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In This Issue

Volume 7 | Number 28

SPECIAL FEATURES

- 04** **Letter from the Editor: What are Things that Should Make You Proud and Fulfilled?**
Karl Kolmetz
- 06** **The Influence of Electric Vehicles on Refining, Petrochemical Processing Balances, & Future Value Chain**
Q&A Panel Members: Daniel Lippe, Marcio Wagner da Silva, Simon Upfill-Brown, Ronald J. Cormier
- 14** **Rock Bottom View The Horseless Carriage in a Fast Evolving World...**
Ronald J. Cormier
- 17** **Balancing Gasoline Quality with Process Safety | The New Routes to Naphtha Alkylation**
Dr. Marcio Wagner da Silva
- 23** **Natural Gas | A Friend or Foe to Renewable Energy**
Jayanthi Vijay Sarathy
- 26** **Safety Talk | Guardrails**
Chris Palmisano

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2021 EDITORIAL CALENDER

Month	March	May	July	September	November
Industry	Refining	LNG	Midstream & pipelines	Ethylene	Polymers
Unit operation	1. Mass Transfer (Distillation) 2. Catalyst Systems	1. Process control Systems 2. Refrigeration Systems	1. Flaring Systems 2. Corrosion Control	1. Fired heaters 2. Rotating Equipment	1. Reactors Systems 2. Pressure Vessel Design
Safety, Sustainability & Digital	Biorefining	Big data	Process Safety	Water treatment – Boilers and Cooling Towers	Environmentally Friendly Circular plastic

Organizer :
Department of Chemical Engineering
Faculty Engineering, University of Malaya



1st-2nd Sept

Regional Chemical Engineering
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Letter from the Editor:

What are Things that Should Make You Proud and Fulfilled?

What are Things that Should Make You Proud and Fulfilled? People tend to be proud of the things in their life, and this is natural. We all want to be happy and proud of our family, our country, our knowledge, our profession, our talents, and keepsakes. Many people are mistaken on which things they should be proud of. To be proud of something, you should have committed time, energy, and effort towards the achievement.

Things that one can be proud of include 1) A teacher when one of their students understand the concept, 2) a carpenter or any worker after a hard day's work, 3) a student completing an assignment and understanding the concepts, 4) any worthwhile task that you have completed.

One should not be proud of things they have been given. These are called gifts and you did not work to achieve your gifts. You should be happy and thankful you have special gifts, but you should not be proud of your gifts.

Everyone one of us has been given special gifts. I am not very artistic, and I am in awe of paintings and sculptures. How did Monet paint pictures that would be out of focus up close, and be almost picture perfect from twenty feet (three meters) away? How did Michelangelo chisel sculptures out of rocks? Leonardo da Vinci, one of the greatest painters and engineers, died in 1519 regretting that "he had offended God and mankind in not having worked at his art as he should have done."

What are some gifts that you should be happy to have? Each of us has special talents. Some people are artistic, some people are good at math, some people can play musical instruments, some people can write far better than me, as well as others. You should be happy to have these gifts, but you should not be proud unless you spend many hours improving and honing your gifts. You should only be proud of your efforts.

It is hard to judge one's achievements. How you judge your achievement should be based on where you started from, not where you currently are stationed. Being born poor verses rich, makes a large difference in what you might achieve. Being born into an affluent family and community allows far more opportunities to achieve things than being born in a poverty stricken household.

Each of us should be proud of the hard work and effort that we have completed. We should be proud of the knowledge we worked to gain. One thing that you can be proud of is completing and obtaining certifications, but only if you have gained knowledge or skills in the certification. Purchasing a certification has no real value. We believe IACPE Certifications are something you can be proud obtaining as you will spend time and effort to obtain the certification. You can also use your gifts to obtain this certification.

All the best in Your Career and Life,

Karl

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The Influence of Electric Vehicles on Refining, Petrochemical Processing Balances, and Future Value Chain

Q&A Panel Members: Daniel Lippe, Marcio Wagner da Silva, Simon Uphill-Brown, Ronald J. Cormier

1. Electric vehicles (EV) sales remained strong through the pandemic. Year 2020 sales were up 30%+ versus year 2019, while much of personal transportation came to a standstill and sales of passenger vehicles fell by 20%. How does this effect Refining and Internal Combustion Engines (ICEs)?

Daniel Lippe: A group of management consultants who specialize in sales of personal gadgets would say: I see the standard S curve. Early adopters account for almost all sales in the first few sales seasons. Then the people who want to be as cool as the early adopters jump in and drive the sales curve up at faster rates.

EV is in the category I call specialty cars. The big 4 specialty car manufacturers (Ferrari, Lamborghini, Porsche, McLaren) had increased sales in 2020. Tesla is in that category and accounted for 80+% of total EV sales. Tesla sales are following the conventional S curve.

Marcio Wagner da Silva: This fact reinforces the necessity of a deep change in the downstream industry, it's necessary to apply the crude oil to noblest purpose like petrochemicals and reducing the transportation fuels production.

Ronald J. Cormier: This trend is even more prolific in Europe, now on track for EVs to represent one of every two new vehicle sales by 2030. In my opinion, only price needs to be addressed, which will improve with additional volume. Performance and reliability (vs ICE) are quickly becoming non-issues.

2. The year 2021 is projected to be EVs best year at 5% of passenger car (pc) sales. Assuming the period until 2030, what percentage of annual pc sales will take place? Is the rate speeding up? When should we expect 10% EV new car sales rate?

Daniel Lippe: Using the Standards S Curve; and accounting for EV roll out plans by most major European and American manufacturers,

EV will breach the 10% barrier by 2023. Based on annual vehicle sales by the major European companies and announcements for conversion to all EV for BMW, Daimler Benz, Volvo, Jaguar, and Land Rover.

EV sales from these European companies will reach 3-4 million vehicles per year by 2024-2025 which is about 22% of annual personal vehicle sales worldwide. If we include all brands now owned by VW Group, annual sales could reach 5 million or 31% of global vehicle sales. Japanese companies are less forthcoming with their timetables for EV production. Battery production is clearly the most obvious limiting factor, but EV sales are likely to breach 10% by 2024 and 30-40% by 2030.

Some People will buy one EV for local commutes and keep one ICE vehicle for long distance trips (anything more than 100 miles from home one way). What happens to the ICE vehicles that are traded in? Car fleet removal rates in USA for 2010-2015 were 11-14 million cars year or 4-5.5% of the operational fleet. However, consumer survey and personal experience also suggest that most consumers drive their new vehicles a lot more than their older vehicles.

If EV sales in USA reach 10% of annual new car sales by 2023-2024, gasoline demand will decline by 6-8%. As new EV sales (cars and light trucks) increase to 25%, the rate of decline for gasoline demand (US) should be 12-15% and maybe 18-20%. I look for US gasoline demand to fall at least 2 mm b/d by 2030 with a downside of 4 mm b/d.

