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Hybrid yacht propulsion systems: An overview

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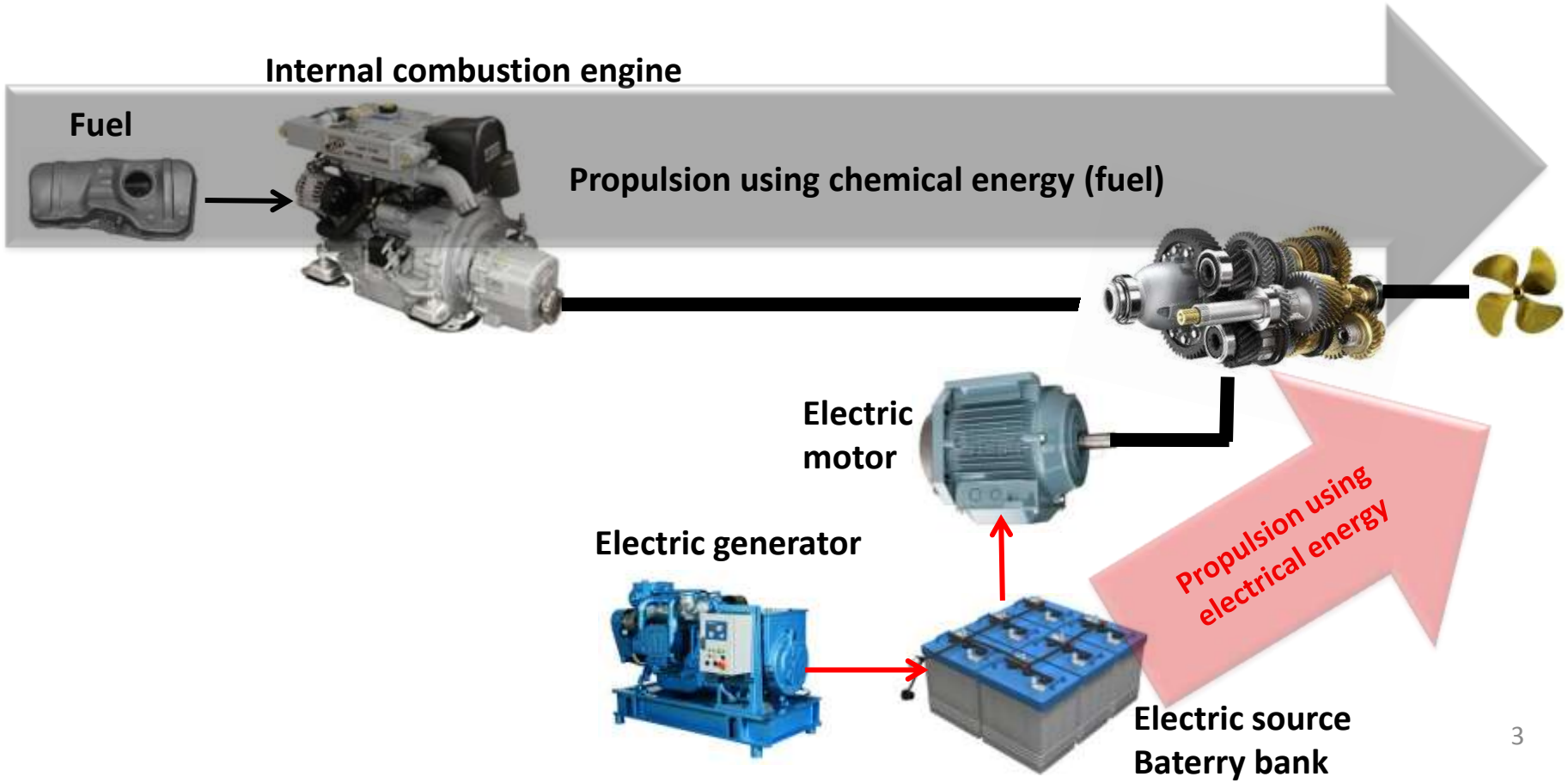
SCOPE OF THE PAPER

- An application of different types of hybrid systems in modern low power ship (yacht) propulsion systems has been investigated
- Different basic systems have been compared
- An influence of adding additional solar modules for range increase for yachts has been explored also

IDEA OF HYBRID PROPULSION SYSTEM

A hybrid vehicle can achieve propulsion using a different type of energy:

- **fuelled power source (diesel engine – grey arrow) or**
- **through a stored energy source (e.g. a battery bank and electric motor – redish arrow).**



WHY ELECTRIC?

