MICRO GAS TURBINES: CHALLENGES AND OPPORTUNITIES

ETN Global Position Paper

Outcomes from the 5th European Micro Gas Turbine Forum

November 2025

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Objective

This white paper summarises the topics and challenges related to the Micro Gas Turbines (MGT) industry discussed during the 5th European Micro Gas Turbine Forum (EMGTF) in Brussels on 15-16 November 2025. The objectives of the meeting were to:

- Create a Micro Gas Turbine community
- Identify industry challenges and opportunities

This document consolidates the outcomes of the forum discussions and lays the foundation for future collective and corrective actions. The base of the information over technical and market overview is taking from ETN Global previous publications such as Decentralised Energy Systems: Towards Carbon-Neutral Energy Solutions for Gas Turbines [1], the Micro Gas Turbine Technology Summary [2] and publications from the existing literature.

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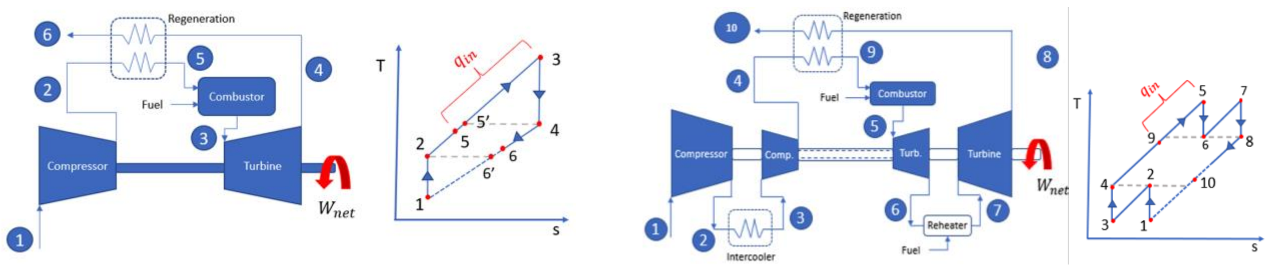
Technology overview

Micro Gas Turbines (MGT) thermodynamic cycle is based on the open ideal Brayton cycle, which consists of four main steps: (1) Adiabatic compression of ambient air, (2) Constant-pressure combustion of fuel, (3) adiabatic expansion in the turbine, and (4) Heat rejection back to ambient conditions.

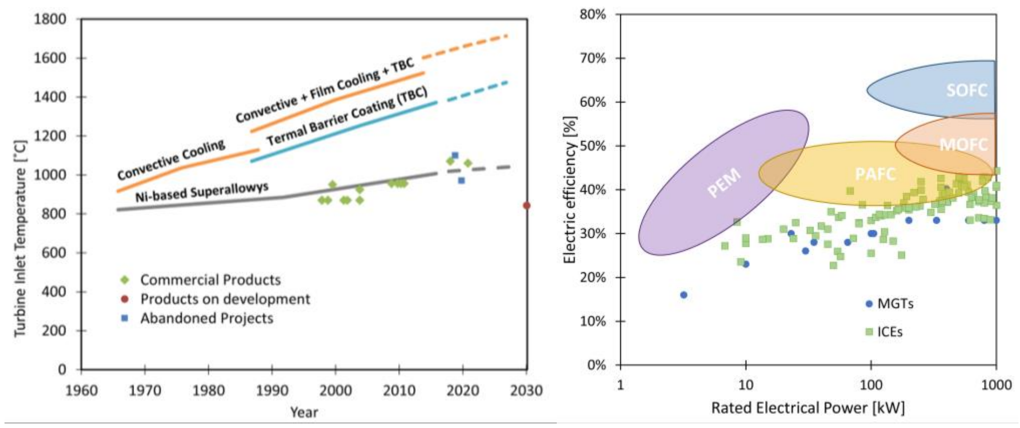
To improve performance, regenerative cycles (Figure 1a) are usually adopted: a heat exchanger recovers energy from the hot exhaust to preheat the compressed air, reducing fuel consumption and increasing thermal efficiency. Advanced configurations may include intercooling and reheating for further gains in performance (Figure 1b). At small scales (< 500 kW), centrifugal compressors and radial turbines are preferred. However, these components limit the pressure ratio (≈ 3.5–5:1) and turbine inlet temperature (800°C-1000°C, Figure 2a), resulting in lower efficiencies (~30%) compared to larger gas turbines, as well as competing technologies in their power range as reciprocating Internal Combustion Engines (ICEs) and Fuel Cells (Figure 2b).



