Right: solar-powered Remote Terminal Unit (RTU) at a pumping site using a Morningstar HazLoc-rated SunKeeper controller. Courtesy of SunWize

What Exactly is meant by the "Digital Oilfield?"

From its origins in the early 1970s when the first pressure/temperature gauges were fitted into subsea wells and data logging via satellite began, the "Digital Oilfield" concept has evolved from simple data gathering activity to the automation, control, and optimization of nearly every process involved upstream (exploration, development, and production) and midstream (transport and storage). Initially adopted for offshore, deep-water facilities where the extremely remote and hazardous nature of operations made automation a valuable asset, Digital Oilfield technology is expanding rapidly into all facets of on-shore operations.

New technologies have transformed the concept from simple data acquisition and monitoring to a fully-digitized management system, one that frees-up valuable engineering resources for analysis, planning and implementation activities rather than reading screens and watching gauges. Key elements of a Digital Oilfield today include (but are not limited to):

- Data management
- Process automation
- Drilling and production optimization

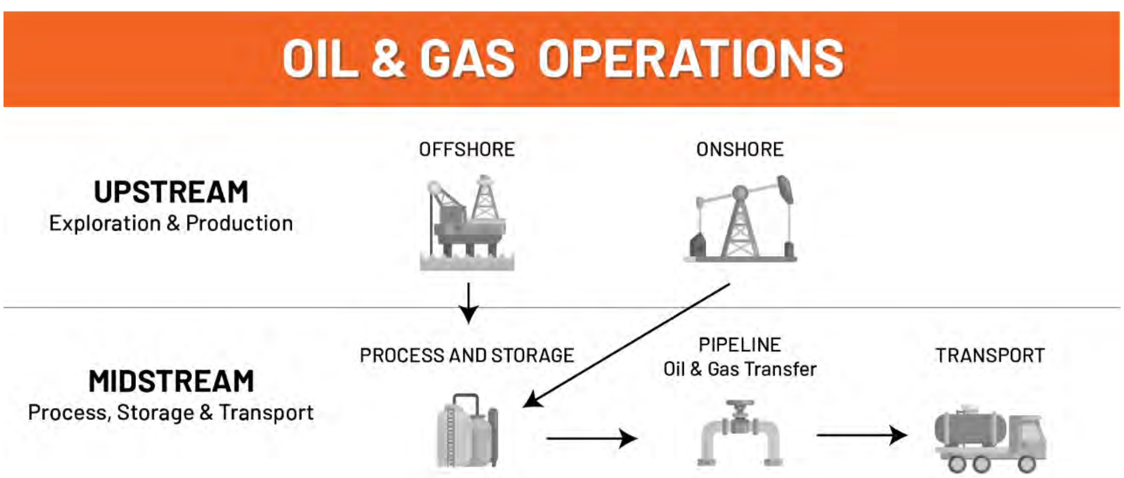
- Control and monitoring
- Sensors and instrumentation
- Pipeline integrity, including cathodic protection
- Robotic drilling and "smart wells"
- Security
- Lighting (fields and platforms)
- Safety management

Of the many definitions of what exactly constitutes a "Digital Oilfield," one of the simplest is "the sensors, telecommunications networks, simulation and optimization, and robotics, coupled with advanced condition monitoring and computational power, which enable major changes to working methods."

What are its advantages for Oil & Gas operations?

Those working method changes drive real-world results. Recent industry reports indicate that Digital Oilfield implementation can deliver on the average an 11% bottom line improvement and 7% increase in productivity. One report highlighting a major oil producer as a case study credits Digital Oilfield adoption with saving the company some $200 million in capital operating expense (CAPEX); one example mentioned was reducing the time it took to check pipeline integrity from seven days manually to just 30 minutes using Digital Oilfield automation technology.