- Electric motors – quiet, clean, economical, less vibrations
- Rechargable batteries
- Electric motors give full torque on any given RPM – usefull for saling in and out of marina

BASIC HYBRID CONFIGURATIONS

- Diesel / Electric
- Serial Hybrid
- Parallel Hybrid

DIESEL / ELECTRIC HYBRID CONFIGURATION

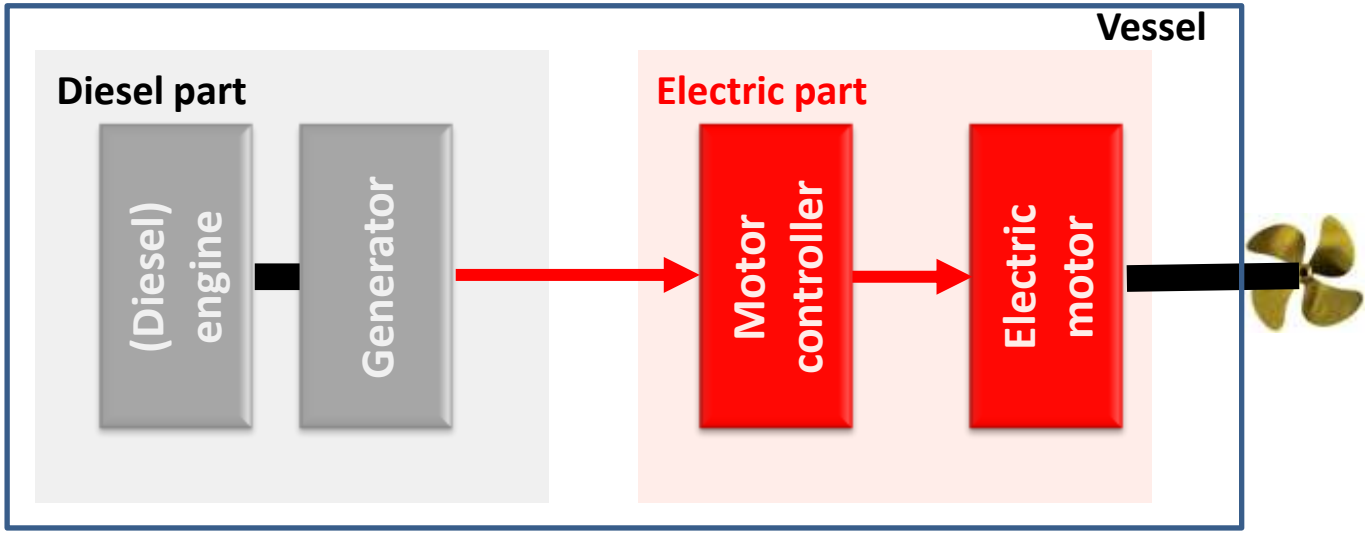


Fig. 1. Diesel/electric hybrid configuration

- **The engine (petrol or diesel) is connected directly to an electrical generator, the power in this system is transferred electrically to the propeller shaft.**

- **This system is not hybrid by the strict definition – no electric storage of energy.**

