DOWN, BUT NOT OUT
LOSS MITIGATION IN REFINERIES AND PETROCHEMICAL PLANTS

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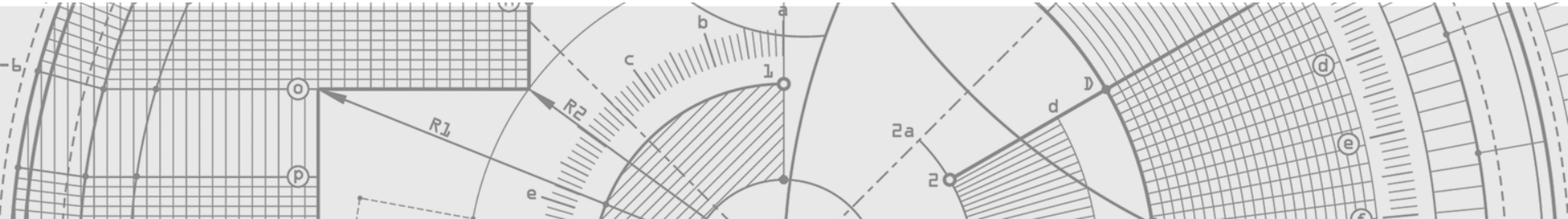


SCOPE OF SESSION

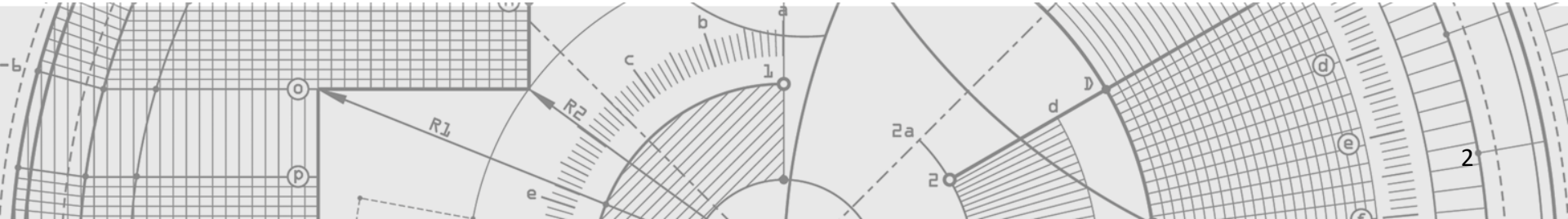
Refining and Petrochemical characteristics

Aspects of mitigation

Refinery case study

Petrochemical case study

Significance of pipeline systems on mitigation options



INTRODUCTION

Typical mitigation possibilities

Types of mitigation

What prevents mitigation

Key differences between

- Refineries
- Petrochemical

CHARACTERISTICS

KEY DIFFERENCES

Refineries

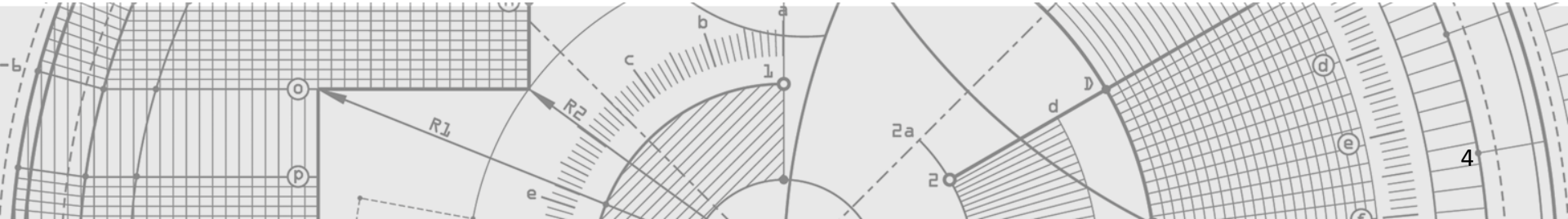
Distil, crack or upgrade hydrocarbons

Create a range of products

Petrochemical

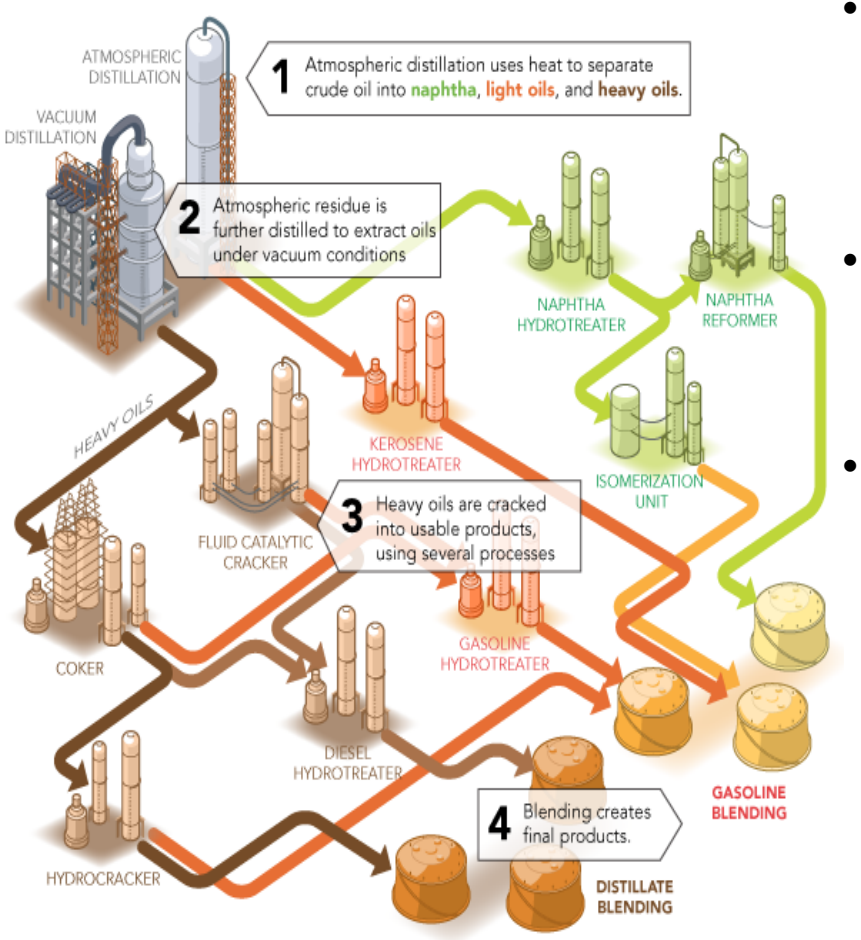
Take a pure intermediate feed and make pure products

