REFINERY POWER OUTAGE MITIGATIONS

www.hydrocarbonpublishing.com/power

Power outage causes
- 1 out of 5 refinery shutdowns!

Millions of dollars lost from
- missed production
- excessive flaring
- unsafe operations
- legal liabilities

Multi-CLIENT STRATEGIC REPORTS

Latest Technologies and Strategies to Minimize Financial Impacts

This first-of-the-kind, comprehensive technology and strategy study details *RISK and CRISIS Managements* to avoid downtime and speed up recovery.

Important topics covered:

- *Refinery emergency preparedness & experiences*
- *Prevention and protection*
- *Recovery, restart, and salvage*
- *Electrical equipment reliability improvements*
- *Safety management*
- *Maintenance advances & asset management - BIG DATA analytics*
- *Onsite power generation - CHP, renewable energy, microgrids*

For more special reports visit: www.hydrocarbonpublishing.com/mcreports

HYDROCARBON PUBLISHING COMPANY
Translating Knowledge into Profitability ®
PO Box 661 Southeastern, PA 19399 (USA) | Tel: 610-408-0117
Fax: 610-408-0118 | **mcreports@hydrocarbonpublishing.com**

TABLE OF CONTENTS

INTRODUCTION

Electrical power is used in every aspect of refinery operations, ranging from site pipelines operations, loading docks and storage terminals, processing units, lighting, instrument air supplies, control rooms, alarms, pollution controls, wastewater treatment facilities, cooling towers, flare units, to personnel facilities. Power supply disruptions and electrical equipment failures (collectively called power outages in this Report) represent over 80% of electrical problems in refineries between 2009 and 2013 according to the US Department of Energy. And the electrical problems account for one-fifth of all refinery disruptions during that period. This Report examines the causes and the myriad effects of power outages due to electrical supply disruptions and equipment failures in refineries, as well as some of the preventative measures which may be taken to avert the far-ranging consequences of a plant shutdown.

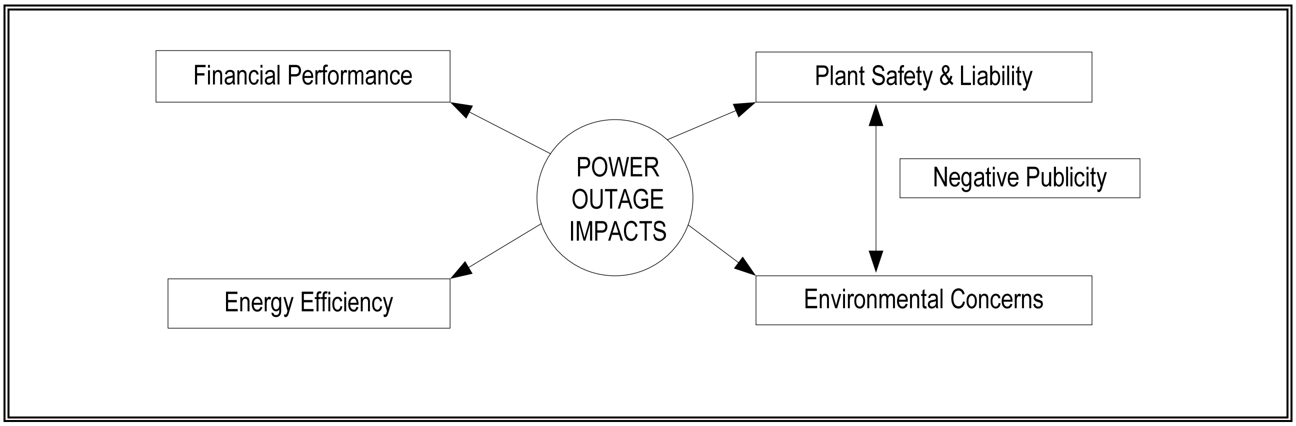
Power outages, mechanical breakdowns, leaks, and fires constitute the majority of incidents which can force a refinery to shut down. According to consultancy ARC, unscheduled shutdowns coupled with poor maintenance practices cost the global process industries 5% of total production annually, equivalent to $20B each year. The firm estimates that 80% of those losses would be avoidable if preventative measures were taken. Ineffective maintenance practices also result in unscheduled downtime which costs refiners on average an additional $60B a year. Monetary losses from refinery shutdowns are generally twofold: a refinery will be forced to pay for equipment repairs, as well as swallow profit losses resulting from stalled production.