SERIAL HYBRID CONFIGURATION

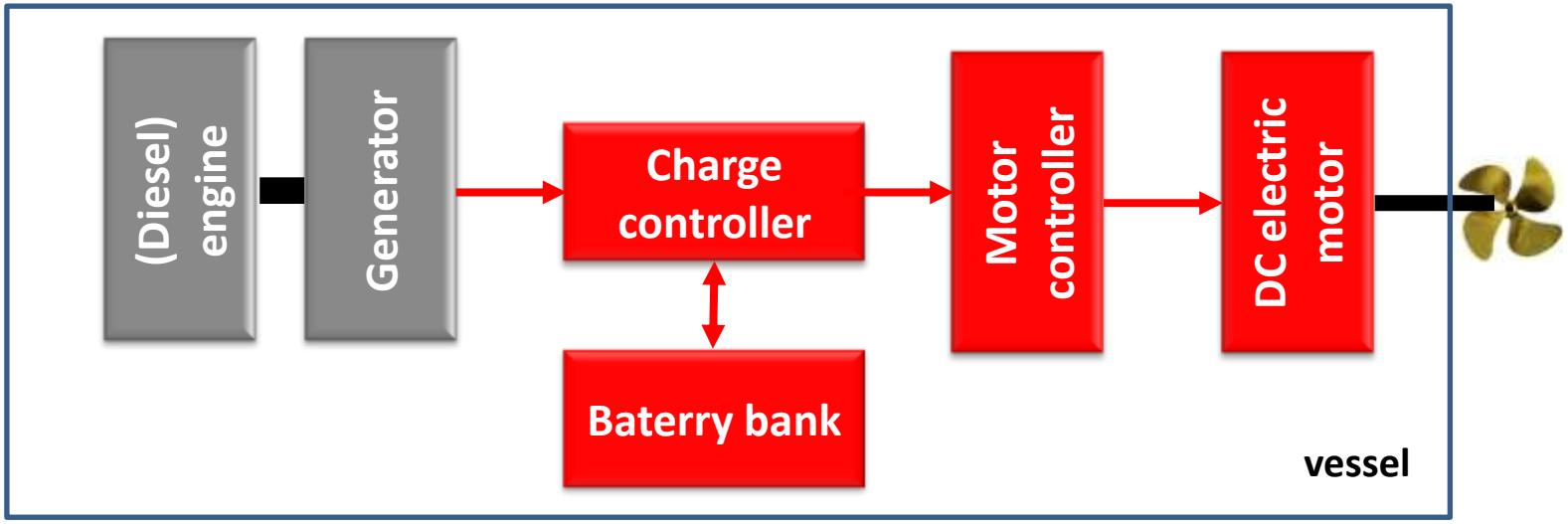


Fig. 2. Serial hybrid configuration

- **Serial hybrid system is similar to the diesel/electric – diesel engine (an internal combustion engine) is not physically connected to propeller shaft.**
- **Battery bank connected to the common electric power buss – usage of stored energy while engine is stopped.**
- **Diesel/electric and serial hybrid systems – if electronic component breaks down, whole propulsion is disabled.**

