The Theoretic to the Practical:
End User Value Propositions for Connected Power Assets

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Introduction

Okay, we get it, asset connectivity is the next revolution of humanity, and its impact will arguably match or surpass those of the Industrial Revolution and the Internet. Global leaders of industry are blazing a path to a connected world where tech acronyms are the new norm in job titles and $1B enterprise initiatives, i.e. IoT (Internet of Things), IIoT (Industrial Internet of Things), IoE (Internet of Everything), M2M (Machine to Machine), TOIs (Things of Interest), to name a few, but what does it really mean for you and me?

Networking industry leader Cisco estimates that 50B ‘things’ will be connected to the Internet by 2020, up 100% from 2015, and will subsequently grow to 500B after that – that network IP traffic will triple over time[1]. Today, with 200 connectable ‘things’ per person in the world today, 99.4% of physical objects are still unconnected[2].

In a time when we read about breaches across government agencies, big-box retailers, financial institutions, and even security providers themselves, it is sometimes difficult to really see an impact other than exposure, vulnerability, and threat where the only clear value becomes an insurance policy with upgraded systems and firewalls for the masses. However, what can confidently be stated and will be discussed in this writing is that when working closely with power system end users, clear and quantifiable benefits can be had for Internet-connected power assets and intelligent power systems in remote and critical high horsepower applications.

Quantifiable Value Propositions in a Difficult Budgetary Environment

Lots of smart people within industry-leading companies have written lots of great papers that continue to impress with the ever-increasing quantifiable magnitude and growth statistics of connected and intelligent devices. However, what seems to often be difficult to link is the benefit for end users with applications of lower magnitudes than a 500 MW single power installation, for example, and what one can do about it in the next two weeks to not miss the connectivity boat before it leaves port.

To use a specific example, in an application below 25,000 paralleled brake horsepower (bhp), or kVA, in an on-shore drilling rig that typically has around 4,500 bhp continuous (rated) power available on-site, it doesn’t take long (about a week) to go through a 10 – 15 thousand gallon fuel tank and, regardless of the recent fluctuations in day rates, interruptions to operations can be costly (and arguably more precious in a macro-environment with increased pressure on cost containment). Additionally, when work forces must be reduced to remain competitive and safety is of the highest criticality, value propositions seem to be obvious. The same can be said for any (fleet of) continuous / critical high horsepower applications, such as marine, rail, off-shore drilling, independent power production, etc. – value propositions are consistent. At the end of the day, Internet-connected power assets and intelligent power systems, including those in remote locations and critical high horsepower applications, save end users money from the perspective of total cost of ownership and safety – relevant value propositions for any budgetary environment; when working closely with end users, identifying and addressing pain points can save end users and consumers a significant amount of money despite an increased capital investment for added equipment, engineering time, and the connected infrastructure costs.

End-User Value Driver	Result	Operational Impact
OPEX (Fuel savings, Cost per kW)	Lower Operating Budget Significantly	Cost Of Ownership Goes Down Significantly for High Horsepower Critical Power Systems
CAPEX (Cost per kW)	Increased Initial Investment	
Dependability, Reliability, Safety (Cost of failure / Opportunity cost)	Improve Reliability / Uptime	
Regulatory Constraints & Safety (CO_2 / NO_x emissions, Power quality, Recordables)	Agency Compliance and Safety Improvement	
Ease of Use (Human to Machine and Machine to Machine compatibility)	Improve Organizational Efficiency and Reduce Redundancy	

Figure 1. End User Value Propositions for New Build or Retrofit for On-Shore O&G Application.

Specifically, we estimate that from the perspective of CAPEX avoidance (premature replacement of operating assets), OPEX avoidance (premature rebuild / refurbish of operating assets), reduced downtime, reduced unplanned maintenance, and fuel consumption cost avoidance, it is feasible to target a 25% reduction in cash flow annually for any particular on-shore oil & gas drilling rig over a course of 7 – 10 years with connected power assets and intelligent systems onboard. These numbers exclude any cost avoidance due to improved workforce safety and organizational efficiency gains, as these considerations would vary somewhat based on organizational structure, which would likely further reduce spending. Depending on high horsepower power application, processing and software content installment, and end user appetite to employ various levels of systems, these figures will obviously fluctuate.