Phillips 66's Bayway, New Jersey refinery in the US was down from Oct. 28 to Nov. 20, 2013 as a result of Superstorm Sandy. According to the company, the storm resulted in unanticipated expenses of approximately $56MM before tax, not even including lost revenue from those three weeks of lost output of refined products. Based on that refinery's nameplate gasoline and diesel production capacity, the shutdown is estimated to incur a total revenue loss of over $650 million and the net profit loss between $5.0 million and $27 million.

Commenting on the company's 1Q 2013 results, CEO Mike Jennings of US independent refiner HollyFrontier remarked that the company's refineries "experienced high levels of downtime due to both planned and unplanned maintenance." The plants suffered a series of setbacks in that quarter, including fires at the 125K b/d Tulsa, OK refinery and the 47K-b/d Cheyenne, WY refinery. Together with an unplanned shutdown at the 105K-b/d Navajo refinery in Artesia, New Mexico, in addition to a delayed restart and power outage at the El Dorado facility, outages cost the company an estimated $98 million over the course of the quarter.

There are multiple impacts due to power outages that negatively affect refineries as portrayed by **Figure 1.** One of the most recognized is the effect on financial performance as fuel production is halted and refiners suspend deliveries to the market. Power interruptions, which require burning of hydrocarbons and subsequent flaring and excessive emission of pollutants, could prompt environmental concerns by governing authorities as well as local communities. There are subsequent fines and penalties if the emissions are found excessive and the incidents are deemed avoidable. Also, worker safety is a major concern of a sudden shutdown. Any injuries or fatalities could lead to lawsuits resulting in legal liabilities. The goal of improving plant energy efficiency to lower production cost and also reduce carbon footprint would be compromised due to higher energy consumption for restarts. Lastly, bad publicity due to potential fuel shortage in the market as well as possible safety and environmental incidents being chastised by the media is a nightmare for any refiner.

FIGURE 1: POWER OUTAGE IMPACTS ON REFIENRY OPERATIONS



REPORT METHODOLOGY

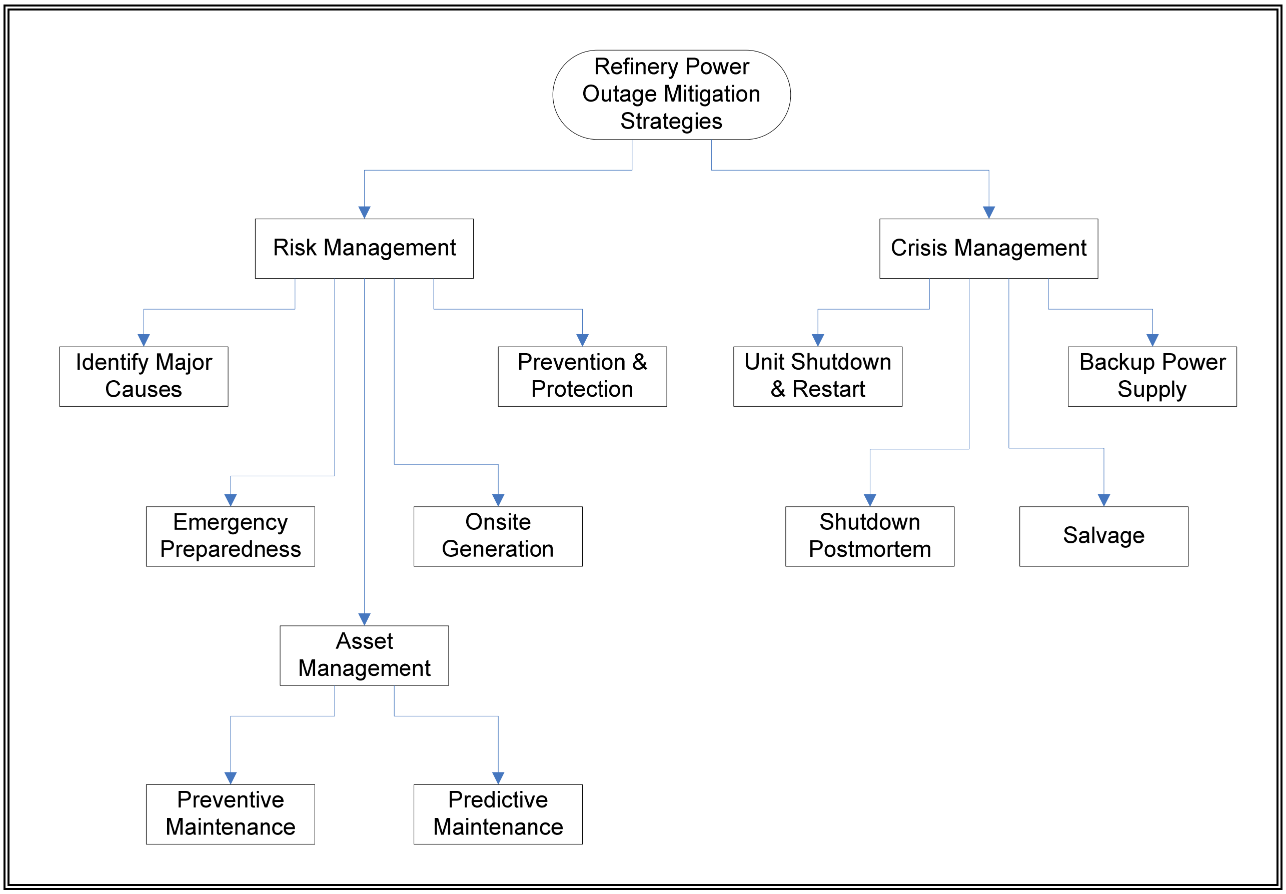
Primary sources of information include personal communication with technology holders and electrical equipment vendors, extensive literature searches and evaluations, and insightful technology and business strategy assessments by a team of analysts and consultants.

