The Electrical Reliability Plan

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A TOOL TO BRIDGE BUSINESS STRATEGY WITH ELECTRICAL INVESTMENT

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MAINTAINING RELIABILITY FOR ELECTRICAL DISTRIBUTION SYSTEMS THAT support processing facilities is a constant challenge due to aging equipment and other factors. Upgrades and replacements require significant engineering, extensive capital, scheduling, and shutdowns. Investment in electrical infrastructure is often marginalized and only addressed upon an unplanned failure or necessary expansion. Without an overall comprehensive strategy, it is difficult to ensure that these expenditures meet the facility's business objectives and contribute to long-term value. An electrical reliability plan (ERP) is a tool that helps align business strategy with capital investment.

An ERP evaluates the facility's electrical infrastructure and determines a prioritized strategy for replacement, modification, or upgrade based on specific criteria of risk to business, safety, capacity, environment, and other factors. The criteria are evaluated, weighted, and risk ranked within the facility's risk management structure. Baselines are established against which an organization can measure risk reduction and continuous improvement.

This article describes components of an ERP and discusses the criteria and evaluation procedures that were used to develop comprehensive ERPs for two large petroleum refineries. The article also discusses how support was achieved from the key facility stakeholders and how the ERPs have benefited the facilities.

Why an ERP?

No organization ever plans to fail; they just frequently fail to plan. Without a complete evaluation of a facility's electrical system, it is often difficult to ensure that the resources spent today will be in alignment with what is allocated and spent tomorrow. Through the ERP process, plant personnel and stakeholders help guarantee that electrical capital expenditures offer long-term benefits and align with the organization's overall goals and strategies.

ERP Framework

One of the first tasks in developing an ERP is to establish the plan's overall framework. Different organizations may want to highlight and emphasize distinct aspects of an electrical plan, such as cash flow, implementation schedule, or technical criteria. Regardless of the specifics, there are three primary segments to understand during ERP development: the plant's electrical distribution system, the organization's business strategy, and the challenge.

The Plant's Electrical Distribution System

Processing plants and petroleum refineries are large and complex industrial facilities. A typical refinery occupies at least 1 km^2 of land and is made up of multiple process units, tankage and storage areas, receiving and shipping resources, and non–process-related structures, such as warehouses, maintenance facilities, and office buildings.

Electrical demand at a petroleum refinery is quite concentrated and significant, as shown in Figure 1. For example, a refinery with a processing capacity near 200,000 bbl/d may be expected to have a maximum electrical demand of approximately 100 MVA. This would be roughly equivalent to the load required for a city of 83,000 homes, where the U.S. average residential electrical demand is just slightly more than 1.2 kW/home [1].

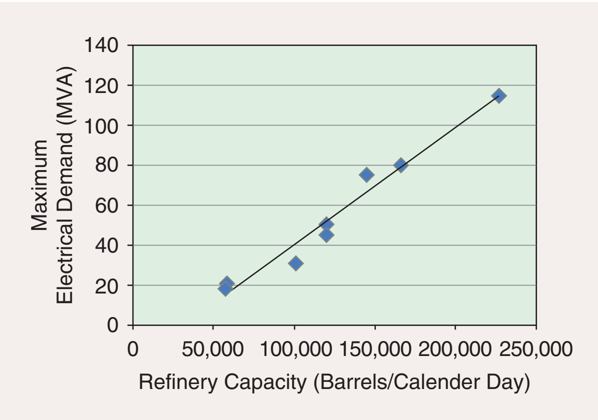

FIGURE 1. The maximum electrical demand versus process capacity.

A typical plant electrical distribution system consists of several key subsystems. The definitions of these subsystems are important when establishing ERP boundary conditions.