Aim to make one main product



THE REFINING PROCESS

CONVERSION OF CRUDE INTO HIGHER VALUE PRODUCTS



- The fractionation units (atmospheric and vacuum distillation) are the first two steps, splitting the crude into various intermediate products
- These products are then treated, converted and blended to produce final saleable products
- Steps:
  - Distillation or fractionation
  - Hydro processing
  - Reforming / platforming
  - Isomerisation
  - Catalytic Cracking
  - Hydro -Cracking
  - Blending
  - Delayed coker / Flexi coker
- Downstream from refining ~ Petrochemical plants

REFINERIES

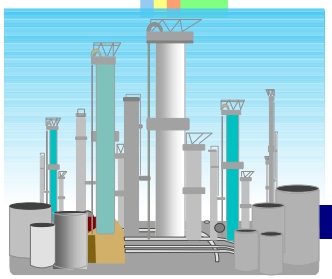
Crude distillation key:

Peripheral process units vary in margin contribution and available workarounds

Key drivers: configuration, location and market focus

Constraint - often the sale, or storage of resultant intermediate

TYPICAL PETROCHEMICAL COMPLEX



The Refinery

Ethylene Unit

Propylene - Propane Mix

Mixed Xylenes → Paraxylene

Toluene

Benzene

Cyclohexane

Styrene → Polystyrene

Styrene Merchant Sales

Cumene

Propylene

Propylene Merchant Sales

Alpha Olefins

Ethylene

Polyethylene

Ethylene Merchant Sales

Heavy Olefins

Acetylene Black

- Engine Oil Surfactants
- Laundry Detergents
- Film, PET Bottles
- Polyester Fibers
- Clothing Carpeting
- Urethane Foam
- Explosives
- Solvents
- Nylon Carpeting
- Hosiery
- Auto Parts
- Food Packaging
- Institutional Products
- Medical Devices
- Video Cassettes
- Tires, Plastics, Computer Housings, Autos Insulation
- Phenolic resin for Plywood
- Polycarbonate Resins for specialty Plastics
- Polypropylene
- Propylene Oxide
- Food & medical Packaging
- Plastics
- Detergents
- Lubricants
- Paper Sizing
- Food Packaging
- Film, Coatings
- Pipe
- Containers
- PVC Monomer
- Ethylene Glycol
- Acrylic Acid
- EP Rubbers
- Butadiene, Isoprene
- Hydrocarbon Resins
- Additives, Solvents
- Batteries
- Tire Bladders
- Recording Tapes

PETROCHEMICAL PLANTS

TYPES OF MITIGATION

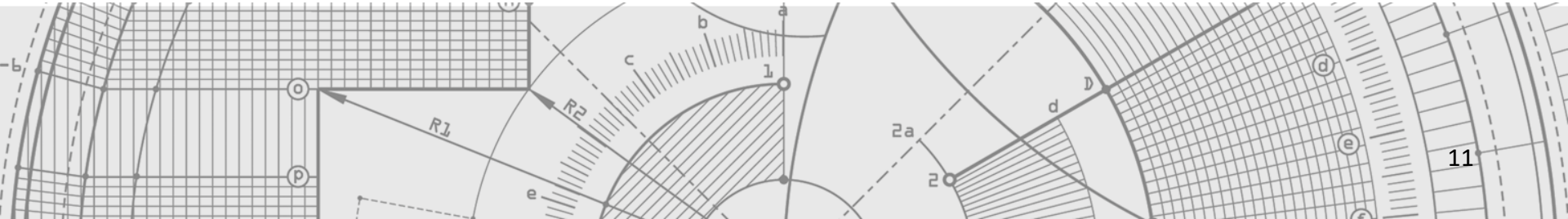
- Expedite PD
- Deferring major replacements – scheduled turnaround
- Shorten delivery times
- Re-configure – partial production
- Alternative feedstock / intermediate product
- Alter crude slate (refineries)
- Alternative finished product
- Inter-company surpluses / capacity
- Alternative transportation

WHAT STOPS IT HAPPENING?

- Damage to key process equipment
- Damage to external utilities
- Authorities
- Permitting
- Extremes of weather
- Inability or unpreparedness to re-configure process equipment
- Strategic / commercial decision to avoid mitigation

REDUNDANCY

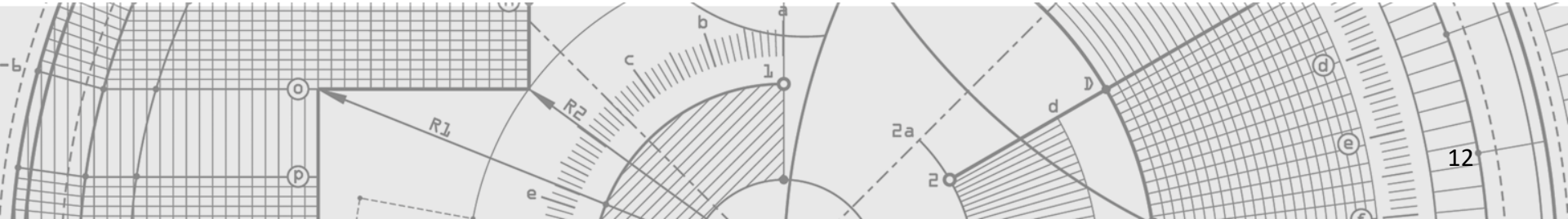
- Plant configuration with component duplication can benefit Insurers
- Units which need to be changed out regularly often have redundancy
- Units which need regular maintenance or replacement often have duplicates



