4IR, IoT and other important changes facing Off-grid Professionals by 2020.

By Mark Dettmer & Frank Lanier

Remarkable trends are changing the way professionals view electric power distribution as the world moves towards the year 2020, with none more noteworthy than the generation and availability of reliable, off-grid electric power at any given location. For over 75 years the meaning of power distribution typically referred to the Grid - a network of alternating current (AC) power generation stations distributing electricity through a system of transmission stations, substations and transformers via a series of wires stretching from power station to home, office and factory.

Even as late as the 1990s, reliable electric infrastructure was deemed available as long as you could reach a site with AC electricity connected to the Grid. It is important to note that throughout the 20th century, almost all electrical devices were designed to use AC electricity, whether 220V (as in Europe, Japan, and Oceania) or 120V, as is the case in North America. During most of that same time, direct current (DC) was viewed primarily as a means to power flashlights, small radios and the like.

Before the term “Micro-grid” became fashionable in today’s renewable energy industry, the world created thousands of micro-grids that were powered by diesel generators (gensets) and small hydro-electric plants near dams, lakes and streams – sites known for year-round falling water sources. Ultimately, these systems were also designed to be sources of AC electric power that conventional devices could simply plug into. As long as the end user could reach that micro-grid (no matter how large or small) they too could build their infrastructure for most needs.

By the year 2000, Germany and Japan started demonstrating that large scale use of Solar Photovoltaic (PV) electric power could be a cost-effective addition to meeting the world’s power needs. Large scale wind powered electric generators (wind turbines) soon followed and by 2010, utility-scale solar plants and wind farms were credibly adding to the world’s grid, although often while being subsidized by government agencies.

Throughout developed nations the public wanted to be untied from the corporate utilities, yet smart marketing strategies fostered the idea that everyday home owners could go off-grid by simply installing solar panels. These same homeowners, by the millions, pushed politicians to provide legal permissions and generous subsidies to allow feed-in assurances to the grid. The ironic result was that people wanting to be truly off-grid, instead tied themselves more tightly to the grid, often through 15 to 20-year power purchase agreements with the utility and third-party contractors.

To off-grid professionals, the true meaning of “off-grid” is to power a site not with AC grid resourced electric power, but instead by generating electric power needs for that specific site alone.

Historically (1920 – 1990) many true off-grid sites were still primarily small, isolated AC generator stations. A rural electric farm in Australia, Canada or even the USA in 1930 would be considered an off-grid site, typically powering a water pump and perhaps some lighting utilizing a small wind turbine, kerosene powered generator or a stream pushing a water paddle generator.

The term “off-grid power professionals” actually started taking on meaning in the 1950s, as microwave-based communication for long distance communications (especially for the military) became urgent on remote sites, often in very harsh climates. The off-grid power profession was to see an even larger growth period starting in the 1990s, as the cell phone industry realized it had to break free of the utility-based grid to provide service to mobile phones along highways. As the price of diesel was low compared to the cost of new solar panel-based technology and also as PV was untrusted by many, gensets prevailed as the off-grid power source of choice.

The Solar Shift

By the mid-1980s however, solar panels were increasingly being used for small, off-grid applications. Solar at the time was very expensive, but as forecasts of global warming become increasingly loud and credible more manufacturers and investment poured into solar panel manufacturing – often at the expense of other alternative power generation technologies, such as the development of fuel cells.

Due to this investment, the costs of solar panels decreased and by the late 1990's solar technology had gained significantly in popularity. In most cases the DC electric power generated by solar panels was stored in batteries, then inverted from DC to AC power. This DC to AC power conversion strategy was not very efficient, but the costs were low enough to become a standard for many applications.

As a result, from solar's first off-grid terrestrial use in the 1980's until 2010, most all commercially made infrastructure related equipment (communication equipment, pumps, etc.) required AC electricity for power, not the DC power stored in batteries or made by solar panels.

By 2000, a boom in the leisure boating industry, rapidly changing 3G cell phone technology and new, more effective LED lighting solutions caused manufacturers and their governments in China and India to invest heavily in solar technology, LED technology, battery technology and anything that could be DC powered – cell phone chargers, laptops, two way radio communications and especially roadway lighting and indoor LED lighting for remote residential and community use.