Marcio Wagner da Silva: The pressure to reduce the environmental footprint produced by the fossil fuels tends to raise, even more, the sales of electric vehicles. Other new technologies like 3 D printing, car sharing apps, and drones had potential to reduce transportation fuels demand. I believe that we can see 10 % increase in EV new car sales until 2025

considering the current trend.

Simon Uphill-Brown: EV vehicle registrations through May of this year were only 2.2% for the US. There is still some acceleration in purchases, but still a long way to go. There still an issue for long distances as nobody wants to sit around and wait for a charge

Ronald J. Cormier: A large rate of ascent is expected in Europe by 2030. As for the US and North America, current targets set under the Biden administration would tend to more closely mimic Europe, though less linearly, since as of now, there is no federal carbon tax causing ICE incentive to bow out over time. Subsidies are still being offered for EV (7-9K Euros in France and German). Overall cost, convenience, performance (with peer pressure quickly gaining speed) will be the defining hurdles delaying driver's conversion to electric. Notwithstanding, ICE bans in China, France, and California are yet another incentive spurring EV adoption worldwide.

3. Battery technology and cost, general drivability, and recharge distribution networks appear to be nearer commerciality. Are there variables, yet insurmountable, still in the way? For example, when do EVs get better/cheaper than what we have now?

Daniel Lippe: Battery supply is the most likely factor that will limit EV production and may prompt manufacturers to raise prices to levels that discourage buyers at the low end. The number of battery factories worldwide, based on announced projects, will reach levels that support 40 million EVs by 2028.

Marcio Wagner da Silva: I believe that these issues will be solved with time, any new technology requires improvements that will be implemented with time, this is applicable also to the prices of EVs. With the scale up of the EVs sales, is expected a reduction in the prices as well as better infrastructure to support the EVs drivers.

Simon Uphill-Brown: There has not yet been a noticeable decline in the cost of EVs. Tesla reduce the price for Model Y in Feb 2021, increased it again June 2021 and dropped it again in July 2021. Price is still around USD \$50,000. There is no question that battery technology continues to improve, but we need cost and mileage to become better to really have a big impact in the sales.

Ronald J. Cormier: Net purchase price seems to be the remaining unsolved issue for most car buyers, who otherwise would likely take the plunge on EVs. Midsize models proxied by Tesla's Model 3 for example are still near \$50K USD drive-out. Model S and legacy ICE-produced luxury firm's (VW/Audi, GM, Daimler, etc.) models still are in the vicinity of \$100K. Two year old, low-mileage used examples still run near \$50-60K.

These categories still beget limited production status, until \$25-35K versions take hold via wider volume sales overall. For now, battery technology/driving range still need improvement, though many households utilize the electric for inside 100 mile trips yet keep an ICE for longer-range trips and vacations. I expect acceptance will improve toward EV recharging needs once commonality sets in and newness wears off. That said, chargers themselves are becoming more efficient – high power chargers can ready the EV 15-30 times faster than the average slow charger, so a 10 minute charge could add an additional 250 mile range.

4. What about the challenges to recharge distribution networks? Ancillary dilemmas such as: battery recycling, limited deposits of battery component metals/mining, and others.

Daniel Lippe: According to data as of 2020, USA has 130,000 public gasoline service stations and 100,000 public EV recharging stations. As EV sales move from the specialty category to mainstream, independent gas station owners will retrofit existing stations and will add EV recharging stations. Buckee's, a leader in refueling stations now offers ethanol free gasoline. Soon Buckee's and other major regional chains will retrofit to add EV recharging. Finally, the automobile industry already has infrastructure in place to deal with recycling batteries. Battery technology will take a few more quantum leaps forward. Research into the use of sodium-ion battery technology is already underway.

Marcio Wagner da Silva: This is a serious limitation of the EVs, it's necessary to develop a sustainable network to allow the achievement of the main goal of EVs which is a cleaner transport. As commented above, I believe that these issues tend to be solved with the time with the maturity of the EVs technologies, but we need to remember that there does not exist a zero-impact technology, it's necessary always to reduce the environmental impact

and this evolves the whole production chain.

Simon Upfill-Brown: A cradle to the grave Life Cycle Analysis is required here. Mining is a generally not environmentally friendly and long-term disposal issues for batteries are not yet resolved. One thing we need to think about is how electricity is generated. Power generation from coal in the US is up to 22% of total from 19% last year, not necessarily good for EVs.

We also need to address the disposal recycling cost of solar panel and wind turbines. There are not items that have an unlimited life. A huge percentage of solar panels are produced in China using cheap power from coal plants. An in depth Life Cycle Analysis need to be completed.

Ronald J. Cormier: Most estimates between now and 2030 predict charging points will increase in Europe from around 200K, up to 1.8 million, assuming electrical supply of 34%/year (proxy +86 terawatt hours) matches installations. This is only a 3% rise in total electrical production in the EU, an incremental rise. However, grid network expansion likely becomes the real bottleneck, if without commensurate upgrades. Friday night car charging for weekend trips may be a bit of a “run on the bank” early-on.

5. When should we expect internal combustion engine (ICE) to start a decline? Will EVs encroach on diesel or gasoline platforms first? Might hybrids bridge the gap? Are there global policies that will speed up displacement?

Daniel Lippe: EV’s will encroach on diesel fuel in Europe and gasoline in North America simultaneously.

Marcio Wagner da Silva: I believe that the internal combustion engines tend to decline after 2030. Some Countries are announcing bans of ICE vehicles starting in 2025 and some relevant producers like VOLVO announcing the intention to stop the production of ICE vehicles. Under this scenario, the hybrids vehicles can act as an alternative in the transitive period, especially in countries where the infrastructure to support EVs are not adequate. The policies have a fundamental role in this transition, and stricter regulations like IMO 2020 can accelerate the energy transition efforts.

Simon Upfill-Brown: EV will encroach on

gasoline vehicles first, light weight and generally local travel. Heavy duty trucks and buses will not go to EV for some time. Firstly, the technology does yet exist and secondly battery life will be extremely short, we may need three vehicles for each bus route, for example.

I believe heavy duty vehicles will likely convert to Compressed Natural Gas (CNG) service first. Renewable natural gas (RNG) is becoming more and more available for example from anaerobic digestion of dairy waste. This RNG can have a carbon intensity of -270 g CO₂e/MJ, but the scale is very small. Hugely effective from an emissions reduction perspective, but less likely to drive significant conversion. Conversion of separated yard waste at the scale of 1 Billion Cubic Feet (BCF) of RNG per production train will likely have a much more significant effect.

The California South Coast Air Quality Management District (a State Government Group) issued a letter dated, August 3, 2021, giving guidance against Zero Emissions (ZE) pathways for heavy duty use such as large trucks, which are not currently commercially available. They recommend Near Zero Emissions (NZE) pathways which are available now such as CNG engines and more importantly Compressed Renewable Natural Gas (CRNG) vehicles. To charge one EV heavy duty truck in California (if the technology was available) would consume the same power as 9 homes. The power grid in CA is already unstable!

Renewable diesel from hydrogenated vegetable oil does not require an engine conversion. But there is a debate in the in the food vs. fuel relationship, which is ongoing with corn and methanol.