As operators make up for lost time in the post-pandemic environment, they are discovering that the digitization of the oilfield is essential to unleashing productivity by freeing up resources for more productive purposes. As a result, the modern Digital Oilfield represents a direct response to industry demand for increased production and decreased down-time, through process optimization and remote management. All this is why the Digital Oilfield market is expected to reach an estimated $28.5 billion USD over the next five years.

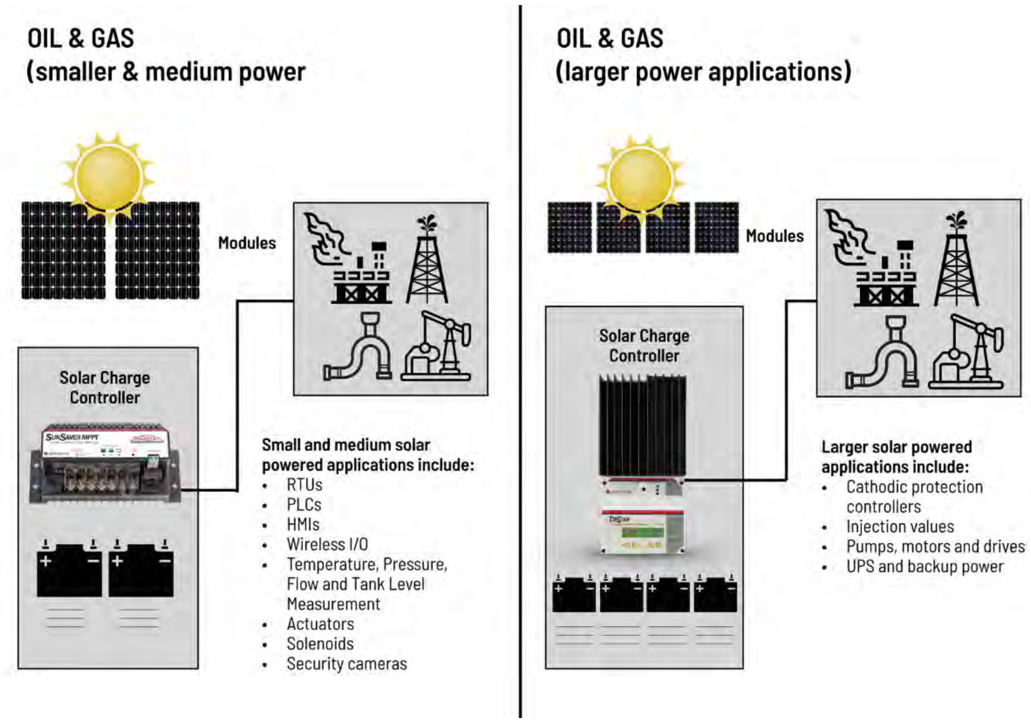


Above: operational areas where solar electricity is most applicable to Digital Oilfield processes

Solar electricity in the Digital Oilfield

Globally there are well over 2 million miles/3.2 million kilometers of oil & gas pipelines, the longest of which stretches over 5,400 miles/8,700 kilometers. The oil & gas extraction sites they support total over 65,000 worldwide, with some 9,000 off-shore. The sheer size and scope of this network means that many operations occur in locations far removed from any electrical grid—yet on-site electricity is needed for every mile of pipeline and at every wellhead and terminal, to provide critical power for the monitoring, control, process automation and production optimization functions that comprise the Digital Oilfield.

Right: Solar electric system implementation on the Digital Oilfield



Diesel and gas generators initially provided a solution at extraction sites, but as Digital Oilfield technology expanded across pipeline networks installing, running and supporting more and more generators became less practical due to two reasons: they require regular maintenance and periodic teardowns which are expensive, and they must be refueled which further increases operating costs (OPEX). A third liability with generators is that, as a source of noise and emissions pollution, their very use compromises any "oilfield greening" initiatives important to operators today. For these reasons operators with remote powering needs have embraced renewable energy for on-site electricity generation, and solar in particular.

