Instrumentation, Cycling and the Power Industry

How Changes in Power Generation Have Impacted the Adoption of Future-Proof Water Analysis Instrumentation

White Paper

Key Words
Silica analyzers, power plant, cycling, base load power, regulation, fracking, future-proof instrumentation, power industry, water analysis instrumentation, power generation, smart instrumentation

Introduction

The cornerstone of modern society is the availability of abundant electricity to operate machinery, power-up consumer appliances, and control our environments. In the late 20th century, fuel was relatively inexpensive and electricity needs in the United States were growing. Power plants were popping up every week to keep up with demand. Over the past several years, the U.S. has seen a significant shift in how power is produced and how it is consumed.

But over the past two decades the U.S. power industry has gone from a surge in new power plant construction, to almost no new fossil fuel plants being built at all. According to the Associated Press, 34 power plants are scheduled to close with another 36 at risk of shutting down within the next 5 years[i].

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Shift in Power Production

In a country with a growing population and an increasing need for power, power plants should not be shutting down. This dynamic shift in the country's power production is often driven by regulatory factors.

Environmental Regulation

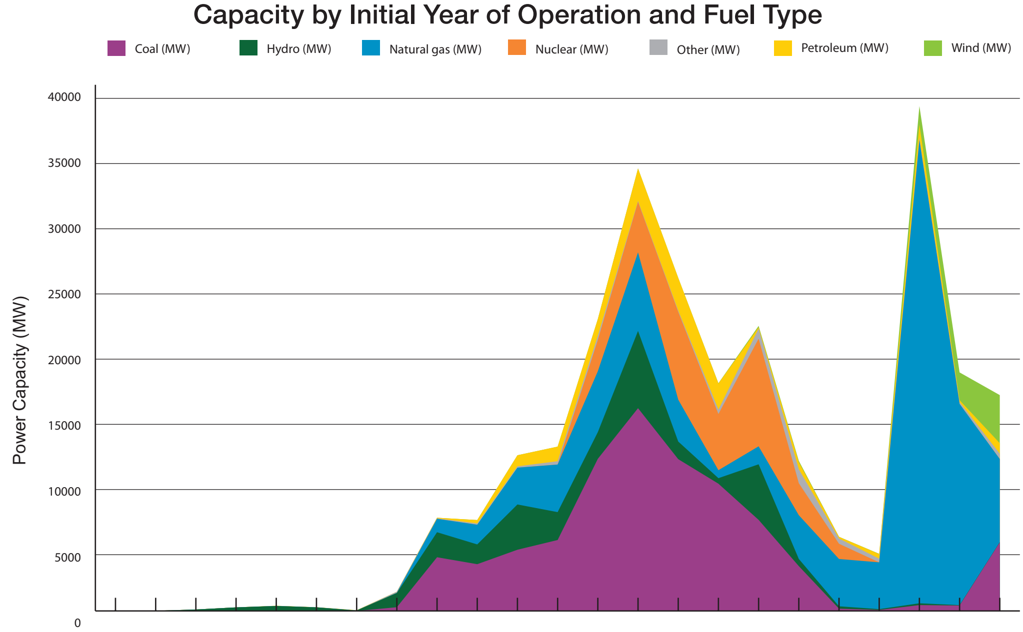
Coal has been the leading fuel in power production for the U.S., accounting for almost 40% of power production[ii]. The abundance and low cost of coal has made it the fuel of choice to power the U.S. Coal powered the Industrial Revolution, and built one of the most powerful nations both in economic strength and international commerce.

According to the Environmental Information Agency, 73% of coal-fired electric generators existing at the end of 2010 were at least 30 years old.

In the decades leading up to the 1970 Clean Air Act[iii], air quality suffered dramatically. Government bodies like the Environmental Protection Agency (EPA) realized that if the burning of coal was not controlled, the impact to public health would be severe. In 1970 enforcement of the control of airborne pollutants went into effect. This had significant impact in how coal was burned and how the output of burned material had to be managed. Power producers had to make significant investments to bring their facilities up to code.

Since 1970, even more stringent laws have gone into effect in the effort to protect the environment, like the Cross-State Air Pollution Rule (CSAPR) and the Mercury and Air Toxics Standards (MATS). In order to comply with federal and state regulations, coal-fired power plants will be required to make significant investments in order to lower their sulfur dioxide (SO_2), nitrogen oxide (NO_2) and mercury emissions. Under these rules and standards, power producers needed to take a closer look at their aging facilities. With the high price tag of upgrades to meet the MATS and CSAPR, power plant owners weighed the costs and benefits of implementing plant upgrades or retiring the plant completely. The decision was based on whether the expected costs would exceed the expected future revenue of the plant. The expected costs could include higher fuel costs, higher operating and maintenance costs, and capital equipment investment. Many owners decided to suspend operations at their plants in the hope that they could be reopened at a later date. Others closed their plants completely. According to the U.S. Energy Information, approximately 15 percent of the coal-fired capacity active in 2011 are expected to be retired by 2040[iv].

