POSE²IDON :
A NEW CONCEPT OF THE « ELECTRIC SHIP »

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SOMMAIRE / *SUMMARY*

Le projet POSE²IDON est un grand projet intégré européen du 7$^{\text{ème}}$ programme cadre FP7, regroupant 30 sociétés européennes autour du thème du navire marchand « tout électrique » et des technologies électriques capables de permettre l'application de ce principe au plus grand nombre possible de navires. Son budget global dépasse les 20 M Euros avec un financement de 50% environ.

La principale innovation concerne l'utilisation de la supraconductivité de 2$^{\text{ème}}$ génération appliquée aux machines électriques tournantes et à la distribution électrique principale, permettant non seulement de réduire les dimensions et poids des équipements mais aussi d'augmenter les rendements globaux de manière significative. Les autres innovations portent sur la conversion des apparaux du navire à la puissance électrique avec des batteries tampon, l'utilisation des transmissions sans fil dans les navires, une solution de « cold ironing » pour gros navires et un système de protection ultra-rapide des réseaux électriques.

La construction d'un démonstrateur de dimension significative d'environ 1 MW permettra à la fois de tester en réel ces développements mais aussi de simuler leurs comportements en vue de tests virtuels.

Une étude portant sur 2 navires intégrant ces technologies montrera la capacité de l'extension du concept « navire tout électrique » et d'en apprécier les risques et les impacts environnementaux.

The POSE²IDON project is a large European integrated project initiated in the framework program FP7. It regroups 30 European companies around the "all electric ship" concept and the electric technologies able to apply this concept on board of more ship categories. The total budget represents more than 20 M€ with around 50%European funding.

The main innovation concerns the development of the second generation superconductivity technology applied to the electrical rotating machines and the main distribution network. This may not only reduce the size and the weight of the electric ship system but also increase its overall efficiency in a significant manner. The other innovations concern the conversion into electric of the auxiliary systems, the wireless technology on board, a "cold ironing" solution for large vessels and an "ultra-speed" protective system for the protection of the electric grids.

A shore based demonstrator of significant size – ab. 1 MW – will allow to test real components but also to simulate their behaviours in view of future virtual tests.

The study of 2 ships integrating these new technologies will check the capacity of the extension of the "electric ship" concept to a wider range of vessels and to evaluate its risks and its environmental impacts.

1. CONCEPT AND PROJECT OBJECTIVES

1.1. « Electric ship » Concept

The "electric ship" concept is until the present day limited to the electrical propulsion which was reserved to ships requiring: -

- Flexibility in manoeuvring
- Reduction of the airborne noise
- Low Acoustic signature in the water
- High torque at slow speed.

Typically the electric solutions were applied for cruise ships, oceanographic vessels, cable layers and submarines. These vessels represented less than 1% of the world compliment. This was the first step in the electric propulsion development. For several years the electrical propulsion has already extended to the supply vessels for the offshore industry and to the LNG carriers, stabilising this electric ship market to near 4% of the global market.

But the electric propulsion has confirmed its advantages in terms of flexibility, maintenance & noise reduction, and represents a major solution to reduce significantly airborne emissions. Its enlargement to new ship types will depend on the capacity to develop new technologies for the propulsion.

- enhancing the overall efficiency and fuel use by manoeuvring,
- reducing the total volume and weight of the power chain,
- reducing the cost distortion between direct mechanical and electric solutions.

For all these reasons the European Commission invited in the FP7 Call 1 the European maritime industry to propose the electric technology extension to a larger range of ships in spite of its advantages on the environmental impact and then to find solutions to overcome the most difficulties to this purpose: **overall efficiency, weight and cost effectiveness**.

POSE²IDON is a response to this extension of the "electric ship" concept, representing the first large integrated project of the European marine electrical industry. It proposes the following R&D technology advances applied to the different ship systems:

- High Temperature Superconducting (HTS) technology applied to the power generation and the propulsion
- HTS DC power transmission and distribution
- Wireless monitoring system concept for the control
- Green shore electric supply or Cold ironing concept
- Electric concept applied to all auxiliary systems
- Arc fault resistance technology for an efficient protective system of the power distribution.

The expected benefits issued from these technologies will be checked by integrating them in the design of **various vessel types**, representing some categories of ships while Classification societies will evaluate the incidences on the safety on board and the environmental impacts.

This implies further volunteer R&D investment valuated by a land based test simulator of significant sizes. **The project doesn't intend any paper work but tangible results** materialised by a large scale on-shore demonstrator**.**

2. ELECTRIC POWER AND PROPULSION

2.1. Progress beyond the state of the art

The project proposes to apply the High Temperature Superconducting (HTS) technology to the power chain: generators, motors, converters, main distribution cables; a technology whose performance is presently demonstrated in some other industrial segments. Over recent years significant research has been conducted into superconducting machines for marine application, and several demonstration projects have been undertaken such as by American Superconductor and Northrop Grumman for the US Navy. These have been highly specialised machines, designed at great cost, with little likelihood of pull through to the commercial arena. This project aims to address the optimisation of superconducting machines for the broad commercial marine market.