PARALLEL HYBRID CONFIGURATION

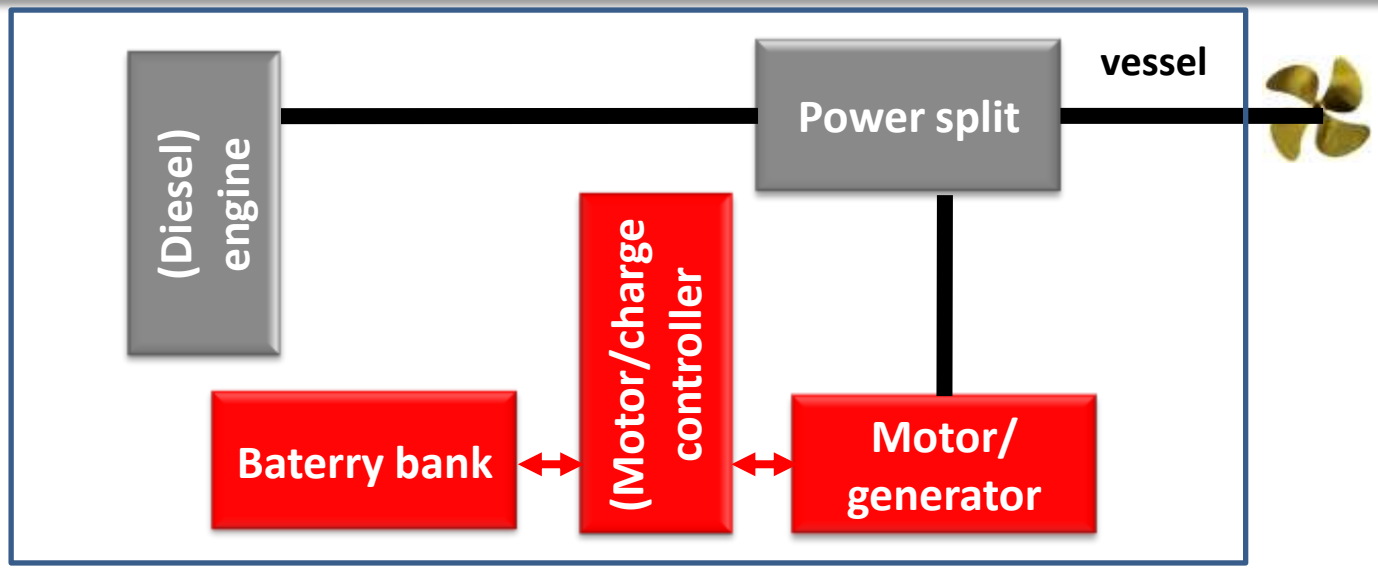


Fig. 3. Parallel hybrid configuration

- **Diesel engine is physicaly connected to propeller shaft in addition to the electric motor. These two systems are connected to set of gears called power split.**
- **Usage of diesel engine or/and electric motor to drive propeller shaft.**
- **Parallel hybrid system – usage of power source that you want or need.**

BATTERIES

- 2 types of batteries: lead/acid and lithium batteries
- Lithium batteries: low maintenance, light-weight and small dimensions
- Batteries are best fitted below or close to water line – add stability
- Rechargeable batteries – in diesel drive mode, from solar and/or wind energy, from shore connection

SOLAR PANEL ON BOATS

- Solar panels placed on roof
- Additional energy for the boat's electric system – charge batteries
- No cost, emission-free
- Usefull at low speed sailing, supplying constant power to on-board devices (GPS, LED lighting, refrigerator...)

THE HYBRID YACHT PRODUCTION

- “GREENLINE” company from Slovenia is producing serial and parallel yacht propulsion system
- Protected hybrid (diesel/electric) propulsion system
  - Hybrid drive
  - Solar roof
  - Lithium batteries

Fig. 4. The “Greenline” hybrid yacht

- “TEMA”, company from Croatia, offers complete electric propulsion systems for zero emission boats, serial hybrids and parallel hybrids.

ANOTHER OPTION

- **Small electro-powered boat “e-Neptun”**
- Powered by: Electro engine supplied from batteries
- Batteries can be charged from shore connection (220 V, AC) or from solar panels

Technical specification of the boat	
Hull lenght	5,95 m
Hull width	2,03 m
BRT	2,09 t
Max. speed	5,95 kt (nm/h)
Cruising speeed	5 kt (nm/h)
Autonomy	3 h
Shipyard	Punat, Croatia

Fig. 5. The “e-Neptun” boat

CASE STUDY

- Simulation of three-phase inverter – PWM modulation
- Usage of inverter: converts DC output of a photovoltaic (PV) solar panel into a AC
- Software: Simplorer Simulation Center 7.0
- Results: voltage/current waveform of inverter's single phase

