

# MAHLE

*Powertrain*

## 2013 European Automotive Powertrain Customer Value Enhancement Award



FROST & SULLIVAN



50 Years of Growth, Innovation & Leadership

## Customer Value Enhancement, Automotive Powertrain Europe, 2013

### Frost & Sullivan's Global Research Platform

Frost & Sullivan is in its 50th year in business with a global research organization of 1,800 analysts and consultants who monitor more than 300 industries and 250,000 companies. The company's research philosophy originates with the CEO's 360-Degree Perspective™, which serves as the foundation of its TEAM Research™ methodology. This unique approach enables us to determine how best-in-class companies worldwide manage growth, innovation and leadership. Based on the findings of this Best Practices research, Frost & Sullivan is proud to present the 2013 Europe Customer Value Enhancement Award in Automotive Powertrain to MAHLE Powertrain.

### Significance of the Customer Value Enhancement Award

#### Key Industry Challenges Addressed by Enhancing Customer Value

The Euro emission norms and the ACEA 2020 target to achieve 95g/km CO2 fleet average is driving OEMs, suppliers and the entire automotive value chain to rethink strategies and revise products and services to suit the dynamic needs of global markets. As a result, OEMs and market participants are adopting expensive, next-generation technologies like gasoline direct injection and selective catalytic reduction that help reduce emission while enhancing performance and fuel efficiency of the internal combustion engine.

Similarly, challenges of range anxiety, expensive battery technology and infrastructural needs plague pure electric vehicles (EVs). The cost of production of Li-ion battery is estimated to be about \$600 per kilowatt resulting in a 25kW battery costing as high as \$15,000. Moreover, as the driving range of a vehicle in pure EV mode (therefore assisting in zero emissions) is dependent on battery size; larger batteries not only increase the cost of vehicle ownership but also adds to the weight of the vehicle. This in turn reduces the design flexibility and adds to packaging constraints. Moreover although charging connector standards have been announced, the adoption has been low from automakers and EV charging station manufacturers posing yet another current market challenge.

In addition the automotive industry is transitioning away from traditionally only manufacturing cars towards being mobility solution providers of the future. A number of new, disruptive business models like car-sharing and mobility integration are coaxing consumers and corporate to adopt greener, more cost-effective modes of travel. Green vehicle fleets is an example that is playing a very important role in corporate strategies further driving OEMs, suppliers and solution providers to focus efforts on green solutions.

Striking a balance, offering a very compelling solution, are range-extenders, which respond to challenges of the EV's range anxiety while enhancing the fuel efficiency. A number of engineering solution providers have therefore pushed the boundaries by

innovating solutions aimed at answering these market challenges. With compact solutions, these rely on their core competencies to provide robust designs for combatting the challenges of weight reduction and packaging space. In addition, they also possess the capability to manufacture these solutions, a key value adding benefit for their customer. With focused investments on greener technologies for the future, these companies continue to provide best-in-class innovative solutions and performance leadership and value-added excellence.

### **Impact of Customer Value Enhancement Award on Key Stakeholders**

The Customer Value Enhancement Award is a prestigious recognition of MAHLE Powertrain's accomplishments in Automotive Powertrain. An unbiased, third-party recognition can provide a profound impact in enhancing the brand value and accelerating MAHLE Powertrain's growth. As captured in Chart 1 below, by researching, ranking, and recognizing those who deliver excellence and best practices in their respective endeavors, Frost & Sullivan hopes to inspire, influence, and impact three specific constituencies:

- **Investors**

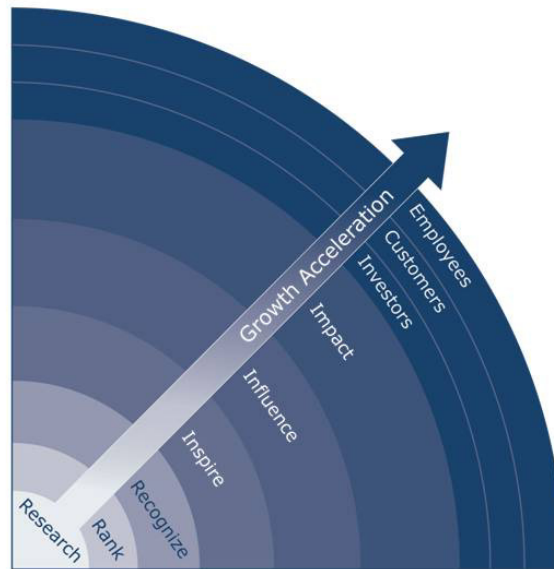
Investors and shareholders always welcome unbiased and impartial third-party recognition. Similarly, prospective investors and shareholders are drawn to companies with a well-established reputation for excellence. Unbiased validation is the best and most credible way to showcase an organization worthy of investment.

