

# VAST Advantages

## What VAST Has

We have developed disruptive technologies that will be of strategic interest to gas turbine OEMs (Original Equipment Manufacturers) and industrial energy users. Attached are two supporting documents:

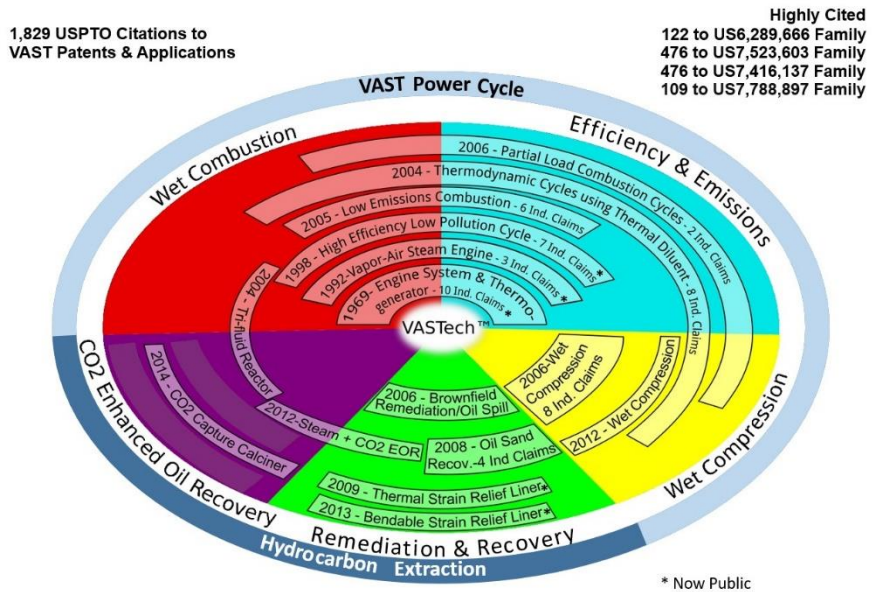
1. *10 VAST® Advantages in Power Generation* provides a 1-page summary of this document.
2. *VAST® Grid Edge Technologies: Enabling Renewable Power*, 21 slides which present:
  - The **Problem** (slide 3)
  - The **Solution** - VAST Advantages (slides 3-10)
  - VAST **Tech** vs gas turbines (slides 6 + 10-13)
  - VAST **TAM** (Total Addressable Market) (slides 14-15)
  - VAST **Patent** Map (slide 16)
  - **VASTeam**™ (slides 18-20)

## Patent Portfolio

Our underlying technology creating these advantages is protected by 28 issued U.S. patents in our IP portfolio. Our patents have been cited over 1,829 times, particularly to our combustion-related patents. Ocean Tomo (a leading world Intellectual Property valuation firm) ranked six of our patents as A+, A+, A, B+, B and B-.

By citation analysis and by expert opinion, our patents contain high quality innovation of current commercial importance to leading industrial counterparts. High quality, highly cited patents are a VAST Advantage.

VAST has filed the first two of several provisional patents covering numerous innovations in our next generation combustor. Additional provisional patents are in draft. These provisional patents will result in multiple new patents protecting new innovations based on our ongoing research.

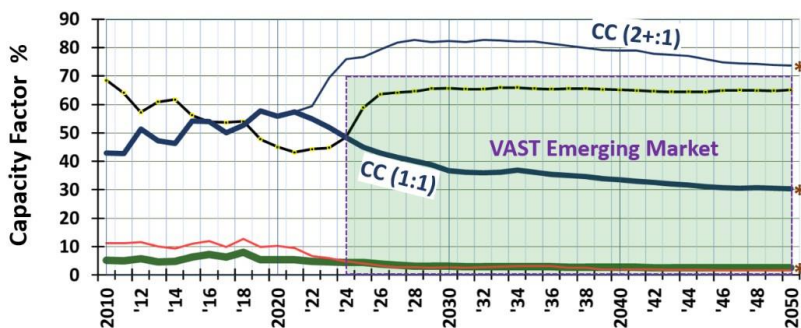


## VAST IP Business Model

VAST is an innovation company, focused on research, design and development (RD&D). VAST seeks suitable industrial counterparts for whom VASTechnologies™ offer significant economic advantages. VAST seeks minority participation in joint ventures built around commercializing our technology or licensing our intellectual property for specific applications to existing product lines of Original Equipment Manufacturers (OEMs).

## VAST Total Addressable Market (TAM)

VAST’s initial target market is backing up solar and wind-powered local microgrids and regional grids. VASTurbines™ will provide cleaner, cheaper, more efficient, more responsive and more robust backup that’s essential to ensuring grid reliability with rising solar and wind renewable power. The market for renewable energy grid backup is enormous, international, and highly fragmented. The U.S. Energy Information Agency forecasts ~331 GW growth in U.S. gas turbine power by 2050, (175 GW Peaker power and 156 GW Combined Cycles) worth \$195 billion or ~\$7.5 billion/year with more globally.



