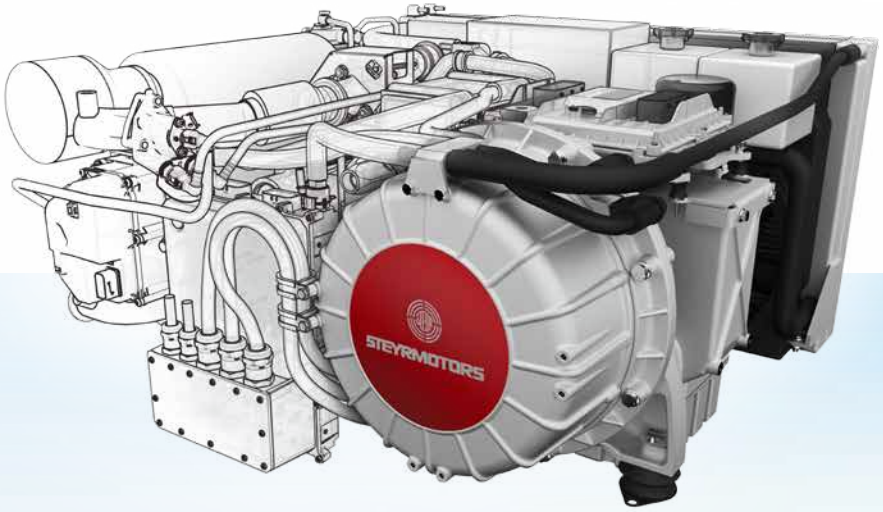
STEYRMOTORS

INNOVATIVE
POWER PACKS

[**COMBUSTION** ENGINES]

[**E-MACHINES** & CONTROLS]

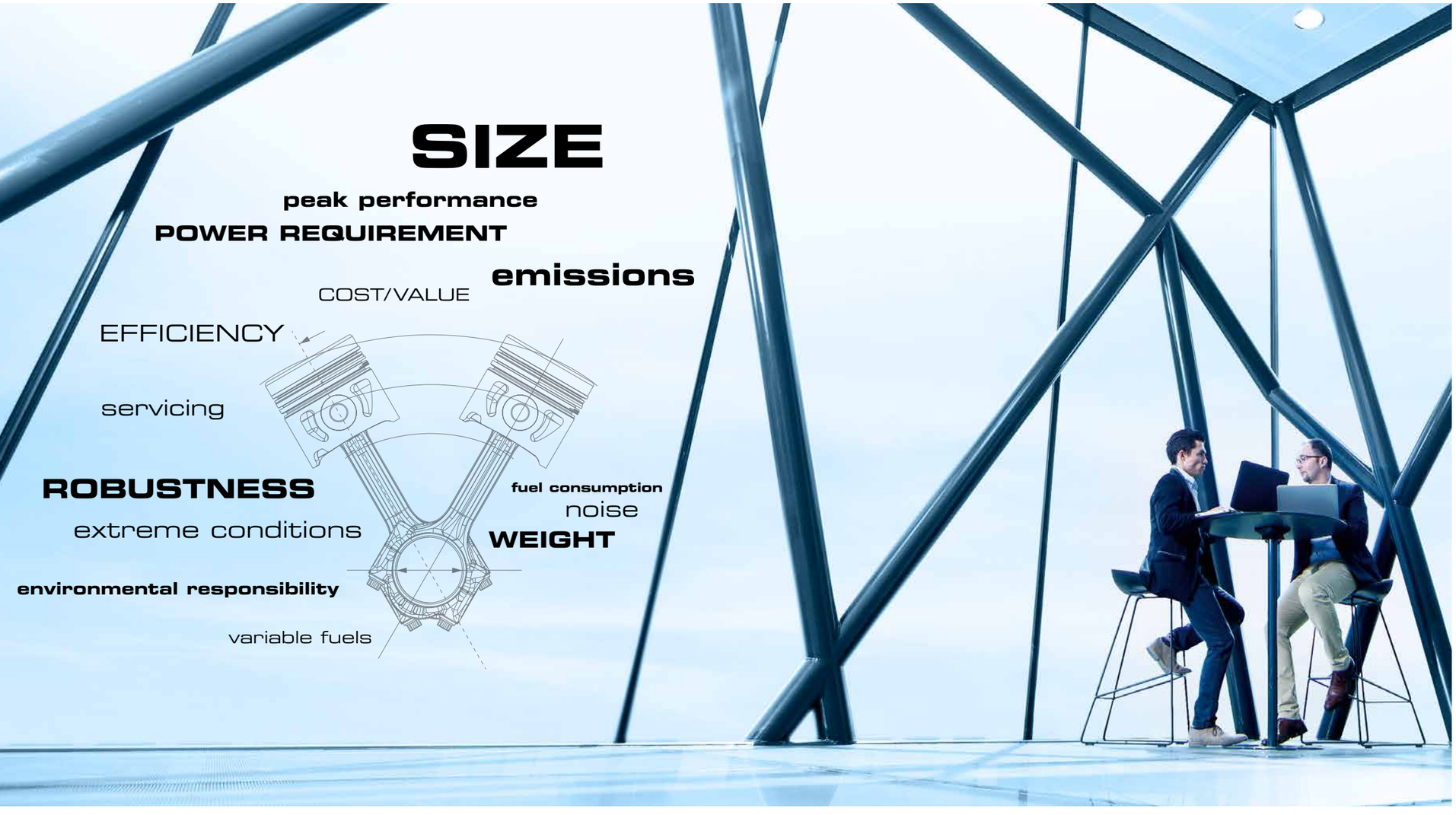
[**HYBRID** SYSTEMS]



ENGINEERING

IS YOUR POWERTRAIN THE **PERFECT MATCH** FOR YOUR DEMANDS?