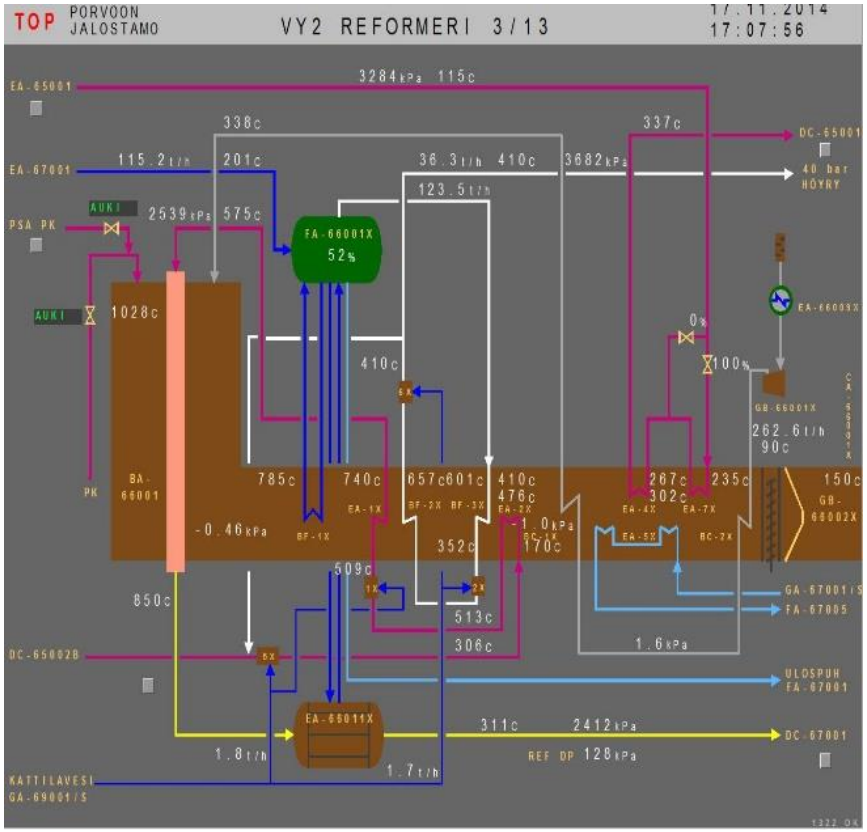
CRITICAL EQUIPMENT

NO REDUNDANCY & LONG LEAD TIMES

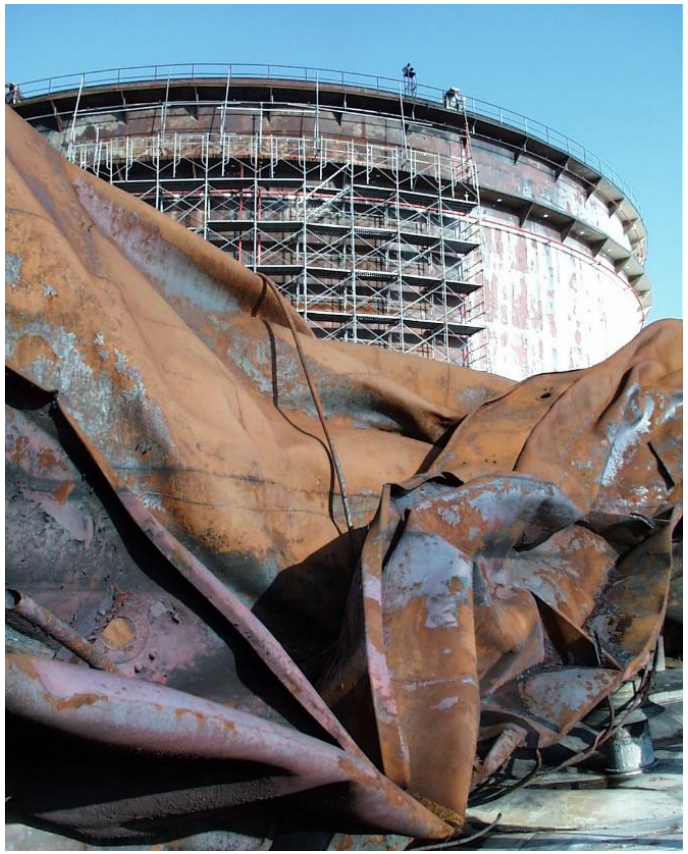
- Refrigerant and cracked gas compressors (ethylene crackers)
- High output electrical motors
- FCC blowers
- Large diameter valves
- High pressure reactor tubes and components
- Components with exotic alloys
- Specialist catalysts



MITIGATION EVALUATION



INFLUENCING FACTORS



It is necessary to identify and understand the nature of the insured's operations, including :

- Make up potential via other assets
- Price effect as a result of outage on local market
- Pre-loss inventory levels
- Available inventory capacity
- Alternative suppliers
- Any turnaround activities which can be brought forward
- Identify long lead time replacement items driving the time-line
- Assess ability to negotiate earlier manufacturing slots

MITIGATION

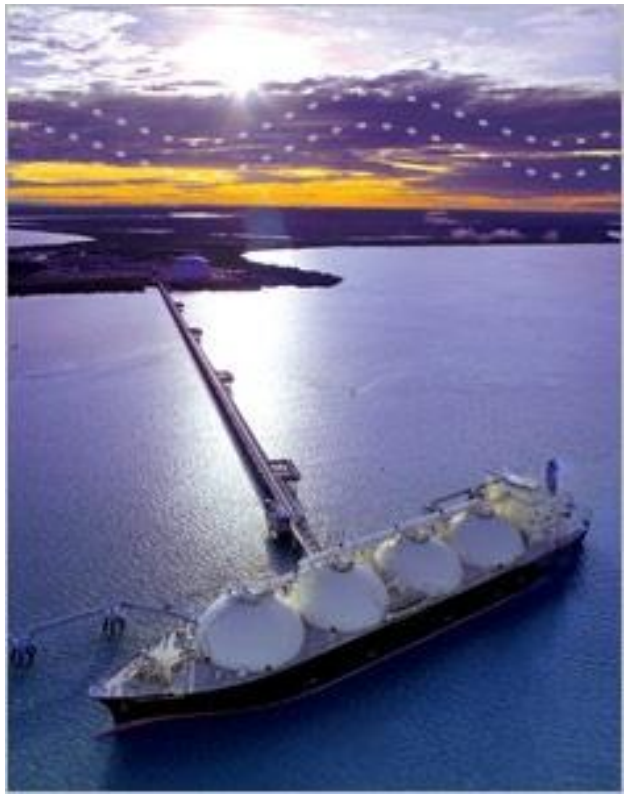
- Engage early
- What mitigation options are available?
- Other costs associated with mitigation – costs may be significant
- Inefficiencies: most facilities cannot be run below circa 60% throughput
- Regulatory , costs related to permitting waivers etc.