1) *Power supply/utility*: The power supply consists of the utility connection to the facility. This supply is generally fed via high-voltage, overhead transmission lines and generally includes the utility substations and transformers that directly feed the processing facility. Equipment is generally utility owned, maintained, and operated. The power supply may or may not include utility, third-party, or plant-owned cogeneration units.
2) *Main substations*: The main substations are normally owned, maintained, and operated by plant staff, and they directly connect the facility to the utility and/or cogeneration supply, if available. They typically operate at a single voltage level, commonly 15 kV, and usually consist of single or double lineups of 15-kV class switchgear.
3) *Distribution substations*: Distribution substations consist of medium- and low-voltage switchgear and corresponding transformers. They receive power via feeder conductors from the main substations and provide power to appropriate utilization substations. Large process loads (motors of several thousand horsepower and higher) are often directly connected to distribution substations, which often feed one or several specific production units and frequently represent the backbone of the electrical system.
4) *Utilization substations*: Plant process equipment (pumps, compressors, actuators, mixers, and so on) are connected directly to utilization substations. At this level, utilization substations generally consist of low- and medium-voltage motor control centers, panelboards, and switch racks. A simplified overall block diagram of a typical plant electrical distribution system is shown in Figure 2.
5) *Other systems*: Other critical electrical systems may include uninterruptible power supplies (UPSs) and their batteries; emergency or standby generation systems; low-voltage (208 Y/120 V) power for lighting, heat tracing, and general branch circuits; and pole structures for overhead, in-plant cable routing.

Once the overall distribution system is understood and defined, the ERP boundary conditions are established. Typically, these boundaries, or bookends, begin at the main substation level and go down to the utilization substation level. The establishment of and agreement on the boundary conditions is a critical prerequisite of a successful ERP.

Business Strategy

Most organizations have many competing opportunities for scarce capital resources. Facility managers regularly assess where these capital resources should be allocated and, as such, create their own plans for cash flow and allocations.

Capital resources may be planned for business improvement, integrity management, health-safety-security-environmental (HSSE) issues, sustainability-related projects, and/or regulatory compliance. Others [2], [3] have commented on the importance of working within an organization's business framework when it comes to allocating capital resources for electrical infrastructure. Once complete, the ERP becomes an analysis tool of the regular capital-resource allocation for the facility. This represents the single most important driver for the creation of an ERP. When plant and corporate personnel are on board and involved with the plan, it is much easier to obtain the future support and funding to make the planned upgrades or expansions.

The Challenge

Most refining and processing facilities in the United States have aging electrical distribution systems in the later stages of life expectancy. Without some type of proactive medium for long-range planning, it is challenging for the plant electrical reliability engineer to have funds allocated by corporate management for necessary electrical upgrades or replacements. Developing a replacement strategy for the plant electrical distribution system is an important component for overall reliability.

Often, when the ERP is presented for the first time, the management team will ask questions, such as is adequate electrical power available? or when, exactly, is that device going to fail? It's fairly straightforward to determine electrical power availability based on load calculations and space evaluations. Attempting to predict equipment failure, however, has numerous challenges.

The life expectancy of major electrical equipment varies widely based on a number of issues, such as the quality of materials, workmanship, loading, maintenance, and environmental factors. An IEEE Petroleum and Chemical Industry Committee (PCIC) article presented in 2010 [4] provides some insight on when to replace aging transformers. Trying to predict the exact day of failure is almost impossible, and there have been numerous studies conducted depicting average, or probable, failure rates. One study conducted by an IEEE Transformer Committee [5] developed the failure graph shown in Figure 3. An important takeaway from this graph is not necessarily the individual magnitudes by year but, rather, the slope of the failure line. As seen at about 40 years, this slope dramatically increases, and the probability of failure grows at an increasing rate.

Thus, rather than try to predict failure or convey a reactive "fix it when it breaks" or "throw it on the next capital project" mind-set, the goal of an ERP is to have a proactive plan that establishes a long-term strategy for a safe, reliable, expandable, and maintainable electrical infrastructure throughout the facility. An analyzed and risk-assessed plan will reassure management that what is done today will maximize value and reduce potential risks and regret spends tomorrow.

To best do this, a reliability electrical engineer must be fully aware of the facility's business strategy. The ERP is the tool that helps bridge the gap between a facility's business strategy and the capital investment required to maintain a safe and reliable electrical distribution system.

Essential Aspects of the ERP

The development of any plan should always begin with the end in mind. Knowing that the goal of the ERP is to provide enough information to facilitate stakeholder buy-in, while

