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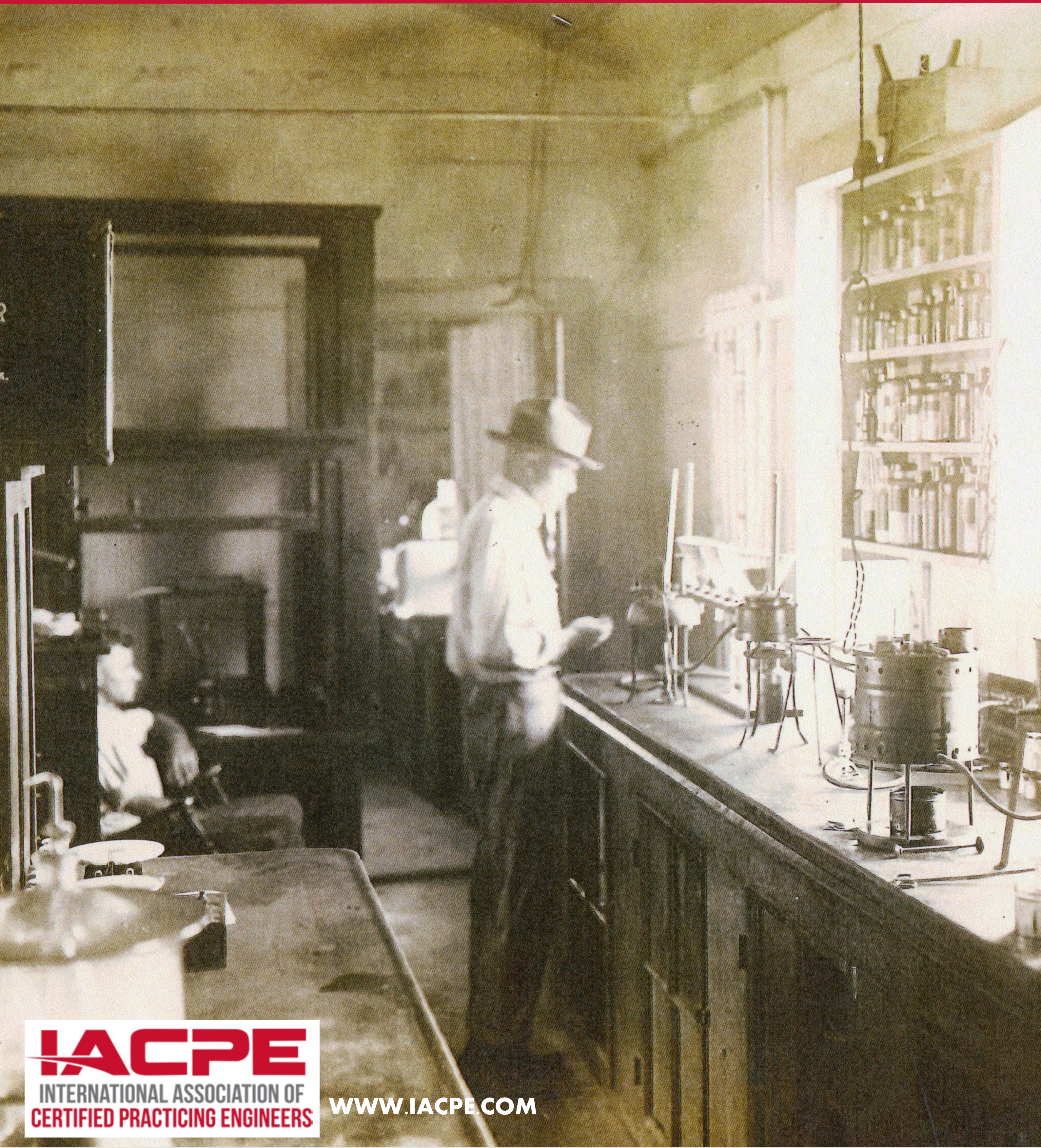

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SPECIAL FEATURES

Approaching Seventy – What is Success

Karl Kolmetz

I will soon have lived three score and ten years. The average life expectancy in USA is seventy-six years. My parents lived to 87 and 90, so I am hoping I have a few more years left. I am trying to plan so that may have a few more good years.

My father's grandmother was Della Victoria Strickland Jenkins. She was born on 18 Oct 1866 and died on 9 July 1945. She is buried at Pleasant Grove Methodist Church, Washington Co, Florida. That is all I know about her. I wish I knew a few stories, but I do not.

Here is a picture of Victoria and her grandchildren. I know of only one person in the picture that is still alive today – the small girl in the front with the flower in her hair is my father's sister Bertha, she is 90 years old this year. My father is standing fourth from the left with black hair looking down. In the early years of his life, he was always looking down in the pictures. Later he would always hold his head up high to over correct.

Her daughter, my grandmother, Mittie Jenkins was a caring loving person who raised her children to be hard working and respectful. Her first husband died in the 1919 flu, but she survived, so I have some inherited flu resistance. She later married John Kolmetz and here I am today.

Every Christmas I received a gift from my grandmother even though she had many grandchildren. I remember going to her house at Christmas. There was no electricity, running water, she had a well and a hand pump in the yard. We would sleep in front of the fireplace under blankets. Northwest Florida in December can be cold.

Here is Mittie and her sons, with my father's head raised.

Since I have no bad stories of Della Victoria, she probably was a good person. I have many bad stories of the other ancestors. I do know her daughter was a good person. I know my father better and he was a mixture of the good and bad, just like you and I am. My success today is in part because of the goodness of Della Victoria, Mittie and my parents. I have six siblings, and all are different, all have achieved different levels of success even with common backgrounds.

What is a good definition of success - Real Success Has at least four parts

Health

Friendships

Family

Giving Back

Health

1. You will not be successful or wealthy without maintaining your health.
2. Maintaining your health does not require major knowledge, but it is difficult to accomplish; eat healthily and exercise. For many people, both are hard to maintain.
3. Many people bring poor health to themselves by living wicked lives – you cannot escape the consequences of your actions. The bible says you reap what you sow.
4. You need to understand what your personality and work are to keep your health even with addictive and destructive personalities.

Friendship

1. Remember the most valuable antiques are dear old friends - H Jackson Brown
2. A friend of mine's child died. I asked my dad, what should I say to him? My dad answered – you do not have to say anything, just go stand by his side.
3. You will move in the direction of the people you associate with. You need to associate yourself with the kind of people that you would like to become.
4. The friends you have will form you as you go through life, make good friends, and keep them the rest of your life.

Family

1. Success is that you are seventy years old, and all your siblings will still speak to you – many family members to not speak to one another in their old age.
2. Communication is important – during both the good and the tough times. Some people often find it hard to put their feelings into words and just knowing that someone is listening can be enough.

Stable Financially

Having enough money so that you can make the decisions that you want to make about.

Health

Friendships

Family

Giving Back

Giving Back

1. The happiest people are not those receiving more but giving more.
2. When you pray, do you pray to be blessed, or that you may be the one giving the blessing.

One hundred years from now there will probably be no one with living memories of you. The good news and bad news are the good that you have done will be forgotten, and the bad that you have done will mostly be forgotten. Bad seems to always live a lot longer than the good. So why should we try to do good, in 100 years no one will really know.

Today our success was developed by those who worked before us, so that we might have a better life. We have no real memories of their lives and struggles. Our success today is because of their struggles and effort to build better lives.

Our lives and struggles will also be forgotten. So why do we then try to do good? Each of us has the capacity to do good and evil and if our deeds will be forgotten why make the effort to do good? Why strive to be successful? It takes a certain type of personality to be successful and make our world a better place despite no real acknowledgment.

Each of us can be successful, ordinary or a failure, based on the choices we make in life. Most people are happy to take credit for their successes but remember that we also must take credit for our failures. You call always tell a tree by the fruit it produces – what fruit are you producing?

There are many people that are very happy just to float through life with no real efforts to be successful and they get the results one would expect. Many people think I am lucky to be where I am. I worked a full-time job and went to night school eleven years – so maybe I am not lucky just hard working. If you work and go to school, you will be lucky also.

There are people that are born with additive personalities and live lives of torment until they realize that alcohol and drugs are their enemy. I had a friend with a large alcohol problem get pulled over for drunk driving, I was thinking the answer to the problem was to quit drinking. Their solution was that I need to quit driving. The alcohol had a powerful hold on her.

I like freedoms, but I believe that alcohol and drugs should be strictly controlled due to the damage that I have seen from my family members. I had two uncles that I rarely saw sober. I knew the additive personality was in my family, so I tried to stay away from alcohol and drugs. Many people fail this test and lead lives of missed opportunities. Many do not have the capacity to resist this temptation, as high as 10% of the population. My seventy years on the earth says that we should make it harder to obtain alcohol and drugs.

Almost everyone at seventy knows they could have been better and accomplished more – this might be the normal human condition. But even at 70 we can try to accomplish good for the next generation. Freedom, prosperity, and happiness are not values, they're not a map, they're not even principles. They may be the fruits of a successful society, but they're not its roots. No good tree bears bad fruit and to restore the fruit we must first attend to the roots. The true roots, the foundation stones of a civilization are not freedom, prosperity, and happiness, but the pursuit of good deeds, hard work, and truth in action.


TrayHeart
Tower Internals Design
TrayHeart is a professional software that performs hydraulic calculations for all types of tower trays, random and structured packings and liquid distributors. The development of TrayHeart started in 1998 and was continued jointly by universities, companies of the chemical industry and tower internals suppliers. TrayHeart ...
is based on multiple calculation models and large databases of packings, float valves, fixed valves, bubble caps, and liquid distributor templates
is a supplier-independent tool. There are no preferred product placements or promoted designs
considers static dimensions, manways and fastenings
offers an interactive 3D-view for all designs
can be used for single stage, profile and data validation calculations
has a unique, logical and multi-lingual user interface, with multiple input and output options
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PROCESS TECHNOLOGY

Daily Plant Monitoring Basic Routines In Upstream Oil & Gas Facilities for Process Engineers in Operations

Praveen Nagenderan C

As a Process Engineer in Upstream Oil & Gas Operator company, effective plant monitoring is crucial for ensuring optimal performance. In this article only the elements were discussed whereas methodology for the elements are not detailed. Here are essential daily monitoring routines:

1. WELL MONITORING: Begin with downhole and collaborate with Production Engineers. Evaluate wellhead parameters, artificial lift parameters, WHCP (Well Head Control Panel) parameters/Subsea Control Module data, and real-time data from DOF (Digital Oil Field) or Real time data servers for anomalies. Conduct variance analysis of the parameters, review well test results, and check water cut against surface facilities to align with daily production allocation.

2. PRODUCTION DATA ANALYSIS: Retrieve daily production data (Oil, Produced Water, Associated Gas, Fuel Gas, Flare, Water Injection, Gas Lift, Power, and Water Discharge Quantity) and perform a 24-hour comparative analysis to correlate with operational activities. Review Production Efficiency, Operations Efficiency, and Operation Availability metrics and identify & understand causes of +/-ve variations. Compare daily production loss forecasts with actual values, linking discrepancies to overall operations and activities.

3. ASSET MASS BALANCE: Prepare a comprehensive asset mass balance for oil, produced water, and associated gas, including fuel gas, flare, and water discharge, using flow meter readings. Adjust for known measurement errors and apply reverse balance techniques or engineering calculations where meters are unavailable. Incorporate backup methods for malfunctioning meters. While this can never be not 100% accurate, but calibrations can bring accuracy close to 95%. This process helps in identifying system leakages, excess consumption patterns, and in general plant performance.

4.UTILITY CONSUMPTION MONITORING: Track daily utility consumption patterns, including power generation, to identify areas for optimization. Prepare daily utility consumption sheets and specific utility consumption sheets against the production data to pinpoint usage trends relative to plant activities, identify potential system leakages & optimization scopes, and carry out daily data against the plant's design utility load summary.

5. PLANT PARAMETERS SURVEILLANCE AND REPORTS: Identify Critical-to-Process & Critical-to-Quality parameters by breaking down the plant into systems, process categorization, process criticality analysis. Determine safe operating limits for all plant parameters and equipment's, and carry out daily surveillance for any deviations. Prepare plant performance report incorporating well parameters, top sides/surface facilities process parameters, equipment's parameters and performance data, utility consumption, controller set point, control valve position, analytical results, chemical consumption details, and brief about plant state describing actual conditions, equipment status, system known deviations, and other system uncertainties. Plant performance report shall be prepared for daily general overall basis, for specific deviation identified through surveillance, and for any non-routine or special activities in the sub-surface or top sides/surface facilities.

6. EQUIPMENT PERFROMANCE EVALUATION:Generate daily performance reports for equipment such as separators, pumps, compressors, turbines, and heat exchangers using real-time data. Compare this data against design/data sheet to identify performance issues and opportunities for optimization.

7. PRODUCTION CHEMISTRY: Review daily quality parameters and ensure they align with specifications. Monitor chemical injection systems for target versus actual injection quantities and parts per million (PPM) values.

8. CONTROL LOOPS ANALYSIS: Review set point changes in PID controllers by the operators, evaluate controller modes (AUTO/MAN) for any changes in the last 24 hours, analyse control loop performance through which control valves problems and controller tuning scope can be identified. Identify trip transmitter's faults by generating reports through real time data from servers comparing process values from control and trip transmitters. Generate reports on control valve % opening for the last 24 hours and compare against datasheet & flow coefficient curves for performance, compare the same with against daily production volumes, and overall plant conditions.

AUTHOR

Praveen Nagenderan C is a chemical engineer graduate and post-graduate in Oil & Gas Engineering, University of Aberdeen with experience in Oil & Gas production and processing facilities. Professional experience covers working in production operations, commissioning & start-up, turn-arounds, and process engineering – operations support and facility surveillance & engineering. Praveen has worked with major oil companies Equinor, EnQuest, Spirit Energy, Expro, Cairn Oil & Gas and Nayara Energy

Combination of Hydrocracking and Naphtha Steam Cracking as Residue to Chemicals Refining Route

Dr. Marcio Wagner da Silva

Introduction and Context

One of the biggest challenges for the oil refining industry is raising the profitability or the so-called refining margin face to a scenario with environmental regulations increasingly restrictive, which requires high costly processes and the volatility of the crude barrel price. Restrictive regulations like IMO 2020 raised, even more, the pressure over refiners with low bottom barrel conversion capacity once requires higher capacity to add value to residual streams, especially related to sulfur content that was reduced from 3,5 % (in mass) to 0,5 %. Refiners with easy access to low sulfur crude oils present relative competitive advantage in this scenario, these players can rely on relatively low-cost residue upgrading technologies to produce the new marine fuel oil (Bunker) as carbon rejection technologies (Solvent Deasphalting, Delayed Coking, etc.), but they are the minority in the market. The most part of the players need to look for sources of low sulfur crudes, which present higher cost putting under pressure his refining margins or look for deep bottom barrel conversion technologies to ensure more value addition to processed crude oils and avoid to loss competitiveness in the downstream market. For these refiners, deepest residue upgrading like hydrocracking technologies can offer great operational flexibility, despite the high capital spending.

Furthermore, despite be more frequently related to bottom barrel value addition and residue upgrading issues, the hydrocracking technologies can offer better conditions to closer integration with petrochemical assets though the improvement of intermediates streams, an interesting case is the synergy of hydrocracking and naphtha steam cracking units aiming to maximize the petrochemicals production in the refining hardware. Recent forecasts indicate a trend of reduction in transportation fuels demand accompanied by the growth of petrochemicals demand as presented in Figure 1.

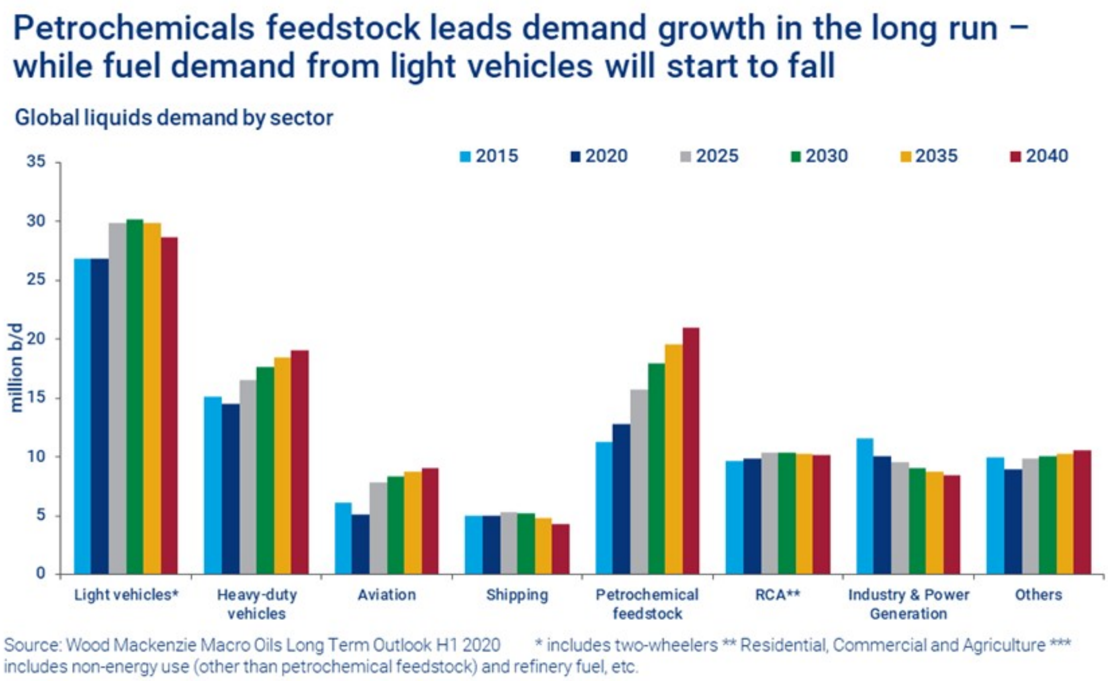

Figure 1 – Growing Trend in the Demand by Petrochemical Intermediates (Wood Mackenzie, 2020)

The improvement in fuel efficiency, growing market of electric vehicles tends to decline the participation of transportation fuels in the global crude oil demand. New technologies like additive manufacturing (3D printing) have the potential to produce great impact to the transportation demands, leading to even more impact over the transportation fuels demand. Furthermore, the higher availability of lighter crude oils favors the oversupply of lighter derivatives that facilitate the production of petrochemicals against transportation fuels as well as the higher added value of petrochemicals in comparison with fuels.

