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The Internal Combustion Engine Has the Most Influence on the Performance Automobiles

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Abstract. This research examines the relative influence of the internal combustion engine (ICE) on automobile performance compared to turbochargers and transmissions. The study draws from historical developments, case studies, and modern technological trends to demonstrate that ICE remains the primary determinant of power, efficiency, and driving dynamics. Data collection relied on scholarly databases, historical archives, and peer-reviewed journals, focusing on advances in engine design, turbocharging methods, and transmission systems. Analysis was conducted thematically to identify patterns in technological synergy and performance outcomes. The findings reveal that while turbochargers and transmissions enhance performance, they operate within the boundaries set by the ICE's capabilities. Historical evidence, from muscle cars to modern hybrid supercars, supports the engine's central role. Even in the age of electrification, ICE innovation continues through synthetic fuels, hydrogen combustion, and efficiency optimization, ensuring relevance in performance, heavy-duty, and enthusiast markets. This paper concludes that the ICE not only contributes to vehicle performance but defines it, making it the benchmark against which all future automotive technologies will be measured.

Keywords: Internal Combustion Engine, Turbocharger, Transmission Systems, Automobile Performance

1. Introduction

Automotive performance is an emergent property of multiple subsystems working in concert. Engines convert chemical energy into mechanical work; turbochargers increase charge density; and transmissions match engine output to wheel torque and speed. Although each subsystem has been deeply studied, much of the literature treats them separately, which obscures a simple but critical fact: the internal combustion engine sets the performance ceiling that the other systems merely approach.

This paper addresses three guiding questions: (1) Which engine design variables most directly raise the ceiling for power, efficiency, and durability? (2) How do turbochargers augment engine potential, and where do they impose thermal or reliability constraints? (3) In what ways do different transmission architectures improve delivery of available power without creating new power? The thesis advanced here is clear: compared with turbochargers and transmissions, the engine has the

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most important influence on automobile performance because it determines the absolute envelope within which support technologies operate.

2. Literature review

This literature review talks about how, together, internal combustion engines, transmissions, and turbochargers make a vehicle perform better, both in terms of power output and fuel efficiency. While many research studies have been conducted on these components individually, fewer studies explore the combined effect. It is important to understand how engine power relates to efficiency in order to optimize vehicle performance. This is a review of past work and combines the existing research to indicate trends, agreement, and knowledge gaps that will ultimately contribute to a wider appreciation of the behavior of these systems as an ensemble. Research into internal combustion engines has quite exhaustively examined the influence of various components on power and fuel economy. Advanced fuel injection systems, for example, are discovered to have improved combustion efficiency by up to 30% and have been able to generate more power output while lowering the consumption of fuel [1,2]. Turbochargers similarly increase performance through additional air intake that leads to full combustion and efficient engines. Studies indicate that modern turbocharging technology can boost horsepower by 20–40% without compromising, and possibly even improving, fuel economy [3]. Over-turbocharging, however, can lead to higher engine temperature and wear, which in turn decreases long-term reliability [4]. Transmissions play a role as well in power and efficiency balance. Research shows that CVTs maximize fuel efficiency by keeping the engine at optimal speed, though they fall short of the power transfer efficiency level of normal manual or DCTs [5]. DCTs, on the other hand, employ quicker shifting speeds and are more efficient by reducing power loss during shifting. Literature comparing CVTs and DCTs reveals that although CVTs are superior in efficiency, DCTs are more efficient in acceleration and overall performance for high-power uses [6]. Here, it is revealed that there is a compromise between power and efficiency with transmission technology. Even though significant research is conducted on each component, limited research incorporates these themes under a single analysis. Although fuel economy and power output are linked by some studies, most studies examine one aspect without regard for its effect on the other. For instance, performance-oriented turbocharger studies hardly ever explain fuel economy, and efficiency improvement studies ignore their impact on acceleration and horsepower. This research disintegration leaves a void in comprehending the interaction among these systems in a complete sense. More studies should be conducted to analyze the impact of fine-tuning one aspect, say, turbo boost improvement or transmission gear ratio tuning, on the total car performance regarding power and efficiency.

