ELECTRICAL EQUIPMENT DESIGN CONSIDERATIONS FOR NOW AND THE FUTURE

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II. STAKEHOLDERS

There are many stakeholders involved in a project. A number of these are well known and have always been the key participants, however, with the broader scope associated with projects such as greater integration than ever before, new parties should now be considered as members of the project team; members that have taken a more passive or disconnected role previously.

More stakeholders means additional input and opinions. One of the concerns which has been expressed is that this can also mean unrealistic expectations and limitations which can be detrimental to innovation. The limitations often come from the mindset that they have always done things a particular way and are not willing to change or there is a financial aspect where an organization has not funded something in the past even if the analysis indicates that it is the best direction.

Future consideration should be part of overall project management strategy. This requires buy in from facility owner, facility operator, project management, engineering company, system integrator and equipment manufacturer. This collaboration may need to be agreed upon by all stakeholders and shall be evaluated against their ethics policy.

Fig. 1 All Groups and Experts Need to be Engaged

End users and EPCs have skilled designers and subject matter experts (SMEs) with the required experience and knowledge to put together and implement projects. These skilled persons have historically been divided into distinct teams based on their function and area of expertise working independent from each other for the most part on given a project. EPC and end users are running leaner than ever particularly with the current economic situation in Oil & Gas. Staff reductions, the emphasis on utilization and tighter budgets dramatically limits training due to the cost and non-productive time. The rate of change is also prohibitive since training must be ongoing to keep pace. By the time technology implementation is completed, the idea / technology is out of date. Taking into consideration just the basic power related aspects of a project alone, there are at least three groups who may be assigned to a project for a typical scope possibly more when you consider all engineering disciplines such as civil and mechanical. From the electrical perspective, there are usually 3 groups.

A. The Power Distribution group focused on the incoming supply to the installation who will coordinate with the utility, local generation, select the necessary switchgear along with the network aspects of power supply, ~~and~~ distribution and control
B. The Process Control group which will address specifying the motor control
C. The Control and automation group which oversees the design and programming of the network and the required network aspects associated with the process.

These 3 groups have specific design responsibilities ranging from engineering studies which must be performed to control and deliver related objectives that they must achieve with the network which is deployed. Historically these groups have worked independently such as meeting with their prospective providers in isolation from the other groups. Where these groups have interacted usually is in defining the information which must be shared across their unique systems which often communicate using different protocols. The reason that these protocols are different is because these groups have worked as independent entities. This is how it has been and in discussions with each group, they value their segregation to a certain degree and the fact that this allows them to exercise control over their area. As a result, SCADA systems are necessary and commonplace as they are necessary to marry these independent systems together at least to the point that the necessary information can be transferred.

Things are changing.

It is now possible to use a common protocol to connect the power distribution control system directly to the process control system which brings numerous benefits. Recognizing this, companies are beginning to change their outlook and are now bringing these groups together earlier than ever before. At a few progressive companies, representatives from each of these groups participate in the evaluation of technology options and set corporate standards for the network and for the components which will be connected to the network so that base requirements will be met.

Other stakeholders that should be taking a more active role earlier in project design are IT, Operations and

Maintenance. Looking out even further, a Connected Enterprise will cross the barrier that has existed between IT and OT such that the front end of the facility can obtain key data directly from their OT system. For these later items, we will discuss this in more detail later in the paper. Another group which is playing an increasingly greater role due to the current economic circumstances are the equipment suppliers or vendors. In a conventional project execution, equipment vendors are not recognized as part of the project team until the PO is placed. The equipment vendor /suppliers bring with them the latest technology; what is available today and what will be compatible for tomorrow. By engaging equipment vendor / supplier early for technology selection and future technology inclusion, project management can benefit from latest technology.