Facing these challenges, the search for alternatives that ensure survival and sustainability of the refining industry became constant by refiners and technology developers. Due to his similarities, better integration between refining and petrochemical production processes appears as an attractive alternative.

Considering the ethylene market, the scenario is even more attractive once is expected an annual growth rate of 5,58 % between 2022 and 2030 and the total size of the ethylene market can reach USD 287 billion in 2030 as presented in Figure 2. Again, the Asian continent is responsible of the major part of this Due to his similarities, better integration between refining and petrochemical production processes appears as an attractive alternative to maximize the yield of petrochemicals. Although the advantages, it's important to consider that the integration between refining and petrochemical assets increase the complexity, requires capital spending, and affect the interdependency of refineries and petrochemical plants, these facts need to be deeply studied and analyzed case by case.

According to data presented in Figure 2, is expected a significant growth in the market of petrochemicals intermediates, especially in ethylene market, and a refining hardware capable to maximize the yield of these derivatives can offer significant competitive advantage through closer integration with petrochemical assets and higher value addition to processed crude oil.

This scenario requires even more conversion capacity in the refining hardware as well as profitable routes to convert these hydrocarbons into petrochemicals in compliance with market demand, in this sense, hydrocracking technologies and their synergies with petrochemical processes like steam cracking can be an attractive route to some refiners.

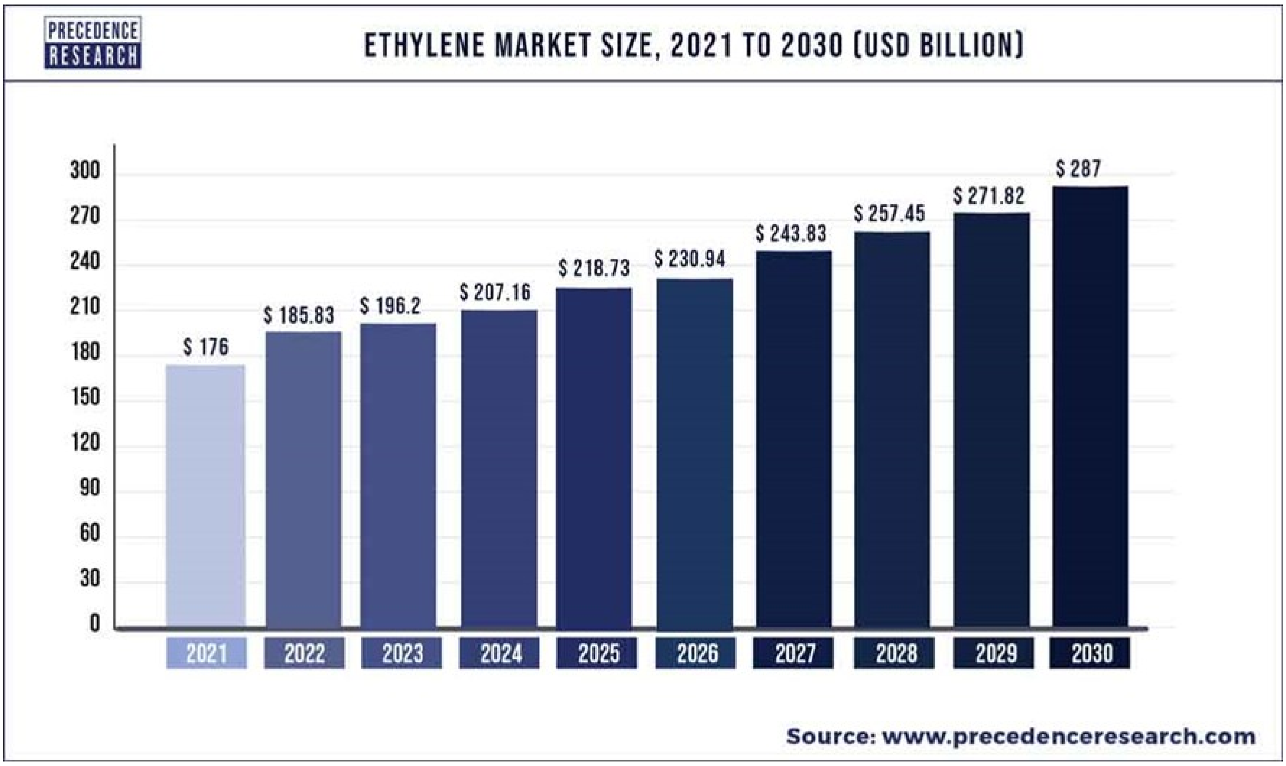

Figure 2 – Evolution of Ethylene Market Size for the next years (Precedence Research, 2022)

Synergies between Refining and Petrochemical Assets – Petrochemical Integration

The focus of the closer integration between refining and petrochemical industries is to promote and seize the synergies existing opportunities between both downstream sectors to generate value to the whole crude oil production chain. Table 1 presents the main characteristics of the refining and petrochemical industry and the synergies potential.

As aforementioned, the petrochemical industry has been growing at considerably higher rates when compared with the transportation fuels market in the last years, additionally, represent a noblest destiny and less environmental aggressive to crude oil derivatives. The technological bases of the refining and petrochemical industries are similar which leads to possibilities of synergies capable of reducing operational costs and adding value to derivatives produced in the refineries.

Figure 3 presents a block diagram that shows some integration possibilities between refining processes and the petrochemical industry.

Process streams considered with low added value to refiners like fuel gas (C2) are attractive raw materials to the petrochemical industry, as well as streams considered residual to petrochemical industries (butanes, pyrolisis gasoline, and heavy aromatics) can be applied to refiners to produce high quality transportation fuels, this can help the refining industry meet the environmental and quality regulations to derivatives.

The integration potential and the synergy among the processes rely on the refining scheme adopted by the refinery and the consumer market, process units as Fluid Catalytic Cracking (FCC) and Catalytic Reforming can be optimized to produce petrochemical intermediates to the detriment of streams that will be incorporated to fuels pool. In the case

Table 1 – Refining and Petrochemical Industry Characteristics

Refining Industry	Petrochemical Industry
Large Feedstock Flexibility	Raw Material from Naphtha/NGL
High Capacities	Higher Operation Margins
Self Sufficient in Power/Steam	High Electricity Consumption
High Hydrogen Consumption	High Availability of Hydrogen
Streams with low added Value (Unsaturated Gases & C2)	Streams with Low Added Value (Heavy Aromatics, Pyrolysis Gasoline, C4's)
Strict Regulations (Benzene in Gasoline, etc.)	Strict Specifications (Hard Separation Processes)
Transportation Fuels Demand in Declining at Global Level	High Demand Products

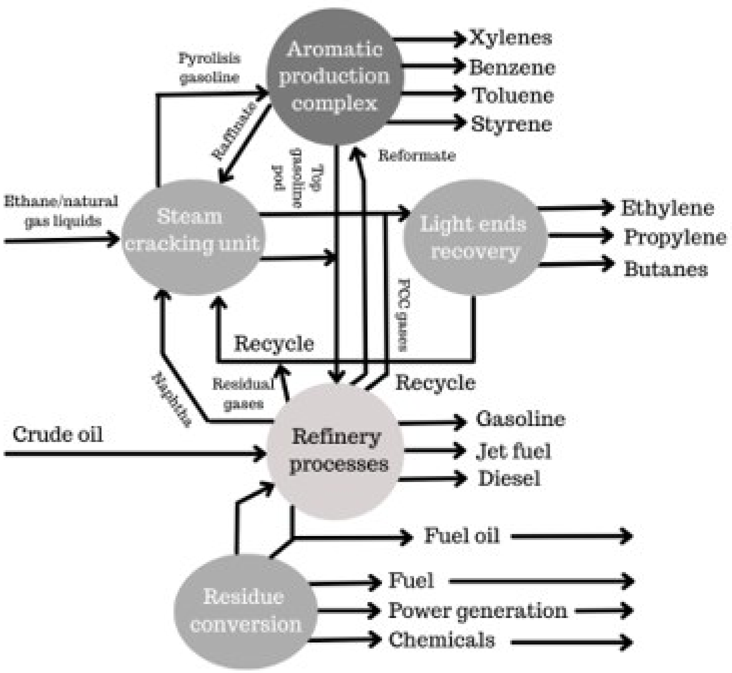

Figure 3 – Synergies between Refining and Petrochemical Processes

of FCC, installation of units dedicated to produce petrochemical intermediates, called petrochemical FCC, aims to reduce to the minimum the generation of streams to produce transportation fuels, however, the capital investment is high once the severity of the process requires the use of material with noblest metallurgical characteristics.

The IHS Markit Company proposed a classification of the petrochemical integration grades, as presented in Figure 4.

According to the classification proposed, the crude to chemicals refineries is considered the maximum level of petrochemical integration where the processed crude oil is totally converted into petrochemicals intermediates like ethylene, propylene, and BTX. In these refining schemes, the combination of hydrocracking and steam cracking units are fundamental to allow the conversion of bottom barrel streams to petrochemicals to maximize the added value to the processed crude.

Hydrocracking Technologies

Despite the high investment for hydrocracking units' construction, this process is what gives more flexibility to refineries to processing heavy oils, so with lower cost, on the other hand, these oils produce a high quantity of derivates with lower value added and with restricted markets like fuel oils and asphalt. Table 2 presents the main differences between hydrotreating and hydrocracking technologies.

The hydrocracking process is normally conducted under severe reaction conditions with temperatures that vary from 300 to 480 oC and pressures between 35 to 260 bar. Due to process severity, hydrocracking units can process a large variety of feed streams, which can vary from gas oils to residues that can be converted into light and medium derivates, with high value added.

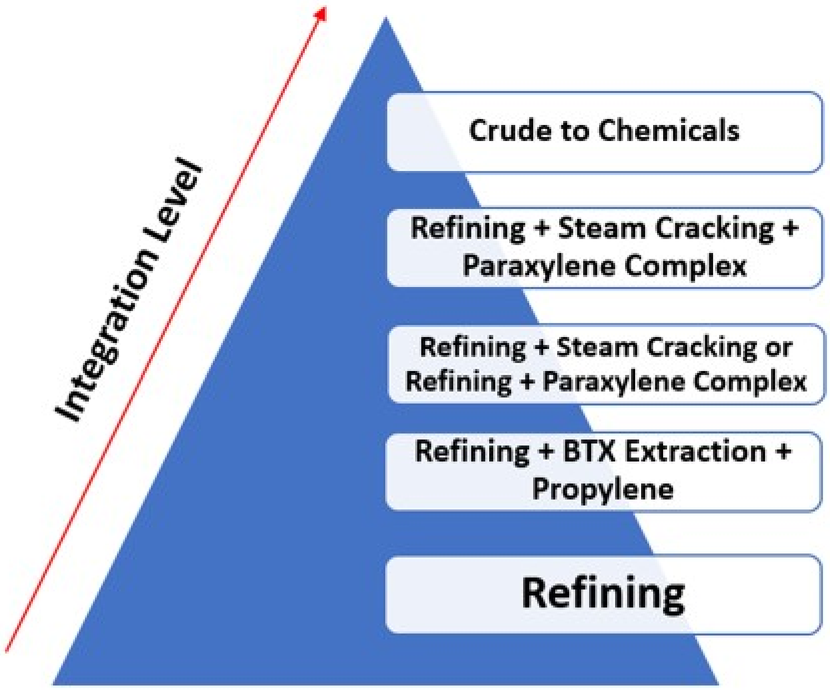

Figure 4 – Petrochemical Integration Levels (IHS Markit, 2018)

Table 1 – Hydrotreating and Hydrocracking Processes Comparison

Hydrotreating	Hydrocracking
Contaminants Removal (S, N,O, Metals, etc.) and C-C bonds saturation	Contaminants Removal (S,N,O, Metals, etc.) ,cracking of C-C bonds and reduction in molecular weight
Minimum Cracking	High Cracking rate
Low Conversion (< 20%)	High Conversion (> 50%)
Feed stream preparation for Conversion Units - FCC / RFCC, Catalytic Reform, Hydrocracking, etc.	Production of Final Products – Transportation Fuels (Diesel and kerosene) and lubricants.
Ni/Co/Mo Typical Catalysts	Ni/W/Pt/Pd Typical Catalysts (Dual Character)

Among the feed streams normally processed in hydrocracking units are the vacuum gas oils, Light Cycle Oil (LCO), decanted oil, coke gas oils, etc. Some of these streams would be hard to process in Fluid Catalytic Cracking Units (FCCU) because of the high contaminants content and the higher carbon residue, which quickly deactivates the catalyst, in the hydrocracking process the presence of hydrogen minimizes these effects.

According to the catalyst applied in the process and the reaction conditions, the hydrocracking can maximize the feed stream conversion in middle derivates (Diesel and Kerosene), high-quality lubricant production (lower severity process).

Catalysts applied in hydrocracking processes can be amorphous (alumina and silica-alumina) and crystalline (zeolites) and have bifunctional characteristics once the cracking reactions (in the acid sites) and hydrogenation (in the metals sites) occurs simultaneously. The active metals used to this process are normally Ni, Co, Mo and W in combination with noble metals like Pt and Pd.

It's necessary a synergic effect between the catalyst and the hydrogen because the cracking reactions are exothermic and the hydrogenation reactions are endothermic, so the reaction is conducted under high partial hydrogen pressures and the temperature is controlled in the minimum necessary to convert the feed stream. Despite these characteristics, the hydrocracking global process is exothermic, and the reaction temperature control is normally made through cold hydrogen injection between the catalytic beds.

Figure 5 shows a typical arrangement for hydrocracking process unit with two reactions stages, dedicated to producing medium distilled products (diesel and kerosene).

According to the feed stream quality (contaminant content), is necessary hydrotreating reactors installation upstream of the hydrocracking reactors, these reactors act like guard bed to protect the hydrocracking catalyst.

The principal contaminant of hydrocracking catalyst is nitrogen, which can be present in two forms: Ammonia and organic nitrogen.

Ammonia (NH3), produced during the hydrotreating step, has a temporary effect reducing the activity of the acid sites, mainly damaging the cracking reactions. In some cases, the increase of ammonia concentration in the catalytic bed is used like an operational variable to control the hydrocracking catalyst activity. Organic nitrogen has a permanent effect blocking the catalytic sites and leading to coke deposits on the catalyst.

As in the hydrotreating cases (HDS, HDN, etc.), the most important operational variables are temperature, hydrogen partial pressure, space velocity and hydrogen/feed ratio.

Depending on feed stream characteristics (mainly contaminants content) and the process objective (maximize middle distillates or lubricant production) the hydrocracking units

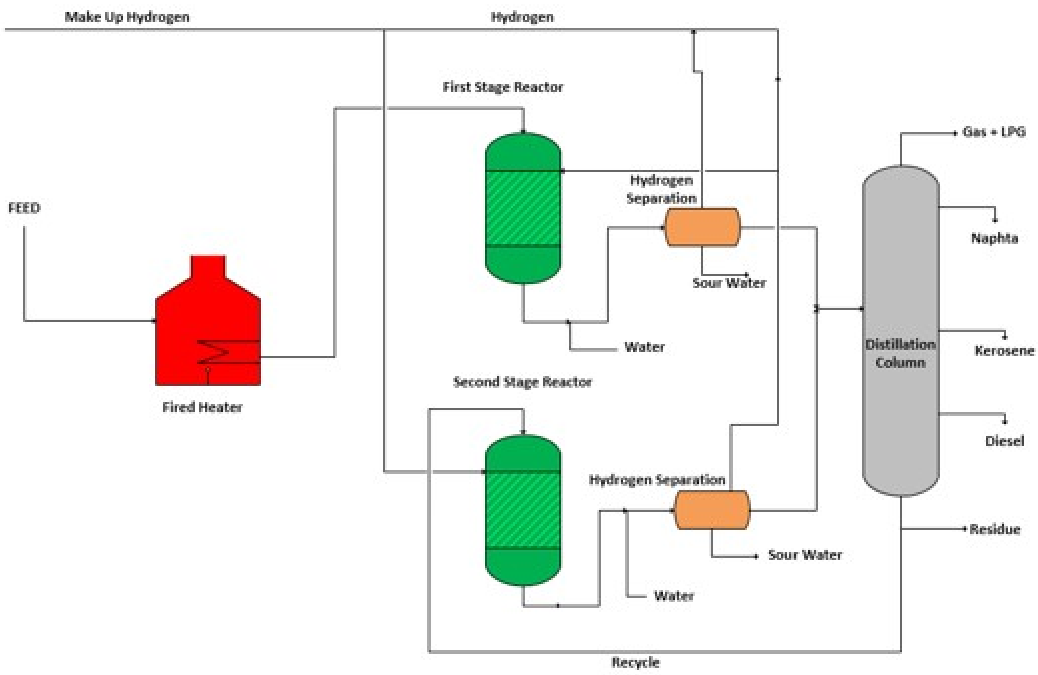

Figure 5 – Basic Process Flow Diagram for Two stages Hydrocracking Units

can assume different configurations.

For feed streams with low nitrogen content where the objective is to produce lubricants (partial conversion) is possible to adopt a single stage configuration and without the intermediate gas separation, produced during the hydrotreating step. The main disadvantage of this configuration is the reduction of the hydrocracking catalyst activity caused by the high concentration of ammonia in the reactor, but this configuration requires lower capital investment.

The application of hydrocracking route to produce lubricating oils offers great competitive advantage once the alternative routes, based on solvent extraction units can produce only Group I and II lubricating oils that present falling demand.

Due to the accelerated technological development, especially in the automotive market, the Group I lubricating oil tend to lose market in the next years this fact tends to lead the refiners to look for capital investment aiming to sustain their competitiveness in the lubricating market. Another side effect for lubricating producers based on solvent routes due to the competitiveness loss is raising the imports to supply the internal market, leading to an external dependence of critical production input as well as negative effects on the balance of payments.

Normally for feed streams with low nitrogen content where the objective is to produce middle distillates (diesel and kerosene), the configuration with two reaction stages without intermediate gas separation is the most common.

