LNG - an Overview

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Darwin LNG

Liquefied Natural Gas (LNG)

1. Allows gas to be sold from remote suppliers

   Indonesia, Middle East, Australia, Algeria, etc.

   to industrialized countries,

   Japan, Korea, Spain, UK

2. The largest producer of LNG is Qatar

3. …….was Indonesia but gas reserves depleted

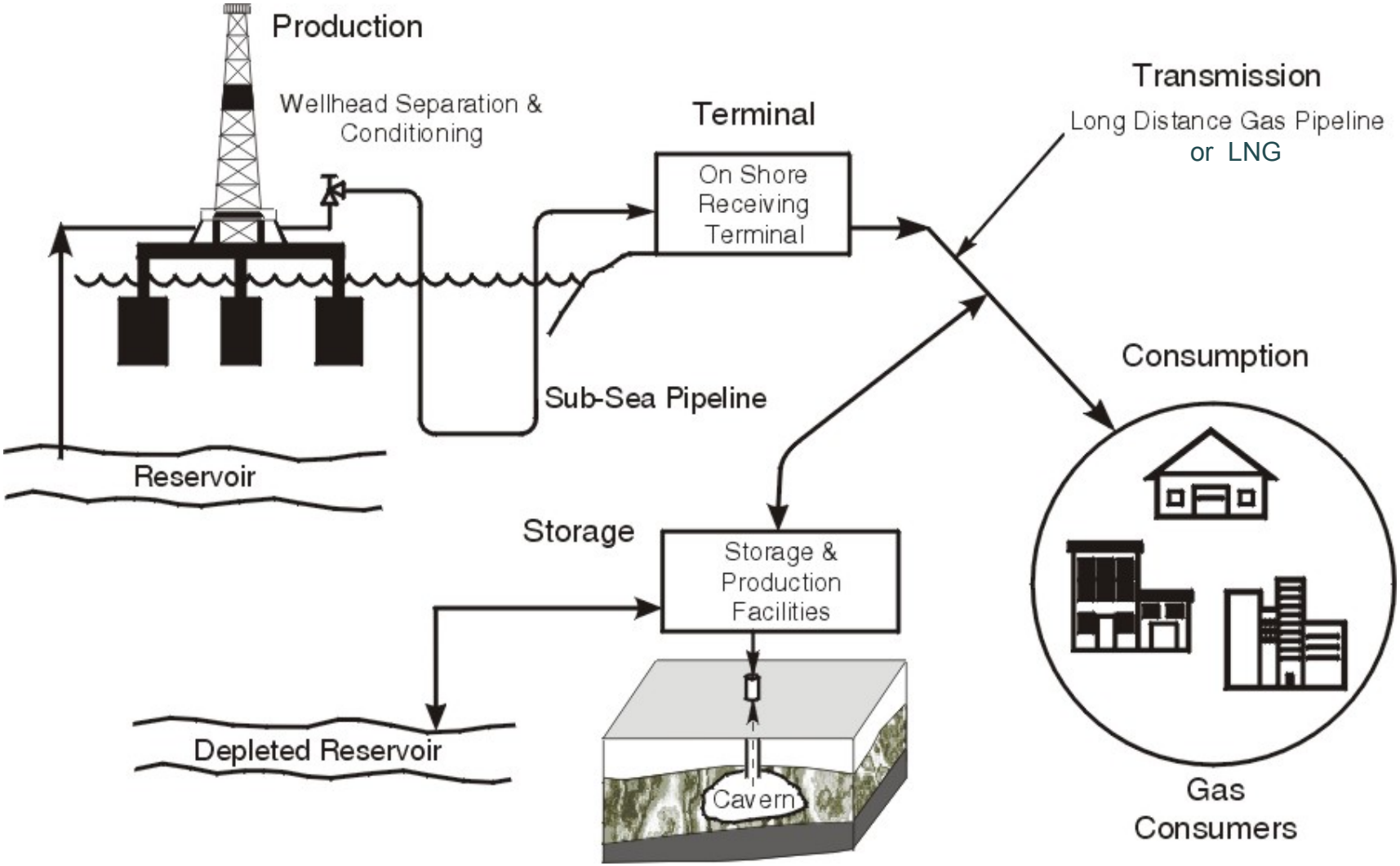
4. The largest market for LNG is Japan

5. International trade in 2013 was ~240 mtpa

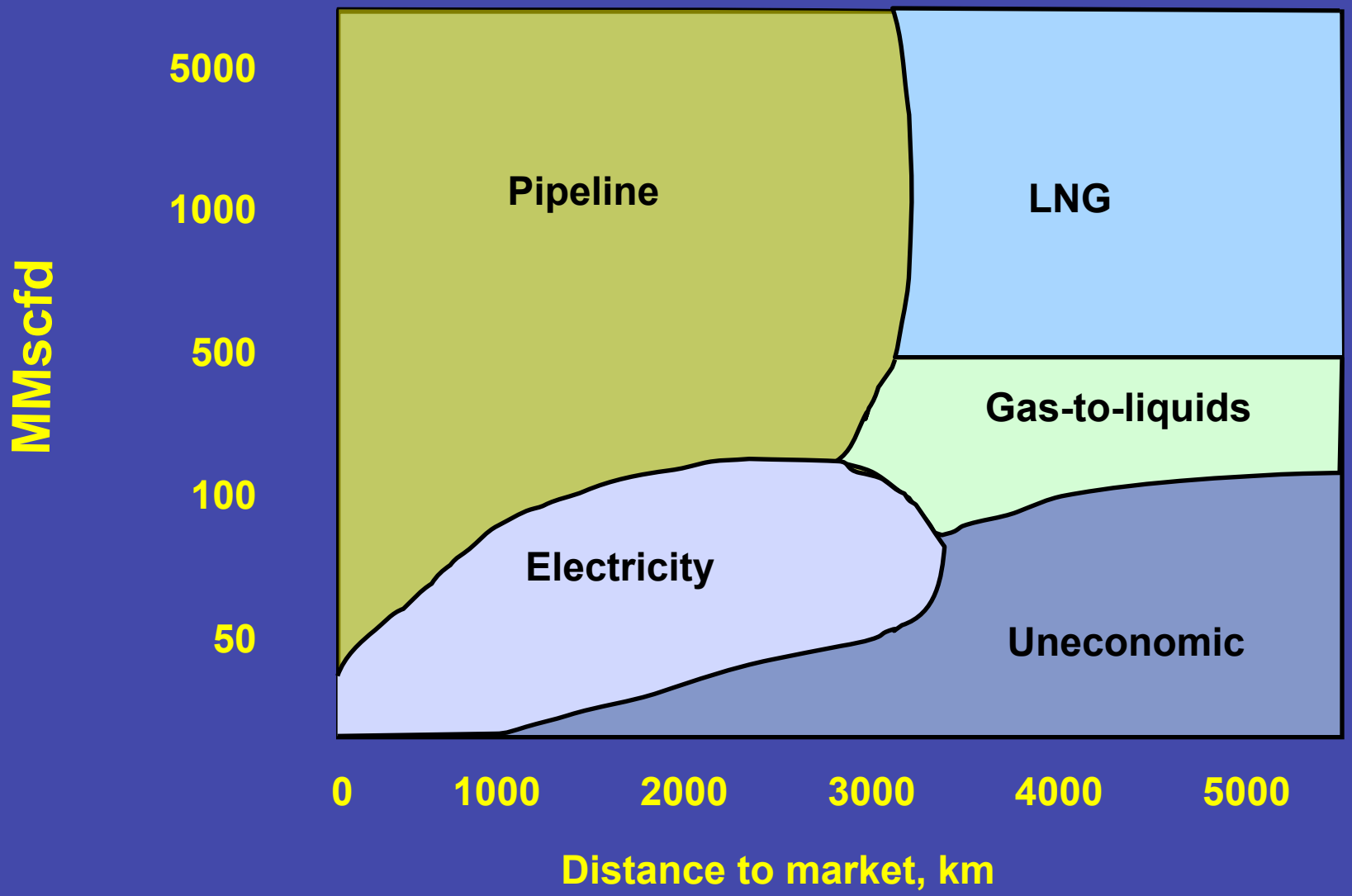
   (Equivalent to 315 bcma. 11 tcf/yr)