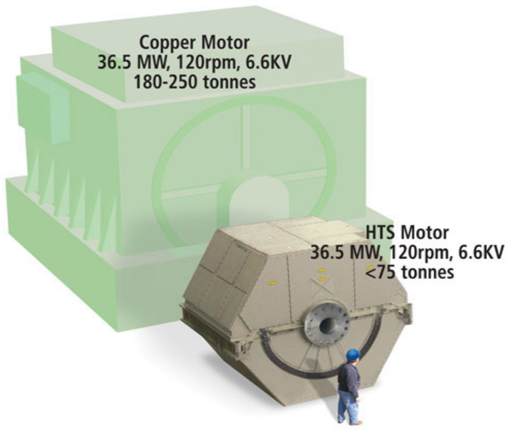


Figure 1 - Comparison between HTS and convention propulsion motor of 36.5 MW

The HTS technology can also be used to induce new innovations within the entire electrical power system. The present electric ships have a very conventional AC power distribution system. On an all-electric ship, the main power is handled by power converters. By integrating power electronics within the superconducting motors or generators, it is possible to open up the solution to new methods of power distribution more flexible, more robust, and more economic. Here again, superconductivity can be employed to transfer power around the ship while taking up less space, with reduced losses and ultimately increased efficiency.

2.2. Benefits of the Electric Ship concept:

Preliminary investigations indicate that the use of HTS technology, within the part of the fleet that currently uses electrical propulsion, could result in a 5 % increase in efficiency (2% for generators, 2% for motors, and 1% for cables + drives). This would result in the benefits indicated in the table 1.

		Total	Passenger	Merchant	Offshore	Navy
Number of expected vessels built per year over the next 5 years		439	40	325	64	10
Number of DE (Diesel Electric) vessels expected out of total to be built		150	25	81	38	6
HFO (Heavy Fuel Oil) & MDO (Marine Diesel Oil) (Conventional DE) consumption per year for the fleet	t/year	110802	28469	59055	20051	3226
HFO & MDO (HTS) reduction per year for the fleet	t/year	5540	1423	2953	1003	161
CO2 (Conventional DE) Emission per year for the fleet	t/year	343485	88255	183072	62159	9999
CO2 (HTS) Emission reduction per year for the fleet	t/year	17174	4413	9154	3108	500
NOX (Conventional DE) Emission per year for the fleet	t/year	11080	2847	5906	2005	323
NOX (HTS)) Emission reduction per year for the fleet	t/year	554	142	295	100	16
SOX (Conventional DE) Emission per year for the fleet	t/year	7914	2034	4218	1432	230
SOX (HTS) Emission per year for the fleet	t/year	396	102	211	72	12
Particles (Conventional DE) Emission per year for the fleet	t/year	456	117	243	83	13
Particles (HTS) Emission reduction per year for the fleet	t/year	23	6	12	4	1

Table 1 - Emissions per ship categories

MECHANICAL PROPULSION	ELECTRIC PROPULSION State of the Art	ELECTRIC PROPULSION New Concepts
Configuration • Power generation limited to the ship services • LV distribution • Propulsion diesel or gas engine with gear box • Variable pitch propeller • Engine in the shaft line axis installation requirement • Long and heavy shaft lines	• Power generation sets supplying the propulsion and the ship service • AC distribution system (HV or LV) • Transformers • Electronic converters • Propulsion E-motors • Fixed pitch propeller • Podded solutions available • Easier installation of the twin shaft lines increasing the ship safety	• HTS Power generation sets supplying the propulsion and the ship service • DC Distribution with HTS cables • No transformers • Integrated Converters • HTS propulsion motors • Fixed pitch propeller • Enhanced Podded solutions • Easier installation of the twin shaft lines increasing the ship safety
Physical characteristics • Large engine requiring a large maintenance space • Constraints for the ship design	• Great number of individual components dispatched through the ship • Flexibility in the ship design • Reduced maintenance space • Greater total weight	• Reduced number and footprint of electrical components • Increased flexibility in the ship design • Reduced maintenance space • Reduced total weight
Efficiency • Better efficiency at the maximal power • Hydrodynamic losses by the variable pitch propeller and particularly at low speed	• Better overall efficiency at intermediate speed 0 to 80% of the maximal speed by adapting the number of the generator sets in order to maintain a good efficiency of the generators • Electric losses due to the number of energy transformations. • Enhanced manoeuvrability for continuous control of the speed • Less airborne noise • Better acoustic noise • Reduced exhaust emissions	• Improved efficiency at all speeds • Reduced electric losses due to HTS technology (no losses) and DC distribution (no transformers) • Enhanced manoeuvrability for continuous control of the speed • Less airborne noise • Less acoustic noise • Much reduced exhaust emissions • HTS cooling system improvement to be checked
Costs – Training • Well known technology with large technology transfer out of Europe • Greater diesel maintenance costs • Well trained crew in diesel technology	• Severe acquisition over costs • Very efficient EU electric industry • Lower maintenance costs • Reduced maintenance crew • Lack of trained crew	• Severe acquisition over costs • Late compared to US • Lower maintenance costs • Reduced maintenance crew • Lack of trained crew

Table 2 - Overview State of the Art and Progress beyond State of the Art in Propulsion

However, due to the size of HTS machines compared to current electrical machines this technology could also allow electrical propulsion to be fitted to ships where space does not allow conventional electrical propulsion currently. This would significantly increase the impact of HTS on the carbon footprint dependent upon the part load characteristics of the vessels targeted.

