

# Hydrogen Purity Analyzers for Safe and Efficient Power Generator Operation





## Introduction

Electrical power generation is an essential service industry spanning the globe that delivers affordable electricity to residential homes, office spaces, public transport vehicles, and other public buildings. Uninterrupted power delivery is critical to a wide array of industrial facilities and manufacturers.

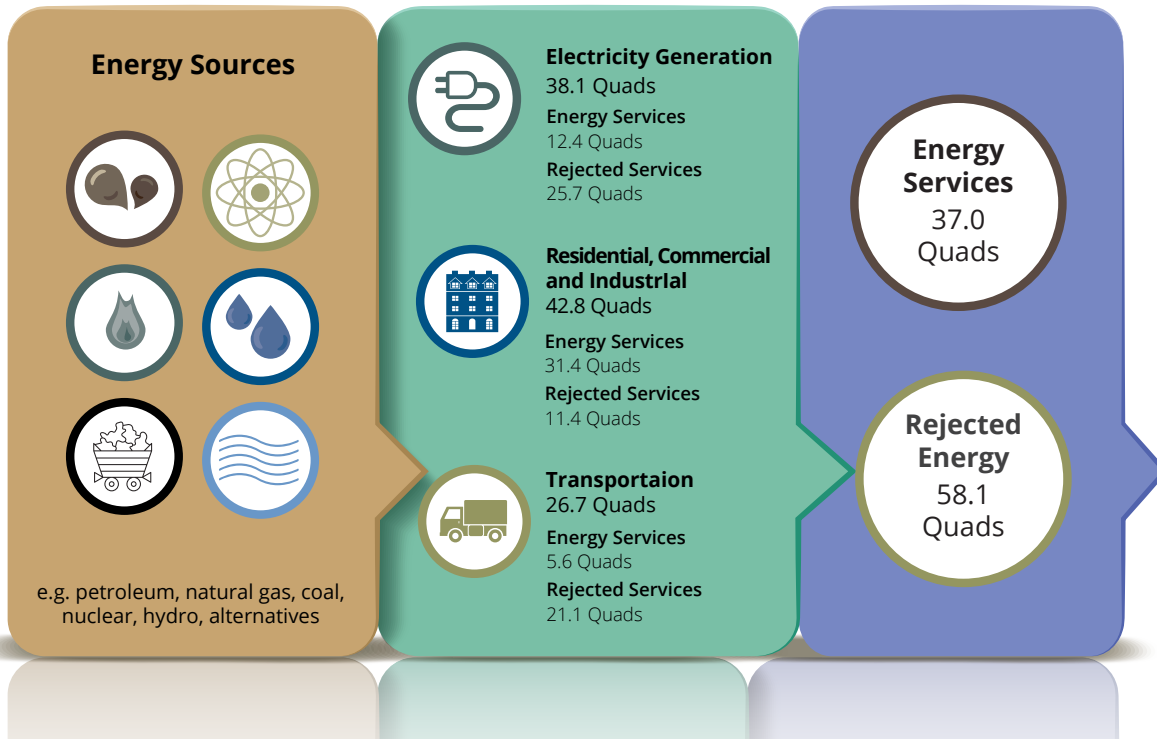
The majority of suppliers rely heavily on interconnected systems to distribute power to consumers. Though these systems are reliable, they are being pressed to produce at an ever-increasing volume, which demands maximum uptime and constant improvement to process efficiency. Maintaining that efficiency and system integrity is vital not only to those producing power, but to the consumers and industries they support.

## U.S. Energy Production

Recent studies from the Lawrence Livermore National Laboratory suggest that the United States wastes anywhere from 61-86 percent of its energy each year. According to this source, the amount of energy squandered by the U.S. economy in 2012 could power the United Kingdom for seven full years.

Of the 95.1 quadrillion BTUs of raw energy input (known as quads) from the American economy in 2012, only 37.0 quads were utilized to their utmost capacity; the other 58.1 quads are classified as “rejected energy.” (Wasted or rejected energy also includes energy lost as heat.)