REPORT SCOPE AND FOCUS

This Report consists of a total of 13 sections. After the Introduction (Section 1) and this Executive Summary (Section 2), there are eight major sections: Section 3 - Environmental and Safety Legislation; Section 4 - Financial Impact of Power Outages; Section 5 - Causes of Refinery Power Outages; Section 6 - State-of-the-Art Technology; Section 7 – Advanced Maintenance Practices and Asset Management; Section 8 – Operational Management: Emergency Preparation, Shutdown, Restart, and Safety; Section 9 - Onsite Power Generation; and Section 10 – Strategic Analysis and Recommendations. In addition to the eight major sections Section 11 is the Vendor Appendix, Section 12 is the References, and Section 13 is the Index (subject and company.)

Refinery power outage mitigations are based on two major strategies: risk management and crisis management, as seen in **Figure 2.** In handling risk management, a refinery must install the most reliable equipment available in the market that can withstand disruptions caused by weather, power surges, blackouts, and any other outside elements. Since no equipment is perfect, the reliability engineers and operators still need to prepare for the worst case scenarios as well as the most frequently occurring possibilities. This is where they utilize prevention techniques to detect and fix problems before they lead to a power failure, and select protective equipment accordingly. When a problem does arise, then the second strategy—crisis management—comes into play. This involves the recovery technologies that allow for safe shutdown and continued operation, and the restart methods that won't lead to the same problem that caused the previous failure.

FIGURE 2: REFINERY POWER OUTAGE MITIGATION STRATEGIES



Major Causes

This Report collected data from reports published by the US Department of Energy. The data were then analyzed in length to reveal significance of power outages at US refineries. Between 2009 and 2013, there were over 2,200 refinery shutdowns or on average 1.3 incidents per day. These refinery shutdowns have been broken down into five categories according to their causes: electrical, leaks, mechanical, maintenance, other problems, and unplanned repairs. Some of the statistics include

- Electrical problems were the second-most prevalent issue, accounting for 20.6% of problems occurring at refineries.
- 53% of electrical disruptions at US refineries were due to a loss in power supply from the third party suppliers.
- Over 14% of power disruption incidents were caused by weather events including hurricanes, lightning strikes, and wind.
- Electrical equipment breakdowns accounted for approximately 29% of all power disruptions.
- Among all the processing units, SRU has had the most electrical problems, accounting for 31% of reported cases followed by the FCCU, CDU, HCU and coker.
- Of the identified rotary equipment that failed, most were FCCU wet-gas compressors, which accounted for 28%.
- The most common equipment to fail was transformers at 35%, ahead of substations and cables.

As revealed in this Report, the shutdown data collected from a reliable source is very valuable and powerful since the aggregate data can be used for benchmarking. A refiner can compare its own data to the statistics of all refineries across the nation to pinpoint its operational and equipment problems and also competitive advantages. For vendors, failure statistics should offer technology innovation and business opportunities since the data reveal which specific equipment market is under served.

Prevention and Protection

The first step to successfully fight power disruptions is to make sure that the incidents can be prevented. Also it is important to have the correct devices to protect electrical equipment from being damaged either by weather, power quality, or outages. This Report presents very in-depth discussions of prevention and protections devices (e.g. protective relays, circuit breakers, fuses, grounding, surge arrestors, and load shedding) and major electrical equipment (e.g. substations, transformers, switchgears, motor control centers, electric motors, and wiring and cables) by identifying the latest designs and operational practices and analyzing causes of failures and solutions.

