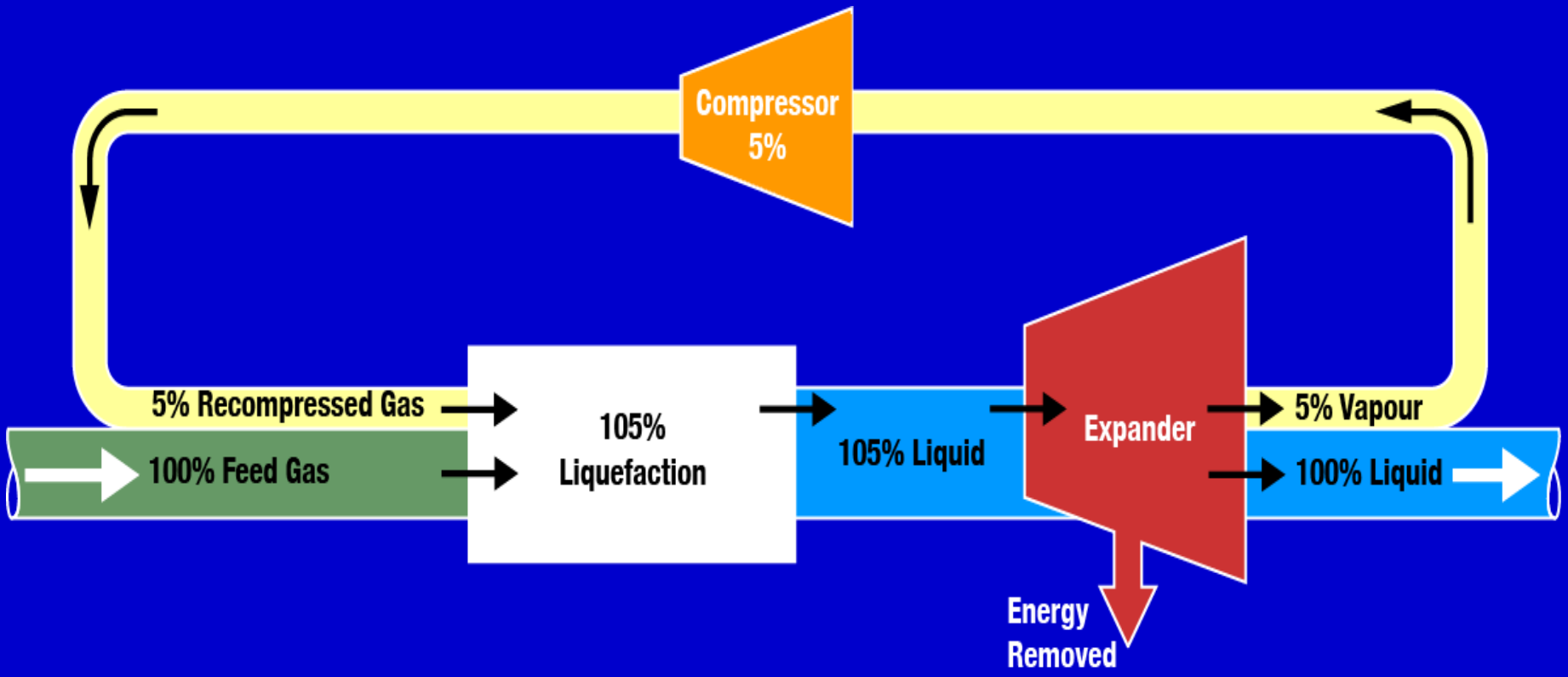



# Liquefaction Process with Retrofitted LNG Expander in an Existing Older Plant




A Projected New LNG Plant with a J-T Valve Requires 110% Liquefaction Capacity to achieve 100% LNG Delivery

If in a projected new plant the LNG pressure reduction occurs across a cryogenic LNG Expander, the entire liquefaction plant has to be sized only for 105% capacity for a delivery of 100% LNG




A Projected New Plant with an LNG Expander Requires only 105% Liquefaction Capacity to achieve 100% LNG Delivery

Cryogenic Expanders
remove
Pressure Energy
from the LNG Stream
and convert it into
Electrical Power

The overall efficiency of the liquefaction process is inversely proportional to the Specific Power Consumption, which is defined as the ratio of the