Most off-the-shelf engines and power systems are designed for universal applicability in order to provide one standardized product for as many customers as possible. However, each business segment and every application has its own demands and priorities. As a consequence, standardized products inevitably lead to suboptimal if not unsatisfactory solutions for the individual application.



WHY COMPROMISE?

Though the cost factor is usually stated, with a skilled and experienced partner, the total lifetime outlay of a customized solution is actually better than the overall expense associated with a standardized product. In fact, the analysis of individual requirements and the development of the best solution is primarily a matter of know-how and time.

Whereas the customer knows in detail the requirements and industry-specific priorities for an application, the engineering specialist knows the technical possibilities in general and can find the perfect way to fulfill the customer's demands. But such an exchange requires time in respect of the people working on the project as well as regarding the time needed in general for the implementation. In order to minimize efforts, manufacturers rather offer standardized products that are easier to produce, and in turn customers buy these compromise solutions out of convenience.

However, the return on investment of customized products is worth the time and capacities, especially in terms of product life time, reliability, resilience, enhanced efficiency and lower fuel consumption. In many cases, it is even possible to adjust and optimize an existing product to fit a specific application instead of developing a completely new product from scratch. The key to a perfect solution is the expertise in applying the best technology in a practical way to solve real-world demands.

We specialize in analyzing, developing and providing your perfect engine or power pack.

CLAIM
WHAT YOU
REALLY NEED

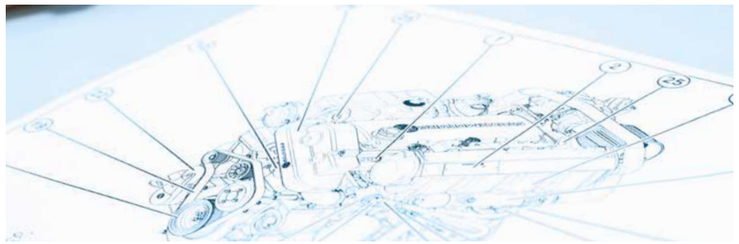
EFFICIENCY IS DEFINED BY THE OPERATIONAL STRATEGY

At first, the basic requirements for engines and power systems seem rather similar and repetitive. The real divide becomes obvious when taking a closer look on a specific industry sector and its applications. You will find that the detailed demands and priorities differ from one industry to another – even from one application to another – always depending on the operational strategy.

In this respect, how should a standard product entirely fulfill so many variable requirements? It simply does not. Customers usually buy oversized off-the-shelf engines for maximum loads or output rather than applying a system that supports the actual modes of operation. This forces the power system to mostly work in inefficient part load operation and leads to unfavorable consequences like high fuel consumption and shorter product life spans. A far more efficient solution is achieved by analyzing real life demands, defining the specific operational strategy for the application and customizing a proven basis.

THE BEST PRODUCTS EVOLVE FROM A BLEND OF INNOVATION AND EXPERIENCE

We strive for more than innovative ideas. STEYR MOTORS provides safe, efficient and reliable solutions that fulfill actual demands defined by our customers but also learnt from our experience. The combination of theory and practice is our success formula. Moreover, STEYR MOTORS remains broad-minded. We are open for cooperation to further accelerate the technical progress of the entire engineering sector. Our ultimate goal is supplying you with the product that fully meets your individual demands and perfectly runs under your actual working conditions.



TAILORED ENGINEERING SERVICES FOR CUSTOMERS & SUPPLIERS

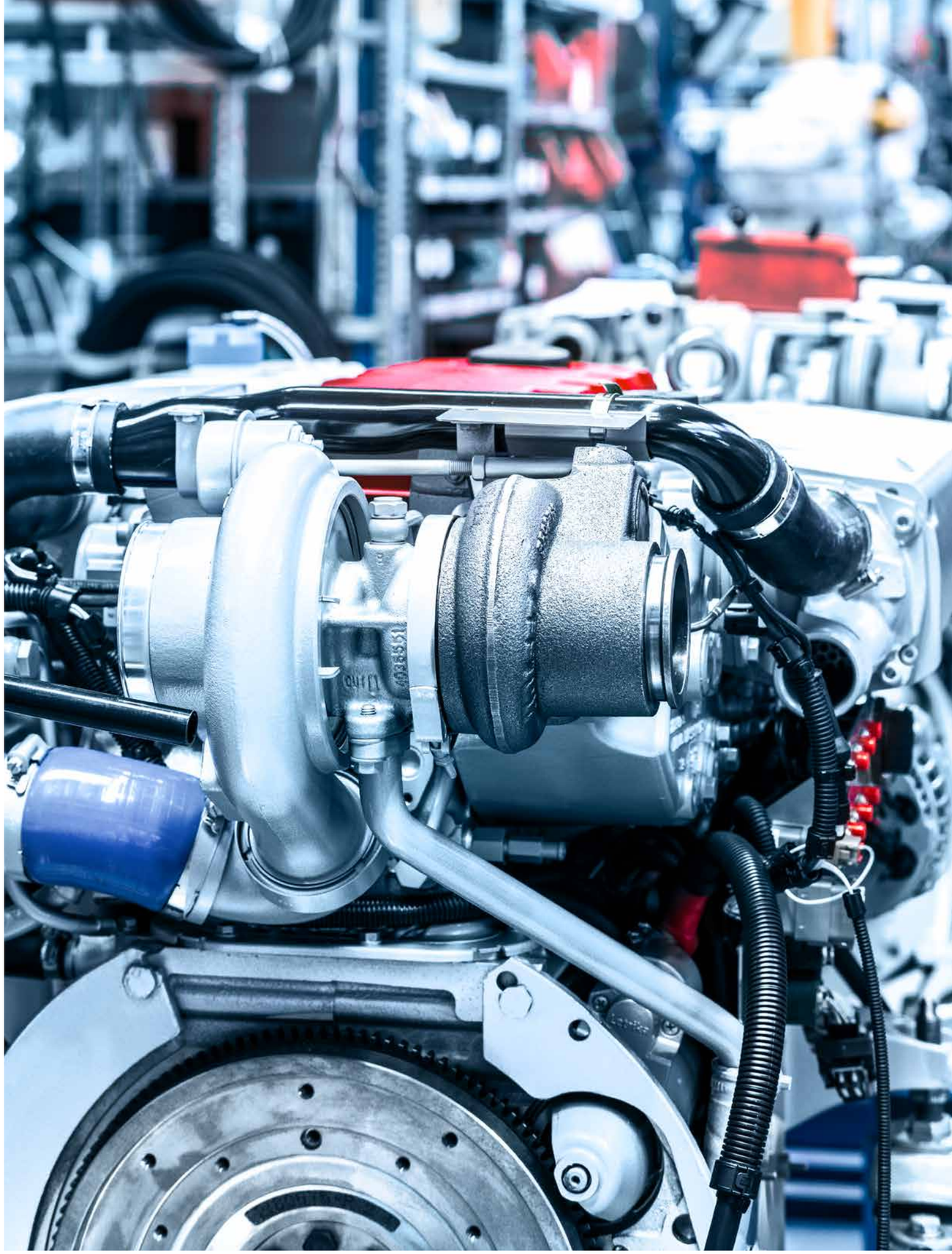
The service spectrum of STEYR MOTORS focuses on customer-specific projects regardless of whether the customer is the manufacturer, OEM or end user of a product. Our engineering portfolio comprises a modular offer to choose from and combine as required for applications on land, at sea or in the air.