## Estimated US Energy Use in 2012 ~95 Quads



**Quad = energy unit; quadrillion British Thermal Units**

Information derived from data collected by Lawrence Livermore National Laboratory.

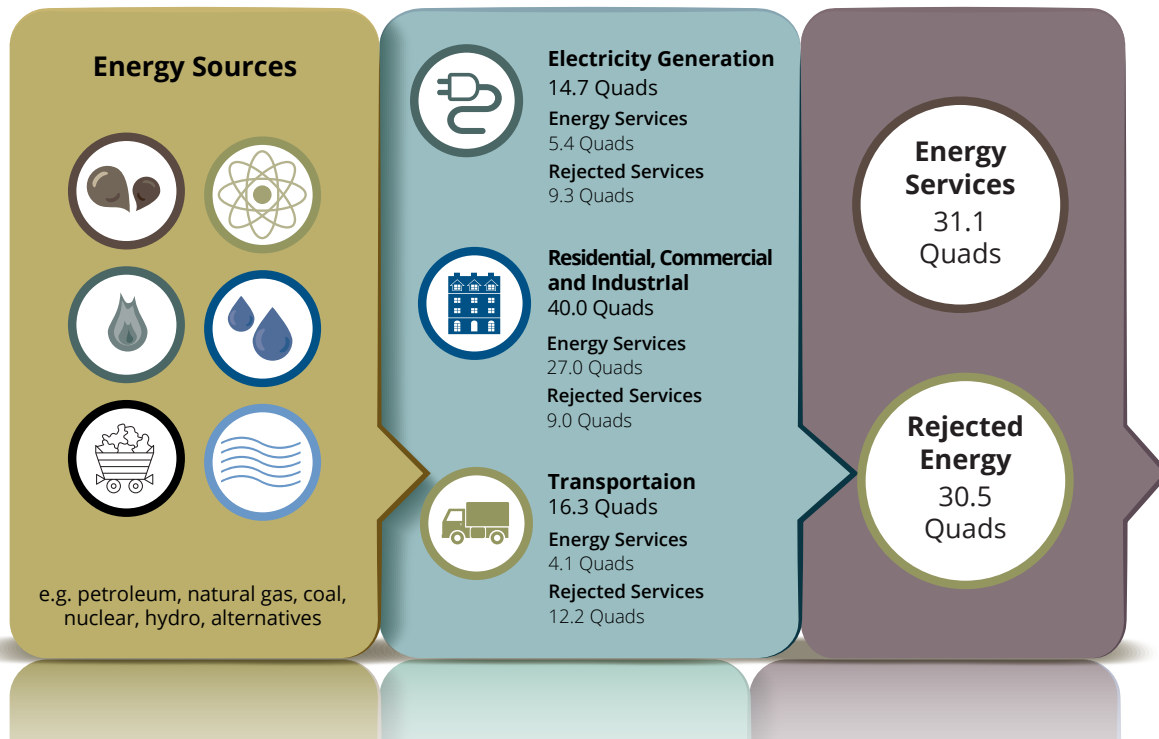
Note: Not all totals equal the sum of the components due to independent rounding and the Electricity Generation feeds into the other categories also.

By these calculations, the amount of energy wasted annually has been between 50-58 percent during the last decade, though that statistic was reportedly raised to 61 percent as of 2012.

This upward trend has been evident since 1970. In successive years, the substantial growth in energy use, for electricity generation and transportation especially, has caused energy waste to gradually overtake energy productivity. These two industries are historically poor at turning fuel energy into motive power or electrical power, and are responsible for the majority of wasted (or “rejected”) U.S. energy overall.

With the global demand for electrical power projected to double by 2030, and demand currently growing at a rate of 2.6 percent each year, improving efficiency in power consumption and production continues to grow in importance.

## Estimated US Energy Use in 1970



### Quad = energy unit; quadrillion British Thermal Units

Information derived from data collected by Lawrence Livermore National Laboratory

Note: Not all totals equal the sum of the components due to independent rounding and the Electricity Generation feeds into the other categories also.