(mtpa = million tonnes per annum. bcma = billion cubic meters per annum)

Overview of Gas Production, Transmission and Storage



Natural Gas Transportation Options



Gas Markets

1. **Electricity Generation**
2. **Industrial**
3. **Residential & Commercial**
4. **…… Transportation ?**

Gas Prices $/MMBtu

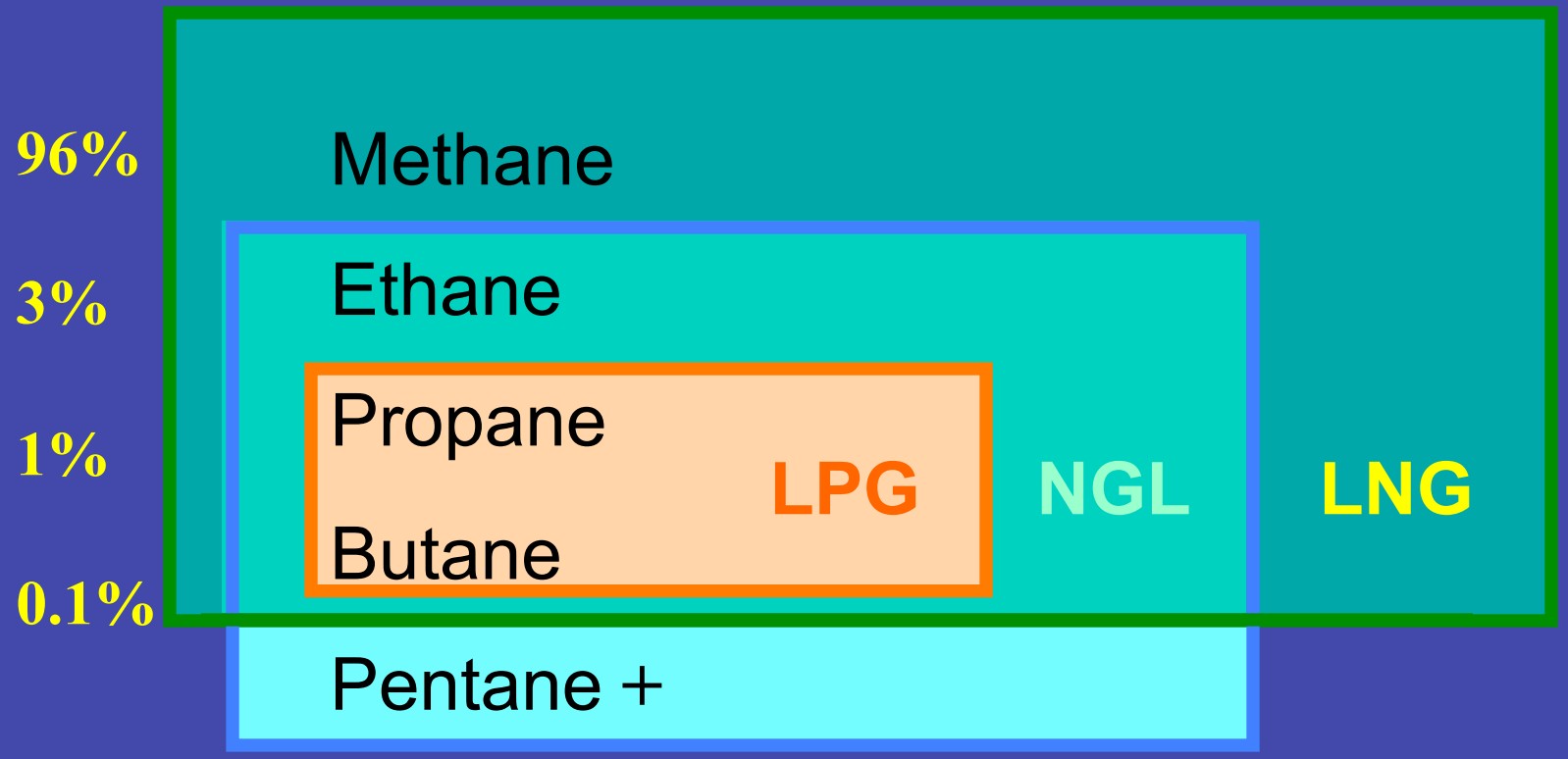
USA 4 – 5

Europe ~ 8 - 9

Japan 14… up to 17

(MMBtu = Million BTU)

WHAT IS LNG?



