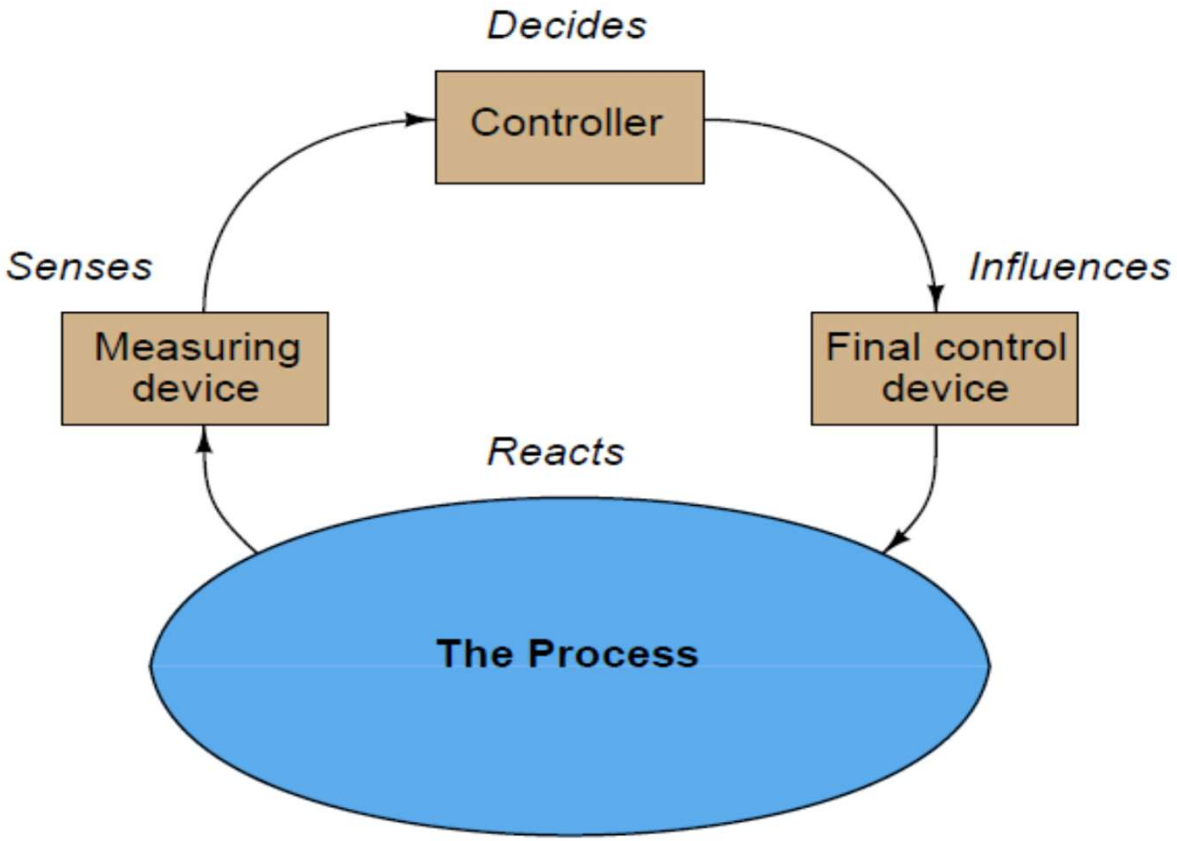
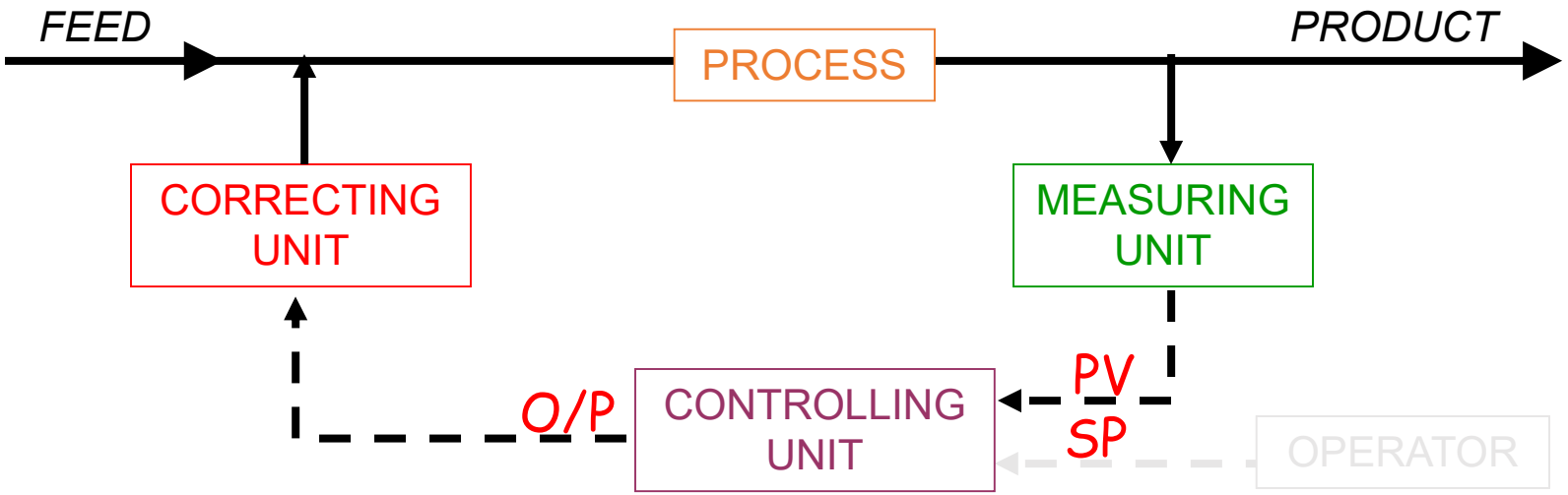
Oil & Gas Industry – Overview and Key Applications

Murali Krishnan T

OVERVIEW OF A PROCESS CONTROL LOOP

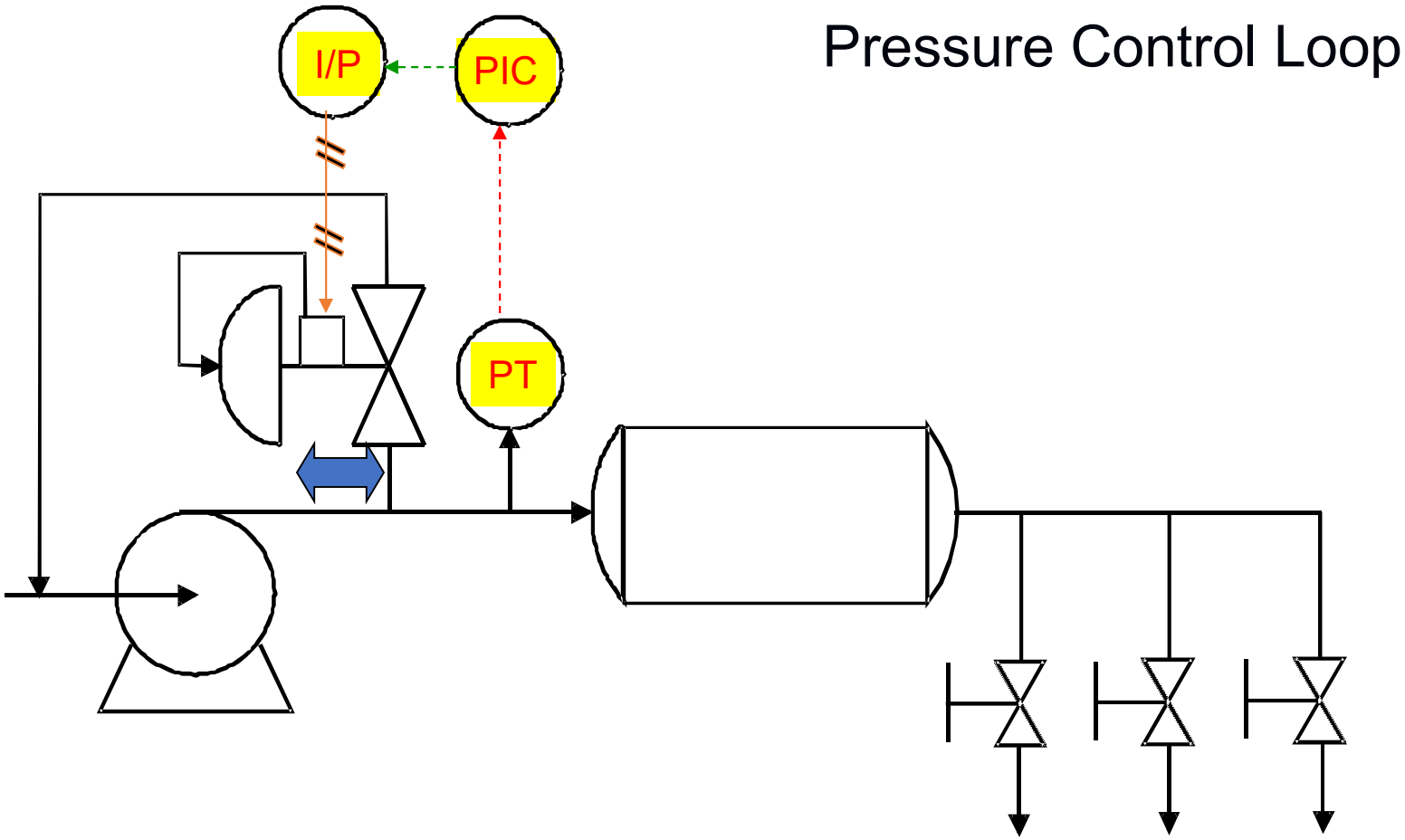


Control Principle



Control theory can be encapsulated as the matching of a measured variable (PV) to the plant requirement (SP).

Basic Control Loop



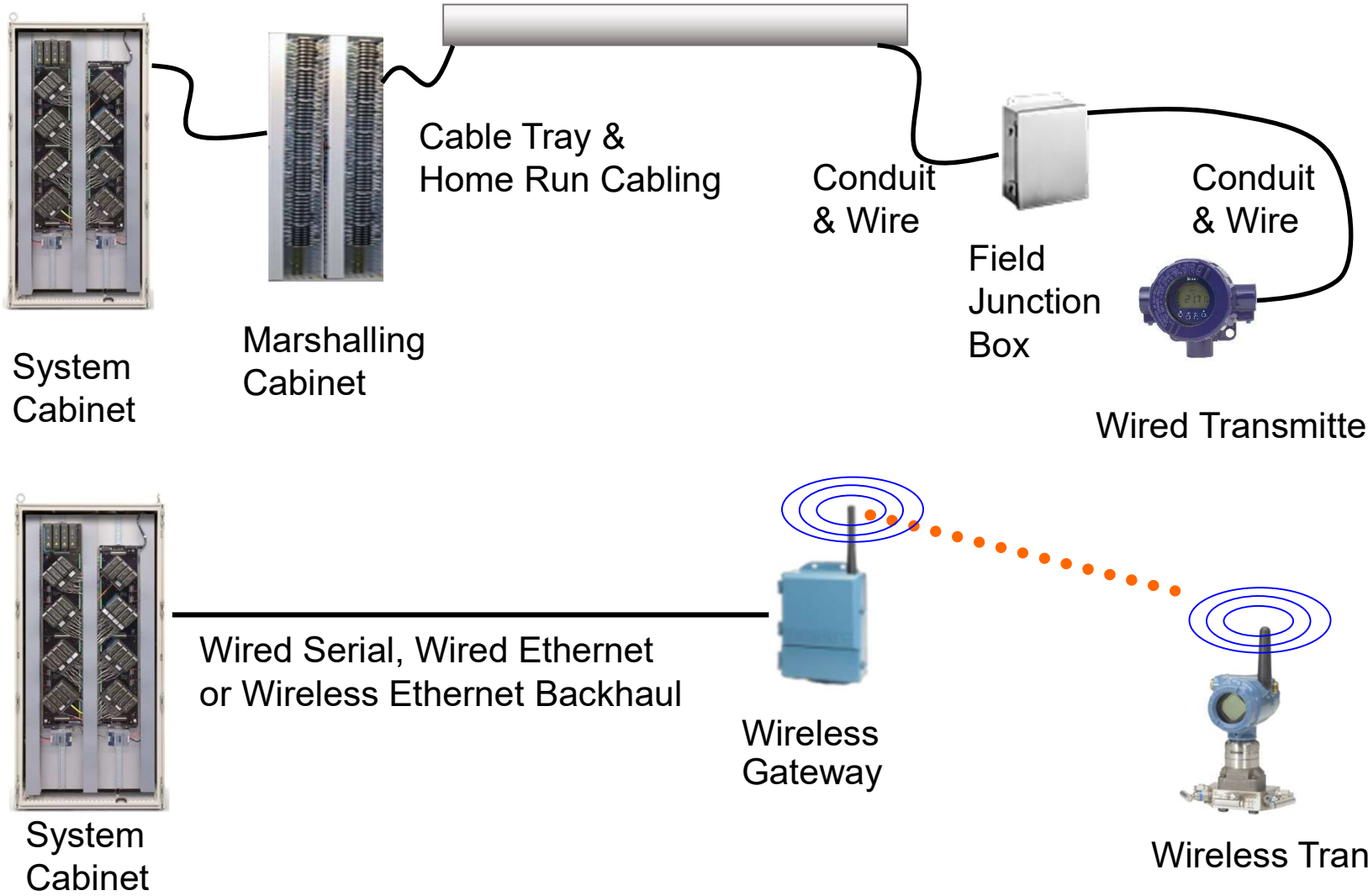
MEASURING ELEMENTS (SENSORS):

- PRESSURE
- LEVEL (DP, RADAR)
- FLOW (Orifice DP, Coriolis, Vortex, Magnetic, Annubar DP, Venturi DP)
- TEMPERATURE (Thermocouple, RTD)
- MACHINE POSITION, MOTION or ACCELERATION
- CHEMICAL CONCENTRATION SUCH AS pH, CONDUCTIVITY, O2, CO2, HC MEASUREMENT

FINAL CONTROL ELEMENTS:

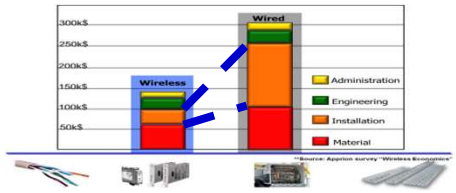
- CONTROL VALVES (Globe, Rotary, Ball)
- ON/OFF VALVES (Ball, Butterfly)
- MOVs
- ELECTRIC MOTORS
- ELECTRIC HEATERS, COOLERS ETC

Wired and Wireless Communication Methods Overview



Benefits of Field Wireless

- Reduce Capital Savings
  - Wire material, Labor, Conduit, Junction boxes, Drawings, etc.



- Reduce Operational Expenses
  - Less maintenance, less downtime, higher productivity, easy modification/expansion

- Improve Safety and Production quality
  - Easy to increase or move monitoring points
  - Reduce difficult or impossible monitoring points like limited space, long distance, dangerous atmosphere

Wireless Typical Applications

Wireless **Field Networks**

Typical Applications:

1. Difficult Process Monitoring
2. Rotating Equipment
3. Environmental
4. Auxiliary Systems (Pump, HE)
5. Operator Safety
6. On/Off Valve Position
7. Process Startup
8. Temporary Installations
9. Wired Alternative

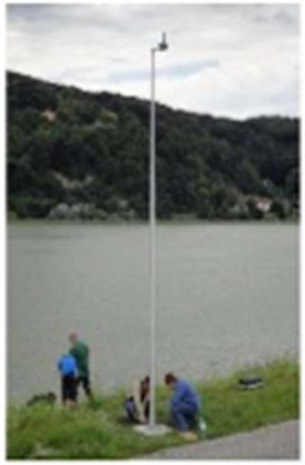
Wireless **Plant Networks**

Typical Applications:

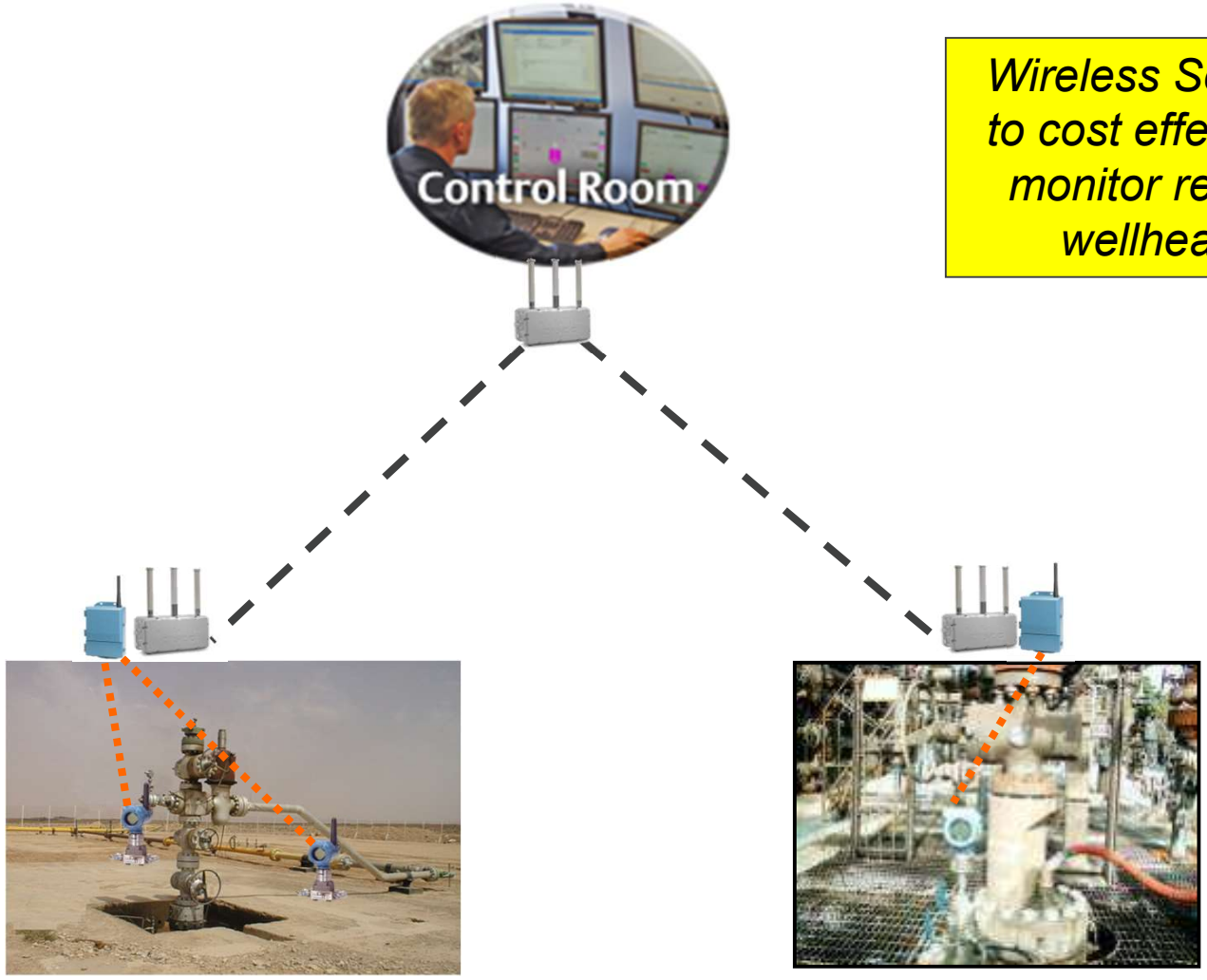
1. Field Data Backhaul
2. Mobile Worker
3. Video - Security
4. Video - Process
5. Location Tracking
6. Safety Mustering

Remote



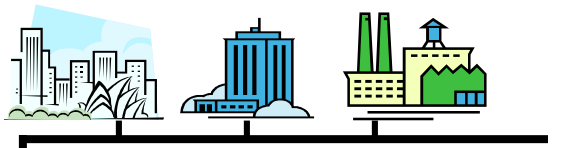




Continuously Monitor Remote Wellheads



Wireless Solution to cost effectively monitor remote wellheads

The Oil & Gas Supply Chain



Natural Gas

UPSTREAM

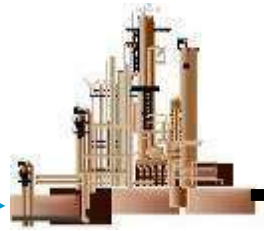
O&G Production

- Crude oil
- Raw natural gas

DISTRIBUTION

Transportation & Distribution

- City gates
- Industry gates
- Power gates



MIDSTREAM

Natural Gas Processing

- Natural Gas
- Liquefied Natural Gas
- Liquefied Petroleum Gases
- Natural Gas Liquids

OIL FIELD SERVICES

Well Related Service

- Drilling
- Completion
- Treatment

Natural Gas / Crude Pipelines, Storage & Hubs

DOWNSTREAM

Crude Oil Refining

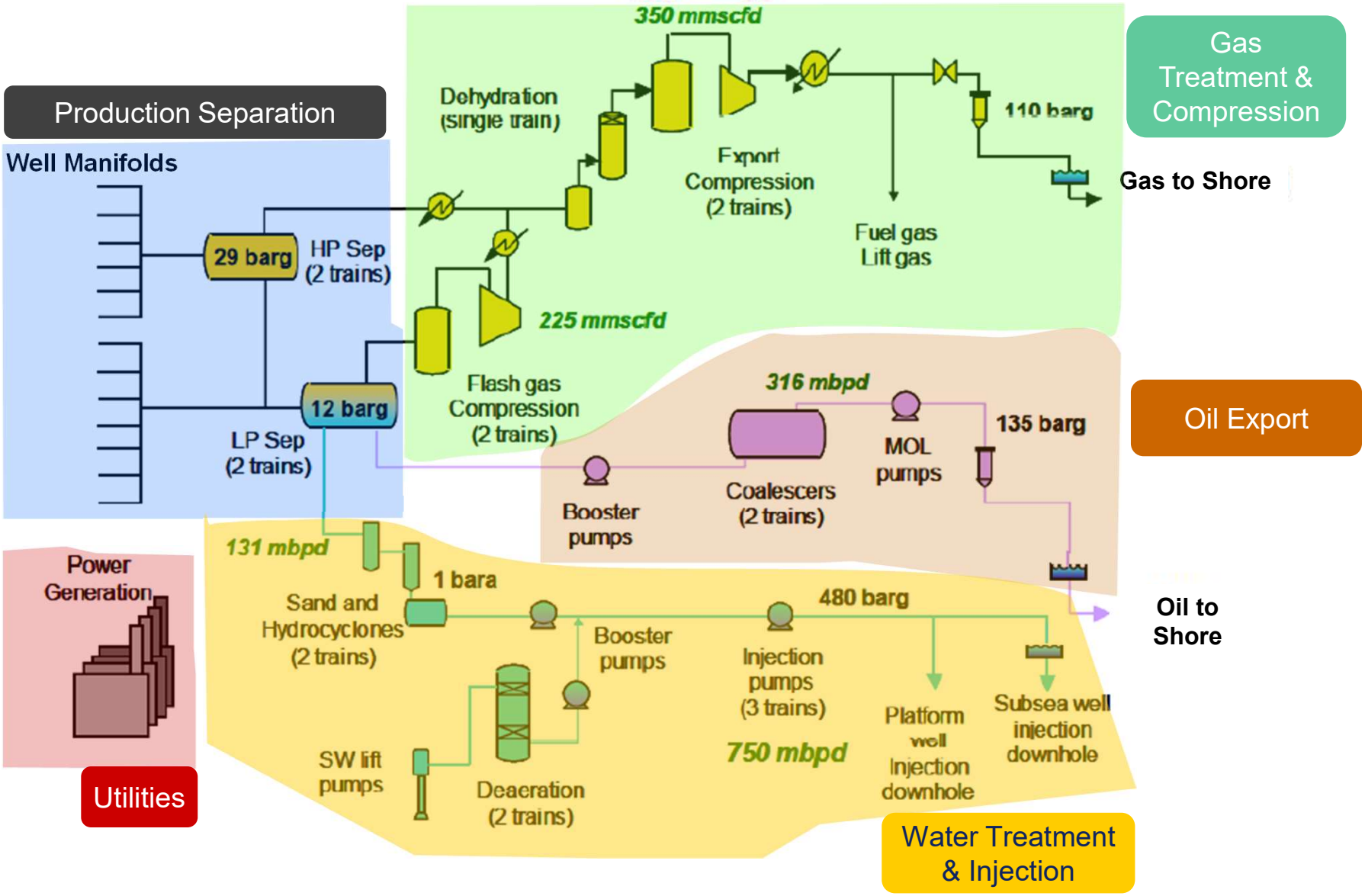
- Gasoline
- Diesel
- Lubricating oils
- Petrochemicals