2010	2020	2030	2040	2050
68%	45%	66%	65%	65%
43%	56%	37%	34%	30%
5%	5%	3%	3%	3%
11%	10%	3%	2%	2%

- Combined Cycle (2+:1) Gas : Steam Turbine
- Coal
- Combined Cycle (1:1)\*\* Gas : Steam Turbine
- Peaker Gas Turbine
- Oil or Gas Steam Turbine

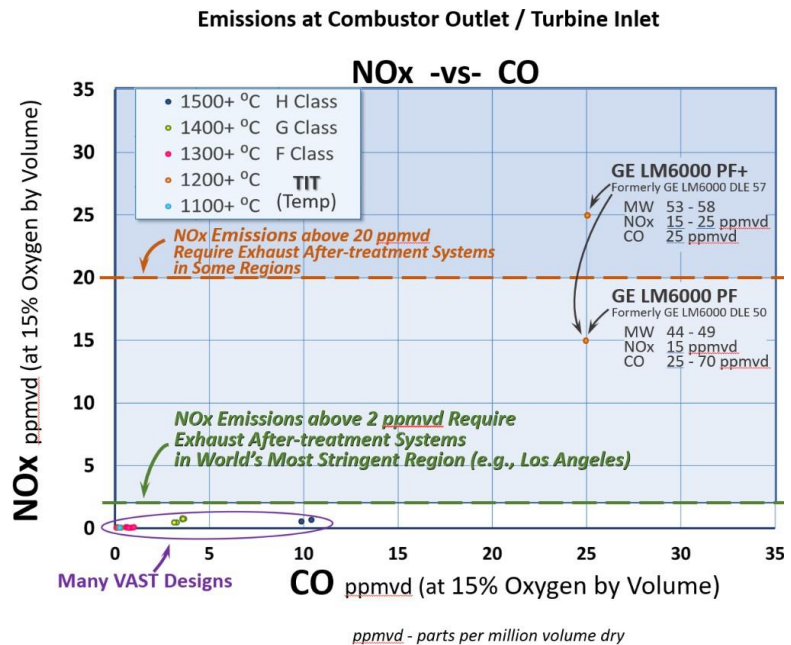
Capacity Factor = Actual Operating Hrs / Total Annual Hrs \*\*1 Gas Turbine with 1 Steam Expander

\* Base Load Declines Driven by Mandated Renewables Growth

VAST power promises cheaper power with higher returns than both simple gas turbines and combined cycle power plants operating up to 50% annual capacity factor. (Capacity factors quantify the portion of full-time that a machine is actually utilized). VAST's multi-fuel capacity increases fuel supply flexibility, thereby supporting greater backup availability.

## VAST Is Cleaner

The VAST® TriFluid™ Combustor achieves ultra-clean combustion by cooling with recycled water instead of excess air. VAST's NOx (nitric oxides) and CO (carbon monoxide) emissions are ~ 10 times cleaner than today's best gas turbines. VAST eliminates the costly exhaust gas treatment Capital Expense (CapEx) and Operating Expense (OpEx) that competitors need to reduce power pollution to mandated levels. VAST burns cleaner and that is a VAST Advantage.

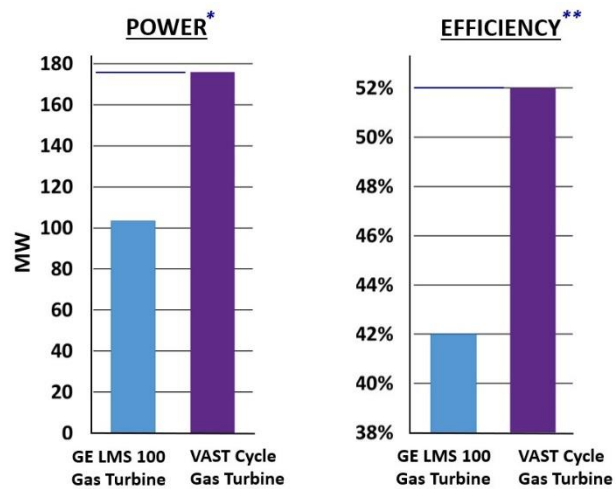


## VAST Helps Reach Real Zero

The VAST Power Cycle is about 24% more efficient than the simple cycle gas turbines it replaces. VAST Power creates ~19% less CO<sub>2</sub> than peaker turbines when using natural gas. When burning ammonia, VASTurbines release zero greenhouse gases. They will likely release the lowest NOx levels of commercial gas turbines. VAST sustainable power likely provides the cleanest backup power and that is a VAST Advantage.

## VAST Is More Efficient

Fuel is the largest portion of a power plant's OpEx. The VAST® Power Cycle increases generating efficiency by ~24% over a simple cycle gas turbine. The VAST® Liquid Recuperator combined with the patented VAST® Wet Compression™ and other fluid dynamics features unique to the VAST TriFluid Combustor enable a 19% fuel cost saving in generating power. This economic edge is a VAST Advantage.