The result of this renewed investment was a lowering of solar panel prices (annually) from approximately $8 USD per watt in 2000, to $1 USD per watt by 2010. By 2015, acceptable quality solar power could be purchased in the US for under a dollar a watt.

During this period, true deep cycle batteries designed for off-grid use were developed and with higher demand and better manufacturing quantity, costs fell. This perfect storm of low-cost solar power combined with improved deep-cycle battery technology resulted in an explosion of popularity. Solar power generation and storage was now cost effective and if designed properly, would be reliable at 95% of the sites where needed. Soon small, off-grid solar stations became the answer for anything outdoors - from parking meters, street signs and traffic signals to garden gnomes. Solar power seemed to be everywhere.

The Fuel Cell Rollercoaster

Development in fuel cell technology had been feverously talked about and invested in since the USA fuel embargo crises of the 1970s, although it had achieved mixed results. With the growing demand for reliable primary and backup power (particularly in the communications sector) fuel cell technology began to take on the challenge of becoming a potential alternative to diesel at some remote sites and a reliable grid back up to replace large stationary battery banks.

The improvement in battery storage solutions and reduction in cost of solar power technology mention previously was a difficult financial and operational combination for fuel cell technology to beat – particularly when coupled with the high cost and complexity of fuel cells in the 1990s. On the plus side, solar PV was not an appropriate source of power at 15% of the world's off-grid locations. In addition, for roughly 25% of the world's biggest grid-tied backup power installations, diesel generators were "messy" and rarely cost effective - as they are noisy, odorous and a potential health hazard due to the exhaust. As a result, by 2000 fuel cell technology researchers had received resurgence in investment by government agencies (particularly military end users) around the globe.

The off-grid solar boom decade (2000-2010) did not go unnoticed by the fuel cell industry. Long term investment into new fuel sources and strategies (methanol, better stacks with higher efficiencies, solid oxide fuel cell technology) allowed the industry to venture into ever smaller fuel cells. By 2015, somewhat portable and reliable fuel cells were being introduced to the market. The price points were higher than solar per watt, but because of bulky battery technology needed for most reliable solar systems, fuel cells were finally able to start building a respectable market – especially with the military and specifically with USA and NATO Countries.

Before discussing the 2020 multi-charging source strategy (solar, traditional generators and fuel cells) for remote, off-grid sites, it is first necessary to look briefly at the use and history of small wind turbines.

Wind: Not Enough and Too Much – Both Problematic

When discussing earlier the rural electrification of farms in the 1930s, wind was briefly mentioned. For roughly twenty years in North America (1930s-1940s) small wind was crucial, however the expansion of the grid in the USA, Canada and Europe post World War II caused small wind to fall out of favor and eventually be forgotten.

In the 1980s, a worldwide movement to recognize global warming inspired the use and development of renewable energies. Solar PV led the way, but a resurgence in wind power was also created, started on a large scale by the Dutch and Germans, as well as some development in the USA, Japan (home of the 1990s Kyoto treaty) and in New Zealand. On a smaller, some would say off-grid use scale, small wind development was led by the ocean-going sailors in the UK and Europe and soon joined by companies in the USA.

For turbines of 10 kilowatts (kW) of output and above, there were many grid tied turbines that were reliable and cost effective. This is still true in 2019, with Bergey being a good example of a surviving, sustainable company from the 1980s. They are known the world over and their turbines can be seen on farms, military bases, commercial businesses and government buildings.

Wind turbine builders with units sized under 5kW production occupy a somewhat bleaker chapter in wind power history - few winners, hundreds of bankrupt companies, thousands of investors losing all and millions, if not billions, of dollars world-wide that were sourced from taxpayer coffers as well as those investors on a 50/50 footing.

The micro-wind world (200 to 1,500 watts) has produced a veritable rouges gallery of wind turbine manufacturers over the years. It is an industry group fraught with over reaching claims, underperforming equipment and unmet expectations.

Small wind energy’s bad reputation was essentially the result of end users (whether misled or in efforts to cut costs) who failed to do due diligence and installed hobby-quality wind equipment for service in commercial applications. The fact is that low quality and a lack of credible over-speed control dooms most wind turbines used in off-grid commercial settings.

