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Installation and Integration of an Oxyfuel Combustion Engine System with CO2 Capture and Storage Facilities on a Ship

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Objective

One goal of the RIVER-project is to install and test the RIVER-Technology, namely the Oxyfuel combustion and Carbon Capture & Storage (CCS) system on a ship operating in real environmental conditions. Therefore, a narrowboat operating on UK's inland waterways was chosen. The tests serve the assessment of any failure of components and the calibration of the developed control strategy for the gas mixture and the cooling system. The overall power requirement under service conditions and fuel consumptions is in focus of attention as well. The demonstrator will have a Technical Readiness Level (TRL) of 5.

Two project partners are mainly responsible for this task, namely Canal & River Trust (CRT) and the Development Centre for Ship Technology and Transport Systems (DST). While CRT is designing, constructing and operating the narrowboat, DST is developing an integration concept of the RIVER-Technology (in collaboration with CRT) and performs the required hydrostatic and stability calculations for the vessel. The additional developed components required for the

Oxyfuel combustion, exhaust treatment and CO_2 storage are designed by the partners Yncréa, University of Bedfordshire, Cleancarb and ECE.

Narrowboat and Integration Concept

principle sketch of the narrowboat is shown in the Figure 1. The overall length of the newly built vessel is 18.95 m and the ships breadth is 2.14 m. The room arrangement of a common 130 Class F vessel is illustrated in Figure 2. In longitudinal direction and starting from the aft, the vessel is divided into the engine bay, day cabin, toilet & wash room, cargo hold and tool cabin.

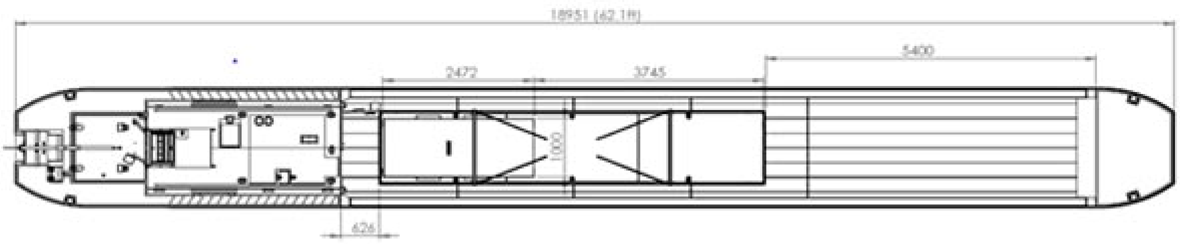

Figure 1: Principle sketch of the narrowboat, Source: CRT

To run the oxyfuel system with 7.5 l gasoil, the following requirements have been identified beforehand:

• Space requirement: max. height 1.8, max width 1.0 m
• Loading capacity: about 4 tons
• Hydrostatic stability: GM 0.35 m

In common, a diesel engine with a gearbox driven propeller is used to operate the vessel. However, it was found that the engine bay is too small to incorporate the whole project technology. Thus, a diesel-electric powertrain concept was elaborated by CRT and DST that allows to decouple the diesel engine from the electric drive engine. A self-contained diesel-generator set is equipped with the additional components for the oxyfuel combustion and is able to provide the electrical power required for the project equipment and to power the electric 3 phase transmission motor connected to the propeller. Further, a frequency converter and a motor control device are required, see Figure 3.