A further aspect is the delegation of work to lower cost centers - workshare. Companies like to delegate certain aspect of design and support to other office – workshare getting is getting more and more popular to reduce the cost. In todays' market, how the right information is shared with workshare offices, maintaining schedules and remaining within or under budget is the first aspect that companies consider. Whether component level detail such as patented confidential technology or other IP must be shared or not with a remote office is a valid question if they do not require it. Sharing only items that need to be communicated should be the approach. More communication some time doesn't mean more understanding. During the workshare with offices across the globe, the project management team should make sure that the plant under design is considering the aspect of future design of upgrade or expansion getting done.

III. SYSTEM DESIGN & REQUIREMENTS

One of the first challenges will be to select an overall approach that meets the expectations of all stakeholders and will stand the test of time for all aspects of the project scope. Coordination of industrial automation and control systems including Process Automation systems and SCADA systems requires robust networks that connect thousands of IEDs reliably. In addition, today's industrial requirements are increasing the demands on network infrastructure. Networks are expected to handle increased network traffic and security services while delivering a full spectrum of real-time control and monitoring capabilities within a site-wide operating environment.

A robust system which has capability and capacity to not only expand but to accommodate new additions which will undoubtedly arise over the life of the installation is a fundamental and key starting point. The system needs to be sustainable. While forward compatibility is certainly an important factor, it is not the only consideration or answer to the problem. Items such as component life cycles enter into the picture. Is the equipment that is being chosen today going to be supported over the life of the installation?

A. The System

- *Network - Field Network Infrastructure*
  - *Scalability*
  - *Expandability*
  - *Reliability & Redundancy*
  - *Remote Accessibility*

B. Elements of System Design

- Asset Management
- Management of Change
- Accessibility

Most modern IED do not support individual user account and have a single set of passwords. For future considerations IED may be selected that support individual user account. IED with individual user account poses another level of challenge where password management system need to be implemented looking at any typical complex network of components and devices on any petrochemical or Oil & Gas facility.

IV. NETWORKS

Communication protocol is very important consideration. For green field project this may be simple solution on apparent basis. As many organizations have a preferred way of communication at their existing facilities, this may prevent the selection of a more suitable network protocol for the entire facility under design. For brown field projects, this may be even more challenging due to variation between legacy systems at an existing facility.

Network scope, security & communication protocol are the most important aspect of this discussion[1][2]. Information Technology or the IT network is part of the solution and have equal stake in the process.

Other considerations when looking at the network are robustness and redundancy.

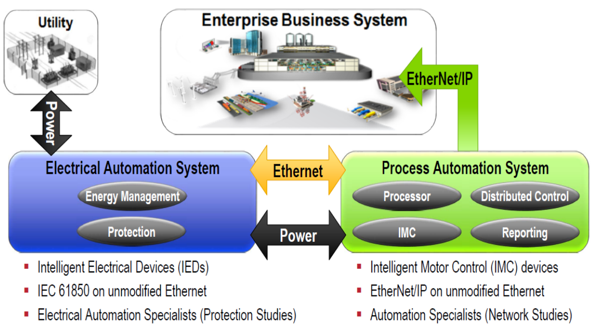

Fig. 2 Network Incorporating Electrical and Process Automation Systems

A. Process Control

Process control is the most important aspect of safe plant operation and production of any industrial commodity. With more and more IIoT devices and equipment connected over network through various communication protocol are major stake in the cyber security of industrial plant.

While it is comparably easy to reboot computers on an IT network, computers & servers on OT are not so easy to reboot on frequent basis as it has more consequences in terms of financial, environmental and plant safety perspective. While selecting OT systems designer may consider following points:

- Adequate design and strong system architecture
- Adequate and expandable hardware software capabilities
- Network configuration for future protocol compatible
- Secure connectivity with Ethernet
- Secure enforcement
- Plan for crisis situation
- Strong password policy
- Redundancy
- Adequate backup power supply (EDG, UPS)

Additionally change management should be a part of system architecture.
The OT computers / server may be equipped with on board logic and parameter for safe operating conditions and compare the real time command received for execution. In case of any unsafe received operating command it can send an alarm to operator / supervisor using different channel.