LPG – Liquid Petroleum Gas
NGL – Natural Gas Liquids
LNG – Liquid Natural Gas

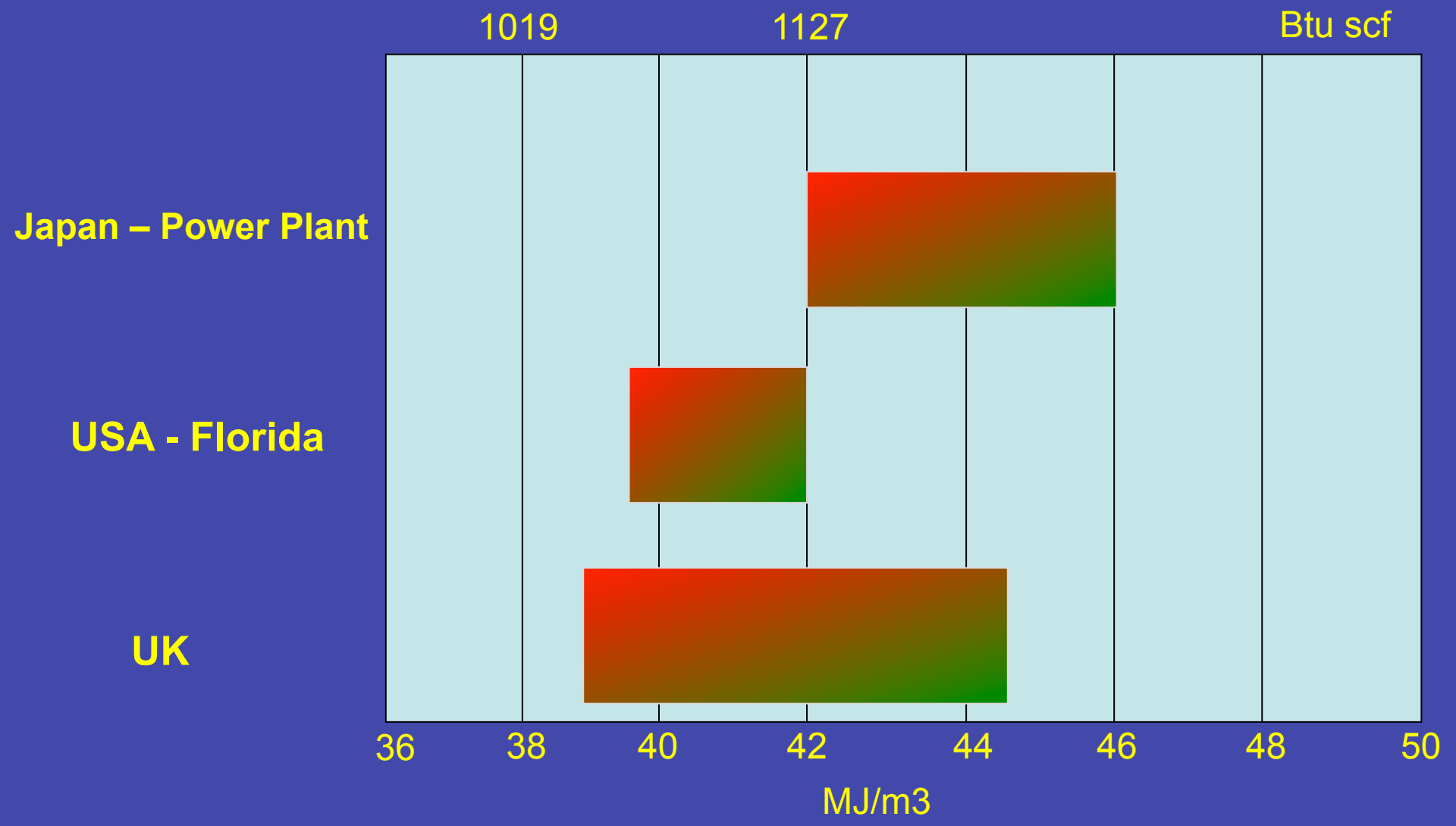
Example LNG Properties

-162°C [-235°F] at atmospheric pressure

		Rich		Lean
nitrogen		0.3		0.5
methane		88.7		97.5
ethane		8.0		1.5
propane		2.0		0.5
butanes		1.0		-
approx. S.G. kg/m^3	0.465	465	0.435	435
CV (higher) MJ/m^3		42		38.5
Btu/ft^3		1127		1033

CV = Calorific value = heating value.

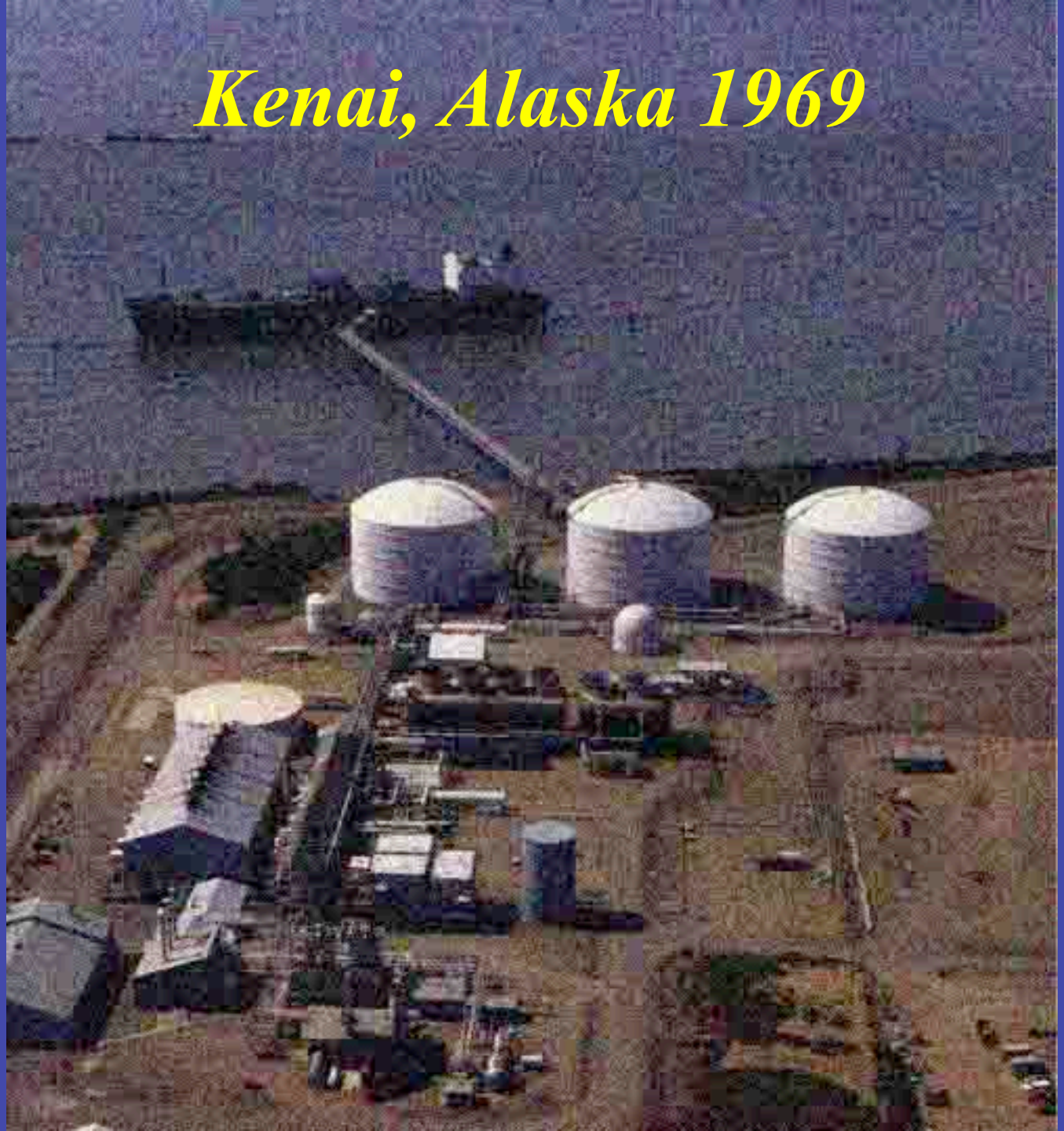
Example Heating Values



Adapted from: Bramoulle, Morin and Capelle, “LNG Quality and Market Flexibility Challenges and Solutions”, LNG 14, Doha, Qatar 2004

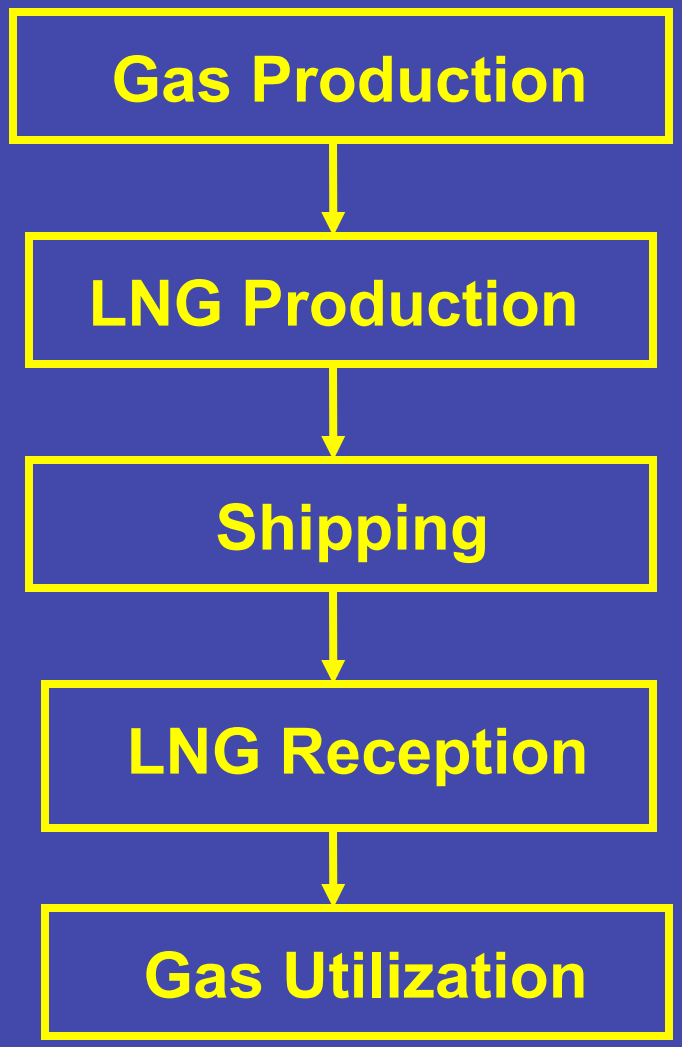
Gas Production Platform
North Rankin A
North-West Shelf Project, Australia