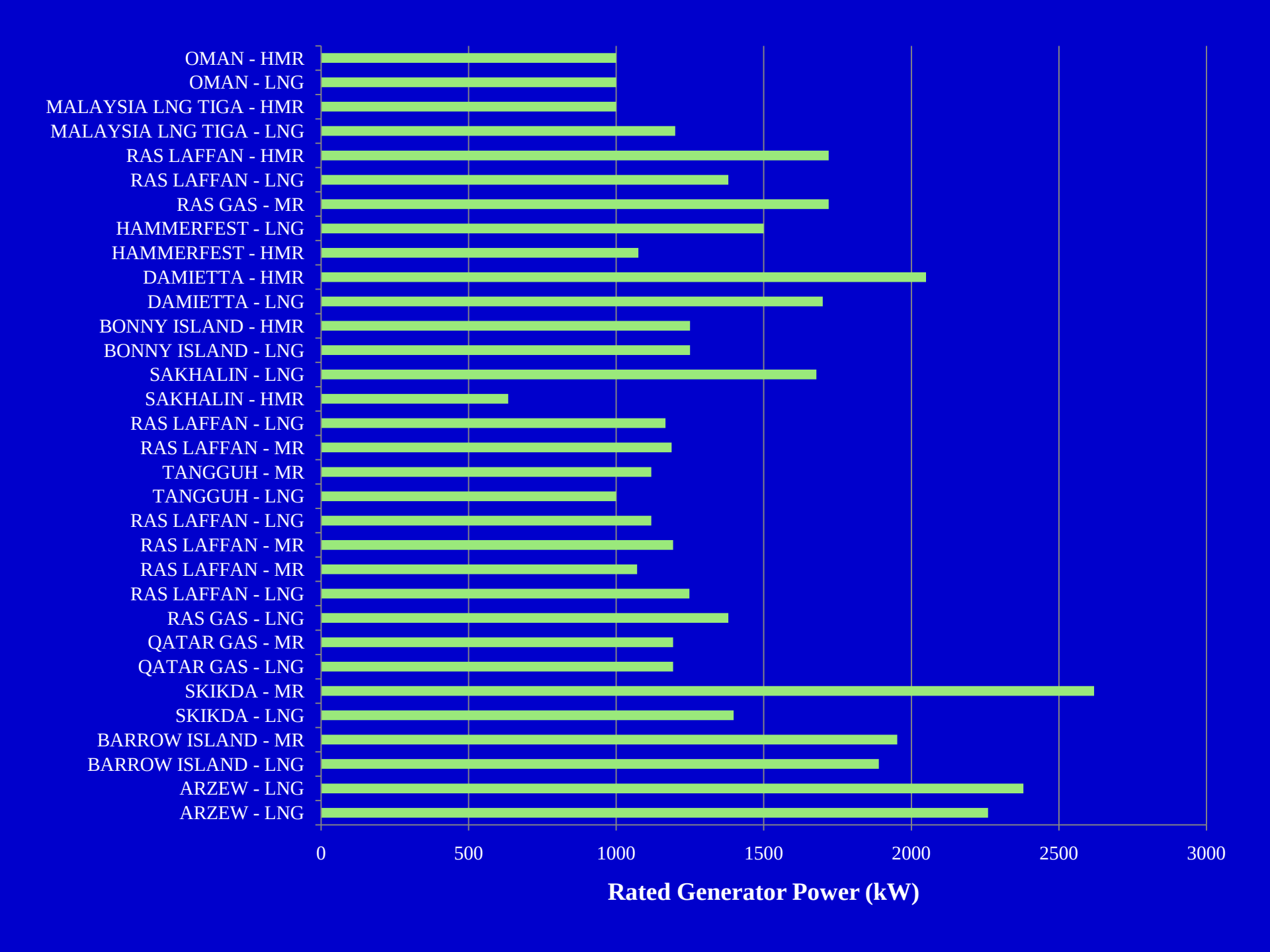
Total Power Consumption
over the
Total LNG Production

The LNG Expander typically increases the LNG Production between 3 – 5 % and decreases the Total Power Consumption by the same percentage of 3-5%

By adding 3-5% to
the LNG Production
and subtracting 3-5% from the
Total Power Consumption,
the Specific Power Consumption
reduces by 6-10%,
and the Overall Plant Efficiency
increases by 6-10%

Cryogenic LNG Expanders are field proven for 15 years

They are installed and successfully operating in most LNG liquefaction plants since 1996 until today, and are also projected for installation in future plants


OMAN - HMR
OMAN - LNG
MALAYSIA LNG TIGA - HMR
MALAYSIA LNG TIGA - LNG
RAS LAFFAN - HMR
RAS LAFFAN - LNG
RAS GAS - MR
HAMMERFEST - LNG
HAMMERFEST - HMR
DAMIETTA - HMR
DAMIETTA - LNG
BONNY ISLAND - HMR
BONNY ISLAND - LNG
SAKHALIN - LNG
SAKHALIN - HMR
RAS LAFFAN - LNG
RAS LAFFAN - MR
TANGGUH - MR
TANGGUH - LNG
RAS LAFFAN - LNG
RAS LAFFAN - MR
RAS LAFFAN - MR
RAS LAFFAN - LNG
RAS GAS - LNG
QATAR GAS - MR
QATAR GAS - LNG
SKIKDA - MR
SKIKDA - LNG
BARROW ISLAND - MR
BARROW ISLAND - LNG
ARZEW - LNG
ARZEW - LNG
0
500
1000
1500
2000
2500
3000
Rated Generator Power (kW)

The increase in LNG Production
is directly proportional to
the energy removed by
the LNG Expander.