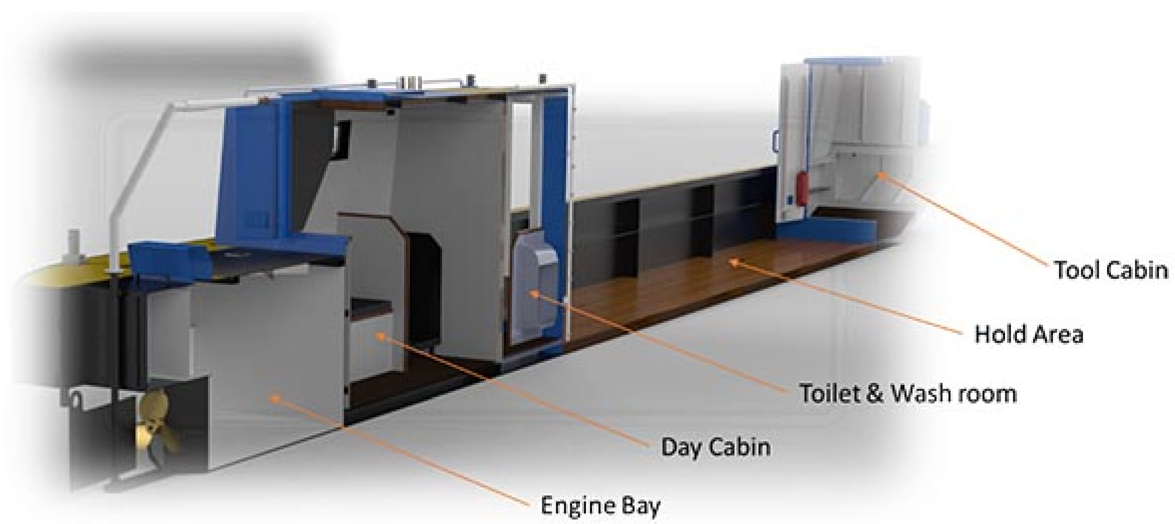

Figure 2: Room arrangement, Source: CRT

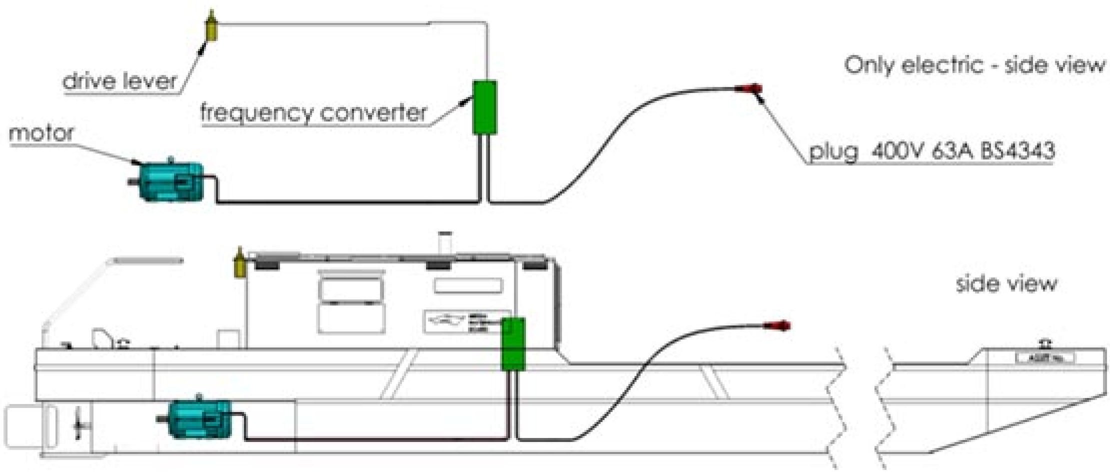

Figure 3: Principle arrangement of the electric system in the narrowboat, Source: DST

The space demanding Oxyfuel engine and CCS is placed in the cargo hold of the ship on a dedicated removable skid, see Figure 4. To maintain enough cargo hold space a project specific vessel was designed by CRT with an increased length of 18.95m (instead of 16.05 m common for 130 Class F vessels). In addition, mounting the project equipment on a skid was found to be advantageous as the equipment can stay connected to the skid when the trial runs are finished. It will be ready for re-use. The required Oxygen bottles and CO2 storage tank will also be placed on the skid.