Ronald J. Cormier: There’s still lots of possibilities for now. I’m not sure I can sincerely predict where these intrigues head just yet, other than what’s apparent based on behavior of their current fundamentals. Hybrids are already on the market and have limited demand as more of a folly—rather frumpy styling as well, a platform dependent on both fossil fuel and self-generated electricity. In the end, these mixed-use consumers do improve, but do not eliminate emissions, which ultimately is the end-game. CNG, and hydrogen hold promise but still need to address volatility hazards, plus large gaseous tank/cell sizes required to produce expected road range.

Electrics currently seem to be causing the

most frustrating change for gasoline passenger car and light truck transport. Diesel platforms, i.e., long-haul commercial cargo transports may better benefit from gaseous fuel sources; shorter-trip municipal cousins (trash trucks, local distribution, taxis, etc. could go either way, since “refueling” is no less convenient whether gaseous or electric really.

In general, I believe an overall value chain will need to continue emerging, before truly linear EV adoption can be the norm. Right now, the picture is much like an ant hill, in which the participants are scurrying around trying to test opportunities. Charge equipment supply will need to standardize (think plentiful i-phone charge cords which all fit multiple models). Investment in site chargers will need to become a sub business of its own which accounts for real estate, electricity sourcing, equipment installation/maintenance and profit margin. This vision really provides the same function as today’s gasoline service station network yet would dispense molecules across the island instead of fossil fuel.

As for bureaucracy which may cause faster change, there’s plenty of examples of federal mandates and carbon tax developments which appear to first be targeting the 2030 point for ICE to EV conversion.

6. 46% of crude oil goes into making motor fuels. The remaining 54% goes into products like medicines, cosmetics, plastics, synthetic rubber, and asphalt. We have witnessed hydrocarbons discovery and refinement into fuels, durable goods, and low-use and disposables over the last 125 years, largely driven by the advent of the ICE automobile, and to the demise of prevailing organic oils, etc. largely used for 19th century home lighting. Should movement away from liquid fossil fuels continue, with phase-in of gas, renewables, solar, nuclear, hydro-generated electric power, and what affects to do you foresee for current oil refining and petrochemicals?

Daniel Lippe: As consumers discover the benefits of EV’s, especially reduced maintenance costs (no oil changes, no need for changing transmission fluids, etc.), they will also discover the disadvantages during the transition period. In USA, and Europe, gasoline and diesel fuel are 83% of refinery product output. In US, small refineries will be shut down. Some refining companies have already announced plans to convert crude oil refineries to bio-diesel facilities.

These plans are mostly Public Relations exercises because EVs do not discriminate between fossil fuel based diesel and bio diesel. US Refining capacity, East Coast first, will decline by 2-3 mm b/d by 2030. A few US refineries may be expanded to increase exports into the Caribbean, South America, and Africa. European crude oil refining capacity will also be shut down. A few refineries will be re-configured to increase production of primary petrochemicals.

Marcio Wagner da Silva: The downstream industry is facing a transitive period which is similar the occurred in the 19th century, in their opportunity the refiners need to change the refineries production from kerosene to transportation fuels at this time the petrochemicals is the new change driver.

The players capable to promote closer integration with petrochemical assets are already enjoying higher refining margins and better competitive positioning, this movement is mainly observed in the Asian market. Currently, close to 64 % of the crude to chemicals investments are made in the Asian downstream sector, in these complexes, the processed crude oil is totally converted into petrochemical intermediates like ethylene, propylene, and BTX. This fact reinforces the petrochemical integration trend at global level, which is a fundamental part of the energy transition.

Simon Upfill-Brown: As quality of life improves in the developing world, I would expect more use of fossil hydrocarbons for plastics and other materials, such as lighter weighting vehicles, food safety, and medical applications. Recycling will become more and more of an issue, particularly the ability to re-use mixed plastics which is difficult and handling contaminants like chlorine in PVC.

Ronald J. Cormier: This is likely a tale of OECD vs non-OECD development. In developing countries/regions, modern conveniences are still initially developing and take higher priority. Most probably, ICE transport conversion will occur at a slower rate than in the west.

From my own consulting work, independent oil refiners do not doubt their minimized future relevance; they have been studying increased chemical production to displace fuels for over ten years. This is a natural first step for their continued profitability and relevance, however problematic since the sizes of these two

consuming markets are massively different. In other words, oil refiners cannot simply convert 100% to chemical production and call it good.

Based on our conversation so far, while there is real plausibility to convert to electric transport, the unknown risks get pushed farther upstream. Bottom line, oil refining will diminish at Pacific Rim and US PADD 1; these refiners will fall off sooner than more complex refiners in more protected markets. These closures will continue until consumption balance reigns. Petrochemicals will continue to grow at GDP (maybe more in developing regions). Questions remain about supply of petrochemical by-products, in a post-EV refining world, though on-purpose conversion technologies (Fischer-Tropsch, et.al.) exist for these. Nuclear/wind/solar should lend themselves to power generation vs. fossil fuels as EV's continue to drive consumption. Petchem will continue current en-vogue closed cycle recycling/reuse efforts, though plenty of unmet tech needs still lack toward complete solutions, for example PVC to its constituents.

7. Driven by changing human mobility platform preferences, oil refining and petrochemicals processing methods will certainly have to conform to changing demand and associated carbon balance. How will current oil upgrades and associated infrastructure and processes change? Will different conversion methods take the place of current ones? Examples? Will products substitution take place?

Marcio Wagner da Silva: The petrochemicals maximization in the refining hardware requires a deep bottom barrel conversion capacity which leads to higher demand by hydrogen to support deep residue upgrading technologies like hydrocracking. In my point of view, the future of the downstream industry will be sustainable by four main pillars: Petrochemical Integration, High Bottom Barrel Conversion Capacity, Renewables coprocessing, and cleaner hydrogen production routes.

The renewables coprocessing in the crude oil refining is an attractive route to reduce carbon emissions, but raises, even more the demand by hydrogen. This fact led to the necessity to develop low CO2 emissions production routes in alternative to natural gas steam reforming, this will require the installation of carbon capture system in the refineries to allow the operation with traditional hydrogen generation units (Blue hydrogen Route) or the

implementation of clean alternatives like electrolysis (Green hydrogen Route).

Under this scenario, is expected a grow in the complexity index of the crude oil refineries, mainly related to installation of petrochemical processing units like aromatics separation complexes and most severe residue upgrading technologies like slurry phase hydrocracking units.

Simon Upfill-Brown: Less engine lubrication oil will be required in the EV future. Some rotating equipment will still require grease and other lubricants. We may make more waxes which have good environmentally friendly applications but requires lower use of solvent.

Ronald J. Cormier: Not a lot of elaboration is required to predict a probable diminished state for oil exploration, refining and the current variety of fossil-fuel products market. This value chain will fall most precipitously after 2030, though net-net dependent on timing caused by developing regions. Petchem can pickup some substitutions, ex: lubricating oils, waxes, heat transfer mediums, etc., though if reduced emissions are the endgame, then lower carbon means a smaller oil business.