Other considerations may include, Industrial component and equipment working on power over Ethernet. More industrial component, devices and equipment are now available running on PoE (Power over Ethernet) than ever before. Industry analysts forecast the global industrial power over Ethernet (PoE) market to grow at a CAGR (compound annual growth rate) 15% during the period of 2019-2025. Selection of these devices will reduce the capital cost investment and make industrial plant more future compatible.

B. Power Distribution Control

The power distribution control through network and IIoT devices will determine the future of network. With more and smaller renewal power sources connecting to the main grid of the power distribution network, this aspect is more important than ever before.
PMS system should be capable of providing intrinsic and extrinsic capabilities with ability to logically separate from more than one firewall [9].

C. Substation Automation

The conventional substation RTU is now replaced by IEDs, PLCs and integration network using digital communications. Intelligent electronic devices (IEDs) being implemented in substations today contain valuable information, both operational and non-operational (for the purpose of enterprise management). Substation automation is getting more sophisticated and smart relays and other logical devices will control and operate the substation equipment using automation. AI need to consider the network security aspect to avoid any mal operation of substation equipment.
One of the challenge is to apply software update patches on server. A system needs to be developed for software maintenance and compliance. Testing should be completed before updating software. Substation automation development and testing plan need to be developed along with SAS designing.

The PLC which were not typically connected to network are now connected to network a comprehensive approach including cyber security needs to be developed for new facility. A multilayer substation security approach may be developed to deter hackers and provide more time for security software to counteract cyberattacks.

On top of that we have a Control System group who takes care of DCS and PLC which will also be communicating over network.

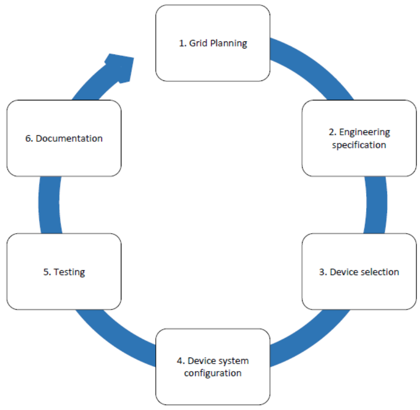

Fig. 3 Digital Substation Design Process

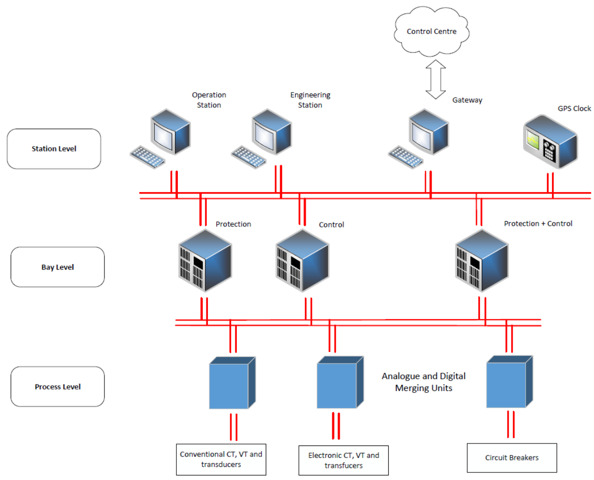

Fig. 4 Digital Substation Layout

Today's substation automation can provide important information for Equipment Condition Monitoring (ECM). With ECM equipment operating parameters are automatically tracked to detect any abnormal operating conditions. Data from protection, control and monitoring IEDs can be used to understand health and performance of substation equipment. Full blown substation monitoring system can be developed from existing IED and SAS.
Developing trends in Optical electrical technology and non-conventional instrument transformer shall be consider for future plant design to accommodate future technology that might show up later in plant life cycle. This non-conventional instrument transformer uses fibre optic cable for communication which will result in massive reduction of copper control cable requirement and so the installation cost. This will reduce the CAPEX of the plant.

