

全球 AI 工业与能源 Global AI Industry and Energy

燃气轮机：在能源转型及 AI 数据中心发展时期的新角色

Gas Turbine: Emerging New Roles in the context of Energy Transition and AI Data Center Expansion

杨斌 Bin Yang

bin.yang@htisec.com

毛琼佩 Olivia Mao

olivia.qp.mao@htisec.com

热点速评 Flash Analysis

(Please see APPENDIX 1 for English summary)

燃气轮机广泛应用于发电、交通和工业动力领域。在发电行业，燃气轮机因其高效率 and 快速启动能力而被广泛使用，尤其是在调峰发电和分布式能源系统中，是燃气轮机主要的应用领域，占比接近 37%。在交通领域，燃气轮机被用于船舶动力系统，提供高效的推进动力。此外，燃气轮机也在工业领域中用于驱动机械设备，如泵和压缩机等。

燃气轮机在能源转型及 AI 数据中心发展中，燃气轮机扮演至关重要的新角色。燃气轮机在发电领域以其高效率、快速启动、结构紧凑、低污染排放、燃料适应性强和良好的环境适应性等特点而受到青睐，尤其适合作为调峰发电和紧急备用电源，同时在联合循环发电中能显著提升整体效率。在 AI 数据中心发展中，在能源转型目标时间渐进、稳定用电需求增加的过渡时期，燃气轮机将承担维持发电系统运营的稳定及安全的重要补充角色。

2023 年燃气轮机市场规模为 201.2 亿美元。我们预计从 2024 年到 2030 年，燃气轮机市场收入将以 3.6% 的复合年增长率增长，到 2030 年将达到近 259.8 亿美元。**燃气轮机行业格局稳定，三足鼎立。**根据全球能源监测机构的研究数据，三大燃气轮机制造商 Ge Vernova、西门子能源和三菱电力占据了全球在建燃气电厂燃气轮机市场的三分之二份额，其中通用电气以近 55 吉瓦的在建燃气轮机容量领先全球市场。燃气轮机行业竞争格局相对稳固，以容量订单来计算，行业排名 Top 3 的企业基本稳定为 Ge Vernova、西门子能源与三菱电力。由于燃气轮机的订单周期较长且体量较大，短期各企业具体市占率则略有波动。

我们预计 2023-2030 年美国数据中心和全球数据中心燃气轮机备用电源的总新增需求年复合增速分别为 18% 与 15%。基于此，预计 2023-2030 年美国数据中心对燃气轮机的总新增需求达到约 30GW，全球数据中心对燃气轮机的总新增需求达到 40GW。

投资建议

建议持续关注 Ge Vernova、三菱重工等企业。

风险

需求不及预期；产能不及预期；政策变化。

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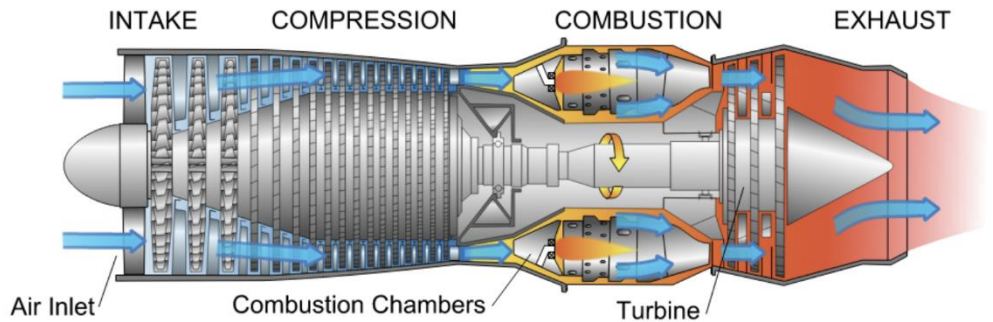
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1. 燃气轮机行业现状

1.1 燃气轮机的应用

燃气轮机是一种旋转式热力发动机，其工作原理是将化学能通过燃烧转化为机械能，最终转化为动力或电能。燃气轮机的技术核心在于其工作过程，包括压缩、燃烧和燃气膨胀三个主要步骤。压气机从外部吸入空气并压缩，压缩后的空气与燃料混合后在燃烧室燃烧，产生的高温燃气流入燃气涡轮中膨胀做功，推动涡轮叶轮旋转。燃气轮机的效率受到燃气初温和压气机压缩比的影响，提高这两个参数可以显著提升效率。

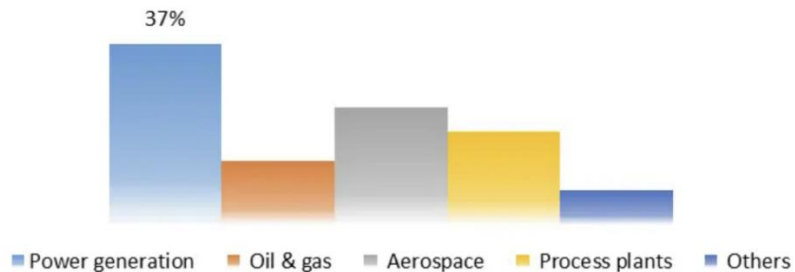
图：燃气轮机运作原理



资料来源: MMR, HTI

燃气轮机广泛应用于发电、交通和工业动力领域。在发电行业，燃气轮机因其高效率 and 快速启动能力而被广泛使用，尤其是在调峰发电和分布式能源系统中，是燃气轮机主要的应用领域，占比接近 37%。在交通领域，燃气轮机被用于船舶动力系统，提供高效的推进动力。此外，燃气轮机也在工业领域中用于驱动机械设备，如泵和压缩机等。