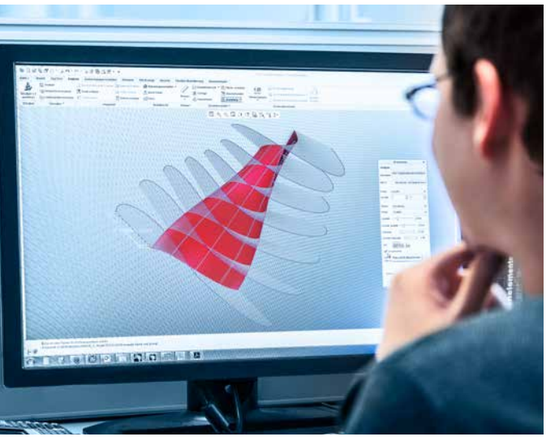
While historically the company's emphasis was on engines operated on diesel and its derivates, more than a decade ago STEYR MOTORS started its R&D in compact and innovative power packs as well as in hybrid propulsion. Since this shift in the company's focus, we have completed a variety of outstanding projects featuring diesel-electric systems as well as non-diesel applications using for example gas or biofuel.

Our particular specialty is the development of innovative power packs: combining a proven and efficient combustion engine with well-matched additional components such as cooling, exhaust and intake systems but also power electronics like e-motors.

STEYR MOTORS is your partner of choice for
a wide and modular range of engineering services:

- Development of customer-specific engine concepts
- Detailed engineering for in-house or external prototyping
- Prototype assembly
- Industrialization/Preparation for series production
- Integrated testing of our prototypes and final products on various in-house test benches according to customer profiles
- Rental of our test benches for independent testing of other engines, prototypes or components
- (Series) production of engines and power packs
- Licensing for (series) production at the customer's site
- Outsourcing of engineering assignments for third-party products to unburden the supplier's own R&D departments
- Customizing of third-party products to fit specific requirements, for entire series but also for small-scale requests





RIGHT SIZING

COMPLIANT & EFFICIENT TODAY, ECO-FRIENDLY & PROFITABLE TOMORROW

THE ENVIRONMENTAL CHALLENGE

In 2015, a reduction of greenhouse gases by 70% until the year 2050 was determined at the international climate conference in Paris. Indeed a challenging target for all of us. Accomplishing this goal requires sustainable and longsighted solutions, especially in the field of engineering. It is no longer acceptable to apply huge, wasteful powertrain that suppress shortcomings due to old-fashioned engineering by sheer size.
The implementation of emission standards like EURO VI, Tier 4 or Stage V is only a first step in taking up this environmental challenge. On top of an advanced engine design with sophisticated exhaust gas aftertreatment, STEYR MOTORS strives for properly sized systems fitting the operational strategy of the specific application. Our use of innovative electric and hybrid technology ensures maximum eco-friendliness while perfectly meeting the application's requirements.

THE ECONOMICAL CHALLENGE

Integrating advanced aftertreatment systems is necessary to fulfill current and future emission standards, but often results in increased size and higher cost of the products. As a consequence, downsizing became a common buzzword in engineering. However, simply reducing power or size is not sufficient for truly innovative solutions.
STEYR MOTORS rather focuses on intelligent engineering that analyzes the specific requirements for an application and provides the best fitting product with the correct power output for the different operational modes. Rightsizing instead of downsizing is what we call this approach and it clearly pays off. Significant savings in the total lifetime cost of a product are possible by applying the optimum operating point in the respective operational mode instead of forcing the power system to frequently work in inefficient part load or full load operation.

CHALLENGE ACCEPTED

Our core competence is developing innovative power packs and engines for various industries and applications. During a remarkable company expansion in 2015, major investments in our tools and equipment further upgraded the headquarters in Steyr to a state-of-the-art R&D center that meets all demands in the field of engineering.
The expertise of highly skilled specialists is combined with latest technologies and a result-oriented engineering process based on best practices from our extensive engineering history. Numerous international projects have already proven our methods successful, fully equipping us to face engineering challenges with ease.