SIGNIFICANCE OF UTILITIES

Refineries and petrochemical plants all require:

- Electricity
- Cooling water
- Steam for heating and energy
- Fuel gas
- Compressed air
- Nitrogen

LOCATION OF UTILITIES



UTILITIES MITIGATION

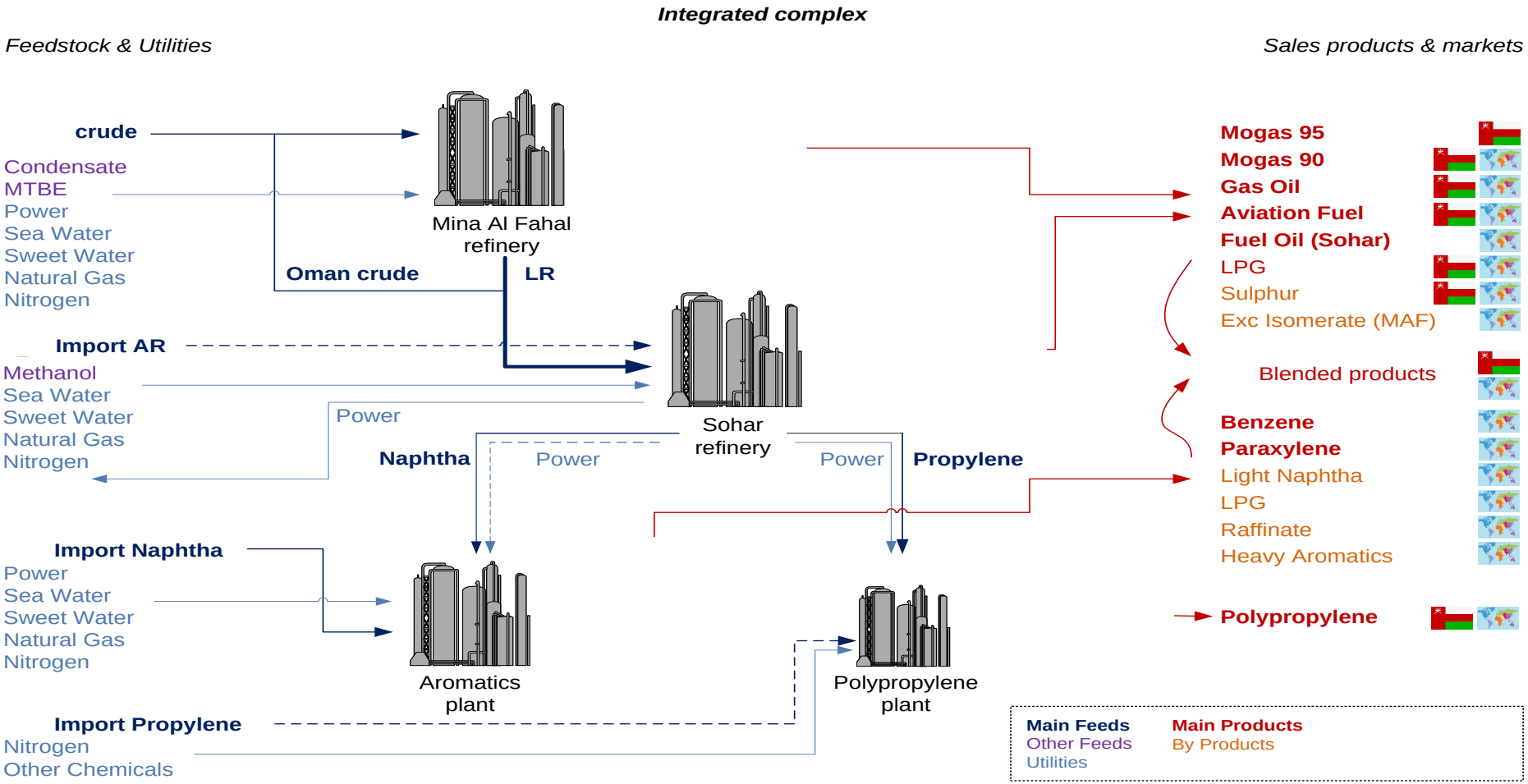
- Electricity
- Steam
- Steam balance
- Fuel gas
- Nitrogen and instrument air

TRANSPORTATION MITIGATION

REFINERY CASE STUDY

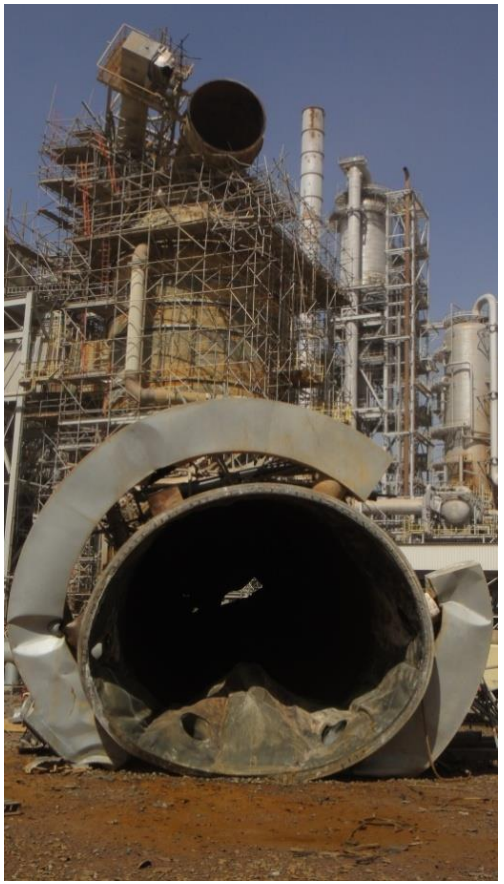
Fire in a wet gas scrubber absorber unit