Capacity by Initial Year of Operation and Fuel Type

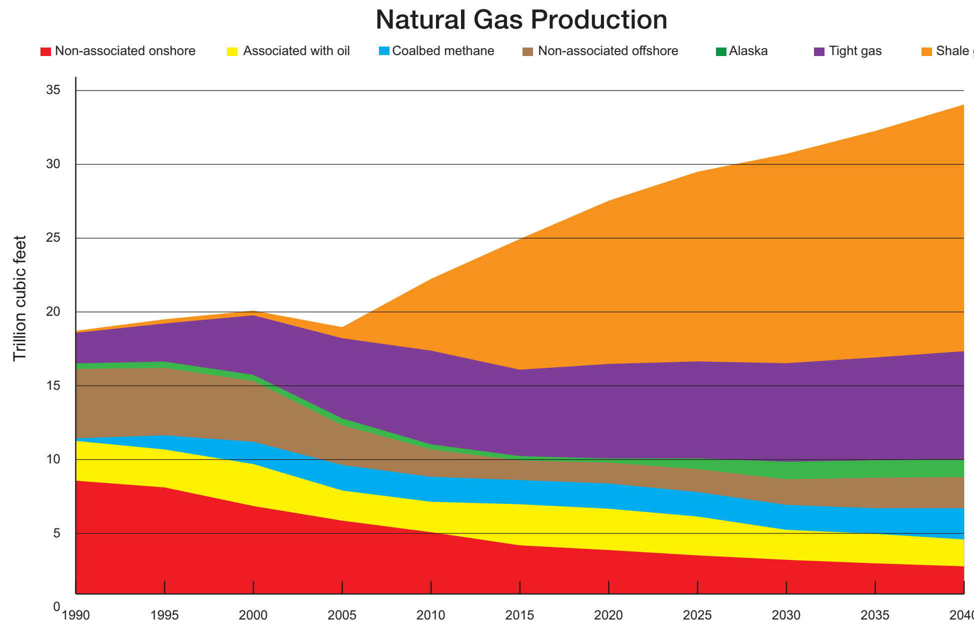


Right: Most new electric power generators built between 1950 and 1990 were coal-fired. This chart shows how power generation has shifted away from coal, towards natural gas.

Source: U.S. Energy Information Administration

The Fracking Effect

The cost and availability of natural gas has had a major impact on the power generation industry. Hydraulic fracturing or "fracking" is the process of extracting natural gas from shale rock layers deep within the earth with pressurized liquid. Fracking technology has been one of the biggest developments in the energy industry, giving the United States access to its large shale gas reserves.



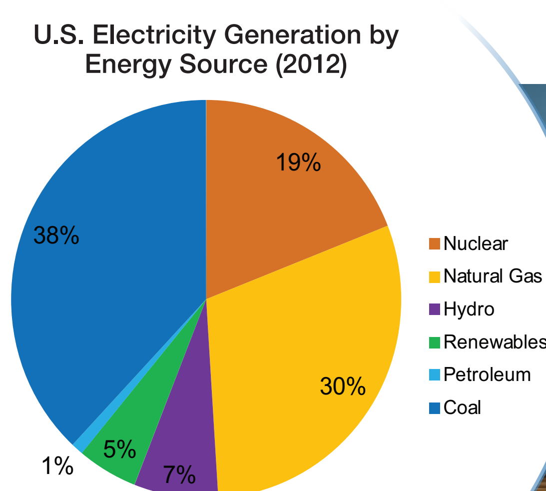
Right: The chart explains how the introduction of hydraulic fracturing has unlocked the U.S. massive shale gas reserves.

Source: U.S. Energy Information Administration

While fracking has been around for a while, only in the past five years have significant advancements been made in the technology. Fracking has become so efficient that it has created a surplus of natural gas on the market. This surplus has driven down the cost of natural gas, making it a viable alternative to coal. Cost isn't the only factor. Natural gas is a cleaner burning fuel. For plants that are able to switch from one fuel source to another, switching to natural gas has not only been an attractive choice because of price, but also because of its ability to help meet current and impending regulations.

Renewable Energy

The introduction of wind and solar power generation has had a significant impact on the operation of conventional power generation. Adding renewable sources of energy to the grid reduces the dependence on coal-burning plants to meet the country's energy needs. To accommodate higher levels of power generated from renewable sources, the grid operators have had to stop and start conventional generators more frequently to provide reliable power for their customers.