In all projects and developments, STEYR MOTORS lays particular emphasis on the implementation of:

- Power requirements
  - default power demand and peak performances
- Robustness and safety
  - maximum operation time and operational safety
- Best power-to-weight ratio
  - compact, lightweight and powerful products
- Resilience and reliability
  - enduring even in challenging conditions (weather, environment)
- Optimum total lifetime cost
  - cost of acquisition, operation, service and maintenance
- Emission standards
  - environmental requirements, eco-friendliness

CONCEPT AND DEFINITIONS

LAYOUT DESIGN AND SIMULATION

FE AND CFD OPTIMIZATION

DETAILED DESIGN

PROTOTYPE ASSEMBLY

FUNCTIONAL AND DURABILITY TESTING

DESIGN AND ASSEMBLY OPTIMIZATION

PRE-SERIES ASSEMBLY

FINAL TESTING

SERIES RELEASE

HIGH-END SKILLS AT YOUR SERVICE

STEYR MOTORS provides your ideal solution from design and concept to customizing, prototyping and series production. Furthermore, the service spectrum of STEYR MOTORS also includes training, documentation and global technical service.

With our experienced engineering team
you are in the best of hands in respect of:

- Engine Design and Simulation
- Thermodynamics Development
  (combustion and exhaust gas aftertreatment)
- Mechanical Development
- Mechatronics incl. Diagnostic System Management
- Thermal Management
- Fuel Injection Equipment
- Software Development incl. OBD & Functional Safety
- Electrical Engineering (E/E)
- Prototyping
- Engine and Component Testing
- Technical documentation

Our products are globally renowned for performing beyond expectation. This achievement has been accomplished by STEYR MOTORS' proven combination of best practices out of a long engineering history together with innovative minds and state-of-the-art equipment.

- PTC Creo Elements, PTC Windchill, CATIA V5
- One-dimensional gasdynamic software
- 3D CFD calculation
- Analytical calculation tools supporting layout and detailed design, including FEM calculation
- 16 test cells and measurement facilities in total
- 10 engine dynamometers with asynchronous machines
- Battery simulation system (150kW, 600V, 500A)
- Emission measurement benches, particulate counter, micro soot sensor (allowing tests up to EURO VI standard)
- Moehwald injector test system for unit injection and common rail technology
- NVH test cell, meeting class 2 standard according to EN ISO 3744, with Siemens LMS (SCADAS +Test.Lab) for testing of airborne and structure-borne noise as well as vibration analysis
- Slow (100Hz) and fast (10kHz) measurement systems
- HIL testing equipment for electronic development
- DoE engine calibration procedure
- Component testing, including AVL Tippelmann flow test bench (450 kg/h flow rate)

TOOLED UP FOR INNOVATION

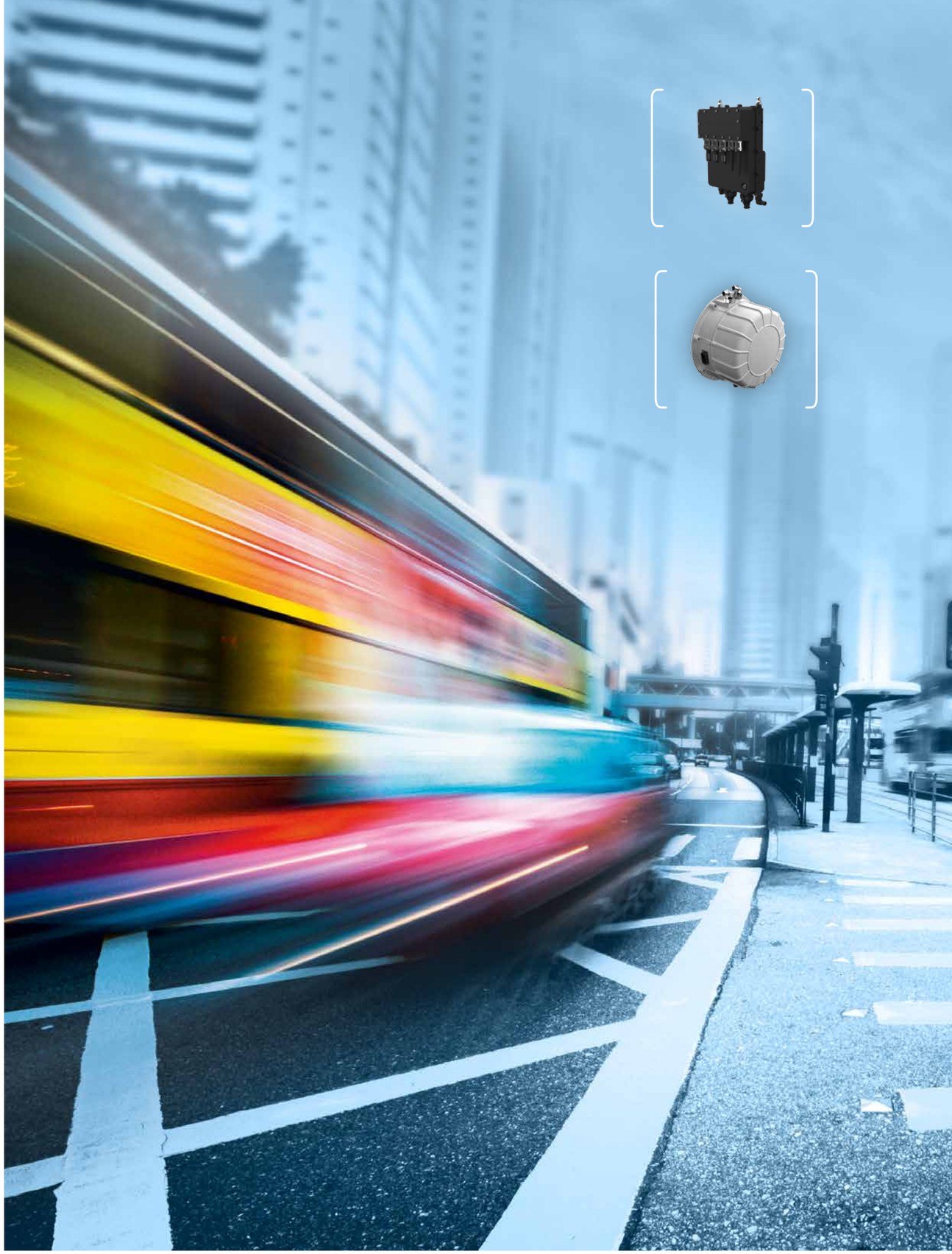
IT'S THE ERA OF **E-MOBILITY & HYBRID APPLICATIONS**