图：燃气轮机下游应用

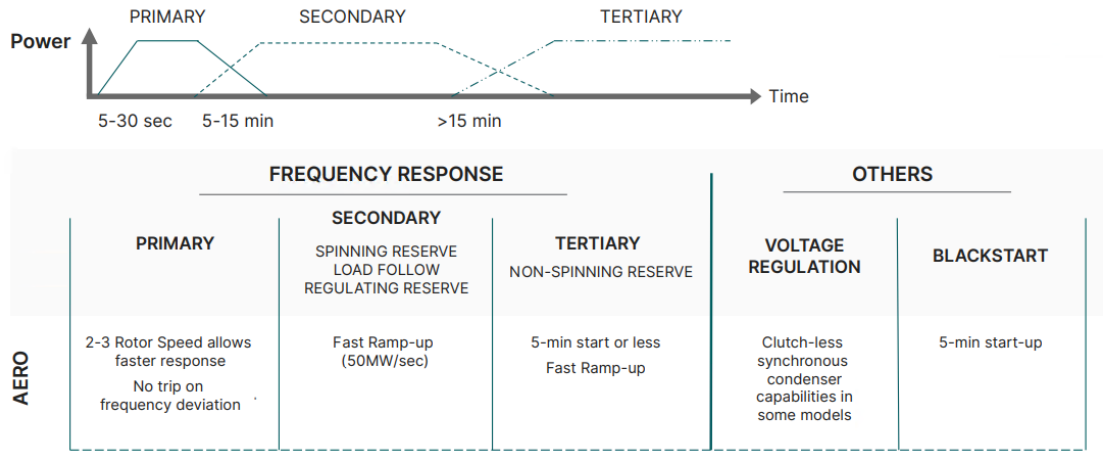


资料来源: MMR, HTI

燃气轮机可以根据不同的标准进行分类：**按功率大小分类**：可以分为大中型、小型和微型燃机。大中型燃机功率范围在 20MW 以上，小型燃机功率范围在 0.3MW 到 20MW，微型燃机功率范围在 30KW 到 300KW 或更小。**按下游应用分类**：可以分为航空燃气轮机、舰船燃气轮机和工业燃气轮机。航空燃气轮机主要用于军机及民用客机，舰船燃气轮机用于各类舰船，工业燃气轮机包括电站燃气轮机、机

械驱动燃气轮机等。按内部结构分类：可以分为重型燃气轮机、轻型燃气轮机和微型燃气轮机。重型燃气轮机主要用于大型电站，轻型燃气轮机（航改机）用于调峰发电等，微型燃气轮机体积小、质量轻。按涡轮转子进口温度分类：可以分为 E 级、F 级、G 级、H 级燃气轮机。这些级别的划分依据燃烧温度，不同国家和企业对等级的划分标准有所差异。

图：燃气轮机电网响应示意图（以 GE Aeros 燃气轮机为例）



资料来源: GE, HTI

1.2 燃气轮机在能源转型及 AI 数据中心发展时期的新角色

燃气轮机在能源转型及 AI 数据中心发展中，燃气轮机扮演至关重要的新角色。燃气轮机在发电领域以其高效率、快速启动、结构紧凑、低污染排放、燃料适应性强和良好的环境适应性等特点而受到青睐，尤其适合作为调峰发电和紧急备用电源，同时在联合循环发电中能显著提升整体效率。在 AI 数据中心发展中，在能源转型目标时间渐进、稳定用电需求增加的过渡时期，燃气轮机将承担维持发电系统运营的稳定及安全的重要补充角色。

图：2022 年美国电力净发电量及其燃料产生的二氧化碳排放量

U.S. electricity net generation and resulting CO₂ emissions by fuel in 2022

	Electricity generation	CO ₂ emissions		
	million kWh	million metric tons	million short tons	pounds per kWh
Coal	831,512	868	957	2.30
Natural gas	1,687,067	743	819	0.97
Petroleum	22,931	25	27	2.38
All energy sources	4,230,672	1,650	1,819	0.86

资料来源: EIA, HTI

数据中心运营商在能源转型期需要考虑用电新型解决方案。数据中心的快速增长意味着任何能源供应中断（如停电）的潜在后果都可能产生颇具破坏性的影响，包括数据丢失、系统停机，如果企业无法访问关键信息和系统，还可能造成重大的财务损失。因此，数据中心运营商必须考虑备用解决方案。