Kenai, Alaska 1969



LNG - Bontang, Indonesia

The Basic LNG Chain



New Exporting Countries

Operating: Angola, Peru

Next: Papua New Guinea PNG
Maybe: Mozambique…

Also: USA, Canada…

Growth

Note: mtpa = million tonnes per annum (year)

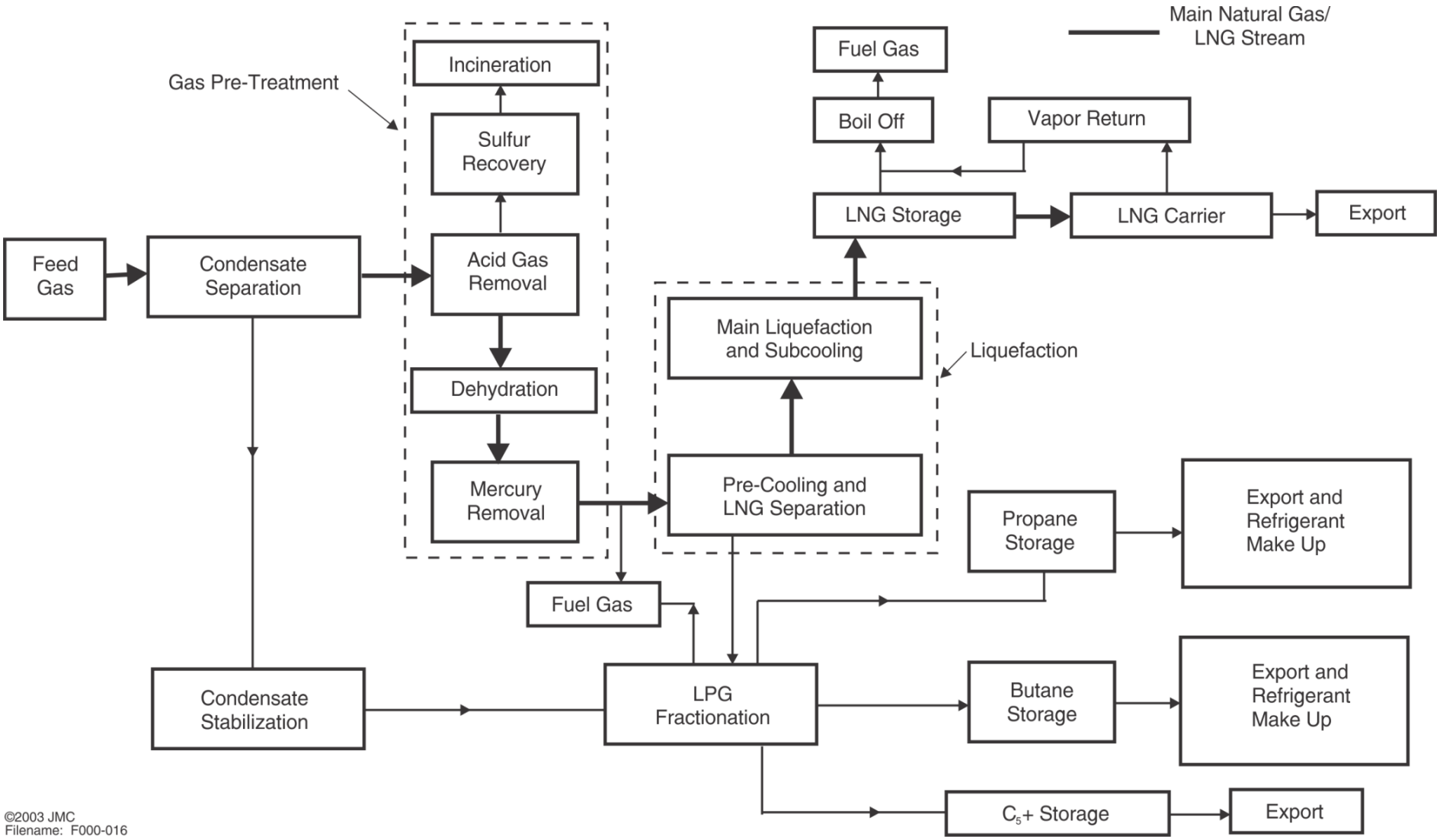
2009	**182 mtpa**
2010	**225 mtpa**
2011	**260 mtpa**
2012	**240 mtpa**
2013	**~240 mtpa***

*** 240 mtpa equivalent to**

315 sbcma [30 200 MMscfd].

LNG plant capacity approx. 20% more than the trade.

General Schematic - Liquefaction



LNG Production Technologies

1. **Widely Used Technologies**
   - **ConocoPhillips (Optimized Cascade)**
   - **APCI (Propane Precooled)**
2. **Other Process Technologies**
   - **APCI (AP-X)**
   - **Linde (MFC)**
   - **Shell (DMR and PMR)**
   - **Black & Veatch (PRICO)**

APCI = Air Products & Chemicals, Inc; MFC = Linde proprietary Multi-Fluid Cascade Technology; DMR = Double-Mixed Refrigerant; PMR = Parallel Mixed Refrigerant.

Contaminants

What's in gas (besides light hydrocarbons)?