REFINERY CASE STUDY



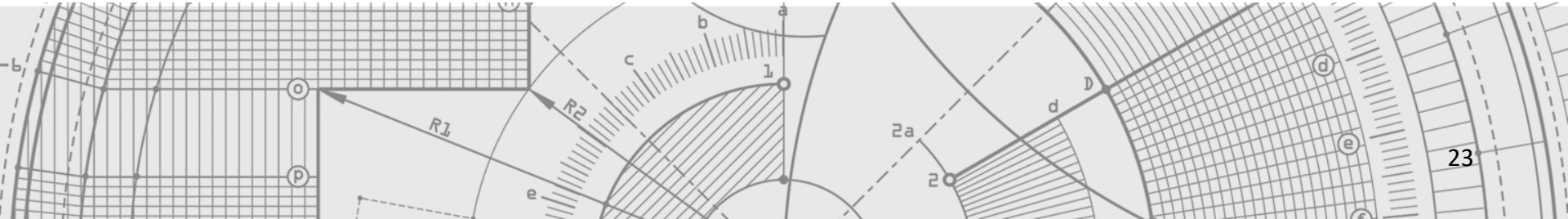
CONSEQUENCES

- Wet gas scrubber being upgraded to improve SOx emissions from Residue FCC
- Loss means no sulphur removal
- Group refinery #2 sends residue to refinery #1, because it has no upgrading unit
- RFCC designed to yield a high proportion of olefins to feed polypropylene plant
- Polypropylene facility cannot operate independently because refinery #1 has the propylene recovery unit
- Refinery #1 supplies naphtha feedstock to Aromatics plant
- Aromatics plant can buy in naphtha from alterative sources, but this will reduce margins on paraxylene and benzene sales
- Refinery is the major provider of gasoline and jet fuel to the local market
- Important to avoid shutdown of refinery #1



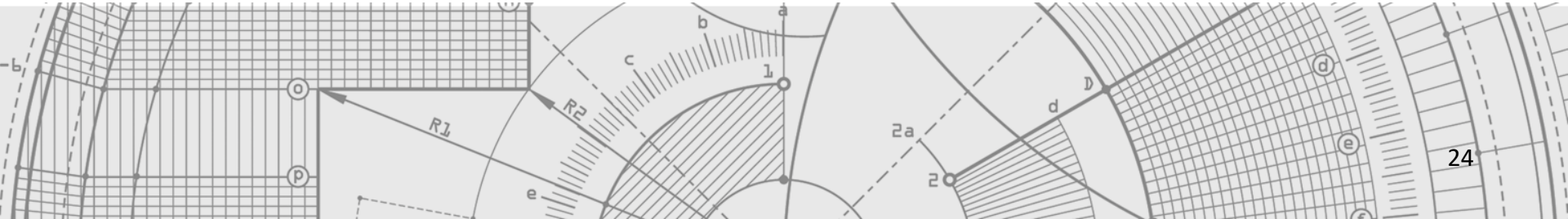
THE PLAN

- Insured secured environmental agency's agreement to operate without meeting sulphur removal requirements during repairs
- Agreed with licensor that the RFCC catalyst regenerator could be operated in 'CO burn' mode with the gases being diverted to another stack ~ never been done before for an extended period
- Downside is elevated temperatures in the catalyst regenerator ~ requires enhanced monitoring
- Additional De-SOx catalyst introduced to the batch to assist with sulphur removal
- This creates a throughput constraint with volumes restricted to 80%
- Need to reduce the long residue component of the crude slate by substituting around 25% of volume with low sulphur VGO
- Linear programme used to assess what could be achieved and the economics of revised operation



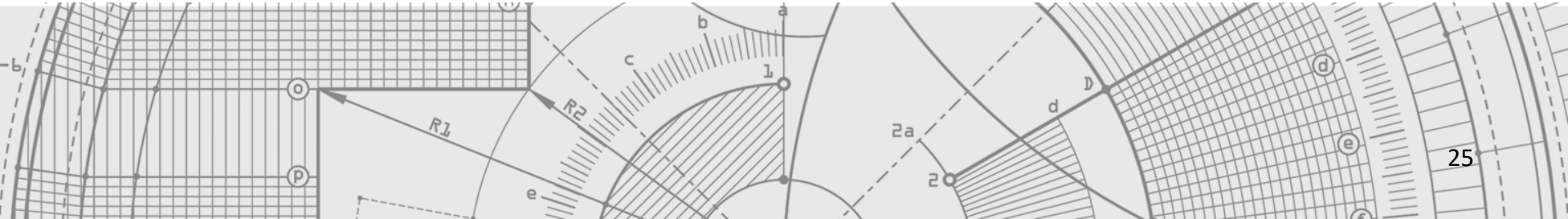
THE OUTCOME

- Insurers' adjustment team worked with the Insured, the technology licensor and the catalyst manufacturer to validate the theory of the plan
- Insurers' consultant undertook numerous LP runs to assess the effects of the volumetric and crude slate changes
- Refinery operated successfully in partial production mode during the repairs
- Polypropylene plant shutdown avoided
- Aromatics plant continued normal operations
- Refinery #2 suffered slight reduction in long residue upgrading as a result of refinery #1 constraints



LINEAR PROGRAMMES

- LP not always accurate because it relies on expressing reactions, distillation, purification etc: as simple equations
- Models usually calibrated against steady state operation so ‘post loss’ operation may be outside the calibration range
- Useful for validation of the insureds forecasts – i.e. can the plant operate at the budgeted / forecast levels?
- Helpful to predict the production from a re-configured facility during partial operations
- Confirms how the plant would have been operated, had no loss occurred (base line)



REFINERY CASE STUDY – FACT SHEET

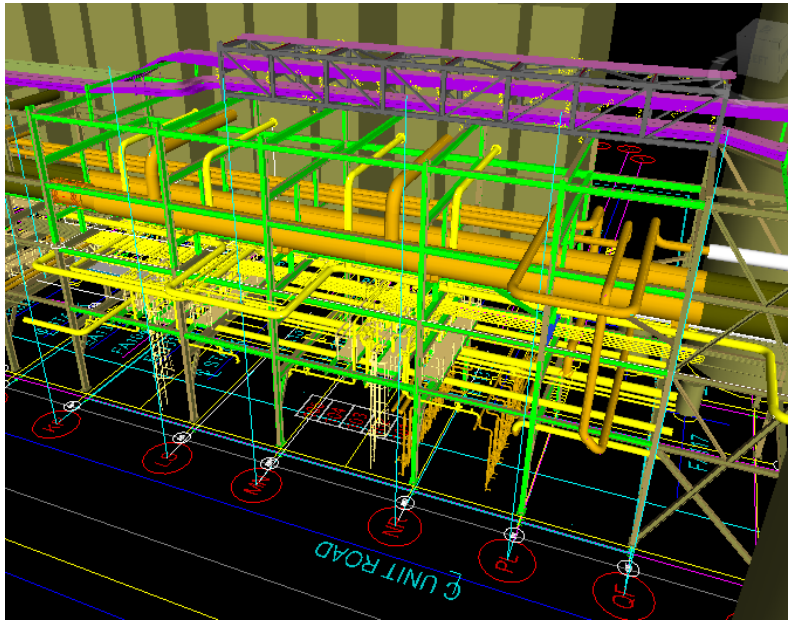
- Fire in Ethylene cracker
- Cabling and instrumentation to all furnaces affected leading to crash shutdown
- Facility provides 25% of group ethylene supply
- Planned Phase 1 Reinstatement (80% production) 6 months
- Planned Phase 2 Reinstatement 9 months