Solar's value proposition for the Digital Oilfield stems from the fact that, unlike generators, solar requires no fueling. Equally important, unlike both generators and wind turbines, solar electric systems have no moving parts and therefore no need for costly regular maintenance or "teardowns."

Along with solar's inherently higher reliability and significantly lower OPEX, the CAPEX side can be offset by new, advanced technology batteries for energy storage for 24/7 operation, particularly lithium-iron/phosphate (LiFePo) types which are both safe and, because they can last 10x longer than conventional batteries in off-grid solar systems, can "pencil out" more economically than other battery types over the long term.

Right: solar electric array with Morningstar controllers powering oilfield lighting in the desert, for Kuwait Petroleum Corporation. Courtesy EcoSol Energy Systems

Also, unlike generators and wind turbines, solar is unaffected by environmental extremes. In fact, solar panels or modules actually become *more* efficient and work better the colder it gets. This can be maximized to great effect in a field installation through advanced charge controlling technology such as Morningstar's TrakStar MPPT (maximum power point tracking) which effectively extracts every possible Watt from a system for running a load for storage for later. Equipped with the right batteries for the application, solar can function equally well under harsh conditions at sea, in deserts, on mountaintops, and even at the poles.

Left: North Sea platform using solar electricity with Morningstar controllers to power telecom, navigation aid, bird deterrence, foghorn, and other critical systems. Courtesy JCE Energy

Using solar electricity to power the Digital Oilfield

Nearly any off-grid powering scheme can be upgraded to solar electricity. Because the many different Digital Oilfield applications and environments out there mean that there are hundreds of possible system configurations and specifications, the detail, design, and components needed are best discussed with a professional system integrator with solar expertise. The following are a few general guidelines applicable to any industrial off-grid solar electric system equipped with energy storage.

Solar electric system types, like electricity itself, comes in two “flavors:” AC (alternating current) and DC (direct current). Since solar electricity produced by modules or panels is DC, these systems are usually simpler and can be used to power and control DC loads and also charge batteries without the need for any power conversion. If the system to be powered had AC components, an inverter is added to provide DC-AC conversion.

Because the module-produced solar electricity must be controlled and regulated to charge batteries and power loads safely and effectively, the “heart and brain” of an off-grid solar electric powering system is the solar charge controller. Depending on the system design and capacity, solar charge controllers can vary in battery bank voltage from 6V to 48V (depending on the type of batteries) and with solar input power capacities typically ranging from 200W to over 3,000W; for larger systems multiple charge controllers are usually specified.

Left: Morningstar’s line of ProStar™ (upper) and SunSaver™ (lower) solar charge controllers with UL/CSA and IECEx/ATEX Hazardous Location certifications, widely-used in on and off-shore oil & gas operations around the globe.

The SunKeeper™ (below) is a small UL/CSA-rated controller used with single-panel systems

For all the brand and model diversity, charge controllers come in essentially two types:

- PWM (pulse-width modulation): simple and cost-effective, PWM controllers are basically a switch that "throttles back" solar electricity to prevent battery overcharging. They are

  ideal for locations with very consistent sunlight, minimal shading, and no physical space limitations. Typical uses are with pole-mounted 36 or 72-cell solar panels which are typical in smaller industrial systems.
- MPPT (maximum power-point tracking): while more costly and complex, they have the advantage of maximizing solar array output in areas where it can widely "swing:" in cold climates where solar modules are actually more efficient, or where shading or inconsistent sunlight affects solar "harvesting." They work by balancing voltage and amperage to find the optimum blend for the panel's output. MPPT controllers are better suited for larger arrays as well as the new PERC (passive emitter) technology higher-output solar cells. Morningstar MPPT controllers have the added advantage of proprietary TrakStar™ technology, based on patented algorithms that enable them to harvest solar energy even more effectively.

MPPT controllers can convert all available solar energy into electricity, while PWM controllers typically "throw away" some of it—but in areas of strong, consistent sunlight that is less of a concern. The point being is that there is no inherent quality difference between PWM and MPPT controller technology. It's simply a matter of which is the right tool for the job.