Benjamin Franklin’s famous quote “The bitterness of poor quality remains long after the sweetness of low price is forgotten” could not be more applicable than to the micro-wind turbine industry.

The good news for remote off-grid sites that are hampered by a lack of sunlight (annually or seasonally) is that there is a credible, commercially rated wind turbine that will produce power from 4 m/S (7 mph) to 35 m/S (80 Mph) of wind speed while in the run or production mode (ON) and will survive 50 m/S (110 Mph) with a remote controlled or manual switch placed in the OFF position. It was developed in 2000 in Germany by superwind GmbH.

Conversely, many hobby turbines try to fool end users and off-grid professionals into using their gear by stating a 110 mph survival speed; however, their manuals state in small print that the unit must be OFF (not producing power) starting at wind speeds as low as 35 to 40 mph.

Other signs of a hobby turbine are a charge regulation system that requires battery power be siphoned off by the turbine to operate the over-speed control or one that uses the battery’s power to operate and/or power the charge controller.

The German made superwind GmbH SW-350 series has autonomous over-speed control via its blade pitch mechanism, as well as a charge control system that uses no battery power whatsoever. Referred to throughout the rest of this document as simply the Superwind, it is the only micro-wind size turbine with a known commercial rating. Yet despite over 18 years of success, few off-grid professionals know of the Superwind or use it, a situation that in all likelihood stems from a bad experience with cheap wind products in the past.

"Come Together"

Of course, "Come Together" is a song by the Beatles; lyrics trying to get two sides to get along. Historically there was just as much one-sided thinking when it came to creating a multi-charging-source strategy at off-grid sites. The goal of an energy product sales person in 1990 was "to have it all". Diesel genset or nothing. Perhaps solar or nothing. Maybe if a research & development application, wind or nothing. Of course, common sense and the experience of true off-grid professionals called for some solar to be used at diesel fuel-based generator sites in the late 90s, if for no other reason than to keep the standby genset batteries charged for starting the generator in the cold or between long shutdown periods.

With the reduction in price of solar PV and improved battery technology, the combination evolved into less fuel used and solar and diesel gensets tolerating each other – working side by side successfully in many applications. After all, by 2005 oil started heading up in price just as solar prices were falling. As oil hit $98 a barrel in 2014, end users realized it was not the cost of diesel, but the cost of refueling off-grid sites that was very expensive when measured in financial and often man-safe (loss of life) terms.

Some comedy

The reputation of solar PV for solving the world's remote power needs was over the top by 2010. Solar installations were being installed all over the world and in the off-grid end use marketplace, little thought was given by those selling solar panels and batteries as to site location.

Every summer and fall thousands of solar panels would be installed in the North of Canada or in Alaska by installers from the continental USA who had no real experience at such locations. By December our company, Mission Critical Energy, would get calls as to how to troubleshoot those same sites in Northern Canada and Alaska.

This cycle has gone on for over a decade and is no joke to the end users who loses power at crucial sites. Within our group we wonder when the world will realize that there is no electric production from Solar PV when there is no light.

If nothing else, this article will allow all to know that 18 to 22 hours of darkness in the winter, combined with a high chance if snow or frost when there is some light on the solar panels, does not a reliable off-grid charging system make.

It is at these locations that experienced, off-grid professionals install wind turbines (Superwind, often with ice-phobic coatings) as wind is a great resource in many places during winter, despite the fact that many of these same sites may have low wind speeds in summer.

From this constant, decade-long drama (which will likely continue into 2020) one can quickly understand that if wind power can keep a solar powered site operational in winter, it can also serve as a backup power resource or a fuel conservation resource for diesel generators as solar has. In fact, at sites where wind is abundant and reliable year-round, solar could be omitted from the equation altogether. However, as solar continues to be a low-cost option, there is no harm in keeping it as part of the overall energy generating strategy.

Global Weather Changes

World weather patterns have shifted dramatically in the past decade and the trend continues. The result, storms of both greater intensity and longer duration, is more of a true concern for off-grid site professionals than the question "is climate change man made?" The effects of these new weather trends have a large impact on the way off-grid professionals have traditionally conducted business for the past 20 years. To avoid site power failures in the near future however, a change in tactics is required now.