SCOPE

- Majority of furnaces suffered some tube and refractory damage requiring full or partial re-tubing
- Around 15,000 feet of pipework affected
- Cabling and instrumentation runs located at the top of the piperack so all runs need to be replaced
- 1,000+ DCS set points lost
- Extent of fire damage was clearly defined

MITIGATION

- Pre-qualified contractors were engaged immediately
- Worked to agree the scope early in the process
- Replacement tubes on hand
- ‘Clear cut’ demolition was deemed the speediest option to re-build 5 complete bays of piperack
- Pipe fabrication was undertaken from 3D computer model
- Cabling and instrumentation was initially the critical activity



BY-PASS TRUSS FOR CABLING

OUTCOME

- Due to mitigation actual Phase 1 re-start was achieved in 4.5 months and full production recommenced in 6 months
- Claim concluded in 9 months
- Illustrates the possibilities of a collaborative approach to a claim situation

PIPELINE SYSTEMS

Crude Oil and Liquid Petroleum Pipelines

Crude Oil Lines:

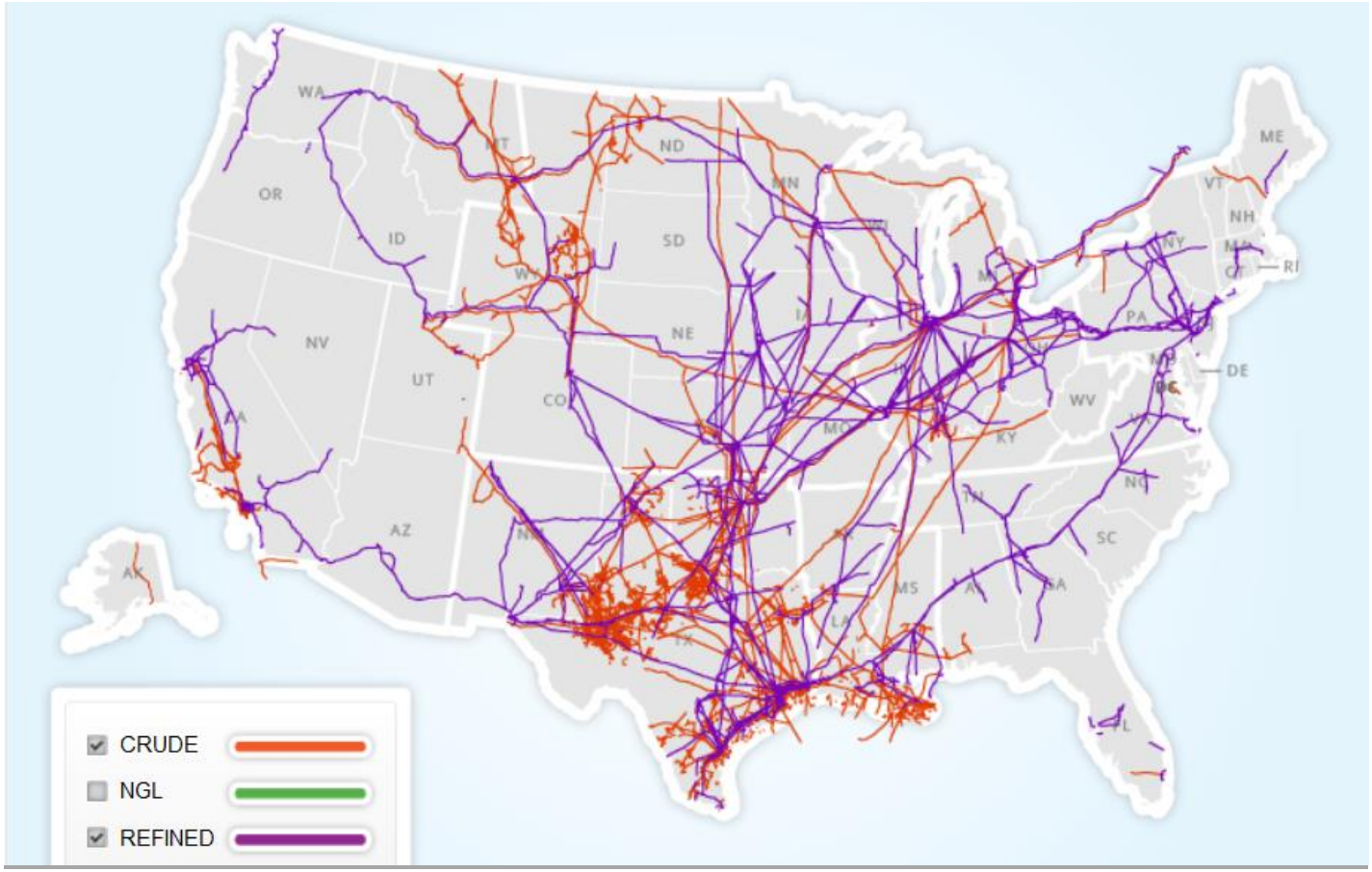
- **Gathering lines** are very small pipelines (2 to 8 inches in diameter) in the areas where crude oil is found. These gathering lines exist all over the country but the bulk of them are located primarily in Texas, North Dakota, California, Oklahoma, New Mexico, Louisiana, and Wyoming with small systems in a number of other oil producing states.

- **Crude oil transmission pipelines (trunk lines)** bring crude oil from producing areas to refineries. There are approximately 72,000 miles of crude oil system lines in the U.S. (8 to 24 inches in diameter). There are also a few VERY large trunk lines. One of the largest in the U.S. is the Trans-Alaska Pipeline System, which is 48 inches in diameter.