(a) *(b)*

Figure 1: Representation of two common cycle configurations for MGTs. (a) Sketch of the ideal regenerative Brayton cycle and the T-s diagram. (b) Sketch of the ideal regenerative, intercooling, and reheating Brayton cycle and T-s diagram. Source: ETN Global [1].

A key strength of MGT systems is their ability to recover waste heat for industrial or residential use. When integrated into Combined Heat and Power (CHP) systems, overall plant efficiencies can be significantly increased by using both the generated electricity and the recovered heat [3].



(a) *(b)*

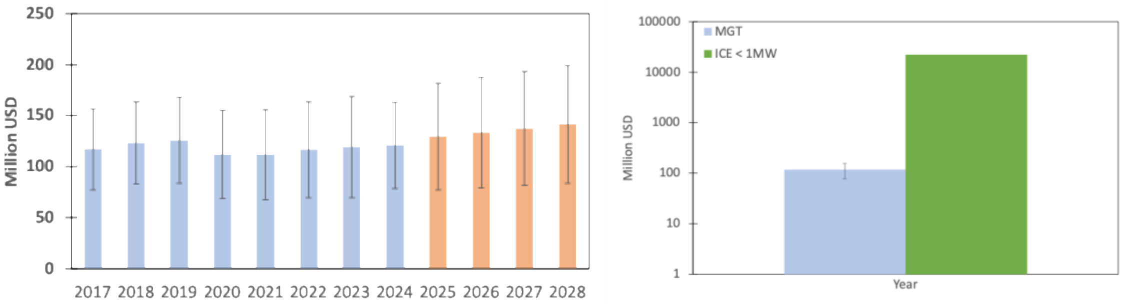
Figure 2: (a) Historical representation of Turbine Inlet Temperature in MGT products [4]. (b) Representation of MGT electrical efficiencies compared to competing technologies [4].

Market overview

The main Original Equipment Manufacturers (OEMs) and MGT companies considered in this study are:

- Ansaldo Green Tech,
- Aurelia Technology,
- Bladon,
- Capstone Green Energy,
- Euro-k,
- Flex Turbines,
- MITIS,
- MTT.

The current market, including new unit sales and services for existing equipment, is estimated to be around 120 million USD. In contrast, the potential market could be several orders of magnitude larger if we consider full market penetration comparable to reciprocating engines, along with possible new dedicated MGT applications.



(a) (b)

Figure 3: Estimated market size (a) and potential market size (b). Sources: (a) sourced and updated from Tilocca et al [4] and including own estimation based on estimated sales and existing equipment, (b) Tilocca et al. [4]. The figures above are speculative and not intended to be a precise estimation rather provide a rough order of magnitude.

One of the main reasons for the lower market uptake is the higher capital cost and lower electrical efficiency compared to competing technologies, such as reciprocating engines. However, these drawbacks are offset by the high fuel flexibility and long time between overhauls (4,000–8,000 hours), which result in lower maintenance costs.

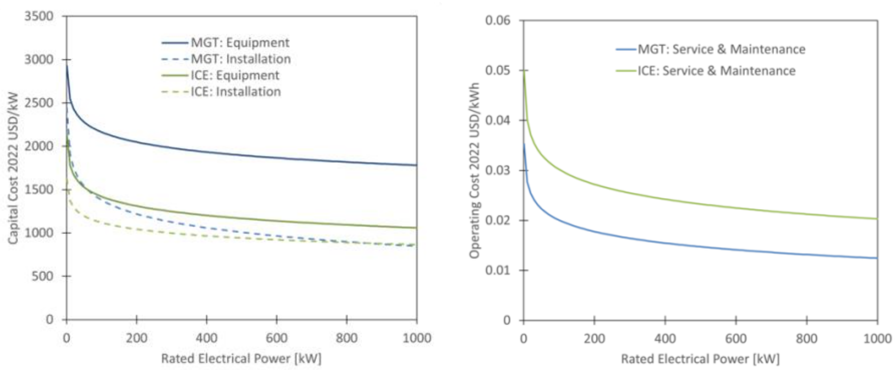


Figure 4: (a) Capital and (b) Service & Maintenance relative costs for MGTs and reciprocating internal combustion engines (ICEs). Source Tilocca et al [3].

For these set combination of facts, MGT are successful in specific market niches:

- Oil and Gas applications including off-shore and gas compression
- Biogas, sewage gas and waste fuels
- Cogeneration with high heat requirements (either mid grade heat or high heat to power ratio)
- Off-grid (e.g. telecom towers)

Barriers

The following barriers have been identified as the main - though not the only - factors hindering MGT commercialisation and preventing the technology from reaching its full market potential.