First, longer duration storms with increased severity have had two notable impacts - less light availability for solar power production and increased wind speed and availability. As a result of the latter, end users who were able to get away with the use of hobby wind charging equipment in the past, now must transition to quality made, commercial rated wind turbines for survival or choose other charging sources such as fuel based gensets (LP, diesel, etc.) fuel cells or (and yes this is sometimes an option) make the large investment to bring the grid into a site. The grid option is a real and honest recommendation we have made to many customers the past five years when feasible.

Another weather induced killer of off-grid sites is heat. While not as media sensational as a monster storm, heat is just as costly from an energy producing standpoint and can rob a site of solar potential as quickly as days of dense cloud cover.

As global temperatures rise, so too has solar irradiance. The power of the sun is measured in watts per square meter (W/m^2), with 1000 watts being the historical high – and the same value that set the standard for solar panel output. In the year 2000, the IEC Standards Board required irradiance sensors (measuring the power of the sun on earth) to have an accurate value between zero and 1100 W/m^2. By the year 2005 they raised this range to 0 to 1200 W/m^2. In 2017 it was raised to 0 to 1500 W/m^2. What this means is that sunlight hitting the earth in different places at different times, is stronger than before.

It is not unusual to see sun power readings higher than "peak" at many solar sites and while 1100 watts per square meter might sound like 10% more energy from a solar panel (we must adjust our planning for this too) it also means that the solar panel is getting hotter internally. When ambient temperatures reach 100 °F and irradiance is 1000 W/m^2, thermal resistance increases in the solar panel cells and an 'M' shaped PV I-V curve appears in the daily output production chart, rather than a healthy single upward dome-shaped curve. The result is that during what is typically the hottest time of day (roughly noon to 3 pm) some solar output is lost. If irradiance is higher, the internal temperature also shoots higher and all PV production is lost.

Ironically, it is in these same temperatures that batteries also suffer due to excessive heat. One simple solution to offset this loss of solar output is by adding additional battery capacity to the system. Even though larger energy storage capabilities can sometimes offset weather related power loss such as this, it is also likely the battery bank at these sites will be shorter lived than at more temperate sites, and will also require replacement more often. As such, end users typically baulk at adding greater battery capacity at such locations, as they will have to be replace more frequently – an expensive event.

There are an unprecedented number of small wind turbines currently helping to power sites in the desert at night by taking advantage of evening and morning thermal air mass movements. This is also advantageous for the energy storage side of the equation, as the cooler temps at night allow them to receive a deeper charge.

It's ironic that the very place one thinks solar would always prevail (and has for decades) is now suffering from too much irradiance, higher temperatures, and the new trend of long duration storms with additional cloud covered days. It's with good reason that the "solar only" powered remote off-grid site strategies are being reassessed.

2020 the first full decade of 4IR

Why would an off-grid professional keep a copy of “The Fourth Industrial Revolution” by Klaus Schwab (2016) on his planning desk? As a reminder that aspects of all industries are changing and that data and communications are not only a growth factor in the off-grid industry, but the key driver that will propel it into a billion-dollar industry.

In 2011 at Germany’s largest tradeshow, the term “4IR” (also mentioned in Schwab’s book) was popularized as Revolution 4.0. Demands for affordable monitoring and SCADA (Supervisory Control and Data Acquisition) devices able to partner with sensors of all types were on the rise.

Also in attendance was a plethora of new fuel cell companies, each claiming they were near industry transforming breakthroughs that would have an important and positive effect on the Grid, the grid battery-backup industry and of course the Off-Grid power marketplace.

By 2018 the fuel cell manufacturers had proven those claims were possible. As we approach 2020, serious players are emerging with credible products at prices worthy of competing with standard fuel based gensets and partnering with renewable energy charging partners in more efficient ways.

The hot, quiet box in the cabinet

As outlined by the USA Department of Energy, a fuel cell uses the chemical energy of hydrogen or another fuel (such as methanol or propane) to cleanly and efficiently produce electricity. Depending on site characteristics however, hydrogen may not be the best choice. Storing hydrogen is costly and availability in remote areas is non-existent. Technologically, fuel cells are unique in terms of the variety of their potential applications; they can provide power for systems as large as a utility power station or as small as a phone or radio charging station.

