Summary

Power Take-Off (PTO) systems are the heart of a Wave Energy Converter (WEC) and many academic researchers and developer companies are actively working to design and improve the PTO. It is known that the economic viability, efficiency and complexity of a wave energy device depends on its PTO system. This thesis pursues the development of a hydraulic PTO for WECs with the intention of encouraging new research activities in this energy field. The ISWEC (Inertial Sea Wave Energy Converter), developed by the Marine Offshore Renewable Energy Lab (MOREnergy Lab) of Politecnico di Torino (Italy), represents the reference device. The work consists in the derivation of a novel spectral-domain model including both mechanical and hydraulic PTO technologies, the creation of a techno-economic design tool and the application of an optimal control technique to the ISWEC. The hydraulic PTO technology aims to drive the ISWEC system, originally designed for the Mediterranean Sea, toward an oceanic implementation. The research activities started with the implementation of a spectral-domain model, able to reduce the computational burden associated to the ISWEC simulation and to give, at the same time, the accuracy of the expected results. The new spectral-domain framework is implemented in a multi-stage design tool. Such a design tool exploits the potential of an in-house MATLAB-based Genetic Algorithm to effectively design the ISWEC system with respect to different deployment sites, PTO technologies, and the desired techno-economic metrics. The comparison between the optimal mechanical and hydraulic PTO devices in four chosen installation sites demonstrates that the hydraulic transmission reduces the cost of energy up to 20% decreasing the initial investment almost of 25%. The economic efficiency together with the high power density of the hydraulic technology is advantageous for the future industrialization, resulting in a more efficient and higher wave energy harvesting. A Model Predictive Control (MPC) is finally proposed for further optimization of the hydraulic PTO performances. The extracted power of the ISWEC is evaluated in irregular wave conditions with promising results. The major outcomes of this dissertation are the detailed overview of the hydraulic PTO advantages together with some guidelines for the modelling, design and control improvement of this technology.