E-POWERED MARINE SOLUTIONS

E-MS engineers are specialized and experienced in innovative and environmentally friendly diesel-electric ship networks and propulsion systems. Compared with conventional systems, the solutions offer fuel-saving possibilities up to 12 percent. The concepts developed are applicable for almost all types of ships and offshore applications. Their compact design leads to distinct space and weight savings, thus increasing cargo hold and/or operating range.

If you are looking for low life-cycle costs of your next ship we offer comprehensive qualified consultancy for electric power generation and distribution – starting with the first idea via construction until commissioning and operation.

“Our commitment: Development of economical and environmentally friendly electric power generation plants for ships and offshore applications which save as much fuel as possible, reduce undesired emissions, avoid unplanned downtimes, with lowest possible life-cycle costs.”

Peter Andersen, Managing Director
The silent engineering.
Ship network and propulsion solutions with unique innovative features.

The E-PP is the core element electric power generation and supply on board a ship for the entire network – independent of voltage and frequency – and the electric ship propulsion. The E-PP consists of a common DC bus which combines generators and consumers via corresponding converters.

Real time monitoring and diagnostics with E-RD
If one decides to integrate a comprehensive data collection, storage and evaluation system, like E-RD, one can control – at any time – the commercial and technical status of all onboard systems and components with reference to a common time base.

E-RD creates the prerequisites to optimize ship operation on a large scale in saving not only fuel but also maintenance costs, avoiding unplanned maintenance and down times.

Variable speed and start-stop with E-OP
Operating generating sets with variable speed and without synchronizing the generators is the first step towards low operating costs. The second is the application of a start-stop function – well known from road vehicles – for the drives of the electric power generating sets.

E-PP combined with E-RD and E-OP leads to the best possible onboard power plants and achieves reductions in fuel costs up to 12 percent.

E-RS for shaft generator usage at slow steaming
Slow steaming operation of ships equipped with shaft generators must be evaluated very carefully because the costs for electric power generation may compensate a great part of the reduced fuel consumption of the main engine.

With the application of E-RS these ships can use the shaft generators with all advantages down to very low shaft speeds. No auxiliary generating set must be put into service during the hours of slow steaming. For such cases the powerful retrofit solution E-RS was developed on the basis of E-PP and E-OP.
Power supply and propulsion

Consistent usage of all E-PP features promises significantly reduced fuel consumption.

E-PP – the electric power pack – is an innovative solution of onboard network and drive technology. It spans from power generation to power supply of all electrical equipment including all kinds of electric propulsion and drive systems. It is prepared for all types of internal combustion engines for power generation as there are diesel engines, Otto gas engines and dual-fuel engines.

For electric power generation, asynchronous alternators are used in combination with converters and a common DC bus. Synchronization is not necessary. Thus, the internal combustion engines can be operated any time at any speed with the best possible efficiency according to the power demands. Power is supplied to all consumers by corresponding IGBT converters with the required voltage and frequency. Running of the generating sets at an operating point of the combustion engines with an unacceptable low efficiency can reliably be avoided by introducing a start-stop function – well known from automotive applications. Thus, at part or low load, high savings of fuel are possible.

KEY FEATURES OF E-PP

- low fuel consumption
- reduced CO₂ and NOₓ emissions
- modular structure
- advanced components
- precise and fast control
- high degree of dynamic control
- prevention of grid failures
- high degree of availability
- different power sources possible
- shore supply possible
- space and weight savings
- comparatively less cabling
- low installation costs
- low noise and vibration
- avoiding excitation of natural frequencies by shifting engine speed

Top: Comparison between a conventional diesel-electric propulsion system (left) and the E-PP (right). Bottom: The E-PP features a DC bus with a high degree of flexibility on both sides, for the electric power generation as well as for the consumers.
Power supply and propulsion

The quality of electric power supply and propulsion systems determines the comfort on board to a very high degree.

A comparison of the E-PP against conventional systems on the example of mega yachts shows the advantages of the solution developed by E-MS.

Diesel-mechanic propulsion

If a high-powered sophisticated yacht shall be equipped with a conventional diesel-mechanic propulsion system, because of the limited space high-speed diesel engines must be chosen. Depending on their output two or more engines will be needed. However, in any case gearboxes and clutches are necessary for transmission of the power to the propellers. Contrary to the two following systems this solution needs more space for the exhaust ducting of the diesel engines.

Conventional diesel-electric propulsion

If a diesel-electric power plant is preferred gearboxes are no longer needed but the space requirements are about the same compared with the diesel-mechanic solution. The reason: Spacious switchboards including the synchronization equipment, numerous transformers and converters for speed-controlled electric drives are necessary. These components require a complex control and automation system and a lot of cabling.