- **Customers**

Third-party industry recognition has been proven to be the most effective way to assure customers that they are partnering with an organization that is leading in its field.

- **Employees**

This Award represents the creativity and dedication of MAHLE Powertrain's executive team and employees. Such public recognition can boost morale and inspire your team to continue its best-in-class pursuit of a strong competitive position for MAHLE Powertrain.

**Chart 1: Best Practices Leverage for Growth Acceleration**

### Best Practice Award Analysis for MAHLE Powertrain

The Frost & Sullivan Award for Customer Value Enhancement is presented each year to the company that has demonstrated excellence in implementing strategies that proactively create value for its customers with a focus on improving the return on the investment that customers make in its services or products. This award recognizes the company's inordinate focus on enhancing the value that its customers receive, beyond simply good customer service, leading to improved customer retention and ultimately customer base expansion.

### MAHLE Powertrain's Performance in Automotive Powertrain

MAHLE Powertrain (MAHLE)'s innovation leadership and performance excellence is a culmination of its rich history, expertise and association with engineering services. It is amongst the key engineering solution providers offering the global automotive industry with solutions aimed at tackling fuel price rise, CO2 emissions and vehicle performance. MAHLE understands that the internal combustion engine (ICE) will remain the primary source of vehicle motive power, but consider downsizing of engines with additive technologies to improve performance and efficiency to propel innovation in the market. The company's focus therefore is on vehicle powertrain advancements, efficiency and cost-effectiveness in the move towards sustainable mobility. In relation to advancements in ICE, MAHLE provides an entire gamut of solutions with key research and development (R&D) focused on engine downsizing, combustion optimization and alternative fuels.

Some key examples of this innovation leadership include projects like the MAHLE's advanced downsizing, the single cylinder project which is ideal for spray and combustion characteristics investigation and project 'Helios' for renewable power generation which included the design and

development of a 25kW Stirling engine. MAHLE Powertrain provides a complete 360° holistic approach to powertrain development with core competencies spanning from concept development to manufacturing.

The MAHLE group has the competence, credibility and expertise to be able to produce customer-specific solution; and feedback in the case of the compact range extender solution also suggests the same. The MAHLE Group's sales in 2011 were over 6000 million Euros. The market for range extenders is expected to witness growth. It is estimated that over 300,000 extended range electric vehicles will be on road by 2018, globally. MAHLE's solutions involving range extenders, powertrain electrification and hybridization is therefore expected to be a key growth engine for the company while strong focus on advancements in conventional powertrain is expected to continue towards 2020.

### **Key Performance Drivers for MAHLE Powertrain**

#### **Factor 1: Product Features and Focus on Continuous Value Addition**

Emission regulations and demand for better fuel economy are playing a key role in OEM strategies, products and solutions. With the ICE and pure EVs presenting specific challenges ranging from expensive additive technology addition to charging infrastructure, a number of OEMs and market participants therefore consider hybrid and range-extender solutions as middle ground that purposefully answers these challenges. Engineering solution providers therefore have a decisive role to play and companies like MAHLE Powertrain are amongst the frontrunners, setting benchmarks for others to follow.

MAHLE Powertrain's compact range extender is an exquisite example of the company's answer to the challenges of today with focus on green and efficient solutions for tomorrow. Aimed primarily at the typical C-segment vehicle, the range extender was conceptualized following a series of analysis that was carried out by MAHLE Powertrain around the usage patterns of passenger vehicles. Frost & Sullivan believes MAHLE Powertrain's focus on 'building solutions around the customer' is a key value adding factor. With low-cost, compact packaging size and impeccable Noise, Vibration and Harshness (NVH) performance drawing up the boundary requirements for the solution, the compact range extender boasts of some very impressive specifications. Targeted at the Euro 6 emission limits, some of the key innovative features of the 900cc, 2-cylinder, gasoline engine with rated power of 30kW is its installation flexibility. It can be installed either horizontally or vertically as opposed to competing range extenders in the market whose installation angle is fixed.