## Energy Efficiency in Power Generation

There are no doubt many avenues of potential efficiency improvements that are being researched and implemented in the electrical power generation industry. One basic and long-established route to maximizing power production occurs at the very heart of electricity generation — the turbine.

Turbine generators convert the energy of flowing water, steam, or wind into mechanical spin energy. The mechanical energy is then converted to electrical energy as the spinning rotor turns inside the stator, which is a cylindrical tunnel lined with rows of copper windings in the generator.

Many power generating plants use hydrogen gas to cool the electrical windings within turbine generators. This improves operating efficiencies by reducing losses caused by the resistance of the windings, commonly known as windage loss.



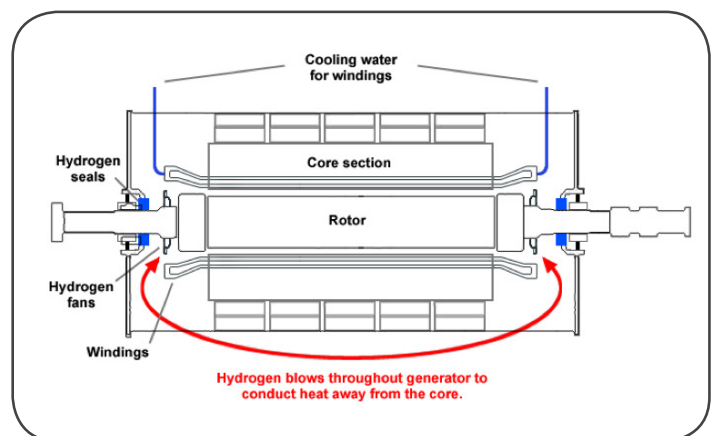


In order to control these losses and keep efficiencies high, the hydrogen purity must be maintained. Even a slight contamination of the hydrogen by oil vapor, water, or air will increase the windage losses in the generator.

As an example, a 1% reduction in hydrogen purity creates a 12% increase in windage loss. A decrease in purity from 99% to 92% can reduce generator output by as much as 2100 KW.

Obviously, this reduction in generator efficiency results in higher fuel costs and replacement power requirements. For example, assuming a replacement power cost of only a few cents per KW/hr, each additional 100 KW of windage loss (assuming an 80% capacity factor) can cost a utility plant hundreds of thousands of dollars per year.

The other factor to consider, of course, is safety. Hydrogen/air mixtures of less than 74% are explosive, so it is important to ensure that the purity level never drops to this point.





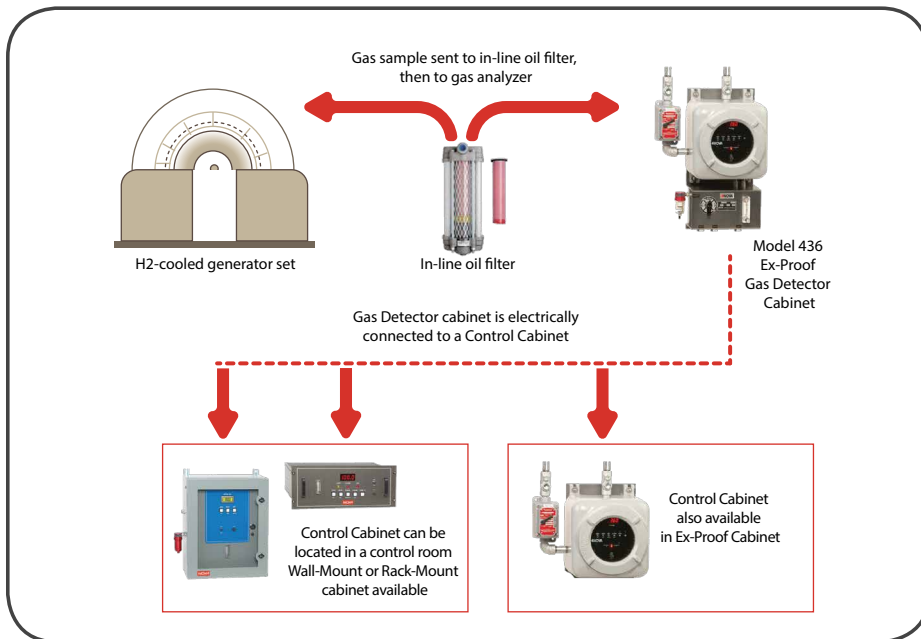
Additionally, it is important to have an alarm system in place to provide a warning if an unsafe or inefficient condition develops in the generator atmosphere. A vital part of a hydrogen purity alarm system is its tri-gas analyzer. This type of analyzer is designed specifically for monitoring hydrogen purity in the internal atmosphere of a power generator, and to monitor the purging procedure during scheduled generator shut-downs.