Crude Oil

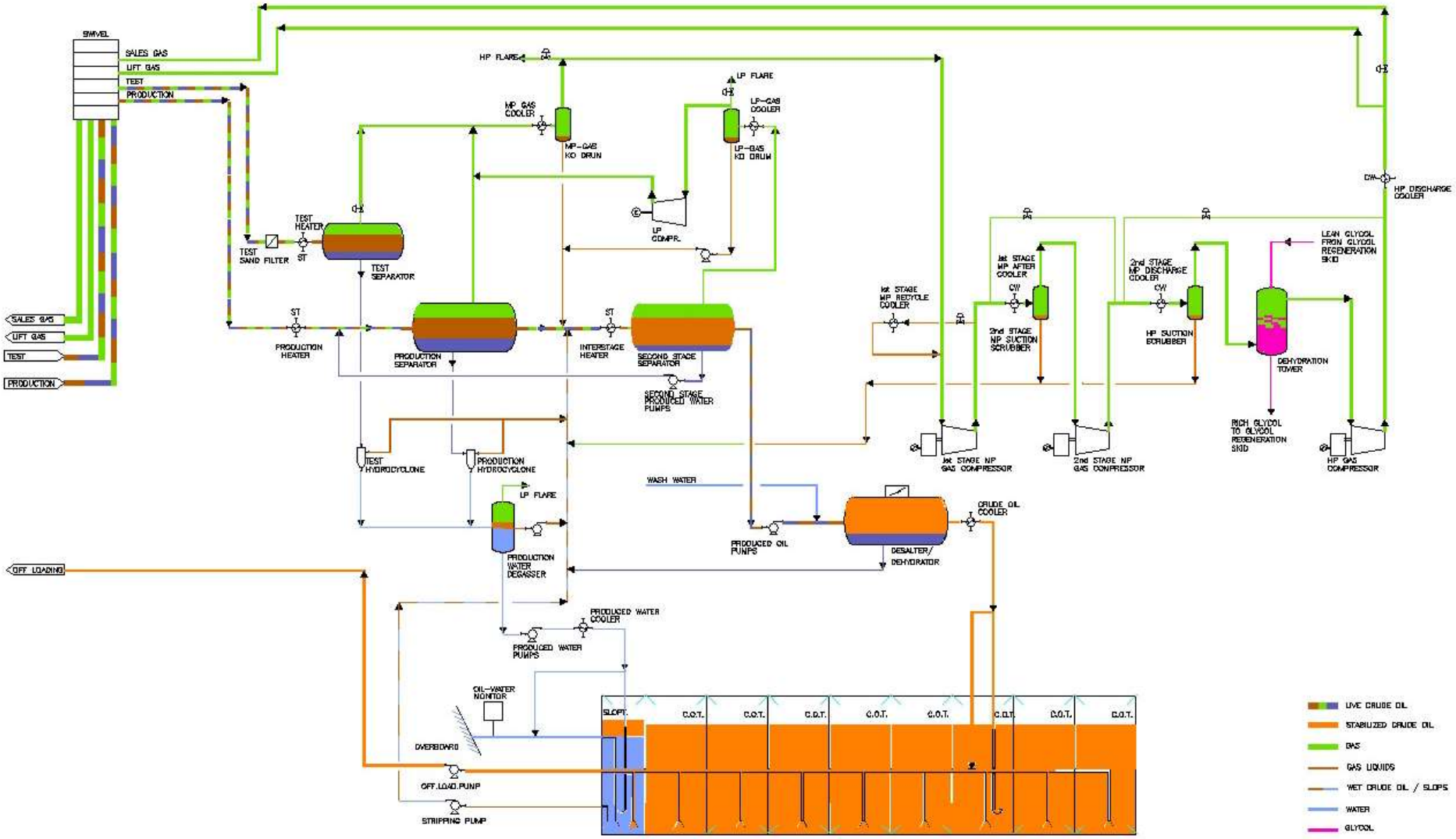
Oil – Key Terms

- Barrel (traditional measure of refining feed and product volumes) – 42 gallons
- Crude Oil – Petroleum as pumped out of the ground after gas, sand and water removal
- API Gravity: The American Petroleum Institute scale for expressing specific gravity of oil.
  - API = (141.5 / Specific Gravity) – 131.5
- Sour – Significant H2S/ Sulfur present; Sweet – lower amounts of H2S/ Sulfur

Offshore Process Overview



Offshore Platform/FPSO Process – PFD

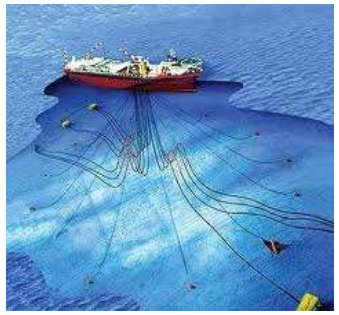


Types of Facility Structures - Offshore

- Offshore installations can be **simple** wellhead platforms with wells coming onto the platform as “Dry Trees” and no processing
- Offshore installations can also be **complex facilities with full separation and treatment processing with multiple wells coming onto the platform as “Dry Trees”**
- Offshore installations can also be **manned** or **unmanned**, they can be **fixed to the seabed, floating or be under the sea or subsea**
- Offshore installations can be **subsea**, where all of the wells are installed as “Wet Trees”, meaning they are under the water on the seabed, processing facilities will also be installed subsea as well

TLP

FPSO



Spar (cylindrical)

Subsea

Piled

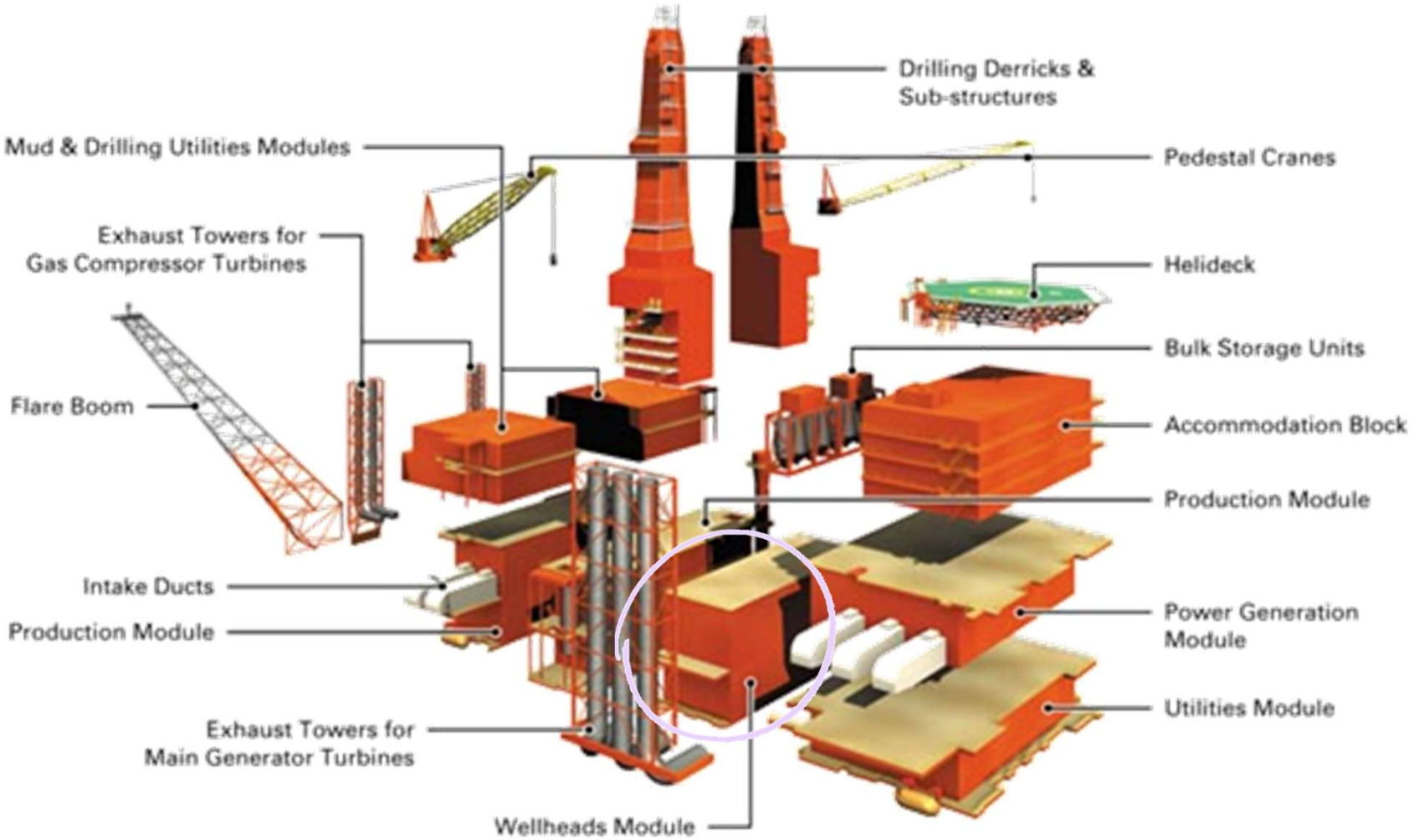
Semi-Sub

Different Types of Offshore Vessels

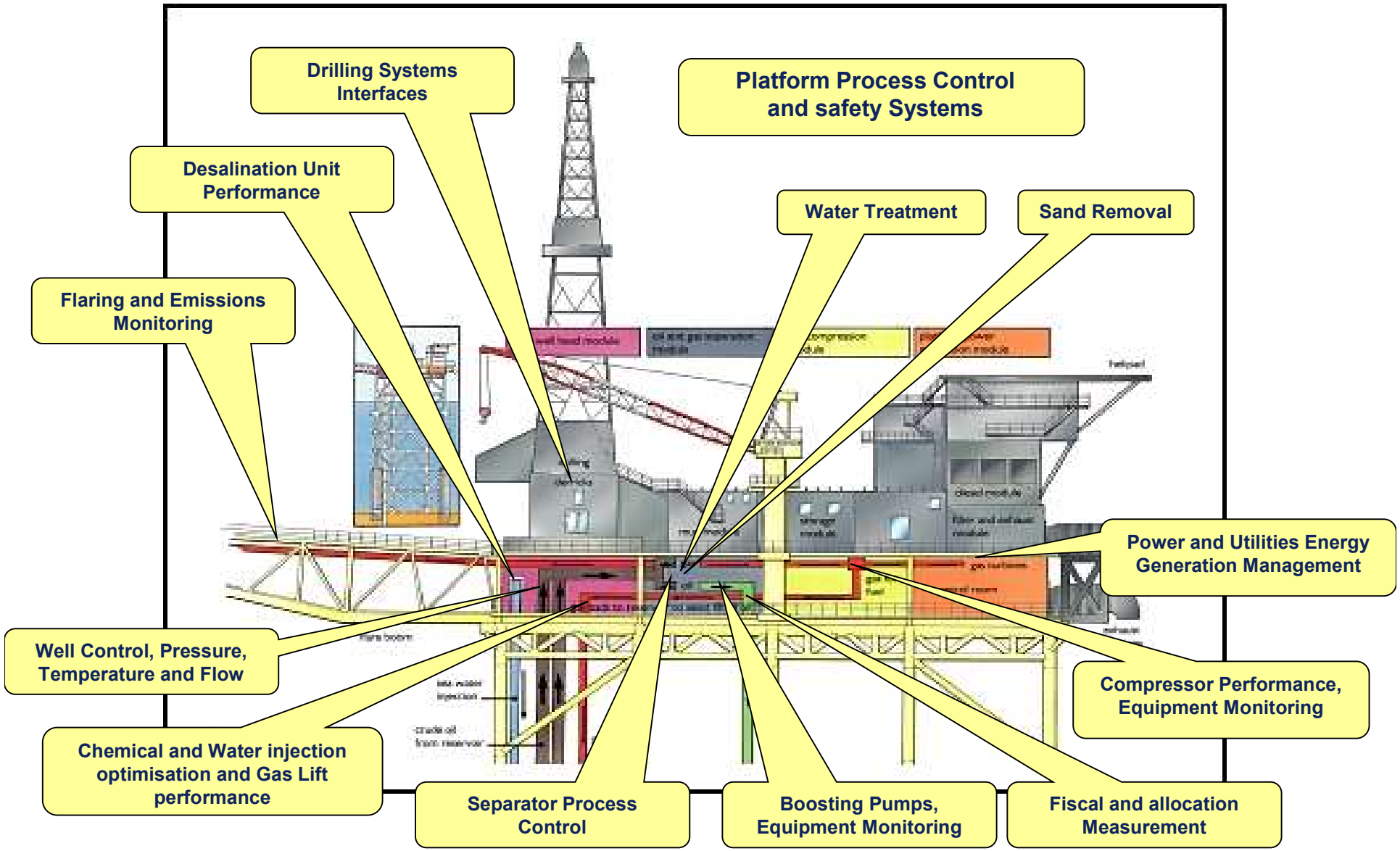
Denomination	Acronym
Drillship	
Floating Production Unit	FPU
Floating Production, Storage & Offloading	FPSO
Floating Storage Unit *	FSU
Floating Storage and Regasification Unit *	FSRU
Floating Storage & Offloading *	FSO
Floating Liquified Natural Gas	FLNG
Liquified Natural Gas *	LNG
Crude Oil Tankers *	

*** Dedicated Midstream vessels, i.e. not used for Exploration or Production**

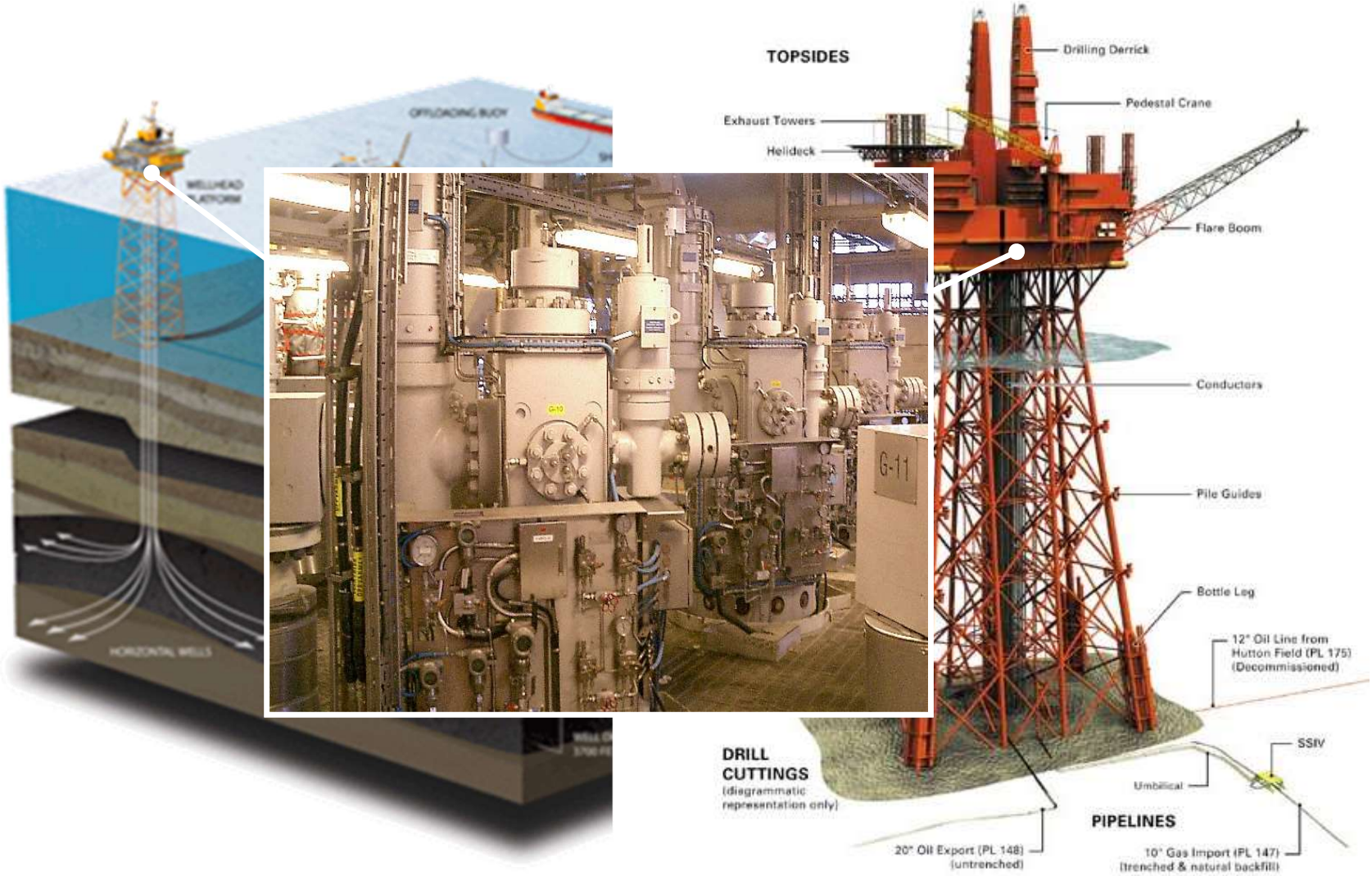
What is an Offshore Oil & Gas Platform?



Process Control Systems

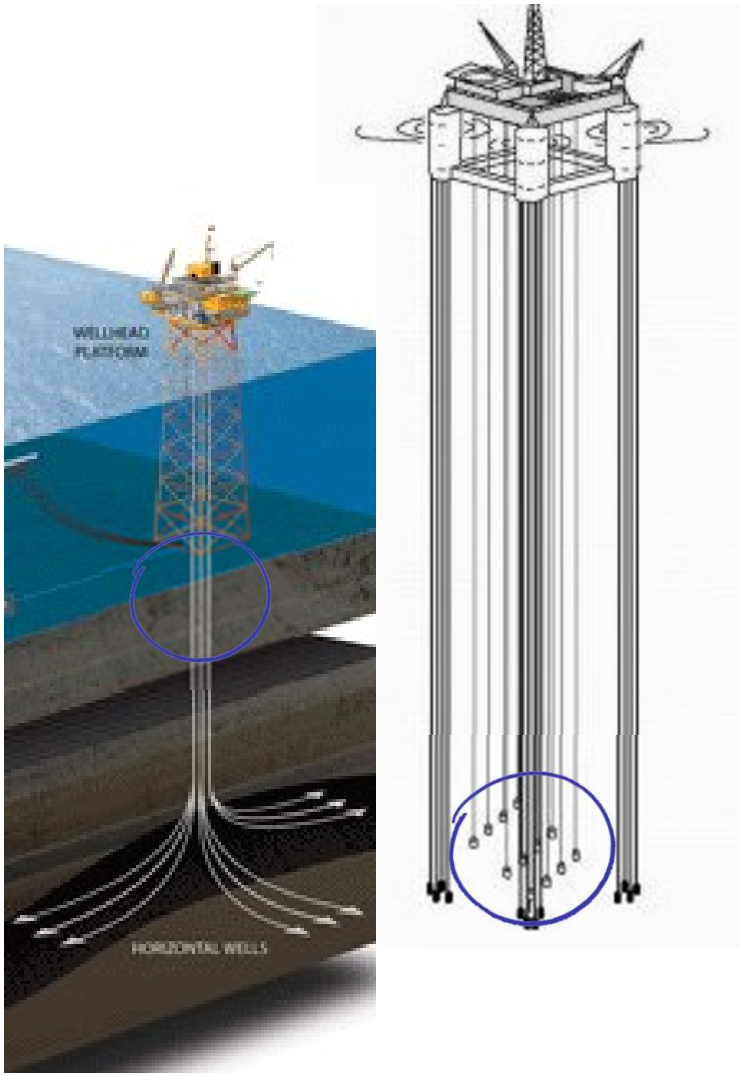


Traditional Offshore Development – Wellheads are Topside ("Dry" Trees)

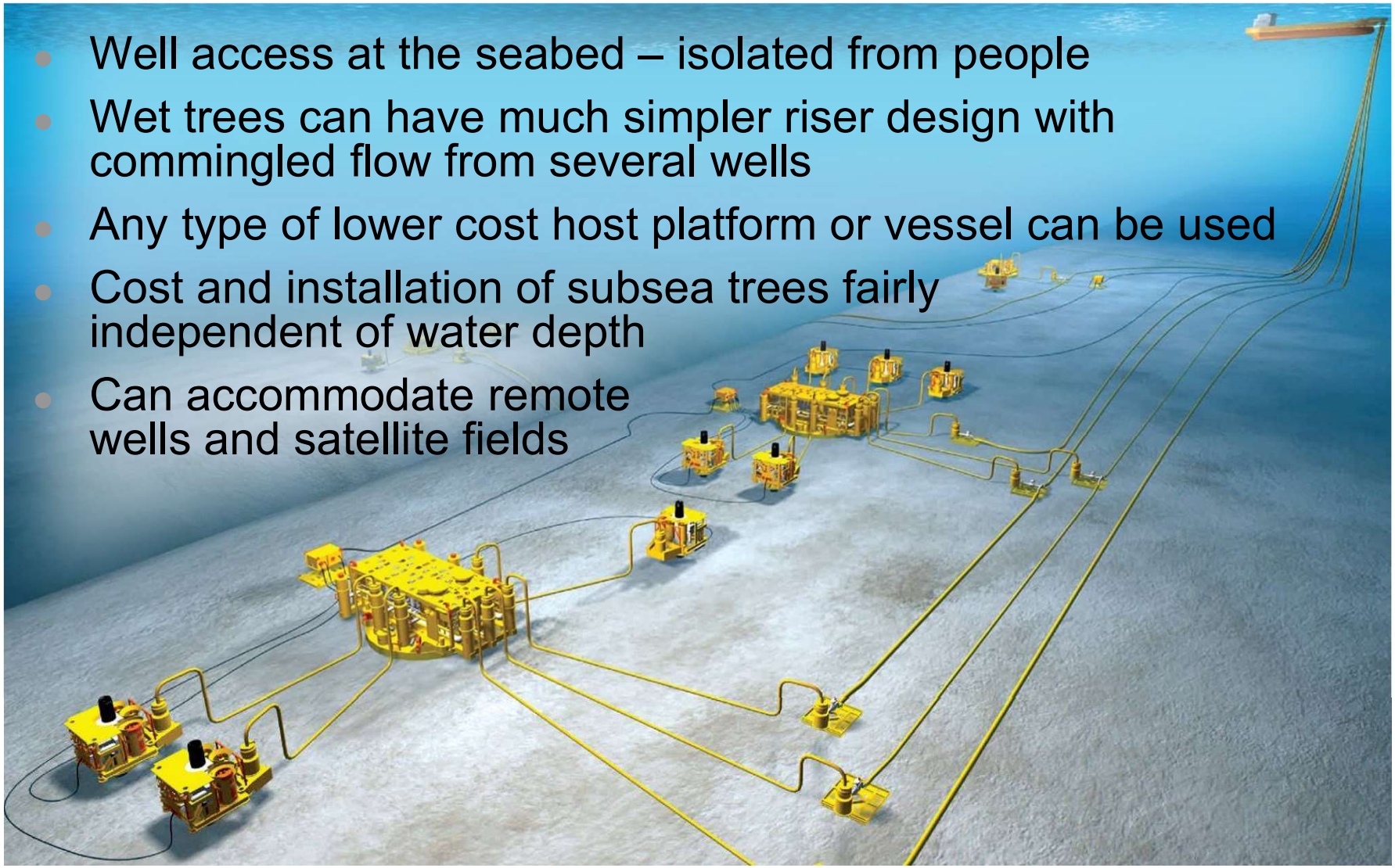


Why Subsea Production – Limitations of Dry Trees

- **Safety concern due to well access at surface**
- Dry trees require complex riser designs
- When water is too deep for fixed platforms, dry trees require high cost platforms such as Spar or TLP due to sensitivity to motions
- Move to deeper waters causes dry trees to be less economical
- Dry trees are only feasible when all wells can be drilled from a single location or within limited reach from the host platform



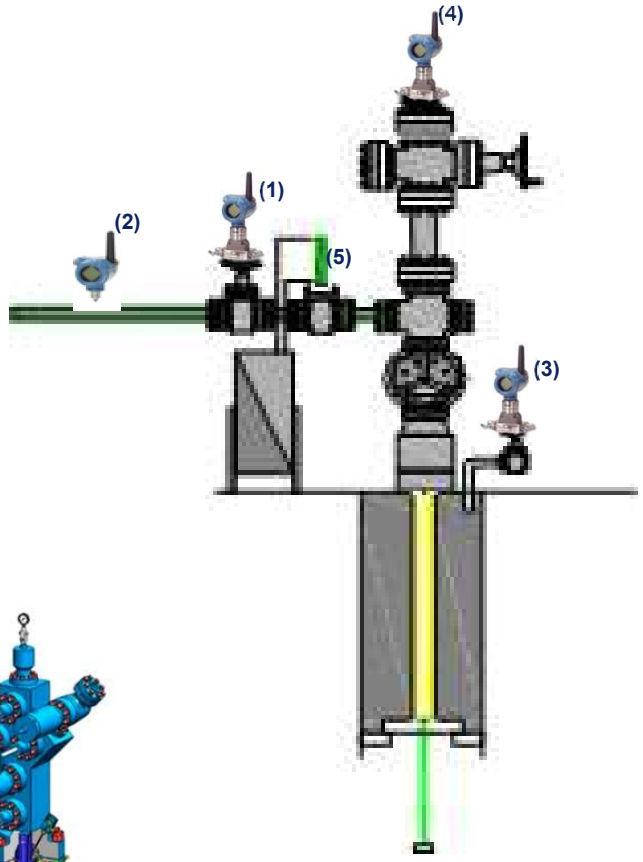
Why Subsea Production – Benefit of Subsea Trees

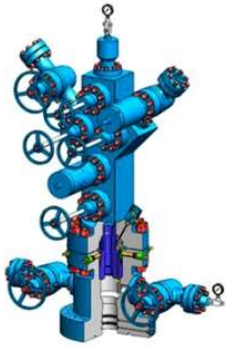


Oil or Gas Production Well

- *Initially a well will produce oil or gas under it's own pressure.*
- *Instrumentation can be located at the following potential measurement points:-*
  - *Flowline Pressure (1)*
  - *Flowline Temperature (2)*
  - *Casing Pressure (3)*
  - *Wellhead Pressure (4)*
  - *Bradenhead Pressure*
  - *System Safety Valve (SSV) (5)*
- *All the instrumentation can be wired or wireless. Data from the transmitters can be sent to DCS or SCADA system.*