H_2O CO_2 H_2S

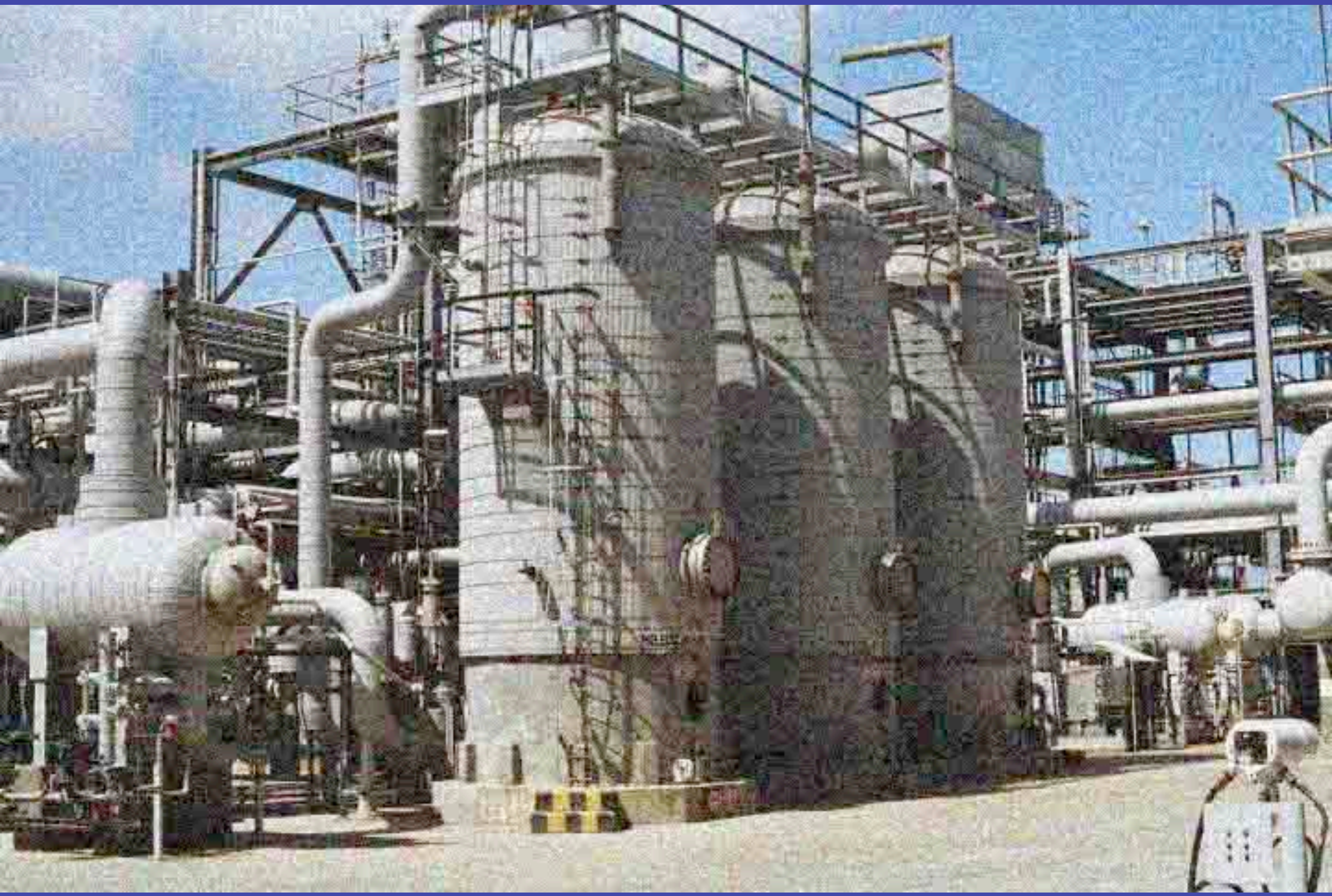
S He N_2 Cl Hg As

Waxes Asphaltenes etc.

Sand Dinosaur Dust

Lubricants Corrosion Inhibitors

Mystery Stuff, etc.

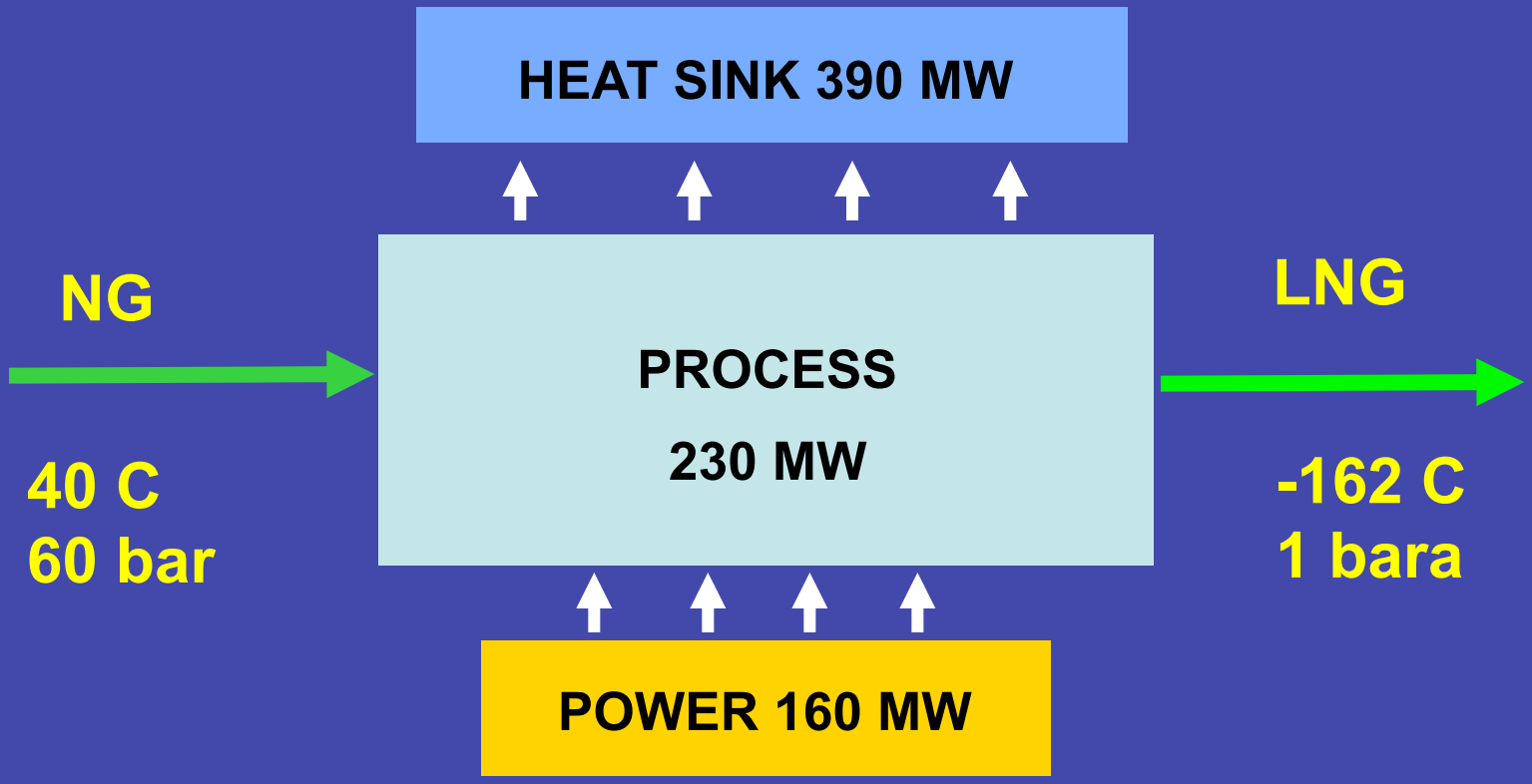


Compressors

Courtesy: Linde

MCR® Heat Exchanger Tube Bundle Shipping

The Liquefaction Heat Balance



LNG Production 3.7 mtpa (500 tph)

Egypt – Idku

1. 2 Trains 3.4 mtpy
2. COP Optimised Cascade process
3. Air-cooled process
4. Very long jetty
5. Space for expansion

Floating LNG – 1

1. **Currently 1-3 mtpa; barge (less motion) or ship (more motion).**

2. **Fields:**
   a. **Australia Prelude (3.6 mtpa), Sunrise, etc.**
   b. **Also Brazil, Malaysia.**

3. **Simple LNG process to save space:**
   a. **N_2 Refrig. cycle (12-15% of gas as fuel)**
   b. **Prico or others.**

Floating LNG – 2

4. **Characteristics**
   a. **Less permitting time**
   b. **Less space for exit**
   c. **Maintenance more difficult**
   d. **Moveable asset – could work for smaller reserves; shorter duration on location; 'standard' gas composition**

5. **Floating versus Land-based**
   a. **Ichthys: 850 km subsea pipeline**
   b. **Karratha is only 140 km subsea**

LNG Carrier

1959 – The Methane Pioneer

'Spot' Cargoes

Growth in the Spot or Short-term market:

"….. <2% in 1993 to >20% today.

(Ref: Maalouf, R., "LNG Journal", May 2012, Pg. 6)

LNG Shipping Update

1. **LNG carriers larger, more numerous:**

   380 in Mar. 2014. **("LNG Journal", Mar. 2012)**

Membrane 60%, Moss 29%, Other 2%

("LNG Journal", Feb. 2012)