## NOVA Solution

NOVA Analytical Systems manufactures the [436 Series Tri-Gas Analyzers](#) specifically designed for use with electric power generators. These instruments are divided into 2 sections. The **control section** contains the main microprocessor board as well as the digital readout meters, alarms, calibration and range switches, power supply, and temperature controller for the H<sub>2</sub> detector.

The gas detector section contains the temperature-controlled thermal conductivity cell, a five-way selector valve, gas pressure regulator, flow indicator, and flame arrestors.

The gas detector cabinet is explosion-proof and is UL listed and CSA certified for use in Class 1 Division 1 Groups BCD hazardous areas. The control cabinet is intended for use in a general purpose, non-hazardous area. In practice, the **gas detector section** might be located at or near the generator, while the control section might be located in a control pulpit or other area.



(Alternatively, the Nova 436 Series is also available in a single stand-alone ex-proof cabinet housing all of the controls and the gas detector.)

**This analyzer measures the following gases and ranges:**

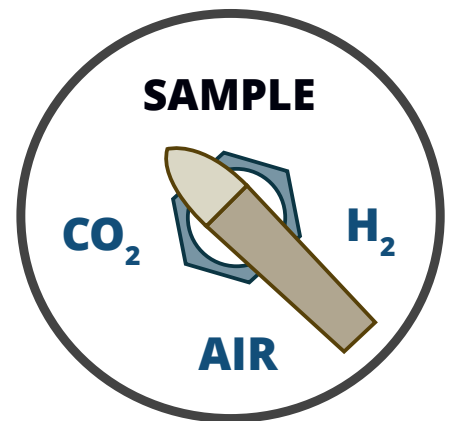
- Range 1: 0-100.0% Hydrogen in Air
- Range 2: 0-100.0% Hydrogen in CO<sub>2</sub>
- Range 3: 0-100.0% Air in CO<sub>2</sub>

We also make a version of this analyzer that is designed for Nitrogen (N<sub>2</sub>) purged generators. In this case, the analyzer has the following ranges:

- Range 1: 0-100% H<sub>2</sub> in Air
- Range 2: 0-100% H<sub>2</sub> in N<sub>2</sub>
- Range 3: 0-100% Air in N<sub>2</sub>

To communicate the H<sub>2</sub> reading, the analyzer has visible display on the control cabinet.

Also, a 4-20 mA output and two alarms are provided for the range of 85-100% hydrogen in air. A fail alarm will also trip if the purity goes over 105% H<sub>2</sub> in Air. This would be indicative of a detector failure. RS485, MODBUS and ETHERNET TCP/IP digital communication is also available.



## Basic Layout & Operation

A temperature controlled thermal conductivity (T/C) cell is located in the gas detector cabinet and is connected in series with the external pressure regulator, flow meter, and selector valve.

This T/C cell is temperature-controlled to approximately 48-50 degrees C to provide good temperature stability. A five-way selector valve selects between SAMPLE, HYDROGEN, CO<sub>2</sub>, or AIR for calibration purposes. The gas that has been selected flows through the flow meter, pressure regulator, flame arrestor, and into the T/C cell for measurement.