V. SECURITY

Unfortunately, the need for security goes hand in hand with increased accessibility. There is a very real threat as can be seen by the most significant reported cyberattacks of the decade listed below, however, there are numerous smaller incidents which may not be reported as well[3][4].

Stuxnet - US & Israeli governments
Shamoon - Iranian state backed hackers - Saudi Aramco
Sony Hack - North Korean attack on Sony pictures
Office of Personnel Breach - Chinese government
Ukranian blackouts - target control systems
Shadow Brokers - North Korean hackers - utilities, etc.
2016 US presidential hack - Russian hack of Democrats
NotPetya - Russian hacking group - devastate networks
Equifax Data breach - Target, Home Depot, etc.
Aadhaar - Indian government breach

Design engineers are challenged to bring, as a business case, network security related solutions which mitigate risk to project decision makers in order to help make an informed decision. To do so the design engineers need to quantify the risk based on network vulnerability and process plant operation hazard scenarios on the other hand decision makers need to stay away from media hype for IT related security breach.

Fig. 5 IT Best Practice of Passwords Allows Security Team to Define Who Can Access and Where Accessed

For any system, there is a tradeoff between accessibility of information and system security. One of the factors which is key and will help determine what is required relates to how much access is really required to meet the needs of the project.

IT will also be part of this design aspect and are equal stake holder. IT should be able to provide the supportive network for the requirement of the plant design. This goes in to Firewall and physical barrier that IT might have consider for their design. The project electrical design team needs to be aware of this aspect of IT design and make any plant communication approach compatible with current and future IT requirements[5].

The current practice of protecting equipment and devices using firewall technology is similar to the medieval technique of protecting the asset with wall. The thicker the wall that is built around the asset, the more it is isolated and a reduced resource in case of need. A heavily fortified structure is perhaps not the best strategy. Cyber security should be inherent to system with proactive monitoring embedded in the solution rather than protecting from outside. Defense in Depth is a technique which does not simply count on a solid firewall alone. It goes further by monitoring what is happening, raising alarms and can take action when it is recognized that the system is under attack. Continuing the analogy, this is similar to putting cameras at the castle wall which will alert the owner to the attack preventing a sustained attack from being effective.

Process control equipment, power distribution control equipment and substation control equipment connected over network communication under various protocol must all be considered[6][7][8]. EPC companies and vendors using the distributed resources across the globe for plant design or product development puts the process at risk and compromise network protocol that can only be visualize once the attack is visible. Plant design or product development is a long vigorous process and sometime more communication does not necessarily turn to more understanding. To develop more understanding most of the time intellectual property is compromised.

In a typical plant design project management team used BRMS (Business Risk Management System) plan to identify and mitigate risk. In the same line we are proposing here to develop BiRMS (Business intelligent Risk Management System) plan to identify, handle and mitigate intelligent.

Advent of IIoT capabilities provides a natural method of attaining the needed information. Using this information effectively without causing any additional risk requires innovation. Design engineer can use these IIoT capabilities and may take the innovation challenge for plant design.

Here are some areas of Cyber security that needs to be consider for plant design. Cyber security strategy focus areas are grouped by: [NIST 800-82]

- Planning
- Incident prevention
- Detection
- Containment
- Remediation
- Recovery & Restoration
- Post incident analysis / Forensics

Incidents are inevitable and an incident response plan is essential. A major characteristic of a good security program is how quickly the system can be recovered after an incident has occurred.

Following special considerations are required when considering security for ICS:

- Timeliness and Performance Requirements
- Availability Requirements
- Physical Effects
- System Operation
- Resource Constraints
- Communications
- Change Management
- Managed Support
- Component Lifetime
- Component Location
- Risk Management Requirements

For risk management requirements it is important to note that any security measure that impairs safety is unacceptable.