Like, the disadvantage, in this case, is the high concentration of ammonia and H_2S in the hydrocracking reactors, which reduces the catalyst activity.

The higher costly units are the plants with double stages and intermediate gás separation. These units are employed when the feed stream has high contaminant content (mainly nitrogen) and the refinery looks for the total conversion (to produce middle distillates), this configuration is presented in Figure 6.

In this case, the catalytic deactivation process is minimized by the reduction in the NH_3 and H_2S concentration in the hydrocracking reactor. It’s important to consider the feedstock quality to define the better residue upgrading technology to the refining hardware, once the hydroprocessing of residual streams presents additional challenges when compared with the treating of lighter streams, mainly due to the higher contaminants content and residual carbon (RCR) related with the high concentration of resins and asphaltenes in the bottom barrel streams.

Higher metals and asphaltenes content led to a quick deactivation of the catalysts through high coke deposition rate, catalytic matrix degradation by metals like nickel and vanadium or even by the plugging of catalyst pores produced by the adsorption of metals and high molecular weight molecules in the catalyst surface. By this reason, according to the content of asphaltenes and metals in the feed stream are adopted more versatile technologies aiming to ensure an adequate operational campaign and an effective treatment.

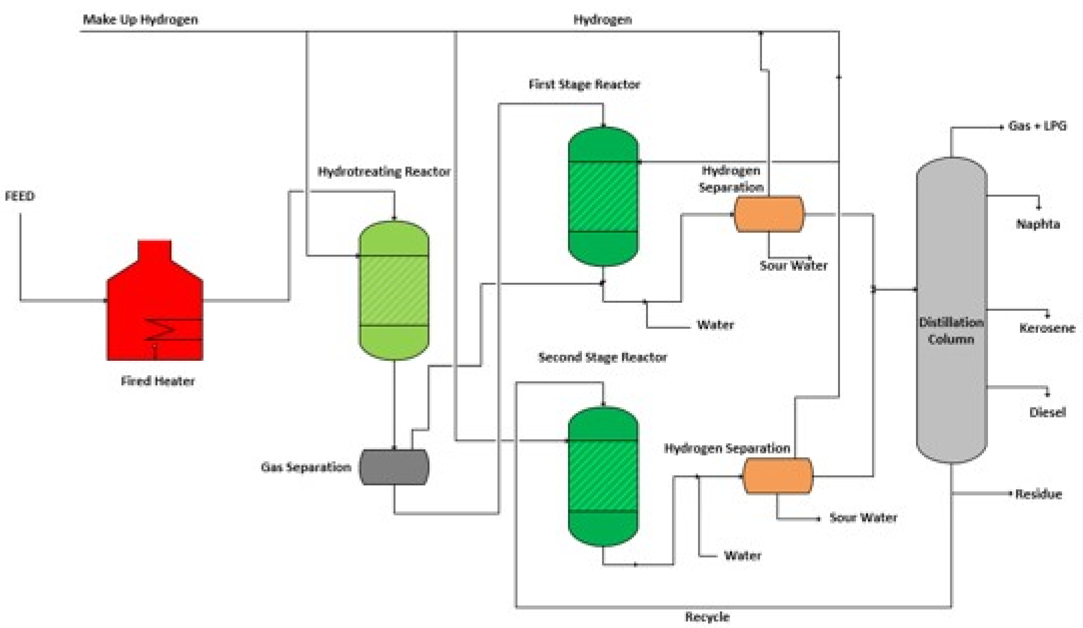

Figure 6 – Typical Arrangement for Two Stage Hydrocracking Units with Intermediate Gas Separation

As quoted earlier, the hydrocracking units demand high capital investments, mainly to operate under high hydrogen partial pressures, it's necessary to install larger hydrogen production units, which is another high costly process. However, in the face of the crescent demand for high-quality derivates, the investment can be economically attractive.

The Residue Hydrocracking Units have severity even greater than units dedicated to treating lighter feed streams (gas oils). These units aim to improve the residues quality either by reducing the contaminant content (mainly metals) like an upstream step to other processes, such as Residue Fluid Catalytic Cracking (RFCC) or to produce derivates like fuel oil with low sulfur content.

Residue hydrocracking demand even greater capital investment than gas oils hydrocrackers because these units operate under more severe conditions and furthermore, the operational costs are so higher, mainly due to the high hydrogen consumption and the frequent catalyst replacement.

Hydrocracking technologies have been widely studied over the years, mainly by countries with large heavy oil reserves like Mexico and Venezuela. The main difference between the available technologies is the reactor characteristics.

Among the Hydrocracking Technologies which applies fixed bed reactors, it can be highlighted the RHU™ technology, licensed by Shell company, Hyvahl™ technology developed by Axens and the UnionFining™ and Unicracking™ Processes, developed by UOP. These processes normally operate with low conversion rates with temperatures higher than 400 oC and pressures above 150 bar. Figure 7 presents a basic process arrangement for the Unicracking™ process by UOP Company.

Technologies that apply ebullated bed reactors and continuum catalyst replacement allow higher campaign period and higher conversion rates, among these technologies the most known are the H-Oil™ technology developed by Axens and the LC-Fining™ Process by Chevron-Lummus. These reactors operate at temperatures above 450 oC and pressures until 250 bar. Figure 8 presents a typical process flow diagram for a LC-Fining™ process unit, developed by Chevron Lummus Company while the H-Oil™ process by Axens Company is presented in Figure 9.

Catalysts applied in hydrocracking processes can be amorphous (alumina and silica-alumina) and crystalline (zeolites) and have bifunctional characteristics, once the cracking reactions (in the acid sites) and hydrogenation (in the metals sites) occurs simultaneously.

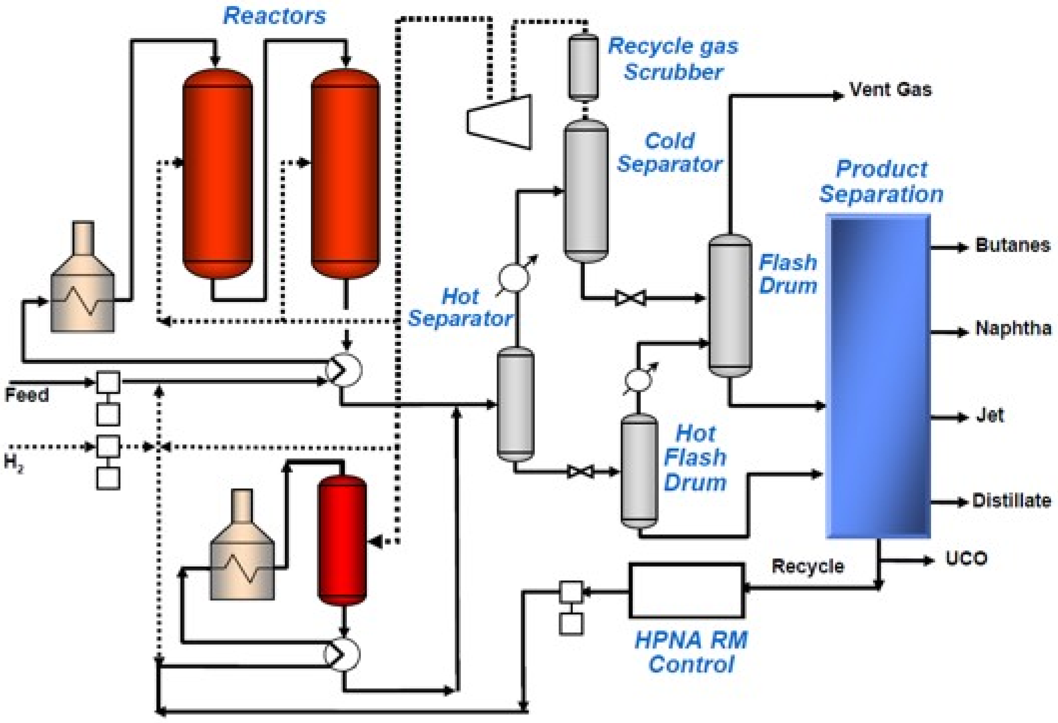

Figure 7 – Process Arrangement for Unicracking™ hydrocracking technology by UOP Company.

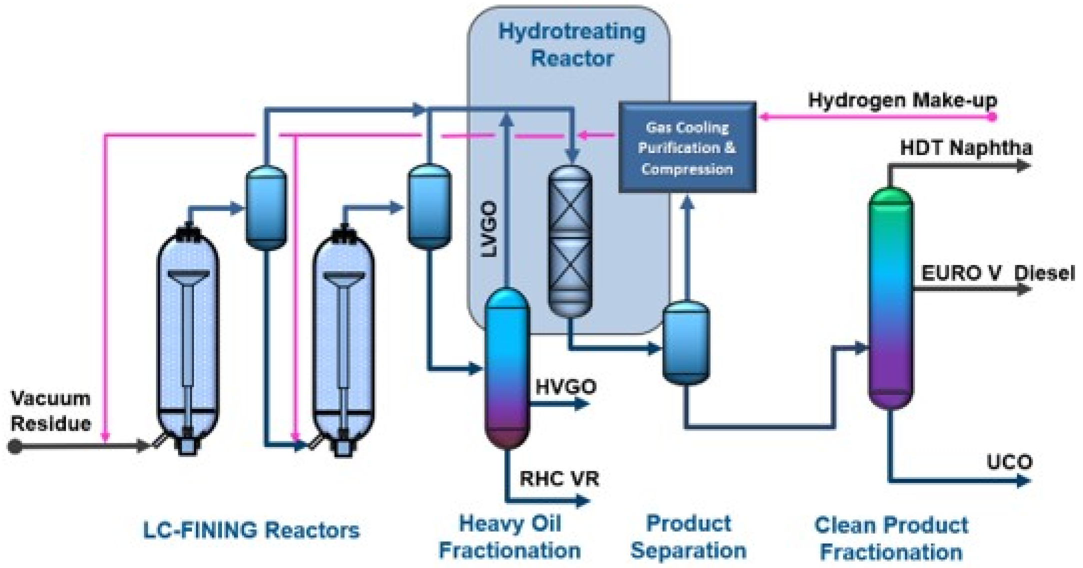

Figure 8 – Process Flow Diagram for LC-Fining™ Technology by CLG Company (Lummus, 2022)

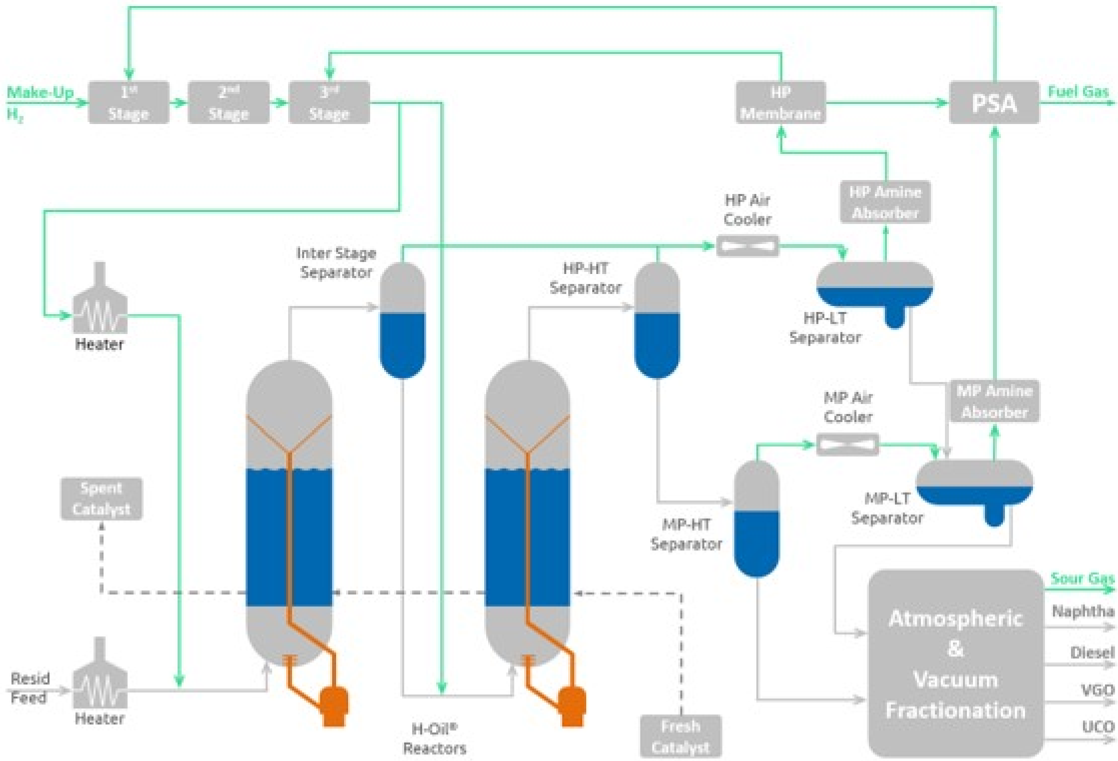

Figure 9 – Process Flow Diagram for H-Oil™ Process by Axens Company (FRECON et. al, 2019)

An improvement in relation of ebullated bed technologies is the slurry phase reactors, which can achieve conversions higher than 95 %. In this case, the main available technologies are the HDH™ process (Hydrocracking-Distillation-Hydrotreatment), developed by PDVSA-Intevep, VEBA-Combicracking Process (VCC)™ commercialized by KBR Company, the EST™ process (Eni Slurry Technology) developed by Italian state oil company ENI, and the Uniflex™ technology developed by UOP Company. Figure 10 presents a basic process flow diagram for the VCC™ technology by KBR Company.

In the slurry phase hydrocracking units, the catalysts in injected with the feedstock and activated in situ while the reactions are carried out in slurry phase reactors, minimizing the reactivation issue, and ensuring higher conversions and operating lifecycle. Figure 11 presents a basic process flow diagram for the Uniflex™ slurry hydrocracking technology by UOP Company.

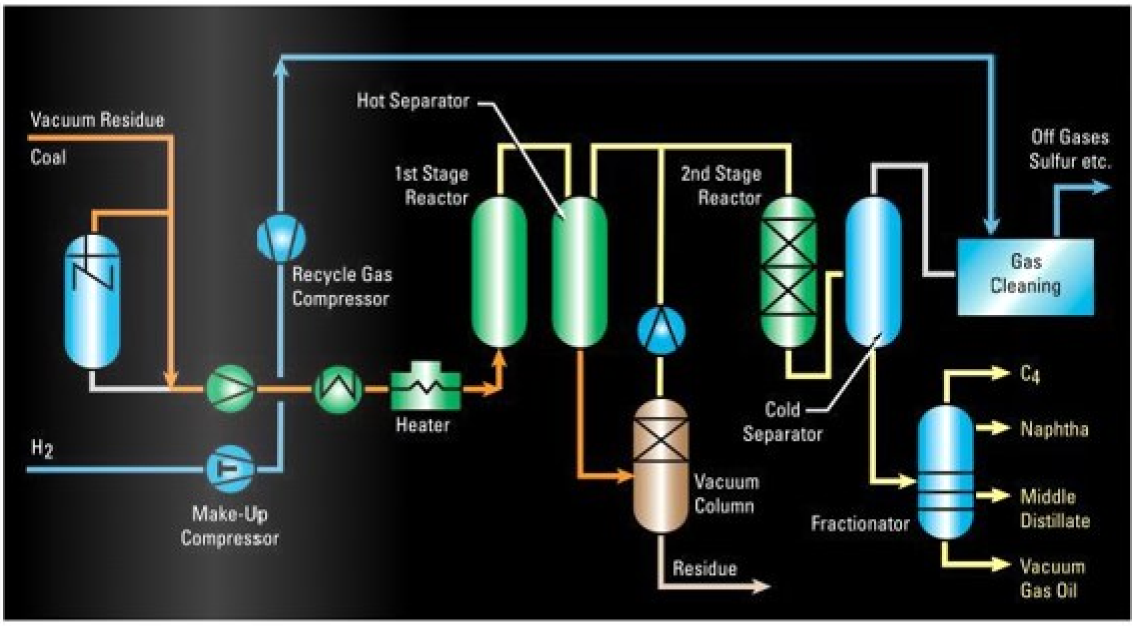

Figure 10 – Basic Process Arrangement for VCC™ Slurry Hydrocracking by KBR Company (KBR Company, 2019)

Other commercial technologies to slurry hydrocracking process are the LC-Slurry™ technology developed by Chevron Lummus Company and the Microcat-RC™ process by Exxon Mobil Company. Aiming to meet the new bunker quality requirements, noblest streams, normally directed to produce middle distillates can be applied to produce low sulfur fuel oil, this can lead to a shortage of intermediate streams to produce these derivatives, raising his prices. The market of high sulfur content fuel oil should strongly be reduced, due to the higher prices gap when compared with diesel, his production tends to be economically unattractive.

Despite the high capital investment and the high operational cost, hydrocracking Technologies produces high-quality derivates and can make feasible the production of added value product from residues, which is extremely attractive, mainly for countries that have difficult access to light oils with low contaminants.

In countries, with a high dependency of middle distillates like Brazil (because his dimensions and the high dependency for road transport), the high-quality middle distillate production from oils with high nitrogen content, indicate that the hydrocracking technology can be a good way to reduce the external dependency of these products.