Current research provides an excellent perspective on the role of engines, transmissions, and turbochargers in vehicle performance but separates such variables in studies rather than their combined effects. While improvements in transmission systems, turbocharging, and fuel injection technology have introduced increased power output as well as efficiency, there are some trade-offs with them. Closing the gap between power studies and studies of efficiency can help to make more even, high-power vehicles. New research needs to utilize integrated system research in optimizing internal combustion engines better.

3. Data collection process

Data collection will be a systematic search of studies, websites, and academic literature in the areas of internal combustion engines, turbochargers, and transmission systems. Sources will be selected

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according to their relevance to the research questions, namely:

How do new advances in engine design, such as piston displacement and compression ratios, influence vehicle performance?

What is the role of turbochargers in increasing engine efficiency and power output?

How do transmission systems assist in modulating speed and fuel efficiency?

The literature review will focus on first-hand sources such as Otto's four-stroke engine historical account [7]. contemporary research on current turbocharging technology [8], and progress in air-cooled engine technology [9]. Interdisciplinary studies on engine power and fuel efficiency correlation will also be featured. Data will be collected from scholarly databases like JSTOR, PubMed, and Google Scholar, in addition to books and peer-reviewed journals. Criteria for selection will focus on recent research for the last decade and foundational pieces that established the field of automotive engineering.

The data will be analyzed using thematic analysis, with repeating themes and patterns of the literature being extracted. The analysis will look for these major themes:

Development History of Engine Technology: How the creation of Otto's four-stroke engine and its further development have impacted automobile engineering today.

Turbocharging and Engine Efficiency: How turbochargers, particularly variable geometry turbochargers, improve low-speed response and high-speed power.

Transmission Systems and Fuel Efficiency: How transmission systems control speed and improve fuel efficiency.

Power Output vs. Fuel Efficiency: The balance between engine power output and fuel efficiency, and how technology improvements attempt to maximize both.

The discussion shall compare different research methods, highlighting areas of research shortfalls. For example, a significant knowledge gap regarding understanding how turbocharging affects long-term engine longevity will be discussed as a critical research area of the future.

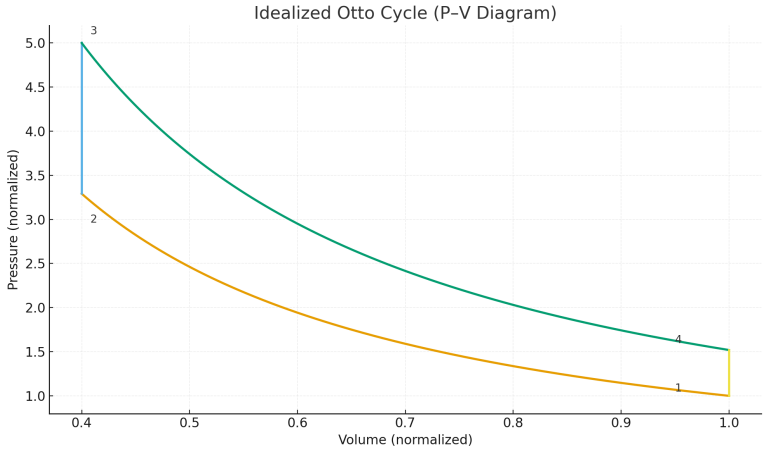

Figure 1. Idealized Otto cycle (P–V diagram)

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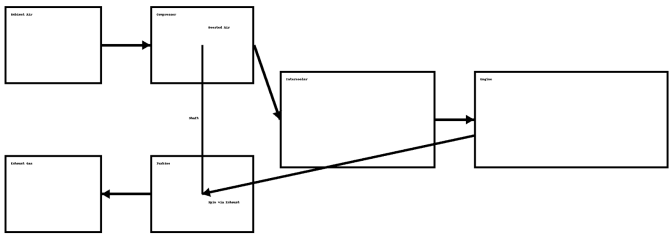

Figure 2. Turbocharger + intercooler airflow schematic

The internal combustion engine has been the cornerstone of car engineering for more than a century, and its evolution in the 19th century was a milestone in the history of cars. Otto's four-stroke engine, invented in 1876, was a revolutionary innovation, establishing a more effective combustion process that continues to shape modern engines [9]. Improvements in engine design since then, such as larger piston displacement, higher compression ratios, and the use of lighter materials, have significantly increased power and fuel efficiency [10]. These design improvements are the foundation of vehicle performance. Turbocharging, while a force to be reckoned with in optimizing engine performance for many years, remains secondary to engine operation (Fig. 1).