Schematic of a Christmas Tree / Wellhead

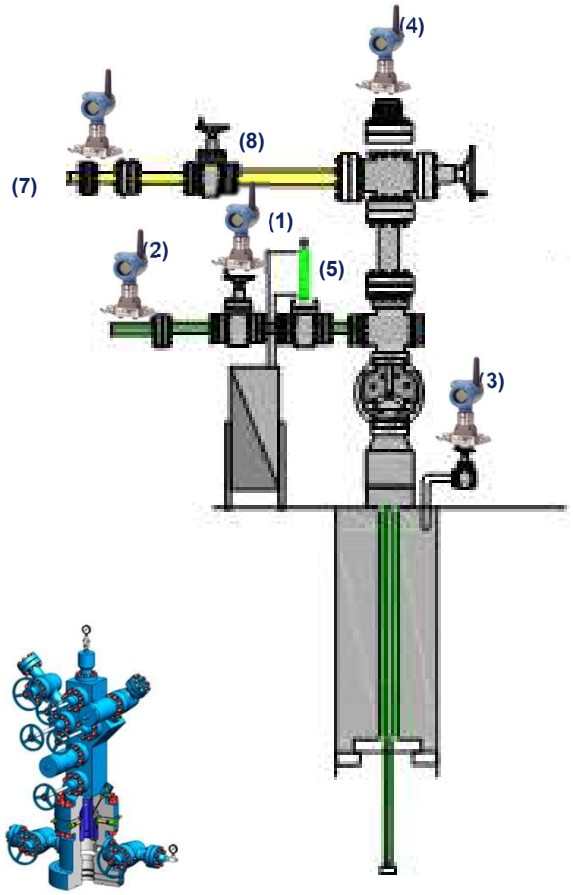




Actual Christmas Tree / Wellhead

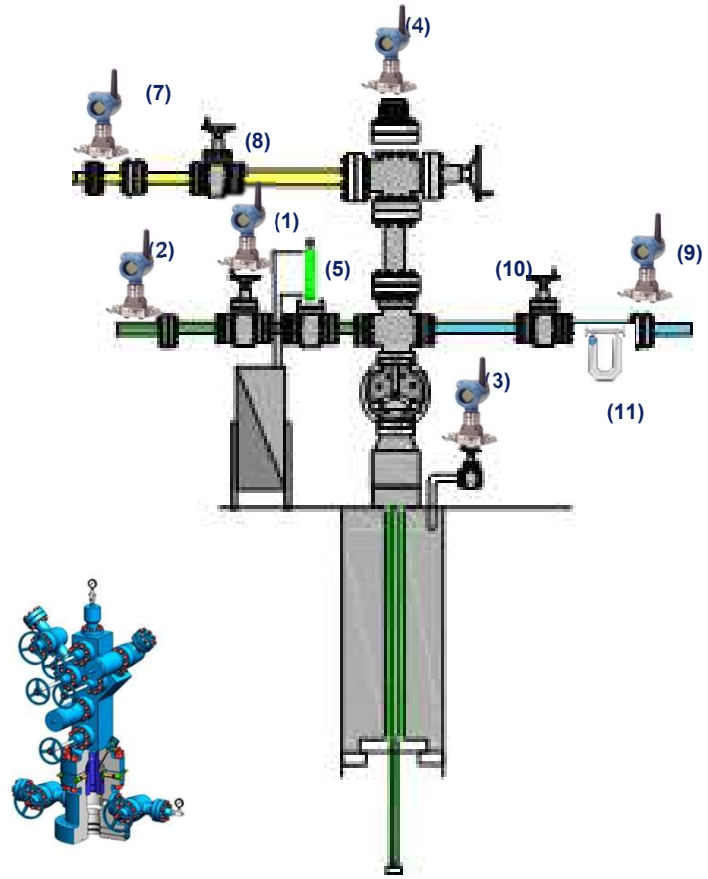
Oil Production Well with Gas Lift (GL)

- *When there is insufficient pressure for the well to produce on it's own, gas is injected through the annulus to lift oil from the well.*
- *Instrumentation can be located at the following additional measurement points:-*
  - *Flowline Pressure (1)*
  - *Flowline Temperature (2)*
  - *Casing Pressure (3)*
  - *Wellhead Pressure (4)*
  - *Bradenhead Pressure*
  - *System Safety Valve (SSV) (5)*
  - *Gas Lift Pressure (7)*
  - *Gas Lift Temperature (7)*
  - *Gas Lift Differential Pressure (7)*
  - *Choke Valve (8)*
- *All the instrumentation can be wired or wireless. Data from the transmitters can be sent to DCS or SCADA system (6).*



Oil Production Well with Gas Lift and Chemical Injection

- *Chemical Injection is periodically used on wells The injection of various chemicals, usually as dilute solutions, have been used to improve oil recovery.*
- *Instrumentation can be located at the following additional measurement points:-*
  - *Flowline Pressure (1)*
  - *Flowline Temperature (2)*
  - *Casing Pressure (3)*
  - *Wellhead Pressure (4)*
  - *Bradenhead Pressure*
  - *System Safety Valve (SSV) (5)*
  - *Gas Lift Pressure (7)*
  - *Gas Lift Temperature (7)*
  - *Gas Lift Differential Pressure (7)*
  - *Choke Valve (8)*
  - *Chemical Inj. Pressure (9)*
  - *Chemical inj. Differential Pressure (9)*
  - *Chemical inj. Choke Valve (10)*
  - *Chemical inj. Flow (11)*
- *All the instrumentation can be wired or wireless. Data from the transmitters can be sent to DCS or SCADA system*



Wireless Improves Offshore Topsides Wellhead Production Allocation

CHALLENGE

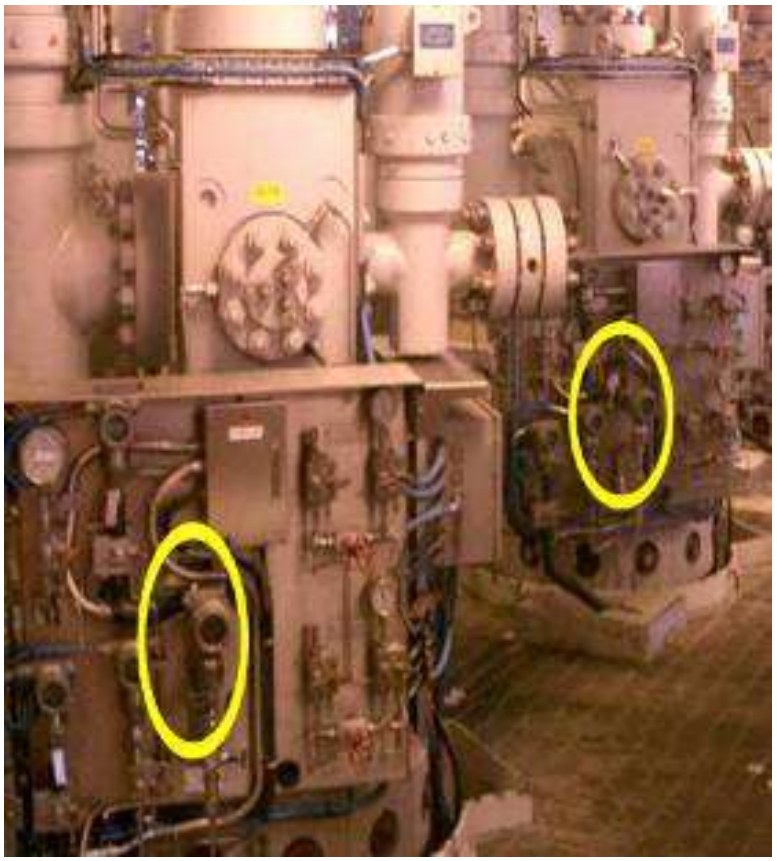
- *Manual collection of key process parameters*
- *Conventional methods require high installation and maintenance costs*

SOLUTION

- *Wireless*
  - *Proven measurement technology*
  - *Pressure, Temp, Level, Flow, Discrete*

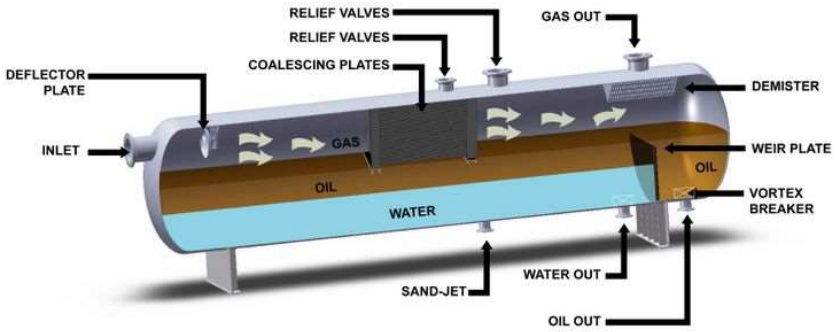
RESULTS

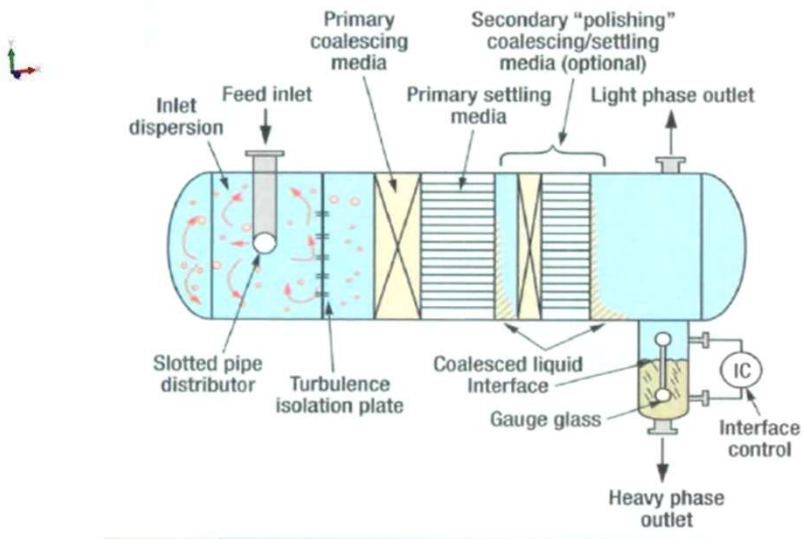
- *Decreased CAPEX & Operational Costs*
- *Lower Safety risks through online Casing pressure monitoring*



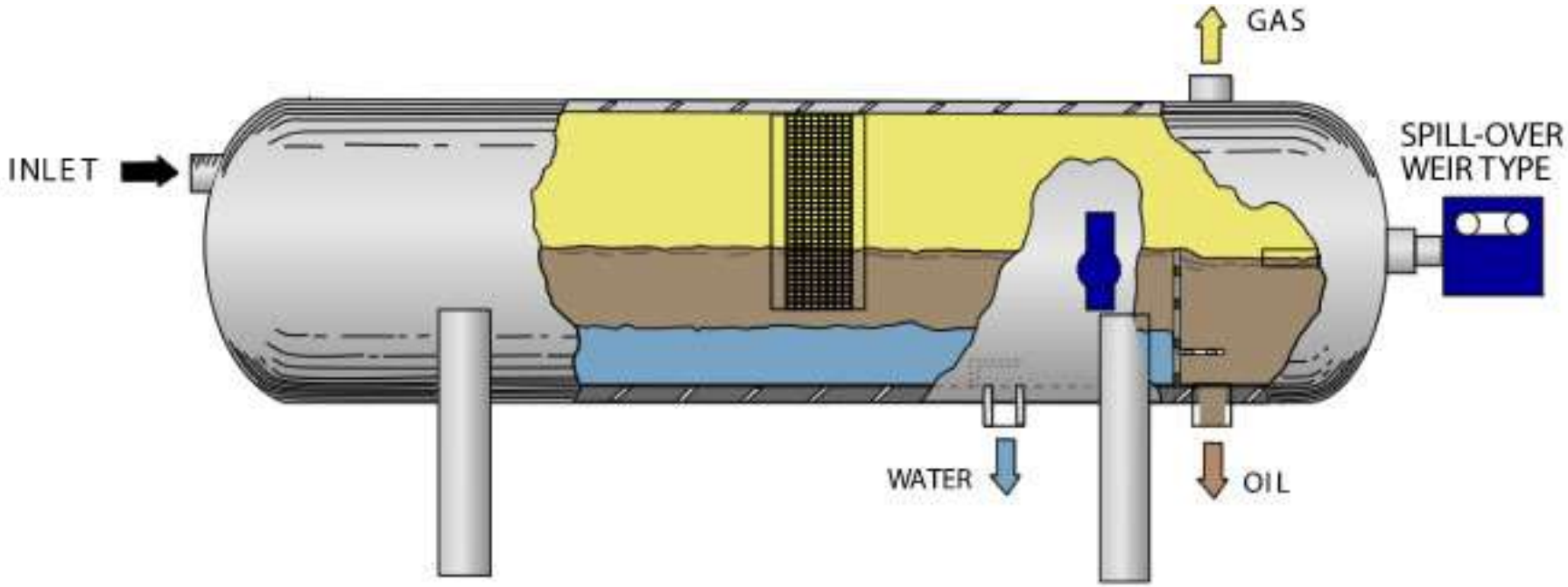
Production Management - Separation

- *Typically Offshore Hydrocarbons will be received at a High Pressure Manifold or a Low Pressure Manifold for transfer to the separation trains. A separation train will consist of a HP separator which will be two phase (Gas & Liquids) and a LP separator which will be three phase (gas, Oil & water), There may be one or multiple trains*
- *The primary function of separator technology is to separate produced fluids from a production well into their individual components of oil, natural gas and water*
- *This allows the flow or production rate of the individual component streams to be measured, providing essential information on the quantity of fluids produced from each well in the field.*



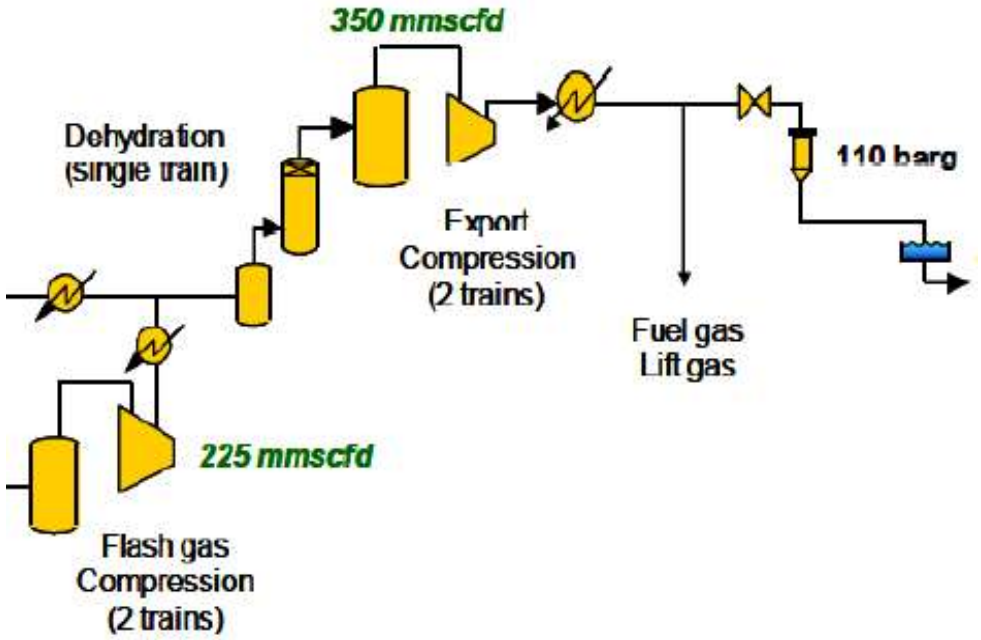


Offshore Platform/FPSO Process – Separation



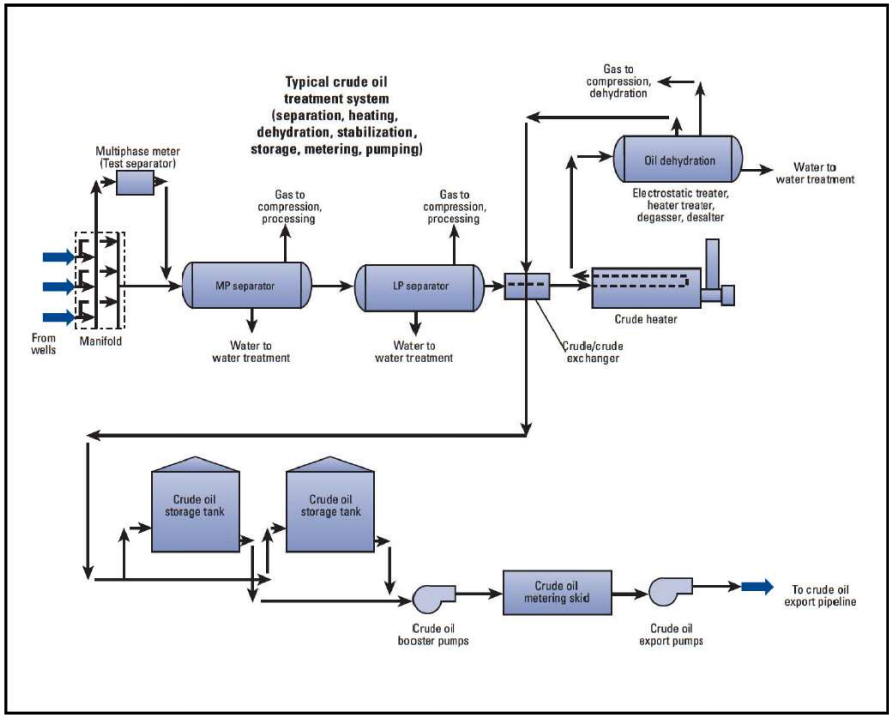
Gas Treatment and Compression - Compression

- *Typically gas removed from the HP Separator will be treated prior to export , this will require gas cooling and dehydration to remove water.*
- *Gas removed from the LP separator will be cooled and compressed via the flash gas compression before being co-mingled with HP gas before dehydration.*
- *Dehydration will involve the use of glycol to remove any residual moisture to prevent hydrate formation and corrosion within the gas export pipeline system.*
- *Following dehydration the gas will be compressed for export*



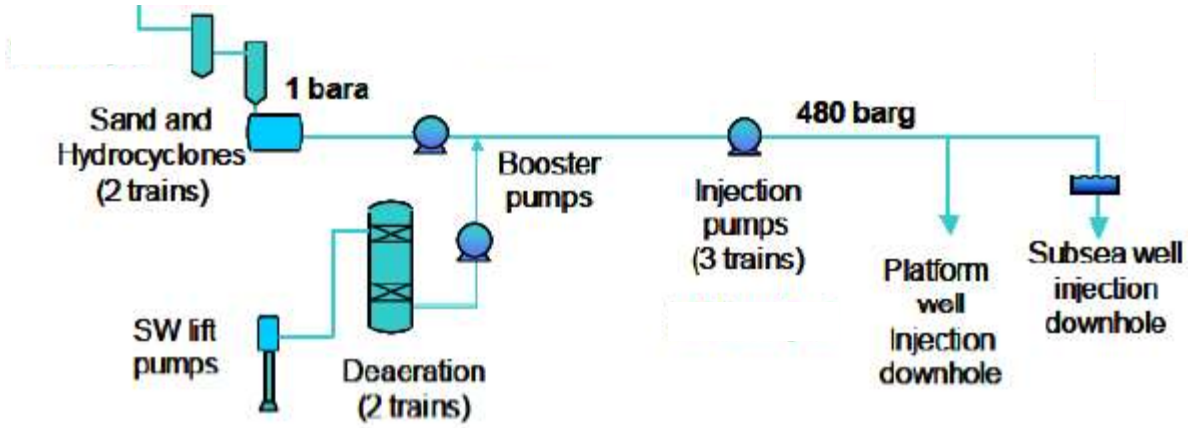
Oil Treatment and Storage – Crude Oil Treatment and Stabilization

- *Treatment, Stabilisation and Storage of Crude Oil involves three process objectives*
- *Crude oil is separated so that it is free of emulsified water or brine and any entrained solids (primarily sand)*
- *Crude oil is stabilised to transform it from "Live" to "Dead", basically by removing any dissolved natural gas to the extent required so that the oil can be safely stored and transported*



- *Stabilisation is achieved by passing the crude oil through pressure reducing separators to remove water and gas, oil is then passed through a heater / treater unit and a dehydration unit to remove further gas and water before it can be safely stored and transported.*
- *Storage offshore can either be via tanks on the seabed where dead crude is stored before export or with FPSO's this is on tanks onboard the vessel or in a FSO which is floating, storage and offloading vessel.*

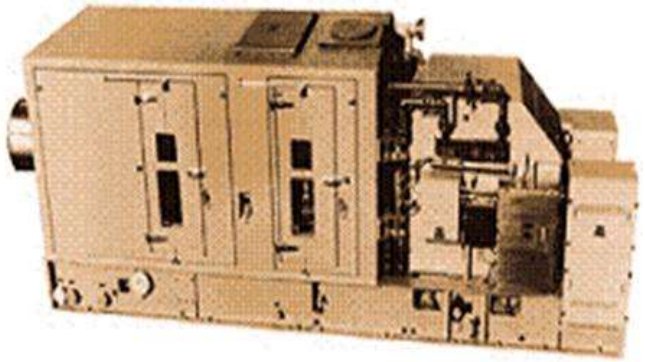
Water Treatment System



- *Produced water is passed through a sand and hydrocyclones unit, removed sand will be transferred to the sand separation package.*
- *The treated water exiting each of the hydrocyclones will be routed via a degassing drum where any remaining gas will be flashed off and routed to the LP flare system.*
- *The de-gassing drums are fitted with an oil-skimming facility and any oil / oily water is routed back to the LP separator for re-processing.*
- *Lifted seawater is de-aerated, treated with chemicals before re-injection.*

Power Generation System

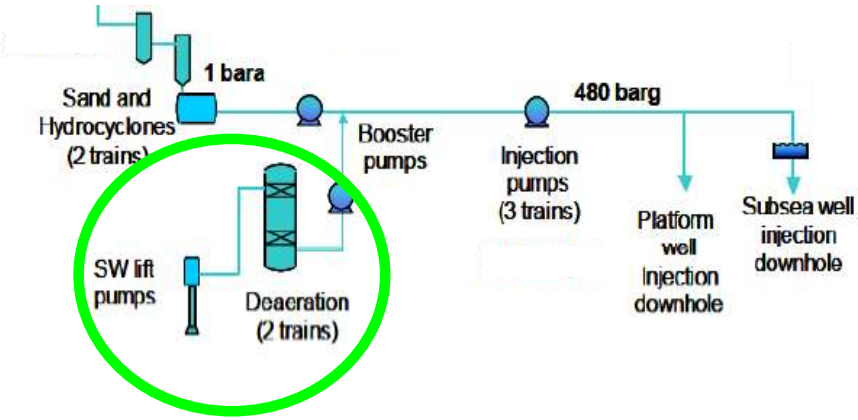
- *The power generation system will provide electrical power for all drilling operations as applicable, production operations and all of the platform utility systems.*
- *The generators will be duel fueled with normal operations being on fuel gas, diesel can be used if fuel gas is unavailable.*



- *Redundancy will be supplied in the form of emergency diesel generators.*
- *A diesel system will also be supplied which supply the cranes, lifeboats and firewater pumps as well.*
- *The diesel will be stored on board in a diesel treatment system, the diesel bunkering is a continuous operation. The system will utilise a coalescing filter that will remove water, salts and particulates from the diesel, these by products will be routed to the closed drain system.*

Seawater System

- *Seawater will be drawn directly from the platform seawater lift pump caissons at a water depth of ~60% below the surface.*
- *Following the lifting and filtration described in the produced water section, a proportion of the water will be treated with an anti-fouling additive to prevent the growth of organic matter.*
- *The anti-fouling system will pulse dose the water for one minute in every five with a copper / chlorine mixture. Once treated the water will be used for the following applications.*



- *Water Injection*
- *HVAC*
- *Living Quarters Ablutions*
- *Drilling Facilities*
- *Fresh Water Generator*
- *Fire Water*
- *Bio-fouling Unit*
- *Sewage Treatment System*
- *Sand Jetting System*
- *Coarse Filter Backwash*
- *Generator and Turbine cooling*
- *Wash-down Facilities*

Firewater System

- *The Firewater system will be powered by diesel driven firewater pumps and will be supplied by seawater.*
- *The system will supply all of the deluge systems, hose reels / hydrants and monitors.*
- *Deluge protection is provided to hydrocarbon processing areas, wellhead / manifold areas and the drilling area*
- *Additives are added to enhance the effectiveness of the deluge systems*

Cooling Medium System

- *The platform cooling system will comprise of separate closed-loop cooling medium systems.*
- *The systems could be an indirect glycol-water cooling system cooled by seawater.*
- *Once used the cooling water will be routed to the water injection system for disposal.*

The systems that require cooling are;

- *Flash Gas Compressors*
- *Main Gas Compressors*
- *Power Generation Turbine Facilities*
- *Turbine Driven Water Injection Facilities*
- *MOL Booster Pumps*
- *MOL Pumps*
- *Air Compressor Package*
- *Export Gas Compressor After Cooler*

Other Platform Systems

Instrument Air and Inert Gas System

- *The system will provide air for use in drilling control process and maintenance and will be provided by oil free air compressors.*
- *Inert gas (Nitrogen) will also be generated on demand by a membrane package using dry compressed air*