During a panel meeting on June 17, 2013 addressing corrective actions to protect future storm damages in the US, Hess's senior vice president Christopher Baldwin emphasized the importance of protecting the electric power supplies to terminals and retail service stations. Rich Johnson, Phillips 66 spokesman, replied to a Platts inquiry that his company is considering elevating the electrical equipment in addition to other improvements to the Bayway, New Jersey refinery. He further added, "At the Linden terminal, we are also constructing and installing critical control buildings and electrical systems above the 100 year flood plain in order to minimize future damage."

Installing protective equipment is an excellent approach to protecting electric systems and preventing power failure. However, these installed devices are also vulnerable to failure. When not working properly, they are unable to protect the rest of the system from dangers such as faults. Several of the devices addressed in the Report are discussed below.

Protective relays

Protective relays detect abnormal system conditions and direct the circuit breakers to operate in the right manner to correct the abnormality. They are provided in electromechanical, solid-state, or microprocessor-based technology. Major improvements are made when upgrading to the latest microprocessor based technology. This was seen in Marathon Oil Co.'s Yates gas plant, located in Lakewood, NM (US), which noted an improvement in reliability after replacing electromechanical devices with microprocessor ones.

Circuit breakers

Circuit breakers, like grounding equipment, are essential to preventing major electrical damage but are also capable of failing themselves. As a means to protect other equipment from overloading and detect faults, a circuit breaker can switch on and off when exposed to a predetermined over-current. Breakers can fail by either failing to trip or tripping prematurely. In September 2011 one of the main circuit breakers overloaded and tripped a sulfur recovery unit at Alon USA Energy's Big Spring refinery in TX.

Fuses

Fuses function differently from circuit breakers, but ultimately serve the same purpose. The device has a circuit opening fusible part that is heated and severed by the passage of current. Fuses will burn off and cut off current if the passing current reaches a certain threshold (current limiting fuses) or if the expulsion effect of gasses produced by internal arcing occurs (expulsion fuses). In December 2010, Tesoro's Golden Eagle Refinery in California (US), an improperly rated fuse failed to protect a transformer from a fault, which led to a fire.

Grounding

Having properly grounded equipment is one of the common preventative measures taken to avoid power failure. Unfortunately, it is possible for the equipment to lose connection to the ground, and it can go undetected until it's too late. Without a properly grounded system over voltages can occur, which could endanger personnel and cause failures in the insulation of motors. Also equipment can be damaged and personnel can be injured if current sensing ground fault protection systems can't work due to a lack of or improper grounding. If properly designed and monitored, a grounding system can limit fault damage, prevent transient over voltages, reduce the risk of an arc-flash, and allow adequate current for ground fault detection.

Surge arrestors

The surge arrestor is a device protecting units from damage whenever a high-voltage power surge causes the voltage to exceed a predetermined threshold. These units are installed directly into the circuit. To maximize the effectiveness of this technology, it is important to correctly install them and ensure no major damage occurs. Like all equipment, surge arrestors are vulnerable to degradation and could cause a power outage should they fail.

Electrical Equipment Reliability Improvements

All of the electrical equipment at a refinery requires power to operate. Having a constant power supply is crucial for the plant to operate safely and economically. The reliability of major equipment and facilities is critical in maintaining electricity supply and quality. There are many ways to ensure the functionality of this equipment, and to prevent loss of power or complete failures. Several of the addressed assets are described below.

Substations

Substations consist of many different types of operating electrical equipment. Within a substation, voltage levels are dropped/increased, and power is distributed to the rest of the electric network. Protecting a substation from failure is achieved by protecting each of the operating assets within the substation (transformers, circuit breakers, cables, switchgear, etc.). On April 14, 2013, utility provider (Entergy Texas)'s substation located north of the Port Arthur, TX refinery hub (US) was shut after an arc flash was observed. This caused Motiva Enterprises', Total Petrochemicals', and Valero Energy's Port Arthur, TX refineries to shut down. The refineries resumed operation on April 18, April 15 and April 16, respectively.

Transformers

Transformers are critical to electric systems, as they change line voltage to its proper distribution and utilization levels. Failure can be avoided through a thorough protection of the transformer's insulation and winding by maintaining electric and thermal stability. Failure, however, can result in power outages or even fires. In October 2011 a transformer fire led to a power interruption at Phillip 66's Sweeny refinery, knocking several units (SRU, wastewater treatment, and flare gas recovery) out of service. The units weren't restarted till the next day.