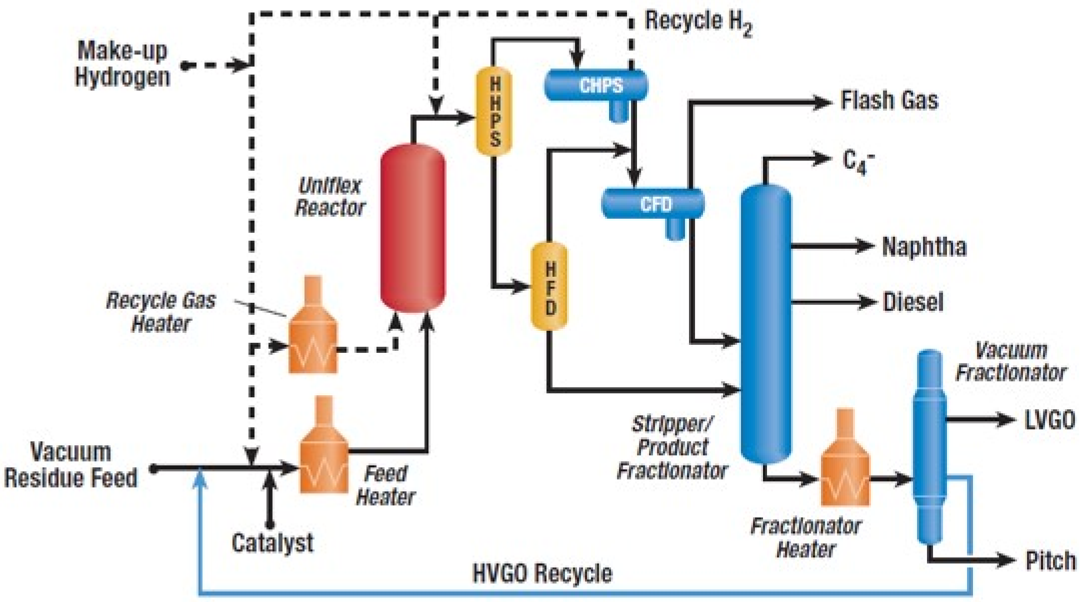

Figure 11 – Process Flow Diagram for Uniflex™ Slurry Phase Hydrocracking Technology by UOP Company (UOP Company, 2019).

Naphtha Steam Cracking Process – Naphtha to Olefins

The Steam cracking process has a fundamental role in the petrochemical industry, nowadays the most part of the light olefins light ethylene and propylene is produced through steam cracking route. The steam cracking consists of a thermal cracking process that can use gas or naphtha to produce olefins, in this review we will describe the naphtha steam cracking process.

The naphtha to steam cracking is composed basically of straight run naphtha from crude oil distillation units, normally to meet the requirements as petrochemical naphtha the stream needs to present high paraffin content (higher than 66 %). Figure 12 presents a typical steam cracking unit applying naphtha as raw material to produce olefins.

Due to his relevance, great technology developers have dedicated their efforts to improve the steam cracking technologies over the years, especially related to the steam cracking furnaces. Companies like Stone & Webster, Lummus, KBR, Linde, and Technip develop technologies to steam cracking process. One of the most known steam cracking technologies is the SRT™ process (Short Residence Time), developed by Lummus Company, that applies a reduce residence time to minimize the coking process and ensure higher operational lifecycle.

The cracking reactions occur in the furnace tubes, the main concern and limitation to operating lifecycle of steam cracking units is the coke formation in the furnace tubes. The reactions carry out under high temperatures, between 500 oC to 700 oC according to the characteristics of the feed. For heavier feeds like gas oil, is applied lower temperature aiming to minimize the coke formation, the combination of high temperatures and low residence time are the main characteristic of the steam cracking process.

The Synergy between Hydrocracking and Steam Cracking – Residue to Chemicals

As aforementioned the hydrocracking units are capable to improve the quality of bottom barrel streams, the main advantage of the integration between hydrocracking and steam cracking units is the higher availability of feeds with better crackability characteristics.

Bottom barrel streams tend to concentrate aromatics and polyaromatics compounds that present uneconomically performance in steam cracking units due the high yield of fuel oil that presents low added value,

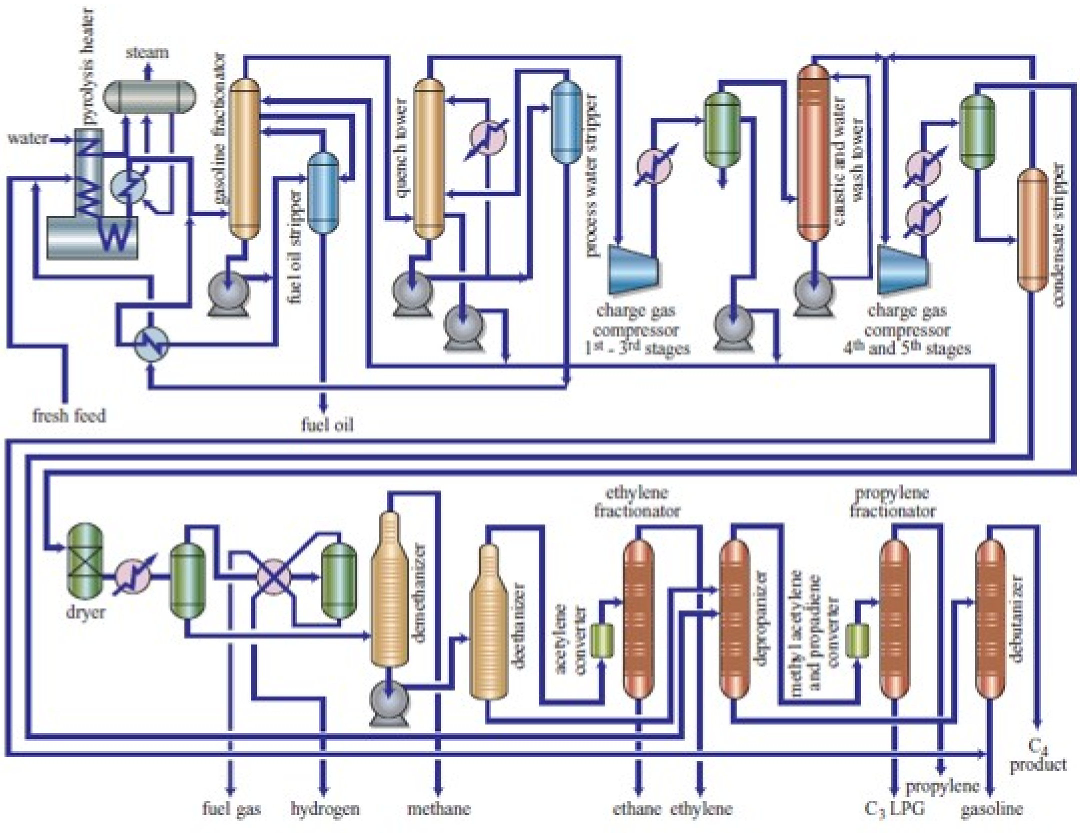

Figure 12 – Typical Naphtha Steam Cracking Unit (Encyclopedia of Hydrocarbons, 2006)

furthermore, the aromatics tends to suffer condensation reaction in the steam cracking furnaces, leading to high rates of coke deposition that reduces the operation lifecycle and raises the operating costs.

Once cracking potential is better to paraffinic molecules, and the hydrocracking technologies can improve the H/C in the molecules converting low added value bottom streams like vacuum gasoil to high quality naphtha, kerosene, and diesel the synergy between hydrocracking and steam cracking units can improve the yield of petrochemical intermediates in the refining hardware, an example of refining configuration relying on hydrocracking and steam cracking units is presented in Figure 13.

In Figure 13, a slurry hydrocracking unit is applied to achieve deep conversion of bottom barrel streams while a diesel hydrocracking unit is applied to destroy diesel and improve the yield of naphtha in the refining hardware, the light naphtha is directed to steam cracking unit to produce olefins, like ethylene and propylene while the heavier fraction is pumped to a catalytic reforming unit where is converted in light aromatics (BTX), achieving high added value to the processed crude oil. It's interesting to observe the synergy between deep hydrocracking (slurry) and FCC units, where the residual stream from FCC is applied as feed to the hydrocracking unit, raising the bottom barrel conversion of the refinery. Sometimes the hydrocracking and FCC technologies are faced by competitors technologies in the refining hardware due to the similarities of feed streams that are processed in these units. In some refining schemes, the mild hydrocracking units can be applied as pretreatment step to FCC units, especially to bottom barrel streams with high metals content that are severe poison to FCC catalysts, furthermore the mild hydrocracking process can reduce the residual carbon to FCC feed, raising the performance of FCC unit and improving the yield of light products like naphtha, LPG, and olefins.

Considering the great flexibility of deep hydrocracking technologies that are capable to convert feed stream varying from gas oils to residue, an attractive alternative to improve the bottom barrel conversion capacity is to process in the hydrocracking units the uncracked residue in FCC unit aiming to improve the yield of high added value derivatives in the refining hardware, mainly middle distillates like diesel and kerosene.

Another alternative to reduce the fuel production near to zero is presented in Figure 14.

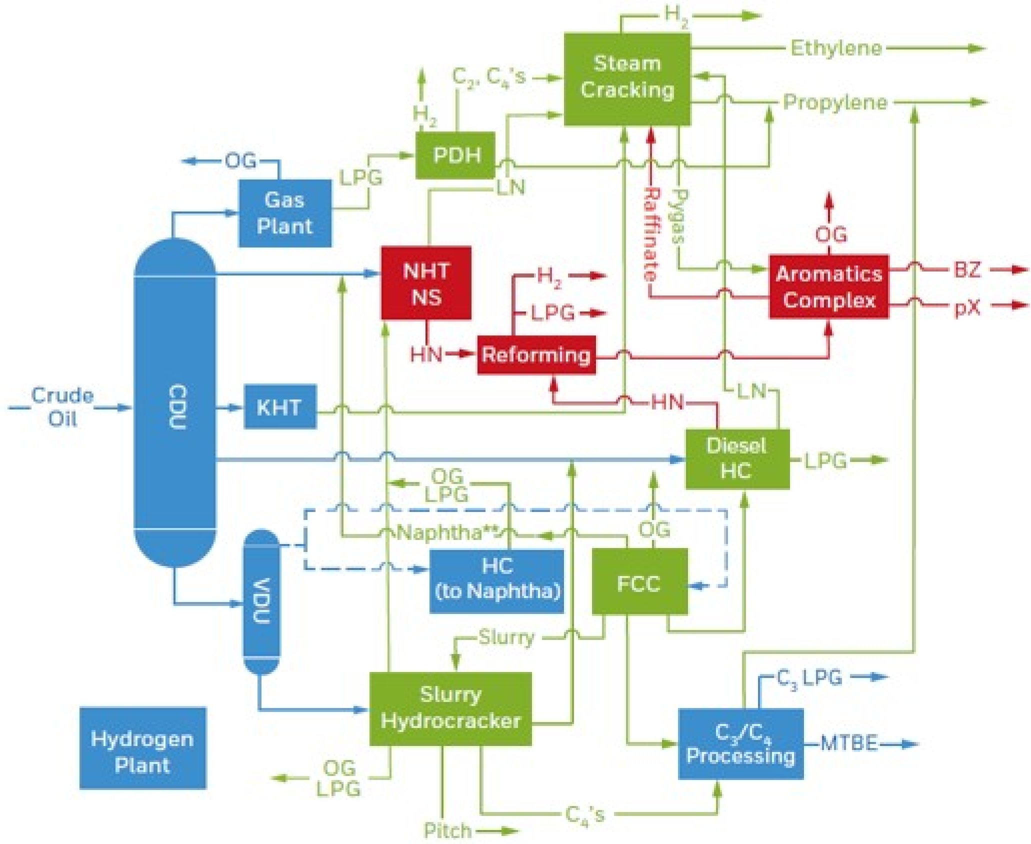

Figure 13 – Integrated Refining Scheme Base on Hydrocracking and Steam Cracking Units (UOP, 2019)

In the refining configuration presented in Figure 14, the kerosene is cracked to naphtha in a hydrocracking unit, in this case, the naphtha is sent to the aromatic complex aiming to produce even more aromatics (BTX) which has higher added value than olefins which is maximized in the alternative of Figure 13. Considering the recent trend of reduction in transportation fuels demand followed by the growth of petrochemicals market makes the synergy between hydrocracking and steam cracking units an attractive way to maximize the petrochemicals production in the refining hardware.

Crude Oil to Chemicals Strategy – The Relevance of Hydrocracking and Steam Cracking Units

Due to the increasing market and higher added value as well as the trend of reduction in transportation fuels demand, some refiners and technology developers have dedicated their efforts to develop crude to chemicals refining assets.

The combination of hydrocracking and steam cracking technologies is fundamental to the crude to chemicals refineries once allows a deep conversion of bottom barrel streams into high added value petrochemicals, Figure 15 presents an example of a crude to chemicals refinery based on the synergy between hydrocracking and steam cracking units, in this

Another great refining technology developers like UOP, Shell Global Solutions, ExxonMobil, Axens, Saudi Aramco and others are developing crude to chemicals technologies, reinforcing that this is a trend in the downstream market. In any case, is applied the combination of hydrocracking and steam cracking units. Figure 16 presents the crude to chemicals concept developed by UOP Company.

Again, it's possible to see in Figure 16 the relevance of hydrocracking and steam cracking units to maximize the yield of petrochemicals.

Closing the Sustainability Cycle – Plastics Recycling Technologies

As described above, we are facing a continuous growing of petrochemicals demand and a great part of these crude oil derivatives have been applied to produce common use plastics. Despite the higher added value and significant economic advantages in comparison with transportation fuels, the main side effect of the growth of plastics consumption is the growth of plastic waste.

Despite the efforts related to the mechanic recycling of plastics, the increasing volumes of plastics waste demand most effective recycling routes to ensure the sustainability of the petrochemical industry through the regeneration of the raw material, in this sense, some technology developers have been dedicated

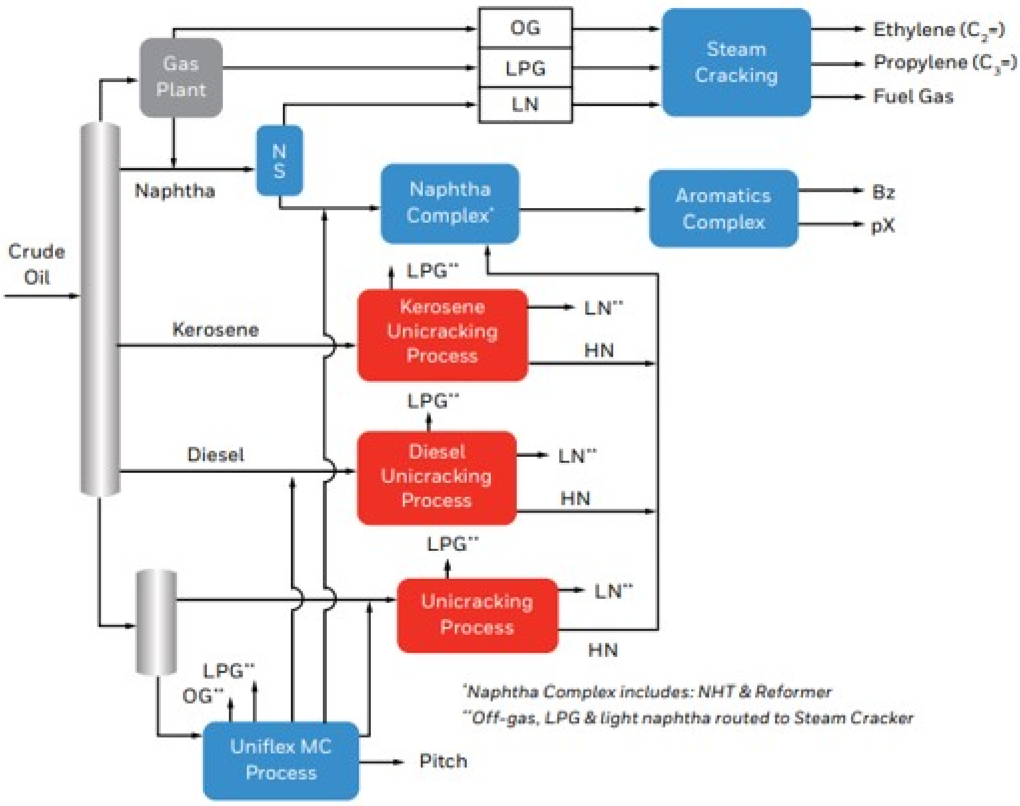

Figure 14 – Refining Configuration with near Zero Fuels Production (UOP Company, 2019).

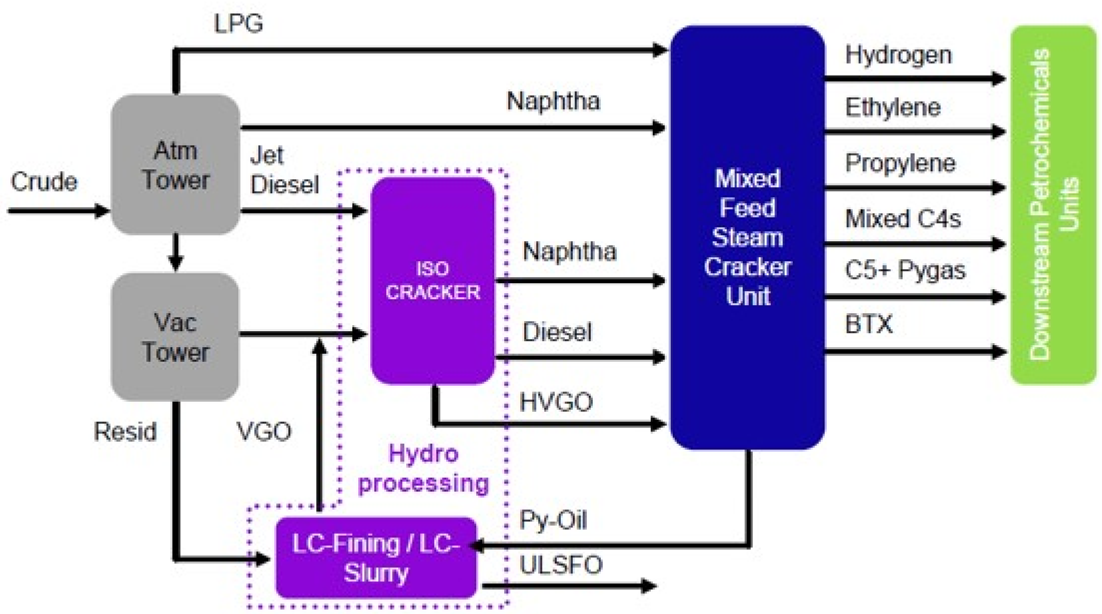

Figure 15 – Crude to Chemicals Concept by Chevron Lummus Company (Chevron Lummus Global Company, 2019)

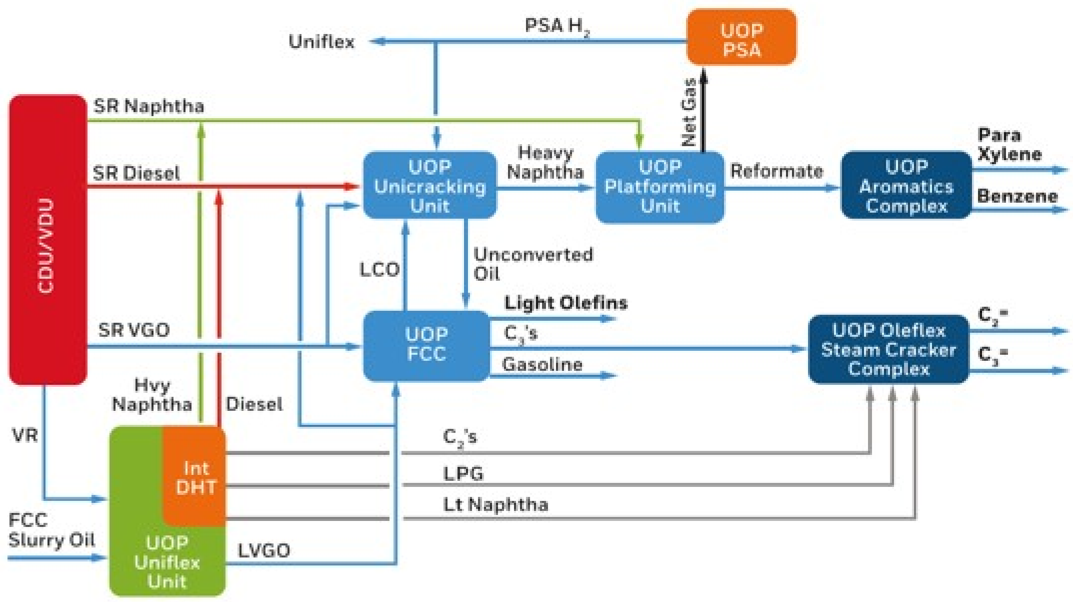

Figure 16 – Integrated Refining Configuration Based in Crude to Chemicals Concept by UOP Company.

investments and efforts to develop competitive and efficient chemical recycling technologies of plastics.