1 kW of removed electrical power
produces
60 tons/year of additional LNG

# Increase in LNG production by the generated power of the LNG expander

| | |
|---|---|
| 1 kW | 60 t/year |
| 100 kW | 6,000 t/year |
| 1000 kW | 60,000 t/year |
| 2000 kW | 120,000 t/year |

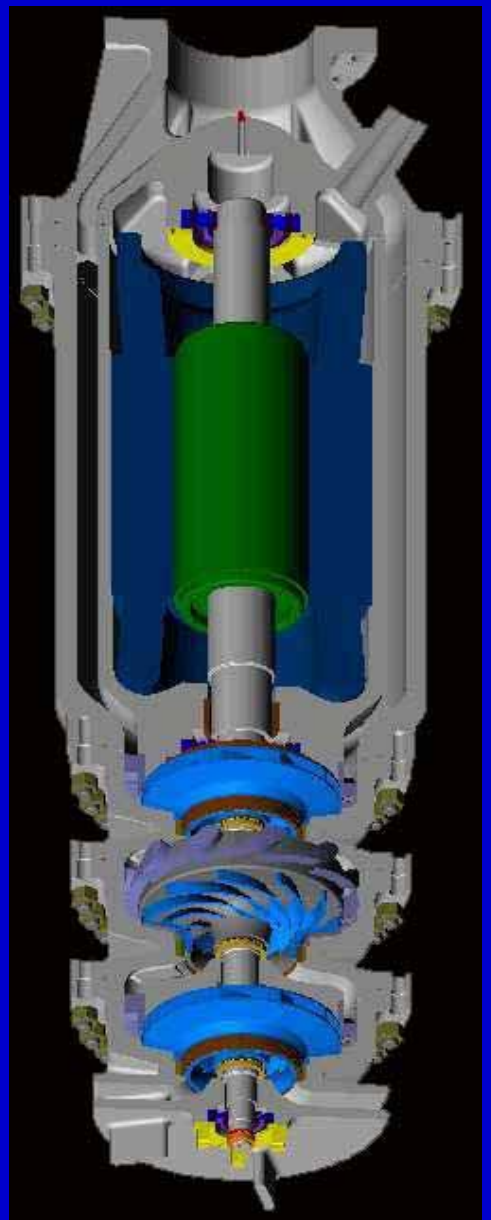
An LNG Expander removing 2500 kW of electrical power from the LNG stream produces 150,000 t/year additional LNG for an annual revenue of 37.5 Mill US $

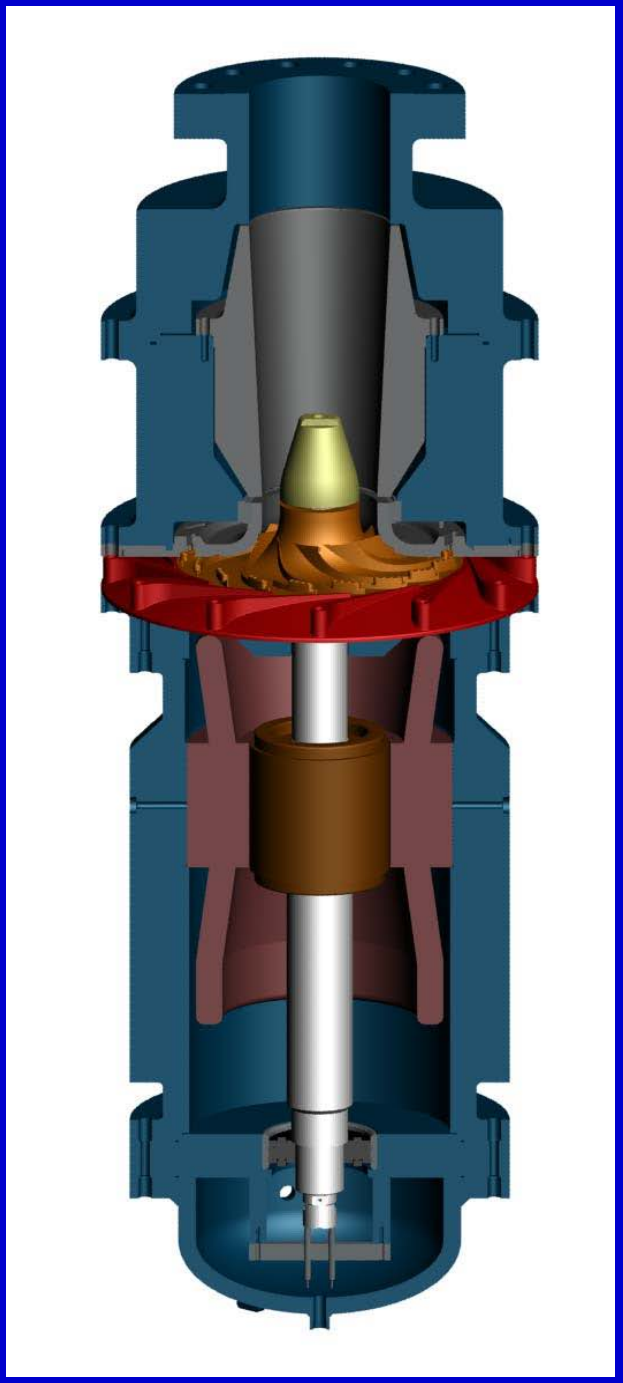
# There are three basic designs of LNG expanders