Conventional management is well versed with the layered approach for HSSE implementation. Layered approach of HSSE can help us in defining Cyber security. The layered approach is:

- Elimination – Network Isolation
- Substitution – Block unused port via software or physically
- Engineering Control – Automatic password management, Firewall, Patch management, N+1 server
- Administrative Control – Training, Password policy, Access Control, Risk ranking

- PPE – Crisis plan

The best way to address any uncertainty and fear around cyber security is to incorporate security in the overall business plan and strategic objectives for the organization [1].

VI. DATA MANAGEMENT

During the design phase, EPC Companies produce massive amounts of data for building the plant. How we can make sure that the same data is transferred and used for the plant operation? Engineering plans or strategy documents shall be developed that define object level attribution and other necessary information for plant operation. The component and devices selected for the purpose should be able to communicate the actionable data package.

With more and more facility Owners seeking dataset developed during detail design phase to transfer for plant operation. It is essential to distinguish the data requirement for plant design, plant construction & commissioning, and plant operation.

- Data set required to complete engineering design
- Data set required for plant mechanical completion and pre-commissioning
- Data set required for plant commissioning and start up
- Data set required for plant operation and maintenance

Not all the data set developed during detail design phase is actionable for plant operation and analytics. The EPC contractors, Owners and Vendors shall identify the required data set for each purpose to avoid duplication of data and accumulation of non-relevant data in the communication network.

Data gathering and analytics – The system should have capacity and capabilities to collect relevant data or actionable data that help in data analytics to make decision based on the AI.

With convergence of OT and IT, industrial communication networks are connected to internet web more than ever. Advances in IED, IIoT and AI pushes the boundary further to communicate non-technical information to enterprise management for commercial decision making, technical decision making and plant operation. What are the business risk involved in merging OT and IT? What strategy business planners need to develop to mitigate the information exchange risk from one platform to another? How business planners can make informed decision about industrial cyber security for OT? The intention of this paper is to look at the changing landscape for the business planners, decision makers for selecting level of OT and IT merger. Developing business information risk mitigation strategy without compromising safety of personnel, equipment, environment & community without driven by media hype for cyber security breach.

Design engineer may consider that component selected for plant are compatible with IT and IT security requirements. Plant operators lean more towards the data collection and analytics that provides information for predictive maintenance and condition based maintenance. This data help minimizing the impact of component failure on plant operation. Design engineer may consider to select the component or equipment under consideration will be able to communicate to current network and future network or other complex network that it will be connected over the plant life cycle to fulfill the maintenance requirement.

Plant owners and executive management team are more interested in consumption and production data for the purpose of data analytics. The relevant data set needs to be available and communicated over network. One aspect of these communication can be linked to metering point. This metering point can be for any commodity including utilities.

VII. SPECIFICATIONS

A. Equipment Specification

Equipment specifications are the usual starting point of defining the equipment design once the overall concept has been agreed upon. The engineer responsible for preparation of equipment specification, need to consider following aspects other than all normal technical consideration made while doing a conventional design:

1) *Connectivity with other operating device*
2) *Cyber security of all connecting devices in chain*
3) *Failure mode protection of network activated device*
4) *Safe communication over the spectrum*
5) *Separate network identification for safety critical device*

B. Facility Specifications

Engineers and designers responsible for preparing facility specifications need to consider following aspects other than all conventional considerations made

1) *Secured IT network and suitable IT infrastructure for providing protection to devices, equipment and network*
2) *Network safety for devices and equipment for manned facility*
3) *Network safety for devices and equipment for unmanned facility*
4) *Define resting position or safe position for equipment / device for unmanned facility*

C. Operational Specifications

Engineers and designers responsible for preparing operational specifications for wired or remotely operated device and/or equipment need to consider the following aspects other than all conventional considerations made

1) *Safe operation in absence of network*
2) *Operational sequence check over network*
3) *Device / Equipment network safety for human interface machines*
4) *Device / Equipment network safety for machines with no human interface*

VIII. EFFICIENCY & COST OF OWNERSHIP

Efficiency has always been a consideration in system design, however, even more emphasis is being placed on this today. There are several reasons for this with the most important depending on your perspective[9].