Fuel cells can be used in a wide range of applications, from transportation to emergency backup power applications. They also have several benefits over conventional, combustion-based technologies currently used in many power plants and passenger vehicles. Fuel cells can often operate at higher efficiencies than combustion engines and can convert the chemical energy in the fuel to electrical energy with efficiencies of 65% or higher.

Fuel cells also have fewer moving parts, are quieter during operation, and have lower emissions than combustion engines. Emissions are typically only water and heat, so there are no carbon dioxide emissions and no air pollutants to cause health concerns at the point of operation.

Fuel cells work like large banks of batteries, but they do not need recharging - only a steady supply of fuel to produce electricity and heat. This being said, after a given period of run time or run time combined with a limited number of starts and stops (cycles), fuel cells do require maintenance and their stacks are not immortal. Each fuel type and technology/brand has its own strengths and limitations, each of which are important for the off-grid professional and end user to understand.

As mentioned previously, investment and research during the early 2000s (particularly by the world’s militaries) led to important developments in smaller fuels cells using “solid oxide” fuel cells, methanol fuels cells and (to a smaller extent) hydrogen.

Solid Oxide was quick to be of interest, as the technology touted the easy use of propane as a fuel source. Although propane or liquefied petroleum gas (LPG) is produced by both oil and gas wells, it does not occur naturally. Raw crude oil or raw natural gas is refined to make different types of petroleum products, one of which is propane. Following its refinement, propane is stored as a liquid under pressure until utilized, at which point it becomes a gas.

Additional refinements are required for fuel cell applications beyond the familiar backyard barbeque grill variety of LPG. Fuel cell quality LPG is highly refined to remove contaminates that can foul out a fuel cell, which would reduce its efficiency or even shortening the fuel stack’s service life.

Fuel cell "fuel" is often expensive, as it must be very clean (to keep the fuel cell operating properly) and in the case of LPG, as water free as possible to prevent fuel lines from freezing in in cold temperatures.

Like all new energy producing technology rollouts, fuel cell manufacturers envisioned their technology would be all or nothing at a given off-grid site. As the realities of remote, off-grid sites operating in harsh conditions became better understood by fuel cell manufacturers however, some realized the need to ensure the batteries required to start the fuel cells were always charged. In a "history repeats itself" moment reminiscent of the 2000s, they turned to solar - even in Northern Canada and Alaska. Déjà vu all over again.

A second remote & off-grid learning curve for fuel cell manufacturers was that end users were often limited by site distance, time of year or both with regards to refueling the fuel cells. To allow the fuel to last longer, their new strategy was to simply (more déjà) add solar PV and a modest size battery bank. Bear in mind that fuel cells were meant to replace large battery banks! Imagine being an end user in Northern Canada - unable to refuel the fuel cell for months in winter and your fuel cell salesperson offers to sell you solar panels to extend the fuel source, as well as keep the batteries ready to start the fuel cell as needed.

The phone in Getzville, NY rings, "Hello - yes, we will help you integrate commercial micro wind at that site." This scenario plays out time and time again.

Driven by disappointed end users of off-grid fuel cells, manufacturers of those fuel cells have of necessity developed relationships with providers of other off-grid charging source equipment or risked the marketing equivalent of a black eye. In fact, much of this problematic mindset comes from the marketing and sales side of fuel cell manufacturers. There is hope however, as more integration engineers within those companies listen to their customers and partner with off-grid professionals, quality micro-wind integration specialists and solar production teams.

The barrier to multi-charging source integration has often been the decision of some fuel cell companies to use solar PV for fuel preservation strategies in order to avoid the installation of properly sized battery banks. Why? Because the fuel cell sales pitch was avoiding the need for such battery banks.

The additional underlying strategy was to also undersize the solar system so that the fuel cell would be forced (through low battery conditions) to start or cycle more often. In many cases this was done not to sell more fuel or shorten the life expectancy of the costly (but replaceable) fuel cell stack, but instead to artificially create fuel cell run time so internal systems remained operational.