One of the most applied technologies for plastics recycling is catalytic pyrolysis where the long chain polymeric is converted into smaller hydrocarbon molecules which can be fed to steam cracking units to reach a real circular petrochemical industry. Another route is the thermal pyrolysis of plastics, is this case, it's possible to quote the Rewind™ Mix technology developed by Axens Company.

Another promising chemical recycling route for plastics in the hydrocracking of plastics waste, in this case the chemical principle involves the cracking of carbon-carbon bonds of the polymer under high hydrogen pressure which lead to the production of stable low boiling point hydrocarbons. The hydrocracking route present some advantages in comparison with thermal or catalytic pyrolysis, once the number of aromatics or unsaturated molecules is lower than the achieved in the pyrolysis processes, leading to a most stable feedstock to steam cracking or another downstream processes as well as is more selective, producing gasoline range hydrocarbons which can be easily applied in the highly integrated refining hardware.

The chemical recycling of plastics is a great opportunity to technology developers and scientists, especially related to the development of effective catalysts to promote depolymerization reactions which can ensure the recovery of high added value molecules like BTX. More than that, the chemical recycling of plastics is an urgent necessity to close the sustainability cycle of an essential industry to our society.

Conclusion

The scenario faced by the players of the downstream industry requires even more competitive capacity to ensure higher value addition to the processed crude oils, mainly considering the current trend of reduction in transportation fuels demand followed by the growing market of petrochemicals that requires a higher conversion capacity in the refining hardware aiming to ensure higher yields of added value derivatives. In this scenario, high integrated refining configurations based on residue upgrading and flexible refining technologies can be economically attractive, despite the high capital investment and the hydrocracking unit can improve the offer of high quality naphtha to steam cracking units, allowing higher yields of light olefins in the refining hardware and closer integration with petrochemical assets, which is a relevant competitive advantage in the current and short term scenario of the downstream industry.

Despite the advantages, it's important to consider that integrated processes lead to a higher operational complexity, however, given current and middle term scenarios to refining industry, a better integration between refining and petrochemical processes is fundamental to the economic sustainability of the downstream industry.

In the digital transformation environment, the companies need to find new ways to ensure added value to the customers and creative ways to destroy his current businesses through the discovering of new markets. To the downstream industry, the closer integration between refining and petrochemical assets ensures both goals with higher revenues and lower operating costs to refiners as well as the high added value to the processed crude oils while offers lower environmental footprint and needed materials to the society. The combination of adequate bottom barrel conversion capacity and the maximization of petrochemicals in the refining hardware can offer a highlighted competitive positioning in the current and future scenarios of the downstream industry helping the players to build an antifragile profile in a highly competitive market.

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Relief Valve Sizing for Pump Discharge

Jayanthi Vijay Sarathy

Oversizing relief valves is not uncommon. In the case of pumping systems which is derated, relief valves are installed on the pump discharge. These are sized based on the maximum shut-off head developed by the pump and if higher than the design pressure of the piping and equipment.

During the design phase, the pump vendor curves would not be available. Therefore, a common practice is to choose a shut-off head between 15% to 25% more from the rated point and the relief valve [RV] is sized for the normal capacity of the pump. But sizing based on a shut-off margin can cause the RV and the associated piping to be oversized and lead to higher procurement costs.

However, when the pump performance curves are available from the vendor, it can so happen that the shut-off head margin would be lower than the assumed shut-off head. Say a value of 25% is chosen during design phase, but the pump vendor curves can indicate lower at around 15% to 20%. Instead with pump vendor curves, a lower head and lower flow rate at which the RV discharges can help reduce the RV size, which can help reduce costs and avoid any valve chattering.

Case Study

To explain with a case study, a suction vessel operates at a design pressure of 19.6 bara. The liquid outlet is connected to a pump and its associated piping at 150 class rating of 19.6 bara design pressure at 380C. A relief valve is installed on the pump discharge with a set pressure of 19.6 bara.

In the design stage where pump curves are not available, a shut-off margin of 25% is assumed to size the relief valve. The pump operates at a rated flow of 31 m3/h at a maximum suction flange pressure of 14 bara. The required differential head is 52.5 m. The fluid is water operating at a density of 1,000 kg/m3. The back pressure acting on the RV discharge

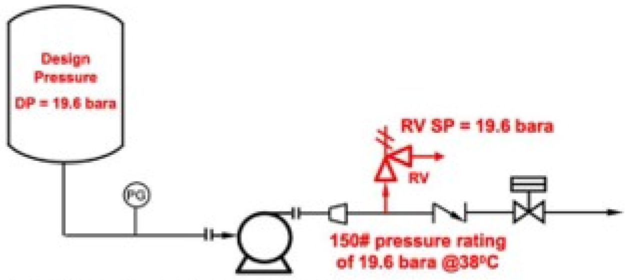

Figure 1. Pump Schematic

Therefore, estimating the maximum discharge pressure of the pump,

$$P_d = 14 + \left[\frac{52.5 \times 1000 \times 9.81}{10^5}\right] = 19.1\ bara \qquad (1)$$

The shut-off pressure is estimated as,

$$P_s = 14 + \left[\frac{1.25 \times (52.5 \times 1000 \times 9.81)}{10^5}\right] = 20.4\ bara \qquad (2)$$

Considering the case of blocked outlet, the RV can be sized based on API 520/521 and the RV designation chosen from API 526 as,

$$A_r = \left[\frac{11.78 \times Q}{K_d \times K_w \times K_c \times K_v}\right] \times \sqrt{\left(\frac{SG}{P_1 - P_2}\right)} \qquad (3)$$

Where,

Q = flow rate [lit/min]

A_r = Required effective discharge area [mm^2]

K_d = Coefficient of Discharge [0.65]

K_w = Back pressure correction factor [1.0]

K_v = Correction factor due to viscosity [1.0]

K_c = Combination correction factor for installations with rupture disc upstream of pressure relief device [1.0]

SG – Liquid specific gravity [-]

P_1 = Upstream relieving pressure [kPag] [Set pressure + allowable over pressure]

P_2 = back pressure [kPag]

A_{corr} = Orifice area based on corrected viscosity [A_r / K_v]

Substituting the values with the requisite unit conversions, where 10% accumulation is added to 19.6 bara, i.e., 2045 kPag,

$$A_r = \left[\frac{11.78 \times 517}{0.65 \times 1 \times 1 \times 1}\right] \times \sqrt{\left(\frac{1}{2045-100}\right)} = 212\ mm^2 \quad (4)$$

$$A_{corr} = \frac{212}{1} = 212\ mm^2\ or\ 0.33\ in^2 \quad (5)$$

From API 526, the selected standard orifice size is 'G' with an effective discharge area of 0.503 in2.

RV Sizing based on Pump Curves

When the pump performance curves are available from the vendor as shown below, the RV size can be re-estimated.

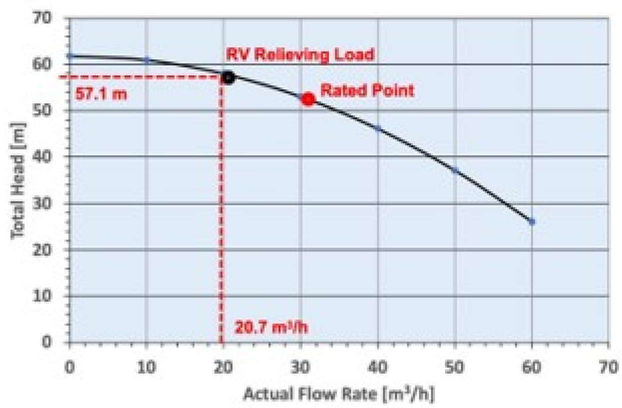

Figure 2. Pump Vendor Curves

The shut-off head margin [Ps] is estimated as,

$$P_s = \left[\frac{61.8}{52.5} - 1\right] \times 100 = 17.87\% \quad (6)$$

Taking RV accumulation of 10%, the relieving pressure of the RV [Pr] becomes,

$$P_r = 19.6 \times 1.1 = 21.56\ bara \quad (7)$$

The corrected differential head becomes,

$$H_d = \left[\frac{(19.6-14) \times 10^5}{1000 \times 9.81}\right] = 57.1\ m \quad (8)$$

From the pump curves shown, the corresponding flow rate for a differential head of 57.1 m is 20.7 m^3/h.

Performing a RV sizing for the blocked outlet case with the new RV set pressure of 19.6 bara and a flow rate of 20.7 m^3/h for 1 barg back pressure, the RV size becomes,

$$A_r = \left[\frac{11.78 \times 345}{0.65 \times 1 \times 1 \times 1}\right] \times \sqrt{\left(\frac{1}{2045-100}\right)} = 142\ mm^2 \quad (9)$$

$$A_{corr} = \frac{142}{1} = 142\ mm^2\ or\ 0.22\ in^2 \quad (10)$$

From API 526, the selected standard orifice size is 'F' with an effective discharge area of 0.307 in2.

Comparing both results, it is seen that when the pump shut-off head margin is lower, the size of the relief valve also decreases.

Therefore, once the pump curves are available from the vendor, it is important to revisit the RV sizes and see, if they can be made smaller along with the associated piping sizes. This also adds to costs savings & avoids mechanical damage due to valve chattering.

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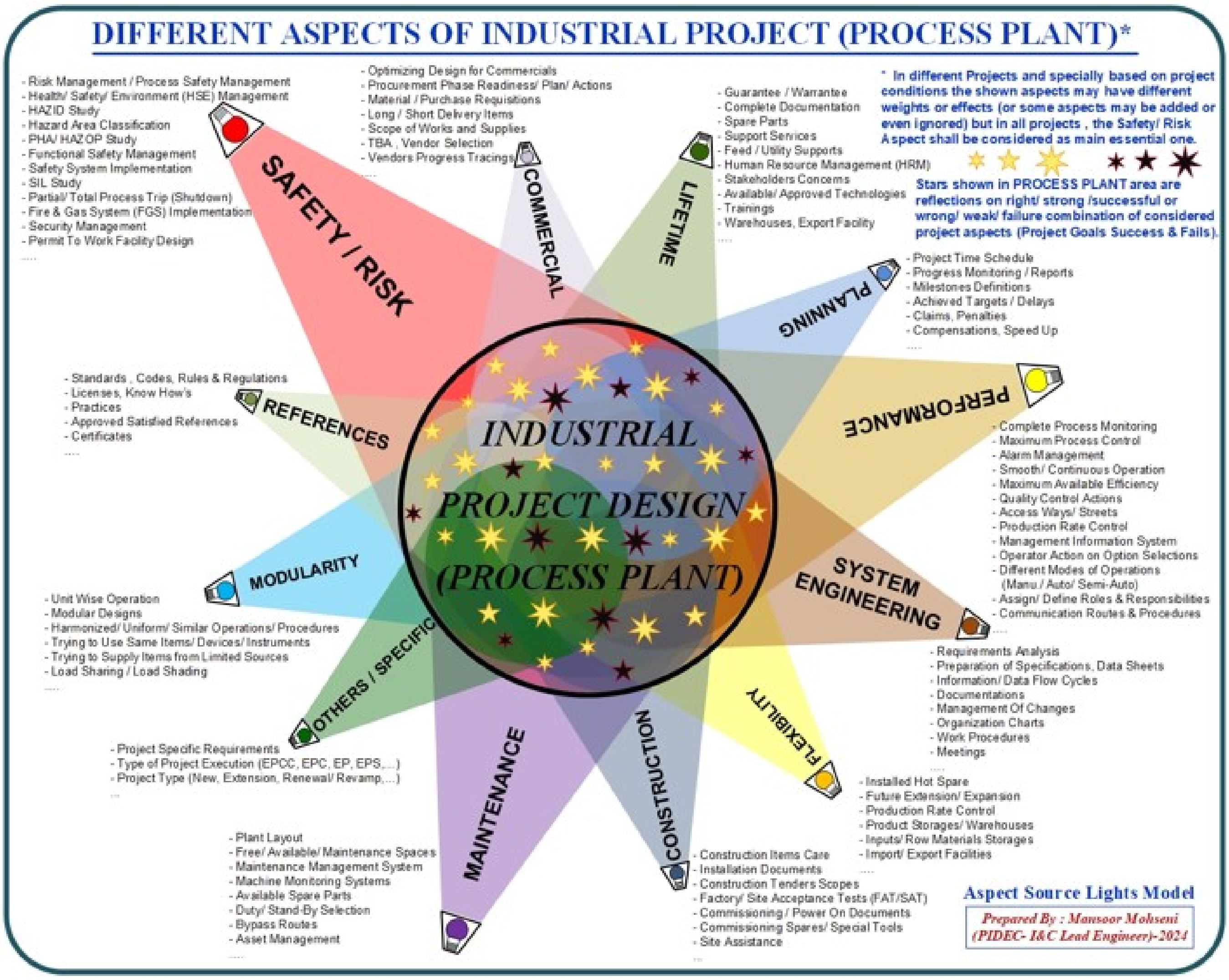
Different Aspects of Industrial Project (Process Plant)

Mansoor Mohseni

Introduction

Design & Construction of a new process plant (including Chemical, Oil & Gas, and Petrochemical Plants) are some of daily growing industrial or engineering projects from beginning of 20th century. During the time, managing such industrial projects are completed for doing more and more complexity and bigger production size further to better performance quality and optimum execution time projects. Industrial or engineering projects include huge activities and required documentation in jobs. different technical and commercial departments while coordinated by different specialist persons in different positions/categories or responsibilities. Of course, handling such complex projects to succeed to the best results need set of powerful skilled managements to care for the inputs and conditions (of their scopes of work and supply), and coordinating all items to reach the best outputs / targets which are in their responsibilities. However, coordination between all managements to have the same approach and totally follow their responsibilities in the right time,

Figure-1 Different Aspects of Industrial Project (Process Plant)



needs much more competency for top managements of project. They shall be familiar with different aspects of industrial projects and coordinate different teams to consider all required/ relevant aspects in their

Top management shall try to get all aspects of the project and combine them partially or totally for reaching the best targets. In fact, we can imagine each industrial project as an area which is highlighted by different light source of aspects and the final project target /output is the combination of total reflection of considered aspects as shown in Figure-1. Industrial projects may have so many light sources of aspects and each of them may have big or small weight of effects on project output. Please notice that each aspect category may have different weight effect by different action parameters (as example in Figure-1 the radiation angle, color and intensity of light sources are 3 different parameters of each aspect which control the weight effect in total reflection further to right combination surfaces). Arranging the light sources of aspects with suitable weights and combining and controlling the right reflection of such rays to produce more bright area (project success) are the skills of top managements of the industrial project. On the contrary, weak management or wrong actions of project teams or insufficient support may produce dark area (project failure).