The current economic situation with respect to oil requires major cost reductions to remain profitable. One of the leading costs to produce is the energy required in the phase of the extraction to market process. Further to this are the environmental aspects with penalties such as carbon tax either in effect or imminent making this both an environmental and cost saving factor. Both of the aforementioned points are very important from the end users point of view. For the EPC Company, the importance of efficiency depends upon the type of contract that it is dealing with. For a cost reimbursable project, it is not so important. In the case of a lump sum project, the capital cost of the project is the driving motivation. If the EPC company can reduce the CAPEX significantly, the higher operating cost (OPEX) will be passed on to the owner operator. The vendor will look at efficiency as selling point with a justifiably higher price tag, however, the efficiency savings get lost during the conversation between vendor, EPC and the end user. There are contracts which can incorporate an efficiency / energy savings component but this is the exceptional case.

The manner in which the procurement process is done needs to be changed if energy reduction is truly a key objective[10]. Conventional procurement methods evaluate on the basis of technical compliance and then cost. New methods should allow evaluation of energy efficiency as a primary consideration. On the basis of current methods, a less efficient machine, which has a lower cost to produce, will win out in the selection process due to a lower CAPEX over a more expensive premium design which can easily overcome the cost difference in the short term, realize better environmental compliance and cost of ownership in the long term OPEX.

IX. CERTIFICATIONS, SPECIFICATIONS & STANDARDS

With more companies, countries, regions and even joint partners (such as IOGP - JIP) developing their own standards, this is leading to a more complex web of codes and regulations that are being imposed not only on the equipment manufacturer but on the EPCs, system integrators, plant operators and owners as well. With more regulations and regulatory bodies asking for their own certifications and compliance, this puts more economic burden on the whole design cycle as well as obviously on product vendor related to the development and testing of product to each of the arbitrary requirements of each regulatory body in addition to their usual development costs. This also makes vendor to develop and get certifications for selective market based on financial return on product. This selective development and certification can lead either to no availability of certain technology in certain regions or non-compliance of components such as IIoT devices over the network. This particular aspect needs to be addressed when creating specifications. Engineers need to realize that requiring unnecessary local code certifications or asking for a product certification that is either not available or will add a cost to the project should be identified and avoided where possible.

The global demand for codes standard and certification is increasing and diversifying to group of companies. Everyone needs to find a better path to make a marketable product that meets the need of industry at an affordable rate.

X. TIMELINE / LIFECYCLE

The authors believe that there are 4 distinct phases in the timeline of a project.

- Design
- Commissioning
- Operation
- Decommissioning

Factors discussed in this paper impact each of these phases in different ways and to varying degrees.

A. Design

The majority of the discussion in the paper has been with respect to initial design. This is the area in which the authors have experience and expertise.

B. Commissioning

EPC companies develop design documentation for plant construction and commissioning. The EPC companies program the process control automation software and the substation automation control automation software. Very important data set can be carved out of the design data set for pre-commissioning and commissioning purpose. The design data set can be helpful in developing mechanical completion plan and commissioning activities plan.

C. Operation

Some may argue that operation is not to be considered as a part of a project. In fact, once operation starts, the project is considered to be over for some stakeholders. The reality is that, while this philosophy may be a good approach for some team members to limit the scope to what they wish to focus on, this is not reality. A facility is dynamic and evolves over time along with the personnel that occupies it.

For predictive and condition based plant maintenance, increasingly more devices and sensors are used in industrial plants worldwide. These devices will be designed for and part of a connected network which will continue to expand over the life of the facility as the demands for input information expand.

D. Decommissioning

Decommissioning is a planned activity for Oil & Gas, Life Sciences and Nuclear plants. Various levels of government agencies and regulators are getting stricter with respect to the decommissioning of plants. For control decommissioning design data, historical data archived during plant operation and changes made during plant life cycle is very important. In addition, for future and trend considerations, owners, operators and regulating bodies would like to keep data set after decommissioning of the plant.