In the case of Methanol Fuel Cells, the wetter (a small water reservoir) must be viable, i.e. full and not frozen. In the case of Solid Oxide fuel cell systems, higher fuel cell temperature requirements and shorter stack cycles (before overhaul or replacement) means that once started, the fuel cell wants to stay running for longer periods of time. In multi-charging strategies, the fuel cell and fuel cell type must be carefully evaluated prior to selection and installation at a particular site – especially frequency of use and seasonal access to the equipment. Fuel capacity and type of fuel, as well as number of stack cycles (starts and stops) available before the stack is exhausted are also important considerations.

The use of micro-wind power in northern climates is now becoming customer driven, replacing or accompanying solar PV, along with methanol fuel cells and solid oxide fuel cells. The fuel cell strategy of shorting the renewable energy sources for more frequent starts is also being replaced by the use of true, off-grid designed "entire system" monitoring and SCADA systems that can simply trigger a maintenance run of the fuel cell when needed.

Multiple charging systems including fuel cells are not difficult to design – only charge controller confliction need be avoided. By using adjustable charge controllers for PV, commercial wind (combined with diversion) and the fuel cell, a remote site can stay powered up reliably and for longer periods of time than when any of the three mentioned charging sources are used solo.

Where there's smoke, there's fire.

Australia, Canada, Greece, Spain and the USA have all witnessed catastrophic damage and loss of life to wild fires in the past decade. Off-grid professionals are used to working with fire service and forestry groups who do not want additional fuel in the forests if there is a fire hazard. As the use of generators and fuel cells are inappropriate in such cases, solar and wind systems typically can get the job done year-round. But what happens when the potential fire zone reaches out of the classic forest area and into sprawling neighborhoods or even cities?

In 2015 and again in 2016, renewable energy-based communication trailers (wind and solar) became some of the few reliable power sources as winds whipped the city and region of Fort McMurray Canada, spreading wild fires. The second event in 2016 drove 80,000 people from the city and destroyed 2,400 buildings.

The renewable energy-based trailers discovered to be so useful the year before, were located in mining and oil company camps and used to provide communications. Even as soot from the wild fires blocked solar panels from working, the wind and firestorm generated gusts kept the Superwind turbines spinning and making the power needed to keep communications alive until the fires were out.

Ironically, during this same period fuel based portable gensets were either rushed away from the fires or fed them. Portable, renewable energy powered battery trailers proved their worth.

While there is a tactical place for solar and wind in disaster planning and disaster recovery, the opportunities are often small and short term for off-grid professionals. The issue receives widespread attention during and immediately after the disaster, however planners and politicians soon forget the benefits of solar and wind when the fights for recovery budgets begin. This idea generally holds true for other disasters as well, such as hurricanes, earthquakes and flooding. Realistically, rebuilding the grid in those areas must take priority, as it serves the most people in the fastest way possible. There is security in having one's air-conditioning or furnace working, the lights on and the cell phone charging at a minimum after a disaster.

Off-grid professionals have a deep respect for the grid and power utility companies. After all, in many cases those same power utility companies are the off-grid professional's customers, using an abundance of off-grid and battery backup assets themselves to ensure services such as reliable communications.

This article opened by stating that there are remarkable and noteworthy trends currently at play that will shape the off-grid industry by 2020. One of these new trends came to light in late 2018 as a result of the Camp Fire.

The Camp Fire was the deadliest and most destructive wildfire in California history. It is also the deadliest wildfire in the United States since 1918 and is high on the list of the world's deadliest wildfires. Like the fires in Fort McMurray, Canada, the Camp Fire touched rich and poor alike and there was catastrophic loss of life and property. Unlike the Fort McMurray fires however, the Camp Fire tragedy was more than likely caused by arcing power utility lines igniting unkempt brush and trees in the power utility's right of way areas during a storm. One of the most remarkable and noteworthy trends for off-grid professional to recognize is how the grid nation-wide will be forever changed by efforts to avoid similar events in the future.

P.S.P.S.

In June of 2019, a booth in the exhibit hall of the National Homeland Security Conference in Phoenix Arizona displayed a sign proclaiming "P.S.P.S. is not a four-letter word."