E-PP, the innovative solution

The E-PP developed by E-MS needs considerably less space and infrastructure in comparison to conventional diesel-mechanic and diesel-electric systems. The reason is, that drive transformers are dispensable and switchboards for power distribution and converter units are combined in the E-PP and thus minimized.

The E-PP consists of the said asynchronous generators, a comparatively small switchboard, advanced high-performance converters, a common DC bus and converters for power supply to the ship network and all electric drives. The control of the system is much faster compared with a conventional system as the generators can take over load within a few seconds, because there is no time needed for synchronizing them. This is a clear safety feature, even for extreme fluctuating loads.

Due to the high integration of components, the automation system can be less complex, needing less cabling.
Optimized fuel consumption due to variable speeds and start-stop function for generating sets.

Up to now electric ship networks are typically operated with a common voltage and frequency. Thus, the combustion engines driving the auxiliary sets must run with a synchronous speed. There is no chance to make use of variable speeds corresponding to actual power demands.

With the technology developed by E-MS the engines driving generating sets can now – at any time – run load dependent with the speed achieving the best efficiency possible. They may be used either at the speed of best efficiency or according to the demand of electrical energy on board with the respective speed whenever best corresponds to the energy needs, thus saving a lot of fuel and reducing undesired emissions.

**And the full speed range**
The higher the speed of the internal combustion engines and the electric machines, the better is their power density and power-to-weight ratio. That means, one can save a lot of space and weight using the highest possible speed as rated speed. This is of greatest importance for narrow engine rooms of several types of ships.

**Using the best operating point**
An additional advantage is the possibility to run the sets above the synchronous speed up to the maximum speed of the internal combustion engines. Thus, smaller sets can be installed, reducing space requirements and weight. In special cases there are, for instance, only three instead of four generating sets needed.

**Variable speed**

If there are two or more generating sets on board it is obvious which advantages can be reached by operating just one set with variable speed at the point of required power with the best possible efficiency instead of running multiple sets at a very low load.
Start-stop function

Fuel optimized power generation – a major increase of diesel-genset efficiency.

The start-stop function has become a common feature of automotive engines, saving fuel and reducing undesired emissions of the internal combustion engines. E-MS now has the solution for maritime applications.

Taking over this technology to operate diesel generating sets, the generator will be used as a motor to speed up the diesel engine instead of using the conventional starter equipment. Thus, one gets a powerful starter motor, which is able to speed up the engine every time to any selected speed.

As the engine is preheated and prelubricated during a mission, no excess fuel is necessary to start the engine. Thus, there will be no smoke emission generated by this function. The injection process will be optimized by the engine management system to save fuel and reduce emissions.

Having this in mind, generating sets should be shut off immediately if the power demand is low and can be taken over by other sets – even for a short period of time. If a sudden rise in power demand occurs, the engine will be started again automatically within a very short time compared with the procedure using the conventional starter system.

As the diesel engines are designed for rapid load changes, there are no limitations for frequent starts.

In addition to operating generating sets at variable speed, a start-stop function – well known from automotive applications – can further optimize the onboard power plants and save even more fuel by switching off surplus generating sets and, as a result, operating the rest at higher efficiency.

SOME BENEFITS OF E-OP

- significant fuel savings
- reducing emissions correspondingly
- reducing running time
- extending maintenance periods
- saving operating costs
- rapid answers on changing load demands

In addition to operating generating sets at variable speed, a start-stop function – well known from automotive applications – can further optimize the onboard power plants and save even more fuel by switching off surplus generating sets and, as a result, operating the rest at higher efficiency.
## Propulsion system comparison

### Propulsion, drive and diesel features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Diesel-mechanic propulsion system</th>
<th>Conventional diesel-electric propulsion system</th>
<th>Innovative diesel-electric propulsion system E-PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel consumption</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Improved utilization of diesel engines</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Utilization of gas engines possible</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Implementation of hybrid drives possible</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Optimized specific fuel consumption</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Reduction of CO₂ emissions</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Reduction of NOₓ emissions</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Reduction of SO₂ emissions</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Less heavy metal and soot particles</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Can fulfill sulfur limits – relevant for marina mooring fees</td>
<td>★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Energy savings at slow speed and dynamic positioning</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Load variations of propulsion drives and / or large consumers without influence on other consumers</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Effective and efficient dynamic positioning</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Low noise and vibration levels</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Simple integration of renewable power sources possible</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Generators don’t have to be synchronized, can be connected and loaded right after reaching rated speed</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Diesel generating sets operated at fixed speed</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Diesel generating sets operated at variable speed</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
</tbody>
</table>