2. **Transition from steam propulsion to:**

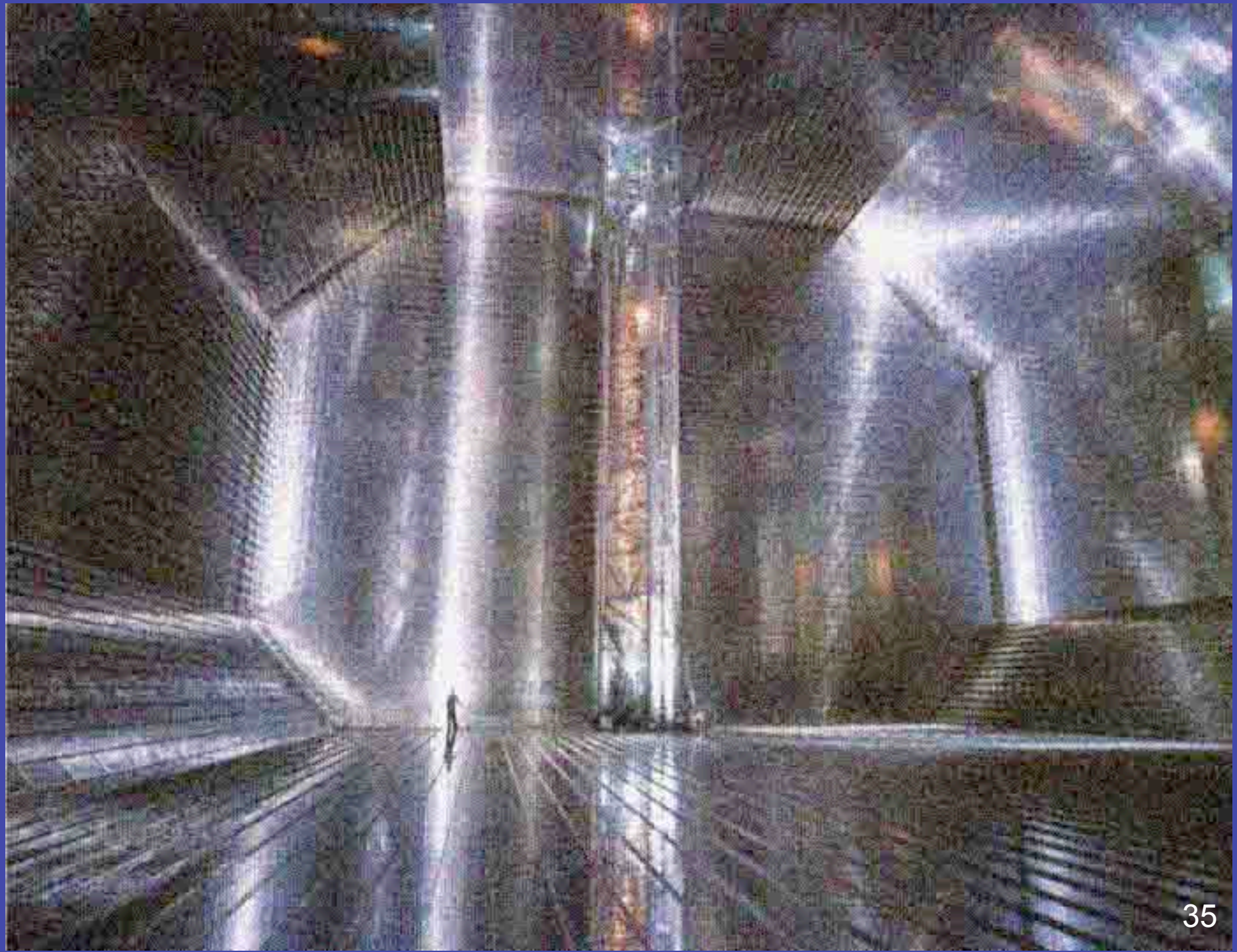
   DRL – Diesel with cargo boil-off recovery (actually recondensing)

   DFDE – Dual-Fuel Diesel-Electric

3. **47 carriers >200,000 m^3, all DRL** **(3/2014)**

DRL = Diesel Re-Liquefaction


L N G



Negishi Terminal, Japan : Single Containment Tanks (background) Inground Tanks (foreground)

Floating LNG Import Terminals

1. **FSRU – Floating Storage and Regasification Unit.**

   Italy: moored open sea; 2012/2013

2. **Also Indonesia – South Sumatra.**
   21 km offshore, 500 MMscfd
   ("LNG World News", 12 May 2012)

3. **Excelerate (open sea or docked).**

   200+ STS transfers

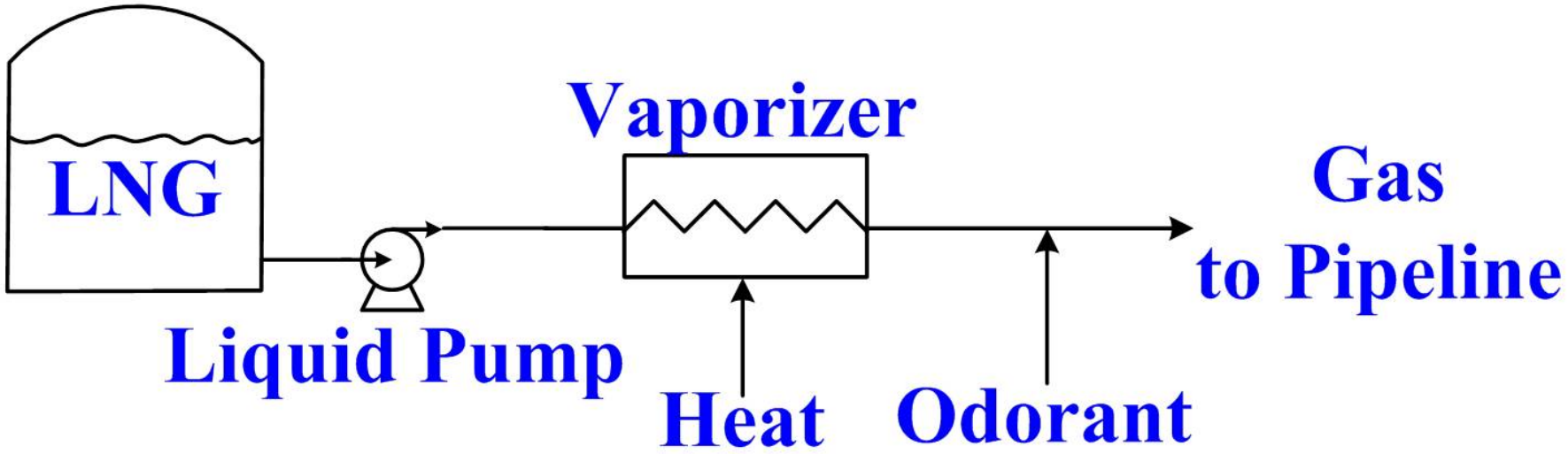
4. **More ship motion than oil tankers**

STS = ship-to-ship.

Floating LNG Import

Courtesy Excelerate

LNG Regasification (simplified)



Recent Developments – 1

1. **Floating LNG (FLNG)**
2. **Floating Reception Terminals**
3. **Nuclear in Japan** **11 March 2011**
4. **Trade Patterns**

Recent Developments – 2

5. **USA self-sufficient in gas**
   …LNG exports?
6. **a. Approx. $350 Billion projected or underway in Australia**
   b. 85 mtpa capacity possible by 2017

("LNG Journal", May 2012, Pg. 1; "The Australian")