8 Once consumers can no longer derive sufficient volumes of synthetic rubber and asphalt from oil, what is your vision of over-land passenger/goods transport? For example, how do vehicle move "when the rubber can no longer meet the road", or once asphalt supply dwindles? What technologies will fill these gaps?

Daniel Lippe: Synthetic rubber and asphalt are essentially specialty products. Synthetic rubber is a chemical based product which we produce from the ethylene/propylene derivatives chain. In the USA, natural gas liquids are the dominant feed for ethylene monomer production. Asphalt is a small volume product and many refineries do not produce asphalt. Asphalt is a virgin component of certain specific crude oils and the vast bitumen deposits in Alberta and Venezuela and Colombia represent a nearly unlimited supply of asphalt.

Chemical companies make synthetic rubber from ethylene plant coproducts (propylene to acrylonitrile, butadiene) and from benzene extracted from reformat (ethylene benzene to styrene). Ethylene producers have always relied on low valued feedstocks and will continue to do so.

One might guess that refinery sourced supplies of propylene, benzene, etc. might decline, but they may not decline since FCCU catalyst producers already have formulations that will yield 25-30% light olefins. There is one certain answer for this question. Refineries, especially in the US Gulf Coast, will adapt and adjust. Refining capacity in Europe will decline.

As gasoline demand declines, naphtha currently used in gasoline (as reformate, straight run, etc.) will be freed up for use as ethylene feedstock. I don't see radical changes in refinery processing or basic olefins plants during the first decade or two of the transition from all ICE to a mixture of ICE and EV in service.

Marcio Wagner da Silva: Firstly, it's important to understand that not all players will totally change their refining profile to petrochemicals, this requires great amount of capital investment and the lack of suppliers for these "black derivatives" can improve the prices, making the market attractive for some players. In my point of view, the refiners with low complexity and lower capital power tends to remain in the market of transportation fuels, fuel oil, asphalt, etc. which can present good refining margins according to the local market scenario. On the other hand, the concrete can be applied to construct road paving in substitution of asphalt and there are some promising technologies like the use of recycling plastics to produce road paving.

Simon Upfill-Brown: There is a new low carbon intensity process to make butadiene from natural gas and ultimately renewable natural gas. We should expect to see more processes like this, rubber is essential for road transportation.

9. Is the Carbon footprint of EV smaller than ICE? Construction of Batteries, Recharge locations infrastructure, electrical generation energy losses with can be as high as 50% and high-power line transfer which loses about 6% during transmission.

Marcio Wagner da Silva: As commented above, there is not a zero-impact technology. It's necessary to balance the pros and cons of each technology, the infrastructure involved to support the EVs are large, and we need to close the sustainable circle through adequate destination of batteries which is still a big problem, but the ICE vehicles also require a large infrastructure, but in this case, we are

accustomed with this and currently fortunately, we are more concerned with the environmental impact than 100 years ago.

We need to make a balance and make the decisions based on the cleaner route to follow. This is one of the main issues related to the EVs. Currently it is not clear the environmental impact of the battery's disposal, especially considering the risk of heavy metals disposal.

Simon Upfill-Brown: A comprehensive Life Cycle Analysis comparison has not been done in my perspective. This would be a great exercise to run. The old ICE is relatively efficient per MMBtu consumed

Ronald J. Cormier: To my knowledge, the jury is still out here. Mine-to-wheel and well-to-wheel economic studies are plentiful, though skewed in many cases by the project sponsor. Fairly inherent though, are elementary comparisons such as coal-fired electrical generation vs. gas or solar-originated molecules. Also important are energy losses through the electrical cycle vs. ICE conversion, currently 70-80%, perfected over a hundred years of driving. What methods in combination provide for really the best option overall?

10. As climate protection and the transition to EVs from ICE become a reality, do you think this is the end for "Big Oil"?

Marcio Wagner da Silva: I do not believe that is the end of major oil corporations. The crude oil refining sector will need to adapt to the new scenario. Despite the falling demand by transportation fuels, in developing economies like Brazil, Mexico, and Africa will remain demanding high amounts of transportation fuels like Diesel. Under this scenario, the low complex refiners can enjoy this opportunity.

Simon Upfill-Brown: The major oil companies are reviewing going to the renewable diesel route without costly refinery upgrades. The companies are looking into how to process bio-based feedstocks like vegetable oils and partially processed biofuels with petroleum distillates to make renewable diesel, sustainable aviation fuel (SAF) and renewable gasoline, without meaningfully increasing capital spending.

Carbon capture or sequestration (Carbon Capture Use and Storage) as compared to current End of Run (EOR) and Carbon Capture and Storage (CCS) and the new 45Q

Legislation (carbon tax credit) could keep Big Oil around for a while and maybe have a more transformative effect on emissions than the switch to EV.

Ronald J. Cormier: If our expectations for EV growth above take hold, there is no other potential but for a reduction to current fossil-fuel refining. However, my sense is that this will not be an apparent death for Big Oil, but more of a slow-bleed demise from 2030 through 2050. Carbon capture and sequestration improvements will help, along with conservative government legislation which only prolong the inevitable.

11. What is the future of Air Transportation?

Marcio Wagner da Silva: Regarding the air transportation, I believe that renewable jet fuel will be the part of the future market. Some refiners and technology developers are investing capital and efforts to develop commercial technologies with very good results.

Simon Upfill-Brown: Progress is already happening in this area for electrical planes. DHL has ordered 12 electrical cargo planes from Eviation.

PANELISTS

Ronald J. Cormier is a versatile, results-guaranteed business builder with unique experience growing corporate profitability and driving cultural change in refining, NGLs, and petrochemicals industries worldwide. Degreed engineer, entrepreneurial leader with MBA, and demonstrated ability to achieve financial targets in midst of continuous organizational change. Collaborative management style, encouraging individuals and teams to set and achieve high standards of performance.

He has nearly 40 years of career in Commercial Product Direction, Business Development, Group Management, and capital asset redeployment roles. He is always open toward unmet professional needs which require passion for growing P/L through leadership.

Daniel Lippe is an experienced presenter to industry associations, petrochemical conferences, and midstream industry conferences. His firm, Petral Consulting Company, provides in depth analyses and forecasts for a broad array of petroleum products and the methodology and approach allows us to provide cutting edge results on critical changes in pricing

and market trends up to two years ahead of most other consulting firms.

His objective for Petral Consulting is to expand the number of clients to our ongoing services and forecasts and to increase the scope and content of these services to include important established global markets and emerging markets for all petroleum and petrochemical products.

Simon Upfill-Brown has more than 20 years C-level international management experience in coatings, chemicals and renewables. Key characteristics include integrity, customer intimacy, team building and motivational skills, operational excellence and detailed understanding of cost flows. Business Growth: Grew one entity by over 90% CAGR over 6 years and another by 14% CAGR over 7 years. Turnaround: Improved EBIT of \$230 million business by \$70 million in five years.