With the solar charge controller doing the heavy "electronic lifting," the rest of the off-grid industrial solar powering system is comprised of usually three elements:

- Solar panels or modules and racking/masting to support them
- Batteries for energy storage. Most commonly used are advanced lead acid (sealed gel or valve-regulated AGM), with both lithium iron-phosphate and nickel-cadmium becoming increasingly popular depending on the application
- An enclosure with suitable breakers, connectors, and possibly additional load-management or communications electronics on board

Solar in Hazardous Location (HazLoc) applications

For oil & gas and other uses where hazardous gasses and liquids might be present (such as mines), having the proper certifications for use in hazardous locations is critical. A hazardous area is defined as one where three fundamental components are in place:

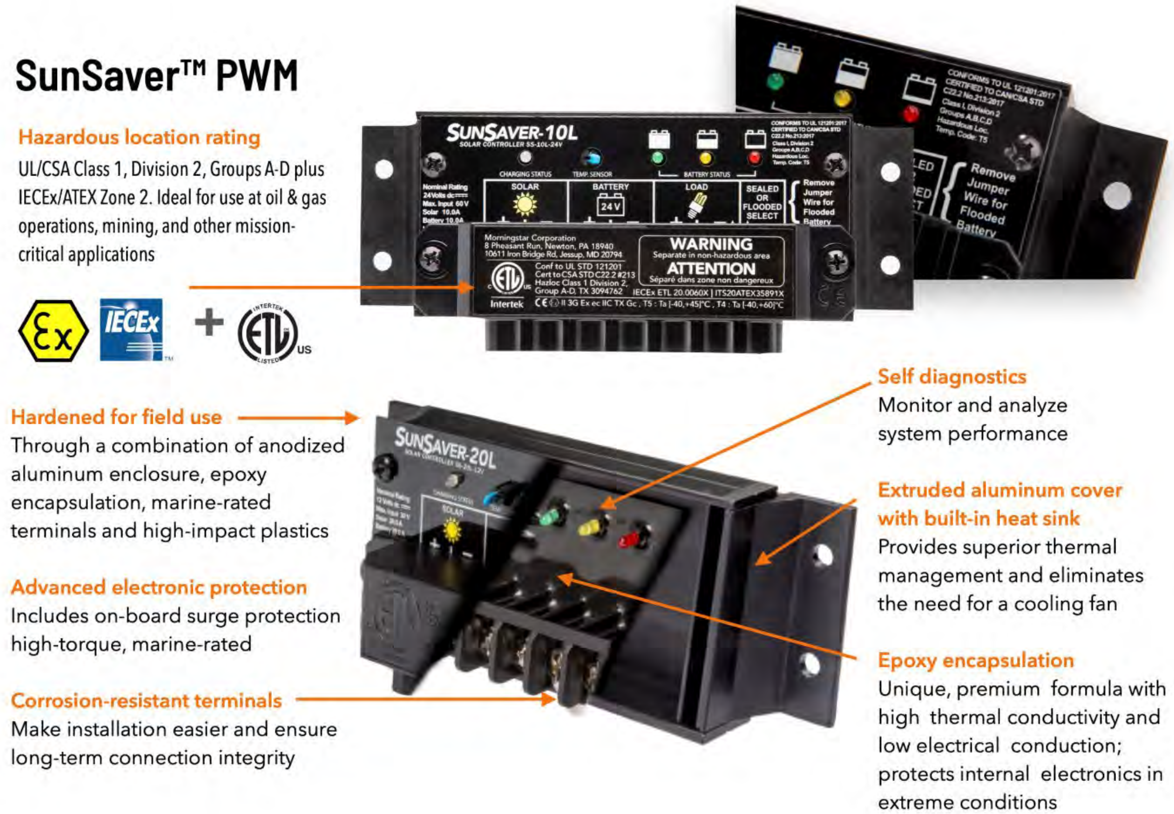
1. A flammable substance:
   a. Gas, vapor, or liquid
   b. Dust
   c. Fibers
2. An ignition source: spark, open flame, excessive heat, etc..
3. An oxidizer: oxygen present in the open air