从历史上看，柴油发电机一直是传统的后备选择，而如果数据中心运营商想要在不损害环境的情况下获得不断扩大的云经济的回报，他们需要通过降低能源消耗、冷却、成本和二氧化碳排放来实现可持续发展。由于基础业务（大型科技公司）经济强劲、有能力将成本转嫁给消费者，以及参与者之间为赢得人工智能竞赛而展开的激烈竞争，所以数据中心是对电力价格最不敏感的电力消费者之一。

燃气轮机现场发电是大型数据中心的首选。该解决方案燃料效率高，二氧化碳排放量低，启动快：从 EIA 的数据可以看出，每单位的燃气发电的碳排放量为煤炭以及石油发电的约 40%。数据中心在外部突然断电或用电受限情况下需要启动备用电源，短时的供电可以由数据中心内的储能电池提供。但若发生长时间断电情况，必须保证备用电源可以覆盖数据中心全部电力需求。所以数据中心必须有足够功率的备用电源。即便是短期的备用发电，仍需要面临碳排放的监管和舆论的压力。例如亚马逊 2022 年要求在克隆肖商业科技园的数据中心安装 105 台备用柴油发电机和 4 台柴油消防泵。这些发电机组的总发电能力为 674 兆瓦。而当发电机组预计发电量超过 50 兆瓦时，就需要获得工业排放许可证。相比于柴油发电，燃气轮机也具有快速启动的特点，通常在几分钟内即可达到发电状态。并且数据中心采用燃气发电能产生更少的碳排放，这使得政府层面的建设审批和用电审批更容易通过。因此数据中心更倾向于使用燃气轮机而非别的化石能源。

另一方面，在外部断电情况下数据中心的备用电源需要稳定持续发电。风能光能发电虽然可以满足数据中心特定时段的用电需求，并通过储能电池进一步延长风能光能供电时间。然而风能光能发电仍有较大的周期性与波动性，特别是季节维度的周期性无法采用储能方式解决。而数据中心的高商业价值要求其 24 小时*365 天都必须有长期稳定且充裕的备用电源。因此，燃气轮机是现在和未来数据中心的备用电源的首选。

1.3 燃气轮机市场概况

根据 Maximize Market Research，2023 年燃气轮机市场规模为 201.2 亿美元。预计从 2024 年到 2030 年，燃气轮机市场收入将以 3.6% 的复合年增长率增长，到 2030 年将达到近 259.8 亿美元。

全球目前在建燃气轮机容量规模的三分之二以上都位于亚洲，其次为北美地区。根据 GEM 数据，Ge Vernova 在亚洲市场占据主导地位，在亚洲在建燃气轮机市场份额为 38%，三菱电力占比 17%，西门子能源占比 16%。

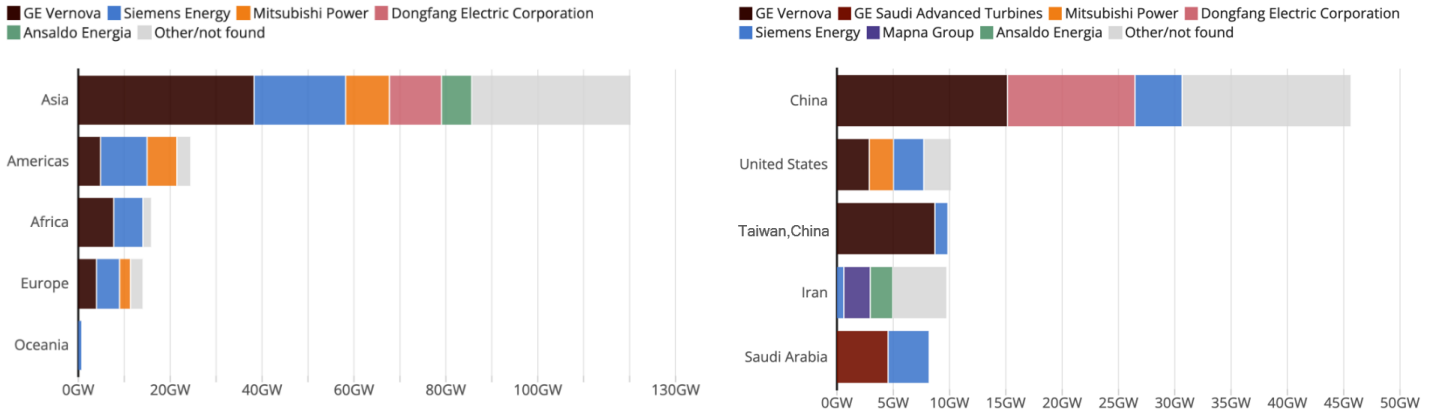
美国的燃气发电量远高于中国，主要原因在于两国的能源结构和政策差异。美国拥有丰富的天然气资源，近年来页岩气革命使天然气供应充足且价格低廉，促使电力部门大量采用天然气发电。2023 年，美国天然气发电量占总发电量的 43%，而中国的天然气发电量占比相对较低，主要依赖煤炭发电。

然而，全球在建的燃气轮机项目中，超过三分之二位于亚洲，主要原因为：1) 亚洲国家，特别是中国和印度，正积极推进能源结构转型，减少对煤炭的依赖，降低碳排放。燃气发电作为清洁能源选项，成为替代煤电的重要途径；