It referred to the new strategy adopted by Pacific Gas and Electric, the power utility that admitted their high-tension electric lines might have caused the Camp Fire in California.

P.S.P.S is an acronym for Public Safety Power Shutoff, a utility generated preemptive power outage to avoid starting wildfires in areas of known high fire hazard prior to a predicted storm.

The implementation of this program and its adoption now by scores of other electric power utilities in 2019 has created chaos for grid end-users and a huge opportunity for those selling backup generators, battery backup systems and power outage survival kits.

There were already swarms of retailers descending on the residential demographic, but now and into the foreseeable future commercial end users (especially in the communications industry) and emergency managers are all thinking through serious investment into battery backup infrastructure and/or simply building stand alone, reliable off-grid power assets.

After all, why pay the grid $17,000 to bring in a power pole and electric line to a broadband tower repeater station when they might shut off the grid every time there is a storm? As such a site would require battery backup regardless, why not just skip the grid entirely?

For off-grid professionals who also provide power backup systems, this situation will generate opportunity in such affected areas for years to come. The momentum for changes in thinking about where and when the grid is used has another remarkable and noteworthy trend acting as catalyst - one that will hold true not only in areas affected by P.S.P.S problems, but throughout the world.

AC/DC: 125 year boomerang

Most say that the decisive battle for AC electricity (Nikola Tesla) vs. DC electricity (Thomas Edison) as a standard for the grid, took place at the Chicago world's fair in 1893 - and Tesla's win had also overshadowed off-grid power since. However, by 2018, storm instigated, preemptive power outages, and the synergy created as the world's leading communications equipment manufacturers changed the power requirements of their radio products, transmitter equipment and repeater stations from AC to DC power, may have Edison as the ultimate winner off-grid. Military end users inspired the trend about 2010, and it took a decade for the idea to take root. Most communications equipment manufacturers have now abandoned AC Power on many products, and produce DC powered equipment, or have announced that they will be doing so soon.

For the off-grid professional this can mean a shift from powering off-grid sites that historically have been in remote areas, to also providing power to towers in suburban and metropolitan areas. It is in these areas that fuel cells, partnered with a bit of solar, could reign as the long-term winner of short cord power sources.

There will also be a surge in growth and need for powering traditional off grid sites located in the harsh, remote regions of the world. As this new DC powered equipment generally requires less power, new sites can do more with less if the integration planning and installation is proper and professional.

In 2015 there was a debate between broadband and narrowband communication techniques, leaving many engineers and radio-deployment specialists debating the benefits of enhanced data rates and long-range reliable communication links. Although the then wired-internet communications industry was at the center of the broadband-versus-narrowband debate, similar discussions were happening in the RF communications industry as well. Increased data rate was the obvious benefit of broadband communication and hence inspired large investments in broadband technologies. As broadband went wireless, fast, affordable and now DC powered, it has come away as the winner for many mission critical applications. Couple this with the ability to bring affordable internet access to remote areas and the sense of growth potential is easily visible to the off-grid professional – all that is left is to seize the opportunity presented here!

Throughout many industries such as oil & gas, rail, mining and even law enforcement, the shift to DC powered communications equipment is hand in glove with the exponential growth and worldwide use of new, wireless broadband communications capabilities. It is now unstoppable.

Überwachungssteuerung und Datenerfassung

(Supervisory Control And Data Acquisition - SCADA)

For many off-grid professionals, the monitoring of off grid sites has been a precarious process. Monitoring systems have traditionally been very expensive, overly simplistic and unreliable (often homemade) or biased to one charging source (solar for example). There has also been no real control capabilities or ability to monitor the entire system or aspects affecting it.

Like a technological Tower of Babel, dealing with this patchwork approach to system command and control is like writing in German, reading in Russian and speaking Italian to your ever-listening English language customer.

The solar PV charge controller industry deserves credit for trying to tidy up the off-grid monitoring problem, but again cost and "constancy of purpose" distractions (are they a charging source manufacturer or a communications monitoring company?) limited how far these groups were willing to go. As the use was also biased to their solar PV product and the battery bank alone, interactions with the load, wind power or a genset/fuel cell was nearly impossible through these systems.