7. **World Economy**
8. **Russian LNG – Artic more open.**

Recent Developments – 3

9. Small- and mini-LNG plants ...once again.

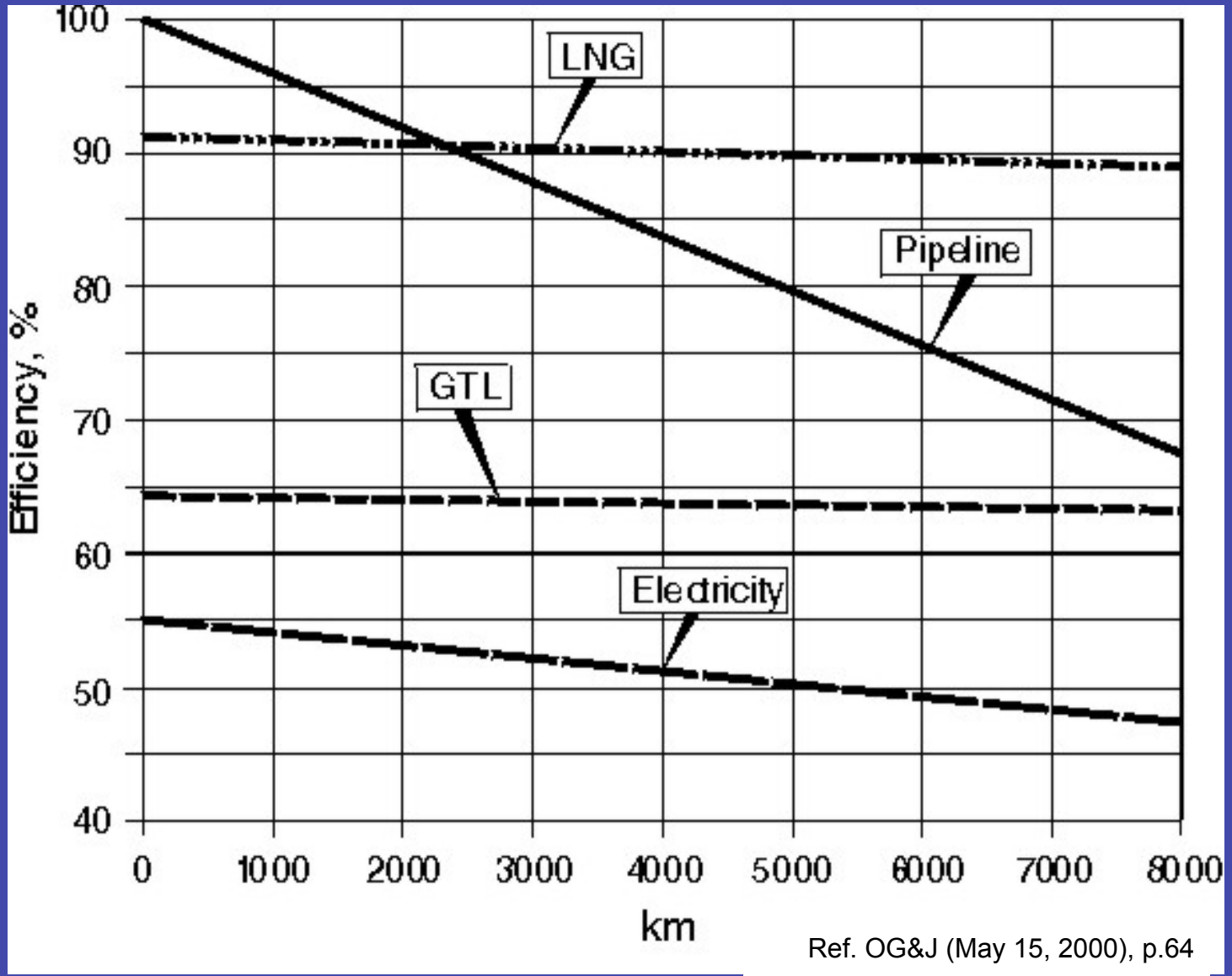
10. LNG as transportation fuel…

Small- and mini-LNG plants

Peak shaving plants built by B&V at Wrenshall, MN for Northern Natural and Alabama Gas Company at Pinson, AL.