However the HTS cooling system represents one of the challenges of the project having to demonstrate its performances in terms of size, consumption and costs.

Compared to the state of the art of the electric propulsion, the new proposed concepts can be summarised in table 2.

2.3. High Temperature Superconductors (HTS): an industrial challenge

A High Temperature Superconductor is a material which retains superconducting properties (zero resistance, able to cope with very high current) at up to 110 Kelvin (-163°C, -262°F). In normal applications it will run at around 30 Kelvin (-243°C, -405°F). This avoids the need of liquid Helium as coolant, which is required for lower temperature superconductors and which is very expensive.

HTS offers an unique combination of properties:

- 100 x the power density of copper without resistance, which yields extremely compact devices
- Practically zero losses, which yield very efficient devices.

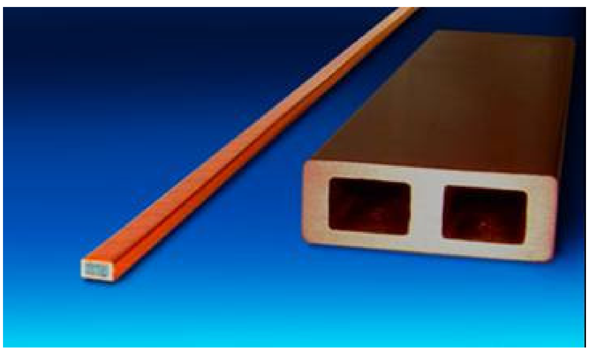


Figure 2 - Comparison of a 1000 Amp HTS Stack with a Conventional Copper Alternative

ZENERGY POWER, one of the few European companies specialized in HTS, met the increasing demand for HTS wires by completing a full-sized manufacturing plant with a design annual capacity of 2,500 km.

The first generation - 1G - HTS, the work-horse for another 2 to 3 years, has successfully allowed the elaboration of prototypes and a commercial penetration of some markets, including partially the ship propulsion but it will not penetrate all volume markets since it will not under-cut bulk copper cost.

Now the second generation – 2G - HTS is in progress and is promising due to its potentiality to continue the HTS wire cost erosion. The chosen manufacturing technology is a pure chemical all-solution process. It will make its market entry, as the first HTS conductor potentially able to greatly undercut the price of copper from 2010 onwards.

2G HTS tapes are produced either by physical or chemical deposition/coating processes. Therefore they are called Coated Conductors. The complicated layer structure comprises a metallic substrate tape, an oxide buffer layer or a buffer layer system and finally a superconducting layer consisting of Yttrium-Barium-Copper-Oxide (YBCO). Main challenge is that only highly orientated superconducting layers yield highest performance.

First deposition experiments were focussed on physical vacuum deposition methods e.g. Pulsed-Laser-Deposition (PLD), Ion-Beam-Assisted-Deposition (IBAD) and Thermal-Co-Evaporation (TCE), because they allow comparably easy access to high quality layers. Due to economic disadvantages like slow deposition rates and high investment costs for devices most groups changed development strategy to chemical non-vacuum techniques.

Final goal for the development is the all solution process meaning the chemical coating of both buffer layer and superconducting, the Chemical-Solution-Deposition (CSD) process. In the last 5 years, CSD-processes especially for the deposition of YBCO layers were developed in the forefront by U.S. and Japanese groups. During the last years, European groups as ZENERGY POWER, make up to the world leaders thanks to European and national funded projects. Successful projects performed basic research and shortened the distance especially to U.S. companies but the all CSD process for long lengths tapes suitable for applications remains a worldwide challenge and requires additional funding in order to strengthen European competitiveness.

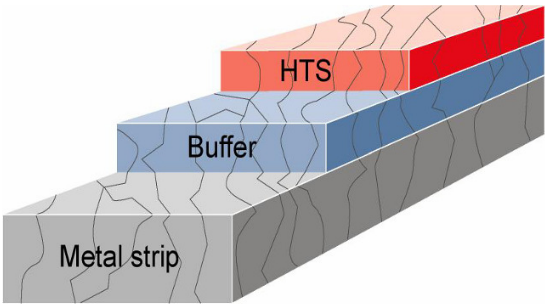


Figure 3 - Architecture of Coated Conductor

According to current projections, 2G is available in suitable quality and piece length from 2008 onwards and the main objective is to industrialize this technology. Industrialized quantities are anticipated to be available "just on time" for the POSE²IDON project.

1G HTS Coil manufacturing has made huge strides and was demonstrated by ZENERGY POWER within different EU projects - ULCOMAP FP5 and HYDROGENIE FP6. Now the equipment of 2G HTS coils in the construction of large rotating machines will represent a large industrial challenge requiring reliability and availability.