“Considering that we have different light sources with different colors and intensities which have rays on one complex surface, so it combines or reflects such lights, and we are the controller/actuator to set different available parameters or variables to control the path and intensities of reflection rays. If we can suitably set the mentioned parameters and modify the (complex) surface of reflector, then we may reach the concentrated return light with good, focused brightness, and as we hop (get away) from optimum set-points we will have more divergence and so less brightness (or other than requested color). In fact, the project aspects are the source lights, the reflectors are the project (company) structures/ conditions/ procedural systems/ communications (and so on) further to effects of external forces, and finally the controllers/ actuators are the management (team) with their levers. In real project situation, If

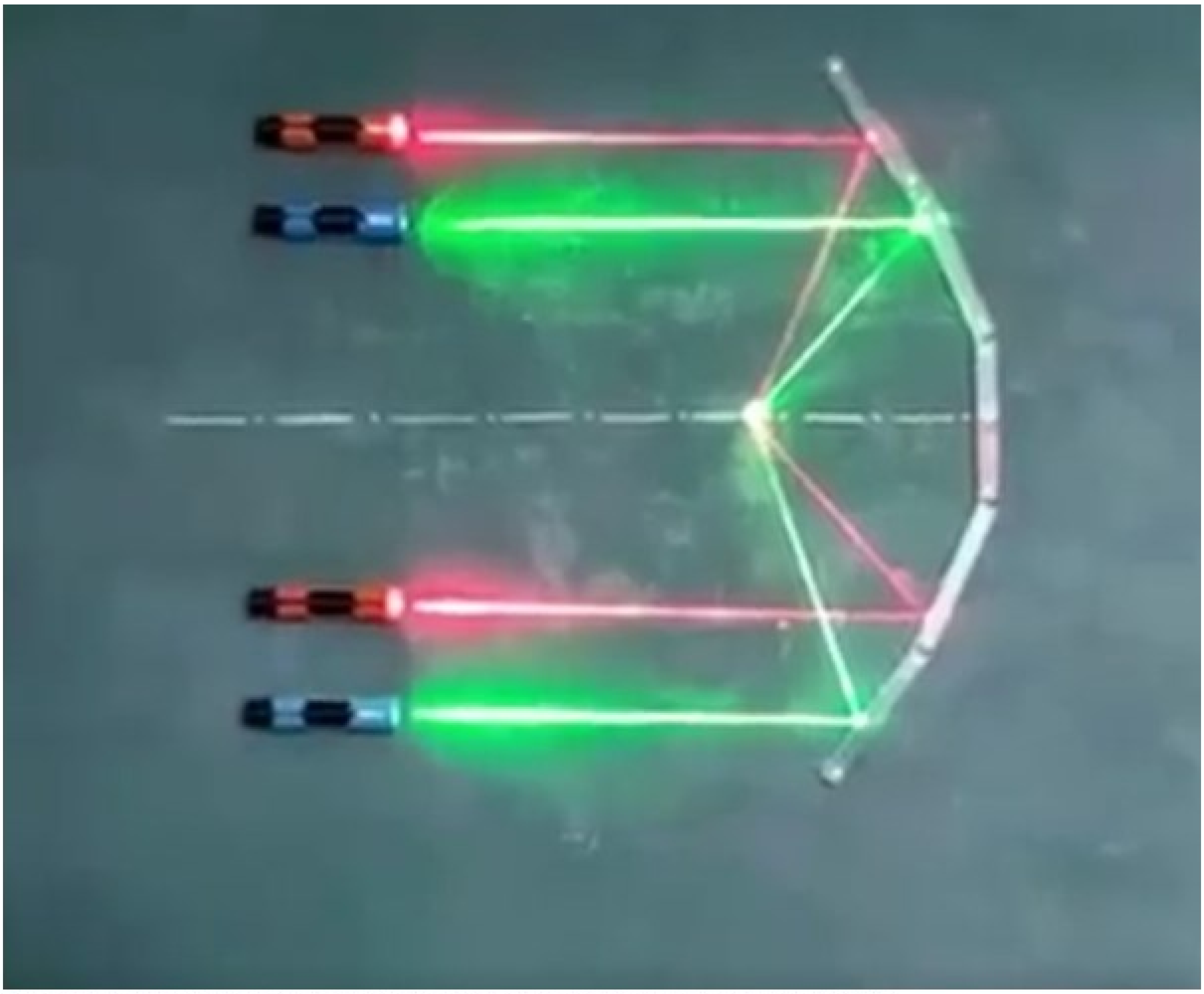


Figure-2 Setting the Reflection Sides to Reach Focused (Light) Point management (team) consider the enough manpower with suitable (minimum) skills and experience for vigilance on the mentioned aspects in each phase/ action, and provide the suitable environment for combining the actions (in company) by their levers so that the best and right actions could be done by maximum efficiencies and at right times, then we may reach to the optimum results. The management levers may include planning, monitoring, push, expedite, arrange, (provide) training, punishment, encouragement, strengthening, supporting, … which can be used to reach the best combination of activities and other factors to get the success of project goals. Of course, the art of using management skills on right time/ situation and the number of actions further to understanding the weight effect of each aspect (on project progress and success) may be considered as actuator actions for right weight combinations." (See Figure-2)

Summary of Different Shown Aspects

Follow to mentioned introduction, we can review the summary of such aspects now.

1. Safety / Risk: It is evident that first and essential aspect of all industrial projects is Safety / Risk items which shall be strictly considered in all designs and activities. For process plants there are some requirements, specifications and standards available which shall be considered and followed by the project responsible. As mentioned, the weight of this aspect is highest, and the right consideration of this aspect (items) may lead to the project successes or even failures.

2. Performance: Such aspect (items) refers to final functional output requirements or desirables and right considerations of such aspect (items) may increase quality, user friendly functions, more efficiency, etc. or may have contrary effects by wrong or weak considerations.

3. Maintenance: Such aspect (items) refers to conditions and situations for saving the project equipment and hardware or optimizing their conditions for best availability and performances.

4. System Engineering: Such aspect (items) refers to considering of systematic approaches on all functions, actions, and procedures to guarantee the stable and continuous executions of project goals.

5. Commercial: Such aspect (items) refers to economic points and limitations of project and has big weight effects on succeeding the project goals or vice versa.

6. Planning: Such aspect (items) refers to project progress planning success and making right job orders at right times.
7. Lifetime: Such aspects (items) refer to stability project goals and conditions which shall be considered on project lifetime.
8. Flexibility: Such aspect (items) refers to considering suitable facilities to enable project owner or user for having different options of productions and selection chances.
9. Construction: Such aspect (items) refers to considering those items which shall be studied or provided for construction phase of project.
10. Modularity: Such aspect (items) refers to considering complex projects definition and implementation by different modules to make better identifications on scopes and better defining relevant functions and responsibilities. Furthermore, using modularity approach helps project managements to reach quicker and more efficient to project goals. Such an approach will have positive effects on all other aspects too.
11. References: Such aspect (items) refer to consider and care for all required standards, codes, rules, certificates, approved references and so on.
12. Others/ Specific: Here we mention such aspect (items) to be considered or cared for those special items which are related to dedicate ones on subject project. On the other hand, each viewer or provider of the Aspect Model can add his/her focused concerns here.

By reviewing the Figure-1 you can find some proposed detail items of each mentioned aspect, but such items are mentioned just as examples while model users may define more and more items for their concerns (although the mentioned items may be repeated or considered as base of model provider). In fact, for using such model, we shall study the different main goals of project and accordingly define the main aspects to be considered as light sources and then mention the detail of each aspect accordingly. Then at the final project execution we may find positive and negative results of the project and highlight them with bright and dark stars. So, by such model we may quickly find the project aspects and check the results of project accordingly.

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This article provided by writer experiences in detail engineering company during execution of many projects with some extraction results from below articles published by Instrumentationtools.com:

I&C Engineer Roles & Responsibilities – Instrumentation Design (https://instrumentationtools.com/ic-engineer-roles-responsibilities-instrumentation-design/)

Instrumentation Engineer Activities & Documents – Detail Design Phase (https://instrumentationtools.com/instrumentation-engineer-activities-documents-detail-design-phase/)

Instrumentation and Control Project Packages – Detail Engineering (https://instrumentationtools.com/instrumentation-and-control-project-packages/)

Keywords

Industrial Project, Process Plant, Project Design / Engineering, Project Aspects, Project Model Definition

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Guidelines for Reducing Corrosion Under Insulation and Its Safety Consequences

Karl Kolmetz , Muhammad Salem Abdul Ajes ST., Reni Mutiara Sari ST.

Introduction

Like other natural events, earthquakes or bad weather, corrosion is a natural event that results in expensive damage that effects almost every industrial sector; Infrastructure, Utilities, Transportation, Production and Manufacturing, and Governmental Functions. Corrosion Under Insulation (CUI) is a problem in the industrial sector, including refining, petrochemical, power, industrial, onshore and offshore industries and it is a real threat to the on stream reliability of many of today's plants. Because the corrosion is hidden under the insulation, CUI tends to remain undetected until the insulation is removed for inspection or whenever loss of containment leaks occur.

Petrochemical industry and other industries have many thousands of meters of pipe that are insulated to prevent heat loss or heat absorption. Corrosion of steel under insulation is considered to be one of the major problems which has caused damage to the petrochemical industry, especially to the insulated equipment and piping systems resulting in failures and accidents.

CUI is occuring in the petrochemical industry and should be a special concern, because this type of corrosion can cause failures in areas that are not normally of a primary concern to an inspection program. The failures are often the result of localized corrosion and not general wasting over a large area. These failures can be catastrophic in nature or at least have an adverse economic effect in terms of downtime and repairs.

Implementation of safety procedures is a good tool in reducing incidents in the petrochemical industry. Over the past 5 years there have been many recorded CUI cases in the petrochemical industry. One of the safety incidents was in an Olefions Plant, on 13 June 2013 in Geismar, an unincorporated and largely industrial area 20 miles (32 km) southeast of Baton Rouge, Louisiana[1].

The phenomenon of CUI can reduced and controlled. This paper will review the guidelines for reducing corrosion under insulation and its safety consequences. The main goal in this paper is review the technical root causes of CUI, review best prevention practices, best inspection practices and a review historical safety incidents.

Definition of Corrosion :

Corrosion or sometime called rust comes from "corrous" which means eating away. Corrosion can be defined as the destructive attack of a metal by chemical or electrochemical reaction with its environment. Deterioration by physical causes is not called corrosion, but is described as erosion, galling, or wear. Based on the reaction medium, corrosion can be devided into two types, namely wet corrosion and dry corrosion. Wet corrosion occurs if transfor ions from the cathode to the anode using a liquid. Dry corrosion do not use the ions such as iron metal attack by oxygen or by sulfur dioxide gas typically occurs at high temperatures.

Forms of wet corrosion can occur evenly or locally. Corrosion is prevalent in the immersion of ferrous metals in fluids. Forms of local corrosion can occur macroscopically and microscopically. The local corrosion that are macroscopically example include; corrosion of galvanized iron system events – zinc, corrosion – erosion, corrosion cracking, corrosion hole, exfoliation corrosion and corrosion melting. Examples of corrosion which are microscopic include; stress corrosion, corrosion fracture and corrosion between the grains.

Any corrosion process depends into two factors: temperature and oxygen in addition to the concentration of dissolved species. Corrosion is increased by increasing both factors, if the oxygen is not available then corrosion may not occur. This means that if we keep the environment beneath the insulation dry all the time, then no corrosion will occur. When precipitation becomes trapped on the metal surface by insulation, corrosive atmospheric constituents such as chloride and sulfuric acid gasses can concentrate to accelerate corrosion.

History of Safety Incidents[2] :
The aging infrastructure is one of the most serious problems faced by society today. In past decades, corrosion professionals focused primarily on new construction specifying materials and designing corrosion prevention and control systems for buildings, bridges, roads, plants, pipelines, tanks, and other key elements of the infrastructure. Today, as much of the aging infrastructure reaches the end of its designed lifetime, the emphasis is on maintaining and extending the life of these valuable assets.

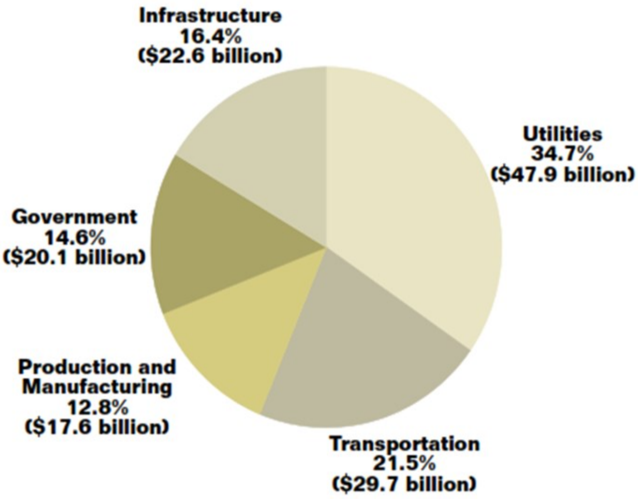


Figure 1 : Cost of Corrosion in Industry Categories.

Utilities, which supply gas, water, electricity, and telecommunications services, account for the largest portion of annual industrial corrosion costs. Direct corrosion costs total $47.9 billion. These costs are broken down into the sectors of gas distribution, drinking water and sewer systems, electrical utilities, and telecommunication.

These categories include industries that produce and manufacture products of crucial importance to the economy and its residents' standard of living. These include oil production, mining, petroleum refining, chemical and pharmaceutical production, and agricultural and food production. The total annual direct cost of corrosion for production and manufacturing is estimated to be $17.6 billion.

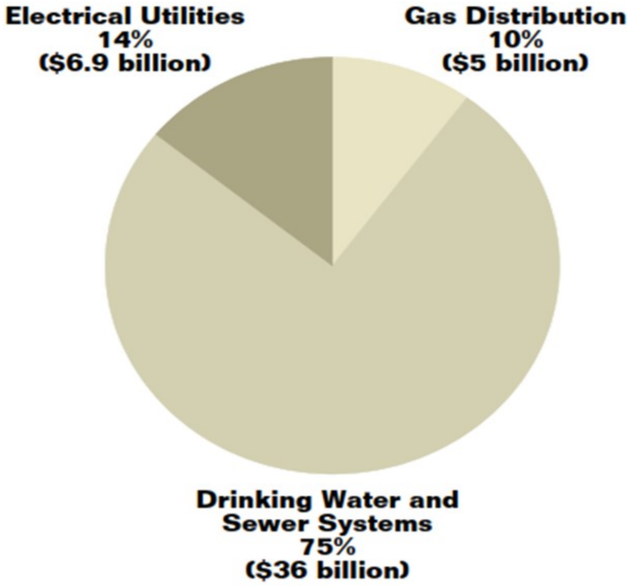


Figure 2 : Annual Cost of Corrosion in The Utilities Category.

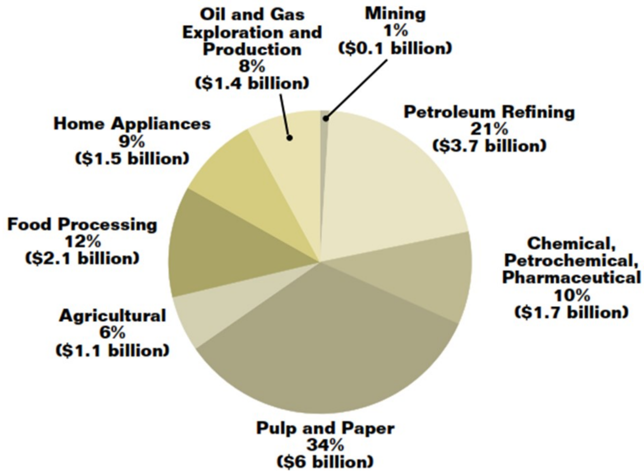
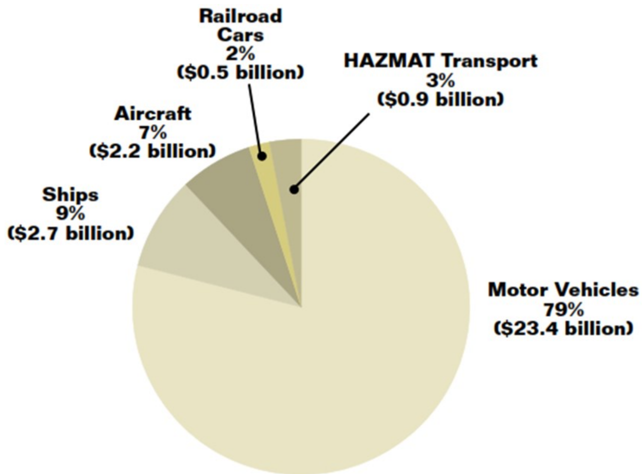


Figure 3 : Annual Cost of Corrosion in The Production and Manufacturing Category.

The transportation category includes vehicles and equipment, such as motor vehicles, aircraft, rail cars, and HAZMAT transport. The annual corrosion cost in this category is $29.7 billion.

Figure 4 : Annual Cost of Corrosion in The Transportation Category.



Corrosion Under Insulation (CUI)
Insulation is used to minimize heat loss, reduce costs and improve efficiency in vessels and piping systems. It may also be employed to minimize heat gain or to protect personnel from the risk of injury from hot or cold surfaces. Traditional insulation systems typically consist of an insulating material such as mineral wool or calcium silicate, which is then protected by an outer layer of cladding. Thin metal sheet or composite wraps are the most common cladding materials.

Figure 5 : Insulation[3].

Corrosion Under Insulation (CUI) is one of the largest maintenance problems facing the petrochemical industry today. According to one specifier from a global oil company, problems such as major equipment outages and unexpected maintenance costs stemming from CUI account for more unplanned downtime than all other causes.

CUI is corrosion that occurs under insulated equipment. CUI is any type of corrosion that occurs due to moisture buildup on the external surface of insulated equipment. Any type of corrosion can occur under insulation the most common types of CUI are galvanic, chloride, acidic, or alkaline corrosion.

Figure 6 : Fenomenon of CUI.

Intruding water is the key problem in CUI. Special care must be taken during design not to promote corrosion by permitting water to enter a system either directly or indirectly by capillary action. Moisture may be external or may be present in the insulation material itself. Corrosion may attack the jacketing, the insulation hardware, or the underlying equipment.

For high temperature equipment, water entering an insulation material and diffusing inward will eventually reach a region of dryout at the hot pipe or equipment wall. Next to this dryout region is a zone in which the pores of the insulation are filled with a saturated salt solution. When a shutdown or process change occurs and the metal wall temperature falls, the zone of saturated salt solution moves into the metal wall.

Upon reheating, the wall will temporarily be in contact with the saturated solution, and stress-corrosion cracking may begin. The drying/wetting cycles in CUI associated problems are a strong accelerator of corrosion damage since they provoke the formation of an increasingly aggressive chemistry that can lead to the worst corrosion problems possible, example stress corrosion cracking, and premature equipment failures.

Types of Corrosion Under Insulation4] :
When using insulation, the corrosion resistance of the metal surface to be insulated is and important factor. The most frequently occurring types of CUI are :

General and fitting corrosion of carbon steel, which may occur if wet insulation comes into contact with carbon steel, particularly if acidic which can leach from the insulation material itself.

External Stress Corrosion Cracking (ESCC) of austenitic stainless steel, which is a specific type of corrosion mainly caused by the action of water-soluble chlorides from rainwater or insulation that does not meet material standards. Austenitic stainless steel is generally susceptible to this type of attack in the temperature range of 13 °C to 202 °C

The Technical Root Causes of C U I :
Causes of CUI are similar in most ways to other types of corrosion, with the largest difference being the environment. Steel corrodes when it is in contact with water and has a free supply of oxygen. When plant and pipework are insulated there is usually a

space in which water can collect on the metal surface with access to air. The ingress of water into the insulation is often caused by one or more of the following :

*Poorly designed and/or installed protective finish or cladding.
*Cladding joint sealant breakdown.
*Mechanical damage to the protective finish.
*Caldding removed and not properly replaced (common around valve boxes).