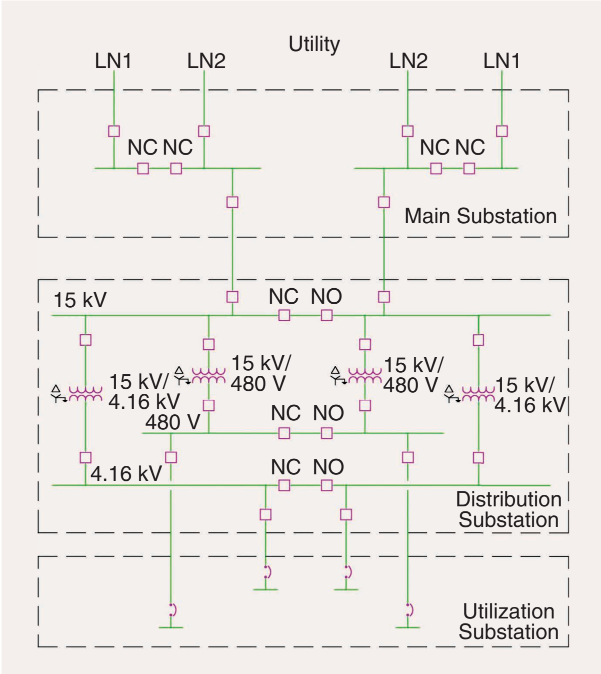

FIGURE 2. A typical plant electrical distribution system. LN: line; NC: normally closed; NO: normally open.

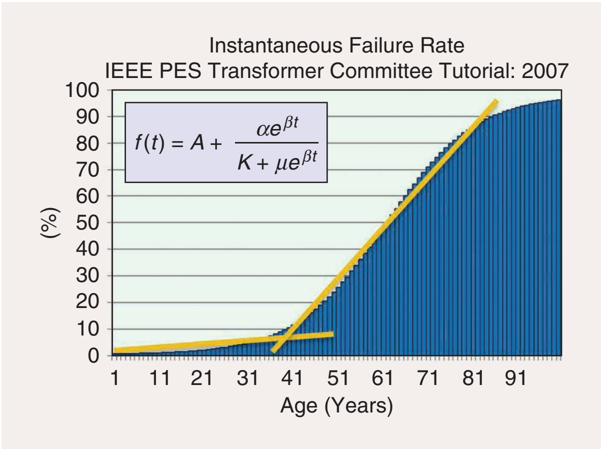

FIGURE 3. The failure probability curve for utility transformers. PES: Power & Energy Society.

simultaneously allowing for future flexibility and modification, is a critical understanding to help formulate the plan's format and framework.

To help ensure success, the ERP (at a minimum) should adequately

1) address and outline specific recommendations
2) develop existing and projected load profiles
3) include implementation and cash-flow schedules
4) prioritize replacement based on agreed-on criteria
5) identify future plant space allocations for necessary expansions and/or additions
6) evaluate risks and impacts.

Together, these items will help the stakeholders evaluate and make risk-management decisions to determine when it is appropriate to commit capital expenditures to upgrade and/or replace components in the facility's electrical distribution system. The following sections describe some of the main components and techniques that have been successfully used in the creation of a facility's ERPs.

Establish Boundary Conditions

The boundary conditions ultimately describe and contain the scope of the ERP. They are the constraints that determine which specific facility electrical subsystems, or components, are included in the ERP and which are excluded.

Typical ERP boundary conditions fall from the main substation level, through the distribution level, down to the utilization substation level. Cogeneration and emergency standby power systems could also be included in the established boundary conditions. Defining these agreed-on limits for the ERP is the first crucial step in developing the overall strategy.

As an example, an ERP may set boundary conditions that eliminate a facility's power supply and systems at or below the utilization substation level from the scope of study. In this example, the focus would be on the main and distribution substation components in that facility's electrical distribution system.

Establish Key Drivers, Weightings, and Ranking Criteria

Key drivers and corresponding ranking criteria for the existing facility are identified and developed. Several potential key ERP drivers are listed in Table 1.

Relative weightings are applied for each of the selected key drivers (W_{KD}) to bring the total weighting to 100%, expressed as

$$W_{\mathrm{KD1}} + W_{\mathrm{KD2}} + W_{\mathrm{KD3}} + \cdots + W_{\mathrm{KDn}} = 100\% \qquad (1)$$

for up to n key drivers.

Finally, ranking criteria are developed for each of the key drivers (RC_{KD}), which will be the scoring system used for each of the infrastructure components evaluated in the ERP. A five-point scoring system has proven to be adequate, where

$$\begin{aligned} RC_{\mathrm{KD1}} &= 1 \text{ if condition 1 is true}\\ RC_{\mathrm{KD1}} &= 2 \text{ if condition 2 is true}\\ RC_{\mathrm{KD1}} &= 3 \text{ if condition 3 is true}\\ RC_{\mathrm{KD1}} &= 4 \text{ if condition 4 is true}\\ RC_{\mathrm{KD1}} &= 5 \text{ if condition 5 is true.} \end{aligned} \qquad (2)$$

Conditions 1–5, as shown in (2), progress from good to worse. Thus, the best condition would yield a low-ranking criteria score of 1 and the worst condition a high-ranking criteria score of 5. The development of the key drivers, weightings, and ranking criteria is essential as they make up the scoring system, which will be responsible for segregating the various electrical infrastructure components.