3. NEW ELECTRICAL AUXILIARIES

3.1. Present situation

New electrical auxiliaries for ship have continuously been developed and tested in the last 10 years, particularly thanks to the technologies developed on board of naval vessels, for instance FREMM frigates or submarines. For commercial vessels, the move to integrated all-electric designs will significantly improve efficiency, effectiveness, and survivability while simultaneously increasing design flexibility, reducing costs, and enhancing operational efficiency.

The trend with electrical auxiliaries is that electrically powered actuators are going to replace the current hydraulic and pneumatic systems: for instance, steering gear systems, stabilisation systems, deck equipment. Moreover, the modern computerized overall control system are likely to communicate "by wire" with a large number of smart components – electric actuators. Therefore it will provide the possibility of intelligent management of the auxiliaries:

- automatic control of each component,
- overall intelligent maintenance at reduced costs with condition-based maintenance,
- detection of abnormal situations and noise reduction.

Currently and mainly for auxiliaries with reduced power demand, electric systems are already in use. In the leisure boat market, bow thrusters, stabilisers, etc. are already electrically driven. Such electric systems for larger vessels with greater power demands are not yet a proposition for the marine industry. One of the objectives of this proposal is to develop electric auxiliaries solutions for vessels from tugs to LNG carriers. The range of applications of electric motors will be increased by improving their efficiency and applying innovative electric solutions such as frameless permanent magnet brushless motors for direct drive. Specific work on the development of compact electronic converters to drive the motors will be carried out.

Steering gears and stabilisation systems will be adapted to all electric ship configurations by developing innovative solutions. Specific work will be focused on improvement of power transmission.

Particular attention will be paid to power recovery. Studies will also focus on the way to recover energy from the use of the auxiliaries (stabilisers, steering gear, etc…). Some work has already been done within the scope of anti roll systems able to produce energy from the roll motion of the vessel.

3.2. Benefits of New Electrical Auxiliaries

The benefits of the work to be undertaken in this Work Package are aimed towards the integration of new electrical actuation systems on new ships to replace the hydraulic actuation systems. Replacing electro-hydraulic systems by completely electro-mechanical systems will reduce the risk of incidents and accidents related to fire and pollution hazards on board, by not using oil piping and pumping. The costs and manpower effort for maintenance of electrical auxiliaries and their associated electrical network will be reduced as there will be smart monitoring embedded within the systems. Such monitoring systems which are integrated with the electrical components will give the possibility of pro-active remedies if necessary, such as replacement of defaulting components (actuators, sensors, cabling). Moreover the applicability of recent advances in high power electrical devices (energy recovery and regeneration devices, high power batteries, permanent magnet and brushless motor) will be investigated within the project for the design of new auxiliaries. The design of a simulator of the complete electrical network onboard the ship to evaluate the operational performance will allow energy management and optimisation at the design phase.

Moreover, from the naval architecture point of view, the new electrical actuation systems will allow a reduced weight and size of the electrical components, as well easiness to dismount/mount the systems on board. As a result of this work package, new ships based on electrical actuation systems (deck equipments, steering gear systems, stabilisation systems) will also benefit from lower emissions, lower noise generation, increased reliability and flexibility, high control capability, reduced operation costs.

3.3. Decentralized Power Battery for Electric Auxiliaries

Shifting to electric activation, for some applications which do not require a permanent power (rudder for instance) it may be of some interest to attach a power battery to the actuators. The association Battery - Actuator allows a downsizing of the vessel electric plant which will have to provide only the average energy to the permanent electric loads. The delocalised batteries will provide the power burst to the actuators whenever necessary a reduction of the cabling weight between the electric plant and the actuator since only a low current to recharge the battery has to be provided by the plant

For all these applications, Li-Ion solution is proposed because it is presently the best performing battery technology in terms of specific mass and volume. Cells can be designed for high energy and low current application for long discharge applications as well as for very high power pulse application where it can almost match the performances of super-capacitors. The higher price of Li-Ion compared to the traditional Lead Acid can be overcome by a much longer operational life and a drastic reduction of the maintenance requirements

3.4. An example: the ship stabilization demonstrator

The expected application is a ship dynamic stabilization system where a battery composed of 120 high power cells is able to provide the short power bursts (up to 150 kW) necessary to move the stabilization mass. This battery is capable also to recover the energy coming from the stabilization system (regenerative braking).

Complementary studies must be performed like adapting the battery management software to the specific application, thermal study of the battery demonstrator, and follow up of the tests on the equipment.

4. GREEN SHORE POWER SUPPLY "COLD IRONING"

Clean air is essential for human or any life. Several port communities have been increasing the pressure on port authorities to reduce NOx, COx, SOx and PM emissions within their ports. The main option is to connect the ship to a shore based power supply instead of using heavy-oil-fuelled generators on-board vessel. For several years now efforts have been made to establish shore connections for use during port time. For small vessels and power less than 1MW, basic solutions are known and have been implemented in some harbours. The main characteristics are typically that the same voltage 440 V 3-phases is used on shore and on board. Further on the frequency is the same for both sides 50 Hz in Europe and 60 Hz in the US. Switching over is performed manually in most cases, the on-board generators are switched off and the shore side takes over. This is like a black out on-board and it takes about one or two hours to set all ship board systems into operation again.