2) 电力需求增长：亚洲地区经济快速发展，工业化和城市化进程加快，电力需求持续上升。燃气发电因其建设周期短、调节灵活，适合满足快速增长的电力需求。

图：分区域燃气轮机在建容量 (GW)

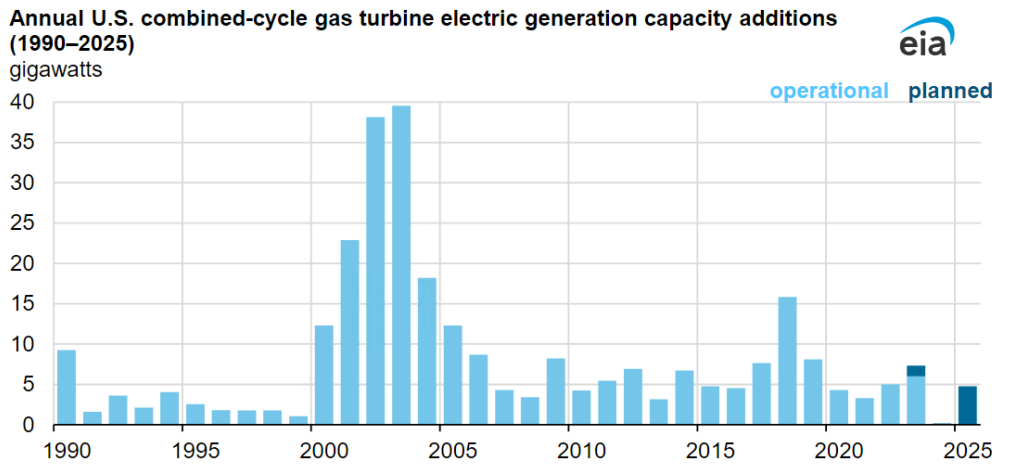
图：制造公司在主要建造地区的燃气轮机在建容量 (GW)



Source: Global Oil and Gas Plant Tracker, August 2024, Global Energy Monitor

预计美国燃气轮机市场未来增长主要来自 AI 数据中心。美国虽然燃气发电量远高于中国，但其电力需求相对平稳，美国燃气轮机建设爆发期为 2000-2005 年，现有燃气轮机规模较大且可以满足发电需求，所以短期美国燃气轮机在建规模相对较小。我们预计美国市场燃气轮机的未来增长将由数据中心推动。

图：美国例年联合循环燃气轮机新装机量

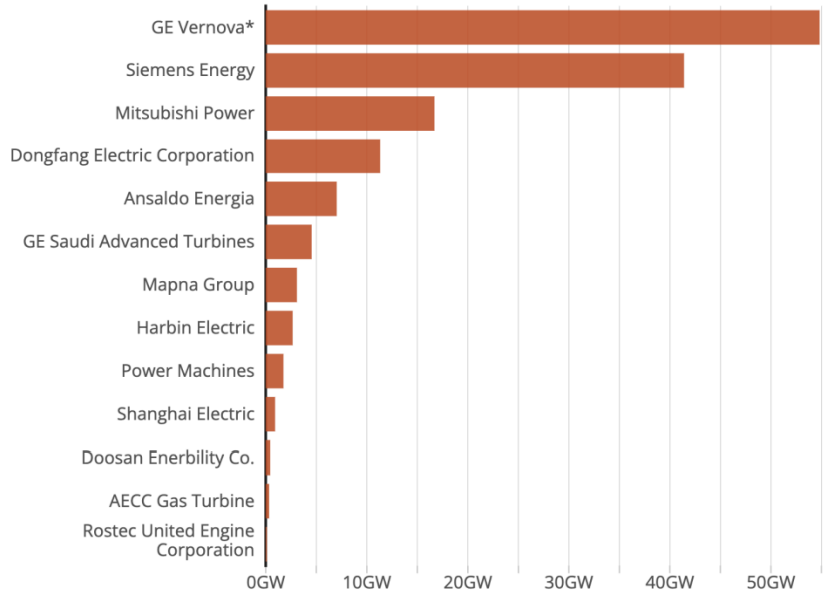


资料来源: EIA, HTI

1.4 燃气轮机行业竞争格局

燃气轮机行业格局稳定，三足鼎立。根据全球能源监测机构的研究数据，三大燃气轮机制造商 Ge Vernova、西门子能源和三菱电力占据了全球在建燃气电厂燃气轮机市场的三分之二份额，其中通用电气以近 55 吉瓦的在建燃气轮机容量领先全球市场。燃气轮机行业竞争格局相对稳固，以容量订单来计算，行业排名 Top 3 的企业基本稳定为 Ge Vernova、西门子能源与三菱电力。由于燃气轮机的订单周期较长且体量较大，短期各企业具体市占率则略有波动。