Variable geometry turbochargers, for example, enable instantaneous changes in turbine size, maximizing low-speed response and high-speed power [9]. Yet the engine's built-in potential for transforming chemical energy into mechanical power is still the driving force. Turbochargers function through the compression of intake air to provide oxygen in larger quantities to the combustion chamber for increased power per cycle. This advantage, however, is with the provision of the ability of the engine to effectively handle and utilize the increased airflow. Transmission systems also assist in vehicle performance by selecting suitable gear ratios to control speed as well as torque. Taller gears yield higher top speeds at the cost of acceleration and economy, but newer transmissions, such as continuously variable and dual-clutch transmissions, try to offer a compromise between performance and efficiency. These systems regulate the power developed by the engine; they do not generate power.

The relationship between power output and fuel efficiency remains complex. While engine and turbocharging technologies have progressed with both attributes, more work must be done in terms of how they interact and converge. For instance, increased compression ratios improve thermal efficiency but can raise fuel consumption or lead to knock unless well-managed. Similarly, turbochargers improve efficiency at certain loads but strain the engine thermally and mechanically, which could affect the life of the engine.

Moreover, engine mapping and control units have revolutionized how engines adapt to dynamic driving conditions. Through real-time monitoring of variables like temperature, throttle input, and fuel pressure, electronic control units (ECUs) can optimize engine performance instantaneously—something turbochargers and transmissions cannot do independently. Even in advanced hybrid systems, it is the control logic of the engine that determines how electric power supplements internal combustion, showing that the engine remains in control of overall power delivery strategy.

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Historically, engines have shown greater adaptability across applications than either transmissions or turbochargers. For example, in motorsports, custom-tuned engines tailored to track-specific conditions consistently outperform cars with superior transmission or forced induction setups alone. This reflects how engineers prioritize engine behavior as the primary means of influencing competitive performance, with all other systems working around the engine's capabilities.

Direct injections improve fuel atomization and combustion timing, enhancing both power and fuel economy, while cylinder deactivation systems shut down some cylinders under light loads to conserve fuel without sacrificing high-end performance. Newer technologies have contributed significantly to performance optimization. These features reflect the broader trend of refining the engine itself to meet modern demands for efficiency and responsiveness, reinforcing the argument that the engine remains the principal source of vehicle performance innovation (Fig. 2).

In summary, the engine remains the central factor in automobile performance, with turbochargers and transmission systems serving as powerful, yet dependent, support technologies. While the synergy of these systems has brought tremendous gains, future development, especially in achieving an ideal balance between power and environmental efficiency, still center on the engine. Its intrinsic role in defining vehicle performance remains unmatched.

4. Historical case studies of engine dominance

The optimum way to critically evaluate the contribution of the engine to car performance is through historical case studies, which repeatedly find that improvement in power, speed, and efficiency has been indirectly spurred mainly by improvements in engine design. While transmission systems and turbochargers have both played critical roles, these technologies have increasingly evolved to match the rising capabilities of the engine and not to replace or supplant it. As the U.S. Department of Energy describes, "Improvements in internal combustion engines over the last century have been the single most important contributor to increases in vehicle performance and fuel economy". Engine innovation has shaped every significant automotive achievement from the initial horseless carriages up to the current high-performance vehicles, demonstrating that it is not just an aspect but the origin of automotive progress.

Engine development has also shaped the usage and perception of automobiles. In the early 20th century, engineers focused on how to increase the thermal efficiency and mechanical horsepower of gas-burning engines, which was central to the making of cars practical transportation for mass usage. Mid-century performance demand from consumers led carmakers to focus on brute power and displacement. According to Lonergan (2021), this horsepower-focused approach became ingrained in car culture [11], particularly in America, where the average consumer associated horsepower with engineering excellence and status (Fig. 3).