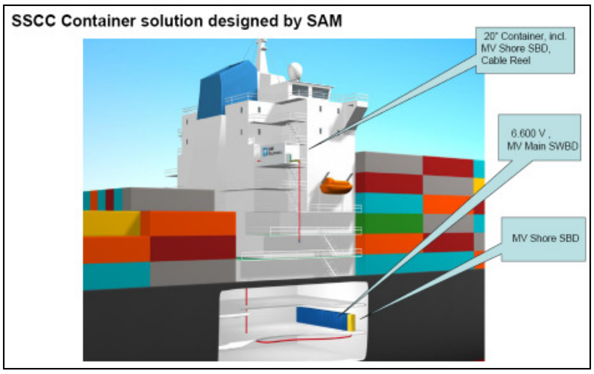
Activities have been reported from some Baltic ports under the leadership of the city of Lübeck. Here a transformer and sometimes also a converter are applied so that both sides may differ in voltage and in case of a converter also in frequency.

For POSE²IDON a much more advanced solution is envisaged. The shore based power will be connected to the on-board main supply bus like one further diesel generator. A high voltage converter in semi-conductor technology will convert any voltage and frequency in a wide range. It has a much lower foot print compared to dynamic converters with rotating machines. In addition it may be also used as converter for the shaft generator, which typically is installed in every ship today to save auxiliary diesel consumption during the voyage. So the installation of the converter pays off very quickly within one or two years. A further main advantage of this solution is on-line switching over from on-board to shore power and back without any interruption and black-out. All ship systems will remain in running status. This innovative solution will lead to only very little extra costs for the ship owner and deliver a fast return of invest. So it is expected that the green technology will be introduced very quickly.

There is also some pressure from the political side, i.e. the city of Los Angeles wants to establish shore connections for all vessels. The city of Hamburg would like to have green power for the new cruising terminal just to ensure a good quality of life for the harbour city with hundreds of new flats. Some ports and also some ships have invested in individual solutions following this trend but as yet no common standard has been introduced. The problem is that too many international parties are involved in the process such as port authorities, ship owners, potential power suppliers, and industries.

The communication process between parties of different economical interests is essential for a successful introduction and will be an important part of the study. We are not looking for an individual solution for a single vessel in one harbour, (this could already be done today for a permanent ferry link for instance). Ports and ship owners are requesting a solution for a whole fleet to visit a number of different harbours in different countries. In the first step a limited number of harbours will be considered for later expansion.

The proposed technical solution is especially designed for retrofit of existing vessels. A container with cable drum and complete power converter and protection system can be installed on one of the upper decks as shown in Figure 4. A cable is led to a main switchboard under the deck, which is extendable by one switch-gear cabinet for feeding into the external power.



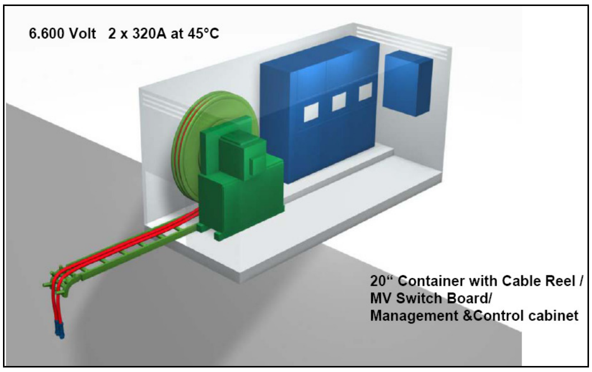


Figure 4 - Clean Shore Supply

5. NOVEL PROTECTIVE TECHNOLOGY

An arc fault in switch-gear assemblies is frequently the reason for a total black-out on board. It is characterised by a substantial arc power, which causes destruction of the switch gear assembly.

The arc-fault produces a sudden surge of heat (arc plasma at temperatures of more than 10000 Kelvin) and an extreme increase of pressure (up to 3 bars) in less than 10 milliseconds. Furthermore, the behaviour of an arc-fault is affected by continuous ignition and extinction processes, a permanent changing of the length and the extent of the arc as well as a fast arc movement. The life time of an arc-fault, in worst case, can amount to ab. 300ms. Overpressure and over temperature result in mechanical and thermal damage or destruction of the equipment and its surroundings, combined with electrical power loss.

Furthermore, ejected hot gases and plasma particles are dangerous for operational personnel. In the case of a fault, the only remedy is to limit the arcing time. As well as Moeller, nearly all producers of low and medium voltage switch-gears provide devices for detecting arcing faults. As a patent search demonstrated numerous types of arc detectors have been developed. Thus the measuring systems used for arcing faults utilise the characteristic properties of an arc e.g. pressure or temperature increases, changes in electrical characteristics and the emission of radiation.