Cost of components

The overall capital cost of MGTs is determined by a combination of system and project-related expenses. As illustrated in Figure 5, the genset itself accounts for about half of the total project cost. The remaining costs arise from engineering, installation, heat recovery, and ancillary systems such as fuel gas compression.

Within the genset, costs are distributed among several key components. Major contributors include the recuperator and the power conversion unit (PCU), each representing roughly 10-15% of the genset cost, while other items such as the compressor, enclosure, and combustor have smaller shares. This cost structure highlights the technological and manufacturing challenges associated with MGTs, where high-speed operation and thermal efficiency requirements drive the complexity - and thus the cost - of critical components.

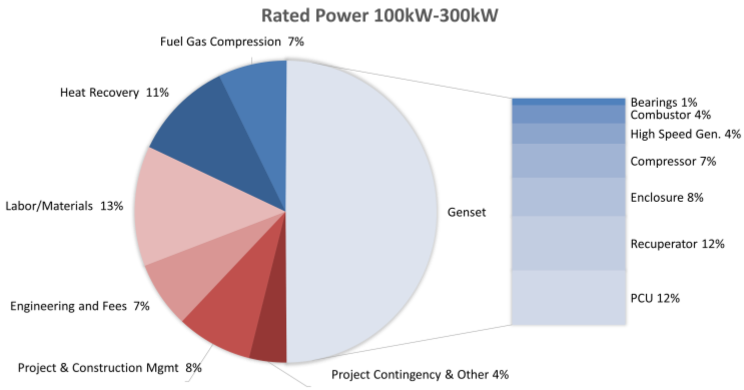


Figure 5: Representative cost distribution of a typical MGT in a 100-300kW range. Source: Tilocca et al. [4]

Recuperator

The recuperator is one of the most cost-intensive components of a micro gas turbine system, typically representing around 10–15% of the genset's total capital cost. Its high price stems from the need for custom-made designs, tailored to specific turbine configurations and operating temperatures. The manufacturing process requires precision engineering and advanced materials to ensure high thermal efficiency, compactness, and durability under cyclic thermal stresses. As a result, the recuperator remains a critical - but costly - element in the overall system architecture. One of the main barriers related to recuperator cost is the lack of standardisation across engine sizes, which range from 3 kW to 400 kW. This diversity prevents the development of scalable, modular designs. Some OEMs design and manufacture recuperators in-house, while others rely on dedicated external suppliers. However, in most cases, these suppliers serve only a single OEM, limiting production volumes and preventing economies of scale across the industry. This fragmented supply chain contributes significantly to the high unit cost of recuperators in micro gas turbines

Power Conversion Unit (PCU)

Micro gas turbines operate at very high rotational speeds, generating electricity through high-speed alternators that produce direct current (DC). This DC output must be converted to alternating current (AC) via inverters, adding a significant cost component relative to systems that employ conventional synchronous generators. The PCU can represent up to 10–15% of the genset cost, largely due to the need for robust power electronics, cooling systems, and control interfaces that ensure grid compliance and operational stability.

Fuel compressor (biogas applications)

In applications using biogas or waste-derived fuels, the fuel gas compressor can become a major cost driver. Because these fuels are typically supplied at low pressures and variable compositions, additional compression and conditioning equipment is required. In such cases, the compressor cost can approach or even equal the cost of the genset itself, representing up to 100% of the genset value. This additional capital requirement significantly affects the economic viability of MGTs in biogas installations, reducing their competitiveness against reciprocating engine alternatives.

Scalable supply chain

One of the main issues highlighted by the community concerns the limited scalability of the micro gas turbine (MGT) supply chain. Reducing the capital cost of key components would require significant upfront investment, which can only be justified by a substantial increase in production volumes (Figure 6). Given the relatively small and fragmented market, such economies of scale remain difficult to achieve, leading companies to adopt conservative strategies that preserve existing technologies and manufacturing practices. A key difference between large gas turbines (GTs) and micro gas turbines (MGTs) lies in their respective supply chain structures. Large GT manufacturers benefit from high production volumes, standardised components, and well-established supplier networks, which enable continuous cost reduction and performance improvement through iterative design and process optimisation. In contrast, MGT manufacturers operate in niche markets with low production volumes, customised designs, and a limited number of specialised suppliers. Many critical components - such as recuperators, high-speed generators, or bearings - are developed for specific models or OEMs, with little cross-utilisation between manufacturers. This fragmentation restricts knowledge sharing, limits supplier competition, and ultimately keeps unit costs high even as technical maturity improves.