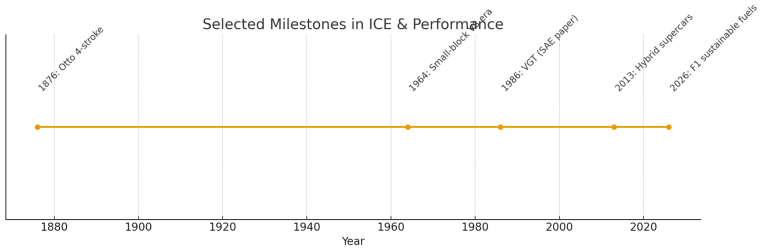

Figure 3. Selected milestones in ICE & performance (timeline)

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Throughout the history of the automobile, the internal combustion engine has been responsible for most improvements in car performance, usually overwhelming transmission and turbocharger improvements. A prime example is the 1960s and 1970s muscle car boom in America, when manufacturers like Ford, Chevrolet, and Dodge led each other in building cars with larger, more powerful engines. The production availability of the Ford small-block V8 in 1964 Mustang has forever changed expectations about performance from consumers [12]. Although gearing configurations in transmissions common during this time, like the three-speed manual, played an important role, the sheer horsepower of the V8 engines defined the muscle car craze.

Similarly, in automobile racing, i.e., Formula 1 racing of the 1950s and 1960s, naturally aspirated engines were the standard. Ferrari and Maserati were extremely interested in maximizing the internal combustion process, with increased compression ratios and improved fuel delivery systems being employed to squeeze out every last ounce of performance. Hargreaves (2018) states that the performance gains during this time were primarily the result of engine developments, with little attention being paid to turbocharging, which did not become significant until the late 1970s [13].

Another self-evident instance is the rise of diesel engines in long-haul trucking. The advent of heavy-duty diesel engines by companies like Cummins and Caterpillar revolutionized long-distance transportation by delivering improved torque and longevity [14]. Transmissions were upgraded to improve handling loads, but the enhancement in capability was clearly founded on engine developments such as enhanced combustion chamber designs and advanced fuel injection systems.

Even the advent of turbocharging during the 1980s, as witnessed on performance cars like the Porsche 911 Turbo, demonstrated that turbochargers were utilized primarily as a means of increasing an already powerful engine rather than to dispense with the need for a well-engineered one [15]. Mismatched turbochargers tended to create turbo lag, reliability issues, and unbalanced power band, problems that could not be fixed without better underlying engine design.

5. Limitations of turbocharging and transmission enhancements without engine innovations

Although high-performance transmissions and turbochargers can greatly enhance the driving dynamics of a vehicle, their worth largely hinges on the performance of the internal combustion engine below. Turbochargers accomplish this by increasing the volume of air entering the engine cylinders, thereby allowing for greater combustion of fuel and theoretically more horsepower. That is, however, provided that the engine has the structural strength and thermal stability to be subjected to that kind of stress. As pointed out by Brown, if a turbocharger is installed on a weak, inefficient, or aging engine design, the consequences might be counterintuitive [16]. Mechanical stress might be increased, engine temperature might rise rapidly, and abnormal combustion processes such as knocking or detonation might occur. Rather than adding performance, such results can reduce engine reliability and lifespan. Turbocharging is thus an enabler, not a salvation, it cannot fix fundamental engine weaknesses. So, the foundation must be sound: a strong and efficient ICE.

Moreover, there are inherent drawbacks to turbocharging itself when it becomes a substitute rather than a supplement.

Turbo lag, for instance, is the noticeable delay between accelerator input and power delivery. This is particularly problematic in engines without a good natural aspiration torque curve. Johnson and Patel note that without the presence of a good low-end torque profile of the base engine, turbocharging does not provide seamless drivability [17]. Similarly, improvements in transmission systems, such as the implementation of Dual-Clutch Transmissions (DCTs) and Continuously Variable Transmissions (CVTs), which are engineered for responsiveness and efficiency, are also bound by ICE's power delivery. Garcia et al. explain that even the most advanced DCT will deliver

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average performance if it is paired with an underpowered engine [18]. Transmission can merely deliver and manage power. It cannot produce it. Attempting to compensate for underpowered engines through technology often leaves performance-driven consumers cold (Fig. 4).