图：全球燃气轮机在建容量（GW）



资料来源：Global Oil and Gas Plant Tracker, August 2024, Global Energy Monitor, HTI

* GE Power 于 2024 年 4 月重新命名并分拆为 GE Vernova

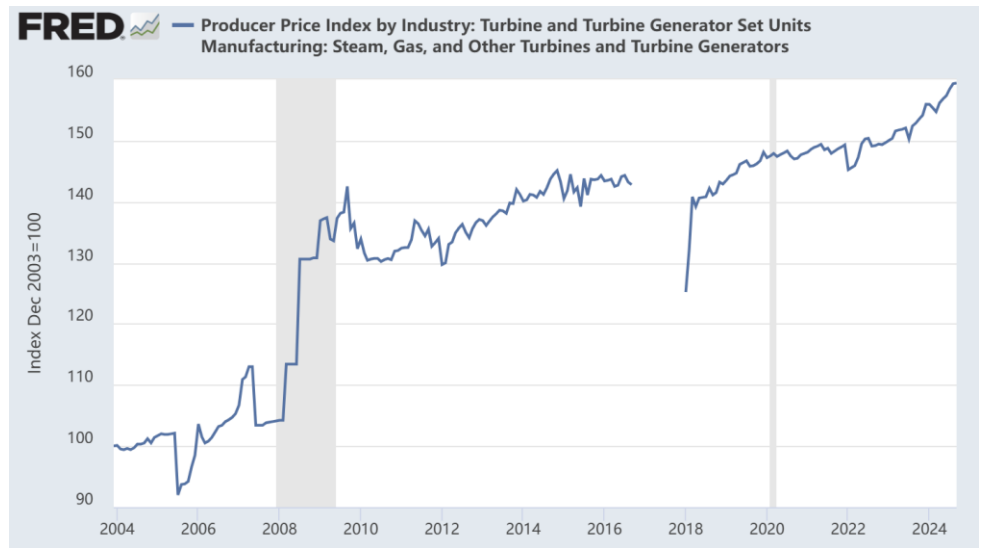
三菱电力新增容量订单市占率跃升至行业第一。虽然三大燃气轮机制造商 Ge Vernova、西门子能源和三菱电力中，整体在建规模最大的为 Ge Vernova，然而根据 McCoy Power Reports 的数据，三菱电力在 2023 年新增订单容量的市场份额中位居榜首，在全球燃气轮机的市场份额为 36%，这是继 2022 年之后，三菱电力连续第二年实现燃气轮机全球市场份额第一。2023 年三菱电力在高级燃气轮机市场中占据了 56% 的市场份额，其中以三菱电力最新型号 JAC 燃气轮机为主导。

1.5 燃气轮机市场近况

2024 年上半年，燃气轮机订单表现有所好转。Q2 动态订单容量同比-6%，相较于同口径下 Q1 (-26%) 有所恢复；Q2 动态订单单位数量同比-4%，相较于同口径下的 Q1 (-10%) 亦有所恢复。燃气轮机大型化，单位价值有所增加。在市场细分领域内，2024 年上半年小型机组订单达 123 台，同比+7%，而大型机组订单达 72 台，同比+33%。

燃气轮机价格持续温和上升。截至 2024 年 9 月，燃气轮机价格指数年初以来上涨了 4%，自可追溯的 2004 年以来的价格指数数据来看，燃气轮机价格持续上升，2004 年至 2024 年复合增速接近 2%。短期来看，2024 年以来价格上升增速有所提升。

图：发电燃气轮机价格指数



资料来源：U.S. Bureau of Labor Statistics，HTI

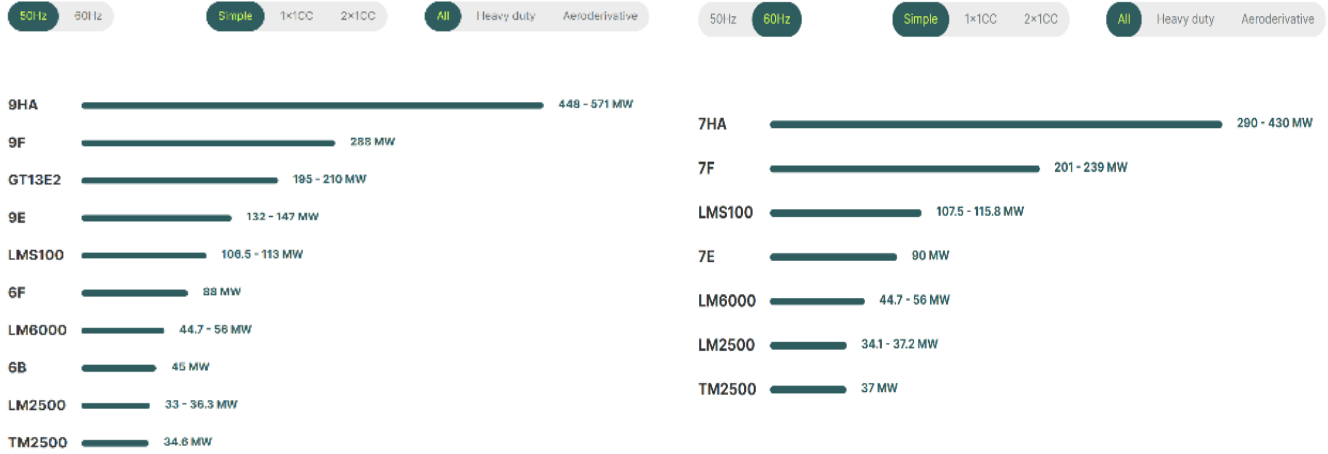
积压订单较多，头部企业扩产。结合目前燃气轮机在建订单容量来看，目前头部企业积压订单容量较高，GeV等企业均有投产计划。由于燃气轮机资本开支周期较长，短期增速波动不影响完整周期的需求，同时，行业格局稳定，我们预计价格体系将维持稳定。