XI. RECOMMENDATIONS

In the paper to this point, we have primarily discussed the challenges which are associated with designing the ideal plant. Items that the authors see which we believe are important questions to ask and items to address throughout the process are as follows

- Include all stakeholders and affected areas in the organization in all key milestones of the project as a minimum including system design, reviews and implementation. Earlier in the paper we suggested IT and Operations & Maintenance should participate throughout the duration of the project and evaluate things as they become available.

- Existing work flows need to be re-evaluated to ensure that the aspects being discussed in the paper are addressed. Examples of items that the new work flow must take into account are the additional stakeholders, the earlier involvement by these parties in the process and scheduled / defined test checkpoints to name a few.
- In a typical plant design, the project management team uses a BRMS (Business Risk Management System) plan to identify and mitigate risk. In a similar vein, the authors propose the development of a BiRMS (Business intelligent Risk Management System) plan to identify, handle and mitigate intelligent issues.
- Spend more time at the initial design stages insuring that all foreseeable factors have been addressed and considered up front.
- As a team, keep an open mind and evaluate all possible directions. Encourage the imagination and solicit feedback from the project team with the potential of smart, scalable, connected technology.
- There should be a clear definition of the responsibility of each supplier of equipment and/or services. This should include the functional requirements in both normal and abnormal (fault) conditions. Precise means should be defined for demonstrating that the required performances are met both during the design phase, during FATs, during commissioning and during plant operation. For systems involving several users, diagnostic equipment should probably be supplied that can be used during system operation to detect any malfunctions.
- Digital 3D models can be used to test designs for functionality as well as to do trials during development. Further along in the project, these same capabilities can be used to give advance training pre-commissioning and for new machine operators post commissioning. They can also be useful in real operation and maintenance.
- Extensive testing should be required from the design phase through to final commissioning in order to ensure that the systems at site will operate correctly. System testing is very expense and time consuming and often not enough time is allowed in the project schedule. The test requirements are based on the performance requirements mentioned above.
- Maintenance is a very sensitive subject since failures in communication systems could result in larger outages than failures in individual pieces of other types of equipment. Also communication system maintenance would require a high level of expertise which most likely would not be available at site. Ideas such how to identify faulty equipment, use of hot swapping, configuration of replacement devices etc. should be included, with recommendations on what to do. What about testing after a replacement device has been installed? How can this be done with a plant in commercial operation?
- Modifications, extensions etc. can happen during plant operation. How are the systems to be designed to allow this to take place without minimal loss of production? How can communication systems be adapted at site without risk of incorrect operation of existing devices?
- How are the different versions of firmware, software etc. to be handled? Even during manufacturing, the same types of devices may have different versions of firmware and/or software. Who determines when firmware/software should be modified and how it is to be done without risking loss of production.
- Realize that what is implemented in the project must survive the life of the asset. Typical plant design life is considered to be 25 to 35 years. Typical project implementation is several years prior to that. Do you want to begin with old and dated concepts considering this facility is to operate to 2060?
- With increasing technology and the pace of change, it is difficult if not impossible for one provider to be the best in all technical areas and technologies required in a project. Farm out areas which require absolute state of the art capabilities.
- Design with a view to upcoming requirements and capabilities - Analytics, Augmented Reality, etc.
- Longevity of key companies, technology and support. Are the providers going to be there in 40 years to support the asset?
- Is the lowest capital cost the best option for the project considering the total cost of ownership? Have OPEX costs, licensing, maintenance costs been considered in the overall picture?
- Can the end user be involved earlier in the design and hand off process? While this does open things up to the potential problem of pushback by those who “have always done it this way”, it is better to address this up front with information sessions and trial runs, etc.
- Determine whether there is there an actual need for remote access and to what degree when considering the approach. Do we want to just include remote access or unmanned operation of the facility as an option because of a definite need or is it because most facilities are moving in the direction of unmanned remote operation.
- Investigate whether the selected equipment, components and devices have a lifecycle and migration path to support the equipment for the timeline of the project.