Figure 4. Transmission trade-offs

For instance, while CVTs increase fuel economy and smoothness, they're notorious for offering a disconnected driving experience, particularly in vehicles with small engines. Miller and Zhang argue that CVT-based powertrains are unacceptable to most consumers for performance applications because they cannot match the acceleration or emotional appeal of a traditional high-output engine [19]. Without big horsepower and torque from the combustion engine, neither turbocharging nor transmission technology can meet the high degree of expectation for enthusiasts and professionals. Overall, while transmissions and turbochargers are useful tools, they will only be able to achieve their potential if paired with a high-performance ICE. They are multipliers and cannot independently dictate or establish true vehicle performance.

6. Hybrid systems and the internal combustion engine's evolving role

Hybrid systems and full electrification efforts are revolutionizing the contemporary automotive landscape. Yet the internal combustion engine retains its starring role, even in high-performance hybrids in which electricity serves as complement, not substitute. Today's supercars, including the McLaren P1, Ferrari LaFerrari, and Porsche 918 Spyder, are all case in point. Each of these range-topping vehicles integrates electric motors with large ICEs. In the McLaren P1, for instance, a twin-turbocharged V8 engine produces the majority of the car's over 900 horsepower. The electric motor helps with acceleration and efficiency, but it's the ICE that establishes the car's soul and overall performance personality [20]. Likewise, the Porsche 918 Spyder taps a high-revving, naturally aspirated V8 engine as its main motivator, with electric motors supplementing off-the-line acceleration and regenerative braking systems contributing to efficiency in general. Not only are these cars fast, but they are also ICE-focused by design, showing that even in hybrid cutting-edge platforms, the combustion engine remains at the performance lead. The Ferrari LaFerrari uses the identical strategy: its V12 provides most of the car's power, and the hybrid system is utilized largely to fill in torque dips and enhance low-speed drivability (Fig. 5).

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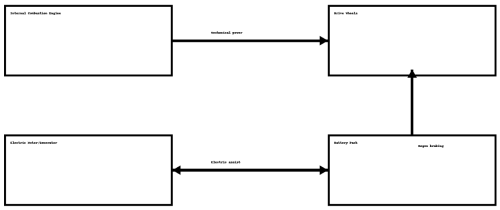

Figure 5. Hybrid power-flow schematic

These decisions are not random; they're found on the recognition that no electric powertrain currently available can equal the range, throttle response, and high-speed capability of an internal-combustion engine. Even outside of the elite performance niche, the internal combustion engine is continuing to stake its claim to relevance. The mainstream Toyota Prius hybrid, which has been famed for its fuel efficiency, still uses the ICE for extended performance. At speed or on extended highway cruises, the electric motor quickly exhausts its battery capacity, and the combustion engine takes over as the power source of preference [21]. This is proof that even in green settings, ICEs are still a necessity.

Advances such as Atkinson-cycle and Miller-cycle engines illustrate how engineers are streamlining combustion technology to environmental demands without giving up too much in terms of performance. Lawrance explains how by altering valve timing and compression ratios, these engines are more economical with fuel while still providing adequate output for modern driving demands [22]. So, as hybrid systems become ubiquitous, the ICE is not becoming obsolete being reinvented. Engineers now merge combustion engines with electric motors not because they must, but because in doing so they can push the performance envelope to unprecedented levels. Although electric systems will perhaps dominate urban mobility at some point in the future, the ICE is still the basis for hybrid performance, illustrating its versatility and its enduring place in the automotive world.

7. Will the internal combustion engine continue to dominate

As the industry commits itself irretrievably to electrification, people ask whether the internal combustion engine has a future. While there are no doubt electric vehicles (EVs) are gaining momentum because of environmental pressure and government policy, there are strong indications ICE technology will not only survive but thrive in specific niches, especially performance, heavy-duty, and enthusiast markets. Synthetic fuel production is one of them. E-fuels that have the same burn properties as petrol but are made from renewable energy are being produced by companies like Porsche and ExxonMobil, with a radical reduction in carbon emissions (Moody, 2024). These synthetic fuels allow the ongoing feasibility of traditional ICE vehicles without essential redesign and could turn out to be an ecologically sound bridge between heritage performance and environmental compliance going forward.