2. 燃气轮机行业的发展趋势

2.1 头部企业技术对比

GE Vernova 产品布局及设计多样化较高。公司 9HA 系列重型燃气轮机是世界上效率最高的联合循环燃机之一，其最新型的 9HA.02 重型燃气轮机联合循环效率超过 64%，功率输出高达 826MW。GE 注重技术研发和航空科技成果转化，其燃气轮机技术在效率和输出功率方面表现出色。

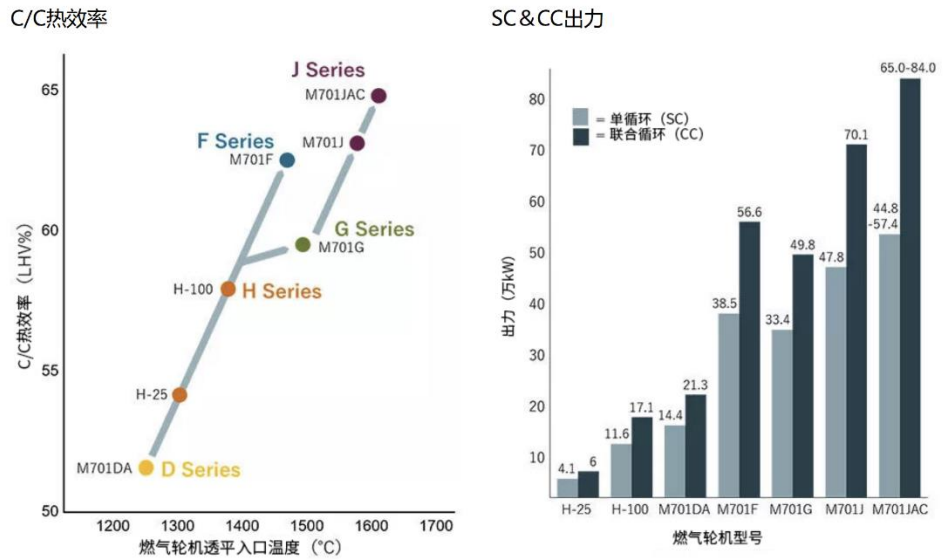
图：GE Vernova 产品矩阵示例



资料来源：公司官网，HTI

三菱电力的所有重型燃气轮机现在都配备了氢气共燃功能，以实现更深层次的脱碳。三菱电力的燃气轮机技术以高可靠性和可用性著称，其 J 系列燃气轮机可靠性达到了 99.5%。三菱电力在 F、G 和 J 级燃气轮机方面拥有丰富的经验，J 级燃气轮机的实际运行小时数已超过 230 万小时。根据 McCoy Power Reports 的数据，三菱电力在 2023 年以 36% 的全球燃气轮机市场份额位居第一，其中先进级的 J/H/G 级燃气轮机市场份额达到 56%。迄今为止公司已交付的燃气轮机发电设备超过 1600 台，重型燃气轮机占比 65%。

图：三菱重工燃气轮机性能比较



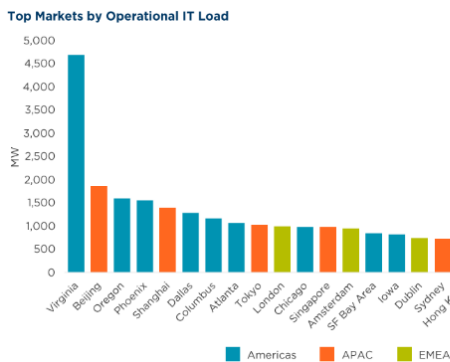
资料来源：公司官网，HTI

西门子能源燃气轮机产品组合具有两大优势：**低生命周期成本和出色的投资回报率**。西门子能源燃气轮机在效率、可靠性、灵活性和环境适应性方面满足了广泛应用需求。西门子能源重型燃气轮机、工业型燃气轮机和航改型燃气轮机产品系列丰富，最大功率可达593 MW。

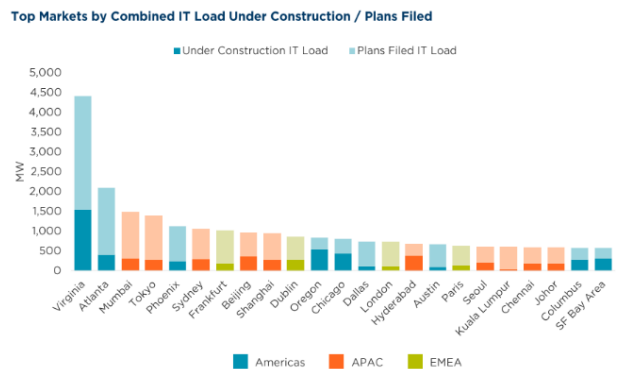
2.2 美国/全球数据中心对燃气轮机的需求拉动达 18%/15%

基于数字化程度提高、云服务的增长特别是AI业务相关的强劲需求，全球数据中心特别是美国数据中心迎来快速增长。据戴德梁行2024年数据统计，美国数据中心运营规模、在建和计划建造规模居世界第一。