Courtesy of Linde

Nominal Gas Transportation Efficiency



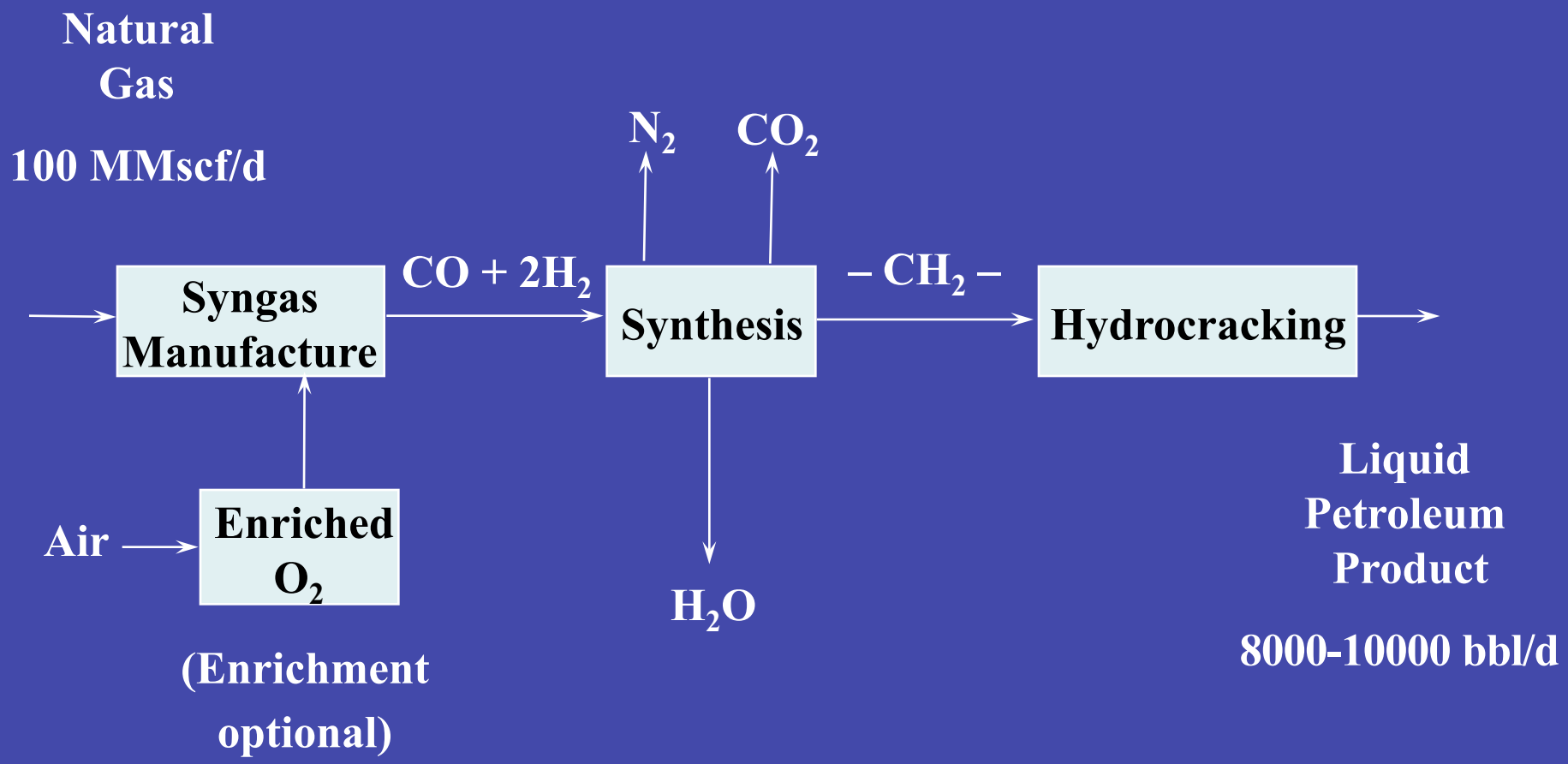
Ref. OG&J (May 15, 2000), p.64

GTL

Gas-to-Liquids

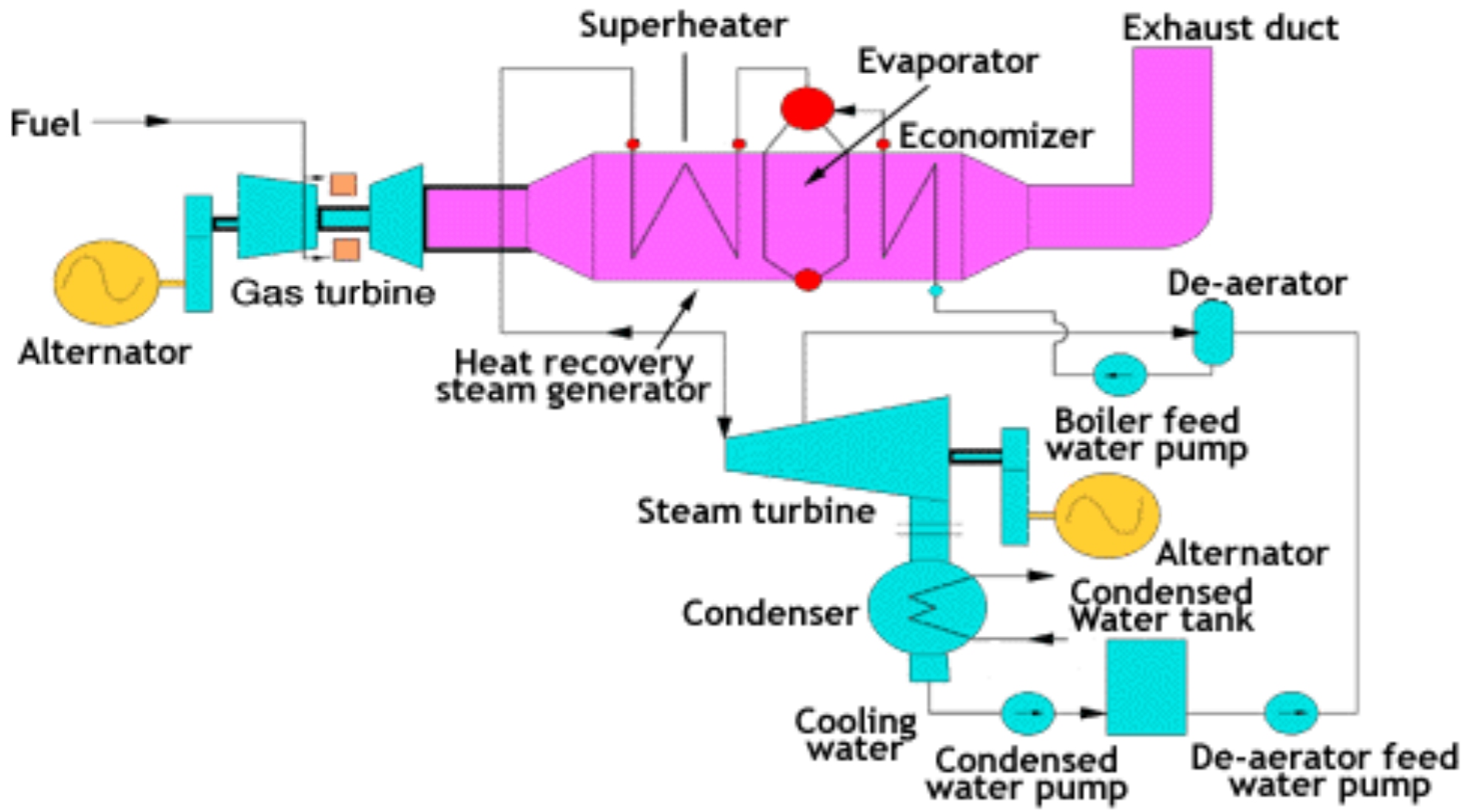
(what kind of liquids?)

Gas to Liquid

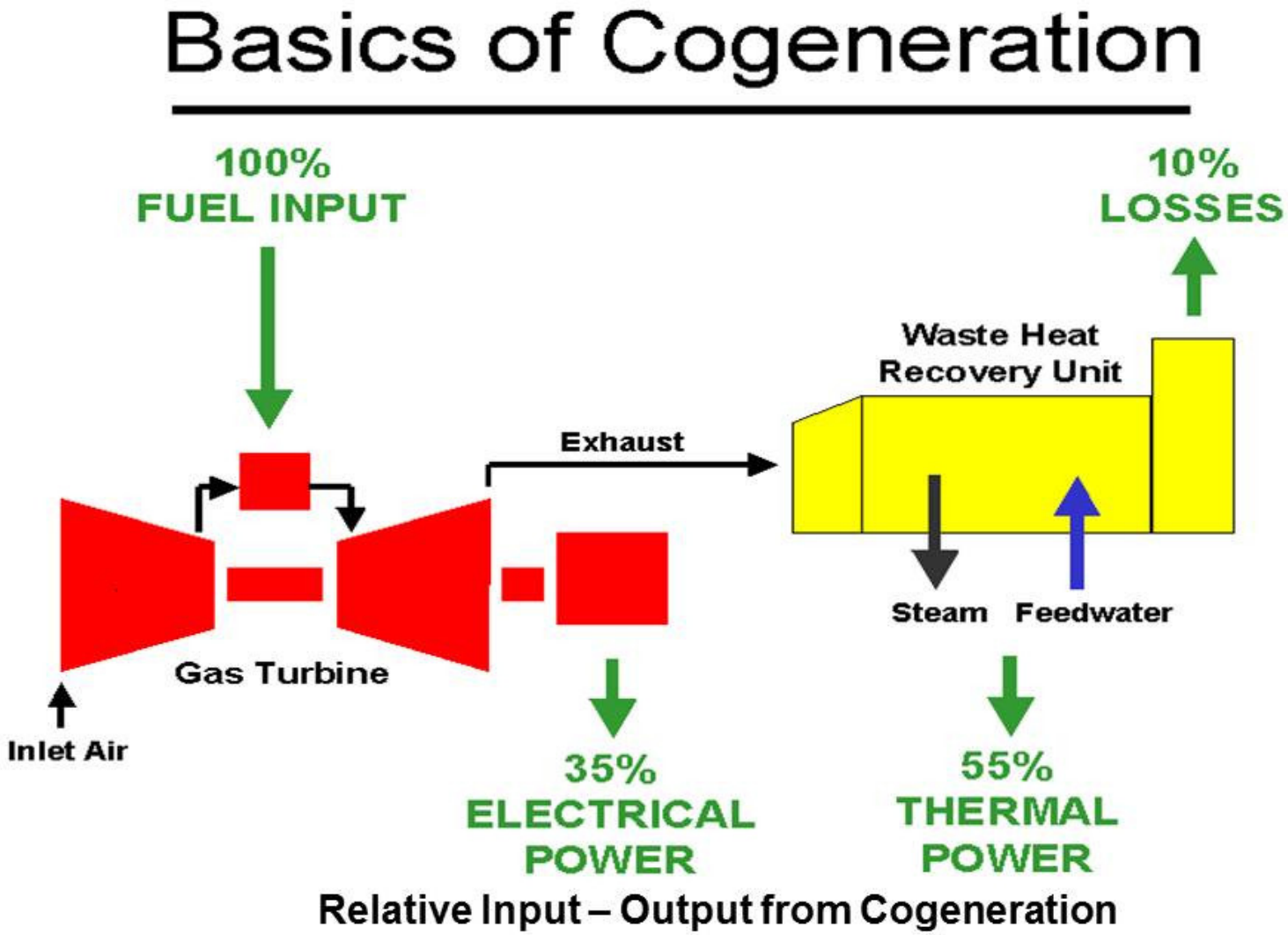


McClain Power Generation Plant

Combined Cycle
Single Pressure-No Reheat



Cogen with Heat Export



LNG as Transportation Fuel

LNG Fueled Support Vessel

LNG Powered Locomotives

Image Courtesy of General Electric

Some Conclusions

1. **LNG industry acts like a pipeline.**
2. **Many similarities to general gas processing, but on very large scale.**
3. **Costs require long-term contracts with credit-worthy parties; the 'LNG Chain.'**
4. **Active growth in Floating LNG.**
5. **New uses as transportation fuel.**

Statoil Snøhvit Plant

1. Europe's first LNG export facility
2. Capacity 4.2mtpa
3. Linde MFC process
4. First shipment October 20, 2007
5. 140km tie-back to subsea templates
6. CO_2 sequestration

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LNG - an Overview

The End

Thank you

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