The compact packing of the range extender is attributed to a fully integrated axial flux generator, housed within the engine crankcase. Moreover, with reduced engine block height as the 2 valves of each cylinder are actuated indirectly by roller rocker arms and camshaft, a balancer shaft is also not needed. Also, a compact intake system that is tightly packed against the engine further reduces size. This compact unit has resulted in a lightweight solution with the dry weight of the engine at about 50kg and 20 kg for the generator as opposed to others which weigh over 75kg. MAHLE Powertrain therefore adds immense value to customer by giving them the opportunity to better design vehicle architecture while focusing on precise weight distribution, packaging and space optimization. MAHLE Powertrain, with its light-weight compact design channels opportunities to reduce overall vehicle

weight, thus resulting in lesser CO<sub>2</sub> emissions, vehicle performance and better fuel efficiency. Moreover, MAHLE Powertrain carries with it, the global reach and long-standing relationships with a number of OEMs in the market. This experience which it embodies is a key differentiating factor as opposed to some of the other engineering service providers and suppliers in the market with competing ICE range extender solutions.

## **Factor 2: One Stop Shop Solution Provider and Manufacturing Capabilities**

MAHLE Powertrain's expertise and core competence is beyond just design and development. The engineering solution provider encompasses the entire gamut of offering right from concept development to testing system, prototyping and even low volume manufacturing. This is understood as a key value adding factor to customers, primarily because it removes the hassle of having to reach out to different providers for different stages of development and commercialization. In order to achieve the best results, MAHLE Powertrain focuses on a holistic approach to system design and integration. Overall system optimization is therefore a pinnacle as opposed to achieving the best by only concentrating only on component-level improvements.

The manufacturing capabilities that MAHLE provided in terms of aluminium blocks and head castings, component manufacturing, cylinder heads and engine assembly is a vital value adding factor as it can aid customer with production ramp up and ramp down challenges as and when needed. A number of engineering service providers in the market do not offer this vital solution and stop with either prototyping or support till start-of-production (SOP). MAHLE therefore has positioned itself in a niche segment with capabilities aimed at responding to future challenges towards sustainable mobility. Furthermore, MAHLE Powertrain has a wide-spread market reach including commercial and off-highway application and even motorsports. It caters to different system and technology requirements including gasoline, diesel and hybrids along with project management services.

One of MAHLE Powertrain's demonstrator projects on "advanced engine downsizing" is an exquisite example of being a one-stop solution provider. To date, upto 14 different downsized engine configurations have been developed and constructed. The project involved downsizing a 2.4L V6 to a 1.2L 3-cylinder engine. The first generation achieved some impressive results, following which a more production feasible solution was aimed. Upon testing of this engine on a demonstrator vehicle, CO<sub>2</sub> emissions of 135g/km were achieved along with a fuel economy of about 5.8L/100km and torque of about 161Nm (at 1,200 rpm). This boasts of MAHLE Powertrain's capability to be a single stop solution provider.

The MAHLE Powertrain brand name carries with it expertise and decades of experience in innovative and bespoke growth strategies. It focuses on optimized technical solutions under stringent timescales while remaining cost-effective. The value proposition it provides in terms of flexibility and the company's ethos to sustain long-term, "win-win" partnerships are amongst MAHLE Powertrain's key value adding benefits within the urban mobility space.

### Factor 3: Focus on the Future of Mobility and Innovation Excellence

The automotive industry today is transitioning away from traditionally only manufacturing cars towards becoming mobility solution providers of the future. A number of market participants are diversifying into providing new business propositions like mobility smartphone apps, carsharing and the like in view of positioning themselves as a mobility solution provider of the future. However, on the other side of the spectrum, these participants are adopting clean-green technologies to reduce emission, enhance performance, address industry challenge and sufficing customer demand. The Euro emission norms and ACEA 2020 target are encouraging OEMs to look at electrification and hybridization of powertrain as a key mobility product strategy, thereby seeking related solutions from suppliers and engineering solution providers. Frost & Sullivan believes that MAHLE Powertrain understands the urgency for such solutions in the quest towards sustainable mobility. In this regard, MAHLE Powertrain recently also developed a feasible demonstrator range extended electric vehicle (REEV).