Moisture combined with oxygen is the largest contributing factor to corrosion. The closed environment of the insulation material over the pipe, tank or equipment creates conditions that encourage build up of moisture and resulting corrosion. The corrosion is often times more severe due to the insulation not allowing evaporation and the insulation acting as a carrier whereas moisture occurring in one area moves through the insulation to another area causing the corrosion to spread more rapidly.
Warm temperatures normally result in more rapid evaporation of moisture and reduced corrosion rates, however a surface covered with insulation creates an environment that holds in the moisture instead of allowing evaporation. Traditional thermal insulation materials contain chlorides. If they are exposed to moisture, chlorides may be released into a moisture layer on the pipeline surface and pitting/stress corrosion cracking may result. Acids, acid gases and strong bases like caustics and salts are aggressive corrosive agents and will not only cause but also accelerate existing CUI.

The Best of Inspection Practices :
Current advancements in the corrosion field allow us to detect and control damage mechanisms such as CUI in pipeline systems through proper material section, and by adjusting operating parameters, controlling corrosion environments, developing systematic procedures, and proper nondestructive evaluation methods.

Advancements in Non-Destructive Test (NDT) methods have enabled the process industry to carry out corrosion under insulation (CUI) inspection without removing insulation. These techniques can be used along with conventional techniques to provide cost-effective, comprehensive CUI inspection of piping networks. Some of the proven NDT methode are:

1.Infrared (IR) Thermography
Infrared (IR) thermography can be effectively used to identify wet insulation in pipelines. Compared to conventional moisture density gauges, IR thermography is more sensitive and faster. In addition, pipelines can be scanned from a distance, which avoids time-consuming construction of scaffolding works.

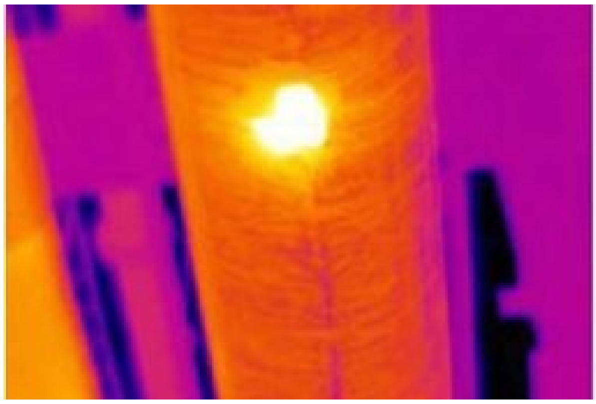


Figure 7 : Wet Insulation Identified By Infrared (IR) Thermography.

IR surveys are typically conducted for non-traced insulated pipelines, but they are also effective for heat-traced lines as well. Any wet insulation will retain heat longer than dry insulation. So two to three hours after sunset, locations where insulation is wet will be hotter than locations with dry insulation. This is the basic theory behind the technique. There are a few considerations when conducting IR surveys to detect wet insulation:

*The best time to conduct IR surveys to identify wet insulation is two hours after sunset. The evenings of sunny days are considered to be the most preferable time.

*The temperature difference between wet and dry insulation is not very large, so it is best to use a small temperature span to increase sensitivity.

2.Long Range Ultrasonic Testing (LRUT)
Guided waves are used in Long Range Ultrasonic Testing (LRUT) to scan pipelines which are otherwise inaccessible for inspection. Guided waves are propagated in a pipe wall from a ring of equally spaced ultrasound probes supported by a collar wrapped around the pipe. The ultrasonic waves are reflected by discontinuities such as girth welds, branches in pipeline circuit, and reductions in wall thickness (an indication of corrosion). These reflected waves are detected and then analyzed with the help of computers.

LRUT can typically scan a length of 60 m to 120 m if the line is straight. If the line is insulated, the length will be reduced, since absorption is greater with some kinds of insulation. Support locations, connections, and bends in pipelines further reduce the span of inspection. Even so, LRUT is considered one of the most effective tools in identifying CUI in pipelines where removal of insulation is difficult.

Figure 8 : LRUT Setup is Used for Both Buried Coated Pipelines and Insulated Pipelines.

The velocity of the guided wave is a function of the thickness of the medium and frequency (mode) of wave. CUI will lead to changes in thickness in the medium (pipe wall) locally. In addition to scatter and reflection, this will lead to mode conversion of the incident waves. Therefore, reflected waves will contain both incident wave mode, plus mode-converted waves. Detection of these mode-converted waves in a reflected signal is a strong indicator of discontinuities such as CUI in an insulated pipeline.

The interpretation of LRUT is difficult compared to tools such as IR survey and will often require a specialist. But it is the most reliable tool to inspect insulated pipelines at non-accessible locations, such as portions of pipelines passing under non-accessible culverts, buried piping and at road crossings, etc.

3.Profile Radiography

Profile Radiography is a proven technique to detect the internal wall thickness and reduction of small bore piping. The technology can also be applied to find CUI, provided that Source to Film Distance (SFD) is sufficient to cover the entire pipe diameter in one shot. This may become difficult when pipeline diameter is more than eight inches and there is insufficient clearance between pipelines running in a pipe rack.

It is possible to scan pipelines of wider diameters by taking only a section of the pipeline in one shot. Consequently, multiple shots will be required to cover the full diameter of some

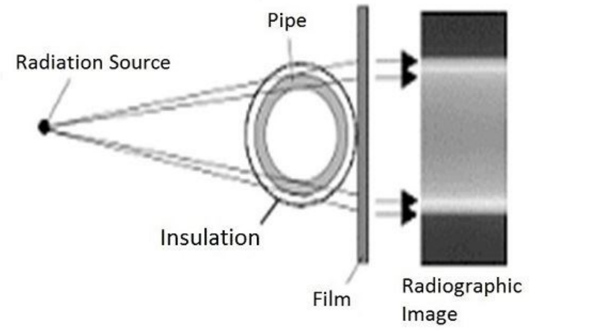


Figure 9 : Schematic of Profile Radiography Setup.

pipelines, thus making the process more time consuming.

4. Computed Radiography

Computed Radiography (CR) uses similar equipment to conventional radiography except that in place of a film to create the image, an imaging plate (IP) is used. CR has the same inherent safety issues as conventional profile radiography.

The computerized images produced by CR allow easy data sharing and result in significant improvements in radiographic inspection productivity as well as faster identification of defects.

The image in Figure 10 was taken by computed radiography technique, showing corrosion deposits at the elbow of an insulated pipe. Wall thickness reduction is calculated using software. Before measurement, the software needs to be calibrated on reference wedges, such as a known-size steel ball or an identical pipe piece.

If effective cordoning is possible, computed RT is an effective tool to detect CUI without removing insulation. Another advantage of this method is data can be easily stored for future comparison or audit.

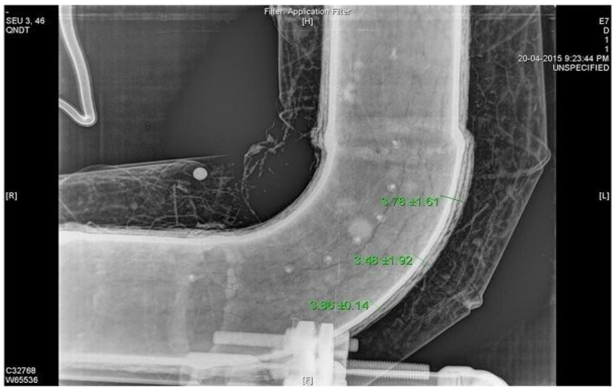


Figure 10 : CR Radiograph Showing Corrosion Deposits.

The sensitivity of PEC is low compared to radiographic methods because this method integrates over a large footprint. As a result, the smallest defect that can be detected has a diameter of about 50 percent of the insulation thickness (between 30mm and 120mm). PEC testing is therefore suitable for general wall loss, but isolated pitting defects cannot be detected. Therefore, PEC is ideal for scanning insulated carbon steel pipelines where corrosion is expected over a larger area.

With using preventive strategies in nontechnical and technical areas as follows[2] :

- Increase awareness of significant corrosion costs and potential cost savings.
- Change the misconception that nothing can be done about corrosion.
- Change policies, regulations, standards, and management practices to increase corrosion cost savings through sound corrosion management.
- Improve education and training of staff in the recognition of corrosion control.
- Implement advanced design practices for better corrosion management.
- Develop advanced life-prediction and performance-assessment methods.
- Improve corrosion technology through research, development, and implementation.

Other factors can be controlled effectively and three issues should be addressed as follows [4]:

1. Protecting steelwork

The necessity of protection against corrosion must be determined for each individual plant and the appropriate measures have to be identified. Generally, the design of the insulation system and corrosion protection depends on the following parameters :

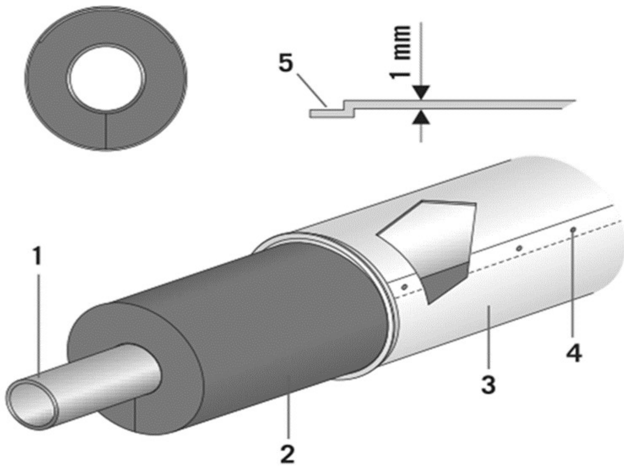
- Operation of the plant (continuous or interrupted/intermittent),
- Operation temperatures,
- Metals used (non-alloy, low alloy steel, austenitic stainless steel or copper),
- External factors.

Before applying the corrosion protection coating, the surface must be free from grease, dust and acid plus the priming coat should be roughened for better adhesion. Blasting is the recommended surface preparation method (for austenitic stainless steel, use a ferrite free blasting abrasive). Follow the coating manufacturer's processing guidelines.

2. Design and planning of the insulation work

The requirement of the planned insulation work must be factored in during the industrial plant design and construction phase. It is therefore advisable to involve all project managers at an early stage to preclude unnecessary and unanticipated problems during insulation work.

All preparatory work must be completed in accordance with the relevant insulation standard and if necessary, apply corrosion protection. Insulation material should be stored and installed in dry conditions. Various conditions must be fulfilled to ensure the insulation does not contribute to the corrosion of the steelwork later on.



1. Pipe - 2. Insulation - 3. Cladding - 4. Sheet-metal screw or rivet - 5. Thickness of cladding

Figure 11 : Pipe Insulation

When making a considered insulation selection, it is important to think about not only obvious properties, such as the thermal conductivity or maximum service temperature of a product. To minimize risk of CUI, it is also important that the insulation does not affect the steelwork, does not absorb any water and is open to vapor, so that moisture can easily egress the insulation.

3. Maintenance and Inspection

To avoid unnecessarily complicating routine maintenance and inspection work, high maintenance areas must be taken into account, especially in the design phase. Removable insulation, such as coverings and hoods, could be fitted in such areas. Easy to remove coverings are recommended to allow rapid disassembly. Bolt are generally fastened with quick release clamps, which can be opened without special tools.

Removable covering or hoods are usually insulated from the inside. The coverings are fastened to the object with lever fastenings, which are fixed directly on to the covering or on to straps. Take the following suggested conditions into account when designing insulated coverings for fitting and flanges:

- The overlap distance of the insulated covering over the insulated pipe should be at 2”.
- The pipe insulation should end at the flanges, leaving a gap equal to the bolt length plus 1.2” and should be closed off with a lock washer so the flange can be loosened without damaging the insulation.
- With valve, an extended spindle should preferably be fitted horizontally or below the pipe to prevent leakage along the spindle shaft.
- The cladding must be fitted to prevent the ingress of moisture in the insulation. On inclined or vertical piping, for example, mount rain deflectors above the removable coverings. If the ingress of moisture into the insulation is unavoidable, make 0.4” diameter drain holes in the removable covering.

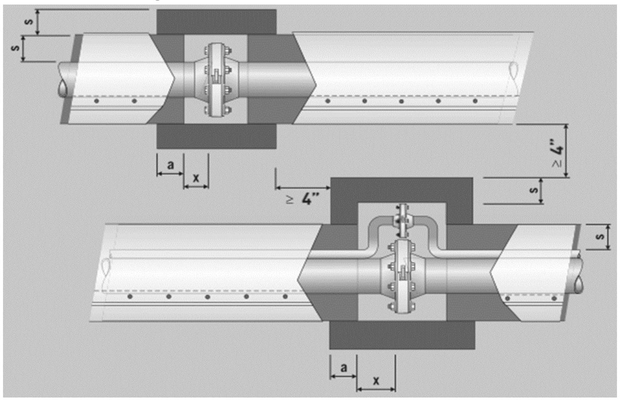
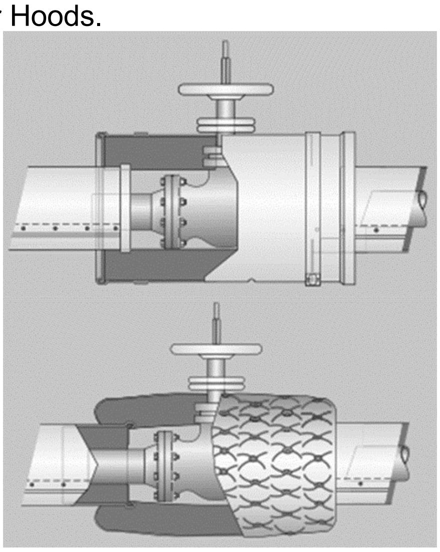


Figure 12 : Minimum Distance Within Range of Pipe Flanges. Figure 13: Insulation of Valve Should Be Designed with Removable Covering or Hoods.



Safety Consequences[6] :
A case of CUI in the petrochemical industry is the explosion in an Olefins Plant where two workers were killed and 114 injured. The explosion was triggered by the failure of a heat exchanger caused by piping corrosion under insulation. This was a small isolated corrosion location that had not been previously found.

Figure 14 : Incident in Olefins Plant[1].

A high commitment from management for Environmental, Health and Safety (EHS) is required. Discipline that focuses on prevention of physical situations with the potential for human injury, damage to property or to the environment through the release of chemical energy in the form of fire, explosion, toxicity or corrosively.

Management direction to achieve the vision of the Process Safety Management (PSM) required some of the following:

- Establish formal organization to drive and monitor process with divisional ownership.
- Develop prescriptive "how to" PSM procedures.
- Appoint qualified person to fill key process safety roles.
- Plan and execute rigorous implementation of PSM requirement develop and provide standardized PSM tools and solutions globally.
- Establish PSM key performance indicators to monitor PSM performance.
- Establish a PSM corporate score card to drive accountability.
- Verify compliance by conducting global PSM focused audits.
- Governance process to sustain the PSM improvement process corporately.

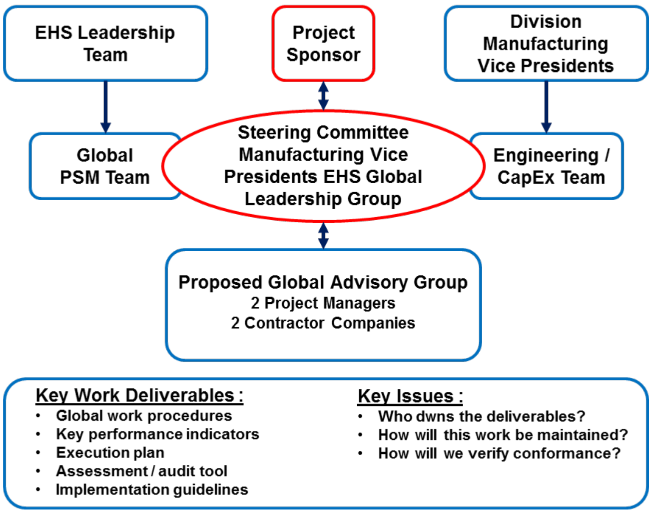


Figure 15 : Establishment of Formal Organization.

The three sequence of PSM procedures are as follows:

1. The first: Appointment of Qualified Persons, Process Hazard Analysis (PHA), PHA Revalidation, EHS Critically Assessment, Risk Management Procedure and Matrix, Target Assessment Methodology, Facility Siting, Management of Action.
2. The second: Operating Procedures, Design Verification, Pressure Relief System Design, Organization Change Management, Management of Change, Mechanical Integrity, Pre-Start-Up Safety Review, Process Safety Information.
3. The third: Process Fire Safety Management, Area Classification and Management, Design & Maintenance of Plant Trips (SILs), Alarm Management, Incident Investigation, Process Safety Variance Procedure, Control System Security.

The process of correct implementation of the PSM procedure can be raise the overall expectations and performance in process safety at each site, consistently communicate the content of each of the process safety procedures and expectations, and can to identify gaps in the facility's practices and develop gap closure plans.

1.Risk Based Inspection (RBI)
Risk Based Inspection (RBI) is a risk assessment and management process that is focused on loss of containment of pressurized equipment in processing facilities, due to material deterioration. These risks are managed primarily through equipment inspection.

An integrated integrity management strategy will contain measures that address and mitigate the possibility of the root causes of

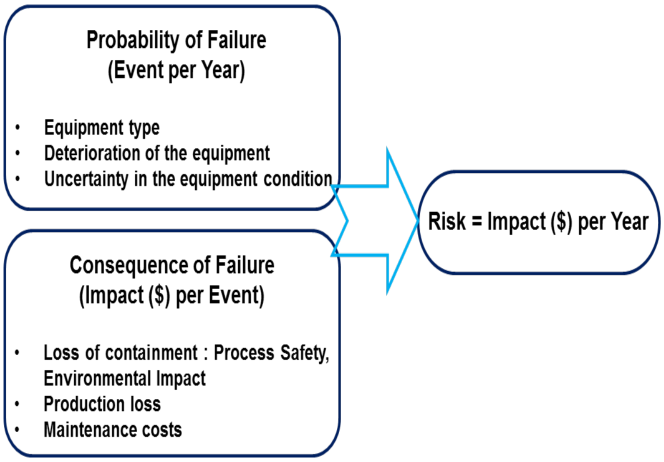


Figure 16: Risk Based Inspection[9].

failure. Design reviews, manufacturing quality assurance, operating training, and systems analyses are examples of such measures. In-service inspection is a backstop to prevent failure when a root cause has led to deterioration from the design intent or the as manufactured condition.

