Implementasi Machine Learning Dalam Perancangan Ship Energy Efficiency Management Plan Sebagai Upaya Pengurangan Emisi CO2 Di Pelabuhan Indonesia = Machine Learning Implementation in the Design of a Ship Energy Efficiency Management Plan as an Effort for Reducing CO2 Emissions at Indonesian Ports

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Abstrak

Meskipun kajian mengenai bahan bakar dan penggerak alternatif sudah banyak, namun target dan aplikasinya dalam pengurangan emisi CO2 di pelabuhan masih kurang mendapat perhatian terutama di negara berkembang seperti Indonesia. Penelitian ini menggunakan machine learning dalam memperkirakan emisi CO2 dari aktivitas kapal di tujuh pelabuhan di Indonesia kemudian dicari variable yang berpengaruh pada total emisi sebagai fokus dalam pengembangan Ship Energy Efficiency Management Plan (SEEMP). Dilakukan prediksi total emisi CO2 menggunakan regresi hutan acak kemudian keefektifannya diverifikasi menggunakan validasi silang k-fold, hasil prediksi kemudian dibandingkan dengan total emisi perhitungan metode bottom-up. Hasil analisis attribute weight berdasarkan correlation menunjukkan bahwa daya mesin dan waktu operasi kapal di pelabuhan memiliki pengaruh yang lebih besar dalam menghasilkan emisi CO2. Prediksi total emisi menunjukkan bahwa model memiliki akurasi yang cukup rendah akibat banyaknya data yang kosong meskipun algoritma model sudah tergolong bagus. Akhirnya, operasi hemat bahan bakar dibahas dengan fokus pada tenaga dan bahan bakar alternatif serta peningkatan efisiensi kerja, penggunaan bahan bakar bersih dari hidrogen dan biofuel mamiliki potensi pengurangan yang paling tinggi dengan cold ironing sebagai alternatif yang dapat memenuhi syarat pengurangan emisi per tahun sebesar 20%. Dibutuhkan data yang lengkap untuk melakukan prediksi total emisi yang akurat serta pengembangan teknis dan ketersediaan sumber daya pada metode yang telah dibahas agar dapat di implementasikan kedalam Rencana Pengelolaan Efisiensi Energi Kapal.

.....Although there are many studies on alternative fuels and drivers, the target and their application in reducing CO2 emissions at ports have received little attention, especially in developing countries such as Indonesia. This study uses machine learning to estimate CO2 emissions from ship activities at seven ports in Indonesia and then looks for variables that affect total emissions as a focus in developing a Ship Energy Efficiency Management Plan (SEEMP). Total CO2 emissions were predicted using random forest regression, their effectiveness was then verified using k-fold cross-validation, the prediction results were then compared with the total emissions calculated using the bottom-up method. The results of attribute weight analysis based on correlation show that engine power and ship operating time in port have a greater influence in producing CO2 emissions. Prediction of total emissions shows that the model has a fairly low accuracy due to the large number of blank data despite the model algorithm exelency. Finally, fuel-efficient operations are discussed with a focus on alternative power and fuels as well as improving work efficiency, the use of clean fuels from hydrogen and biofuels has the highest reduction potential with cold ironing as an alternative that can meet the requirements of 20% annual emission reduction. Complete data is needed to make accurate predictions of total emissions as well as technical development and resource availability on the methods discussed so that they can be implemented into the Ship Energy Efficiency Management Plan.