图：全球数据中心运营规模 (MW)



图：全球数据中心在建与计划规模 (MW)

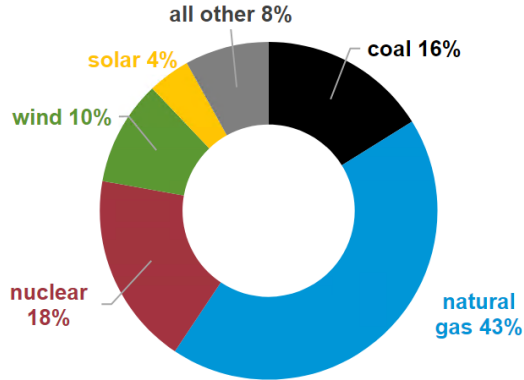


Source: Cushman & Wakefield Research, datacenterHawk. DC Byte, Structure Research, HTI

天然气是美国发电的最大单一能源，占 2023 年发电量的 43%。天然气发电厂占 2023 年美国发电量增加的第二大来源，仅次于太阳能。再加上国内供应增加和天然气价格相对较低，天然气发电厂能够满足美国许多市场的各种需求，这是其增长的主要原因之一。2022 年，联合循环燃气轮机(CCGT)占天然气机组的最大份额，其次是简单循环燃气轮机 (SCGT)、蒸汽轮机 (ST) 和内燃机 (ICE)。

图：美国 2023 年各发电类型占比

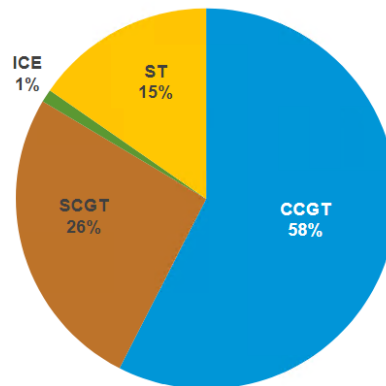
Share of electricity generation by resource type (2023)



资料来源： EIA， HTI

CCGT 电厂效率高，因此能够在较长时间内产生低成本电力，并且配置为提供电力以满足负载,然而联合循环系统启动时间长，通常需要几十分钟甚至更长，不适合需要快速启动的应用。简单循环燃气轮机、蒸汽轮机和内燃机这三种技术可以快速启动并快速达到满功率，而蒸汽轮机和内燃机效率较低。数据中心追求备用电源快速响应以及效率的平衡，因此我们预计数据中心备用的燃气轮机电源技术以简单循环燃气轮机为主。

图：美国 2023 年各发电类型占比



资料来源： EIA， HTI

据 IEA 2024 年对于 2026 年全球数据中心电力需求预测基准需求约为 800 TWh，相较 2022 年的约 460 TWh 的需求，2022-2026 年复合增速为 14.84%。我们预测 2023-2030 年全球数据中心电力相关设备复合增速约为 15%，美国数据中心电力复合增速约为 18%。

据 Cushman & Wakefield 统计，2023 年美国数据中心容量约 16.8 GW，全球数据中心容量约 33.62 GW。我们预计由于环保等政策不同，美国数据中心对于燃气轮机的需求较高于别的地区。

我们预计，数据中心备用电源相关燃气轮机年复合增速与数据中心新增规模线性相关，2023-2030 年美国数据中心和全球数据中心燃气轮机备用电源的总新增需求年复合增速分别为 18%与 15%。基于此，预计 2023-2030 年美国数据中心对燃气轮机的总新增需求达到约 30GW，全球数据中心对燃气轮机的总新增需求达到 40GW。

APPENDIX 1**Summary**

Gas turbines are widely used in power generation, transportation, and industrial power sectors. In the power generation industry, gas turbines are popular due to their high efficiency and quick start-up capabilities, especially in peak-load power generation and distributed energy systems. These applications account for nearly 37% of gas turbine use. In the transportation sector, gas turbines are applied in marine propulsion systems, providing efficient thrust power. Additionally, gas turbines are used in the industrial sector to drive machinery, such as pumps and compressors.

Gas turbines are playing a critical new role in energy transition and the development of AI data centers. In the power generation sector, gas turbines are favored for their high efficiency, rapid start-up, compact structure, low emissions, strong fuel adaptability, and environmental resilience. They are particularly suitable for peak-load generation and as emergency backup power. In combined-cycle power generation, they significantly improve overall efficiency. In the growth of AI data centers, gas turbines serve as a key supplementary role in maintaining operational stability and safety of power systems during the transition period, as stable electricity demand increases under energy transition timelines.