Right: The chart explains the breakdown of energy sources and percent share of total electricity generation (4,054 billion kilowatthours) in 2012.

Source: U.S. Environmental Information Administration

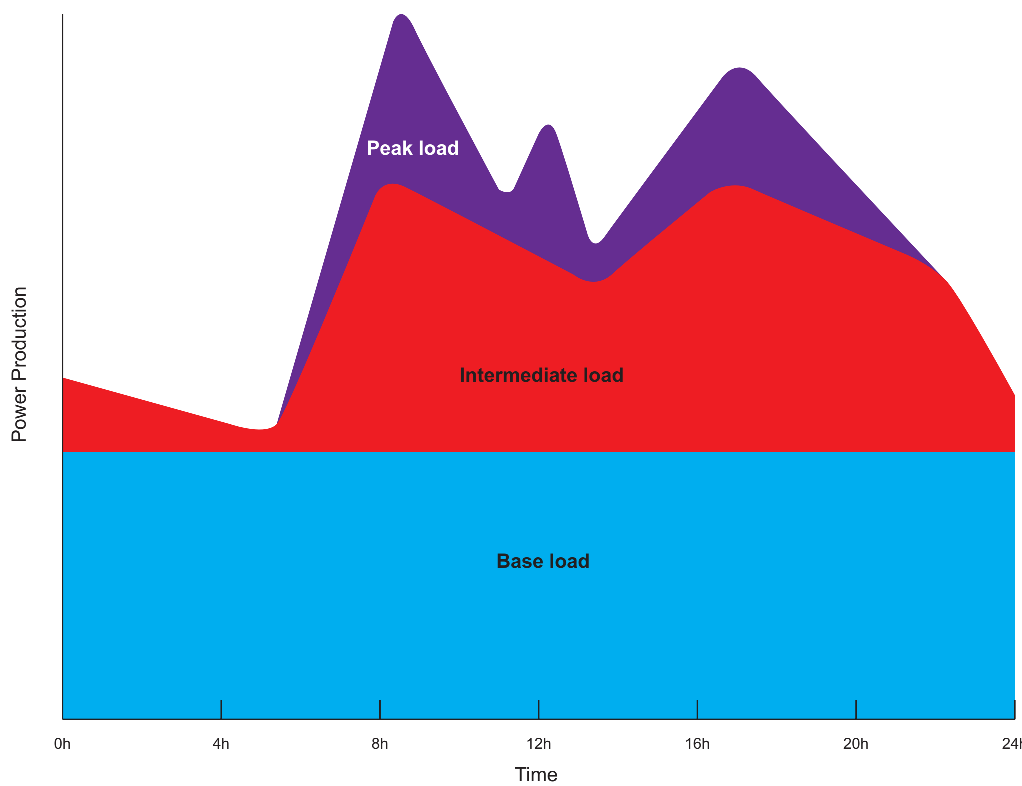
Regulation, hydraulic fracking, and renewable power generation have all played a role in changing how power plants need to produce power. Power plants now needed to be able to ramp up and ramp down in order to match power consumption demands.

This change in power requirements is referred to as cycling. The use of steam in power generation means that water quality is a vital component of controlling the cycling phases. Monitoring the water with analytical instrumentation allows for fine-tuned control of the cycling process.

From Base Load to Cycling

Most of the power plants built before 1980 were designed as base load plants. Base load plants run continuously and are operated to produce a specific amount of power to meet a particular area's energy demands. It is more economical to operate base load plants at a constant production level because of their high fixed costs, low marginal costs and relatively constant power usage. These plants are "workhorses" by design, but with very little flexibility.

Typical Day Load Curve: Base Load vs. Peak Load



Right: The chart explains how energy demands fluctuate over the course of a day. For example, a household typically needs more power at 6:00 p.m. than at 3:00 a.m.

Moving forward to the 2010s, base load plants have become the victim of their own design. Earlier, we discussed the effect of regulation, hydraulic fracking and renewable sources of energy on power derived from fossil fuels. Power plants have been forced to cycle aging coal power plants that were originally designed for base load operation. Cycling refers to operating power plants at varying load levels. Depending on the demand requirements, a power plant cycling might entail shutting the system on or off, and changing the load level from high to low. It often takes days for coal power plants to change their power output. Plus, shutting down and restarting a plant puts a tremendous amount of stress on the plant's boiler, steam lines, turbine, and auxiliary components.

It has become cheaper to replace aging equipment with a simple cycle direct-fired gas turbine then to repair, bring up to code, or maintain the older coal fired plants. In some cases, base load plants have been converted into peaker plants to provide backup for the gas turbines.