[E-MACHINES & CONTROLS] [HYBRID SYSTEMS]

Before the mainstream trend towards e-mobility and hybrid systems, STEYR MOTORS had already launched its first range of products into the marketplace. In 2008, the introduction of the world's first parallel hybrid propulsion system for marine applications was a major break-through. Today, the vast experience gained in e-mobility and hybrid power packs stretches far beyond the marine sector. STEYR MOTORS applied its expertise in various vehicle, industrial and even railway projects, leading the way for today's advanced powertrain concepts.

The latest addition to STEYR MOTORS' portfolio is a highly innovative electric solution that provides the flexibility to implement many different e-solutions based on the same hardware concept. The combination of a permanent magnet machine using transversal flux technology with a state-of-the-art active inverter enables unprecedented performance and power density. Therefore, the brand-new e-machine STEYR E1 is perfect for the development of small but surprisingly powerful hybrid power packs.

	KEY FEATURES OF THE STEYR E1
TECHNOLOGY	Permanent Magnet /Transversal Flux
CONTROLLER	Active Inverter
NOMINAL VOLTAGE RANGE	300 VDC to 400 VDC
ELECTRICAL OUTPUT (CONTINUOUS, S1)	40 kW
PEAK ELECTRIC POWER (S2)	50 kW
MAX. TORQUE (E-MOTOR)	152 Nm
RATED SPEED	2800 rpm
MAX. VOLTAGE RANGE	260 VDC to 430 VDC



WE TESTED **POSITIVE FOR ACCURACY**

STEYR MOTORS refrains from impractical show concepts. We develop, manufacture and test components, engines and power packs without risking unexpected breaks from the first idea till the end of the product life cycle. The extensive know-how and engineering equipment at our R&D center in Steyr ensures top-class products whose performance has been accurately verified. In addition to the evaluation and testing of our own developments, we also offer other manufacturers and authorities the possibility to rent our high-end equipment for independent testing of their engines and prototypes. STEYR MOTORS is open-minded and welcomes inquiries for the wide range of test services.

ENDURANCE TESTING

- Thermo-shock testing
- Durability testing

FUNCTIONAL TESTING

- Vibration measurements
- Battery simulation
- Flow measurement
- Semi anchoic chamber (class 2) with LMS measurement equipment (sound power, sound pressure, structure-borne noise)

EMISSION TESTING

- Emission measurement up to EURO VI
- Indication

FURTHER TEST BENCHES AND EQUIPMENT

- Cold start chamber
- Component testing for aggregates
- Tilting table
- High voltage test container (1.8 / 3.6 kV)
- Injector test system (common rail and unit injection)
- Swirl port measurements (flow test bench for intake and exhaust port development)

INDUSTRIAL APPLICATIONS
CUSTOMIZED POWER PACKS FOR HIGHEST EFFICIENCY

Evaluating the operational strategy and applying the best fitting technology is of particular importance for industrial applications. Heavy machinery is often equipped with huge engines to support the maximum load while most of the time only part load operation is needed. Therefore, STEYR MOTORS specializes in applying customized, highly efficient power packs that support the default power requirements but in addition provide a temporary boost for peak performances. Significant economic benefits such as lower fuel consumption, decreased failure times, prolonged overhaul periods, and consequently more billable working hours, are achieved by maximizing the use of the optimum operation point of the power system. Furthermore, emissions are reduced and thus environmental requirements are easily met with these perfectly fitted power packs.

Equipped with decades of engineering experience, STEYR MOTORS has the know-how to power your application whether it is a heavy goods, agricultural or rail-bound vehicle, a construction or production machinery, a stationary or mobile power generator. The scope of engineering services ranges from simple adjustments of the application's performance map to the integration of extra auxiliary drives or the complete design and manufacturing of innovative hybrid power packs.

Due to the diversity of industrial applications please contact us to supply you with the relevant information for your individual field of business.

Exemplary industrial applications include:

DIESEL-ELECTRIC POWER PACK FOR ELECTRIC LOCOMOTIVE

- for areas without overhead electric lines, substituting shunt locomotives
- compact module (approx. 1 x 1.3 x 1.7 m) with 160 kW power output
- numerous tailor-made and adapted components

HYBRID POWER PACK FOR EXCAVATOR

- high-performance 2-cylinder common rail diesel engine
- combined with a powerful in-line e-machine
- operational modes matched to the different power requirements of the excavator (default power supply, boost for peak performance)

VEHICLE APPLICATIONS
MASTERING CHALLENGES WITH EASE

STEYR MOTORS has a long history in the development of vehicle engines which dates back to the Steyr Daimler Puch group and has been extended ever since. Our unique Monoblock technology with best power-to-weight ratio, highest reliability and durability as well as outstanding cooling performance is applied in numerous land and amphibious vehicles all over the world.

Our engine design features a standardized core and individual housings for easy adjustment to different geometrical boundary conditions of the engine compartment. The high pressure injection system can be implemented either as unit injector system to secure operation even under extreme conditions or as common rail system to fulfill highest emission standards. The patented two-stage unit injection technology of STEYR MOTORS is also highly appreciated by customers throughout the world for its multifuel capability. Furthermore, all engines can be equipped with STEYR MOTORS' innovative e-machine to create state-of-the-art serial and parallel hybrid systems – our renowned power packs.

Due to the wide range of successfully completed vehicle projects for industry and military, STEYR MOTORS is used to meeting highest demands. Operational safety, reliability and robustness were proven time and again when powering vehicles that are applied in desert heat, arctic temperatures, high altitudes, dusty or humid surroundings.