Switchgears

Switchgears are made up of a combination of electrical disconnect switches, fuses, or breakers that are used to control and distribute power throughout a system. Protection of switchgears is essential for smooth operation for any part of a refinery. In September 2009 harsh weather triggered an electrical switchgear failure cutting power to the flare gas recovery unit compressors at Flint Hill Resources's Corpus Christi, TX Refinery in the US. Switchgears are also vulnerable to arcing, which is considered the greatest electric threat to worker safety.

Electric Motors

As far as consumption of electric energy goes, nothing in a refinery comes close to the amount of power provided to motor driven devices. Motor driven equipment will typically account for 70% of energy consumption in refineries, so special attention must be made towards their proper selection and operation. In Apr. 2013 Exxon Mobil's Beaumont, TX (US) refinery had over 400 pounds (0.19 mt) of hydrogen sulfide flared into the atmosphere as a result of a compressor tripping. Shell's Deer Park, TX refinery had to flare process gas following a pump failure in October 2011. Motor failure will occur due to thermal, electrical and mechanical contributions. There can be a singular source, or a combined effort between multiple factors that wear down a unit and eventually cause failure.

Wiring and Cables

Wiring and cables are very vulnerable to damage and degradation, especially when installed aboveground. This damage is mainly caused by heat and excessive loads, so systems that are kept cool and carry less current are expected to have a longer lifespan. Of course, they exposed to the elements are also at risk of weather related damage, while underground ones are much less likely to be damaged. Deciding between aboveground and underground option means choosing the increased protection for underground systems or the lower installation cost for aboveground. Other methods, most notably cable rejuvenation, can cure degrading cables and prevent costly cable failure.

Emergency Preparedness Strategies

If refineries hope to be prepared in the event of an emergency, proactive activities like assessing potential risks, outlining possible emergency scenarios, practicing contingency operations, deploying sufficient system resources, and implementing management and employee training are all considered critical. The use of a mass notification system for every day, non-emergency, intra- and inter-facility communication can also prove a critical asset in alerting workers to the occurrence of an incident and coordinating a proper response by emergency personnel. It can also be used to notify community officials, emergency response agencies, neighboring facilities, and the local community. The Report devotes an entire section on experiences shared by refiners on their emergency plans and plant shutdown procedures. The discussions highlight their concerns and successes in overcoming difficult times.

Preparation for any type of emergency begins with understanding the threats that exist within a refinery. Any type of event that could lead to injury, death, environmental damage or prolonged shutdown must be evaluated. Different methods of Process Hazard Analysis (PHA) are available to assess the urgency of hazards, severity of these hazards, and the amount of investment that should be put towards preventing or mitigating these hazards. The study discusses several well-known methods, such as risk analysis matrix, Layers of Protection Analysis (LOPA), and Process Safety Management (e.g. PSM Metrics, HAZOPs), that are not only used to plan for hazards, but also help personnel and management visualize and quantify the importance of hazard prevention and mitigation.

Onsite Power Generation

A very unique section of the study is devoted to onsite, independent power generation capabilities that refineries can invest in to help alleviated the problems of power failures. Three onsite power generation technologies are discussed: combined heat and power (CHP), renewable energy, and microgrids. These units will decrease a refinery's dependence on the utility power supplier and allow for continued production when outside power outages occur. Onsite power generation will also help lower electric costs and perhaps even the carbon footprint. Of course, there are challenges associated with the independent power supply. The objective of the Report is help refining executives to sort out the pros and cons so that a better decision can be made on near- and long-term investments.

Combined heat and power (CHP)

Cogeneration is an efficient and clean way to generate power and thermal energy from a single fuel source. Heat that is normally lost in normal power generation is captured. CHP systems have efficiency levels as high as 80%. The heat that is produced by combustion of fuel creates steam that spins a turbine to make electricity. In a normal power plant this heat is emitted into the atmosphere. In CHP the steam is sent the heating systems. In 2011 CHP accounted for 7% of the total electricity capacity with 25 GW being produced by CHP plants in the industrial sector. This Report has detailed discussions of CHP technology and highlights refinery cogeneration experiences around the world. In addition, there are variations of cogeneration such as trigeneration (e.g. cooing-heating-power and hydrogen-steam-power), combined cycle, and integrated gasification combined cycle (IGCC.)

Many refineries use their cogeneration units for different tasks. Some refineries use cogeneration units to provide direct power to the refinery while others use them as a back-up generator when the main power supply is cut. Refineries account for 17% of cogeneration use in the US. According to CONCAWE, a survey shows that 96 refineries in EU consume about 50MM mtoe (million tonnes of oil equivalent) worth of energy a year—i.e., nearly 7% of their crude throughput—leaving behind only 93% of the energy content of the total crude purchased for making fuels. This Report addresses technology advances of various options in the type of engine that is used in the cogeneration plant. Steam engines, diesel fueled engines, natural gas engines, gas turbines, fuel cells, and microturbines.