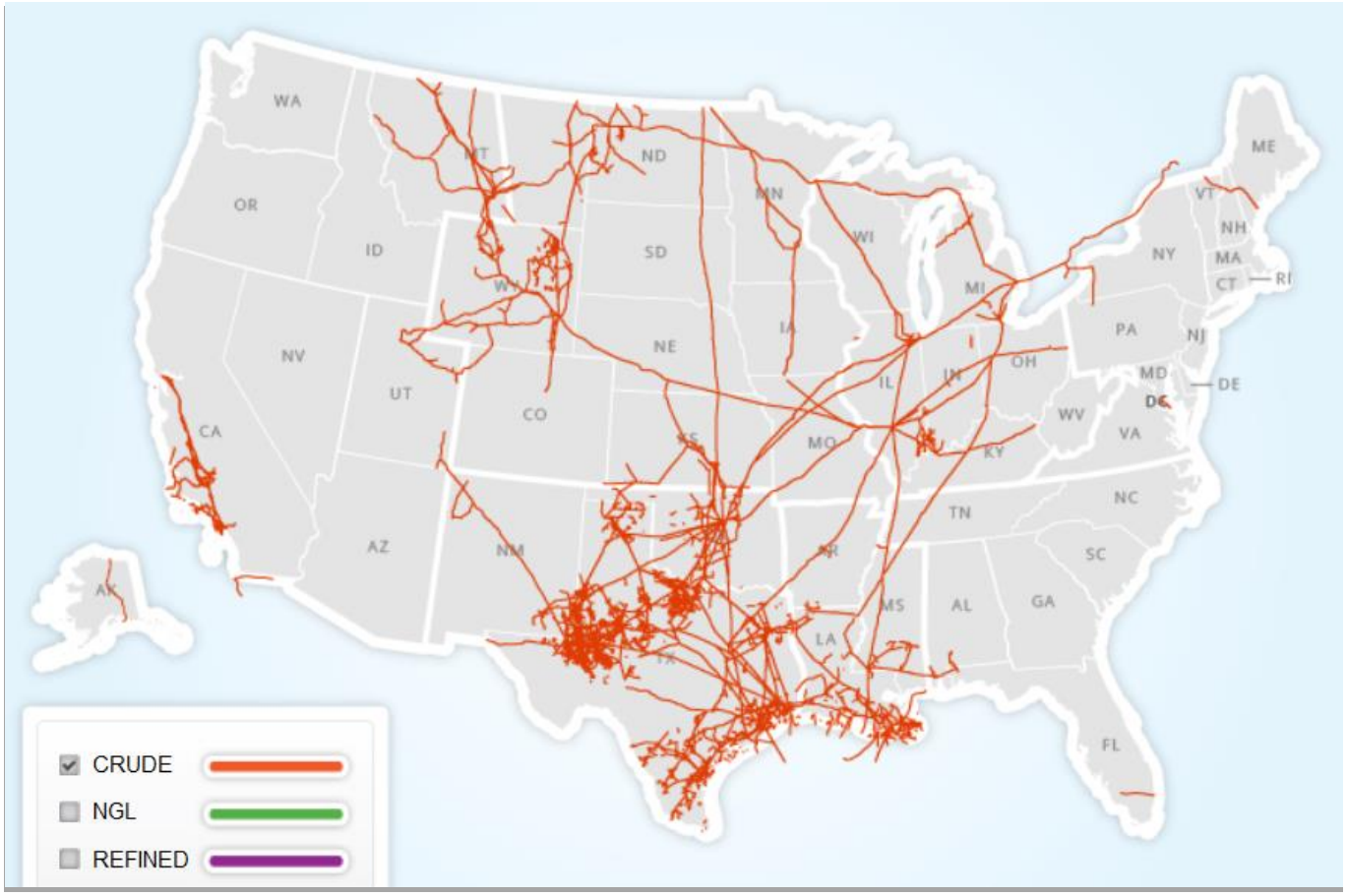
Liquid Petroleum Pipelines:

- Carries refined petroleum products – gasoline, jet fuel, home heating oil and diesel fuel. These refined product pipelines vary in size from relatively small, 8 to 12 inch diameter lines, to much larger ones that go up to 42 inches in diameter. There are approximately 63,000 miles of refined products pipelines nationwide. They are found in almost every state in the U.S.
- These pipelines deliver petroleum products to large fuel terminals with storage tanks that are then loaded into tanker trucks.
- Trucks cover the last few miles to make local deliveries to gas stations and homes.
- Major industries, airports and electrical power generation plants are supplied directly by pipeline.

U.S. Crude Oil and Liquid Petroleum Pipelines



U.S. Crude Oil Pipelines



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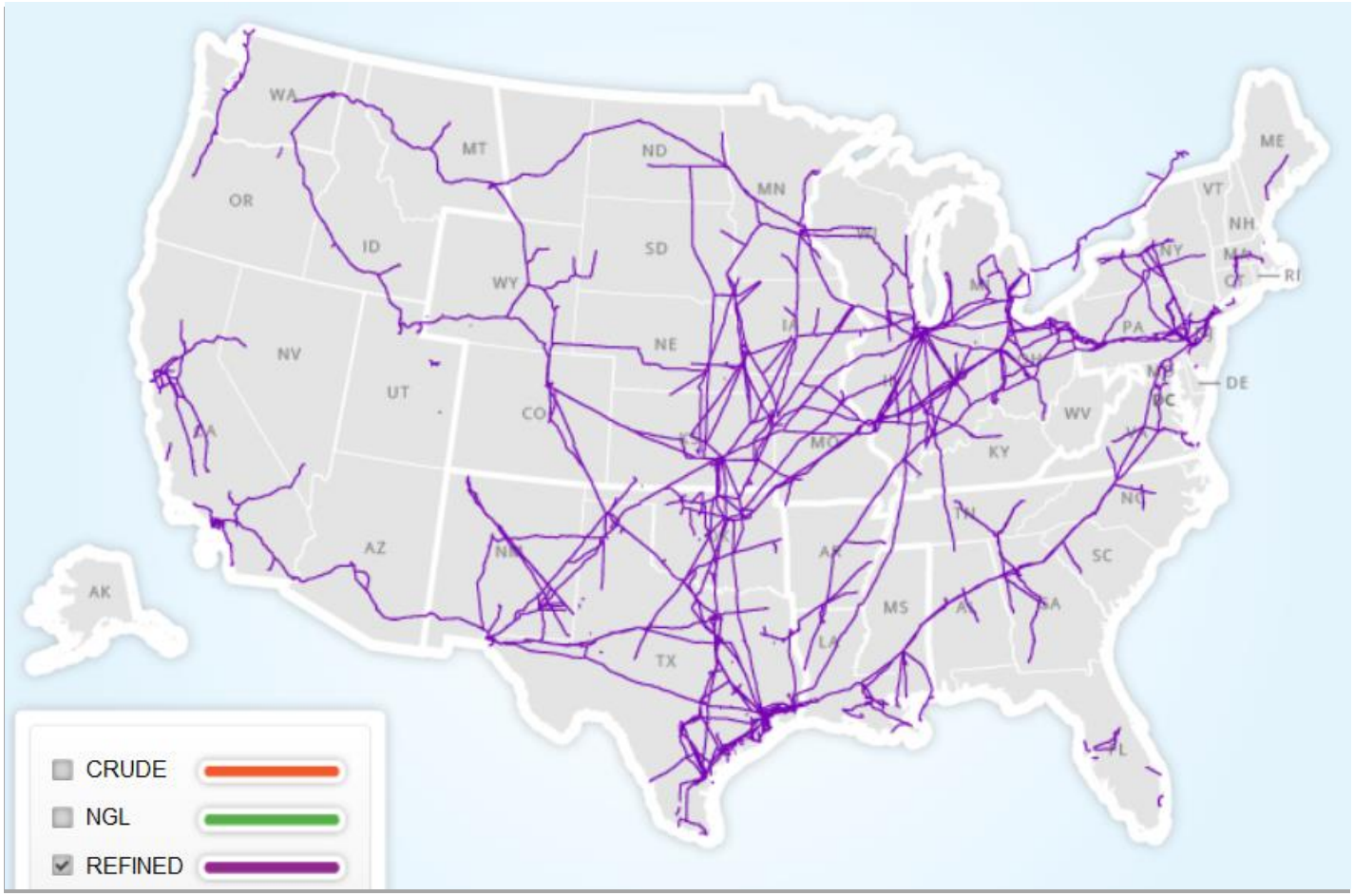
Liquid Petroleum (Refined Products) Pipelines