- Evaluate the technological capabilities, present equipment, components and devices along with the future 5 year development plans for any primary suppliers.

XII. CONCLUSION

With the rapid pace of change and the complex scope of most new projects today, it is increasingly important to establish the correct functional approach and team members to address a project. This team should not only include all of the key stakeholders as discussed in the paper, this group needs to review the project on a regular basis to insure that the key objectives continue to be met as things progress and evolve such as things often do particularly for those initiatives with extended timelines. With the rapid pace of change and innovation, the challenge will be to have a concept which remains state of the art over the course of several years prior to commissioning let alone after.

Furthermore, objectives and requirements can change from initial concept of the project to those that will be required once in operation. Examples are items such as environmental compliance requirements (carbon capture) and other regulatory requirements which can change dramatically during the period of the project.

The archaic law / code system is not able to keep up with the latest trends in technological development, it will be a challenge for design engineer to design a plant / equipment / component that will be compatible for future technology and at the same time make it suitable for today's code compliance.

XIII. REFERENCES

[1] R. Paes, J. Ostrzenski, D. Fordney, I. Wrigley "REDUCE TOTAL COST OF OWNERSHIP VIA THE INTEGRATION OF INTELLIGENT FIELD DEVICES

[2] D. Mazur, W. Stewart, H. Clark, R. Paes "ANALYSIS OF PLC vs. DCS IN INDUSTRIAL PETROCHEMICAL APPLICATIONS" *IEEE PCIC Vancouver 2019*. Paper 2019-31

[3] J. Flores, A. Martinez, J. Zaccaria, R. Paes, "YIKES! ARE PLANT CONTROL AND POWER ASSETS SAFE FROM CYBER-ATTACKS?" *IEEE PCIC Europe 2014 Amsterdam Paper AM-53*.

[4] J. Flores, A. Martinez, J. Zaccaria, R. Paes, "CRITICALITY FOR PLANT CONTROL AND POWER ASSETS TO BE SAFE FROM CYBER ATTACKS!" *IEEE PCIC Europe 2017 Vienna*. Paper EUR17_71

" *IEEE PCIC Europe 2016 Berlin*. Paper BER-73

[5] R. Paes, D. Mazur, B. Venne, J. Ostrzenski "A GUIDE TO SECURING INDUSTRIAL CONTROL NETWORKS – (IT/OT) CONVERGENCE" *IEEE PCIC Calgary 2017*. Paper 2017-10

[6] H. George, A. Arnett, "A CASE STUDY OF IMPLEMENTING CYBERSECURITY BEST PRACTICES FOR ELECTRICAL INFRASTRUCTURE IN A REFINERY" *IEEE PCIC Vancouver 2019*. Paper PCIC 2019-11

[7] R. Preston, M. Duck, C. Finnegan, R. Munoz, "INTEGRATING CYBER SECURITY REQUIREMENTS INTO A POWER MANAGEMENT SYSTEM" *IEEE PCIC Vancouver 2019*. Paper PCIC 2019-14

[8] O. Sikander "UNLOCKING OIL AND GAS SECURITY SYNERGIES" *E&P Magazine January 2020*.

[9] R. Paes, M. Throckmorton "THE INSTALLATION AND SETUP OF A VARIABLE SPEED DRIVE FOR OPTIMAL PERFORMANCE" *IEEE PCIC Europe 2017 Vienna*. Paper EUR17_52

[10] R. Paes, B. Toner, G. Bankay, G. Agashe "ENERGY OPTIMIZATION IN PETROCHEMICAL PROCESSES" *IEEE PCIC Vancouver 2019*. Paper 2019-37

XIV. VITAE

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