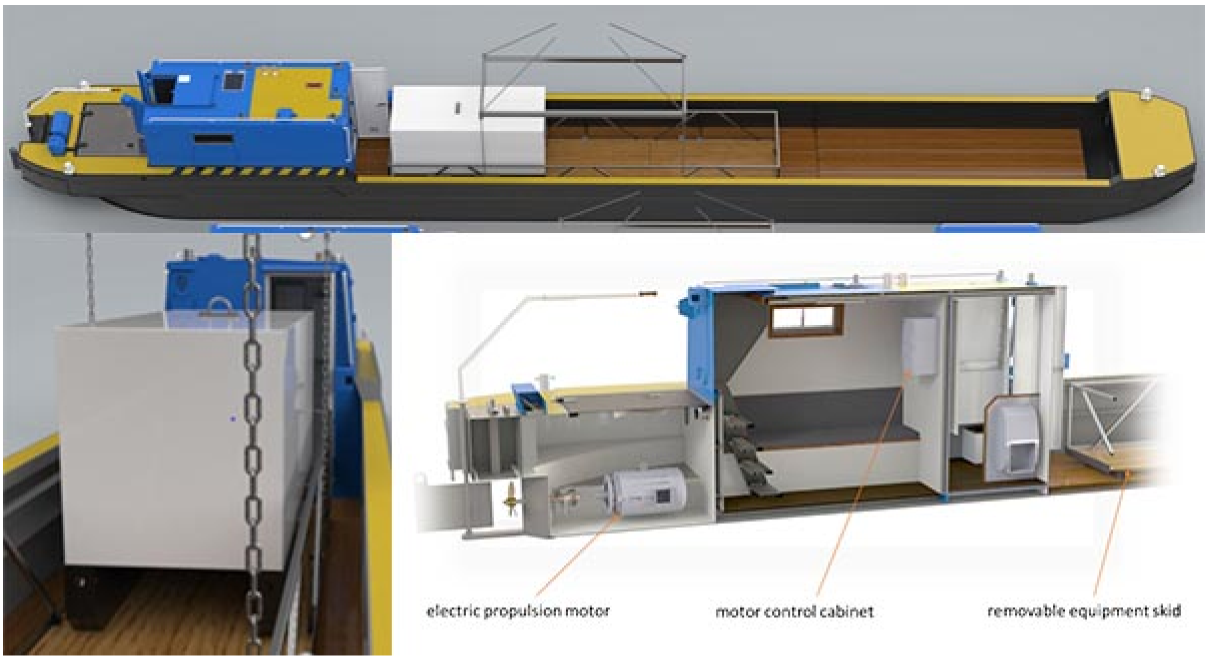

Figure 4: Usage of cargo hold for the skid and generator set, (top) side view and (bottom left) perspective view from the front, (bottom right) view into the engine bay and cabin, Source: CRT

The construction of the vessel started in March 2020 and will be completed by July 2020 ready to accommodate the skid and commence 'on water' trials.

Development Centre for Ship Technology and Transport Systems e. V. (DST)

DST is a research institute and tank test facility with more than 65 years of experience in Research & Development (R&D) in the field of inland waterway transportation (IWT) and coastal shipping. It is also a partner institute of the University of Duisburg-Essen.

Figure 5: Development Centre for Ship Technology and Transport Systems in Duisburg, Germany, © DST

Key business elements of DST are the investigation of the special flow conditions of ships in inland and coastal waters with restricted depths and the support of the inland navigation sector in the development and modernization of vessels. Within the last couple of years, the environmental performance of IWT has moved into focus and resulted in many projects for the holistic greening of the fleet. Furthermore, issues of transport engineering and logistics as well as transport economics are in focus with the objective to access new potential of inland navigation and thus contribute to economic and ecological approaches to meet the increasing demand for transport. In addition, port management concepts and modern transshipment solutions belong to the scope of the DST. Since 2008 the DST operates a ship handling simulator, called SANDRA. In addition to use in research projects, the education and training of crew members in the simulator is becoming more important.

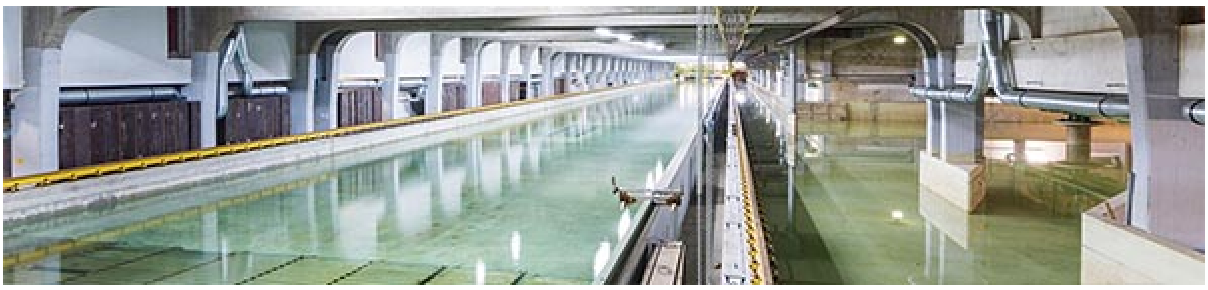

Figure 6: Shallow water tank facility at DST, © DST

The main contribution of DST in the RIVER-project is the integration of the newly developed oxyfuel combustion and CCS system into a small inland waterway vessel. For the ship, suitable basic system configurations were investigated and compared with a common diesel engine approach in terms of required tank capacities (additional weights and volumes), fuel consumptions and mechanical power distribution. Another task is the elaboration of a feasibility study for a conventional large inland cargo vessel. DST is also responsible for the identification of technical and financial barriers of the newly developed technology.