Normally, the current switch-off is dependant upon the shunt trip of the circuit breaker, which limits the arcing time to about 70-80msec. As a large number of laboratory tests and practical experience showed, lowering the dwell time of an arc fault is the best way to reduce damage. Short reaction times in the order of about 20ms are necessary. Then the arc energy is restricted to below 100kWs. The Moeller Company was one of the first manufacturers of electric switch-gears that focused on arc-fault protection and developed the ARCON system. In contrast to most other competitors the Moeller solution uses fibre optic cables as fast optical sensors for the arc radiation allowing complete optical detection within the whole assembly (typically a switch-board with a length of 6-12m). The ARCON system can differentiate arcing faults from other phenomena such as high frequency noise, electromagnetic interference or lightning.

The novel protective technology has not been introduced on-board of vessels up to now. The innovative aspect of this task is to adapt the technology for on-board operation by reducing its footprint for installation (shorter distances) and reducing its sensitivity to over-voltage, interference, physical shock & the harsh environment. Later, the arc-fault protection system shall be improved to achieve a reduced lifetime for the arc-fault of less than 2msec. Due to the fast monitoring of an arc fault in the power distribution the quenching time of the arc is drastically reduced. Short arcing times minimise the risk to personnel and to destruction of equipment. The implementation of an advanced arc fault protection system on ships takes care for a reliable and secure distribution of energy. Because the physical destructions of switchgear assemblies are limited to its striking roots, polluting effects by combustion of equipment and cables are restricted to the inevitable. A further advantage is that components and operational units do not need to be replaced due to arc fault but after a short check they are ready for re-commissioning. This new generation of arc fault protection has the potential to cover the demands of low and medium power distribution for AC as well as DC.

6. WIRELESS OPERATION FOR CONTROL AND MONITORING

A typical vessel with a length of 200 m carries today about 170 Km cable. The number of fire sensors reaches about 2000. A single diesel engine is fitted with 60 sensors. Planning, installation and maintenance of this configuration is a major cost factor in ship building and operation. Weight, space and cable feed-through requirements are top of the list. Wireless operation of sensors and field devices is one possible option to propose a response to these requirements. It is expected that a 50% reduction of cables can be achieved saving material, space, weight, installation and maintenance costs in the same order of magnitude. Several wireless standards like Blue-tooth and WLAN have been tested. The results were promising. Even under direct radiation of a turning radar antenna a Blue-tooth link could be operated with no error and a data rate reduction of only 3%.

Hand-held applications are already proposed for the open wing but need to be demonstrated below the deck: engine room, cabins, etc. As wireless propagation is much more restricted here, some research will be required under the management of MARINELEC, a French SME specialised in the automatic control systems. So one of the results of this task will be a planning tool taking into account various propagation problems and limits of wireless communication in closed areas. Later, suitable components, architectures and application examples will be able to be selected, developed and tested.

The diagram of Figure 5 shows a field strength measurement on a modern cruise bridge. The frequency range of interest, the 2.4 GHz band (for WLAN, Bluetooth etc.), is free of any interference.

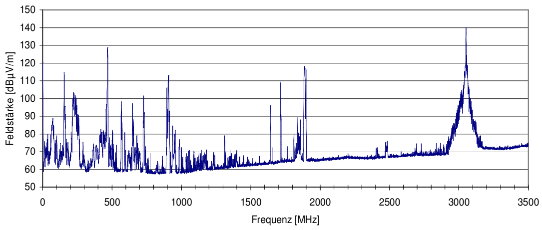


Figure 5 - Field Strength Measurement on Cruise Bridge

7. SELECTION OF THE SHIPS

An important ship design parameter is the **relative** ratio between electric propulsion power and ship service power (hotel, service, auxiliaries). This ratio may lead to different concepts.

The table 3 gives a simplified figure of the ship type positioning on view of this ratio:

Service / Propulsion	Small – Medium	Large
Small / Medium	A Oceanographic vessels Seismic vessels Mega yachts River vessels	B Ferries Small cruise liners Offshore supply vessels Dredgers Short sea shuttles Cable layers Multi-purpose vessels
Large	C Container ships Ferries Tankers LNG Ice breakers and arctic vessels Tugs	D Cruise liners FPSO Shuttle tankers

Table 3 – Ship type repartition

The interest and the problems for using the all electric ship design can be summarised per category as follows:

Category A

- Silent propulsion
- Great manoeuvrability at low speed
- Difficult integration of all the electric components on board

Category B

- Existing large electric plant available for the ship services that could be used also for the propulsion
- Typically a target of the electric ship
- Difficult installation on board

Category C

- Electric ship could increase the ship safety and reduce the exhaust emissions
- Parameter of the efficiency at maximal speed concerns the ship profitability
- Electric motor badly adapted for such large propulsion (100 000 HP)
- Integration problem for the small and medium size ships

Category D

- Increased manoeuvrability
- Silence inside the ship
- Economical efficiency
- Large ship supporting the excess of weight
- A large deck with a capability to plug different auxiliaries depending of the mission

A market analysis will collect the positive and the negative arguments applied for each ship type concerning the possible application of the "electric ship" concept and will anticipate to their conversion thanks to the new proposed technologies.