### Ship power management

<table>
<thead>
<tr>
<th>Feature</th>
<th>Diesel-mechanic propulsion system</th>
<th>Conventional diesel-electric propulsion system</th>
<th>Innovative diesel-electric propulsion system E-PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generating sets are ready for supply of power 10 seconds after start</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Management of individual and variable speeds of each diesel-genset</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Load dependent and fuel optimized Start Stop of diesel-gensets</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Sub-networks for generators, drives, motions and ships network are independent from each other in respect of voltages and frequencies</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Extended redundancy due to modularized operation</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Ultra-fast recovery of power supply after black-out</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Real-time monitoring and control of all major components</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Online support for analysis of failures and maintenance requirements of major components</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Integrated control and power management via internal bus communication</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Simple add-on of features in existing systems</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
</tbody>
</table>

### Operation safety, protection, selectivity

<table>
<thead>
<tr>
<th>Feature</th>
<th>Diesel-mechanic propulsion system</th>
<th>Conventional diesel-electric propulsion system</th>
<th>Innovative diesel-electric propulsion system E-PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 50% redundancy of power supply for ship network and emergency operation</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Protection elements, ultra-fast and highest level of protection</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Reduced level of short circuit currents</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Ultra-fast reaction time of protection devices</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Selective tripping for all important components</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Arc fault protection for each functional unit</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Minimized harmonic distortion</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Highest protection standard for equipment, maneuverability, crew</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
<tr>
<td>Simple connection to on-shore power supply</td>
<td>★★</td>
<td>★★★★</td>
<td>★★★★</td>
</tr>
</tbody>
</table>
Remote Diagnostics

Real-time monitoring and remote diagnostics are the prerequisites to realize at any time how a ship network performs.

In case of faults it is of greatest importance to know exactly why and where a defect occurred. The E-RD helps by providing all information needed to get the full picture.

As the E-PP – the electric power pack – is characterized by a high degree of integration E-MS engineers were motivated from the very beginning to develop special equipment to collect as much information as possible about the status of the onboard systems and all major components. The result is E-RD – a device for collecting operational data of ship networks and propulsion systems, allowing not only to view the data but also to analyze it with a wealth of methods. Real-time monitoring and remote diagnostics are only the first steps.

The next steps are under development as there are fully automated prognosis of faults and future operating conditions as well as on-condition maintenance.

To optimize the performance of onboard systems is one important task but to obtain an equipment to predict the evolution of operating parameters over time goes far beyond. The step from preventive to on-condition maintenance is only a consistent decision.

**SOME BENEFITS OF E-RD**
- identification of system faults without being on board
- reduced response time
- observation of long-term trends
- fast decisions to overcome faults
- prediction of measures against faults
- avoidance of critical system conditions

E-RD collects operating data from a lot of systems on board a vessel, such as the complete power generation plant as well as all consumers. The variety of different data sources allows for a multitude of different visualizations and reports correlating data from different sources. The evaluation of the data can be carried out at any desired location on board or via internet connection at the ship-owner office or at the services of E-MS involving the supplier of relevant subsystems.
On the basis of a remote monitoring system, the modular nature of the E-RD allows for a number of applications, such as remote diagnostics, on-condition maintenance, operational optimizations, up to prognosis of faults and operating conditions based on the data recorded and analyzed. The ultimate goal is a fuel-efficient and highly reliable operation and reduction of life-cycle costs.
Energy-efficient retrofit solution for shaft generator operation.

Slow steaming with strongly reduced service speed and operating constant-speed shaft generators at the same time at high efficiency are a contradiction.
E-MS has a solution: E-RS – an energy-efficient retrofit system for conventional shaft generators.

Slow steaming means reduced service speed of a ship. In case the ship network for a diesel-mechanical driven ship is served by a shaft generator (PTO), the propulsion engine has to run on rated constant speed at all reduced load conditions but the most efficient slow steaming mode is to power the propeller on the „propeller curve“.

To gain the efficiency difference between these two modes, the shaft generator has to be switched off and auxiliary generating sets have to serve the ship network. By doing so, the operator has to take into account that auxiliary sets are less efficient than main engines, are using MDO instead of HFO and add to the maintenance costs.

E-RS – the energy efficient retrofit solution solves this problem and enables the ship to operate at the highest efficiency possible at all times and operating conditions.

E-RS is using a power converter system providing power supply from the shaft generator at variable speeds without the need to run auxiliary sets.

The economic contemplation of the E-RS investment mainly depends on the running time and degree of slow steaming, the cost difference between the different kinds of fuel used and the fuel quality of the auxiliary generating sets. Calculations for existing ships have shown return on investments between one and two years.

Parallel operation of shaft generator and auxiliary sets is possible and the converter system can be combined with a bypass breaker to the existing plant, ensuring that known onboard operating modes remain available and can be utilized as before.