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Another frontier of ICE evolution is hydrogen combustion. While hydrogen fuel cell vehicles generate electricity to power electric motors, hydrogen internal combustion engines operate exactly like gasoline ICEs except for emitting only water vapor.

Lee adds that hydrogen ICEs preserve the visceral driving experience—immediate throttle response, pleasing engine sound, and mechanical feedback—while minimizing emissions exponentially. This technology can be a workable solution for drivers not looking to compromise performance or driving experience in the name of sustainability. On the motorsport side, internal combustion engines will remain at the forefront of racing. Formula 1, the pinnacle of car performance and technology, has committed to the use of sustainable fuels by 2026 but plans to do so with hybrid internal combustion power units. This option emphasizes the importance of combustion engines in delivering the drama, pace, and emotional engagement that define motor sports. Pure electric powertrains, while sufficient for urban use, currently don't have the stamina, recharging potential, and sensory delight that motorsport demands.

Finally, even in the mass market, the ICE will likely continue in niche uses. Trucks, SUVs, and performance vehicles that demand high torque will be favorably served by ICEs for the foreseeable future. Electrification has its advantages, but limitations in battery weight, charging infrastructure, and energy density guarantee that ICE technology continues to be competitive in most real-world applications. The internal combustion engines of the future will be more efficient, cleaner, and smarter, but they will still do the same basic job: delivering power, responsiveness, and reliability. In conclusion, while the global car trend is shifting towards hybrid and electric cars, the internal combustion engine is far from being a thing of the past.

8. Conclusion

Its versatility, emotional appeal, and performance advantages ensure that it will continue to have a vital role to play, especially in markets where dynamic driving and power remain priorities. If performance remains a valued trait, the internal combustion engine will be the benchmark against which all new technologies are measured. Conclusion In this research, it has been consistently demonstrated that the internal combustion engine (ICE) is and remains the central and most influential determinant of automobile performance. From the initial foundation set by Otto's four-stroke engine to the current hybrid systems of today's supercars, the ICE has not only provided the basic power necessary for motion but has also determined the very paradigm in which turbochargers and transmissions are engineered to operate.

While transmission and turbocharging technologies have accomplished a lot to improve drivability, acceleration, and efficiency, ultimately their value lies in relation to the ability of the engine they are supporting. Turbochargers, for instance, can only amplify the combustion efficiency and air intake of a strong engine design, and modern transmissions are merely how the engine's power is optimized not generated. The case studies of muscle cars, Formula 1 engines, heavy-duty diesel trucks, and modern hybrid supercars all work to illustrate this point more clearly. What is demonstrated by these examples is that engine design alone has historically propelled performance, and support systems have evolved to refine or complement the engine's capability. Even when turbochargers and advanced gearboxes appeared, their use was applied to enhance well-designed engines.

Moreover, newer hybrid designs such as the Porsche 918 Spyder or McLaren P1 continue to utilize ICEs as the primary power source, illustrating the irreplaceable role of combustion in high-performance use.Going forward, the ICE development continues in the face of environmental challenges. Synthetic fuels, hydrogen combustion, and more efficient engine cycles are creative

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pathways to secure ICE viability in a sustainable future. Despite the growing dominance of electric vehicles, especially in urban scenarios, limitations in battery energy density, charging infrastructure, and driving dynamics enable ICEs to retain the advantage in terms of performance, endurance, and emotional connection.

In summary, this paper reiterates that the internal combustion engine doesn't merely contribute to vehicle performance. It determines it. Turbochargers and transmissions are handy devices, but they operate within the performance boundaries set by the engine itself. As auto technology continues to evolve, ICE's central role in delivering power, speed, and driving experience ensures its continued relevance. So, in the hierarchy of automobile components, the engine will remain the single most influential factor in determining vehicle performance for decades to come.

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