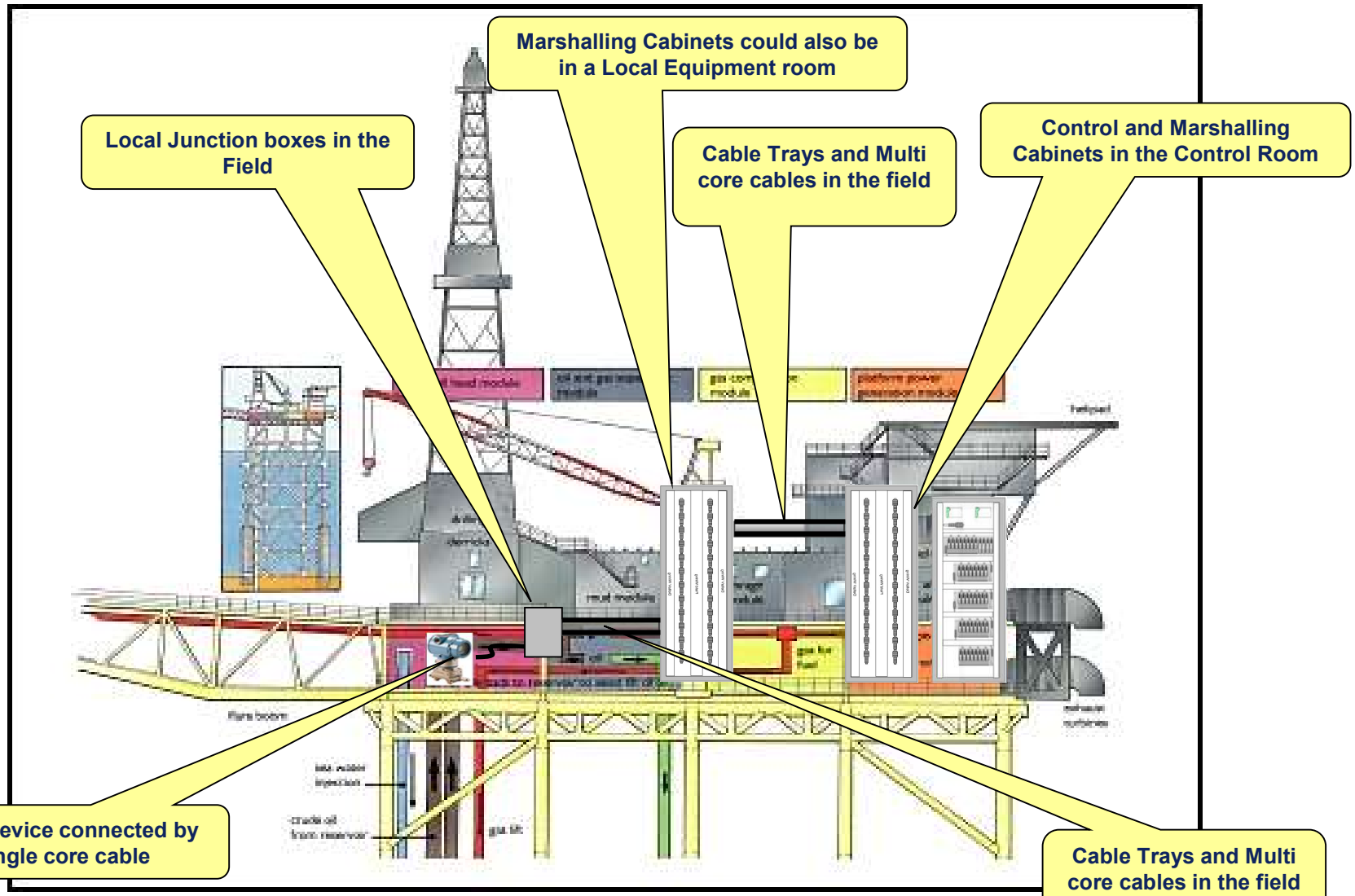
Fresh Water

- *The system will use a reverse osmosis process (RO) to desalinate seawater, Saline affluent will be routed to the seawater discharge system.*

Sewage System

- *Sewage will be collected via the sewage system and be treated in a USG certified MSD system*
- *The package will include maceration and electro – chlorination. Treated sewage will be co-mingled with seawater and untreated laundry water and routed to the seawater discharge caisson.*

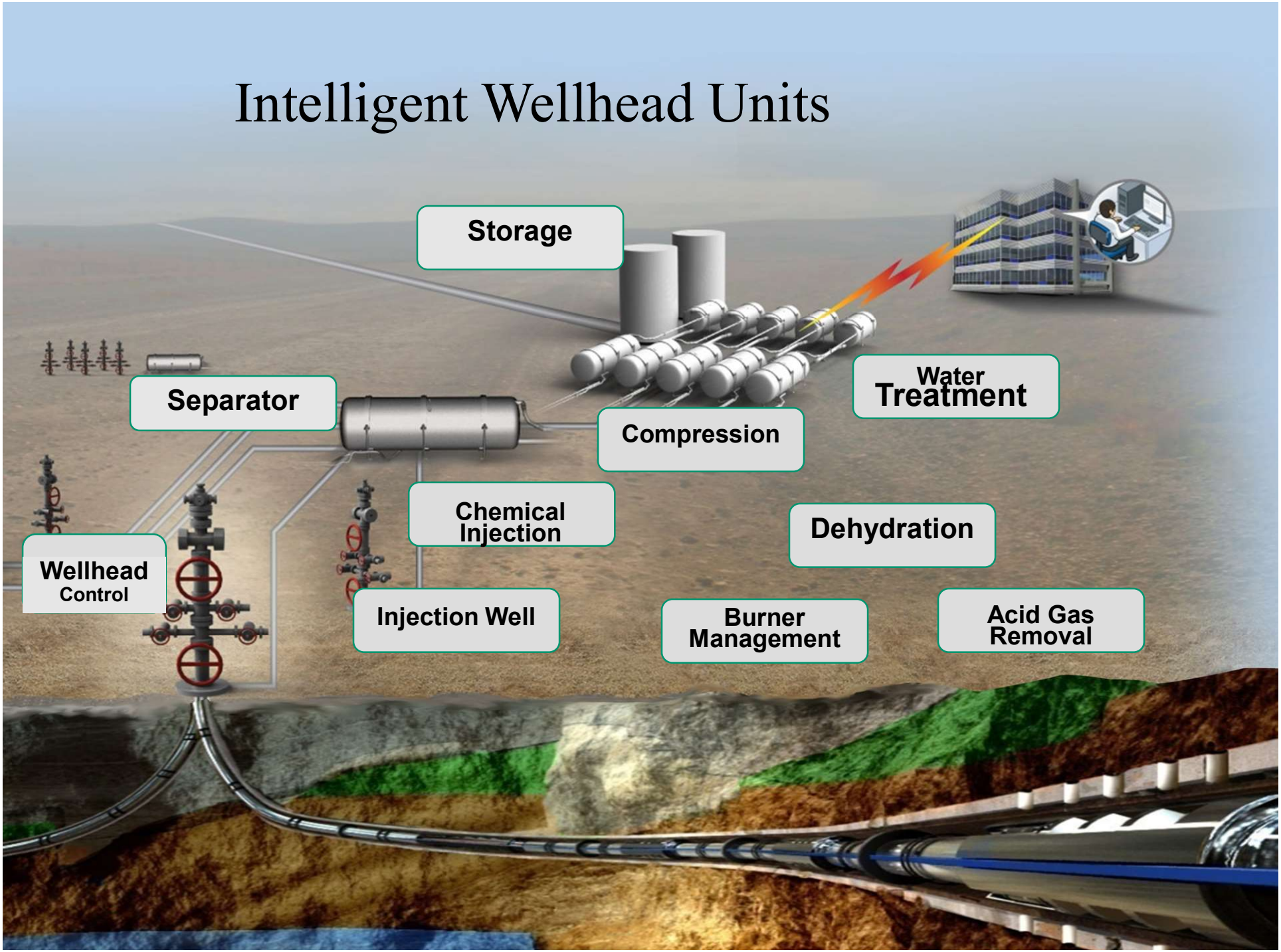
Typical Control System



Custody Transfer

- *Measurement is completed in multiple areas on the platform topsides to ensure that all elements of the production are accounted for;*
  - *Production Wellheads*
  - *Injection Wellheads*
  - *Separators*
  - *Fuel Gas*
  - *Flare Gas*
  - *Export to Pipeline / Tanker*
- *A dedicated measurement system will be built for the export system, on the other measurement areas this will be done by individual flow meters*
- *Measurements will be calculated in a dedicated measurement flow computer system or as a virtual system built into a DCS or SCADA system*

Intelligent Wellhead Units



The Intelligent Field – A Collaborative Environment

Executive KPI's

Onshore Control Room

Onshore Production Office

Offshore Production Office

Integrated Offshore Control Room

The Intelligent Oilfield

Types of Facility Structures - Onshore

- Single Wellhead with or without processing
- Multi Well Well-Pad with or without processing
- Central Gathering Facility with or without processing
- Gas Oil Separation Plant (GOSP)

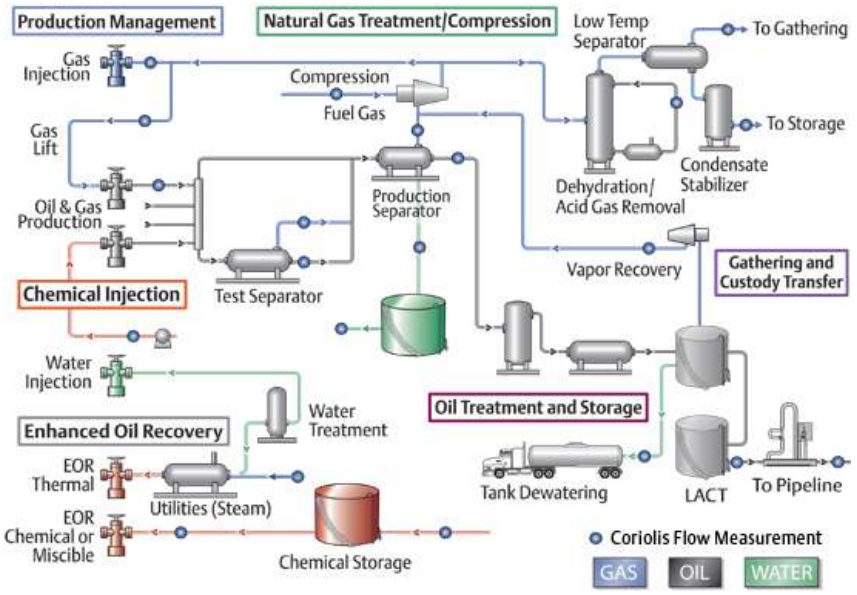
4,000 wells

157 batteries

8 oil storage & treatment

1 gas processing

1 water treatment

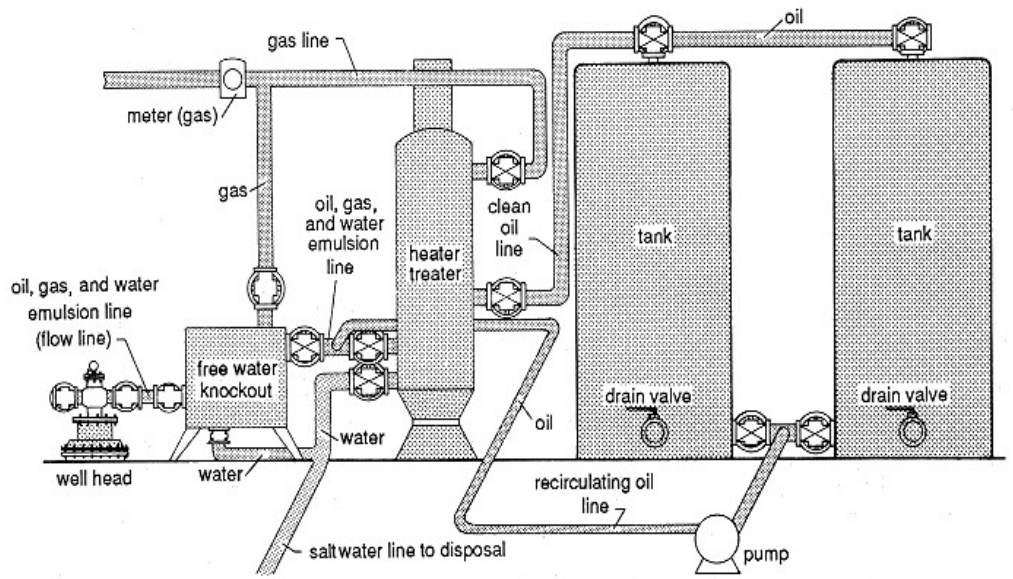


Crude Oil Production Well

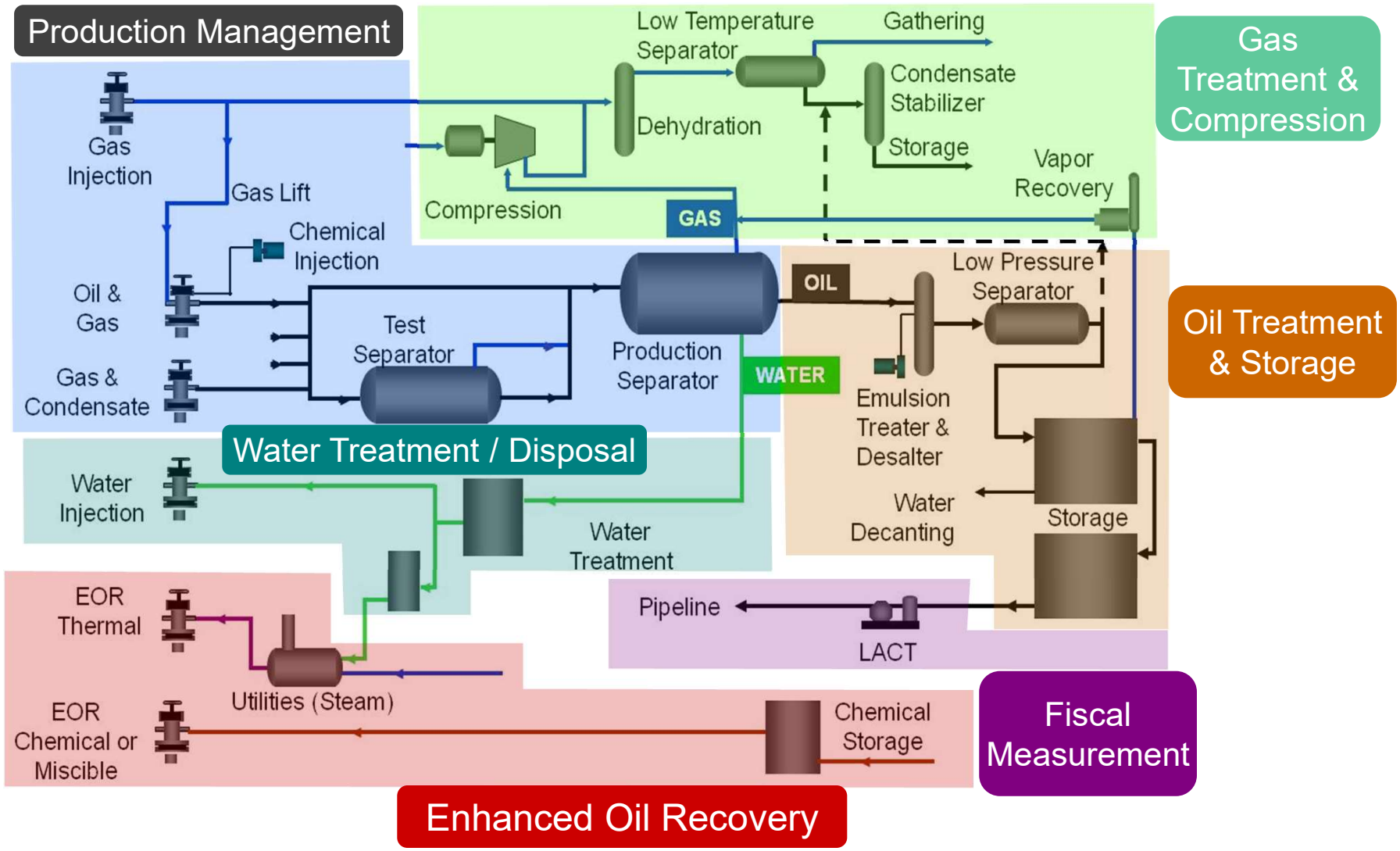
Facilities at every crude oil production well Onshore could include all or some of the following;

- Wellhead
- Two or Three Phase separation
- Heater Treatment
  - Breaks water / oil emulsions
  - Changes viscosity of oil
- Allocation or Fiscal Measurement System
- Water Treatment
- Chemical Treatment
- Oil Storage

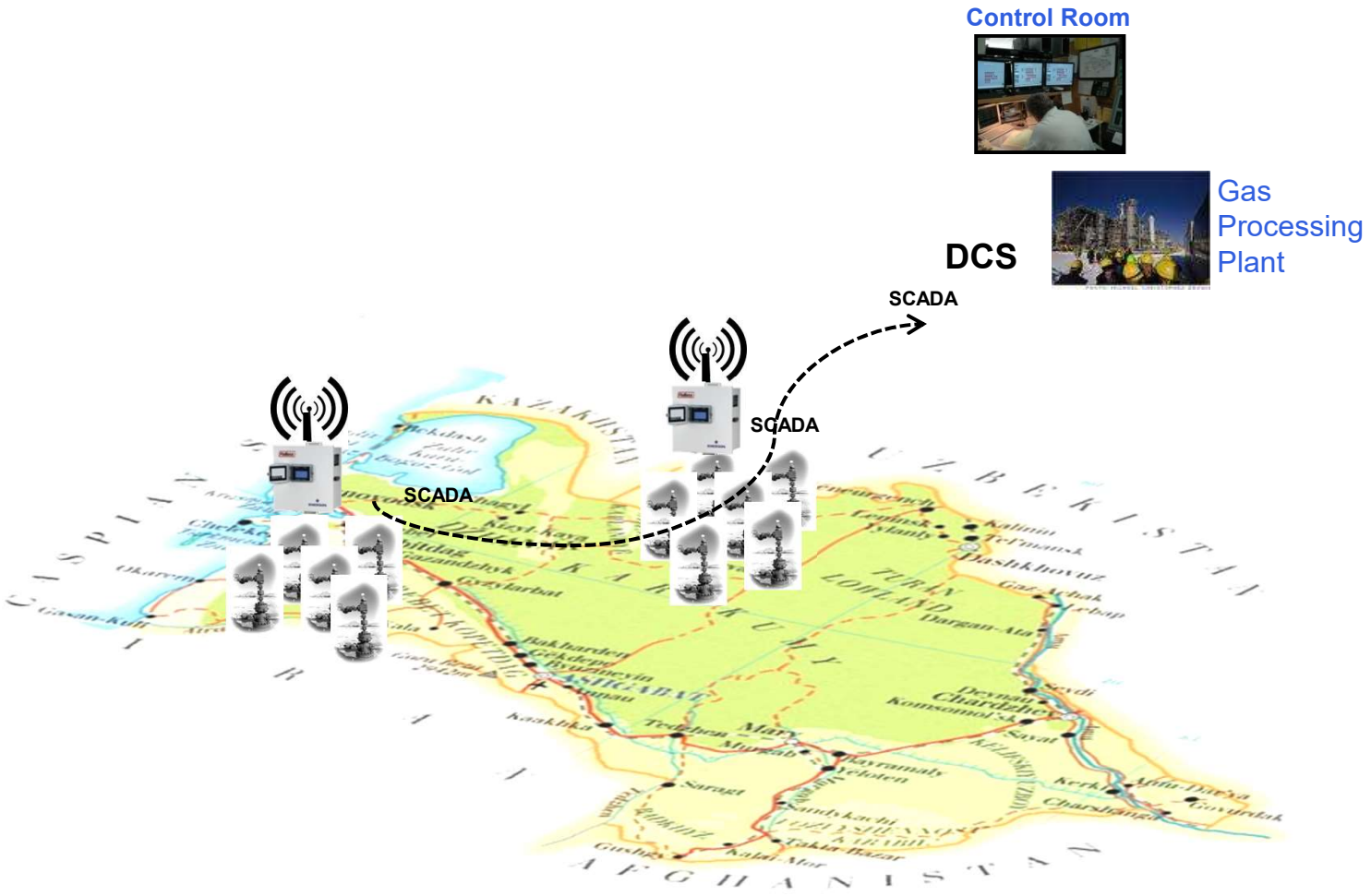
Pump Jack Onshore Oil Well



Onshore Process – Unit Operations



Gas Processing Plant with Wellheads



Marine Vessels

FPSO, FLNG,FSRU
Oil & Gas Tankers

What is an FPSO?

- A converted tanker or purpose built vessel
  - may be ship shaped, multi-hull production semi-submersible or a cylindrical shaped production spar / Mono Hull
- Hydrocarbon processing facilities are installed on board
- Processes well stream fluids into Oil, LPG or LNG
- Units without processing facilities are referred to as an FSO or Floating Storage & Offload Unit

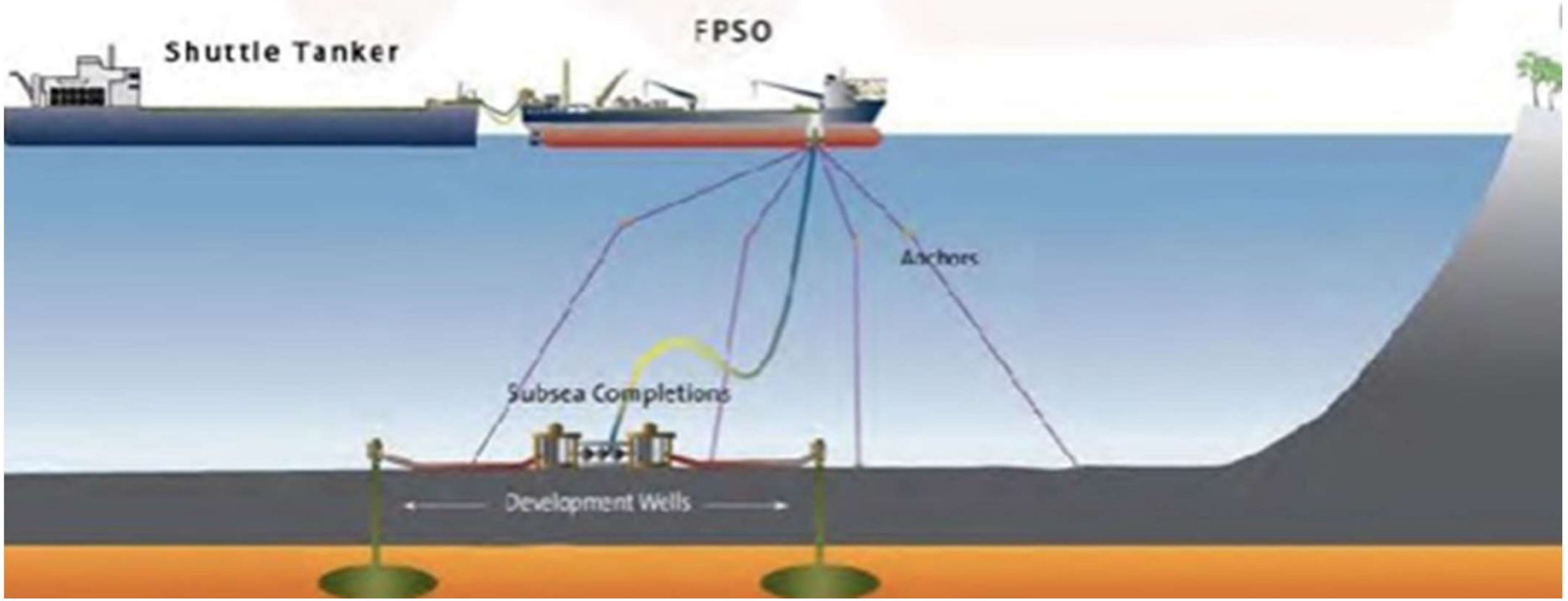
Xikomba – offloading to shuttle

Girassol – Multi-hull semi-sub

Sevan Voyageur – Mono-Hull spar type

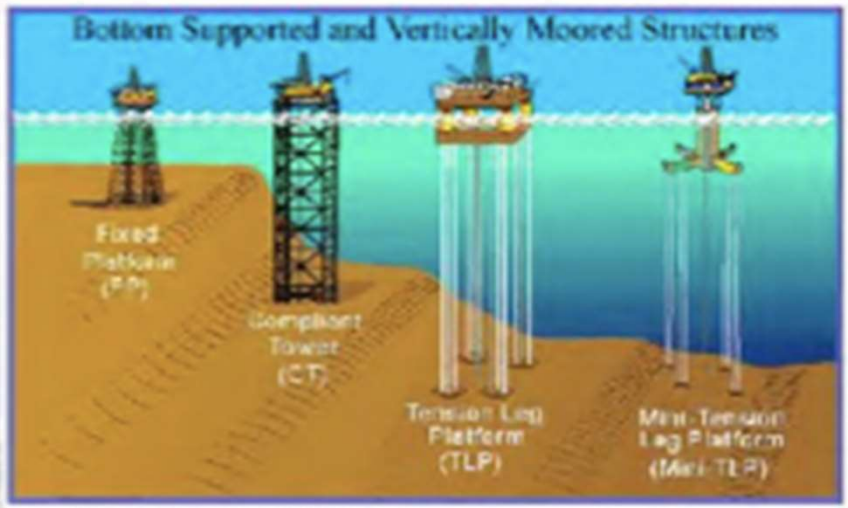
What does an FPSO do?

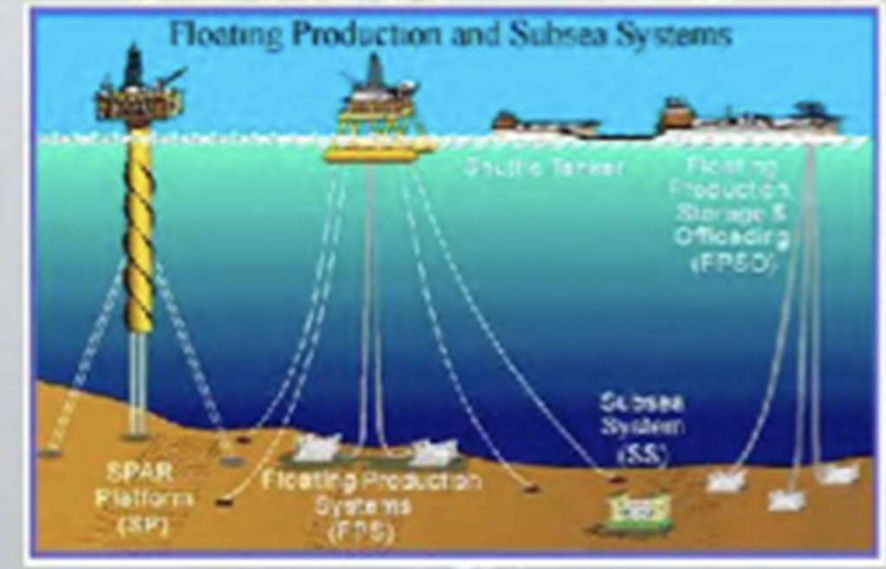
- Processes hydrocarbons received from local production wells i.e. from a platform or subsea template
- Well stream is processed & stored on the vessel, offloaded to a shuttle tanker or exported via a pipeline



Why use an FPSO?