Cogeneration provided an estimated 92% of the electricity produced in the surveyed refineries in 2012, up from 76% in 1992. Overall, cogeneration capacity has risen by 125% over the period of 1992-2010. Because of cost and reliability of local power grid, approximately one-third of the EU refineries purchase all their electricity outside with the majority of the rest importing some fractions of their power.

Government regulation and technological advances remain the primary drivers for the development of cogeneration technology. Furthermore, governments throughout the world are offering economic assistance including financing grants, tax incentives, and low-interest loans to make cogeneration technology more affordable. In recent years, there has also been a trend of deregulation in the area of power generation that has allowed energy intensive industrial plants the opportunity to explore options for onsite power production. Opportunities to improve energy efficiency, reliability, and security in addition to improving environmental performance associated with power generation are available in many countries by installing CHP plants.

Renewable Energy

Renewable energy is slowly integrating its way into the electricity industry. In fact, US-based oil and gas companies have invested around $9B on renewable, non-hydrocarbon energies between 2000 and 2010. Of course, there is and has been a level of competition between refiners and renewable energy, but with all the recent policies pushing towards a greener environment, many refiners may have no option but to consider implementation of renewable energy sources.

Perhaps the greatest criticism of wind- and solar-generated energy lies in the intermittency (inconsistency) with the two main generation sources, wind and solar. Cost could be a deterring factor for refiners if no tax incentives or government subsidies are allowable. A study conducted by San Diego Gas & Electric in the US performed a test to account for the intermittency of a combined solar and wind system suggested applying fast-acting generators or back-up storage as a way to account for the occasional dips below demand that can occur in wind and solar power.

Microgrids

Microgrids are essentially small scale versions of the centralized electricity system. They improve reliability, reduce carbon emissions, allow diversification of energy sources, and reduce costs. Microgrids, like the bulk power grid, generate, distribute, and regulate electricity to the consumers. They, however, do it on a local basis, so if one area suffers damage from winds, there won't be a large blackout, just a local one, allowing for continued operation for the rest of the refinery. Microgrids can help improve the reliability and efficiency of the entire refining process.

A microgrid differs from a conventional power plant when it comes to their microsources. For one, the microsources (such as CHP, wind, and solar) are of much smaller capacity with respect to the large generators in conventional power plants. These generate power at distribution voltage, which can be directly fed to the utility distribution network. The microsources in microgrids can therefore be installed close to the customers' premises so that the electrical and heat loads can be efficiently supplied with satisfactory voltage and frequency profile and negligible line losses. Microgrids are also suitable for supplying power to remote areas of a country where supply from the national grid system is either difficult to avail due to the topology or frequently disrupted due to severe climatic conditions or man-made disturbances. With the ability to draw from multiple sources, microgrids offer a solution for the intermittency of renewable energy.

Maintenance Advances and Asset Management

This Report focuses on two primary Reliability Centered Maintenance (RCM)-based approaches of maintenance: preventive, which is performed periodically, and predictive, which relies on condition monitoring and data analytics. Particularly critical equipment that has large production losses or safety issues are likely to warrant the more complex and sophisticated maintenance strategies like condition-based/predictive maintenance, while less critical ones will warrant a time-based/preventive maintenance or run to failure approach. This is where a life-cycle cost analysis (LCCA) comes into play. LCCA evaluates all relevant costs over the time an asset is in use.

Electrical equipment maintenance is just as important as maintenance work on the refining units themselves. This Report discusses the maintenance techniques for the different types of electrical equipment including protective relays, circuit breakers, surge arrestors, transformers, switchgears, wiring and cables, electric motors, and UPS systems. Also, the study sheds lights on the rising use of wireless devices and instrumentation for data collection in a refinery as it is becoming more prevalent due to the growth and ease of availability of wireless technology throughout the world. In a 2011 survey of plant workers from various trades and industries, 68% of those asked preferred wireless data collection and transfer over wired.

Big Data is typically defined as a vast, seemingly insurmountable collection of data points. In a refinery, where hundreds, if not thousands, of sensors and monitoring devices for electrical and processing equipment are installed, millions of data points are collected daily. For effective data analysis, there are measures that must be taken to effectively manage large data sets. The study addresses several latest issues related to constraints, overcoming obstacles, cloud data storage, and cyber security.