The gas turbine market size in 2023 was \$20.12 billion. It is projected that from 2024 to 2030, gas turbine market revenue will grow at a compound annual growth rate (CAGR) of 3.6%, reaching nearly \$25.98 billion by 2030. The gas turbine industry landscape is stable and dominated by three major players. According to data from the Global Energy Monitoring Agency, three main gas turbine manufacturers, GE Vernova, Siemens Energy, and Mitsubishi Power, occupy two-thirds of the market share in gas turbines for gas-fired power plants under construction globally. GE leads the market with nearly 55 GW of gas turbine capacity under construction worldwide. The competitive structure of the gas turbine industry is relatively stable, with GE Vernova, Siemens Energy, and Mitsubishi Power consistently ranking as the top three companies by capacity orders. Due to the lengthy and large-scale nature of gas turbine order cycles, short-term market shares of each company may vary slightly.

We anticipate that from 2023 to 2030, the annual compound growth rate of new demand for gas turbine backup power in U.S. data centers and global data centers will be 18% and 15%, respectively. Based on this, it is expected that from 2023 to 2030, the total new demand for gas turbines in U.S. data centers will reach approximately 30 GW, and for global data centers, about 40 GW.

Investment advice: it is suggested to continuously monitor companies like GE Vernova and Mitsubishi Heavy Industries.

Risks: Demand below expectations; capacity shortfall; policy changes.

附录 APPENDIX

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中性，未来 12-18 个月内预期相对基准指数变化不大，基准定义如下。根据 FINRA/NYSE 的评级分布规则，我们会将中性评级划入持有这一类别。

弱于大市，未来 12-18 个月内预期相对基准指数跌幅在 10% 以上，基准定义如下

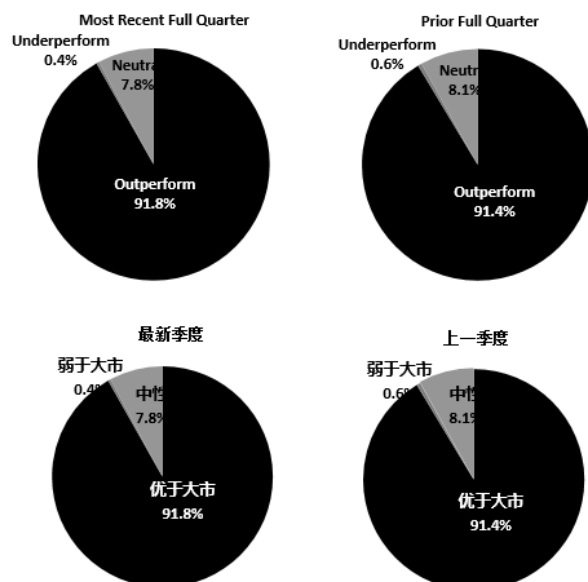
各地股票基准指数：日本 - TOPIX, 韩国 - KOSPI, 台湾 - TAIEX, 印度 - Nifty100, 美国 - SP500; 其他所有中国概念股 - MSCI China.

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评级分布 Rating Distribution

Ratings Distribution



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Benchmarks for each stock's listed region are as follows: Japan – TOPIX, Korea – KOSPI, Taiwan – TAIEX, India – Nifty100, US – SP500; for all other China-concept stocks – MSCI China.

截至 2024 年 9 月 30 日海通国际股票研究评级分布

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投资银行客户*	3.5%	4.4%	0.0%

*在每个评级类别里投资银行客户所占的百分比。

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此前的评级系统定义（直至 2020 年 6 月 30 日）：

买入，未来 12-18 个月内预期相对基准指数涨幅在 10%以上，基准定义如下

中性，未来 12-18 个月内预期相对基准指数变化不大，基准定义如下。根据 FINRA/NYSE 的评级分布规则，我们会将中性评级划入持有这一类别。

卖出，未来 12-18 个月内预期相对基准指数跌幅在 10%以上，基准定义如下

各地股票基准指数：日本 – TOPIX, 韩国 – KOSPI, 台湾 – TAIEX, 印度 – Nifty100; 其他所有中国概念股 – MSCI China.

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	Outperform	Neutral (hold)	Underperform
HTI Equity Research Coverage	91.8%	7.8%	0.4%
IB clients*	3.5%	4.4%	0.0%

*Percentage of investment banking clients in each rating category.

BUY, Neutral, and SELL in the above distribution correspond to our current ratings of Outperform, Neutral, and Underperform.

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SEBI 研究分析师注册号: INH000002590

地址: 1203A, Floor 12A, Tower 2A, One World Center

841 Senapati Bapat Marg, Elphinstone Road, Mumbai 400 013, India

CIN U74140MH2011FTC224070

电话: +91 22 43156800 传真: +91 22 24216327

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Name of the entity: Haitong Securities India Private Limited

SEBI Research Analyst Registration Number: INH000002590

Address : 1203A, Floor 12A, Tower 2A, One World Center

841 Senapati Bapat Marg, Elphinstone Road, Mumbai 400 013, India

CIN U74140MH2011FTC224070

Ph: +91 22 43156800 Fax:+91 22 24216327

Details of the Compliance Officer and Grievance Officer : Prasanna Chandwaskar : Ph: +91 22 43156803; Email id: prasanna.chandwaskar@htisec.com

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