Apply Ranking Criteria and Weightings

Applying the established ranking criteria and weightings to the various ERP components will differentiate the relative importance of the components. The total score (TS) of each component is

$$\mathrm{TS} = W_{\mathrm{KD1}} RC_{\mathrm{KD1}} + W_{\mathrm{KD2}} RC_{\mathrm{KD2}} + \cdots + W_{\mathrm{KD}n} RC_{\mathrm{KD}n}. \qquad (3)$$

The infrastructure component with the highest overall score will be the highest risk and should reflect the highest-priority opportunity for upgrade. The component with the second highest overall score will have the second highest risk, and so on. The resulting table is then sorted by the overall total score from highest to lowest (worst to best) to help clarify the recommended upgrades. A sample is shown in Table 2.

Input from all appropriate facility stakeholders is needed when establishing key drivers, relative weightings, and ranking criteria. This helps ensure that everyone (management, maintenance, operations, reliability) is on board with the parameters used in the assessment.

Evaluate Existing Conditions

Field walk-downs and evaluations of the appropriate infrastructure components for each key driver are then conducted. Which items are evaluated during the this process heavily depends on the established key drivers and ranking criteria. For example, assume that a safety key driver is included with ranking criteria based on available arc-flash energy levels and whether the equipment at appropriate locations is constructed to withstand potential arc-flash events. In this case, the evaluation would determine

Table 1. Potential ERP key drivers

Reliability	Safety
Maintainability	Available plot space
Turnaround timing	Cutover timing
Capacity	Economic impacts
Environmental impacts	Lost profit opportunity

arc-flash energy levels, and field evaluations would determine equipment construction type at each of the evaluated components in the ERP.

Review the Facility Shutdown Schedule

Once the evaluation and ranking are complete, the focus shifts toward implementation. Planned outages or maintenance shutdown schedules are reviewed to identify windows of opportunity for the projects associated with upgrading various ERP components. Often, the highest-valued component may need to be rescheduled due to available shutdown windows (or the lack thereof). For example, a highly ranked distribution substation serving a processing unit with a six-year maintenance cycle may need to defer for four years while a slightly lower ranked distribution substation serving another processing unit with a two-year shutdown schedule is slated for immediate project sanction.

Establish a Project Design Basis

A project design basis should be developed to provide a consistent approach to estimating overall project costs and document specific client and facility preferences for methods of construction, type of equipment, and system configuration. A cost/benefit analysis during this activity is frequently required to ensure that the decisions will offer a real, long-term benefit to the facility. An overview of various types of substation options and considerations can be found in [6].

Develop Preliminary Design and Total Installed Cost Estimates

Feasibility-level engineering designs are completed for the various ERP electrical infrastructure component upgrades, including preliminary single-line diagrams, electrical equipment layouts, and plot plans. A scope of work is also created and a total installed cost (TIC) estimate prepared for each component, and these will be used in the development of the ERP cash flow.

Develop a Proposed Project Schedule and Cash Flow

The overall ERP project schedule and cash flows are developed after the various ERP electrical infrastructure components have been ranked, TIC estimates completed, and facility shutdown schedules reviewed. The implementation and cash flow schedules will help facility management determine when it is appropriate to make capital expenditures to upgrade components in the electrical distribution system.

The overall execution schedule is generally created first as it will drive the project cash flow. Often, due to capital constraints and other factors, the process of modifying the schedule, and reviewing the resulting cash flow, goes through many iterations. Examples of project and cash-flow schedules are shown in Figures 4 and 5, respectively.