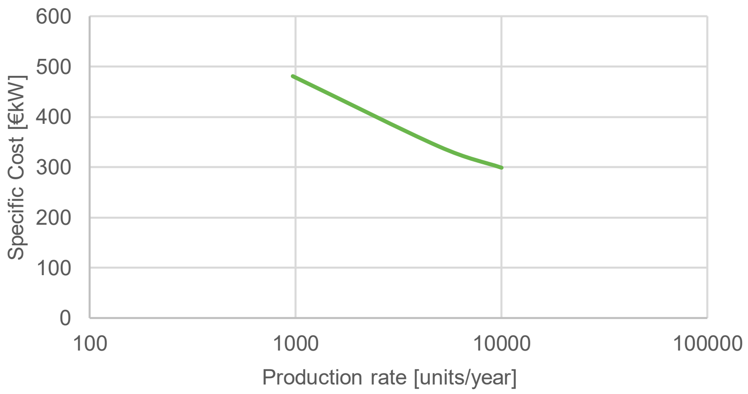


Figure 6: Reduction in capital cost as a function of production volume. Source: Gavagnin [5].

Ununiform certifications and regulations (Europe)

The lack of harmonised certification frameworks and grid regulations across European countries poses another major barrier to MGT market expansion. Each national market often applies different technical requirements, grid codes, and certification procedures for power generation units, even within the same power range. For OEMs, this fragmentation translates into significant additional engineering, testing, and administrative costs when adapting products to meet country-specific rules. Unlike larger OEMs in the industrial gas turbine sector, which can spread these compliance costs across a global sales base, MGT manufacturers typically lack the production scale to absorb such expenses. Furthermore, certification procedures for small-scale distributed generation are not always aligned with those for reciprocating engines or renewable technologies, creating uncertainty and prolonging time-to-market. This situation discourages new entrants and limits the competitiveness of smaller MGT producers. The issue is compounded by the diversity of engine sizes within the MGT sector - ranging from a few kilowatts to several hundred kilowatts - which complicates the establishment of unified testing and regulatory standards. A closer collaboration among stakeholders, including OEMs, utilities, certification bodies, and policy institutions, would be essential to streamline certification pathways and reduce redundant costs across national markets.

Opportunities

Several application segments are emerging as promising opportunities for MGT technologies in the next decade. During the Forum it emerged that in the period 2025–2035 is expected to see strong growth across diversified markets (Table 1), driven by increasing demand for decentralised, efficient, and fuel-flexible power solutions.

Table 1 Expected CARG for several MGT related applications.

Applications	CAGR 2025-2035
Naval Hybrid Propulsion	5%
Advanced Air Mobility Hybrid Propulsion	66%
UAV Propulsion	8%
e-Auxiliary Power System	3%
Combined Heat and Power	5%

High-growth applications such as *Advanced Air Mobility (AAM)* stand out with an estimated CAGR of 66% for hybrid propulsion systems. The combination of lightweight design, high power density, and multi-fuel capability positions MGTs as a strong candidate for range extenders in electric aircraft and urban air mobility platforms. In this scenario the development of innovative concept on turbomachinery design and manufacturing allowing cost. Reduction and performance improvement (blade colling) and compact /cost effective design for recuperator together will be an enable for MGT penetration in the segment.

Similarly, the *Naval Hybrid Propulsion* sector shows a steady growth potential (5% CAGR), supported by the need for compact, low-emission, and reliable onboard power systems. Project like MARPOWER, presented during the Forum present the opportunity to scale the unique, high-efficiency MGT technology developed by Aurelia for the 400kW-41%efficient A400 to larger 5MW >45%efficiency generators.

In stationary applications, *Combined Heat and Power (CHP)* systems remain a stable yet underexploited market, with a 5% CAGR and significant potential for further penetration. High-efficiency micro gas turbines can complement or replace conventional technologies, particularly when coupled with hydrogen or synthetic fuels. *e-Auxiliary Power Systems* (3% CAGR) and *Prime Power for Data Centres* represent additional niches where MGTs could play a key role, following the trend of larger turbines and the increasing need for resilient, clean, and continuous power supply.

Finally, *fuel flexibility* emerges as a major enabler across applications. The ability to operate with hydrogen, waste gases, or synthetic fuels derived from processes such as pyrolysis enhances both sustainability and energy security. Together, these opportunities indicate that micro gas turbines—supported by innovation in materials, combustion systems, and hybridisation—can play a strategic role in the transition toward cleaner and more distributed energy systems.