These rapid changes in the industry have led to the plant equipment suppliers struggling to meet this new need. Most instrumentation has been designed for continuous operation. One would conclude that less demand on the instrumentation would be advantageous; however, similar to the plant, instruments that are suddenly put into a cycling scenario must endure the extremes of the process conditions.

As an example, Sodium analyzers, which are used for corrosion control in the steam water cycle, use a reagent. This reagent, Diisopropylamine, is used to adjust the pH of a water sample to remove interference from other ions. Modern sodium analyzers usually do this by diffusion through specialized tubing. For this design to work, the sample needs to be constantly flowing through the instrument. When the flow is stopped, the diffusion will continue into the sample that is now stagnant causing the concentration to grow in one spot. Over time, this will weaken the tubing and cause premature failure.

For colorimetry measurements, lack of sample flow can cause the instrument to go into a hold mode for long periods of time. Colorimetric measurements typically use reagents; little or no movement of the reagents in the tubing can cause the reagents to solidify and clog the tubing. This will eventually lead to instrument failure. To combat this, plant operators have had to plumb alternative water lines to the sample inlets in order to supply a constant flow of sample water during down time. The time, materials and labor required for this additional plumbing work is an added expense. Even worse, it increases the chances for errors by not switching sample lines when the plant comes back online.

Future-Proof Instrumentation

While most existing instrumentation installed within the past five years has suffered during the shift to cycling, some instrumentation has been designed to adapt to the change. Instrumentation that was designed to be a platform for future expansion has benefited from software and hardware enhancements.

One such example is the product evolution of the Thermo Scientific™ Orion™ 2230 Silica Analyzer. In base load applications this colorimetry-based silica analyzer performs exceptionally well. Thermo Fisher Scientific engineers however indentified an opportunity to introduce product enhancements through innovative software and hardware to meet the dynamic application needs of the cycling process.

The 2230 Silica analyzer uses intelligent sensing to monitor the sample. In certain predefined states it will initiate specific subroutines. Each defined state allows the instrument to take action without plant operator intervention. This allows the operators to focus on other priorities in the plant. Through customer interaction and monitoring market trends the Silica analyzer platform was enhanced with intelligent self monitoring providing added flexibility. As strict regulations are introduced and the demand for power continues to fluctuate, product innovations will become a common occurrence. The need for an intelligent instrument platform, like the Thermo Scientific 2230 Silica Analyzer, is rapidly becoming a requirement in plant operation as plant managers are asked to meet strict regulations within reduced budgets. “Smart” instrumentation with “predictive” maintenance modes and “self healing” fault protection are the features of choice for an industry, which in the past, has relied upon manpower that only specialized in the instrumentation they maintained and repaired.

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Conclusion

The power industry is a vital component of our society's daily energy requirements; however its future is burdened with volatile fuel prices, pressure from environmental groups and ever changing regulation. Plant shut downs are not an option. The ability to adapt to the needs and requirements of today, while trying to prepare for the future is a constant struggle. The plant operator must not only survive, but thrive in this constantly changing environment. These hurdles will require collaboration with instrumentation suppliers to provide innovative solutions that will help power the future.

Learn how our silica analyzer with smart sensing technology can fulfill your power plant monitoring requirements. Contact your local water quality specialists, call 1-800-225-1480 or visit www.thermoscientific.com/processwater.

Biographies/References

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Glossary of Terms

Power plants that can be dispatched (scheduled) to provide energy to a system include:

Base load power plants: These plants run continually to provide that component of system load that doesn't vary during a day or week. Baseload plants can be highly optimized for low fuel cost, but may not start or stop quickly during changes in system load. Examples of base-load plants would include large modern coal-fired and nuclear generating stations, or hydro plants with predictable supply of water.

Peaking power plants: These plants meet the daily peak load, which may only be for a one or two hours each day. While their incremental operating cost is always higher than base load plants, they are required to ensure security of the system during load peaks. Peaking plants include simple cycle gas turbines and sometimes reciprocating internal combustion engines, which can be started up rapidly when system peaks are predicted. Hydroelectric plants may also be designed for peaking use.

Load following power plants: These plants can economically follow the variations in the daily and weekly load, at lower cost than peaking plants and with more flexibility than baseload plants.

Non-dispatchable plants: They include such sources as wind and solar energy; while their long-term contribution to system energy supply is predictable, on a short-term (daily or hour) basis their energy must be used as available since generation cannot be deferred. Contractual arrangement ("take or pay") with independent power producers or system interconnections to other networks may be effectively non-dispatchable.

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