- Fixed platforms enable production to an average max depth of 1,400 feet (425m)
- FPSOs allow production far deeper than fixed platforms





- FPSOs allow development of short-lived, marginal fields in remote locations where a fixed platform is impractical & uneconomical
- FPSOs can be relocated to new locations and reused

FPSO Advantages

- They eliminate the need for costly long-distance pipelines to an onshore terminal
- Particularly effective in remote or deep water locations where seabed pipeline are not cost effective

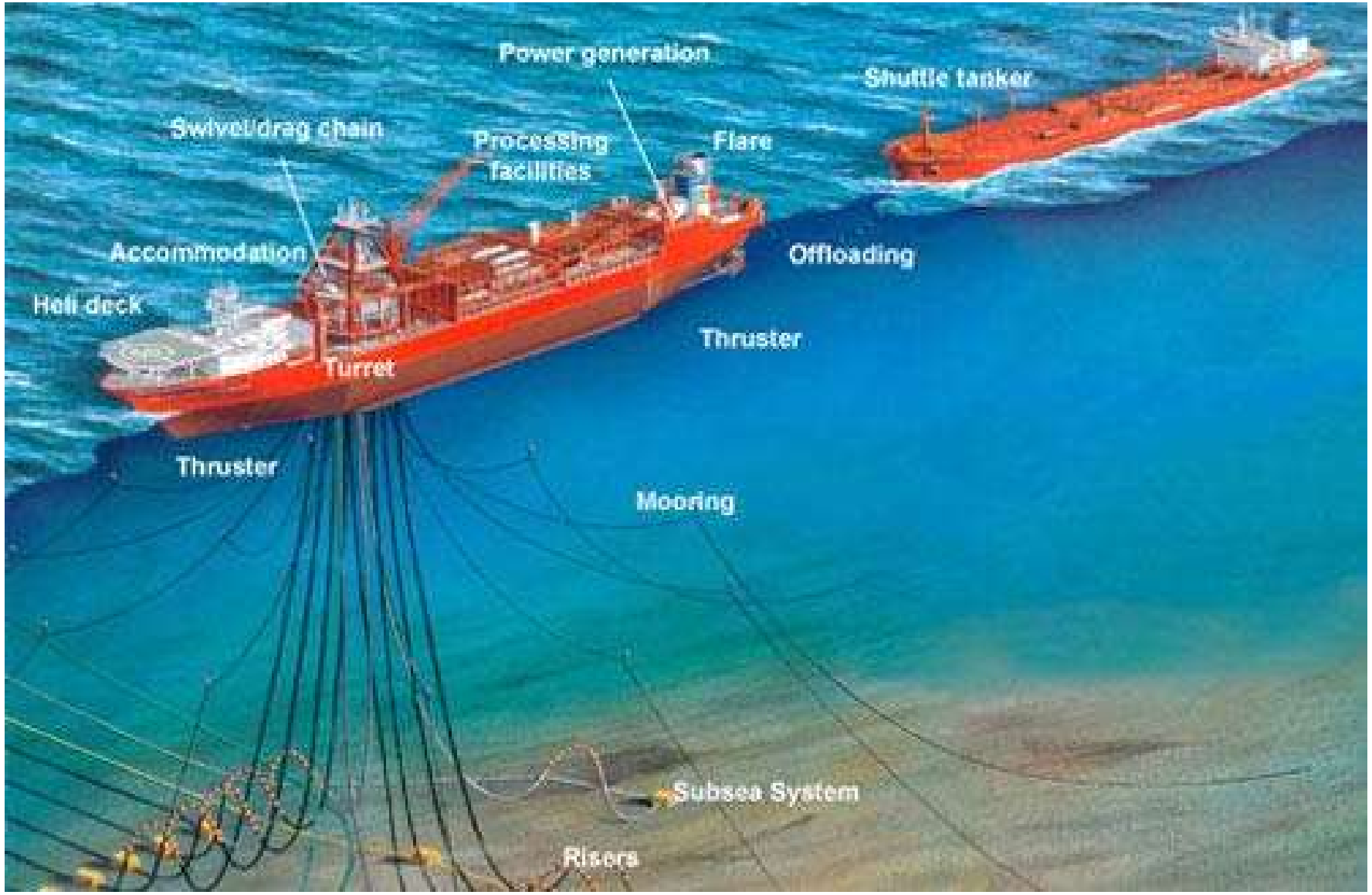
- In bad weather situations (cyclones, icebergs etc.) FPSOs release mooring/risers and steam to safety.
- On field depletion FPSOs can be relocated to a new field

Types of Processing Units

Process/Product Types

- OIL – oil, gas & water from the well stream are separated. Gas & water may be injected into well to increase reservoir pressure or gas may be exported
- LPG – has onboard liquid petroleum gas processing and export facilities
- LNG – takes well stream and separates out the natural gas (primarily methane and ethane) and produces LNG

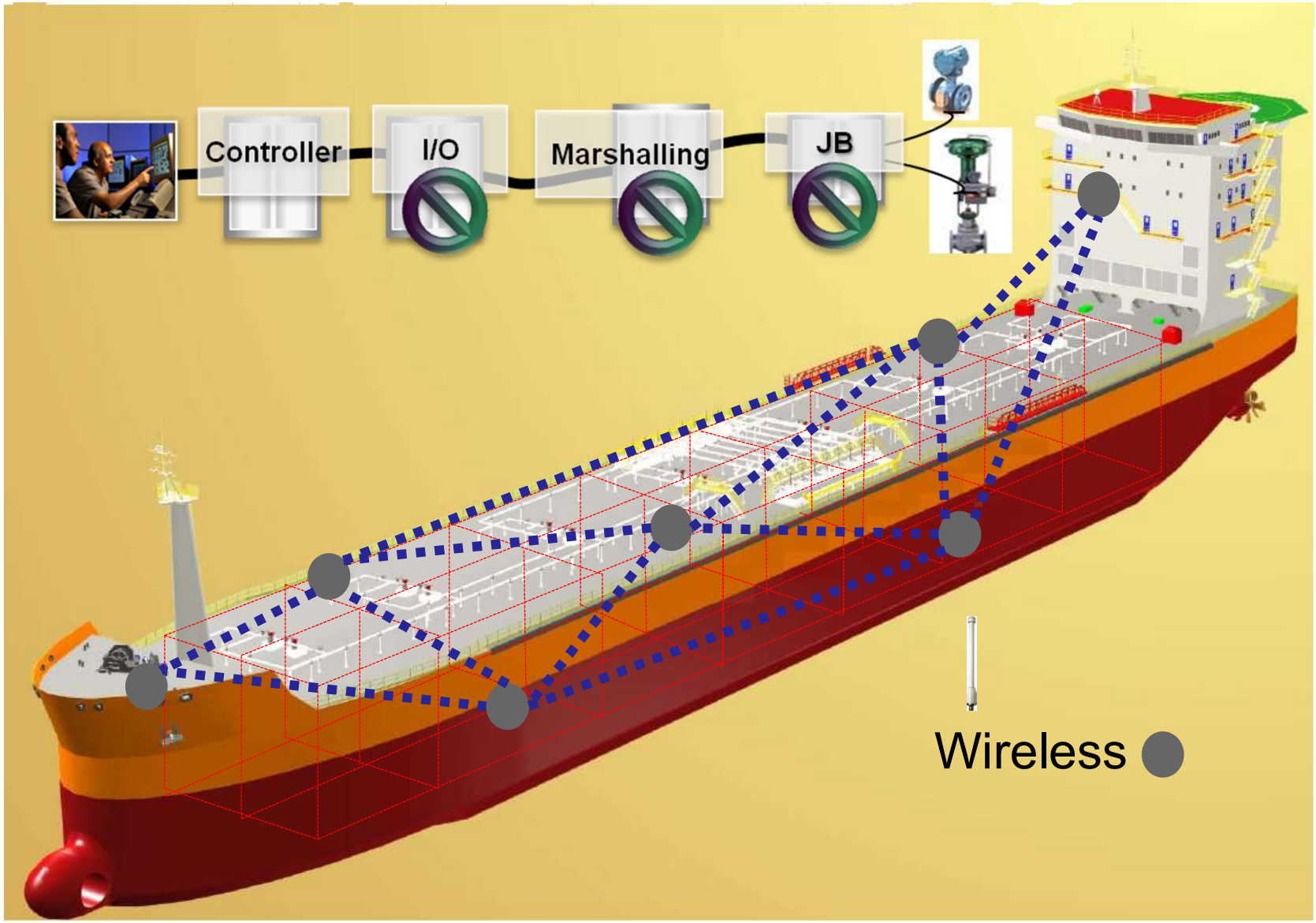
A Typical FPSO

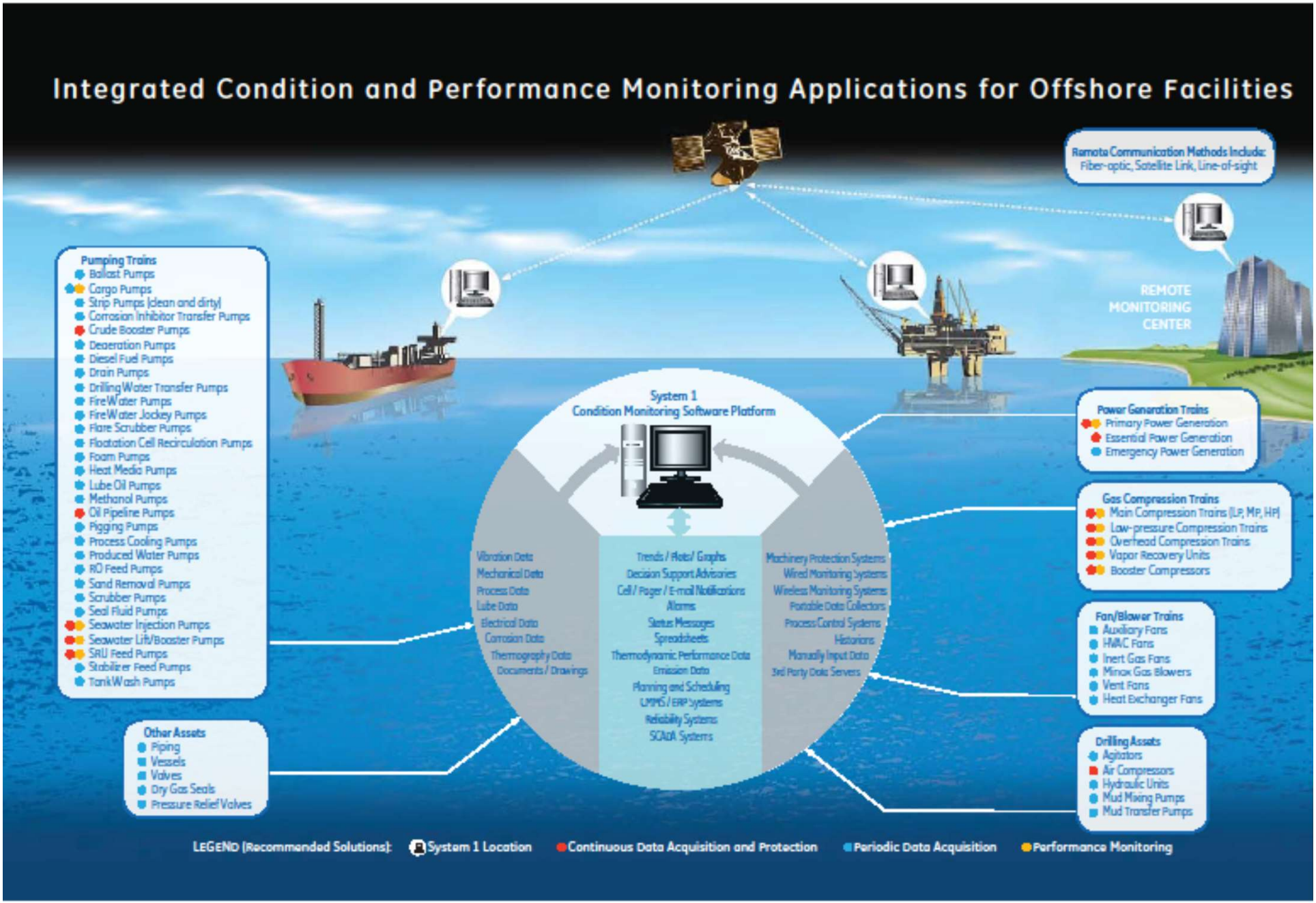


System Modular in Zone

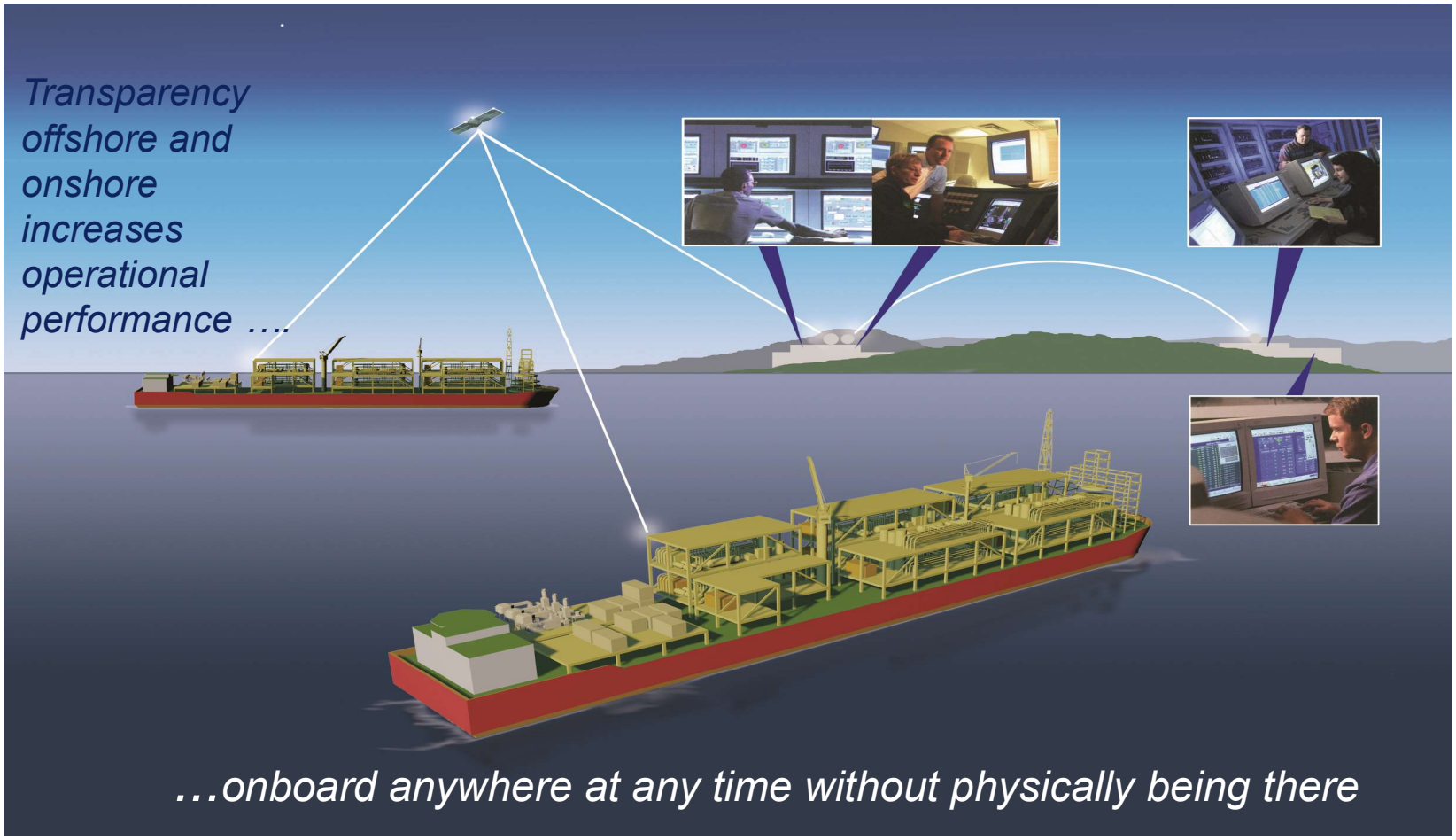
- ✓ Topsides Plug & Play concept
- ✓ Built & test as stand-alone
- ✓ Only electrical, power & network connections

Process Control System including Wireless

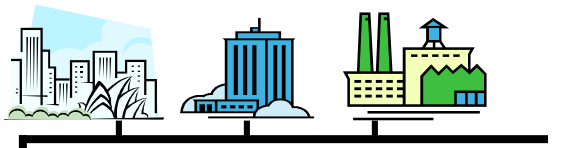



Integrated Condition and Performance Monitoring Applications for Offshore Facilities
Remote Communication Methods Include:
Fiber-optic, Satellite Link, Line-of-sight
REMOTE MONITORING CENTER
Pumping Trains
Ballast Pumps
Cargo Pumps
Strip Pumps (clean and dirty)
Corrosion Inhibitor Transfer Pumps
Crude Booster Pumps
Deaeration Pumps
Diesel Fuel Pumps
Drain Pumps
Drilling Water Transfer Pumps
Fire Water Pumps
Fire Water Jockey Pumps
Flare Scrubber Pumps
Flotation Cell Recirculation Pumps
Foam Pumps
Heat Media Pumps
Lube Oil Pumps
Methanol Pumps
Oil Pipeline Pumps
Pigging Pumps
Process Cooling Pumps
Produced Water Pumps
RO Feed Pumps
Sand Removal Pumps
Scrubber Pumps
Seal Fluid Pumps
Seawater Injection Pumps
Seawater Lift/Booster Pumps
SRU Feed Pumps
Stabilizer Feed Pumps
Tank Wash Pumps
Other Assets
Piping
Vessels
Valves
Dry Gas Seals
Pressure Relief Valves
System 1
Condition Monitoring Software Platform
Vibration Data
Mechanical Data
Process Data
Lube Data
Electrical Data
Corrosion Data
Thermography Data
Documents / Drawings
Trends / Plots / Graphs
Decision Support Advisories
Cell / Pager / E-mail Notifications
Alarms
Status Messages
Spreadsheets
Thermodynamic Performance Data
Emission Data
Planning and Scheduling
CMMS / ERP Systems
Reliability Systems
SCADA Systems
Machinery Protection Systems
Wired Monitoring Systems
Wireless Monitoring Systems
Portable Data Collectors
Process Control Systems
Historians
Manually Input Data
3rd Party Data Servers
Power Generation Trains
Primary Power Generation
Essential Power Generation
Emergency Power Generation
Gas Compression Trains
Main Compression Trains (LP, MP, HP)
Low-pressure Compression Trains
Overhead Compression Trains
Vapor Recovery Units
Booster Compressors
Fan/Blower Trains
Auxiliary Fans
HVAC Fans
Inert Gas Fans
Minox Gas Blowers
Vent Fans
Heat Exchanger Fans
Drilling Assets
Agitators
Air Compressors
Hydraulic Units
Mud Mixing Pumps
Mud Transfer Pumps
LEGEND (Recommended Solutions):
System 1 Location
Continuous Data Acquisition and Protection
Periodic Data Acquisition
Performance Monitoring

Smart Plant from Field Equipment to Onshore Support Center



The Oil & Gas Supply Chain



Natural Gas

UPSTREAM

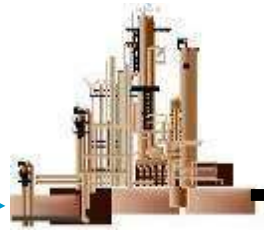
O&G Production

- Crude oil
- Raw natural gas

DISTRIBUTION

Transportation & Distribution

- City gates
- Industry gates
- Power gates



MIDSTREAM

Natural Gas Processing

- Natural Gas
- Liquefied Natural Gas
- Liquefied Petroleum Gases
- Natural Gas Liquids

OIL FIELD SERVICES

Well Related Service

- Drilling
- Completion
- Treatment

Natural Gas / Crude Pipelines, Storage & Hubs

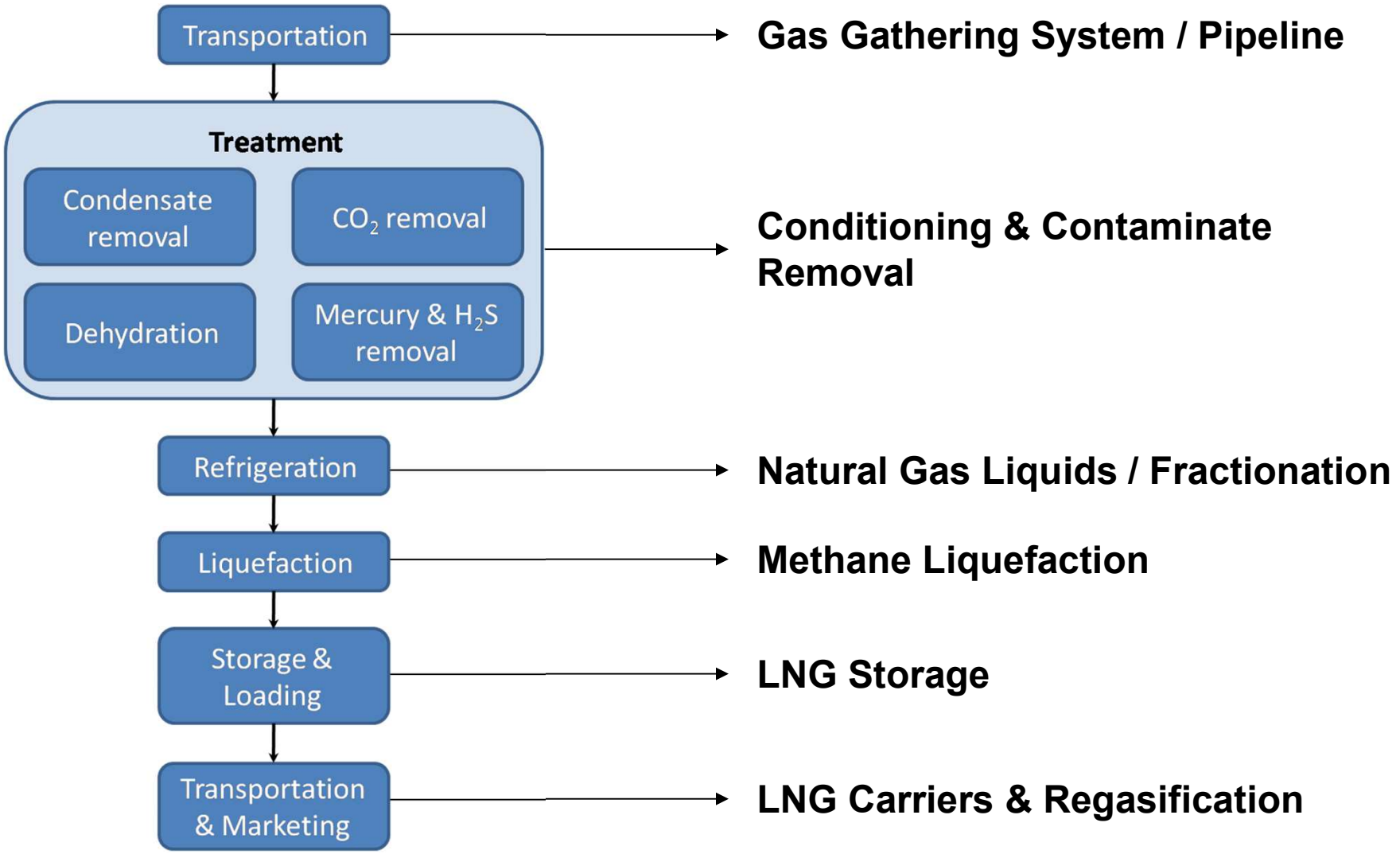
DOWNSTREAM

Crude Oil Refining

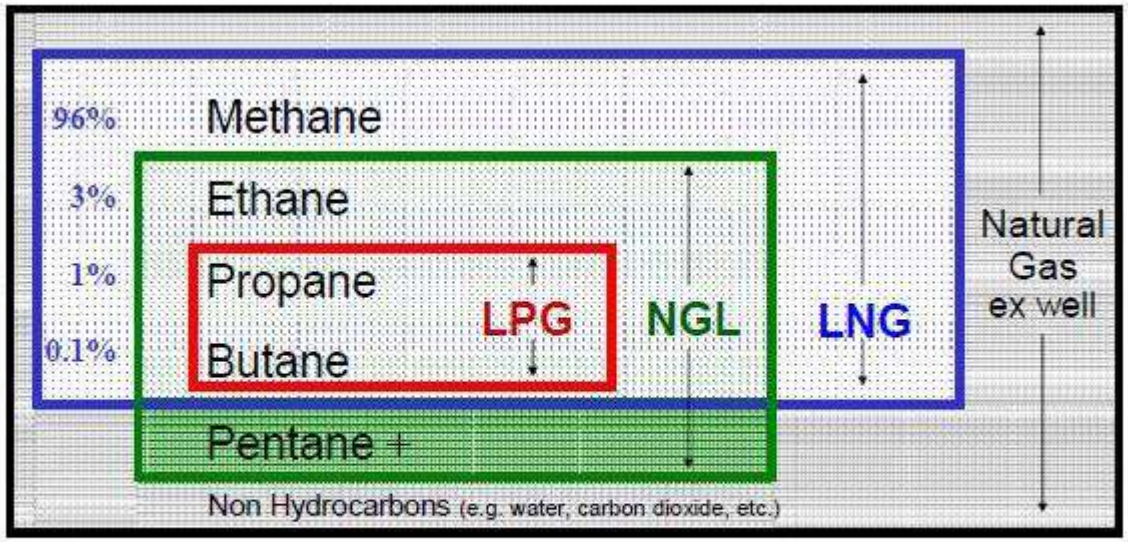
- Gasoline
- Diesel
- Lubricating oils
- Petrochemicals

Crude Oil

Scope - Gas Plant / LNG / Regas Process



The Chemistry of LNG?