Oil seals between the rotor shaft and the main structure keep the hydrogen locked inside of a typical generator. While this effectively prevents H<sub>2</sub> from escaping, it does introduce the possibility of oil vapors mixing with the hydrogen atmosphere inside the generator. To protect the hydrogen analyzer, an oil vapor absorber filter is highly recommended. Without this filter, oil vapor will contaminate the T/C cell. The oil vapor filter assembly is available with the 436 Series through Nova.

**Example before & after photo of a generator monitoring system upgrade at a North American power plant. The original systems were quite old and were no longer performing well. A new NOVA gas analyzer system was installed by the customer.**

## Backup Monitoring

During scheduled generator shut-downs, many facilities monitor the generator atmosphere using the permanent analyzer and use a portable analyzer as a backup. Using two analyzers allows an extra degree of verification of the content of the generator atmosphere.

**Before**



**After**





The Nova Model 380 portable analyzer has the same type of detector and measures the same 3 ranges of H<sub>2</sub> / CO<sub>2</sub> / Air as the continuous analyzer.

## Alternate Atmosphere Monitoring

In some cases, a facility may require an additional sensor to independently verify that a low oxygen (O<sub>2</sub>) condition exists inside the generator.

An electrochemical O<sub>2</sub> sensor can be added to a tri-gas analyzer to provide an O<sub>2</sub> reading in addition to the H<sub>2</sub> / CO<sub>2</sub> / Air readings. This configuration of analyzer should have a separate display for the O<sub>2</sub> reading that is active at all times regardless of which of the other ranges is selected. An analyzer for this generator type will have the following ranges:

- Range 1: 0-100% H<sub>2</sub> in Air
- Range 2: 0-100% H<sub>2</sub> in CO<sub>2</sub>
- Range 3: 0-100% Air in CO<sub>2</sub>
- Separate Range: 0-25.0 % O<sub>2</sub>

Although it is not recommended practice, some power plants have considered that this method of atmosphere monitoring may allow a less-than-pure H<sub>2</sub> atmosphere to be used in the generator if the absence of O<sub>2</sub> can be determined. In this condition, the analyzer will read less than 100% H<sub>2</sub> and should read 0% O<sub>2</sub>. The remaining percent is assumed to be an impurity associated with the H<sub>2</sub> supply or some other non-O<sub>2</sub> gas.



**MODEL 380K  
HYDROGEN ANALYZER**



**MODEL 380**  
Standard



**MODEL 381** for Nitrogen  
purged generators



**MODEL 382**  
with active O<sub>2</sub> channel

**Some generators are designed to have the H<sub>2</sub> atmosphere purged out with nitrogen (N<sub>2</sub>) instead of CO<sub>2</sub>. In this case, the monitoring analyzers must have the following ranges:**

- Range 1: 0-100% H<sub>2</sub> in Air
- Range 2: 0-100% H<sub>2</sub> in N<sub>2</sub>
- Range 3: 0-100% Air in N<sub>2</sub>

The Nova 380 family of portable gas analyzers is available for various generator conditions.

Nova also offers portable flue gas analyzers to allow optimization of various combustion processes within a power plant.

## Conclusion

As energy demands continue to increase for power generators, improving energy efficiency within the generator becomes ever more essential to the success and safety of the operations. Reliable gas analyzers to monitor the generator atmosphere in real time is an important first step toward closing the gap between electricity production and energy waste.



## About Nova

Nova Analytical Systems, a Unit of Tenova Goodfellow Inc., has been designing and manufacturing dependable gas analysis equipment for over 30 years. Nova offers portable gas analyzers, continuous gas analyzers and sample conditioning equipment for industrial applications. We serve a diverse range of traditional and emerging industries all over the world.

Our integrated approach to design and manufacturing allows us to configure our products to suit each application, while still being able to offer the best price, long-term reliability and proven technology in each analyzer. We back up our products with excellent, prompt service.

With our inclusion into the Tenova Group of Companies, Nova Analytical Systems gains international presence as a key player worldwide for gas monitors and analyzers for industrial application.

For more information on Tenova Goodfellow, please visit our [Tenova landing page](#).

For more information on the Tenova Group of Companies, please visit: [tenovagroup.com](http://tenovagroup.com).

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