**SOME BENEFITS OF E-RS**

- easy and cost-efficient implementation on ships in service without off-hire periods
- there are no major adjustments necessary concerning power management and power distribution, thus only minimal changes of existing switchboard systems
- minimized modification of main engine control
- power supply from the shaft generator at variable shaft speeds under slow steaming operating conditions
- maximum flexibility at all modes of operation – before and afterwards
- shortest return of investments conditions
- fuel savings of up to 15 % for the main engine with an efficient electrical power supply management
Consulting references

E-MS is also active as consultant concerning electric power generation and power supply on board of ships and offshore installations.

The activities cover all applications of electrical energy for marine propulsion solutions and other large consumers on board.

Geared towards every application, the main task of E-MS consultancy is efficient and environmentally friendly electric power generation with diesel-electric, Otto-electric or dual-fuel-electric generating sets and shaft generator systems.

In detail the assistance of E-MS covers
• definition of system topologies and related interfaces in case of onboard networks
• checking and evaluation of technical specifications and proposals for and from relevant system suppliers
• development of basic onboard system topologies as a standard for different types of ships
• examination, discussion and annotation of test conditions for onboard power plants
• support for working out of specifications for proposals for deliveries of components and services like engineering and commissioning
• integrated engineering

List of consulting references

<table>
<thead>
<tr>
<th>Year</th>
<th>Vessel Description</th>
<th>Technology</th>
<th>Owner/Supplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Diesel-electric powered water tanker with water treatment</td>
<td>technical consulting</td>
<td>Siemens Marine Solutions (Germany)</td>
</tr>
<tr>
<td>2005 - 2007</td>
<td>Sedco 702 drilling rig</td>
<td>technical consulting</td>
<td>TransOcean Deep Sea Drilling Inc. (Houston, USA)</td>
</tr>
<tr>
<td>2005 - 2007</td>
<td>Sedco 706 drilling rig</td>
<td>technical consulting</td>
<td>TransOcean Deep Sea Drilling Inc. (Houston, USA)</td>
</tr>
<tr>
<td>2006 - 2007</td>
<td>60 m mega yacht, innovative diesel-electric drives with propulsion power of each 2 x 1,600 kW</td>
<td>technical consulting</td>
<td>unknown owner (France)</td>
</tr>
<tr>
<td>2006 - 2007</td>
<td>Offshore drilling vessel „Discoverer America“</td>
<td>technical consulting</td>
<td>TransOcean Deep Sea Drilling Inc. (Houston, USA)</td>
</tr>
<tr>
<td>2007</td>
<td>Propulsion systems on board of river cruise vessels</td>
<td>representative study</td>
<td>German owners</td>
</tr>
<tr>
<td>2007</td>
<td>Offshore drilling vessel</td>
<td>technical consulting</td>
<td>TransOcean Deep Sea Drilling Inc. (Houston, USA)</td>
</tr>
<tr>
<td>2008 - 2009</td>
<td>Offshore drilling rig</td>
<td>technical consulting</td>
<td>Siemens AG – Industry and Marine Solutions (Germany)</td>
</tr>
<tr>
<td>2008 - 2010</td>
<td>4 x 85 m mega yachts (V850 Series), innovative diesel-electric drives with total propulsion power of each 3,200 kW</td>
<td>technical consulting</td>
<td>European owners</td>
</tr>
<tr>
<td>2008 - 2011</td>
<td>140 m mega yacht</td>
<td>technical consulting</td>
<td>Lürssen Yachts (Germany)</td>
</tr>
<tr>
<td>2011 - 2013</td>
<td>150 m river cruise vessel</td>
<td>engineering, consulting</td>
<td>Chinese shipping company</td>
</tr>
</tbody>
</table>

Vessel references

With the river cruise vessel „Viking Legend“ built by SET in Tangermünde in 2009 the success story of the E-PP started. Meanwhile, about 50 cruisers of the same type and with the same equipment for the electric power supply and propulsion system are in service.

The consistent use of the automatic control of E-PP and E-RD leads to substantial savings in life-cycle cost and protects the environment. This applies to almost all types of ships.

This shows the E-MS order book: A 140 m mega yacht with a high-sophisticated power supply and propulsion system designed by E-MS is currently under construction in Europe, for the first time featuring not only the E-PP but also the E-RD.

In addition, some river cruise vessels will receive E-MS equipment and the power supply and propulsion system of a research vessel for an Asian customer is as well on order. A second research vessel is planned. Both research vessels as well as the new river cruisers will be equipped with the E-PP and the E-RD.

The idea behind E-PP and E-RD is simple, the realization demanding and the result day by day convincing.
Applications for

River cruise vessels
Mega yachts
Container vessels
Offshore platforms
Offshore support vessels
Cruise liners
Research vessels
Ferries
Ice breakers
etc.