Table 2. The sample results of ranking criteria and weightings

	Ranking Criteria												
	Safety		Capacity		Reliability		Impact		Maintainability		Timing		
Component	**Raw Score**	**Weighting 5%**	**Raw Score**	**Weighting 20%**	**Raw Score**	**Weighting 20%**	**Raw Score**	**Weighting 25%**	**Raw Score**	**Weighting 5%**	**Raw Score**	**Weighting 25%**	**Total**
Substation 5	3	0.15	5	1	4	0.80	3	0.75	4	0.20	5	1.25	4.15
Substation 8	3	0.15	4	0.80	5	1	3	0.75	3	0.15	5	1.25	4.10
Substation 3	4	0.20	5	1	5	1	3	0.75	3	0.15	3	0.75	3.85
Substation 12	3	0.15	3	0.60	4	0.80	3	0.75	5	0.25	5	1.25	3.80
Substation 7	3	0.15	4	0.80	5	1	2	0.50	3	0.15	4	1	3.60
Substation 2	3	0.15	4	0.80	4	0.80	2	0.50	3	0.15	4	1	3.40
Substation 9	3	0.15	5	1	5	1	1	0.25	3	0.15	2	0.50	3.05
Substation 4	3	0.15	2	0.40	5	1	1	0.25	3	0.15	4	1	2.95

Calculation notes: A raw score of 5 represents an elevated level of risk or severity of impact, and 1 represents a low level of risk or severity of impact. Category weightings were determined through conversations with plant and project personnel.

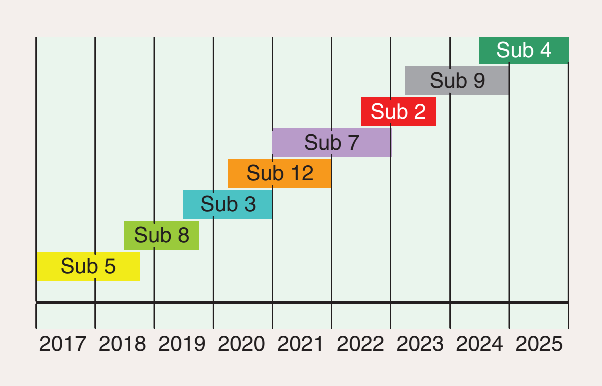

FIGURE 4. An execution schedule. Sub: substation.

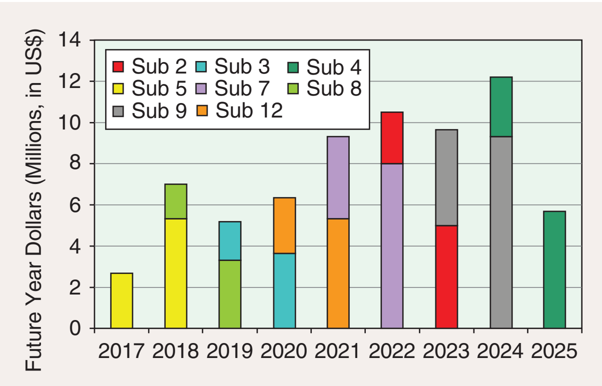

FIGURE 5. ERP cash flow. Sub: substation.

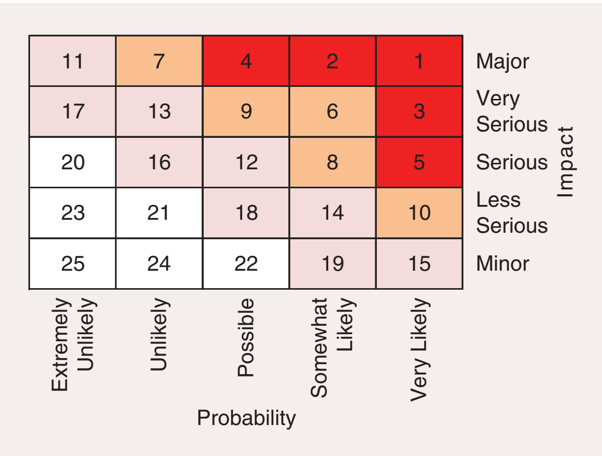

FIGURE 6. An impact-versus-probability matrix.

Risk-Management Analysis

The final component of the ERP framework is generally the organization's evaluation of risk, which includes many different categories and is generally structured around an impact-versus-probability matrix. Example categories include safety, security, environmental, reputation, and revenue. A sample matrix is shown in Figure 6.

The organization's evaluation of these types of matrices gives them another way to prioritize the ERP. ERP infrastructure components can be evaluated against other (non-ERP) competing capital projects using a matrix similar to Figure 6. This type of evaluation would typically be done outside of the ERP scope but would likely provide input into it from project-schedule and cash-flow perspectives. Next, two case studies that utilized the ERP methodologies presented in this section will be described.

Case Study 1

The refinery had not had many electrical service failures to the process units and was considered to be reliable by management. The refinery was reaching an age at which the existing infrastructure was working beyond manufacturer-recommended replacement times but not beyond typical service life, as equipment testing indicated. Available capacity, in both electrical power and connection space, of the original installation was challenged by previous expansions and new growth put in place to meet additional business goals.