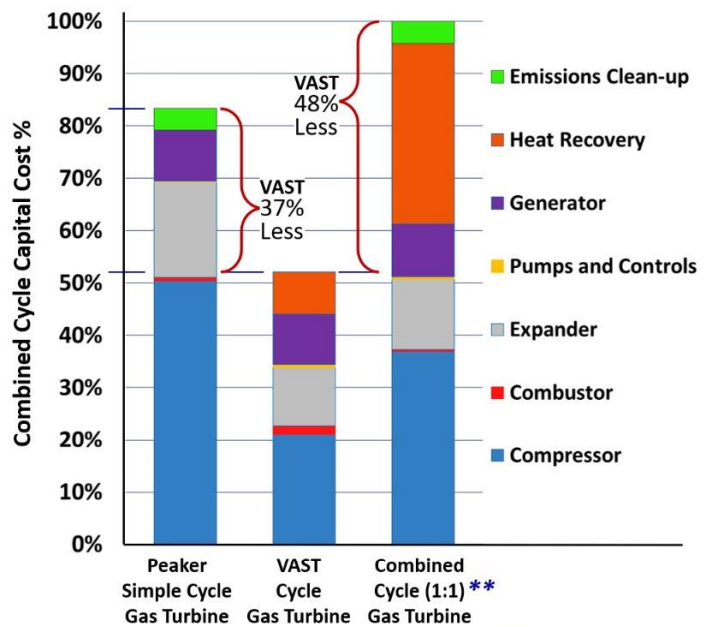


\* VAST Produces ~70% More Electricity with same expander, depending on Pressure

\*\* VAST has 24% Higher Efficiency Consuming 19% Less Fuel Reducing CO<sub>2</sub> by 19%

## VASTurbines Are Cheaper

VAST uses recycled water instead of compressed air to cool the combustor. This reduces by over 50% the size of the air compressor required. This cuts in half the cost of the gas turbine's most expensive component. A VASTurbine's compressor accounts for only 25% of the total equipment cost, compared to 60% in a typical gas turbine. Using the patented VAST® Wet Compression™ will further reduce compressor cost and improve efficiency. VAST requires less costly equipment and that is a VAST Advantage.



## VAST Cleanup Is Cheaper

To meet California's stringent emission regulations, competitors must use post-combustion exhaust gas treatments such as SCR (Selective Catalytic Reduction). This adds 7-10% in CapEx cost and significant OpEx expense. VAST does not incur those costs because we never create the NOx or CO that need to be removed. VAST's cleaner combustion enables cheaper cleanup.

## VAST Reduces Maintenance

VAST precisely and accurately controls combustion and the Turbine Inlet Temperature. This lowers thermal wear and tear which reduces maintenance, improves availability, and operating uptime. VASTurbines do not subject critical parts of its hot gas path to rapid temperature changes leading to metal fatigue and increased OpEx. These financial benefits and improved availability are VAST Advantages.

## VAST Virtually Eliminates Water Purification Expense

The VAST Liquid Recuperator recycles exhaust heat via steam and hot water. It condenses and recovers net water thereby eliminating the critical cost of supplying boiler quality replacement water currently incurred by simple water spray cooling to reduce NOx. Operational simplicity and cost savings are breakthrough VAST Advantages.

## **VAST Recovers Combustion Generated Water**

In addition, VAST recovers the water formed by burning natural gas (~12% of its mass), and similarly for other fuels, providing advantage on board ships or in deserts.

## **Long Duration Energy Storage (LDES)**

LDES was defined as full system backup for >4 hours. However, 100% renewable power must accommodate climate variations over four months. It must provide three times the worst backup needed for two weeks duration.

Of the competing technologies for LDES, VAST has lower CapEx & higher IRR than other forms of LDES to achieve Real Zero emission levels for Greenhouse Gases and traditional NOx and CO air pollutants. Backup power is premium priced power, offering higher profitability. The VAST Solution™ offers clean, effective backup limited only by the fuel supply.

## **Multi-fuel**

VAST® FastRamp™ Turbine offers ultra-clean NOx and CO emissions with ~19% less CO<sub>2</sub>, when combusting natural gas, than today's best simple gas turbine peakers. As Alternative Fuels such as hydrogen, ammonia or methanol become available, the VAST FastRamp Turbine can switch to using those fuels. This multi-fuel capability increases availability and can reduce fuel costs.

## **Rapid Ramping**

The VAST FastRamp Turbine promises the rapid startup and backup essential to ensure the reliability of intermittently powered renewable microgrids. The capacity to deliver additional power rapidly offers the opportunity to capture the premium prices paid for quickly delivered power.

## **Summary**

VASTech™ is Cleaner, More Efficient, and Cheaper in terms of CapEx/OpEx. These major advantages combine to offer the significant savings with increased market penetration and profit-making opportunities, generating the bottom-line VAST Advantage.

For additional information, visit [VASTPowerSystems.com](http://VASTPowerSystems.com)