Undoubtedly, preventing power failure by improving each electrical unit's reliability is best achieved by an excellent asset management program. This Report completes discussions of advances in maintenance practices by evaluating major commercial asset management systems by electric equipment vendors (such as ABB, Eaton, Flowserve, Motorstix, General Electric, Power Analytics, Qualitrol Corp, Rockwell Automation, Schneider Electric and AssetPoint, Schweitzer Engineering Laboratories, and Siemens) as well other refinery asset management programs, which could be developed in the future for enhancing reliability of power supply and electrical equipment. These programs are being marketed by Emerson Process Management, Honeywell Process Solutions, Integraph, Invensys (now part of Schneider Electric), KBC, Metso, and Yokogawa.

Enterprise Asset Management (EAM) is expected to play a major role in the future since the strength of an asset management program relies heavily on the management of all maintenance related data. As mentioned earlier, a predictive maintenance program is only effective if data is collected, stored, protected, analyzed and distributed properly. Several major companies (such as IBM, Oracle, OSIsoft, and SAP) offer their software and services that ensure efficient and safe data management solutions.

Finally, the future of incorporating big data analytics into a maintenance program is the implementation of a *prescriptive* maintenance approach. Like predictive maintenance, this method will detect failure mechanisms well before an actual failure; however, prescriptive measures can detect future failure and suggest the best course of action to take. While it does not yet have a strong presence in equipment maintenance yet (or any for electrical equipment), this Report expects that prescriptive analytics will have a strong presence in the future for asset management.

Recovery, Restart, and Salvage

While extensive preventative measures and preparation are necessary to limit damage, it is also very important to know how to continue, resume and clean up the operation in the event of power failure. The longer a refinery is down, the more money the refinery loses, and the more chemicals are potentially lost to flaring. The ability to get a refinery back up and running as soon as possible after a shutdown is critical for reducing profit loss.

This Report addresses the various methods a refinery can quickly and effectively resume operation for interrupted processes as well as the top priority, i.e. operational safety that saves life. Refineries can (and should) take further steps towards improving asset reliability as a way to increase uptime and avoid the harmful implications of power failures. However, the fact still remains that some contributors to power failure cannot or will not be addressed, and refineries must plan for these events. Effective planning and preparedness that direct personnel leading up to and following a shutdown can keep a temporary power outage from becoming a catastrophic one.

In the event of a major shutdown, a refinery must shift from preventive measures to mitigating ones. These are the occasions where a refinery must ensure that personnel and nearby areas are safe and out of harm's way, units have been properly shut down, and resources and crews are allocated for eventual restart. This Report captures experiences shared by refiners, who attended the previous US National Petrochemical and Refiner Association, NPRA (now called American Fuel and Petrochemical Manufacturers, AFPM) Technology Q&A meetings. Units in discussions are crude desalter, crude distillation, hydrotreating, FCC, hydrocracking, coking, hydrogen plant, and utilities system and auxiliary equipment. Resultant unit over-pressurization, temperature excursion, and personnel safety are the major concerns.

In term of equipment salvage, flooding is a considerable threat to the reliability of electrical assets. When equipment is exposed to high concentrations of salt water, the units experience significant damage. Motors, transformer windings, and other similar equipment need to be overhauled and rewound. This will cost nearly as much as a new piece of equipment. Cables must be completely scrapped. Bus bars and non-insulated items can be cleaned and reused. Switchgear, breakers, and similar equipment must be cleaned, and overhauled with new components. It is often the case that assets will require replacement should this type of failure occur. The National Electrical Manufacturers Association, or NEMA, provides some requirements and recommendations for different types of electrical equipment that have been exposed to water damage.

Backup Power Supply

The main forms of backup power come in battery form or generators. Generators are used to power the main refining units. Backup generators helps get units back online within a specified time, even if they are running at reduced rates. Generators can vary in their capacity and fuel source, where diesel and natural gas powered units are most common. Installation and utilization of backup systems can vary based on the reliability and importance of processing units. In July 2009, Pasadena Refining's Pasadena, TX (US) complex was able to continue providing feed to a crude unit after a lightning strike causes an outage in the tank farm thanks to the use of a backup generator.

Uninterruptible power supply (UPS) is a crucial device in a refinery since it provides backup and maintain a power supply to essential control circuits and instruments during a time of total power failures. The unit initiates a battery backup power when it does detect a failure to keep all electronics—particularly electronic analog control system it is attached to- running. Uninterruptible supply systems can also improve the quality of downstream electrical supply by compensating for voltage sags and harmonic distortions. The Report compares and examines three types of UPS designs (i.e. single-conversion, double-conversion, and multi-mode) and two types of UPS setups (i.e. distributed backup and central backup.) Pemex Refinacion's Madero refinery in Tamaulipas, Mexico, is said to install two UPS 900 kVA systems to protect its repumping stations. Each UPS can protect a 600/4150V hp motor, which delivers half of the refinery production. According to Pemex, the key drivers of the installations are to improve reliability and energy efficiency.