- Single phase liquid expanders in downward flow
- Single phase liquid expanders in upward flow
- Two-phase liquid-vapour expanders in upward flow

# Single phase downward flow expander

- Generator Rotor
- Generator Stator
- Thrust Equalization Mechanism (TEM)
- Fixed Geometry Inlet Guide Vanes
- Runners

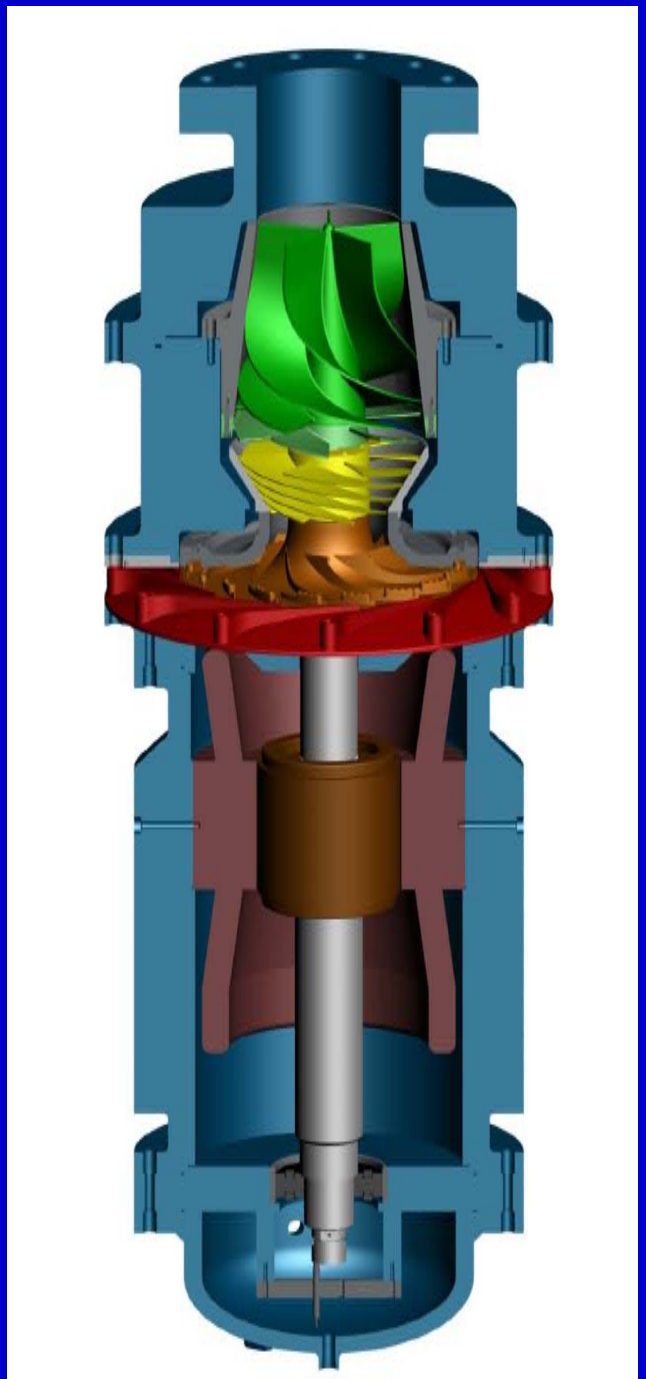




Expander designs in upward flow

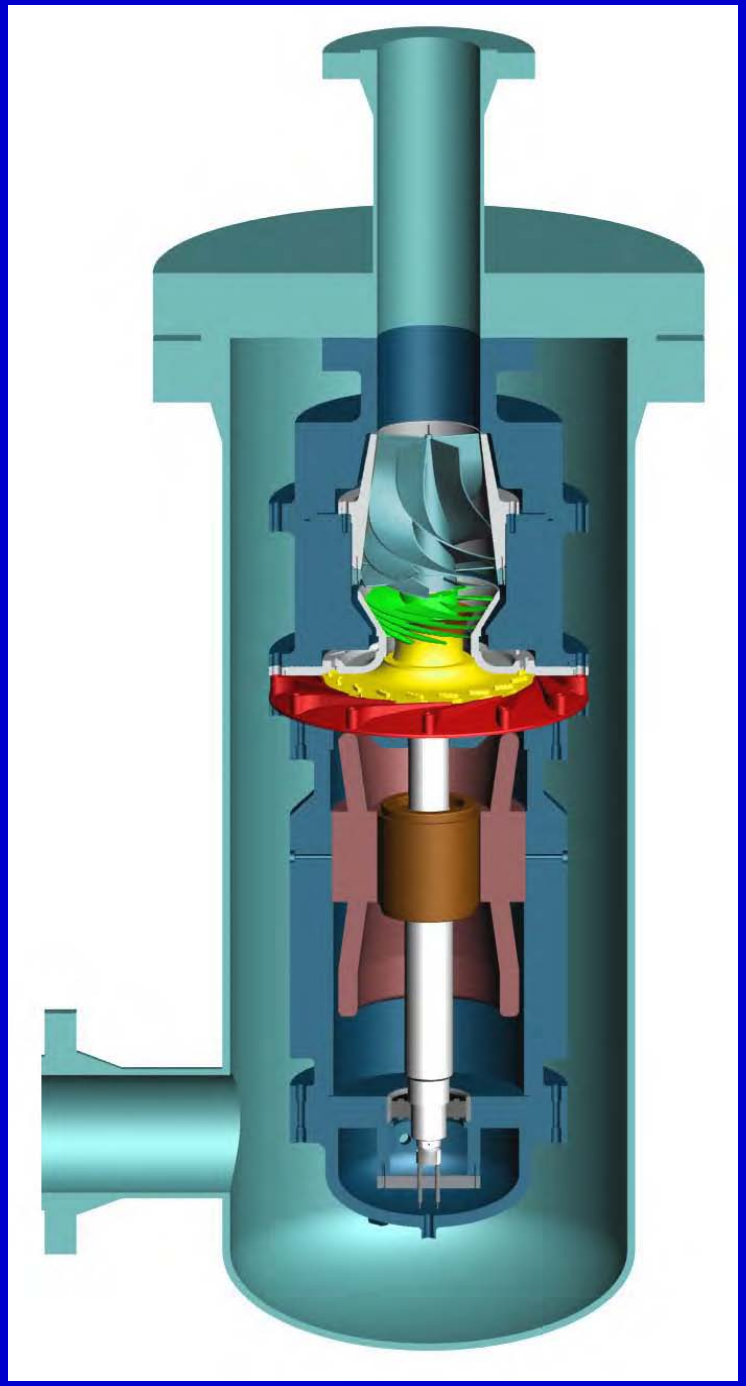
← for liquid single phase LNG

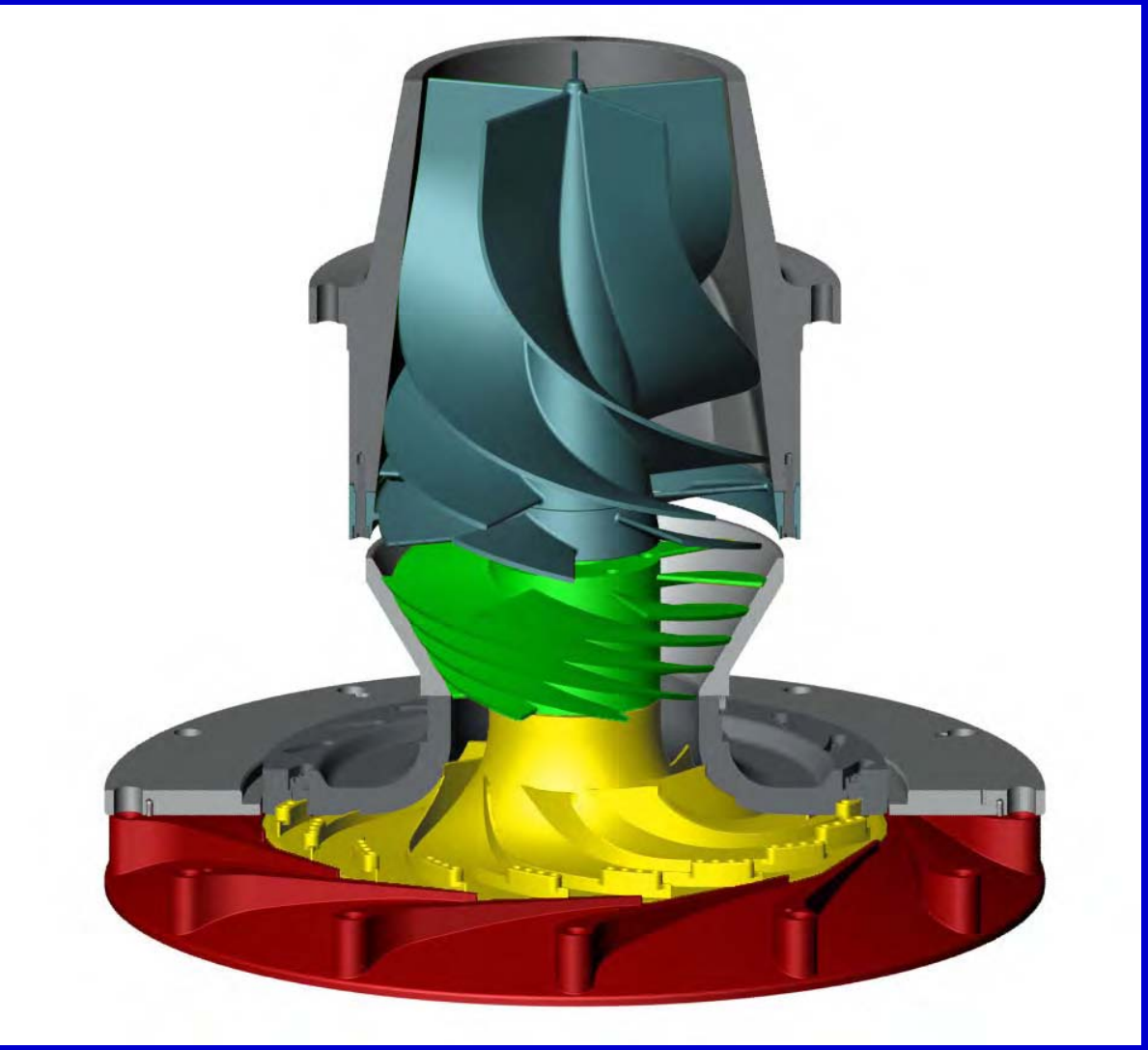