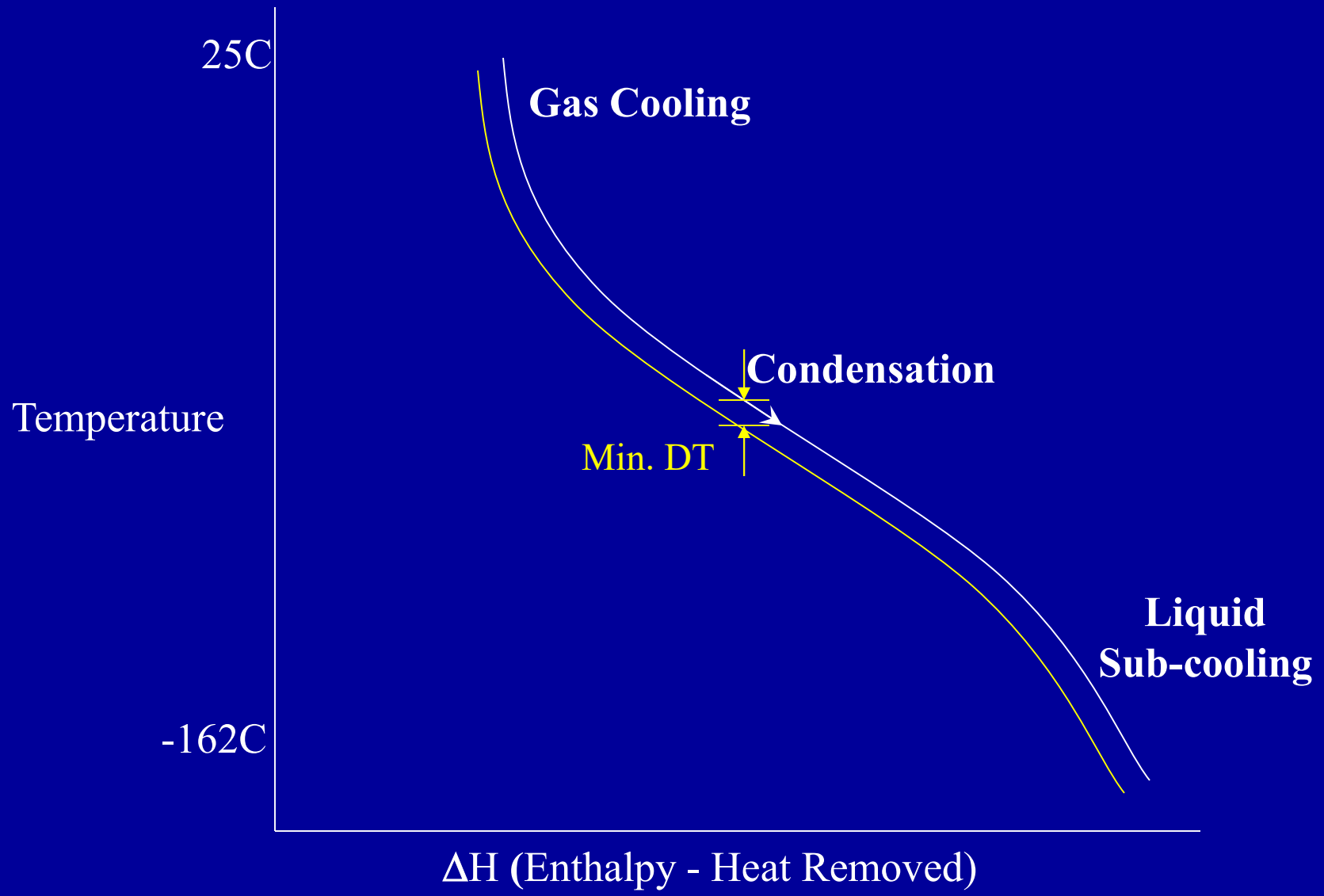
LPG – Liquid Petroleum Gas
NGL – Natural Gas Liquids
LNG – Liquid Natural Gas

Inlet Gas – Produced Gas – Wet Gas – Raw Gas - Casing Head Gas and Associated Gas are all common references to Raw Natural Gas

LNG Supply Chain

1. Natural gas is transported from production fields via pipeline to liquefaction plant
2. Prior to liquefaction, contaminants, such as carbon dioxide, water and sulphur are removed to avoid them freezing and damaging equipment
3. Gas is cooled to -161°C at atmospheric pressure, using compressors, condensers, pressure expansion valves and evaporators to compress to 1/600th of original volume.
4. LNG is piped to storage tanks prior to loading on specially equipped carriers
5. Carrier delivers LNG to receiving / regas terminals for conversion to gaseous state
6. Natural Gas dispatched / piped to end user

Natural Gas Liquefaction Processes



LNG Process & Equipment ?

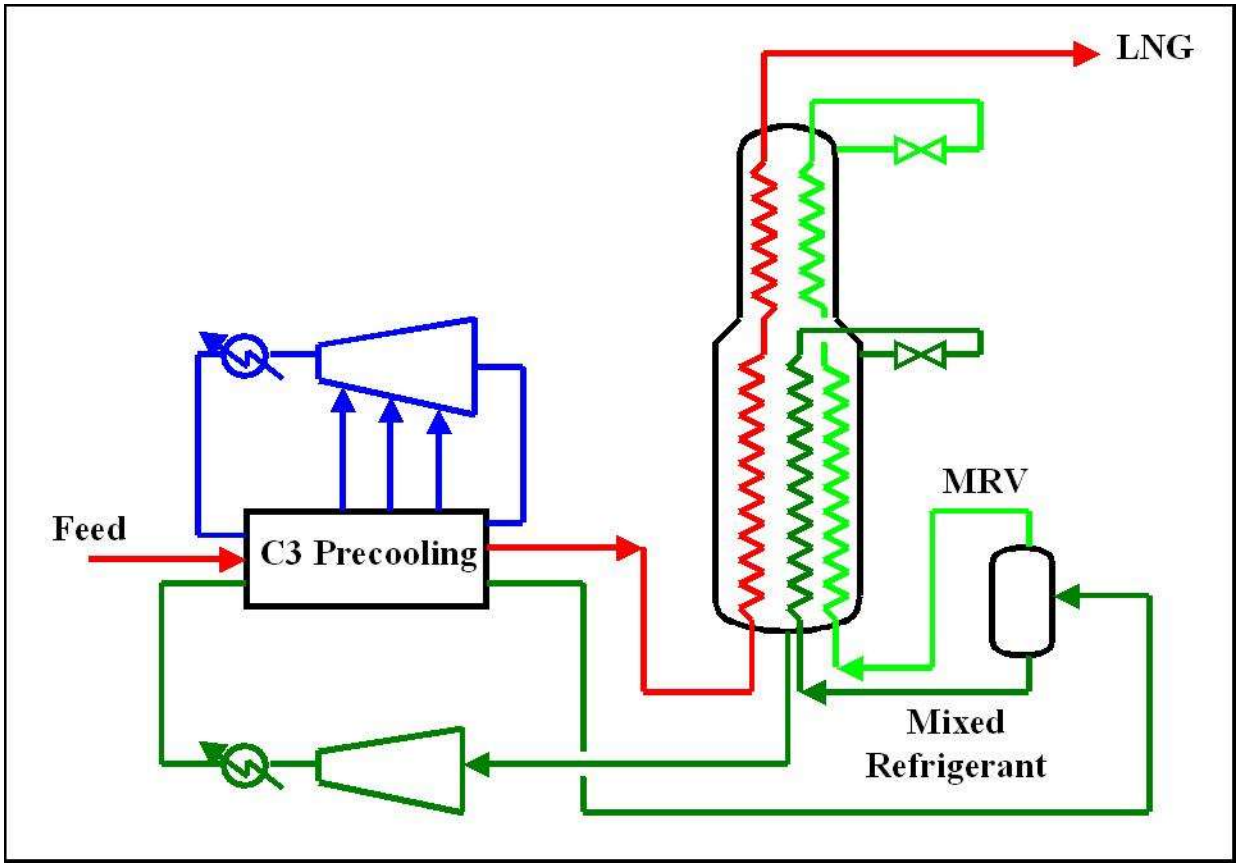
Big Refrigeration System

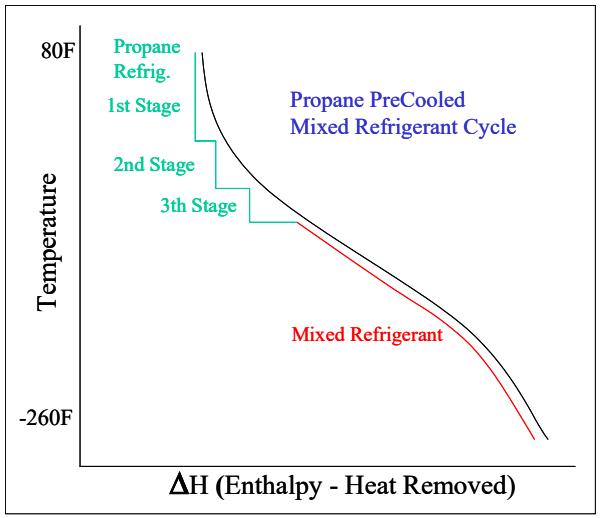
- Compressor/Driver
- Refrigerant Condenser
- Evaporator (Process Heat Exchanger)

Similar to the AC System in Our Home!

C3 Precooled – Mixed Refrigerant Process

- Most Widely Used Licensed by APCI
- 1st Plant in Algeria Operating Since 1972
- Plants Built by KBR, Chiyoda, JGC, FW





QatarGas LNG Plant

All Processes Use Similar Equipment

GE MS7001 FB Gas Turbine

- Most New Plants Use Large Gas Turbine (& Combined Cycle) to Drive Refrigerant Compressors
- Some Older & Smaller Trains Have Steam Turbine Drives
- Many Peak Shaving Plants on Electric Drives
- Use Large Process Type Centrifugal Compressors
- Main Difference is in the Cryogenic Heat Exchangers

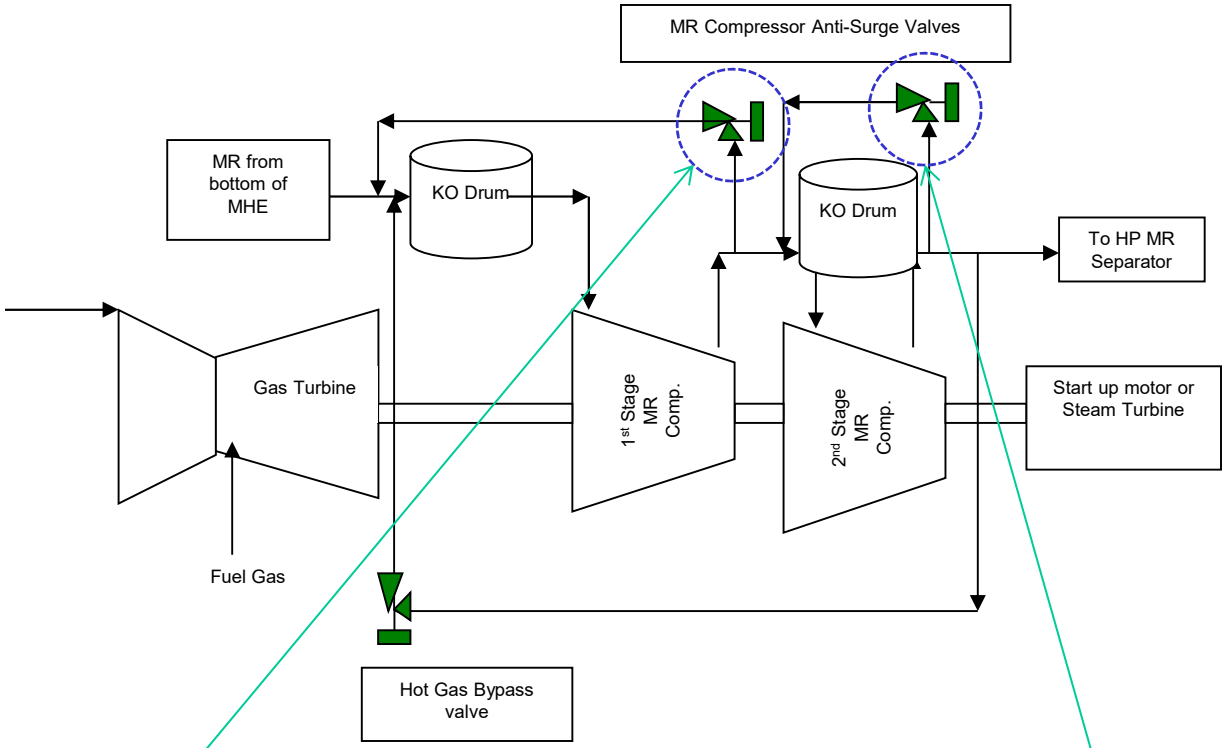
Main Cryogenic Heat Exchanger Use by Mixed Refrigerant Process

Air Products & Chemicals
& Linde: Spiral Wound Ex.

- Max. Diameter: 5,030mm
- Height: ~55m
- Stainless Steel Core
- 25mm Aluminum Tubing
- Externally Insulated
- Chill & Liquefy Gas
  - From –34ºC to –152ºC
  - At 55 to 69 Barg


Specialty Valves for
LNG Application

Mixed Refrigerant (MR) Compressor Anti-surge Valves (High Pressure Drop)



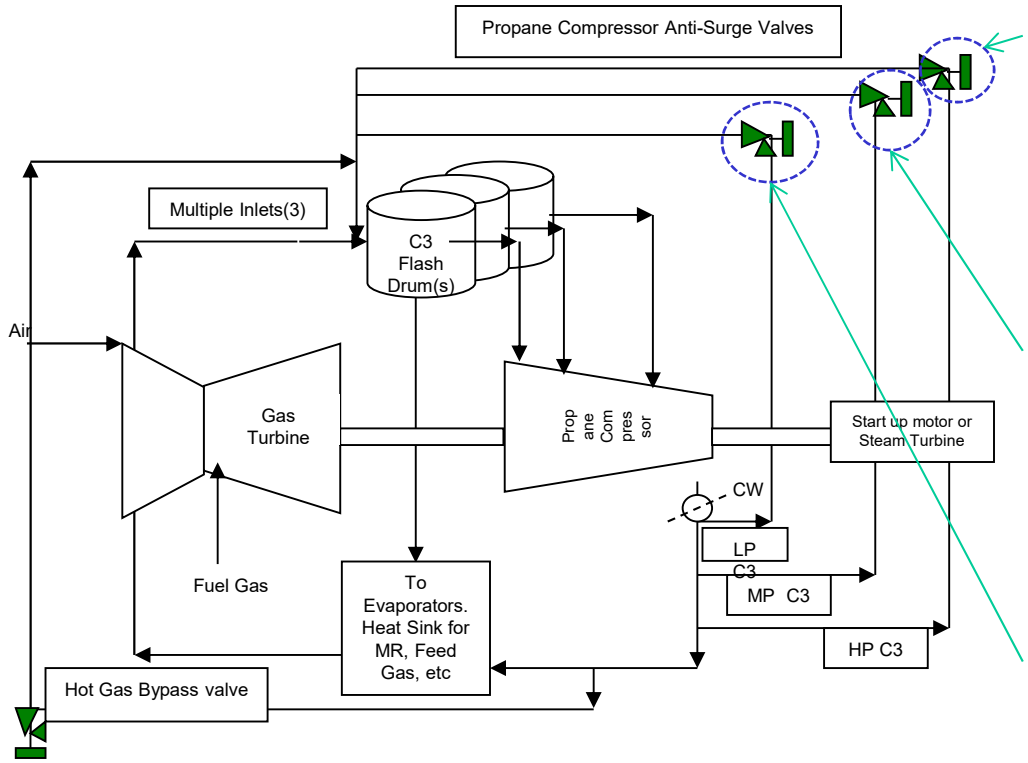
1st Compressor

Parameter	Typical Value
Inlet Pressure, P1	13 barg/(195 psig)
Pressure Drop, dP	10 bard/(150 psid)
Inlet Temperature	32 C/(90 F)
Valve type/size/pressure class	FB/16-24"/300 or 600#
Valve Material/Trim Material	CS/Std
Shutoff Requirement	Class IV or V
Trim type	Whisper III or WhisperFlo
Actuation	Compressor surge actuation package (490, 2625, QEV, DVC6000 or 3570, supply regulator)

2nd Compressor

Parameter	Typical Value
Inlet Pressure, P1	45 barg/(650 psig)
Pressure Drop, dP	31 bard/(450 psid)
Inlet Temperature	121 C/ (250 F)
Valve type/size/pressure class	FB/16-24"/600#
Valve Material/Trim Material	CS/Std
Shutoff Requirement	Class IV or V
Trim type	Whisper III or WhisperFlo
Actuation	Compressor surge actuation package (490, 2625, QEV, DVC6000 or 3570, supply regulator)

Propane (C_3) Compressor Anti-surge Valves



3rd Stage

Parameter	Typical Value
Inlet Pressure, P1	14 barg/(200 psig)
Pressure Drop, dP	12.5 bard
Inlet Temperature	60 C /(140 F)
Valve type/size/pressure class	FB/16"-20"/300# or 600#
Valve Material/Trim Material	CS/std
Shutoff Requirement	Class IV or V
Trim type	Whisper III or WhisperFlo
Actuation	Compressor surge actuation package (490, 2625, QEV, DVC6000 or 3570, supply regulator)

2nd stage

Parameter	Typical Value
Inlet Pressure, P1	14 barg/(200 psig)
Pressure Drop, dP	10 bar/(150 psid)
Inlet Temperature	60 C /(140 F)
Valve type/size/pressure class	FB/16"-20"/300# or 600#
Valve Material/Trim Material	CS/std
Shutoff Requirement	Class IV or V
Trim type	Whisper III or WhisperFlo
Actuation	Compressor surge actuation package (490, 2625, QEV, DVC6000 or 3570, supply regulator)

1st stage

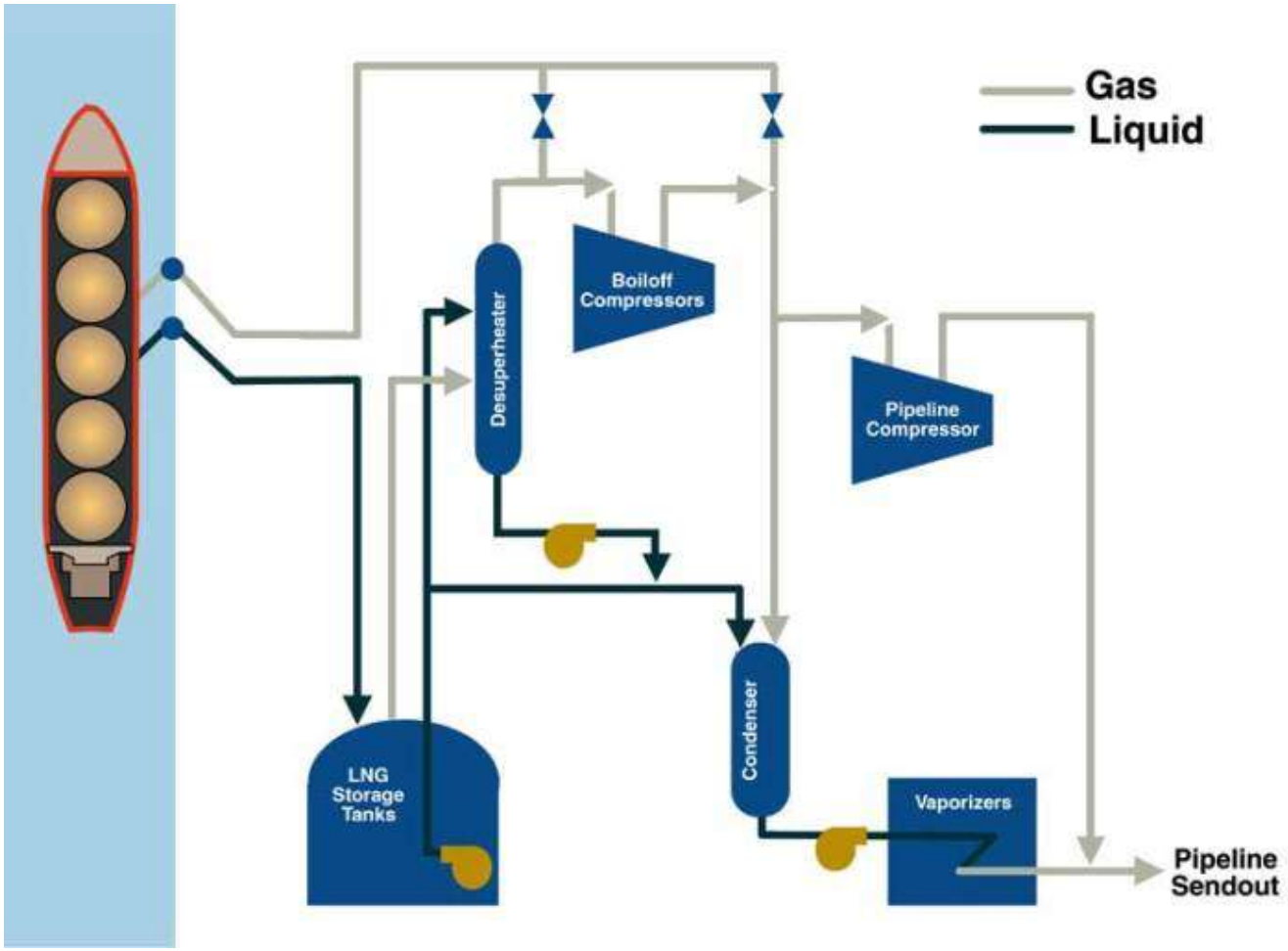
Parameter	Typical Value
Inlet Pressure, P1	14 barg/(200 psig)
Pressure Drop, dP	7 bard/(100 psid)
Inlet Temperature	60 C /(140 F)
Valve type/size/pressure class	FB/16-24"/300# or 600#
Valve Material/Trim Material	CS/Std
Shutoff Requirement	Class IV or V
Trim type	WhisperIII or WhisperFlo
Actuation	Compressor surge actuation package (490, 2625, QEV, DVC6000 or 3570, supply regulator)

LNG Customers Goals

- Maximize Production
  - Reduce process variability
    - Base Level Loop Tuning
    - Control Valve performance assessment & remediation
  - Drive towards multiple constraints simultaneously
  - Use ambient temperature as a feed-forward input
  - Maximize yield on most valuable NGL products
- Minimize Energy
  - “Ratio” gas treatment to production rates

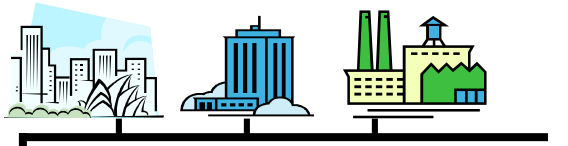
Solutions: Powerful Tools Speed Troubleshooting and Optimization

Receiving & Regasification Process



Source: Trunkline LNG Company

The Oil & Gas Industry – Crude Has NO Value Without Refining!