Over the years of expansion, the reliability engineers had been involved with the project engineers to ensure that the expected system loads were analyzed for impacts, and they were becoming concerned. The financial impact of the desired business growth was negatively affected by the required electrical infrastructure expansion to an extent that went beyond the immediate project needs. The result was either to install a low-reliability electrical service with impacts to the business, limiting the financial result, or delay the project and possibly miss the financial gain of getting a new product to market ahead of competitors.

The ERP was put in place to help address the immediate need of clearly identifying the best option for the location, size, and cost of the electrical services needed across the refinery. This also allowed the refinery to properly address the risks and corresponding mitigations presented by the ERP, resulting in the electrical infrastructure project to be split off from the business growth project and stand on its own merits. This was a lower risk to the business compared with other integrity projects that were also vying for capital funds.

The ERP consisted of the following:

- *Boundary conditions*: The established boundaries of data collection were from the ownership connection to the outside utility at 13.8 kV at the main substations, through the distribution substations operated at 5 kV and the utilization motor control center operated at 2,400 and 480 V. Subsequent revision histories included emergency generation, UPSs, and dc distribution centers. The boundaries for the ERP evaluation focused on the distribution substations operating at 5 kV but included some utilization voltages at the 2,400- and 480-V levels to capture opportunity.
- *Key drivers, weightings, and ranking criteria*: Key drivers were established based on the main concerns the

refinery had for the electrical equipment. It was determined that safety, capacity, reliability, impacts to refining, maintainability, and timing of turnarounds would be the baseline key drivers.

Each key driver was then weighted by priority, totaling 100%. Any considerations for weighting must be determined by the location. A cross-functional team assessed and agreed on the impact that each key driver and associated weighting had on alignment with business goals. The weights are relative to one another, based on how the team sees the impact of the category in relation to the others. For example, a site may consider maintainability weighting high if there are limited electrical technology resources. A typical cross-functional team to access this weighting criteria consists of an electrical reliability engineer, electrical technology foreman/superintendent, HSSE representative, operations representative, and business development representative.

A ranking criteria of 1–5 was established based on how well a distribution center met that category, from best practice (score = 1) to major deficiency (score = 5). An example would be for capacity: a score of 1 indicates loading less than 75% of base rating and greater than 1 space available. A score of 5 indicates loading at or above the base rating and no space available for connection.

Evaluating Existing Conditions

Field walk-downs and evaluations of the current state at each main through utilization substation were then conducted. The field data and evaluations were used to determine actual ranking criteria scores. Additional information was also used, such as a complete listing of all existing equipment nameplate data, historical equipment test data, historical replacement or upgrade projects, historical equipment maintenance data, previous load flow and protective coordination studies, and interviews of electrical technicians and reliability engineers. Finally, the timing of opportunity outages for cutover of services to minimize business impact was gathered.

Applying Ranking Criteria and Weightings

The established ranking criteria scores and associated weightings were then applied, resulting in a total score for each of the distribution substations. This was used to establish the planned execution strategy for investment.

Establishing a Project Design Basis

The refinery established a basis of design, which allowed optimization of several project parameters. This basis

1) set plot space for future planning of optimum locations for service and access
2) set building layouts to benefit maintenance accessibility
3) set equipment types for safety and reliability as well as improved operation due to one-type training
4) set plot space layout and building and equipment designs that reduced engineering effort
5) set standard purchasing agreements and made great improvements in constructability, such as modular pretested installations.

All of these and other design benefits worked to improve the cost and schedule impact of these electrical projects, thus allowing for additional opportunity to improve the electrical safety, reliability, and maintainability of the refinery with little or no impact on its operation.

ERP Estimates and Schedules

Preliminary-level TIC estimates were created for each distribution substation, utilizing the established design basis. An execution strategy and schedule were developed that aligned with the prioritization scores determined by the overall ranking and the refinery turnaround schedule. An overall cash flow for the electrical infrastructure investment followed from the combination of the proposed execution schedule and the preliminary TIC estimates, providing a baseline for all estimates of impacts and risks to the plan.

Later Updates

The ERP has expanded over the years as a living document that is revisited biannually. Adjustments were made for changing unit outages (turnarounds) and business environment (growth projects) as were additional enhancements that gave the facility the ability to review modifications across the facility to determine the best opportunity to reduce risk for both the site and the corporation.