Exemplary vehicle applications include:

VEHICLE ENGINES
- 2-, 4- and 6-cylinder engines for communal, civil and military use
- various applications in all-terrain vehicles (ATV), light tactical vehicles (LTV) and utility task vehicles (UTV)

RANGE EXTENDERS AND GENSETS FOR HYBRID AND ALTERNATIVE PROPULSION
- compact 2-cylinder diesel concept for light duty vehicles
- powerful 6-cylinder diesel-electric system for trolleybuses

DIESEL-ELECTRIC GENERATORS AND AUXILIARY POWER UNITS
- lightweight systems for mobile and stationary use
- efficient onboard power supply for heavy duty applications

For more details please have a look at our vehicle brochure.

MARINE APPLICATIONS
SUPREME SAFETY AND RELIABILITY

In the field of marine engineering, highest reliability of the power and propulsion system is of paramount importance as a vessel has to be safe and constantly operational at sea. Such requirements are a core competence of STEYR MOTORS. Therefore, the marine sector is an integral part of our business fields. A particular focus in this respect is placed on (fast) rescue boats, tenders, work boats and various kinds of lifeboats, because these applications present the most challenging requirements in marine engineering.

Since 1988, high-performance inboard marine engines for commercial and leisure boats have been designed and manufactured in Steyr for customers all over the world. From free fall lifeboats that drop from a height of more than 60 meters (200 ft) to racing yachts or rigid inflatable boats with dry run improvement of the raw water pump for immediate start while still being lowered into the water, the references of STEYR MOTORS' marine applications are numerous.

An outstanding proof of our engineering expertise was shown in 2008 when the world's first parallel hybrid propulsion system for small to medium-sized pleasure and work boats was introduced. Today, the in-line hybrid system called STEYR HDS provides the highest level in comfort and safety.

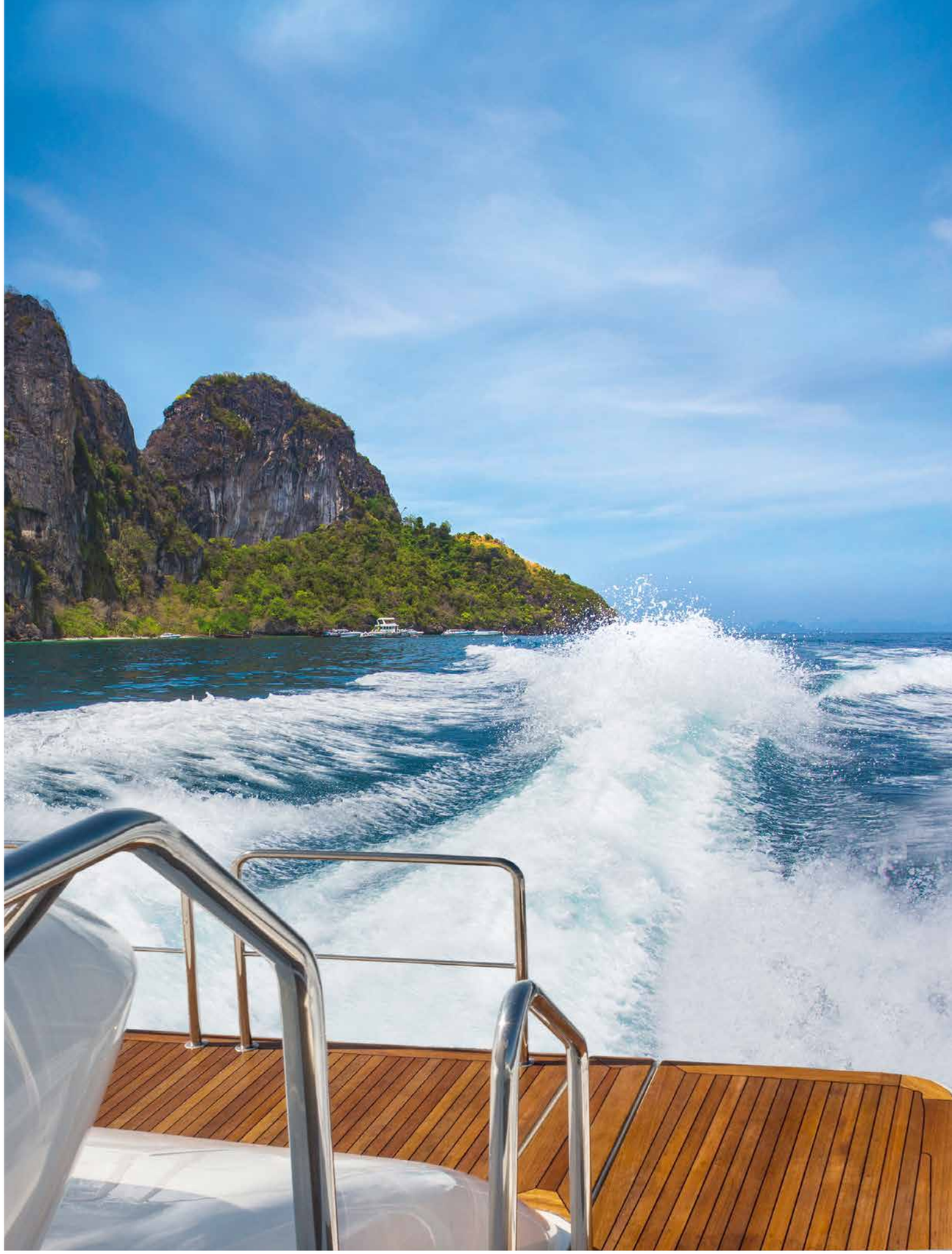
Exemplary marine applications include:

US NAVY'S 7M RIBS MKIII
- 6-cylinder diesel engine
- customer-specific developments and adaptions
- engine break-in at our testing facilities

SOLAS KIT FOR RESCUE AND SAFETY APPLICATIONS
- engines equipped to endure vessel capsizing
- immediate start even in very low temperatures (-15 °C)
- continuous running up to an angle of 30°
- withstanding a drop from heights of more than 30 meters

INTEGRATED FLYWHEEL GENERATOR (IFG)
- compact electric power source
- highly efficient, quiet and low-cost system
- robust permanent magnet technology

For more details please have a look at our marine brochure.