Conclusions

The MGT market has experienced a period of stagnation in recent years, primarily due to technology costs, limited production scale, and competition from established distributed energy solutions. However, these same challenges now represent opportunities. Innovations in hybridisation, digital control, and fuel-flexible combustion are opening new pathways for performance improvement and cost reduction. Considering the rapid electrification of mobility, the decarbonisation of heat, and the diversification of energy sources, the potential for growth is of *several orders of magnitude* compared to the current installed base, this takes into account the unrealised potential of the existing market together with new emerging opportunities. The sector now stands at a pivotal point, where rethinking applications, business models, and integration strategies can unlock a new phase of expansion for micro gas turbine technologies.

Further work

Community

To strengthen collaboration and information exchange, it is recommended that the community meets in person at least once per year, ideally alongside a major industry event. In addition, more frequent remote meetings and the establishment of dedicated working groups (WGs) would facilitate continuous progress on specific technical and market topics throughout the year. Within this framework, the ETN Global Energy Integration Working Group will serve as the central hub for the MGT community, facilitating coordination and knowledge sharing.

Stakeholder involvement

The group should aim to broaden participation by engaging a larger number of suppliers and OEMs, including both established and emerging players. Expanding representation across the value chain will help ensure that discussions and outcomes reflect the full spectrum of technical, manufacturing, and market perspectives.

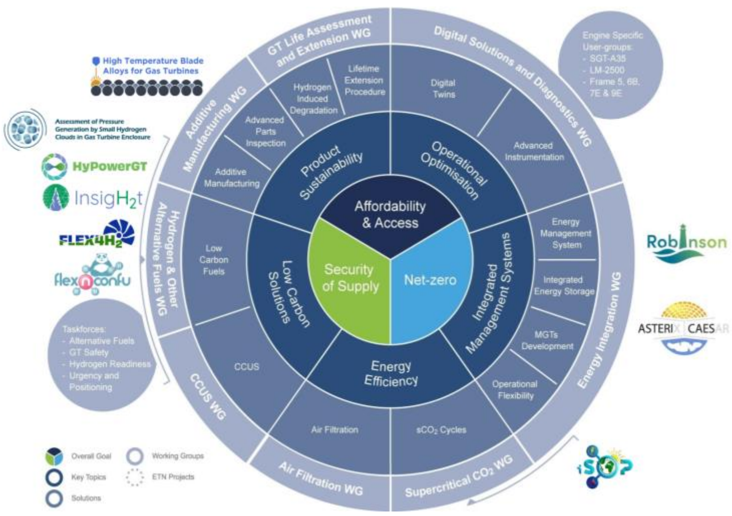
At the same time, it would be highly beneficial to involve end users and associations or institutions representing their interests, as their input would provide valuable insight into operational needs, market expectations, and real-world deployment challenges.

Strategic direction

To define and guide the forum’s future activities, it is proposed to establish a Steering Committee composed of representatives from key stakeholder groups. This committee would convene in an online strategic meeting to discuss priorities, set objectives, and coordinate the roadmap for the next phase of the community’s development.

About Energy & Turbomachinery Network (abbrev. ETN Global)

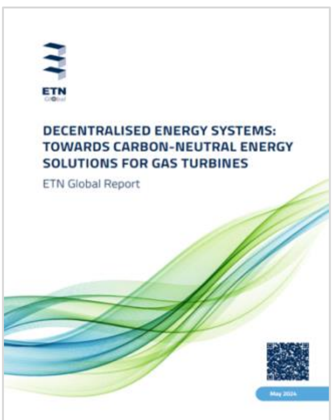
ETN Global is a non-profit membership association that brings together utilities, energy companies, industrial power and heat users, turbomachinery manufacturers, suppliers, service providers, and the related research and development community. Through cooperative efforts and by initiating common activities and projects, ETN Global encourages and facilitates information exchange and cooperation to accelerate research, development, demonstration, and deployment of safe, secure, affordable and dispatchable carbon-neutral energy solutions. ETN Global addresses the main challenges and concerns of gas turbine users in projects and Working Groups, composed of experts across the entire value chain.



ETN Global Technology Platform

This activity is framed within the Energy integration WG. Other previous reports of this WG regarding closely Micro Gas Turbine include:

- Decentralised Energy Systems: Towards Carbon-Neutral Energy Solutions For Gas Turbines
- Micro Gas Turbine Technology Research and Development for European Collaboration



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