Dr. Marcio Wagner da Silva is Process Engineer and Project Manager focusing on Crude Oil Refining Industry based in São José dos Campos, Brazil. Bachelor's in Chemical Engineering from University of Maringa (UEM), Brazil and PhD. in Chemical Engineering from University of Campinas (UNICAMP), Brazil. Has extensive experience in research, design and construction to oil and gas industry including developing and coordinating projects to operational improvements and debottlenecking to bottom barrel units, moreover Dr. Marcio Wagner have MBA in Project Management from Federal University of Rio de Janeiro (UFRJ) and is certified in Business from Getulio Vargas Foundation (FGV).

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Rock Bottom View

The Horseless Carriage in a Fast Evolving World...

Ronald J. Cormier, *Engineering Practice* Contributing Author



Greetings from the porch of this old central-Texas ranch, in the midst of a relatively cool summer (by Texas standards) with plenty of rain. Such conditions obviously are not the usual expectation in the southwest US during deep summer. Most readers herein are STEM-educated and accept the thesis of detrimental step change with respect to global climate, especially vs. even 50 years ago. More and more, this label is no longer “climate change”, but “climate crisis”; it’s time we all support less impactful use of resources which better support ability to support life on Earth.

Most recently in the US, such trends have manifested as real, sustainable and unrelenting change. These include a structurally shifting jet stream, causing Texas’ summer benefit. Yet to the detriment of the US West and Pacific Northwest, these regions have experienced exceptional heating, little precipitation, and associated wildfires, many of which are as yet uncontrolled. Rest of World (ROW) is experiencing similar weather benefits or maladies, redefining earlier long-time “garden spots” locales, which, in many instances, are not so much so today.

To that end like many tech firms, Engineering Practice Magazine’s (EPM’s) staff is notably engineer-heavy, with long industry careers in hydrocarbons-based energy. During our professional stints, mass-balance and process-efficiency were naturally at the base of all professional practice design calculations and capex spending justifications. Heretofore, while such design conventions also included calculation and definition of process emissions, the impact of this single radical in the equation being an accepted stoichiometric result, simply determined by Mother Nature. Assuming that we had wrung out all bi-product credits and had complied with required minimal governmental bureaucracy, we were then “fit for purpose”. No longer however, can such minimal consideration drive mechanisms and designs, if toward a better, livable society.

Frustrating technology is at hand which will guide our way forward for retained benefits of mobility and lifestyle, yet we hope with much

less impact on Mother Earth. A major part of the emissions intrigue is impacted by our methods of personal transport. Let’s concentrate for a second, solely on how we move about the earth, along with our possessions and materials. After one hundred years of largely internal combustion engines (ICE), evolving low-emission types of vehicles include hybrids, hydrogen fuel-cells, electrics (EV) and the like which are becoming significant reality. Though major players like Air Products/Chemicals, Inc., and Nikola have bet on hydrogen-based platforms, current early consumer buying fundamentals since 2010 have initially favored EVs.

As the world continues along the path of technological innovation, environmentalism, and new energy, the electric vehicle (EV) industry has likewise evolved and expanded. Despite the COVID-19 pandemic slowing global economic growth, EV is looking forward to a potential rebound. Crucially, this transition will position novel international competitors against traditional powerhouses like Tesla.

While the global EV market suffered a concerning -14% sales slump in 1H2020 (most notably in China and USA), this loss was somewhat normal, given similar decrease across all automobile sectors, re: Covid. However, Europe was the outlier with some +25% growth in EV sales. As the rest of the world lags behind on climate action, the EU has enacted significant reforms, incentivizing energy efficiency in the past decade. These include imposing higher penalty payments for excess emissions (carbon tax), implementation of a “super-credits” system, and enforcement of annual emission targets. With expectations of a 40% reduction in emissions by 2030, the Paris Agreement and the EU’s own climate and energy framework, suggest that these commendable efforts are likely to flourish. Consequently, this will act as an incentive for automakers to pursue investments towards sustainable alternatives, and away from ICEs.

In contrast to Europe, China, the world’s largest EV market, EV sales have declined for

two consecutive years, since capturing over half of the global market in 2018. In the broad view, the Communist Party of China regime recognizes new energy as a battle arena, leading to global leadership recognition. So Chinese domestic EV companies are likely to receive generous financial support if competition weakens too much. The surge in global demand and supply benefits EV growth, but will also reshape it. In 1H2020 Tesla, the most dominant EV firm in the world, controlled 18% of the global market, 6% more than its largest competitor, VW. Even as investors continue to bet on Tesla's expected growth, there is no doubt that the still premature EV market has unmet needs that will attract new, competitive firms, looking to capture customer segments that Tesla now enjoys.

Keep your eyes peeled on upcoming issues Engineering Practice Magazine. We intend to feature articles, roundtables, and webinars, meant to keep close pulse on these issues, continued developments, and expected outcomes. It should be an interesting ride for our readership, many of whom will likely be key to critical environmental improvements.

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- Bank of America

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Balancing Gasoline Quality with Process Safety | The New Routes to Naphtha Alkylation

Dr. Marcio Wagner da Silva

INTRODUCTION

The process accident occurred in PES (Philadelphia Energy Solutions) Company in June of 2019 restarts the discussion about the security of naphtha alkylation units based on HF (hydrofluoric acid) as a homogeneous catalyst. In the last years, some refiners have decided to stop the operation of his HF alkylation units due to the unacceptable safety risks.

The high toxicity and corrosion risks associated by hydrofluoric acid require great attention of inspection equipment team to control the integrity of process equipment when this managing system fails the consequence is drastic like it's possible to conclude based in the previous analysis conducted by CSB (U.S. Chemical Safety and Hazard Investigation Board).

In the last years, some process accidents involving Alkylation units call the attention regarding the safety characteristics of these process units, below we quote the last process safety accidents involving alkylation units:

- 1 – PES Refinery in USA, 2019
- 2 - CITGO Corpus Christy Refinery in USA, 2009
- 3 – Hube Globe Company in South Korea, 2008
- 4 – Marathon Petroleum Refinery in USA, 1987
- 5 – Ciniza Oil Refinery in USA, 2004

This short list of process accidents calls the attention of the authorities to the real safety risks associated with the presence of alkylation process units based on HF close to urban centers once a great release of HF can affect the population and cause severe damages and human losses.

GASOLINE PRODUCTION PROCESS

The final gasoline is composed by a blending of different naphtha streams, as presented in Figure 1.



Figure 1 – Example of Process Streams Blending to Produce Gasoline

The use of straight run and reformed naphtha is normally minimized, aiming to direct these streams to petrochemical intermediates market due to the higher added value of these streams in this market.

Cracked naphtha (Naphtha from FCC) contributes positively to the octane number of the final gasoline, however, due to the current restrictions related to the sulfur content in the gasoline (maximum of 10 ppm), the use of cracked naphtha without treatment step is limited. Refineries that have catalytic alkylation units in his refining scheme normally direct this stream to produce aviation gasoline that have higher market value when compared with automotive gasoline, for this reason, the participation of the alkylation naphtha is minimized in the composition of this fuel.