→ for liquid-vapour two-phase LNG



# Existing Field Proven Two-Phase Expanders

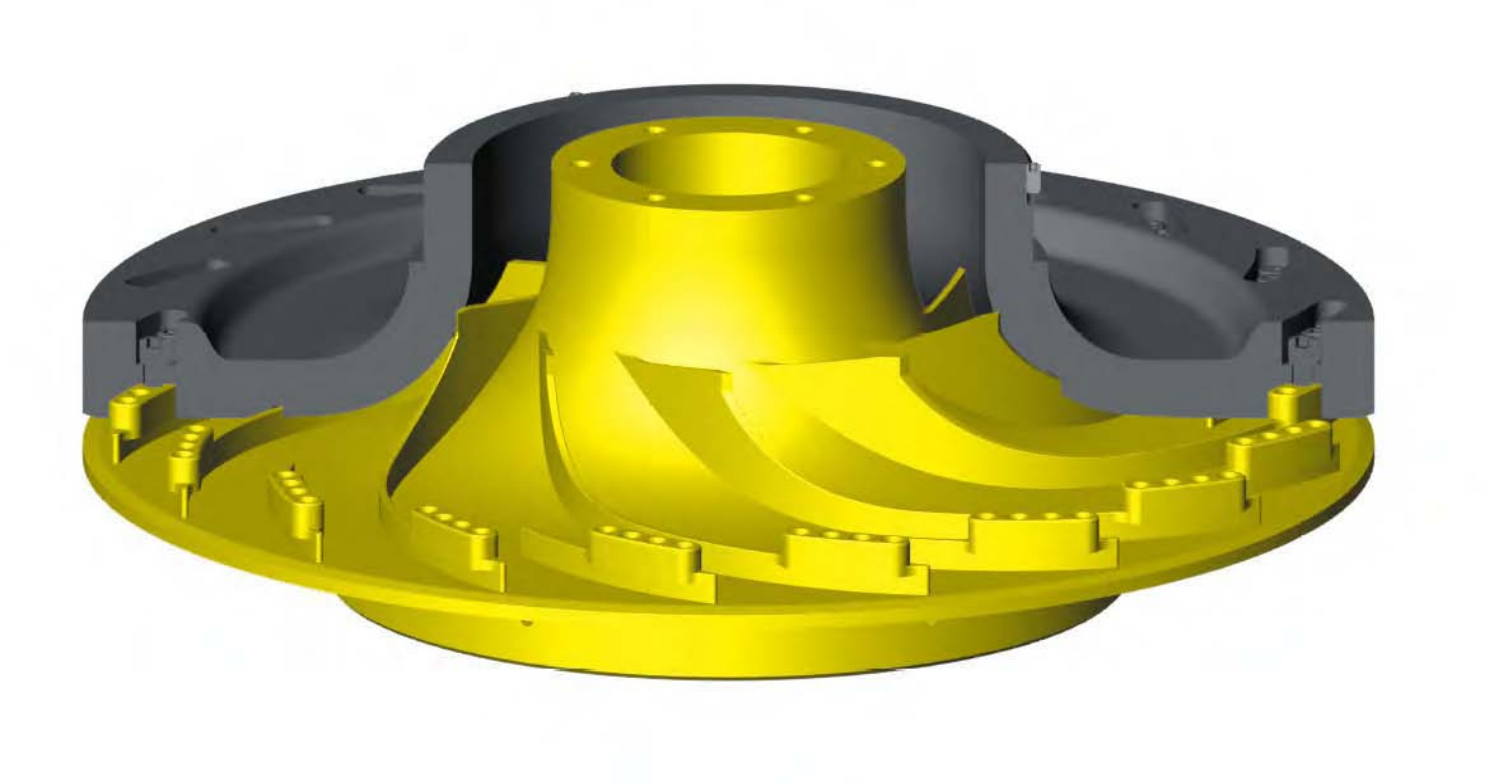
Cross section of a Two-Phase LNG Expander inside the flame proven pressurized stainless steel containment vessel