The frustration was palpable when in 2017, I (Mark Dettmer) was twice chastised after giving presentations at both the International Wireless Communication Expo (IWCE) and during an Off-grid Master Class at the Wireless Internet Service Providers Association (WISPA) Conference.

In both lectures, I wrapped up the talk with a key phrase "Your customer's loss of service is not a good monitoring system." Foolishly thinking I was presenting to Off-grid Professionals, I was surprised to find that nearly a third of the audience at each event were the actual end users. To a person, they wanted to know:

1. Why were they the last to know when their off-grid systems were in crisis and why was there no warning?
2. Why, after having made substantial investments in these sites (through their installer integrator) they were helpless?

The opinion was that some in the Off-Grid profession industry had been trapped in an ancient world – some even wondered if this was intentional as a job preservation attempt. Conspiracy theories aside, even our company had been searching for five years for the ideal monitoring and SCADA solution for off-grid use - something specialized and very difficult to find.

After an international search inspired by these lecture attendees (and through a poll of our customers world-wide) we were able to find a hidden gem in use in Canada, New Zealand and by a handful of end users in the U.S.; a remote telemetry unit (RTU) in use for three years that was near perfect for the off-grid industry. Made in BC Canada, it had originally been created by a wireless internet service provider to solve their own off-grid monitoring issues.

In 2017 we began testing and in 2018 along with the manufacturer, began developing and proving a product that would help change the off-grid professional world. The final step in late 2018 was to harden the device against any threat of suspicious, third party spy capabilities or control. In late 2018, the FlexSCADA Q5 and Q5 Pro series was launched.

The ability for remote stations to have the capability to monitor and control themselves while communicating to the installer or system owner is a true game changer.

"Internet of things" (IoT) capabilities through powering sensors, collecting, distributing and using that data in real time can help maintain autonomous use at an off-grid site. With this cutting-edge technology, it is now possible to have a remote site wind sensor autonomously shut down a wind turbine when windspeeds increase to dangerous levels, keep the turbine within survival operation mode until wind levels subside, then bring it back online. Tiered temperature sensors can help batteries stay cool in the heat without wasting power. The owner can, with a glance of their smart phone, see the site status in real time and receive email notifications if there is something wrong or unusual.

Historically these capabilities have cost thousands of dollars, used critical power and been “clunky” to say the least. Now, using advanced manufacturing techniques and parts (such as AMS Cortex 7 components and Static Ram) these devices can be purchased for under $800 and use so little DC power that the energy out to the device is measured in milliwatts.

The IoT bidirectional activities of powering sensors, gathering data, sending data, powering loads, monitoring and protecting loads through digital fusing that can be reset remotely - even analyze loads through a built-in oscilloscope, all while controlling charging platforms is remarkably advanced technology.

Fuel savings, battery life insurance and extension, fewer service calls (by way of helicopter to some locations) are just some of the many ways this equipment can easily pay for itself at off-grid sites. Just as important, the FlexSCADA Q5 line can shut down a shaky grid line, forcing a battery backup into use, preventing down-run grid brownouts from harming sensors, motors and communication gear.

For P.S.P.S., monitoring and SCADA also allows means to observe an undersized battery backup system and take action through situation escalation notices.

For end users with hundreds or thousands of off-grid sites (wells, pipelines, and communication towers, etc.) the FlexSCADA solution can be inter-mapped with layered geography, weather, fire danger, P.S.P.S. and other geospatial data, allowing for interactive planning as well as preemptive action or damage control in real time.

Imagine seeing 650 well head sites and pipeline control stations (along with their communication towers) all with green “OK and Working” indicators superimposed on a regional map highlighting roads and asset coordinates. Now imagine a hurricane path warning map showing real-time radar data. As the storm approaches, users can plan for the contingency, even take pre-emptive actions to shut down equipment remotely via the FlexSCADA. As the storm departs, the status of each site is displayed, allowing disaster planners to easily determine which sites are in need of attention, allowing them to prioritize the allocation of manpower for the fastest and most cost-effective recovery effort. This is IoT meets 4IR in the off-grid industry.

The new power of off-grid is not just about electricity – it’s about embracing future technology and the benefits it brings to the industry. 2020 will be here soon and rest assured it will arrive with a 2030 mindset.