The compact range extender fits into a very interesting market span where it can operate as an enabler for an integrated mobility solution in the future. For example, based on initial tests conducted by MAHLE, it is expected that an electric driving range of over 60km and a combined driving range of close to 500km can be achieved. In a hypothetical driving situation, where in a consumer drives the vehicle on electric to a nearby public transport station to use an integrated mobility service to commute to work is a very compelling solution. Furthermore the compact range extender can be envisioned to play an important part in a car sharing initiatives or even in company fleet vehicles where in fuel cost savings and company CSR activities fit in.

MAHLE Powertrain's range extender solution therefore provides a win-win solution that clearly fits into the mobility market space. Moreover, with initial test in-house results pointing to NEDC CO2 emission to be possibly less than 45g/km, the vehicles can potentially qualify for a number of tax incentives and grants. For example in France under the Bonus-Malus scheme, vehicle emitting less than 50g/km CO2 can benefit with bonus of upto € 5,000. Similarly in the Netherland, vehicles emitting less than 50g/km are exempted from registration tax BPM. Its focus therefore is on the future of mobility appropriately fitting into various environmental thresholds in Europe.

MAHLE Powertrain's REEV and compact range extender solution therefore represent a significant move towards innovative excellence. The realization of a solution feasible for production demonstrates a clear core competence in continuous innovation along with a broad spectrum of applications. The centroid of MAHLE's innovation is the fact that it should fit itself into society to tangibly respond to challenges in the quest towards sustainable mobility.

## Conclusion

MAHLE Powertrain embodies futuristic innovation, customer value addition and performance quality. Answering some of the key challenges that the market faces in terms of compact size and CO2 emission reduction with focus set on production-feasible solutions, the MAHLE Powertrain brand name carries with it experience and integrity to find solutions for the most challenging customer concerns. This is the single most distinguishing factor that sets MAHLE Powertrain aside as opposed to competitors in the market. MAHLE Powertrain's compact range extender is an example of the company's expertise and capabilities in engineering excellence with competencies ranging from a clean sheet to manufacturing and implementation. As a result of these significant facets that MAHLE Powertrain exemplifies, it emerges as a very deserving recipient of the 2013 Frost & Sullivan European Customer Value Enhancement Award in Automotive Powertrain.



## The CEO 360-Degree Perspective™ - Visionary Platform for Growth Strategies

The CEO 360-Degree Perspective™ model provides a clear illustration of the complex business universe in which CEOs and their management teams live today. It represents the foundation of Frost & Sullivan's global research organization and provides the basis on which companies can gain a visionary and strategic understanding of the market. The CEO 360-Degree Perspective™ is also a “must-have” requirement for the identification and analysis of best-practice performance by industry leaders.

The CEO 360-Degree Perspective™ model enables our clients to gain a comprehensive, action-oriented understanding of market evolution and its implications for their companies' growth strategies. As illustrated in Chart 5 below, the following six-step process outlines how our researchers and consultants embed the CEO 360-Degree Perspective™ into their analyses and recommendations.

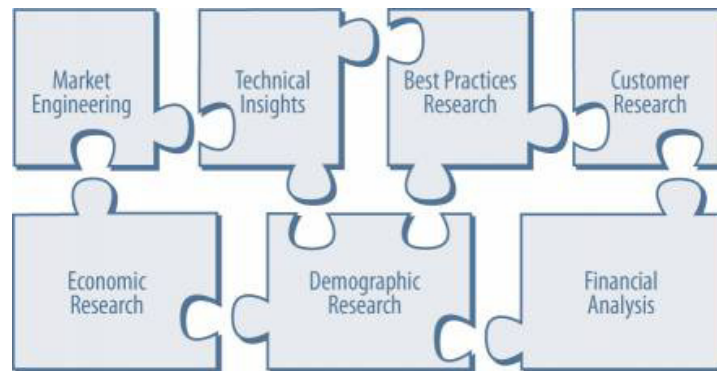
**Chart 2: How the CEO's 360-Degree Perspective™ Model Directs Our Research**



## Critical Importance of TEAM Research

Frost & Sullivan's TEAM Research methodology represents the analytical rigor of our research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all seven of Frost & Sullivan's research methodologies. Our experience has shown over the years that companies too often make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Frost & Sullivan contends that successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. In that vein, the letters T, E, A and M reflect our core technical, economic, applied (financial and best practices) and market analyses. The integration of these research disciplines into the TEAM Research methodology provides an evaluation platform for benchmarking industry players and for creating high-potential growth strategies for our clients.

**Chart 3: Benchmarking Performance with TEAM Research**



## About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best-in-class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best-practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from more than 40 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.