With that, there are three primary ways to prevent an electronic device from causing an explosion

1. **Explosion-proof:** isolate or protect from an explosion through an explosion proof device or enclosure
2. **Intrinsic safety:** design and build to remove the possibility of a spark or other source of ignition (i.e., by keeping operating temperature low)
3. **Isolate the explosive substance** from anything that could possibly ignite that material (not always possible)

Morningstar ProStar and SunSaver charge controllers are designed around intrinsic safety principles, to meet HazLoc certifications. In selected models that includes:

- Fanless design—many charge controllers, and nearly all higher-powered ones, use cooling fans to get rid of excess heat during operation. But in addition to their inherent reliability and efficiency issues, cooling fans require air-flow around hot internal components to work and exposing the controller's innards to potentially hazardous vapors. Removing the fan removes the hazard—which Morningstar does across its entire product line. That's accomplished through advanced electronic and mechanical design for superior thermal management, and a hallmark of Morningstar engineering.
- Encapsulated components—selected Morningstar models have internal components sealed in superior-grade epoxy plastic, to further insulate them from hazardous and extreme environments.
- Designing to HazLoc standards—all internal circuitry and external connections are designed for intrinsic safety, to eliminate sparks or overheating that could cause ignition of hazardous gases. Besides the superior control of energy, the integrated design and construction of Morningstar products reflects enhanced safety in all aspects, to prevent risk factors accumulating
- Comprehensive and ongoing testing and evaluation to rigorous HazLoc standards, to ensure safety and compliancy and achieve the necessary Quality Assurance Notifications and Registrations required for HazLoc certification.



Above: the Morningstar SunSaver solar charge controller used in oil & gas production around the globe. Called "the most successful solar controller in the industry," the SunSaver is in its third decade of production and has earned the highest reputation for reliability through the industry's lowest failure rate. SunSavers now meet both UL/CSA North Americas and IECEx/ATEX HazLoc International/European certification standards

When it comes to charge controllers and other critical components, it's vital for system planners to be aware of the agencies and certifications behind a fully-compliant, safe solar electric powering scheme:

- **North America:** UL (Underwriters Laboratories) and CSA (Canadian Standards Association). Compliant devices will have an ETL label, which (summarized) means that they meet the UL/CSA standards for Class 1/Division 2 (areas where explosive concentrations of gasses, vapors and liquids are not normally present but may accidentally exist) and Groups A-D substances (which include Acetylene, Hydrogen, Propane, Gasoline and Methane among others).
- **Rest-of-World:** IECEx (International, various agencies) and ATEX (Europe, also various agencies). Their Zone system is roughly comparable to the Class/Division scheme in North America, with Zone 2 approval applicable to areas where an explosive atmosphere is unlikely to occur under normal conditions except for short periods, from propane, ethylene, or gasses and vapors of equivalent hazard.

Morningstar ProStar and SunSaver controllers meet both UL/CSA and IECEx/ATEX standards, and the Morningstar SunKeeper controller (used in small, single panel systems). meets U/CSA. In addition, both standards also have operating temperature requirements and the devices are rated for safe operation to the maximum ambient temperature marked while not exceeding the surface temperature limit designated, i.e., 212° F/100° C (which is boiling water) for T5.

To learn more

Morningstar Corporation's free guide to Solar Powered Industrial Systems profiles over 30 successful projects, including oil & gas, and provides product information and specifications. Download it here: https://www.morningstarcorp.com/landing_page/download-guide-solar-powered-industrial-systems/

For those interested in solar-powered solutions for the Digital Oilfield and other industrial applications, Morningstar has a distribution network spanning over 100 countries, with access to the leading solar professionals around the globe. To access them, contact Morningstar Corporation directly at sales@morningstarcorp.com