The process of risk based inspection should form part of an integrated strategy for managing the integrity of the systems and equipment of the installation as a whole. Its aim is to focus management action on prioritizing resources to manage the risk from critical items of equipment. Risk based inspection is a logical and structured process of planning and evaluation.

Inspection is also a priority for equipment where the fabrication, inspection or operating history is unknown, where there is inadequate maintenance, or where there is lack of the materials data required for assessing fitness for service. Risk based inspection involves the planning of an inspection on the basis of the information obtained from a risk analysis of the equipment. The purpose of the risk analysis is to identify the potential degradation mechanisms and threats to the integrity of the equipment and to assess the consequences and risks of failure.

First, the requirements for plant integrity management by RBI are established within the context of existing regulations, inspection codes and practices. Reviews the regulations, guidance and practices relating to risk assessments and RBI. Identify the systems, the system boundaries and the equipment within them requiring integrity management. Drivers, criteria and limitations for a risk based approach to inspection planning must be ascertained as RBI may not always be possible or appropriate.

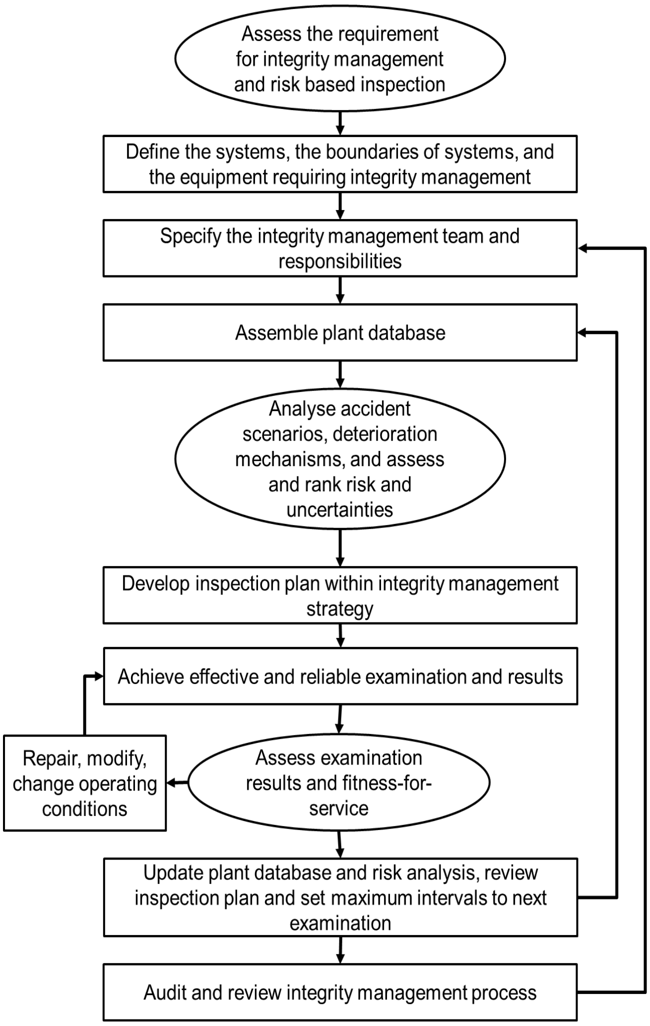


Figure 17 : Process Diagram for Plant Integrity Management by Risk Based Inspection[8].

For risk based inspection, information and opinions from several functions and disciplines are normally needed. It is recommended that these were best obtained from a team of relevant individuals. Risk based inspection requires a wide range of information in order to assess the probability and consequences of equipment failure and develop an inspection plan. A plant database containing an inventory of the equipment and associated information is a useful way of managing the relevant data. The information and associated uncertainties identified by the risk analysis about potential deterioration are used to develop an integrity management strategy and appropriate inspection plan.

In order for inspection to be an effective part of integrity management, the techniques and procedures used must be capable of achieving a reliable examination. The techniques and procedures must therefore be matched to the potential deterioration identified by the risk analysis.

Assessment of the examination results and fitness-for-service are essential parts of the RBI process. For equipment where fitness-for-service cannot be assured, repairs, modification or changes to operating conditions may be recommended.

2. Mechanical Integrity Program
Mechanical Integrity is the process of ensuring equipment is in satisfactory condition to safely and reliably perform its intended purpose. Mechanical Integrity programs have been an essential element of process Program Safety Management in the chemical and petroleum industries for decades. Although maintenance is a major part of a Mechanical Integrity program; Mechanical Integrity is not just maintenance. Mechanical Integrity covers the proper design, fabrication, construction or installation and operation of equipment throughout the entire process life cycle.

Figure 18 : Chart of PSM Program.

Guidelines and best practices for compliance with this program are mainly based on Industry standards for piping in highly hazardous services. Piping systems in highly hazardous service shall be identified and registered; namely the steps required to place in the Mechanical Integrity system for future inspections. Mechanical Integrity is clear standards and external standards on inspection and maintenance of local organizations such as:

Evaluation to determine if a potential spill under normal operating conditions could exceed threshold external authority reportable quantities. If the piping system has the potential to release highly hazardous chemicals in quantities greater than the threshold limit, then the piping system shall be registered.

- Explaining the party responsible for the steps of registration, inspection, and follow -up associated with the inspection program.
- Including specific expectation and reproducing the requirements inspectors should follow from external standards are critical for consistent global mechanical integrity inspections.

Mechanical Integrity programs cannot rely solely upon contract inspectors and need adequate involvement of plant personnel familiar with plant operations. Effective communications and involvement of persons familiar with all modes of operation within the plant is critical to develop a robust inspection plan.

An effective program to leverage learnings from other incidents should include discoveries of excessive corrosion or any other losses of mechanical integrity. Leadership and employees in petrochemical industry must be were aware of the potential severity of CUI incident. This awareness must spark leadership and company Mechanical Integrity program steering team to launch a initiatives such as[7]:

A mandatory refresher training for all site and production plant leaders on the key elements and responsibilities under the corporate Mechanical Integrity program.
The creation of a list of high priority CUI inspection locations, by technology, to be inspected as soon as possible.
The creation and delivery of new CUI inspection training to train maintenance and operations personnel how to better identify areas susceptible to CUI.

The launch of an additional, one-time Mechanical Integrity program audits of all major sites. (The Mechanical Integrity program of each site should be audited as part of the sites' ongoing periodic EH&S audits. This special audit was intended supplement this auditing with a highly visible site-wide, Mechanical Integrity focused audit to respond to this near miss event.)

Process Safety Management systems and best practices rank as one of "the most important system" to prevent incidents. An effective mechanical integrity program would certainly be among the top systems.

Justifying the expense of an effective CUI inspection program is often challenging since to identify all areas of CUI requires an expensive process. But the failures prevented by an effective CUI inspection program are often very dangerous and they can occur in areas where and there were no previous indications of corrosion.

Conclusions:
Corrosion Under Insulation (CUI) is a phenomenon that can't be avoided but can be reduced. Corrosion affects almost every industrial sector, Infrastructure, Utilities, Transportation, Production and Manufacturing, and Governmental Functions. To determine the occurrence of CUI, inspections conducted by several NDT methods can be utilized.

The design and specification of insulation, correct construction installation and preventative maintenance practices are the best prevention of CUI. By following appropriate strategies and obtaining sufficient resources for corrosion programs, best engineering practices can be achieved. Controlling corrosion requires expenditures, but the payoff includes increased public safety, reliable performance, maximized asset life, environmental protection, and more cost effective operation in the long run.

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Rock Bottom: Progress, Both Close & Far….America's Oil Country Increasingly Runs on Renewables, but What if 100% Renewable Power Reigned Across the US Grid?

Ron Cormier

Welcome back to another edition of *TVRB*. Renewable commodity resources continue to gather attention, especially in this US federal election year, and as political parties continue to maintain divergent views/platforms toward support for these important initiatives. While we here at EPM, do not take sides politically, we are strong supporters of our industry's continued lifeblood; STEM careers will continue to provide and challenge coming generations of engineers and practitioners who assure our energy and materials-based way of life, while maximizing a clean world in which to enjoy such innovation.

Texas, the biggest oil-producing state, has turned to solar power and battery storage to see it through extreme weather. But with demand rising, much more power will be needed across the USA.

During the scorching summer of 2023, the Texas energy grid wobbled as surging demand for electricity threatened to exceed supply. Several times, officials called on residents to conserve energy to avoid a grid failure. This year it turned out much better — thanks in large part to more renewable energy. The electrical grid in Texas has breezed through a summer in which, despite milder temperatures, the state again reached record levels of energy demand. It did so largely thanks to the substantial expansion of new solar farms. And the grid held strong even during the critical early evening hours — when the sun goes down and the nighttime winds have yet to pick up — with the help of an even newer source of energy in Texas and around the country….

Batteries.

The federal government expects the amount of battery storage capacity across the country, almost nonexistent five years ago, to nearly double by the end of the year. Texas, which has already surpassed California in the amount of power coming from large-scale solar farms, was expected to gain on its West Coast rival in battery storage as well.

The swift growth of battery storage as a source of power for the electric grid, along with the continued expansion of large-scale solar farms, could not have come at a better time. Texas, like many other states, is facing a surge in its power needs from data centers, new manufacturing plants, cryptocurrency mines, growing residential demand and increasingly intense summer heat. Officials estimate that Texas, already the nation's largest electricity consumer, could roughly double its demand in just a few years.

"Every state is going to go through this. Texas just happens to be the farthest along because we are growing our energy usage first," said Michael Lee, the chief executive of Octopus Energy U.S., a subsidiary of the British electricity provider. "We're seeing this in every other state, and all over the world."

Officials estimate that Texas, already the nation's largest electricity consumer, could roughly double its demand in just a few years.

Renewable energy sources have taken off in Texas, the nation's premier oil-and-gas state, in large part because of the relatively easy process for connecting to the state's grid and its mostly deregulated market for energy, company leaders and energy experts said. But some of those same advantages have also come under scrutiny since the grid's catastrophic failure during a prolonged winter freeze that killed hundreds in the state in 2021.

Governor Abbott took steps to try to prevent a similar failure from happening again. Since then, leaders in Texas, along with energy companies of all types, have been debating how to ensure there is always enough energy supply, while also preserving the state's relatively free market. Since the winter storm, officials have pushed for the construction of new gas-fired power plants, arguing that predictable, "dispatchable" energy is more reliable in an emergency than wind and solar.

In the energy market in Texas, mostly deregulated in the 2000s, generators are paid, with some exceptions, only for the energy they provide to the grid, rather than for having capacity to do so in the future. And in contrast to other states, the main electricity grid in Texas is contained entirely within the state.

In a somewhat unlikely turn, renewable energy companies have been arguing for keeping the market open and less regulated. However, contrary to usual smaller-government initiatives, Republican leaders have pushed for increasing government intervention, including incentives to build additional gas-fired power plants.

The Sun Will Destroy the Earth One Day, Right? Maybe Not.

"The abject irony is that the once-freewheeling power market is now on the precipice of becoming fully government-controlled," said Aaron Zubaty, the chief executive of Eolian, which invests in energy projects. "New technologies have provided market solutions and scaled rapidly," he said. The result, he added, is that legacy gas-fired power generators and their political backers are trying to increase barriers for the newcomers and "push the market to go all-in on natural gas." Despite that bureaucracy, Texas has turned to solar power and battery storage to see it through extreme weather.

He pointed to the swift growth of batteries, even without any state mandates, as an example of why interventions were not necessary to bring innovation. The increasing importance of batteries to the Texas electricity grid could be seen on a Tuesday in August when the state hit a new high for energy demand, a load that might have threatened the grid only a few years ago. But that day, the state produced near-record amounts of solar energy. When the sun went down, large-scale batteries put out more power than ever before.

Texans barely noticed the crunch this time. The air-conditioners hummed along.

Demand for power in Texas is growing at a rapid clip. A big part of the increase, experts said, has been from the electrification of the oil and gas fields of the Permian Basin — an expanse of oil-rich West Texas where fracking has boomed. In other words, oil and gas companies are increasingly turning to electricity to power their operations in Texas.

Despite few people living there, the region is expected to see energy demands rivaling those of major cities. "The Permian Basin is forecasting to become about the size, electrically, of the Houston area," said Pablo Vegas, the head of the Electric Reliability Council of Texas, the state's market operator, known as ERCOT.

Texas, which is the nation's second most populous state, already consumes far more energy than any other state. Officials recently changed how they calculate the potential growth in energy demand and now estimate that the state could nearly double its peak demand by 2030.

The current record for demand at a single time (that Tuesday in August) was about 86 gigawatts. (By contrast, the demand record in California, set in 2022, is 52 gigawatts). In six years, ERCOT has said, Texas could see peak demand above 150 gigawatts. The forecast raised concern among some state leaders about the grid's ability to meet such fast-rising demand. Texas Lt. Gov. Patrick said in a social media post that the state should take "a close look" at the increased demand from data centers and crypto mines.

The state's power needs are a big reason that efforts by some Republicans in the legislature to rein in renewables — sometimes called "unreliables" by critics — are unlikely to succeed, said Ed Hirs, an economist and energy fellow at the University of Houston. "At this point the legislature can't do anything to stop the growth of solar and wind and batteries," Mr. Hirs said. "The state desperately needs it."

Much like an external battery for a cellphone, batteries that connect to an electricity grid are meant to provide stored energy for a short time, running only for a few hours. They charge up when energy is plentiful, and prices are low, and they put out their power when energy supplies begin to flag, and prices rise. As a result, the growth in batteries complements the development of wind and especially solar power, whose ups and downs vary throughout the day.

The potential pricing windfall has led

businesses to rush to build more battery facilities. The queue for new energy projects waiting to link to the Texas grid includes nearly as much power from batteries as from solar, according to ERCOT data. "Texas is such a unique place," said Matthew Boms, the executive director of the Texas Advanced Energy Business Alliance, which promotes renewable energy businesses. "You have a free market and a grid that's all in one state. That's attracted all this private investment in battery storage, and solar and wind."

The result has been a lot of recent construction. Not far from downtown Houston, by the site of a former gas-fired power plant, large containers filled with small lithium-ion battery cells — half a million cells in total — sit in neat rows. They were not doing much on a relatively cool and cloudy late summer day but were ready to discharge power to the grid when needed.

The batteries, owned by Jupiter Power, began operating last month. "Two or three years ago there were barely any batteries anywhere," Andy Bowman, the chief executive of Jupiter Power, said. "That's capitalism working."

How We Get There from Here

What sorts of policies could produce these enormous shifts in energy technology and practice? Here are some possibilities just for the transportation sector:

- Promote more public transit by increasing its availability and providing compensation to commuters for not purchasing parking passes.
- Increase safe biking and walking infrastructure, such as 5 dedicated bike lanes, sidewalks, crosswalks, timed walk signals, etc.
- Adopt legislation mandating BEVs [battery-electric vehicles] for short- and medium-distance government transportation and use incentives and rebates to encourage the transition of commercial and personal vehicles to BEVS.
- Use incentives or mandates to stimulate the growth of fleets of electric and/or hydrogen fuel cell/electric hybrid buses starting with a few and gradually growing the fleets. Electric or hydrogen fuel cell ferries, riverboats, tows, and other local shipping should be incentivized as well.
- Ease the permitting process for the installation of electric charging stations in public parking lots, hotels, suburban metro stations, on streets, and in residential and commercial garages.
- Set up time-of-use electricity rates to encourage charging at night.
- Incentivize the electrification of freight rail and shift freight from trucks to rail.

These initiatives would require coordinated action from US Congress, federal agencies, state legislatures, and local officials. Together, they represent an unprecedented level of government activism, a fabric of incentives, mandates, standards, and laws unmatched in US history. Much of that government activism is scheduled for the next five to 10 years, while Republicans, who fervently oppose nearly every one of these goals, are expected to control the House of Representative and well over half of the 50 state legislatures.

Is such bureaucracy realistic? Uh, no. No, it isn't. No real technical or economic barriers exist (only crony protectionism) to ramping up production of WWS technologies, as history suggests that rapid ramp-ups of production can occur given strong enough political will. For example, during World War II, aircraft production increased from nearly zero to 330,000 over five years.

The phrase "given strong enough political will" is open-ended enough to allow virtually anything through. But what would create this political will, equal to what gripped the US in the wake of the Pearl Harbor In many ways, the more interesting question is (assuming we could conjure up the political will for this kind of wholesale transformation to WWS) ... would we want to?

The resultant total-system costs would be lower than the business-as-usual scenario. Which is great, since BAU sucks, as most everyone agrees (again, except those people profiting from BAU). What they don't try to show is that the resultant system is the optimal system, i.e., the optimal balance of costs and benefits. Insisting on 100 percent WWS — excluding nuclear, biomass, cogeneration, natural gas, etc. — almost certainly raises the total-system costs relative to a broader portfolio of low-carbon options. Just a little bit of nuclear or biomass power, for instance, would reduce the amount of power-plant overbuild necessary.

Lots of people remain extremely skeptical. They say, why not accept a little bit of asthma, or some nuclear waste, in exchange for a cheaper system? But that misses the point. What could we do if we aimed to create an entirely sustainable, pollution-free energy system? After all, the cost-benefit trade-offs of less sustainable systems almost always mean higher benefits for the already privileged and more costs for the already less privileged (in other words..”lets not be half pregnant. Instead, drop the excuses of protectionism, and make it work”) …

What kind of power system would you choose for society if you had no idea where you might personally exist in that society?

If you didn’t know whether you’d be rich or poor, living in a gated suburb or right next to a power plant or waste dump? You’d probably design a system that is equitable and healthy for everyone. That’s our highest aspiration… Whether we pursue our highest aspirations is up to us.

There you have it. Until EPM’s November edition of *The View from Rock Bottom*, we leave you with these thoughts to ponder as you, our readers and our industry continue to shape forward progress.

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