It was important to identify risks to the business so that these proposed projects could be evaluated on their own merits for the mitigation effects of risk reduction. The business had to adopt a common risk evaluation across all sites. This was put in place after the initial ERP was completed, so alignment of the risk ranking criteria took place with outside peer review and agreement. This solidified the value of the ERP to management.

The ERP has been presented to refinery management and technology leaders at each update to provide opportunity for learning and improvement. This also allows for aligning business goals with the direction of infrastructure investment.

Case Study 2

For most oil and gas refineries, reliability is a key performance indicator that is closely tracked by site and corporate management. This particular refinery has had a strong push from corporate managers to continue to focus on and improve equipment reliability, with the belief that promoting a culture focused on reliability will inherently increase site safety, lower potential environmental impacts, and increase profits.

The electrical team decided to create an ERP that focused on the site's distribution system. The plan was to look 10 years out but with a strong emphasis on the next five years. A total of 43 substations were included in the assessment, with relatively newer substations (<15 years old) being excluded. Although the onsite electrical team had a strong sense for the substations that should be near the top of the list for replacement, detailed justification and prioritization still needed to be developed.

A number of methodologies were reviewed for conducting the ERP study, such as including the probability of failure calculations in the analysis of each substation. Although valid, and most likely necessary as a final justification to replace a substation, this method would have proven to be very complex and time-consuming, given the number of substations that needed to be evaluated. The team determined that calculating the probability of failures solely as a means for replacement would most likely yield results nearly identical to the methodology described herein.

The ERP not only needed to address an upgrade/replacement plan, but also to be written and communicated in a format that nonelectrical personnel could comprehend. One way this was achieved was by aligning ranking criteria with the company's risk-ranking matrices. This allowed management to rank and weigh the recommended electrical upgrade capital projects with other nonelectrical capital projects. The proposed upgrade/replacement plan (similar to Figure 4) was superimposed on the site's 10-year turnaround schedule, explicitly indicating the substations to be replaced, the unit outages being targeted, and the project durations from option selection through construction and commissioning. The resulting schedule was similar to the one in Figure 7. This was ideal and received very good feedback because it was presented in a format that site personnel were very familiar with. The 10-year cash-flow schedule followed, based on order-of-magnitude level estimates (±50%) and was included in the site capital plan.

Another method used to communicate and garner site acceptance was including all potential stakeholders when developing the ERP. This included the site electrical team; electrical maintenance, environmental, operations, and accounting departments; management; and corporate subject matter experts. Stakeholders had the opportunity to review the ERP criteria parameters and provide input at various stages. The team established and agreed on the criteria category weightings and ranking criteria. After the initial substation weightings and rankings were developed, the category weightings were adjusted to better differentiate between substations.

Once completed, the ERP was socialized at the many levels of the company. This was a key, if not the most important, step of the entire process. This refinery is split into three unique processing areas. Each area has a leadership team that meets once a week and focuses on identifying and eliminating defects and improving the area's reliability. ERP findings and recommendations were presented to each leadership team, with the presentation tailored to the area; that is, substations that affected each team's units were the focus. In some instances, the findings from the ERP were critical enough to place into the teams' defect database for tracking purposes. Maintenance, projects group, leadership team, and safety meetings were some of the various additional forums that helped socialize the ERP in the facility. A summary of the ERP was also sent out to all site employees in the weekly "Reliability News" letter.

Refinery electrical system reliability does not end at the substation distribution level. The first phase of the ERP