FURTHER HIGHLIGHTS OF ENGINEERING

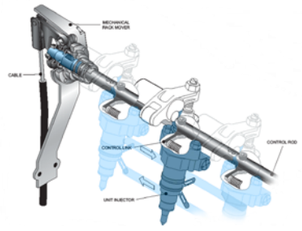
Our power packs and engines are designed for specific purposes or applications within a certain business sector. However, many developments can be adapted and thus adopted to other fields and applications. On the one hand, this provides a proven basis and likewise a cost reduction by re-using an existing system. On the other hand, due to our passion in engineering, this brings forth very special developments and outstanding features across business fields and specific applications.

HIGH PRESSURE UNIT INJECTION WITH EMERGENCY OPERATION SYSTEM

Our patented unit injection system secures the application's operation as every single cylinder has its own fuel supply. If one fails, the others continue to operate independently to run the engine or power pack. Furthermore, the system withstands shortages in electricity which is particularly important in marine and aircraft applications. Though the high pressure unit injection system is primarily controlled electronically, STEYR MOTORS' unique emergency operation system is a mechanical backup system that guarantees the operation even without electricity.

MULTIFUEL CAPABILITY, ALTERNATIVE FUEL SYSTEMS AND FUEL DENSITY COMPENSATION

STEYR MOTORS faced all types of fuel qualities and sulfur contents while powering numerous applications throughout the world. The challenge for engines and power packs was solved by a multifuel capable system operating on many different fuels and fuel qualities from diesel (F54, EN 590ff) to kerosene (JP8 / F34) or maritime diesel fuel. This know-how was further applied to create a system that uses natural gas (LNG/CNG). Moreover, STEYR MOTORS also developed a fuel density compensation kit that ensures the power output even in high altitudes where the air density is lower.



FURTHER HIGHLIGHTS OF ENGINEERING

EFFICIENT COMMON RAIL TECHNOLOGY, ADVANCED AFTERTREATMENT SYSTEM

As an efficient and eco-friendly alternative to the reliable unit injection technology, STEYR MOTORS offers a common rail system with high pressure pump and conduit as well as system specific software. Besides extremely short spraying distances and switching times, the common rail system enables pre-injection, main injection and post injection to ensure clean and efficient fuel combustion at every operating point. High engine power and smooth operation with low consumption is guaranteed by this state-of-the-art injection technology. In addition, emissions can be even further reduced by applying STEYR MOTORS' advanced aftertreatment system together with the efficient common rail technology.

COMPACT POWER PACKS FOR STATIONARY, MOBILE AND FLIGHT APPLICATION

A prime example of the modular and tailored engineering competence of STEYR MOTORS is the unique 2-cylinder power pack that can be equipped either with unit injection or common rail technology. The assembly of engine, e-machine, aftertreatment system, radiators, fans and all peripheral components within a compact frame including acoustic insulation walls is applicable for various purposes and easily transportable due to its small size and low weight.

The diesel-electric power pack can be used as a stationary solution or for land and amphibious vehicles, boats, even large unmanned aerial vehicles. Its vast application potential includes for instance the use as an auxiliary power unit for the electric supply of an application independent from the main engine, but it can also be used as a mobile system that enables a weight reduction by a temporary removal when it is not needed. Furthermore, the power pack can be used for large drones and thus provides the benefit to run the unmanned aerial vehicle on kerosene instead of gasoline or diesel. STEYR MOTORS has already gained valuable know-how in this field by developing an aircraft engine.

Besides the combination with the STEYR E1, it is possible to run other DC and AC generators, hydraulic pumps, CVT transmissions and more with this outstanding development. Last but not least, the multifunctional system is also an ideal enhancement for electric-driven vehicles by applying it as a range extender.

INNOVATIVE BY TRADITION
EXPERIENCE IS THE BEST TEACHER

For more than 150 years, Steyr has been a place of innovative spirit and passionate dedication to engineering. The foundation was laid by Josef Werndl in 1864 as he founded the initial company that step by step turned into the famous Steyr Daimler Puch group. The broad know-how in the development and production of high-quality arms, bikes, bearings, engines, trucks, tractors, busses and tanks is legendary. When the Steyr Daimler Puch group was divided up due to social and economic reasons the great engineering legacy was inherited to the specialized succeeding companies. STEYR MOTORS is one of the last companies out of this remarkable history that continues to live the traditional engineering spirit. Founded in 2001 as a completely independent company after a management buyout, STEYR MOTORS draws from the extensive know-how and experience of the past in order to provide innovative products and services for current and future demands. Today, STEYR MOTORS is a globally renowned expert in engineering and manufacturing of high-performance engines and propulsion technologies. The combination of profound knowledge and successful practice with a modular engineering offer ensures products and services that stand up to all challenges presented by the various fields of application.

CERTIFIED & PATENTED **KNOW-HOW**

STEYR MOTORS holds numerous industrial property rights, patents, certificates and awards that underline the long history and expertise in engineering. The following information is merely a selection out of various achievements with new additions constantly in progress.