Channel Complications for High Horsepower Applications

One of the most complicating elements of high horsepower applications are the many levels of the sales and support channel and the various motivations across each. It should be noted (again) that one of the most fundamental drivers of industrial change and the foci of this writing are around the needs of end users of equipment (in the forms of improved OPEX, improved dependability / reliability / safety, regulatory constraints / safety, and improved ease of use). For example, if a purchasing agent somewhere mid-channel buys on selling price alone, it is possible that this agent would see increased personal compensation due to project savings, when in fact, the pain of the end user (that the purchasing agent works for) can be opportunity cost in the form of forfeited day rates, or otherwise, when a product of poor quality fails unexpectedly or operates with low efficiency.

Similarly, connected power assets and intelligent systems deliver monetary benefits to the end user, not channel mid-points, so it is imperative that products be developed understanding the habits, needs, and circumstances of the end users, as return on investment is contingent upon their use case. It is absolutely necessary to work closely with end user partners, listening closely to the Voice of Customer throughout the process to deliver the best possible user experience, and provide a solution to *solve* a problem, not a solution *looking* for a problem. Connected power assets and intelligent systems wring operational opportunity out of the site when implemented properly and the assets are running; this provides an annuity of savings for the end user.

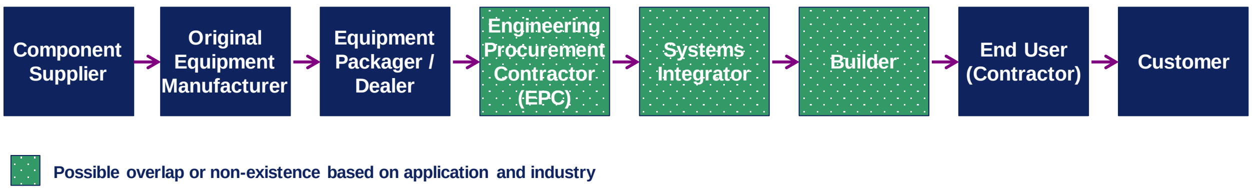

Figure 2. High Horsepower Power Equipment Sales and Support Channel.

Technical Feasibility

In first-world markets, we are all consumers of technology and are conditioned to a lifestyle where we take our personal devices everywhere…we know the benefits (and shortfalls) of a connected world and can make the mental technological leap, where impossible becomes feasible and then even expected. Barriers are being removed with technological innovation, rapid steps of incremental forward movement, and global competition, specifically in the areas of mobile / wireless communications, cloud computing, and processing capabilities (local and remote) to the point where costs are palatable for a much larger audience – a connected world is more accessible than ever.

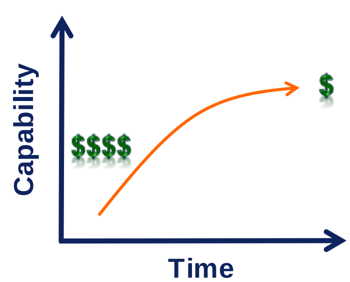

Figure 3. Mobile Communications, Cloud Computing, and Data Processing Evolvement.

From a power systems end user perspective, it is now possible to capture high speed performance anomalies that can exist anywhere within a connected system, including energy input, combustion events (as a result of varying fuel quality or a wearing component), generator bearing vibration and insulation health, and total electrical system performance, to name a few. We are at a point where we can explain deviations from expected levels and system correlation when elements such as variable fuel quality (less or more complex hydrocarbons and increased levels of inert combustion elements that may exist in nature) and sometimes unreliable / unavailable field personnel are a fact of life.

$$C_\alpha H_\beta O_\gamma N_\delta + \frac{a_s}{\phi}\cdot(O_2 + 3.76\cdot N_2) \rightarrow$$

$$n_1\cdot CO_2 + n_2\cdot H_2O + n_3\cdot N_2 + n_4\cdot O_2 + n_5\cdot CO + n_6\cdot H_2 + n_7\cdot H + n_8\cdot OH + n_9\cdot NO + n_{10}\cdot N + n_{11}\cdot C + n_{12}\cdot NO_2 + n_{13}\cdot CH_4 + ...$$

Figure 4. Combustion[3]: Different Volumetric and Energy Level Inputs at Various Operating Nodes Result in Changes in Prime Mover Performance Stability (faster / slower combustion, in-cylinder temperatures, etc.) / Power Output / Emissions Levels.