Isomerization naphtha has low contaminants content (sulfur and nitrogen) and high octane number and, for these reasons, the participation of this stream in the formulation of gasoline is maximized in refineries that have isomerization units in the refining scheme. In markets with high demand for gasoline, refiners can add butanes to gasoline pool, however, the participation is limited due to the high vapor pressure of this stream that can lead to break quality requirements (Reid Vapor Pressure – RVP). Normally, butanes are added to LPG pool, respecting the limits to avoid breaking the mixture quality related to heavy limitations.

Nowadays, due to the environmental and quality regulations over the gasoline the hydrodesulphurization of cracked naphtha is fundamental to be possible the refiners meet the sulfur content in the final gasoline that can be low than 10 ppm in most restrictive markets. The alkylated naphtha is one of the main octane boosters in the gasoline pool and, according to the refining scheme, is a fundamental stream to refiners achieve the current quality requirements of final gasoline.

TRADITIONAL TECHNOLOGIC ROUTES TO NAPHTHA ALKYLATION

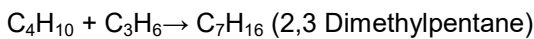
Gasoline is one of the most consume crude oil derivate and is normally produced through a mixture of naphtha from different refining process steps. The streams normally involved in the gasoline production process are straight run naphtha, cracked naphtha, coke naphtha (after hydrotreatment) and reforming naphtha.

One of the main parameters of gasoline quality is the octane number that is a measure of combustion quality of this derivate, one of the streams that contributes to raising the octane number is the reformed naphtha, produced in the Catalytic Reforming Unit. However, due the severe restrictions related to the carcinogenic aromatic emissions, mainly benzene, some refiners have avoided the application of this stream to formulate gasoline, directing the reformed naphtha preferably to petrochemical intermediates production in aromatics complexes.

An alternative to the reforming naphtha is the production of branched hydrocarbons (with high octane number) through Catalytic Alkylation Process.

The alkylation process involves the reactions between light olefins ($C_3 - C_5$) and isoparaffinic hydrocarbons like isobutane. The reaction product called alkylate is a mixture of branched hydrocarbons with higher molecular weight and higher octane number.

An example of typical alkylation reaction is represented below:



The reaction is catalyzed in strongly acidic reaction environment, the acids normally employed in the industrial scale technologies are Hydrofluoric Acid (HF) and Sulfuric Acid (H_2SO_4).

The main advantage of alkylation process is the production of a stream with high octane number, high chemical stability and practically free of contaminants as nitrogen and sulfur. These characteristics turn the alkylate a component attractive to the gasoline formulation to the automotive and aviation industries.

The feed stream goes through a pretreatment (generally molecular sieves or alumina) before being pumped to the reactor, the objective is to remove process contaminants mainly water, diolefins and sulfur and nitrogen compounds. Water is especially damaging to the process, once accelerates piping and equipment corrosion process, and beyond requires higher HF reposition.

After pretreatment the hydrocarbons streams are put in contact with the hydrofluoric acid in the reactor and the hydrocarbons mixture and HF solution is separated through gravity in a settler vessel, the hydrocarbon phase is sent to the fractionating section while the aqueous phase (containing the most of HF) is cooled and sent back to the reactor. As alkylation reactions are exothermic, the reactor is continuously refrigerated aim to keep the reaction ideal conditions.

Alkylation process feed streams are generally obtained from LPG produced in deep conversion units, mainly Fluid Catalytic Cracking (FCC) and Delayed Coking. The LPG produced in these process units have high olefins content, ideal for the alkylation process. The isobutane stream is normally obtained through separation of LPG produced in the atmospheric distillation unit, FCC or Delayed Coking in deisobutanizer towers.

As aforementioned, the acids generally employed as the homogeneous catalyst to the alkylation process are HF and H_2SO_4 . Figure 2 presents a process flow diagram to the alkylation process catalyzed by HF.

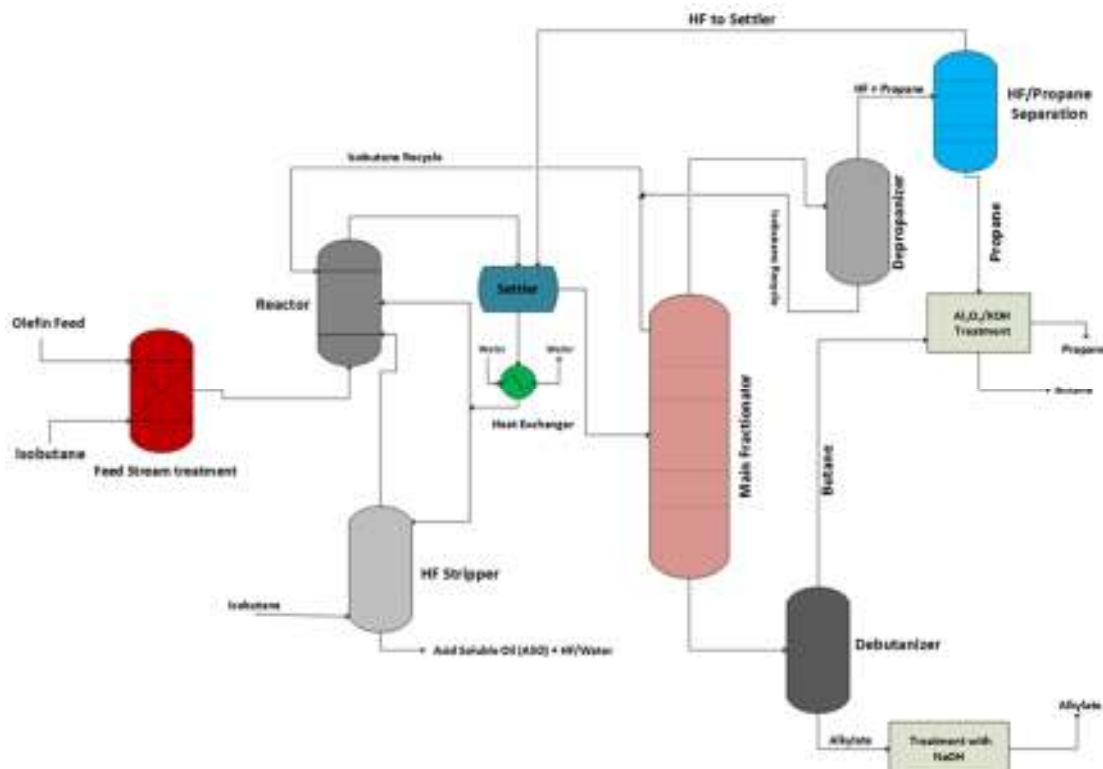


Figure 2 – Typical Process Flow Diagram to Catalytic Alkylation Unit using HF as Catalyst

higher simplicity of this process and the lower need of catalyst replacement that leaves to lower operational costs.

However, regulatory pressures have led some refiners to convert their HF alkylation units to operate with H_2SO_4 , due to the high volatility and higher risks presented by the hydrofluoric acid, some licensors developed technologies to convert HF units to operate with sulfuric acid like the ALKYSAFE[®] technology, licensed by STRATCO Engineering Company and the ReVap[®] process, developed by the companies EXXON MOBIL and CONOCOPHILLIPS which uses additives to reduce the HF volatility, making the unit operation safer.