PATENTS

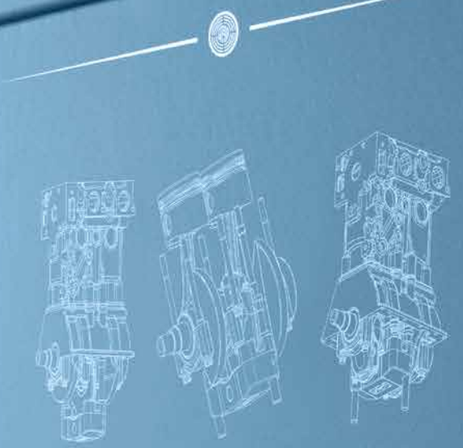
- Fuel injection pump unit and process for its calibration
- Combustion engine with an electric machine for hybrid traction
- Electricity generating unit consisting of a combustion engine and a generator
- Piston-type combustion engine with mass-balancing device
- Water pump for a combustion engine, which can be dismounted without removing the drive belt
- Fuel injector for an internal combustion engine with two opening phases
- Method for controlling a diesel engine with exhaust gas recirculation
- Fuel injector unit consisting of an injection nozzle and a controllable injection pump with a special sealing sleeve
- Method and installation for controlling an exhaust gas recirculation valve based on engine speed and load including dynamic correction

CERTIFICATES

- ISO 9001:2008
- NATO approval for vehicle engines
- SOLAS approval for marine engines
- DIN EN15085-2 welding certification
- Several certificates and type approvals for marine and vehicle engines (EPA, RCD, EIAPP/MARPOL, RINA, RMR, CCS, BSO II, etc.)
- Leitbetriebe Austria membership (Austria's Leading Companies network)

AWARDS

- WirtschaftsOskar/US-A-BIZ-Award 2016 in the category Spectacular
- Qualitech Technology Award 2011
- Innovation Award of Upper Austria 2010
- Pittmann Innovation Award 2009
- Innovation Award of Upper Austria 2008



RECIPROCATING-PISTON INTERNAL COMBUSTION ENGINE WITH MASS BALANCING DEVICE

SINCE 2007

US 8,748,200 B2

AT 509 820 B1

STEYRMOTORS

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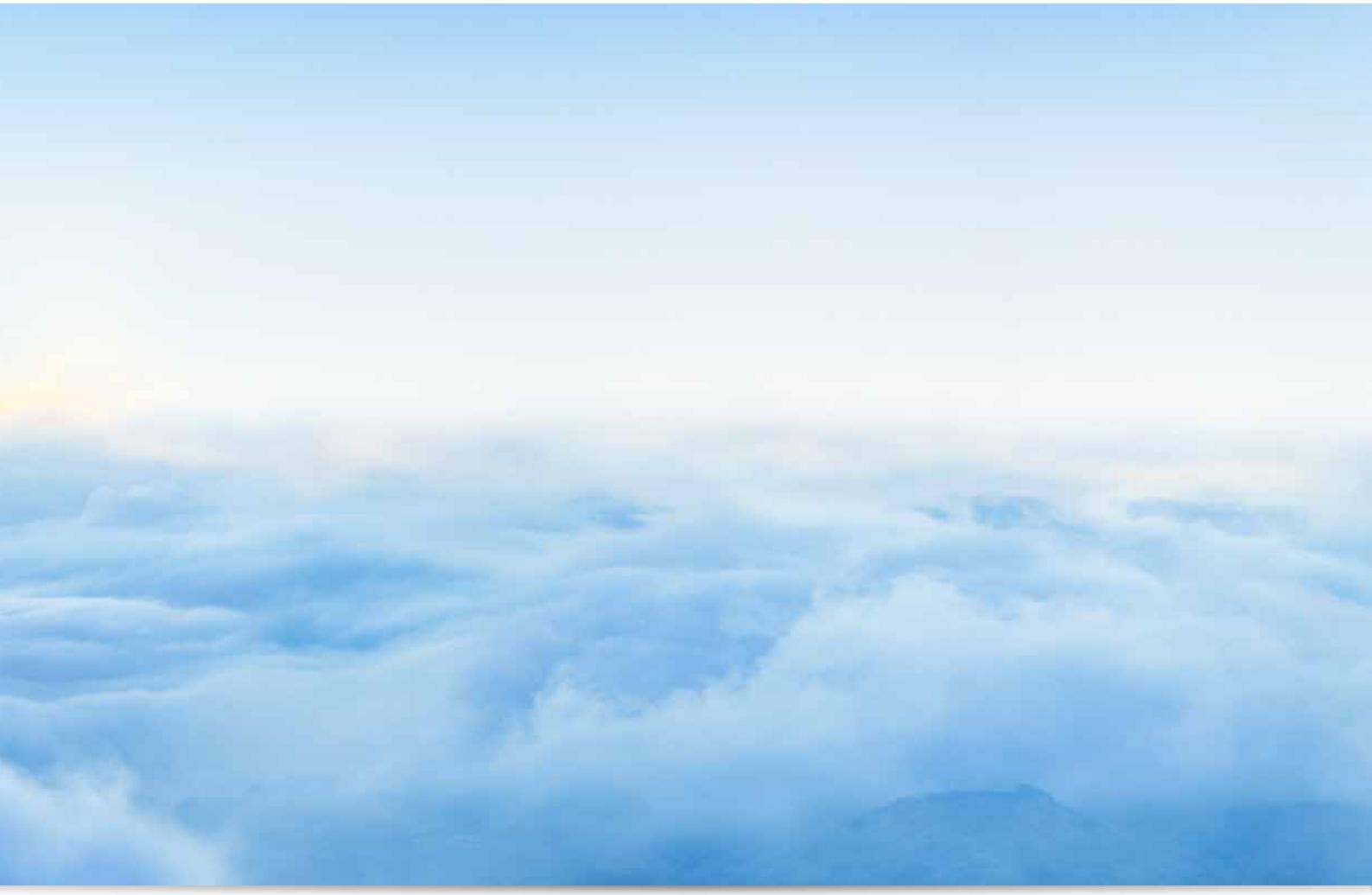
ENGINEERING

MARINE ENGINES

VEHICLE ENGINES

INDUSTRIAL ENGINES



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