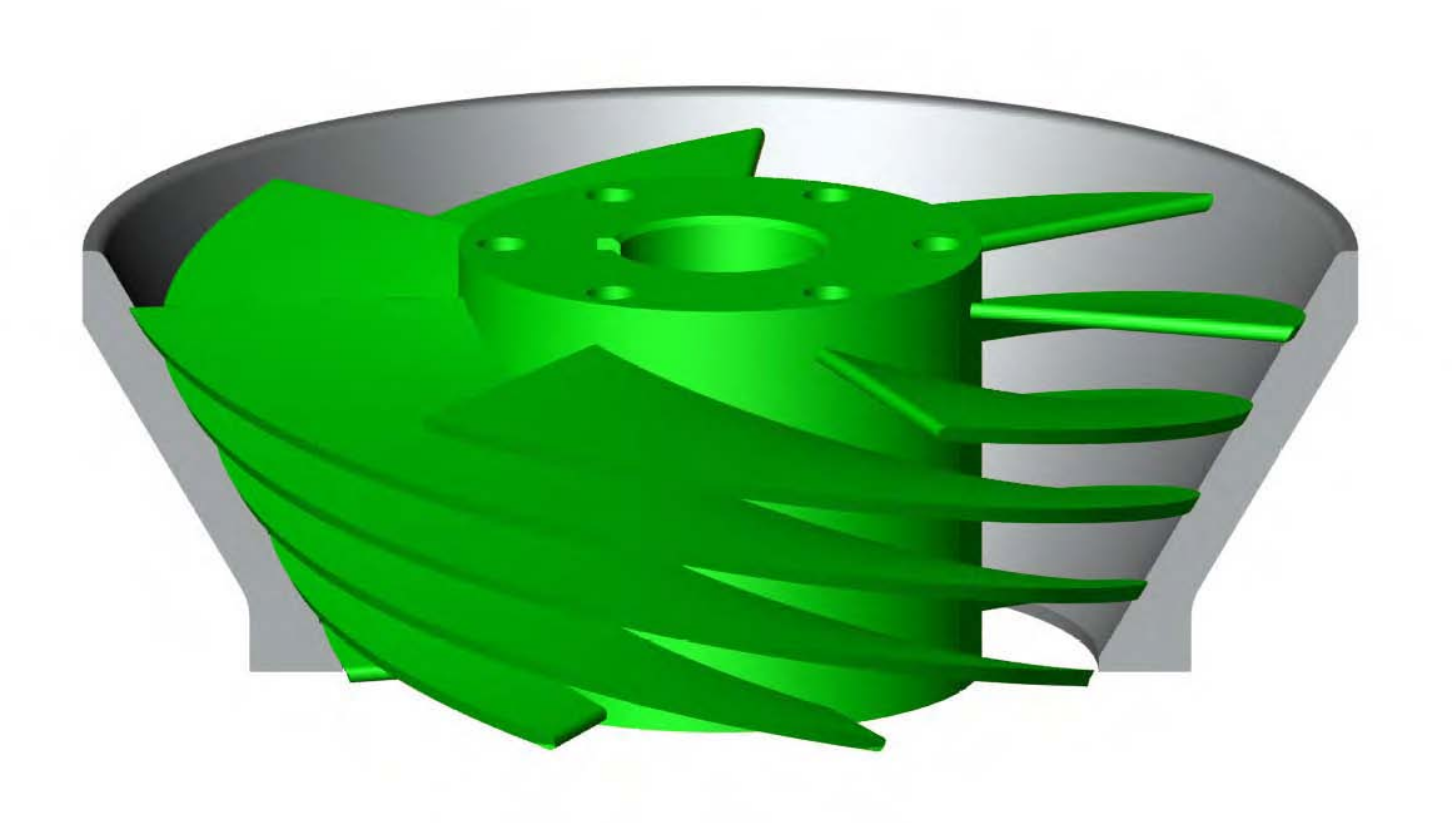


Two-Phase hydraulic assembly with red nozzle ring, yellow turbine runner, green jet exducer, and metallic blue two-phase draft tube

Nozzle Ring with converging nozzles generates high-velocity vortex flow

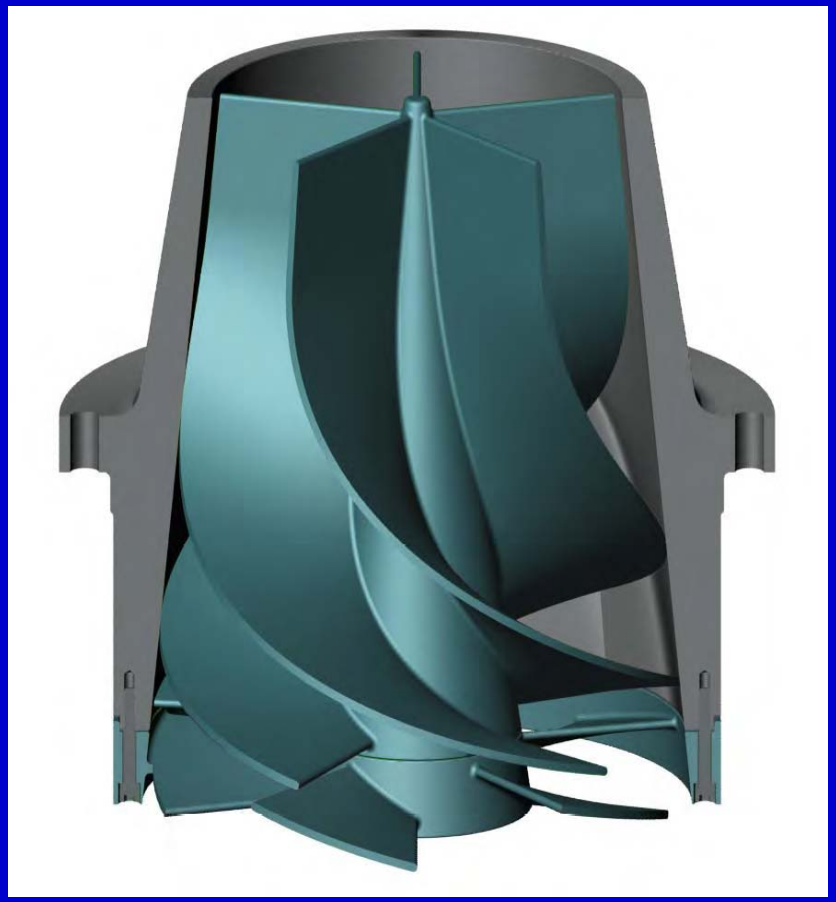


Turbine runner converts angular fluid momentum into shaft torque



A radial outflow turbine for the expansion of two-phase LNG

# Two-phase expander draft tube



recovers pressure from the remaining kinetic fluid energy


# Two-Phase LNG Expander at the Ebara Cryogenic Test Stand in Nevada, USA


Two-Phase
LNG Expander
at the
Ebara
Manufacturing
Facility
in Nevada, USA

*Terima kasih atas perhatian Anda*

*Thank you for your attention*

*Hans E. Kimmel*