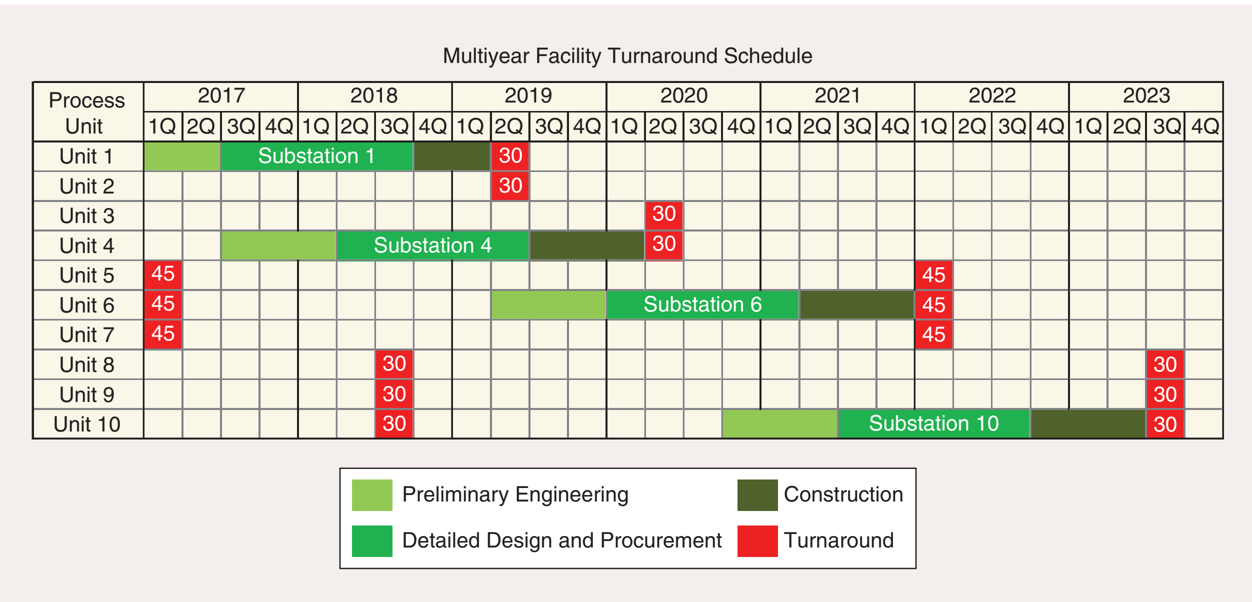

FIGURE 7. An ERP sample implementation schedule shown with the facility turnaround schedule. Q: quarter.

focused only on substations; however, the same methodology is being implemented to review critical power systems (such as UPSs, batteries, and emergency generators), and process-unit utilization equipment (such as motor-control centers, switch racks, and individual motors).

Case Study Takeaways

These two case studies have outlined how the respective ERPs were developed and presented throughout the facilities. These two examples were successful because each location had individuals who were champions for the ERP. If the facility lacks a champion, then the likelihood that the plan will just be shelved is very high. Once the champion and other key stakeholders join together, there is a much better chance for initial and future success.

Some of the key takeaways from the case studies that help ensure a successful plan include the following:

1) business sustainability and growth
   - the realization that utilities and infrastructure positively or negatively affect a corporation's business operation, strategy, and profitability
   - cost/benefit evaluations and risk management
   - safety and reliability enhancements
2) organizational buy-in
   - the value of involving stakeholders from many areas of the operating facility and at the peer and corporate levels
   - adequately socializing the plan throughout the organization
   - organizing the plan's format and presentation in a manner familiar to the facility
3) established parameters
   - agreement on boundary conditions
   - the creation of a design basis for the facility
   - plot space allocation for future electrical distribution system projects
   - facility staff alignment with weightings and ranking criteria
4) continuous monitoring and improvement
   - periodic re-evaluations and updates
   - extending the ERP concept to other areas
   - better maintenance and operational familiarity
   - progressively enhanced cost-effectiveness.

Conclusion

An ERP's primary benefit is creating awareness of electrical infrastructure and how it promotes real, long-term value for the facility. The ERP provides a framework where facility management will be made aware of the risks related to their facility's electrical infrastructure and able to evaluate capital-related decisions appropriately.

The additional benefits of ERP are especially prevalent as a result of developing an established design basis. By establishing an agreed-on basic design of the specific systems, enhanced benefits are realized through

1) better equipment and system familiarity for maintenance and operational personnel
2) reduced future project costs due to familiar engineering and constructability
3) improved electrical consistency throughout the facility
4) increased safety/reduced exposure hours
5) improved organizational metrics regarding costs and schedule.

The ERP, when properly executed as described here, provides a schedule of when the highest-priority electrical projects should be proposed, what they should consist of to mitigate found shortfalls, how much they should cost in implementation, and what risk reductions may be expected. Other opportunities may be found in these reviews as well that do not cost capital but build a reliable, more sustainable electrical system (e.g., feeder relocations, arc-flash reduction, or load leveling).

The ERP provides assurance to facility management that an engineered plan has been developed to address long-term electrical infrastructure needs, which may be used to guide the allocation of available capital toward the highest-value electrical infrastructure project. With the proper plan, the typical gap between electrical infrastructure funding and the facility's business goals can be linked together with a solid bridge that will help ensure real, long-term value toward facility and corporate objectives.

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