The principal process variables of the alkylation process are the isobutane/olefins ratio, reaction temperature, acid/hydrocarbon ratio, acid purity, residence time in the settler and operation pressure.

To alkylation processes with HF, the reaction temperature varies from 20 to 40 °C while sulfuric acid processes operate under lower temperatures, among 4 and 10°C, under higher temperatures the sulfuric acid can suffer decomposition to $SO_2 - SO_3$. Operating pressure is generally sufficient to keep the hydrocarbons in the liquid phase, normally lower than 5 bar. The residence time in the settler is important because if this time is quite low, undesirable reactions can occur as organic fluorides production, in the case of HF which raises the catalyst consumption and reduces the alkylate production.

Acid purity must be maintained higher as possible through the removal of ASO (Acid Soluble Oil), water and dissolved reactants in the HF case and through fresh acid replacement in processes with sulfuric acid as the catalyst.

The main disadvantage of the alkylation processes with homogeneous catalyst (HF or H_2SO_4) is the need to handle strong acid highly concentrated, that leaves a greater process safety risk and high maintenance costs, mainly related to avoid corrosion in piping and equipment and, as aforementioned, equipment failures with content losses can have dramatic consequences.

ALTERNATIVES & SAFER TECHNOLOGIES TO NAPHTHA ALKYLATION

Aiming to eliminate these risks, some licensors have dedicated their efforts to develop heterogeneous catalysts that can replace the strong acids in the alkylate production processes, the UOP Company developed the process called Alkylene[™],

that apply a solid catalyst with continuous regeneration during the process. Among other technologies can be cited the processes LURGI EUROFUEL[™], developed by Lurgi Engineering Company in cooperation with SUD-CHEMIE, the ALKYLEAN[™] process, developed by the companies ABB-Lummus and Akzo Nobel and the process FBA[™], developed by Haldor Topsoe. Figure 4 shows a process scheme to the Alkylene[™] technology, licensed by UOP Company.

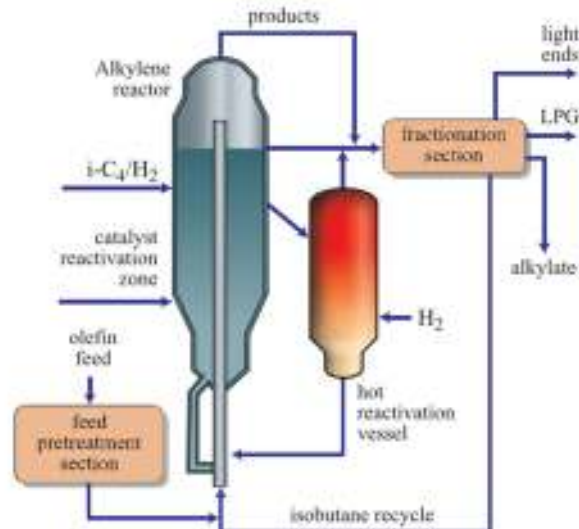


Figure 4 – Process Arrangement for Alkylene[™] Technology, developed by UOP Company (Encyclopedia of Hydrocarbons, 2006)

Another attractive technology to alkylation developed by UOP Company is the ISOALKY[™] based on the ionic liquid catalyst and it's possible to revamp the conventional liquid acid units to apply the new technologies. The heterogeneous catalyst applied in substitution of liquid acids are based on zeolites and as presented above can offer higher operational safety to refiners and adjacent communities once eliminate not only the process risk but also the all logistic and handling of strong acids like HF and H_2SO_4 . Even refiners with low capacity of capital investment are looking to change the HF by sulfuric acid (H_2SO_4) as the catalyst in his processes once the sulfuric acid is present lower toxicity than hydrofluoric acid (HF). Another interesting technology dedicated to produce alkylated naphtha through safer route is the Alkysafe[™] process also developed by UOP Company which applies ionic liquids as homogeneous catalyst against strong acids in conventional processes, this technology is presented in Figure 5.

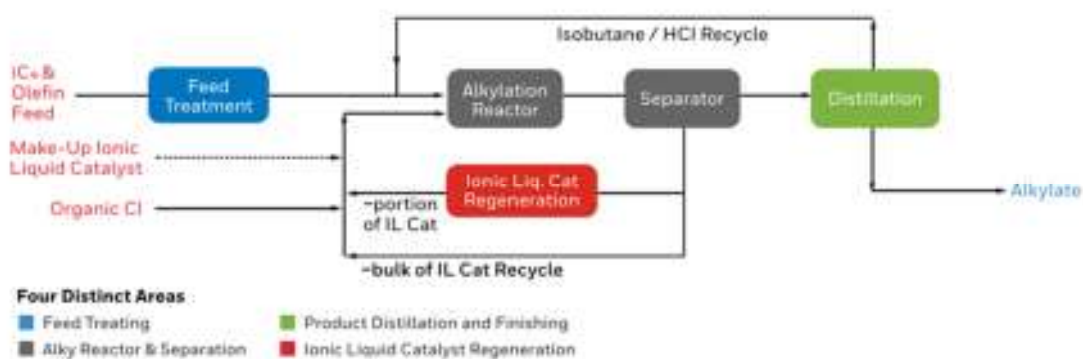


Figure 5 – Block Diagram for the Alkysafe[™] Naphtha Alkylation Technology by UOP Company

The Lummus Company also developed with partners a solid catalyst naphtha alkylation process called AlkyClean™, presented in Figure 6.

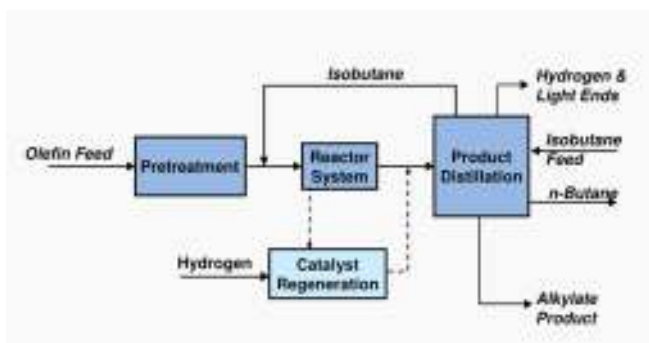


Figure 6 – Block Diagram for the AlkyClean™ Naphtha Alkylation Technology by Lummus Company

Despite the effectiveness of the naphtha alkylation processes based on strong acids, the large number of incidents and accidents involving these units are leaving governments and regulators to raise the pressure over the refiners relying on these units, despite the significant capital spending, as quoted above there are technical alternatives to produce alkylated naphtha in safer manner.

CONCLUSION

The catalytic alkylation process is very attractive to countries with high gasoline consumption and there is a great availability of LPG, as the United States. The production of specific fuels like aviation gasoline still depends on the alkylation catalytic units, so the new and safer technologies can be attractive to refiners with significant demand by this derivative.