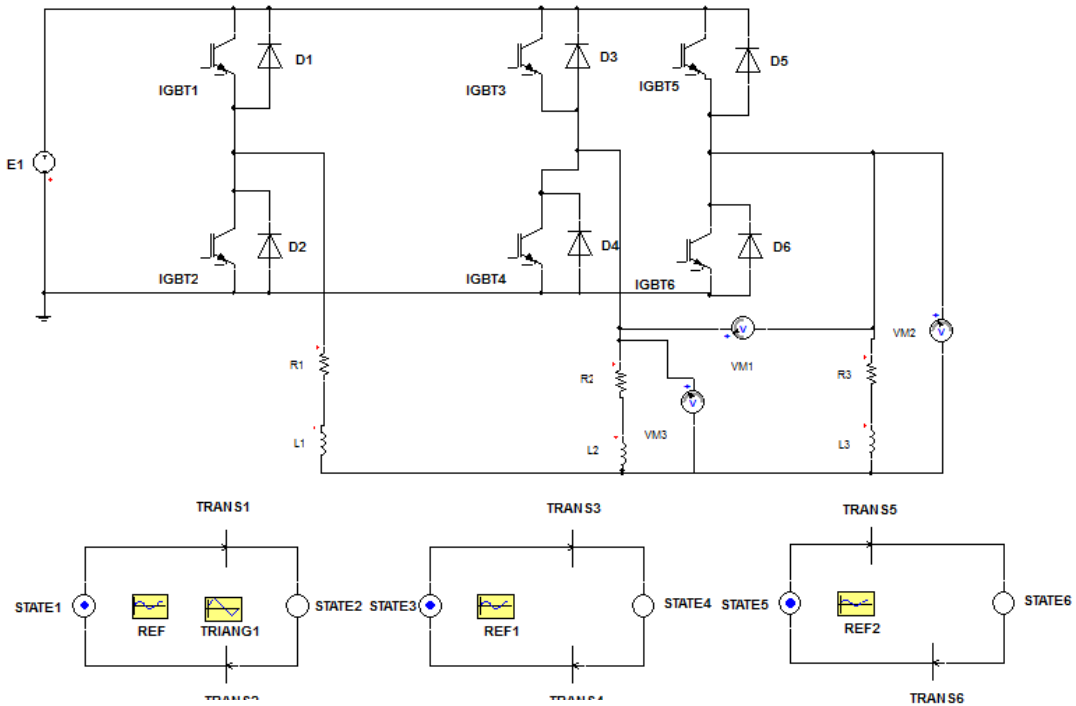


Fig. 6. Electric scheme of three-phase inverter

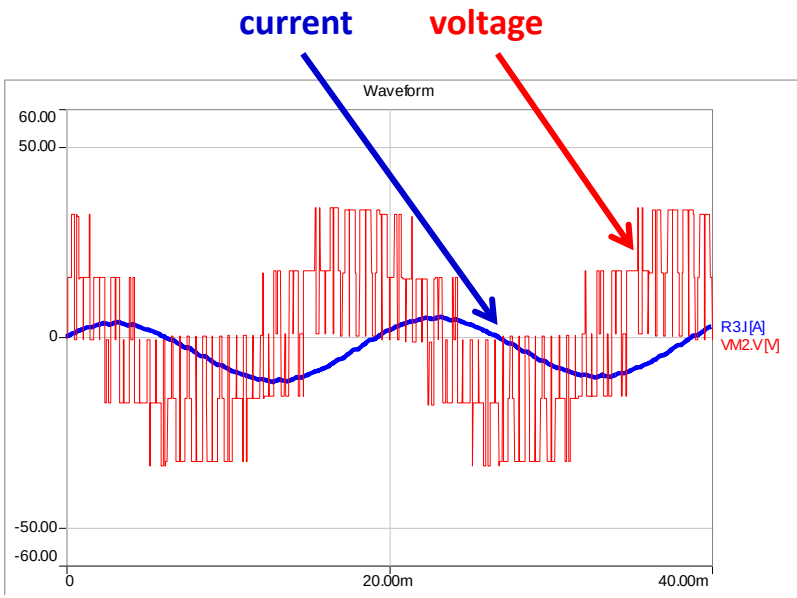


Fig. 7. Waveform of inverter's single phase

CONCLUSION

- Hybrid is about:
  - environment
  - efficiency and fuel saving
  - easy to upgrade
  - well-being on board

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Thank you for your attention!
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