The project will then confirm this estimation by 2 or 3 examples of ship by completing their design including theses innovations

Environmental impacts and risk analysis will complete these examples with the participation of the major European classification societies, DNV, GL and BV.

8. SHORE SCALED TEST DEMONSTRATOR

8.1. Propulsion and Power system

The aim of this work package is to achieve demonstration of the key new technologies developed within the programme. This stage of the project will start only after a major gate review following the initial technology work packages.

The demonstration system will include generators and motors of significant size – around 1 MW- using HTS technology and integrated power electronics, the new distribution architecture and HTS power distribution cables. The practical demonstration of this system is an essential stage in getting market support for the technology, and through the involvement of classification societies a means of achieving certification for vessels adopting this technology. The work package will include the manufacture of the demonstration scale equipment, installation and commissioning at a suitable land based test site, and the completion of a set of operational validation tests which will demonstrate the ability of the equipment to perform in realistic conditions.

The final test facility will provide a show case to the marine industry to witness at first hand the benefits that can be obtained by adopting the new technologies being demonstrated.

8.2. New electrical auxiliaries

The shore based demonstrator linked with the propulsion demonstrator above will allow testing of different types of new actuators (rotation and translation) and different sizes of electric actuation systems for different cases of applications on ships: rudder-roll systems, deck equipments, stabilization systems. The demonstrator will be designed for the 50-100 kW range and will allow testing of different scales of actuation systems, conditions of energy supply, and conditions of reaction forces. The demonstrator will integrate a range of actuators able to reproduce perturbation forces applied to the ship actuators (hydrodynamic, inertial, friction, damping, restoring loads). It will allow to validate performance requirements as well ship electrical network integration (current instant loads, overall power absorbed and rejected on the network, level of distortion).

The demonstrator will include three main components:

- the ‘reaction force’ simulator which simulates the perturbation loads on the actuation systems (e.g. rudder-roll, deck equipments, stabilizers)
- the bench component which hosts the actuation systems (equipped with specific control systems) to be tested
- the electric power supply for the actuation systems which will allow to simulate different conditions of energy supply, corresponding to conditions in a more global energy management.

These physical demonstrations of the marine ruggedized actuation systems, stabilisation systems or deck equipment are very important for ship owners, for instance for professional vessels like tugs, buoy layer ships, supply vessels. Such demonstration phases are also crucial for industrial end-users, considering the size of vessel, the energy management, the efficiency, the operation and maintenance. The demonstrations will also include tests of energy recovery devices from stabilisers by using of batteries on physical demonstrator, where batteries equipment will be combined to the energy supply component.

Following work will be undertaken**:**

- specifying and managing detailed mechanical and electrical design,
- construction of the key components,
- software development for computerised control of the key components of the demonstrator; tests preparation and integration of key components on electrical benchmark;
- productive tests and analyses: comparison between simulated comportments of the electrical auxiliaries and tests results obtained by the land based demonstrator;