As previously mentioned the alkylation process offers an alternative to produce gasoline with high octane number, with low contaminants content and without emission of harmful compounds to human health, as the case of naphtha from catalytic reforming process.

Despite the high capital investment and operational costs associated to the new technologies of catalytic alkylation units, these processes can be very attractive to the refiners which operate in markets where the demand to high-quality gasoline and petrochemical intermediates is high and it's always to understand that the lower costs of HF units do not compensate the risks of a severe process accident as occurred in PES refineries, in this case, the refining complex was shutting down and the PES company ended his activities and human life was exposed to risks.

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Natural Gas

A Friend or Foe to Renewable Energy

Jayanthi Vijay Sarathy

Dawned the Victorian era of Industrialization when steam drove the cog & wheel, the world has come a long way, but only finding itself in a quandary over climate change & environment. With growing populations, the 21st century inhabitants of the blue planet, now undeniably are fighting the consequences of their past actions in the name of sustainability and climate change while they still din over their energy security & economic growth.

IEA'S PROJECTION OF FUTURE OF RENEWABLES

Hydrocarbons have traditionally catered to three main industries namely; Transportation, Power Generation & Petrochemical Products and Renewables for now, aim to supplant the hydrocarbon dependence in the transportation and power generation industry.

Towards this, Wind & Solar photo voltaic power have picked up pace in recent years with advances in battery storage to compliment energy storage. The IEA also quotes that "*Renewables will have the fastest growth in the electricity sector, providing almost 30% of power demand in 2023, up from 24% in 2017. During this period, renewables are forecast to meet more than 70% of global electricity generation growth, led by solar PV and followed by wind, hydropower, and bioenergy. Hydropower remains the largest renewable source, meeting 16% of global electricity demand by 2023, followed by wind (6%), solar PV (4%), and bioenergy (3%)*" [1].

THE UNSEEN CONSEQUENCES OF RENEWABLES

The downside of wind & solar power is that wind farms do not always enjoy a consistent flow of air & the sun does not always shine. Therefore, this can be only be attended to by switching over a 12-hour cycle from renewables to fossil fuels which is technologically impossible unless those high efficiency power storing batteries were available in the first place. The alternative is a Fast-Firing Natural Gas Power Plant with which power production can be ramped up to as much as 600 MW in 30 min to power the grid [1]. However taking a view on some of the existing battery operated power stations [2], the following shows the capacities & the operational duration,

From this table, the supply times of battery power stations can only act as a short backup until the natural gas power plant comes back online during a power failure.

Table 1. Battery Storage Power Stations [2]

Station	Storage [GWh]	Dispatch [GW]	Supply Time [hrs]
Tesla S. California, USA	0.08	0.02	4
Ontario, Canada	0.053	0.013	4.1
Stocking Pelham, UK	0.05	0.05	1.0

ENVIRONMENTAL CONSEQUENCES

Renewables also require vast swathes of open land that is obstruction free but leads to deforestation with flora and fauna displacement. Whereas, Energy storing batteries, require raw materials mined from the earth & mining must continue to replace old batteries. According to Wood Mackenzie [1], "*...energy storage deployments are expected to grow by more than 5x (38% annually) over the next five years, reaching 44 GWh of annual deployments globally by 2024, the majority of which will be lithium-ion based systems*". This begs the question as to where would battery waste be disposed. The same report [1] discusses, "*Disposing of EV batteries is costly, while the decommissioning of lithium-ion battery storage systems is essentially non-existent, considering the viable recycling technology and infrastructure available at this time*". "*...Supply responses are under way, but it pays to be patient as new capacities compete to produce lithium and other battery-grade chemicals that will satisfy the EV onslaught.*" But until then, shipping to poorer countries that lack or possess poor infrastructure to segregate & recycle isn't a viable option from an environmental standpoint and neither does it help burying battery waste under the earth, only for them to contaminate the water table.

Therefore in saving the climate, we create issues for the environment. In case the world switched over to the power equivalent of Renewables, then it will also demand the additional expense of an equivalent Fast Firing Natural Gas Infrastructure to compensate for the unavailability & erratic supply of renewables caused by natural causes.

The more the world clamours for Renewables, the more number of Natural Gas Plants have to be built to compensate for erratic renewables which defeats the very purpose of venturing into a Green Future

LONG TERM SOCIO-ECONOMIC IMPACT

The simple truth is, Fossil Fuels were never the enemy of the planet. It is man's "Insatiable thirst for Consumption", that has ripped through the fabric of society, climate and environment. Human existence exists in a limited spectrum. Too less or too much of anything is a problem. The world has traversed through the eons of time often feeling dissatisfied that, what they have is never enough, so much that strife & war has often been the final solution.

However in the 21st century, mankind under its illusory definition of self-sufficiency, has taken matters into its own hands to provide themselves with an abundance of energy resources at the cost of both climate & environment. While doing so, mankind is blinded by the historical amnesia, that it is their unrefined habits of endless consumption, which will lay forth their own weapons of self-destruction, waiting for history to repeat itself. Imagine a world where everybody is so independent that eventually nobody would feel obliged to listen to each other. It is at that moment when mankind has hit the dead end of progress.

Free energy will not set mankind free but will only exacerbate the habits of endless consumption with no responsibility or accountability. Hence, a balance is the need of the hour, between a source of

endless energy that can potentially blow the lid off on consumption & a source of limited energy, which requires sweat & toil to keep reminding us the need for responsibility & accountability towards consumption.

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Safety Talk

Guardrails

Chris Palmisano

In the US lack of guardrails during retrofit and construction projects kills approximately 1000 and inflict disabling injuries of approx. 100,000 annually! Do you remember the last time you saw a dangerous condition at a runway, stairway or around a floor, roof or wall opening, because of no guardrails? Unfortunately, many of you can recall working on projects where guardrails were either installed late or not at all. But worse yet, some of you are on one of these jobsites right now!

The conditions on jobsite projects change quickly. Areas that didn't require guardrails yesterday, may need them today. Make guardrail installation a part of doing the job, not a follow-up task when time permits.

Guardrails are not a luxury, they're an OSHA requirement. Remember that any guardrail worth building, is worth building right. Floor to top of rail must be 42" with posts not exceeding 8' centers. A 4" high toe board, strong enough to stop tools, materials, etc. from rolling or being knocked over the edge, is a must. All guardrails must be built strong enough to withstand a 200 pound force in any direction.

The minimum requirements for wooden rails are 2" x 4" stock for posts and top rail, with a 1" x 6" mid-rail. The material should be selected to avoid defects and splinters. If you prefer steel use 1 1/2" pipe, or 2" x 2" x 3/8" angle for posts and mid-rail. Other materials of equal or greater strength may be substituted, however, due to its unpredictable strength and brittleness, re-bar is NOT an acceptable material for use as guardrails.



Guardrails can be taken for granted. When you find yourself reaching out for something to grab hold of as you fall, then it's too late to think about guardrails. Check for guardrails in areas that they might be needed now. On equipment, stairs, anywhere required. And make sure that they are in good condition.

THINK SAFETY and prevent falls, use guardrails.



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