Natural Gas

UPSTREAM

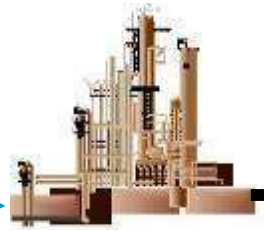
O&G Production

- Crude oil
- Raw natural gas

DISTRIBUTION

Transportation & Distribution

- City gates
- Industry gates
- Power gates



MIDSTREAM

Natural Gas Processing

- Natural Gas
- Liquefied Natural Gas
- Liquefied Petroleum Gases
- Natural Gas Liquids

OIL FIELD SERVICES

Well Related Service

- Drilling
- Completion
- Treatment

Natural Gas / Crude Pipelines, Storage & Hubs

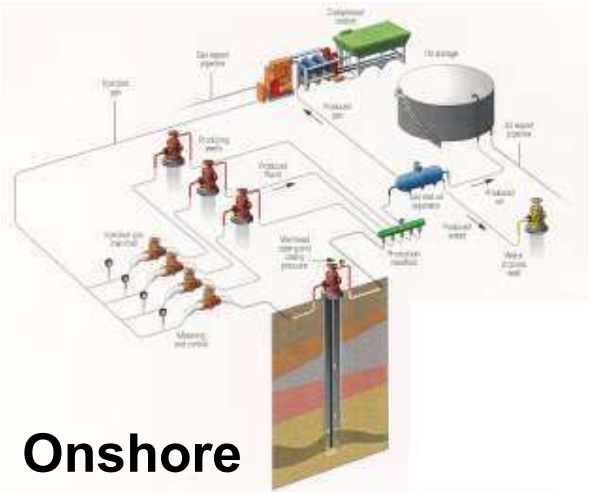
DOWNSTREAM

Crude Oil Refining

- Gasoline
- Diesel
- Lubricating oils
- Petrochemicals

Crude Oil

Crude Characteristics



Onshore

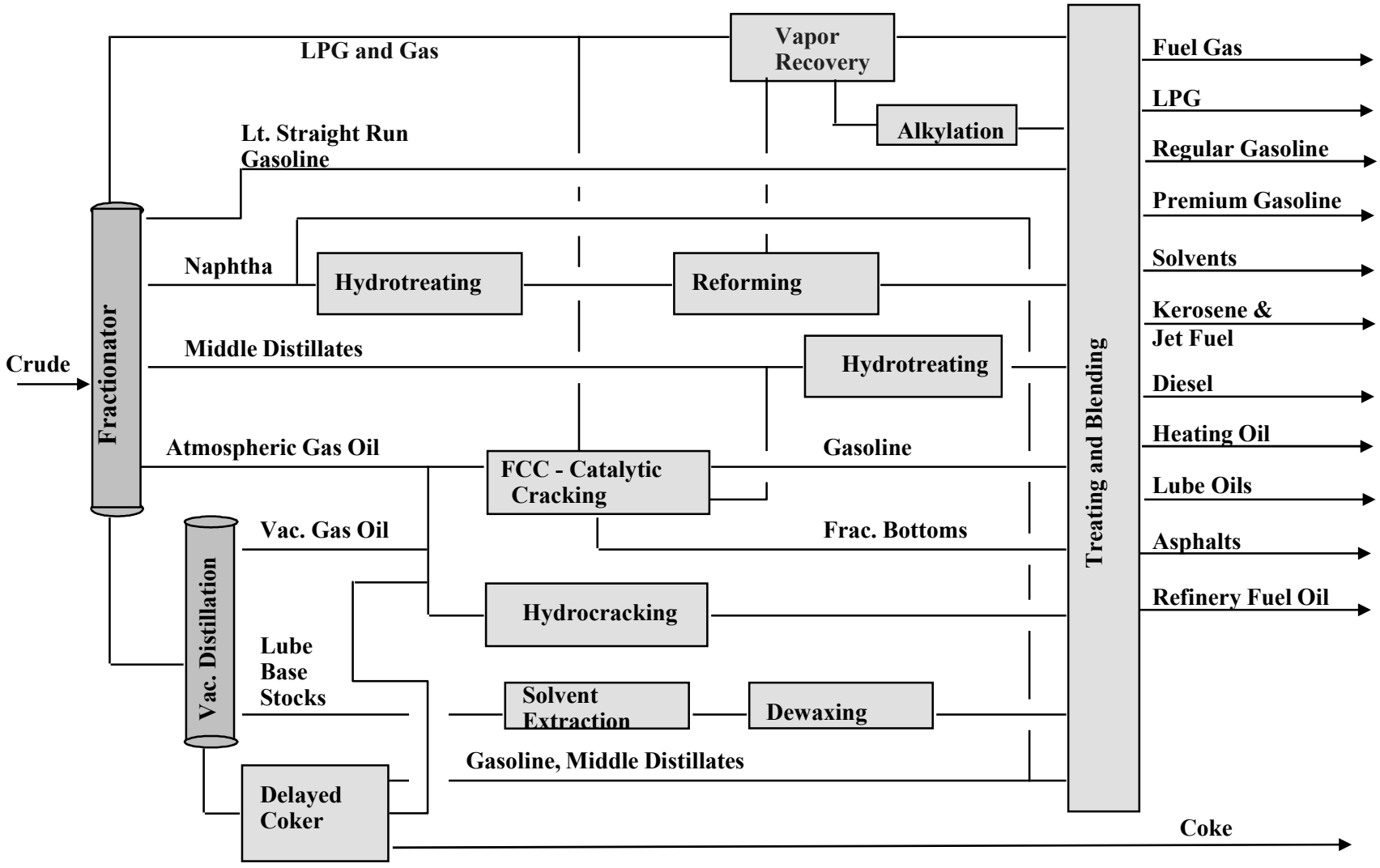
Offshore

- Variety of hydrocarbons produced
  - Light to heavy oil
  - Free flowing to shoe polish
  - Paraffin / wax
  - "Foamy"
  - Sweet to Sour (H_2S)

API Range	Description	Viscosity	Color	Components
0° – 22.3°	HEAVY	Extreme	Dark	Asphalt
22.3° – 31.3°	MEDIUM	Moderate	Brown	Gasoline & diesel
31.3° – 47°	LIGHT	Fluid	Light yellow	Condensate/gasoline

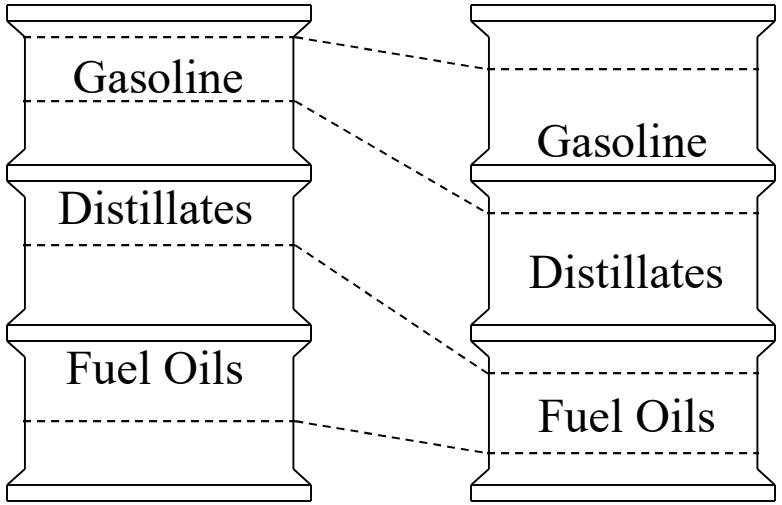
Understanding the Refining Industry

Simplified View of Refining Processes



Petroleum Products Supply and Demand

Fuels Gas	Deg F
Chemical Feeds	-100
LPG, Butane	
Gasoline	100-350
Jet Fuels/Kerosene	250-550
Diesel fuels	
Gas Oils	
Lube Distillates	550-800
Fuels Oils	
Asphalt	800+
Coke	



What Are The Refiner's Concerns?

Distillation Process

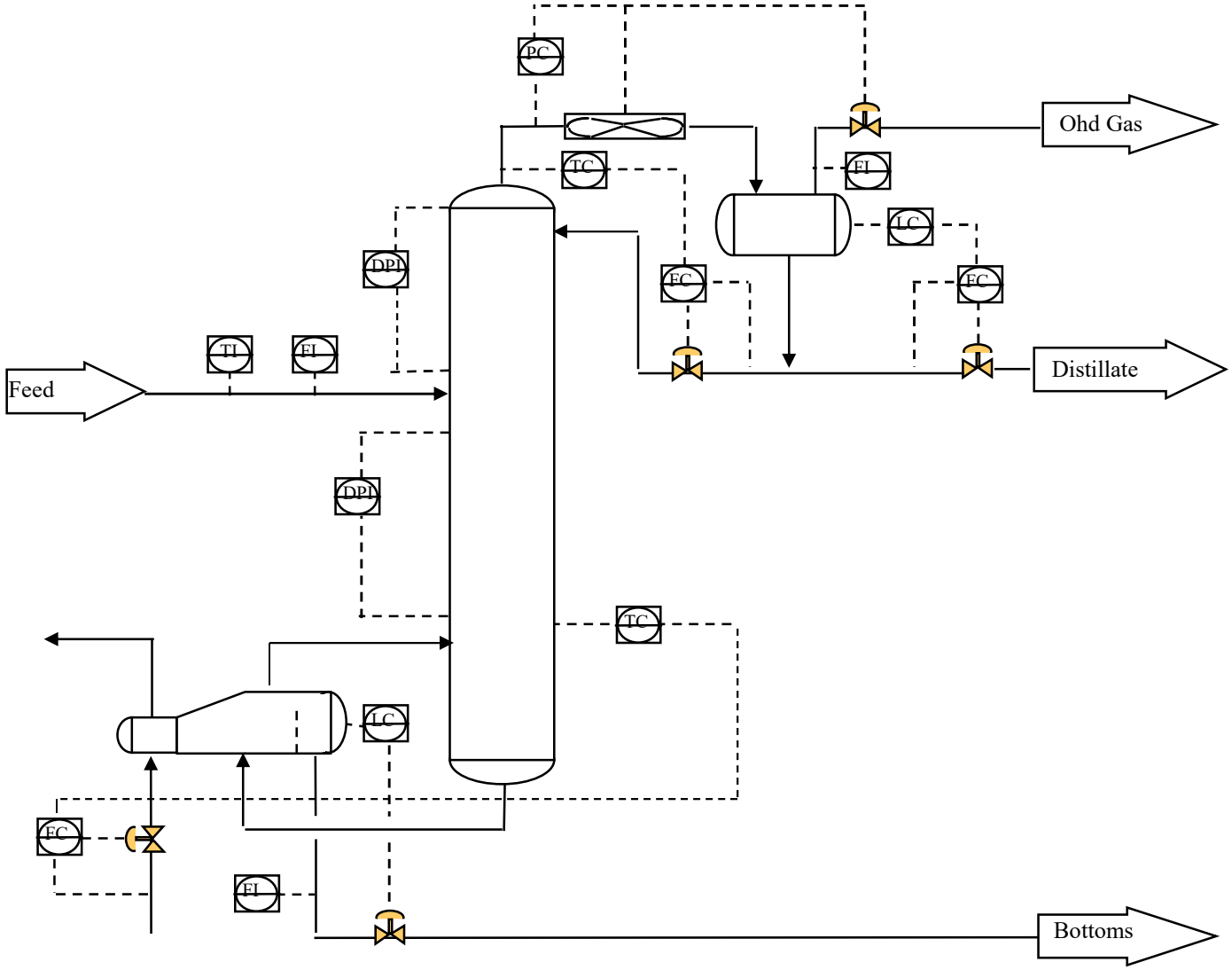
Distillation is the separation of two or more miscible components in a liquid solution by a series of vaporization and condensation.

Separation if possible when the vapor composition is different from the liquid composition.

Key factors affecting the distillation effectiveness are:

- Feed Temperature and Composition
- Reboiler and Condenser Duties
- Pump-around Duties
- Tower Pressure
- Product Draw-Off Rates

Simple Distillation Column

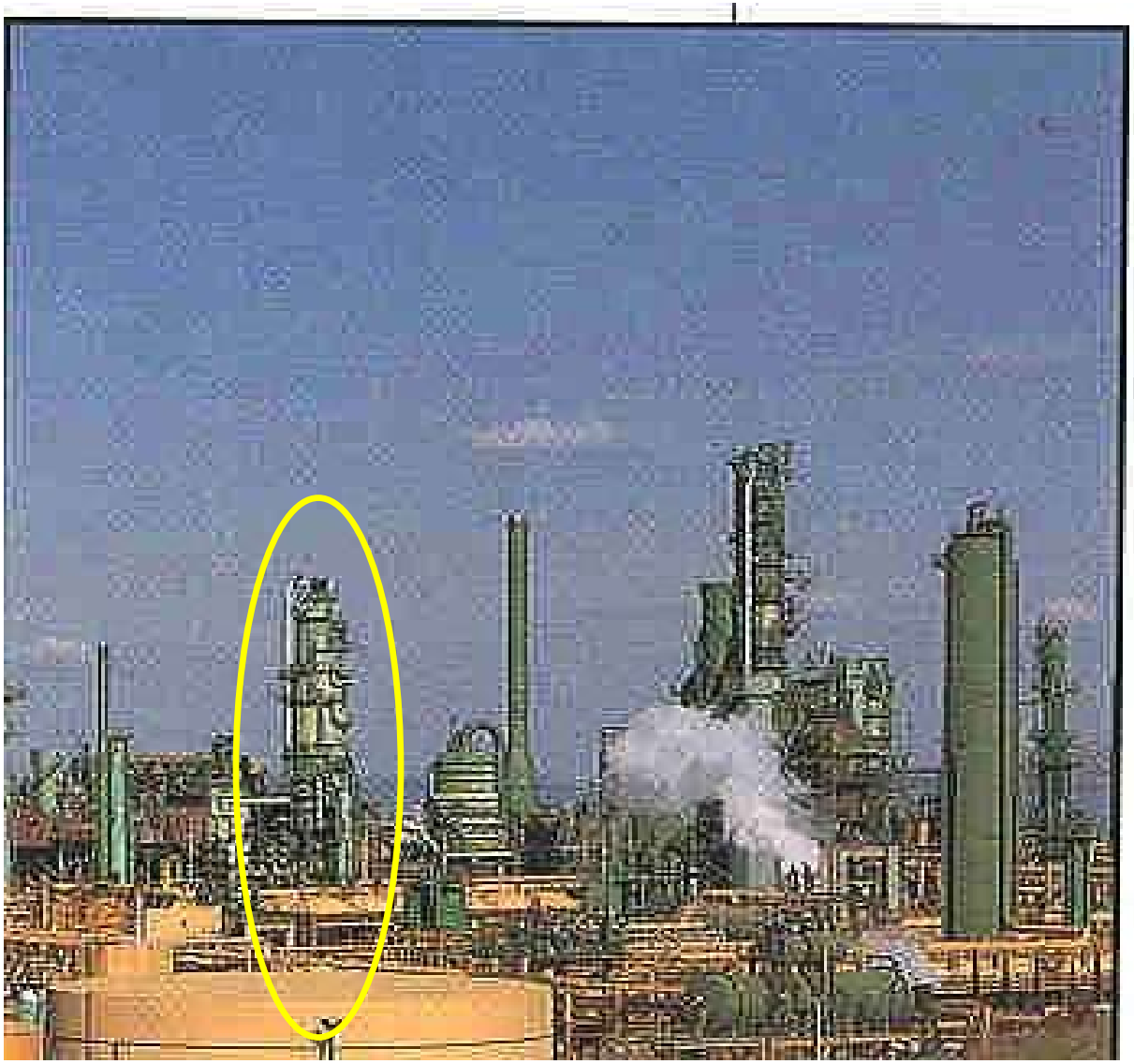


Distillation Control Considerations

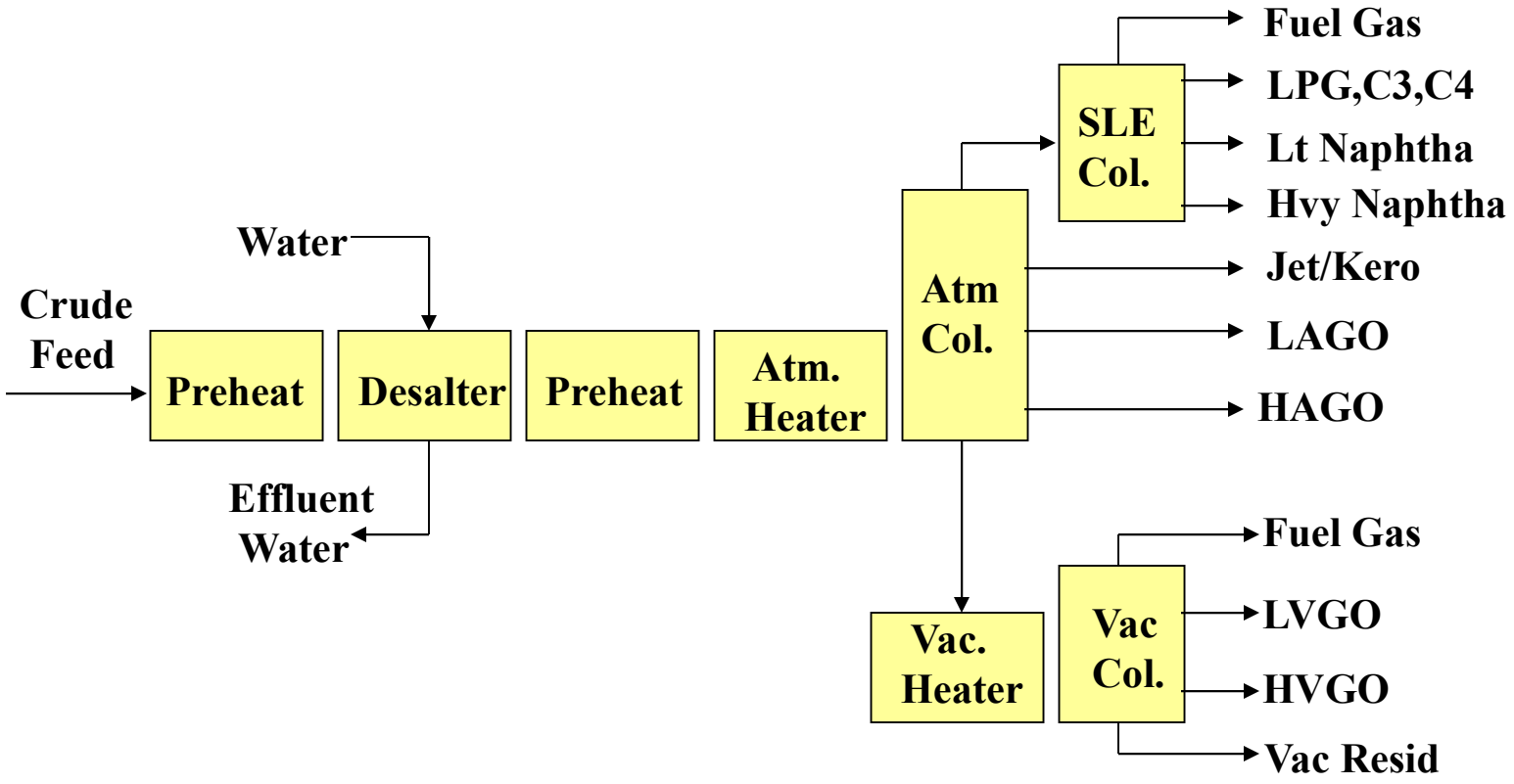
The basic controls will include:

- Tower top and bottom temperature cascade to reflux and reboiler flows
- Tower top pressure control with valve constraint
- Non-linear level controls with cascade to distillate and bottoms draw-off flows
- Feed flow rate and temperature feed-forward
- Pressure compensated temperatures
- DP constraints for tower flooding

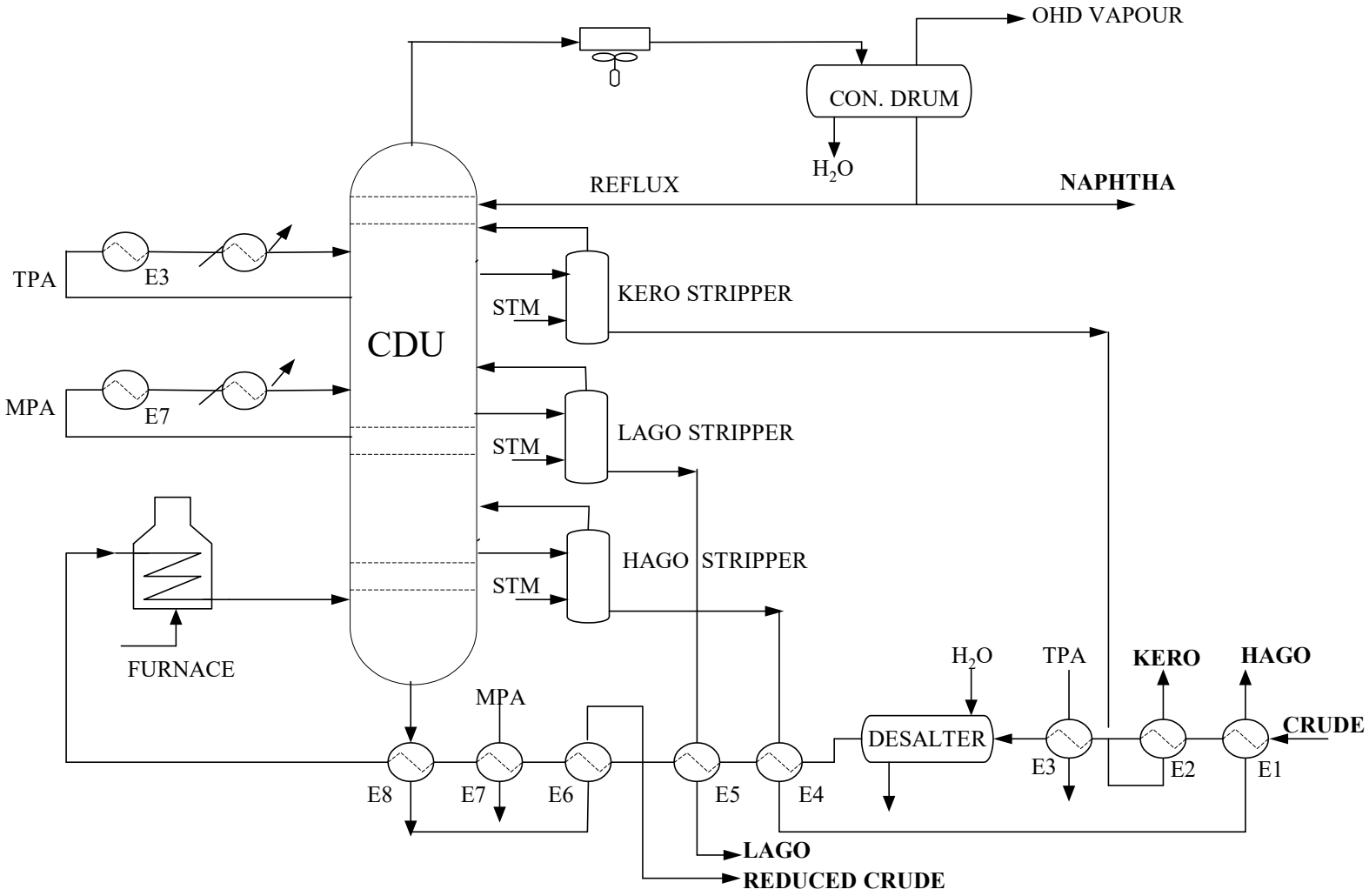
CRUDE UNIT



Crude Distillation Process Schematic



CRUDE DISTILLATION UNIT



CDU Control Considerations

The major controls are:

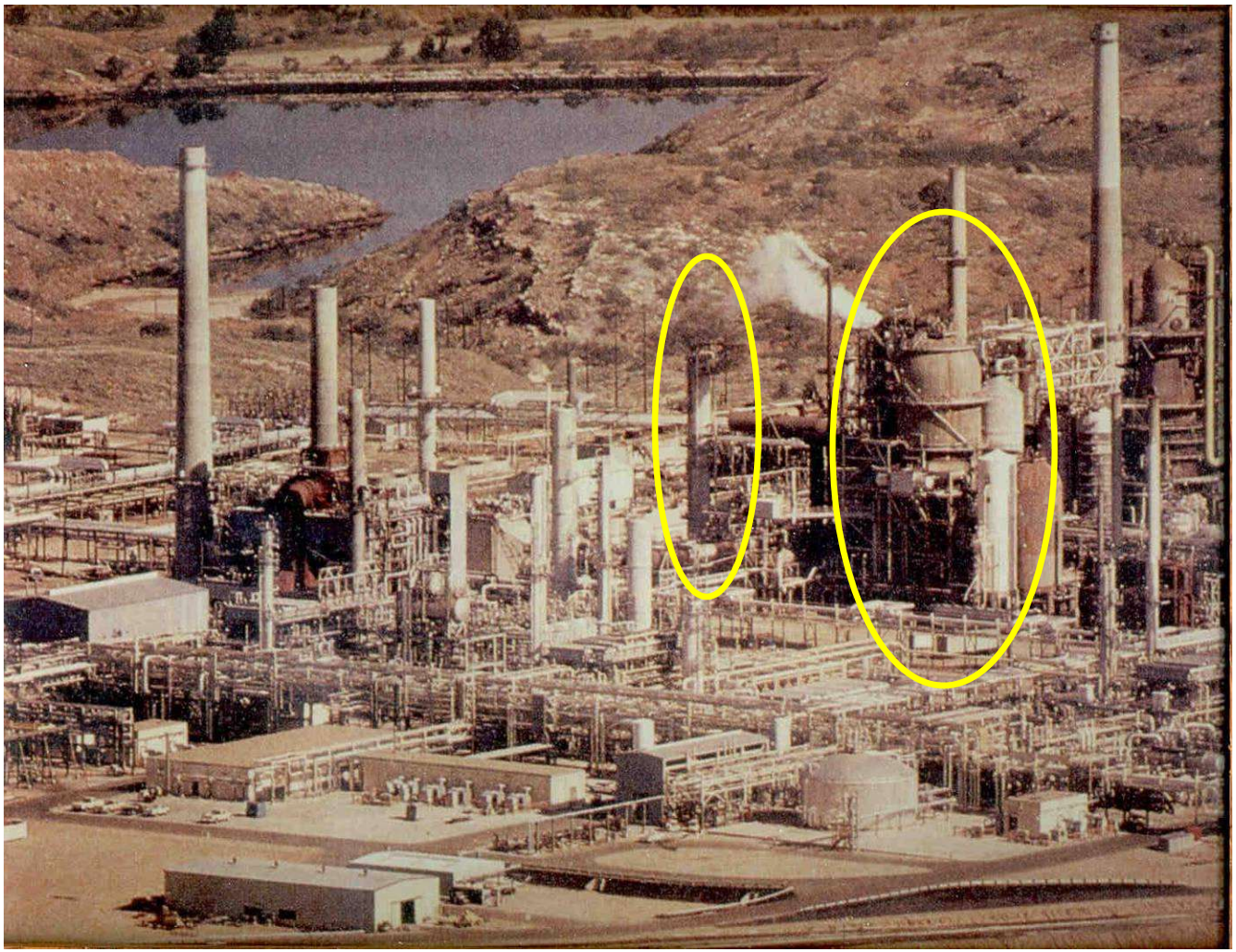
1. Crude Heater with Combustion Control, excess O2 Minimization and Pass Balance Control
2. Interactive Cut-Point and Yield Control with Tray Loading Calculation and Stripping Steam Optimization
3. Energy Minimization with Preheat Maximization, Pump-around Controls, Overhead Pressure and Overflash Minimization
4. Feed maximization with Crude Switch and Mode Swing Controls