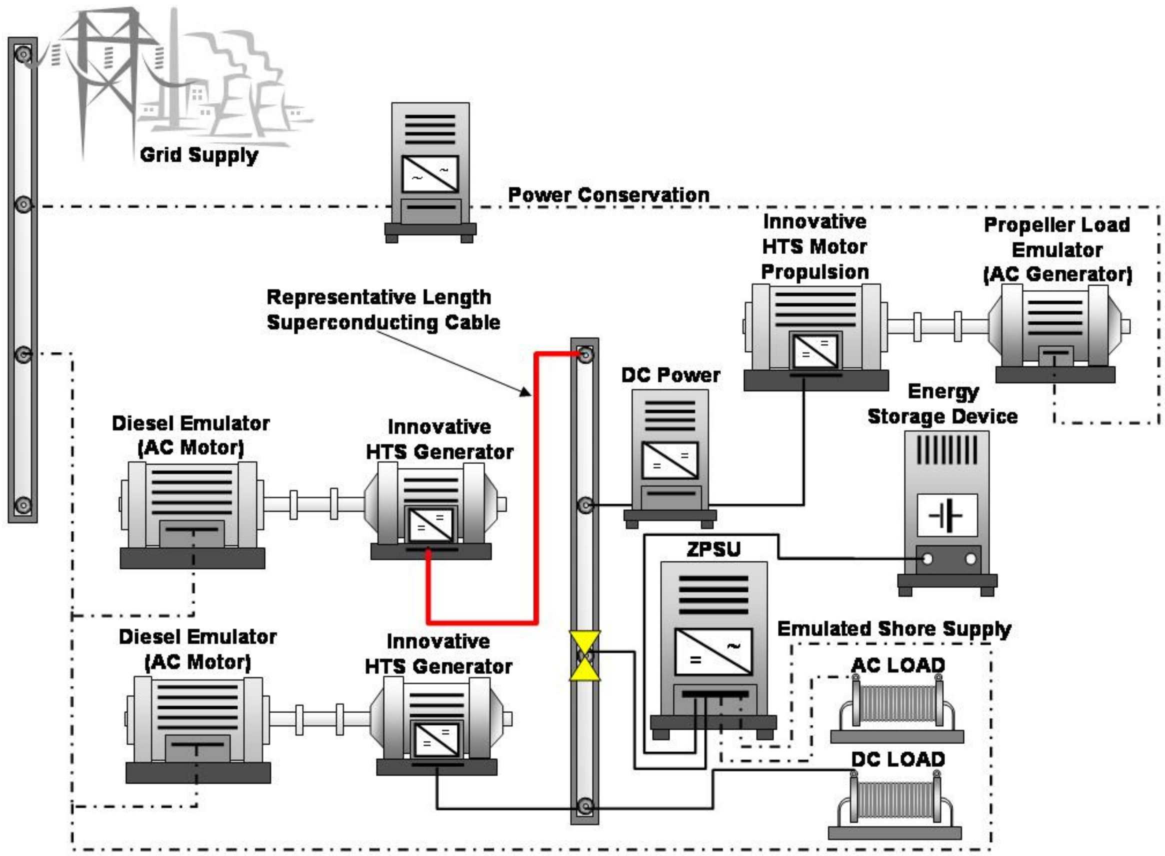


Figure 6 – Principle drawing of the shore based demonstrator

9. PROJECT ORGANISATION

The "cluster" is subdivided into packages as showed in Figure 7:

<u>3 technical "work packages"</u>

WP 1 for the HTS technology (leader CONVERTEAM)

WP 2 for the new electrical auxiliaries (leader SIREHNA)

WP 3 for the shore connection, the arc fault protection and the wireless control (leaders SAM Electronics and MARINELEC)

<u>5 transverse integration packages</u>

A-1 for the ship integration and design (leader MARIN)

A-2 for the shore based demonstrator (leader CONVERTEAM)

A-3 for the risk and environmental impact analysis (leader DNV)

A-4 Project coordination (BMT Defence Services)

A-5 Dissemination and external events (leader GICAN)

The overall budget of POSE²IDON represents a little bit more than 20 Millions Euros whose about 50% are funded by the European Commission.

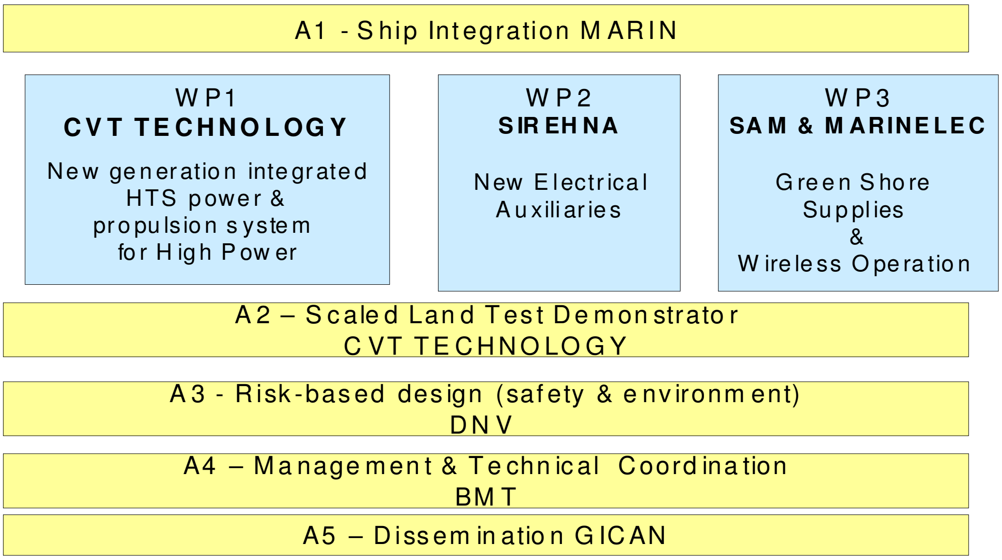


Figure 7 - Scheme of the project organisation

10. WORK SCHEDULE

POSE²IDON project is expected for a duration of 48 months starting from the first of January 2009.

The technical work packages should be in the situation to give definitive results within 24 months in order to construct the shore based demonstrator, to commission it and to test the different components.

A mid-term conference will inform the scientific community about the results of the work packages.

At the end an exploitation plan will resume the obtained results on the capability to extend the "all electric" concept to a wider range of vessels and will propose some trends or innovative subjects for increasing the achieved performances.

11. CONCLUSION

POSE²IDON, the most important large scale project funded by the European Commission for the benefit of the European marine electrical industry, should permit to apply the electric ship concept to a wider range of vessels and so should permit to reduce the gas emissions by a better efficiency and control of the propulsion and auxiliary systems.

The R&D technologies developed in this project should permit the European manufacturers to access to a sophisticated level for the marine equipment and then to present realistic solutions to limit the environmental impact of the marine activities and combat the climate change.

The shore based demonstrator will offer the guarantee that POSE²IDON won't be a paper work but will put in evidence the real benefits of the developed technologies and will persuade the ship owners and state's authorities to adopt them on board of the new vessel generation.