Shutdown Postmortem

After power supply disruptions and electrical equipment failures, it is crucial to find the cause(s) in order to keep history repeating itself via a technique called Root Cause Analysis (RCFA). Knowing the various contributors to equipment failure is great, but being able to trace an individual failure to a specific source or set of sources will not only prevent future failure to that particular unit, but also protect similar units within the refinery. Imperfections in the design, installation or operation of any asset can be exposed through a thorough analysis of the operating conditions and surrounding influences. RCFAs can effectively improve electrical reliability throughout the refinery as they lead to getting rid of any harmful procedures, changing poor operation, educating the staff, modifying design flaws, and reaffirming the functionality of similar or identical equipment. This Report discusses several well-known RCFA methods: Fault Trees, FMEA, and STEP. They can be applied depending on the type of failure and the components and number of components involved.

Personnel Safety

Protecting onsite workers from harm is a top priority for any industrial process. An estimated 16% of deaths in oil facilities are related to electrical accidents, explosions, or burns. Government legislation and company policies reflect the importance of workplace safety. Losses associated with decreased production and environmental enforcement pale in comparison to the cost of a lost life. With regards to electrical equipment, this Report examines the three main safety concerns: arcing, electric shock and fires.

For most involved in the electric field, arcing is the greatest concern when it comes to worker safety. As opposed to most faults, where current is rushed to a low impedance conductor, and arc fault will travel through a high impedance conductor, like air. Pressure and temperature will rapidly build up, and either an arc-flash or arc-blast will result.

An electric shock can be considered as any event where electric current travels through a person's body. According to the IEEE, shock hazards account for 61% of all non-fatal electric injuries. These encounters can be avoided through lockout/tagout, and circuit interrupters like GFCIs, EGFPDs and ELCIs. Lockout/tagout (LOTO) is a highly recommended procedure when workers are performing maintenance or are exposed to electrical equipment in any other way.

Fire is a huge threat to refineries. Just about all of the chemicals and products at refineries are highly flammable and even explosive. With regards to electric equipment, fires are prevented significantly by abiding by standards set by the API, NFPA and IEC. Zones of protection have been established that define the fire risk with regards to ambient chemicals and their properties. Equipment cannot be installed in these zones if they can cause these chemicals to combust.

Finally, safety management has become the leading priority for refiners around the world. Any incidents caused by power failures, process malfunctions, natural disasters and other unexpected elements would not only result in loss in production, but also lead to worker fatalities. Lessons need to be learned from the incidents even though many of them are not electrical- and power- related. If the incidents were due to negligence or preventable, the outcomes would remain the same, i.e. criminal and civil lawsuits and bad publicity. It is important to learn from past errors and catastrophes to improve a facility's safety management and procedures.

Featured Companies

This Report is the first-of-kind study covering technologies and strategies offered by refinery suppliers to tackle the power failure challenges. Nearly 150 electrical equipment vendors around the world that provide technologies to mitigate power outages are identified and discussed.

Major companies included in the discussions on prevention and protection, recovery/restart/salvage, electrical equipment reliability improvements, refinery power systems, and onsite power generation, are ABB Group, Aggreko, Alpha Technologies, Alstom Grid, American Electric Technologies Inc, Basler Electric, Belyea Co Inc, Benjamin Electric Co, Bharat Heavy Electricals Limited, China Electric Power Equipment and Tech, Chint Group, Cooper Industries Plc., EATON, EFACES Engenharia, Emerson, General Electric, Hubbell Inc., Hyosung Corp Power & Industrial Performance Group, Hyundai Heavy Industries, IBM, Kirloskar Electric Co. Ltd, LS Industrial System, Maven Power, Mitsubishi Electric, Nissin Electric, Novinium, Oracle, OSIsoft, Phoenix Contact, Powell Industries, Qualitrol Corp, Russelectric Inc, S&C Electric, Schneider Electric, Schweitzer Engineering Lab, Shihlin Electric and Engineering, Siemens AG, Toshiba Transmission Distribution & industrial Systems, Vijai Electricals, and Xian Electric Engineering. The above listing does not represent all the companies discussed in the study.

PRICING INFORMATION

Order this publication at Hydrocarbon Publishing Company's online store at: http://www.hydrocarbonpublishing.com/store10/product.php?productid=C01300.