We have broached a new world where operational theory can be applied with specific rules (based on decades of data capture and application expertise from a massive installed base) to critical assets in nearly real-time; all the while, the logic rules continue to get better and learn during operation. It is conceivable to connect the dots of components and sub-systems to explain, control, and optimize total system performance. Spooky, perhaps, but invaluable when trying to protect and enhance the operation of a critical asset at the lowest possible cost of ownership; the most value is unlocked when using all of the information together in concert as a complete system, not individual components.

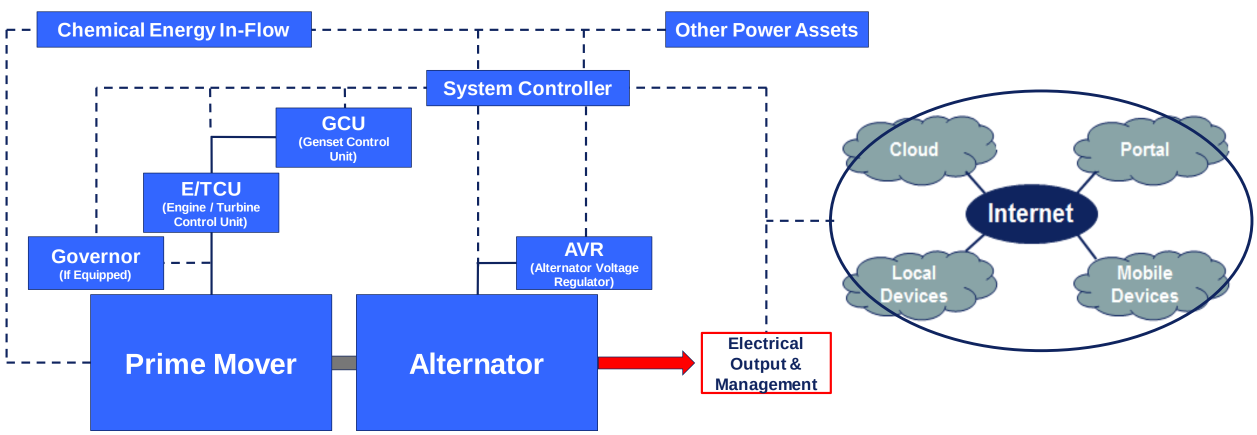

Figure 5. A Holistic Power System Approach Unlocks the Maximum Value for the End User.

Ultimately, the summation of the parts comprises the power system, not an individual piece or assembly. The process of converting chemical energy (for fossil fuel-based power systems) to mechanical power to electrical power, which the end user ultimately buys, is a multiplicative process. Thus, efficiency, failure, and optimization are not isolated to one space, but are the product of everything working as a whole on-site and must be considered together. When high-speed computing, operational algorithms, and remote connectivity are applied, the quantifiable benefits become reality with an installed base as they too evolve from monitoring to data extraction / asset optimization to predictive behavior to preventive behavior and control.

Finally, a connected system discussion would not be complete without security. Typical and consistent feedback from end users across industries is that security is of the highest concern. While no one ever wants to be on the front cover of the newspaper for a breach, it is the world in which we live. No system will ever be 100% secure (if someone says this, they are either lying or they simply don't know better), but it is possible to have a fairly hardened system, particularly when architecting it from the ground-up across the layers of Open System Interconnection (OSI) with security as *the* top priority; it must be culturally engrained as a moral responsibility.

Summary

When focusing on end user pains, it is possible to deliver innovative and quantifiable value to mature industries, particularly with the rapid advancement of technologies and where a significant amount of domain expertise can be leveraged, i.e. electrical power management in critical high horsepower applications. No one expects adoption to occur overnight, and opposing concerns such as cultural inertia and fiscal uncertainty are always around us, but it is difficult to argue saving money as opportunities continue to be increasingly made available with the natural deployment of the connected world around us. Security will always be a threat, but if consciously addressed up-front, directly, and continuously to mitigate risk, responsible developers and corporations alike can clearly benefit in industry from technology in the same ways that we have come to expect in our personal lives.

Resources:

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3. Heywood, John B. *Internal Combustion Engines Fundamentals*. McGraw-Hill, Inc., 1988. Print.