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Affects of Pipelines and Storage on Refinery Losses

- Mid-West Region Refinery: Use of crude pipelines and conversion of truck/rail car loading facilities to enable VGO and LCO to be exported from site, thereby overcoming the storage volumes constraint, and allowing higher crude throughput rates to mitigate the business interruption loss

- Purchased finished product from outside sources to mitigate reduced production can be moved to existing customers via pipeline, truck, and/or rail car

- Lack of physical onsite crude storage can result in distressed crude sale losses and incremental storage expenses for crude already in transit

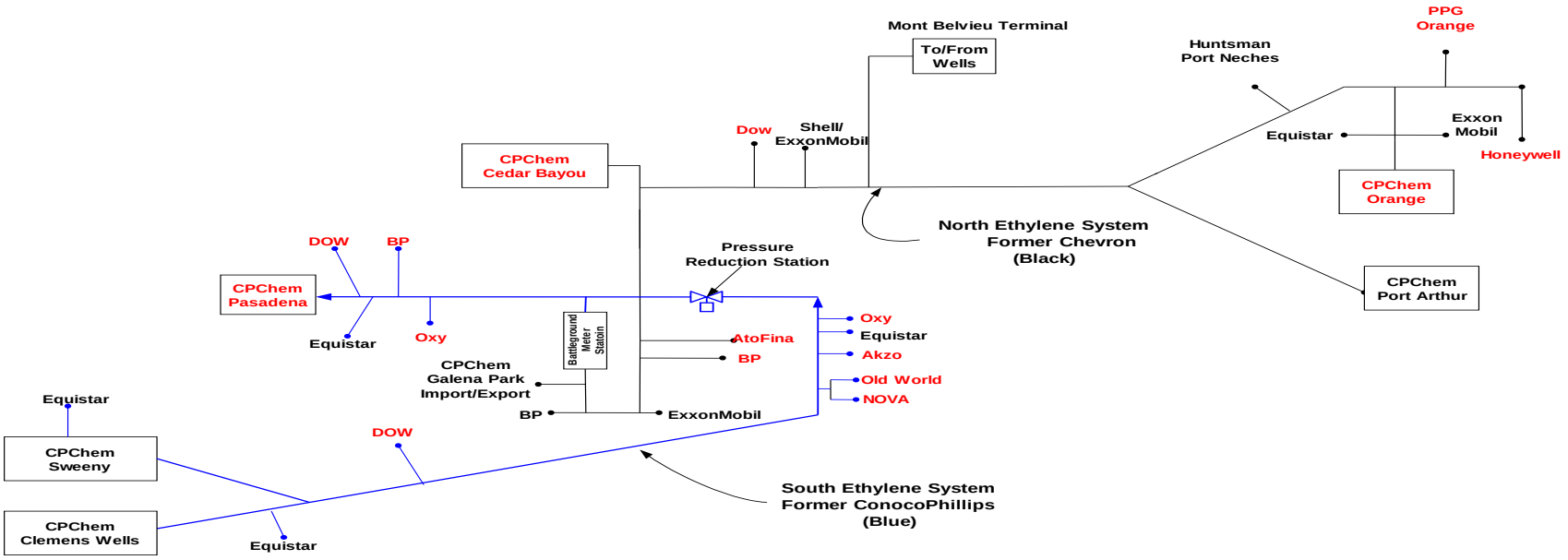
- Crude slates can often be modified to yield preferred volumes of intermediates in order to mitigate processing and storage constraints. LP models are often used to predict finished product yields under these modified conditions

Ethylene Storage and Exports

- Ethylene is stored in large underground caverns and transported to customers through a pipeline system.

- There is growing interest in exporting ethylene overseas via export terminals. Currently, a small amount of ethylene (300K Tons Annually) can be exported from a single terminal operated by Targa Resources at Galena Park, Texas. However, three new ethylene export terminals have been proposed in the U.S. Gulf Coast with announced operational dates in 2019 and 2020. Ethylene can also be transported internationally by refrigerated ships

Gulf coast ethylene pipeline schematic



European ethylene pipeline systems

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Petrochemical Pipelines
Dow's Gulf Coast Pipeline

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Petrochemical Pipelines
Dow's Gulf Coast Pipeline

- Operates over 3,000 miles of cross-country pipelines along the U.S. Gulf Coast.
- The pipeline systems stretch from Brownsville, Texas to New Orleans, Louisiana.
- Transports both liquid and gas products with the vast majority of products being hydrocarbons, which are combustible if released and exposed to an ignition source.
- Products transported include:
  - Butane
  - Natural Gas (methane)
  - Ethylene
  - Propylene
  - Propane
  - Ethane-Propane Mix

QUESTIONS & DISCUSSION