APC for CDU

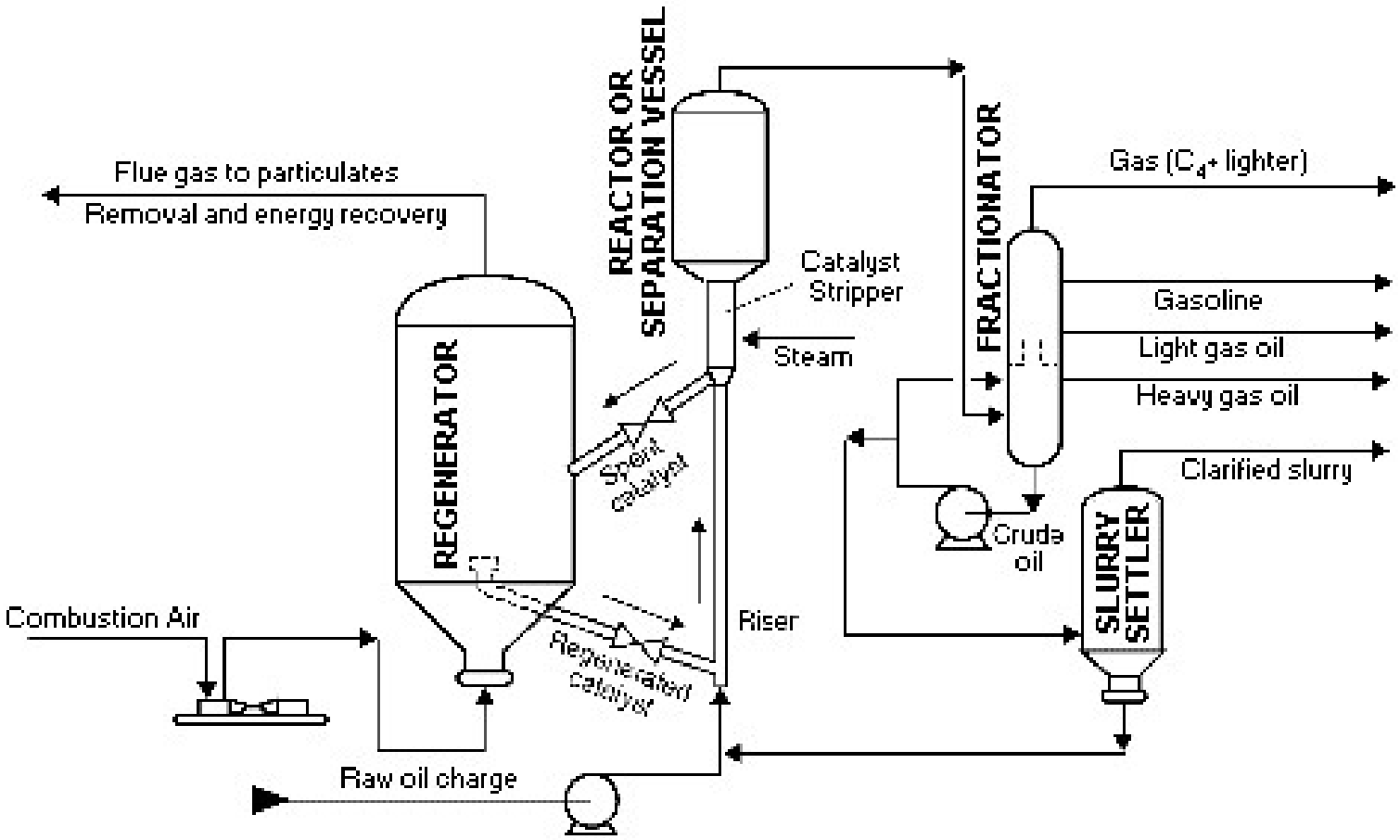
The control objectives would be:

- To maintain stable operation within constraints
- To meet product stream quality specifications
- To maximize the yields of higher valued products
- To minimize energy consumption

Fluid Catalytic Cracking (FCC) UNIT



FCC Unit: – Process Diagram



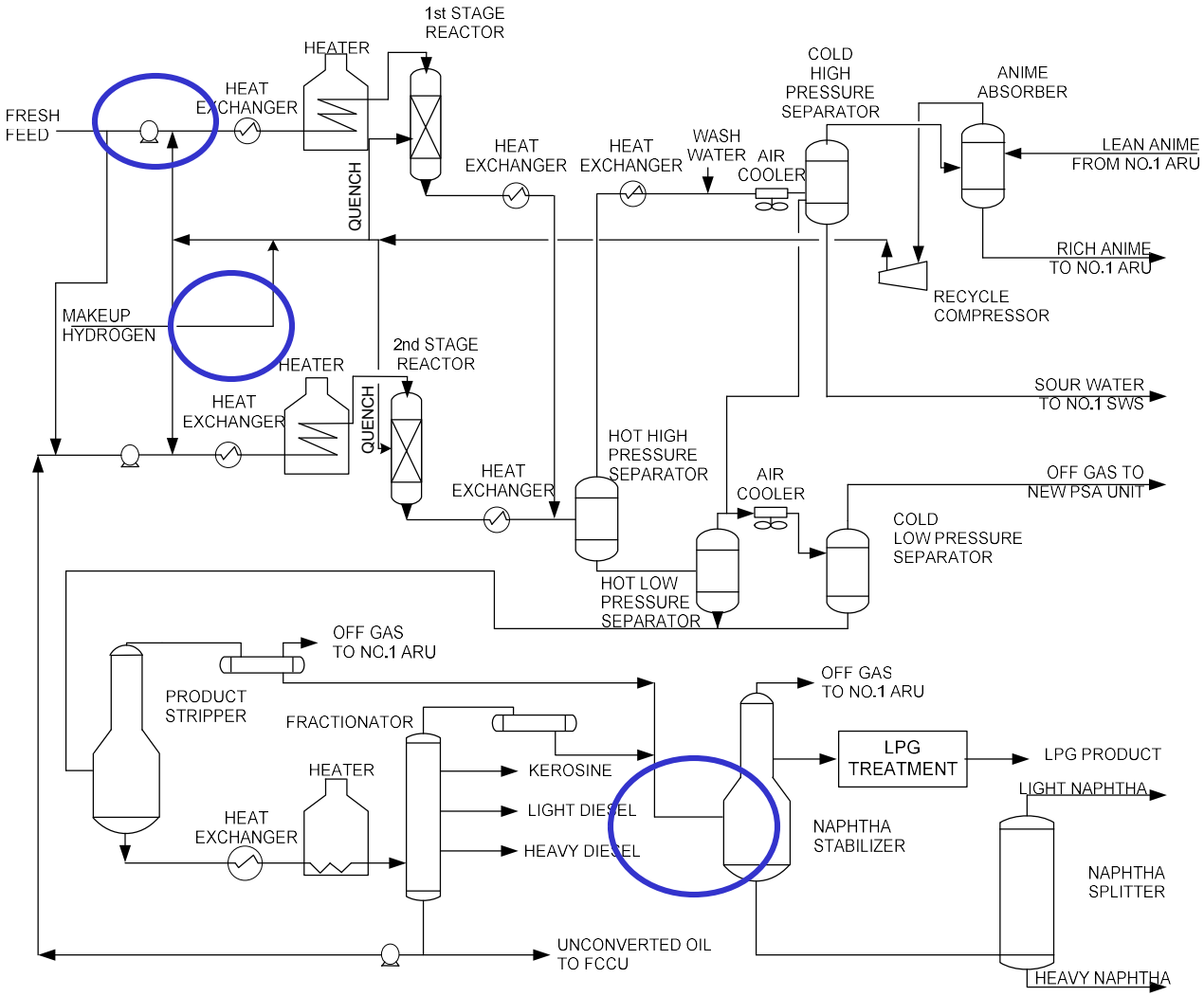
What Does The FCC Do?

- Heats a heavy oil mixture (gas oil) to about 600 F
- Mixes in a hot catalyst (1300 F)
- Reacts the combine mixture to produce lower molecular weight molecules, primarily in the gasoline boiling range, from the heavy oil
- Separates the catalyst from the reaction mixture
- Separates the reactants into various boiling range fractions
- Burns the reaction carbon from the catalyst in the regenerator and recirculates the catalyst back to the reactor

FCC Control Considerations

- With high price differential between products and feed and the volumetric gain, FCC is the most profitable unit in the refinery.
- For high conversion, the operation will encounter more equipment constraints.
- In fluidized bed, temperatures and pressures in reactor and regenerator must be well balanced.
- In addition to conversion, maximum waste heat recovery and minimum catalyst loss should also be considered in the control.

Hydrocracking – Process Diagram



Fresh feed is Vacuum Gas Oil from the Vacuum Distillation Column

Makeup Hydrogen comes from the Catalytic Naphtha Reforming unit with the remainder provided as necessary from the Steam Methane Reformer (“Hydrogen Plant”)

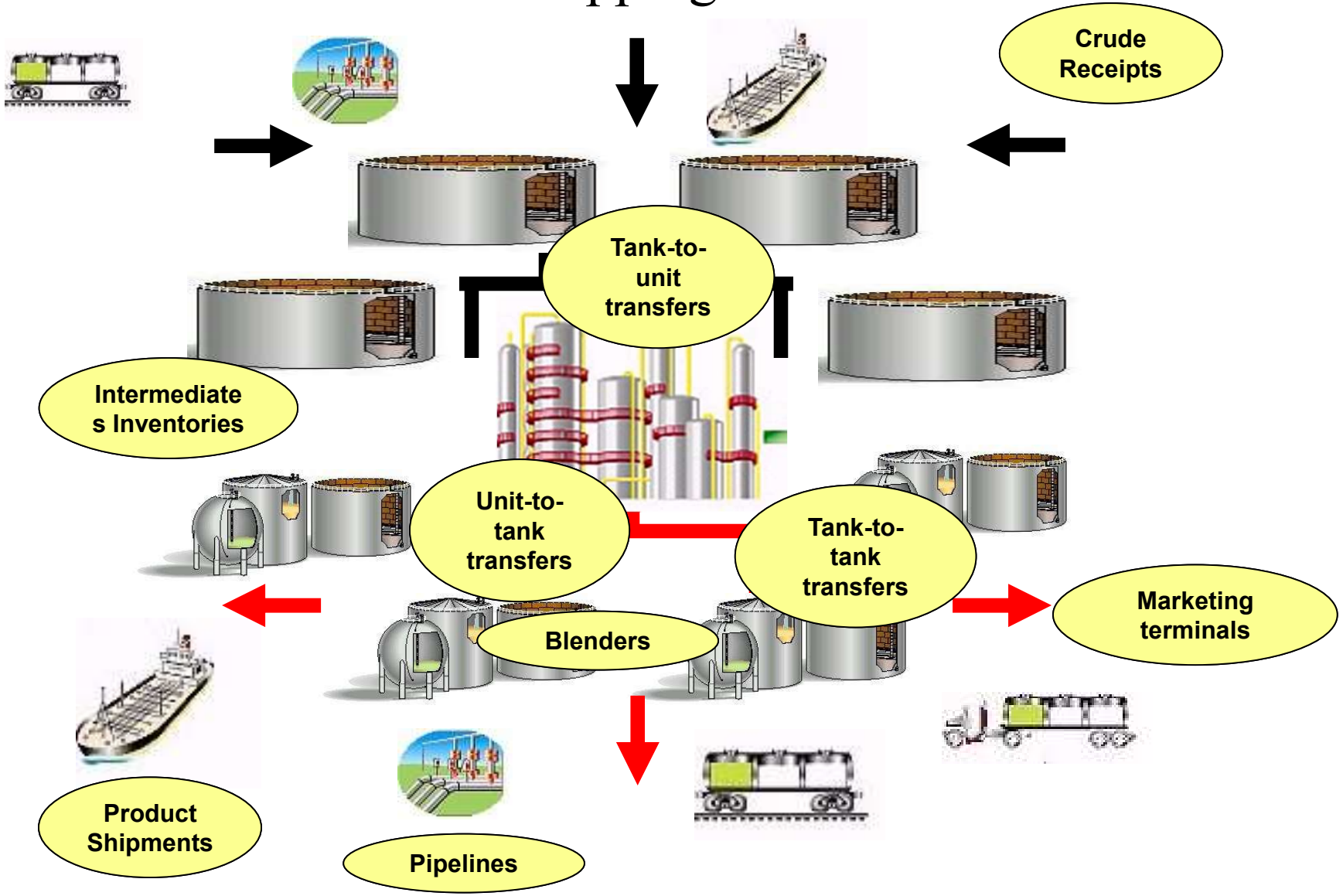
Primary products are low sulfur diesel fuels

What Does The Hydrocracker Do?

- The Hydrocracking process converts (or cracks) heavy feedstocks into lighter components by selective reactions with hydrogen in multiple heated catalyst beds. The process is most commonly used to create diesel, kerosene/ jet fuel and gasoline product streams.
- The products produced have low sulfur concentrations (ppm) which meets recent product specifications

Refinery Offsites, Terminals and Shipping

What Happens in the Refinery Offsites, Terminals and Shipping Areas?



Terminal Automation Functions

Inventory Management

Blending

Pipelines

Unit Feed

Vessels

Tank Management

Movement

Trucks

Railcars

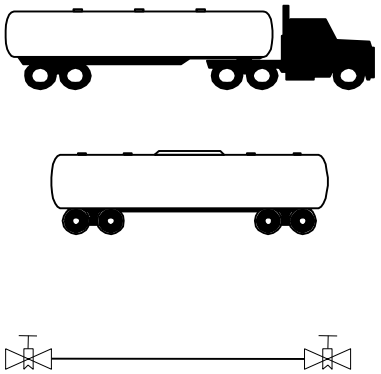
Blending

In-Line

Components

Product

Online Analyzers
Blend Property Control
Online Blend Optimization
Product Certification

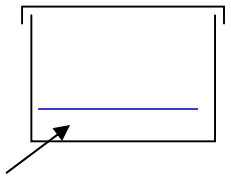


Each Part of Blend On-Spec

Tankage

Components

Product



Heel

Total Blend On-Spec

"Digital transformation is about reimagining how you bring together people, data, and processes to create value and maintain a competitive advantage in a digital-first world."

Satya Nadella, CEO Microsoft

DIGITAL TRANSFORMATION ROADMAP

SAFETY

Zero injuries. Zero incidents.

- Employees removed from hazardous activities
- Constant monitoring of worker and plant health
- Threat prevention and response – cyber, physical – is automated, part of culture

RELIABILITY

No unplanned downtime at minimal cost

- Analytics predict health of all equipment
- No reactive repair: pre-failure corrective action by automated closed-loop systems
- 'Avatars' perform field tasks

PRODUCTION

Production optimized to market conditions

- Continuous visibility enables active business management
- Business areas optimized in real-time across interconnected systems
- Predictive digital twins enable exception management along entire value chain

ENERGY & EMISSIONS

Recognized sustainability leader

- Continuous analytics predict and prevent releases
- Energy consumption measured and dynamically optimized with production
- Energy sources balance business and shared community goals

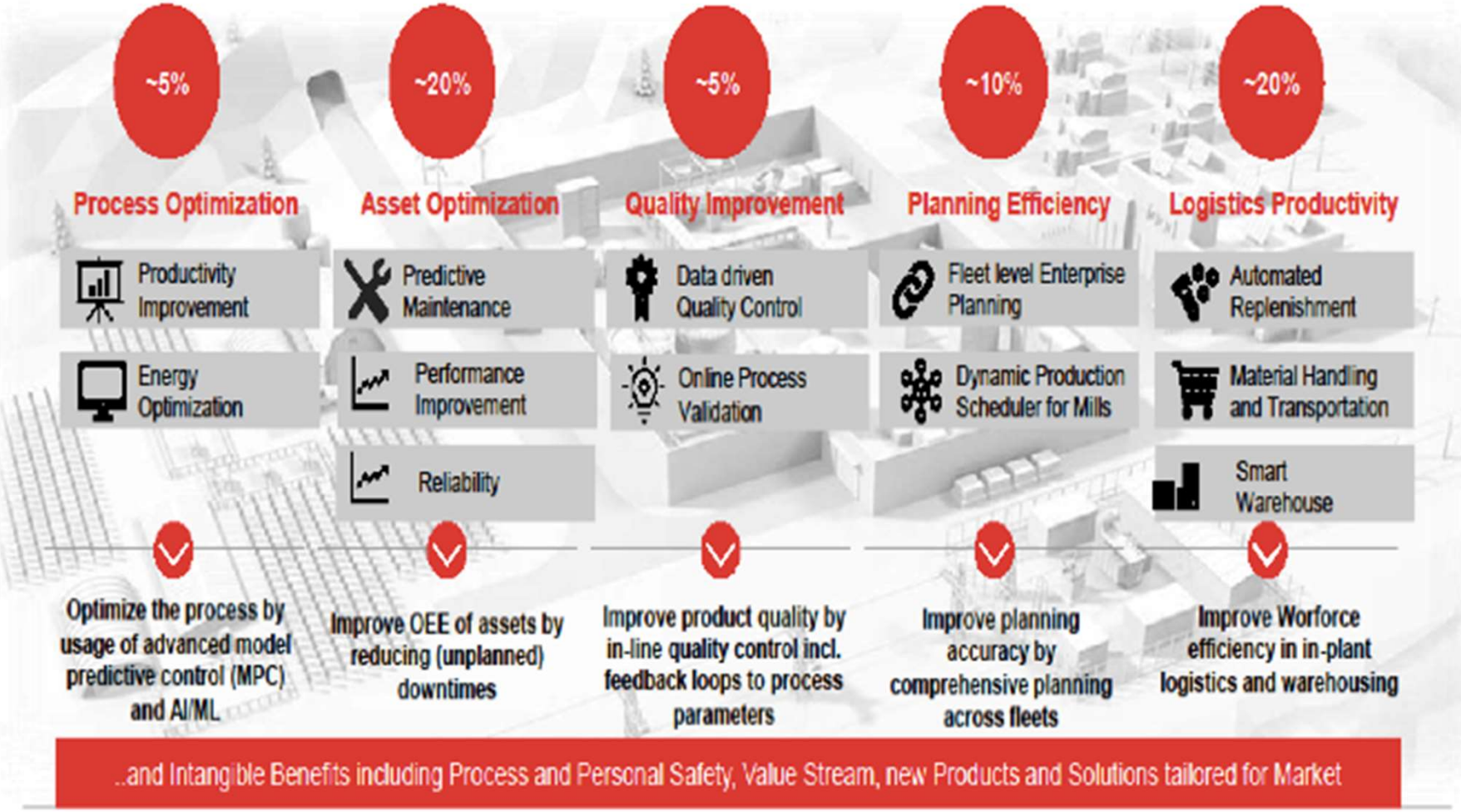
WORKFORCE

Empowered workers drive even more value

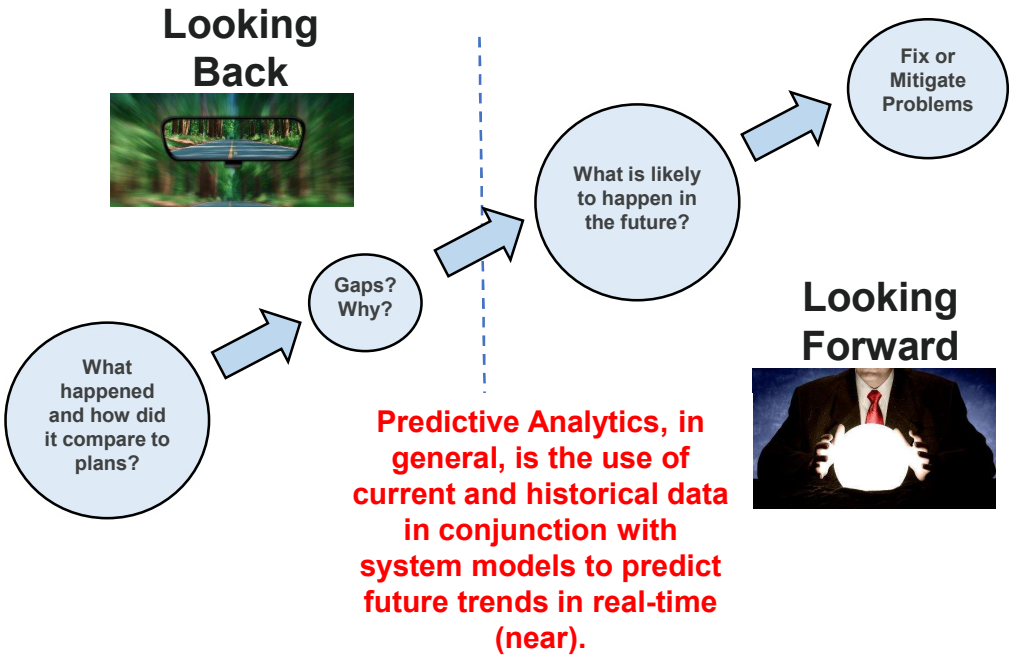
- All routine tasks automated: staff takes larger role in meeting KPIs
- Collaboration embedded in culture and work processes
- Faster, better decisions supported by analytics and on demand expertise
- Career-long development and certification through virtual tools

Typical Business Benefits of Digital Transformation in Process Industries

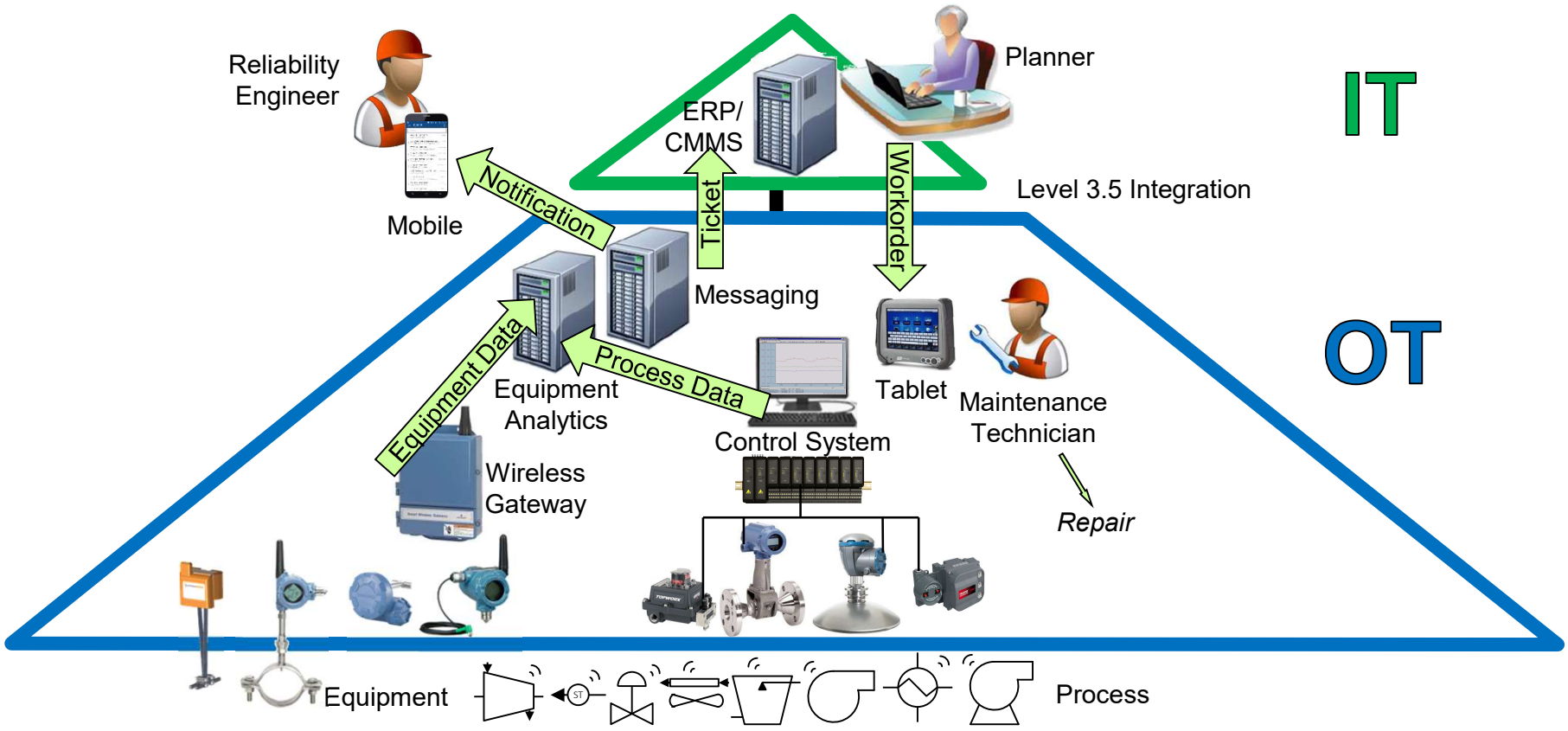
Bottom line and Top line Impact



Creating Value From Digitalization - Looking Forward



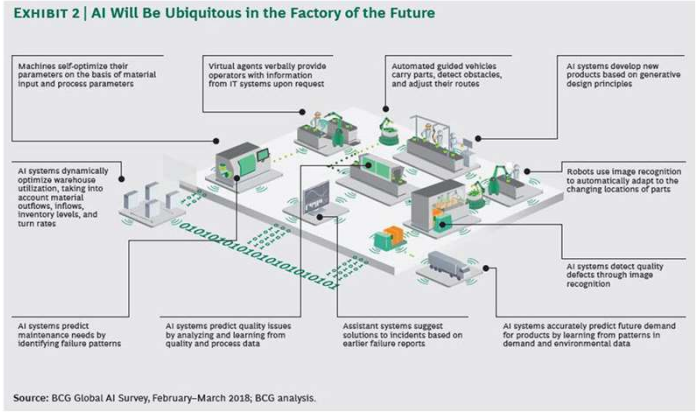
Digital Workflow Integration



The use of AI and Machine Learning in Process Industry

- Energy Management
  - ISO 50001
  - Cost Management:
    - Raw Mat, People, Energy
  - Good PR
  - AI/ML has been proven to be effective
- Process Optimization and Advanced Control
  - Small scale use of Fuzzy Logic, Neural Net, MPC since 1990
  - Proven in Process Analytics, Quality Prediction etc
  - Larger Scale use of AI/ML in Process Optimization of large units has not been easy
    - Good application knowledge needed
    - Constant tuning/re-modelling

- Asset Performance and Management
  - Adv Diagnostics and Expert System in use since 1990
  - More recent expanded use
    - Equipment Useful Life Prediction
    - FMEA and Failure Prediction
    - Criticality Analysis
    - Maintenance and Shutdown Scheduling Optimization



Virtual Reality (VR) For Field Operator Training

- Digital Twin for simulated environment and process data
- Ideal for learning of scenarios eg: Abnormal Situation Management, Operator Field Intervention, Collaboration with Control Room