INTEGRASI PERHITUNGAN NILAI PERPINDAHAN PANAS DAN ESTIMASI BIAYA SELUBUNG BANGUNAN BERBASIS BUILDING INFORMATION MODELING-VISUAL PROGRAMMING LANGUAGE PADA BANGUNAN KANTOR SEWA DI IKLIM TROPIS

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ABSTRAK

Sektor bangunan global menyumbang 35-40% emisi karbon dunia, menempatkan efisiensi energi selubung bangunan sebagai prioritas arsitektural di iklim tropis. Penelitian ini mengembangkan dan memvalidasi algoritma otomasi berbasis *Building Information Modeling* (BIM) dan *Visual Programming Language* (VPL) menggunakan Autodesk Revit dan Dynamo untuk menghitung OTTV, RTTV, dan estimasi Rencana Anggaran Biaya (RAB/BOQ) secara *real-time* pada bangunan kantor sewa bertingkat tinggi kelas premium, berlandaskan SNI 6389:2020. Algoritma ini mendobrak isolasi data BIM konvensional melalui ekspor berformat JSON ke dalam dasbor analitik berbasis web (Streamlit). Hasil validasi terhadap algoritma komputasional menunjukkan tingkat keandalan yang sangat ekstrem dengan galat rata-rata (MAPE) <1,5% terhadap formula manual, mengonfirmasi kelayakan presisi sistem. Simulasi parametrik atas 80 skenario mengungkap bahwa tuntutan pasar properti yang mengejar nilai sewa tinggi (*flight to quality*) memaksa penerapan *Window-to-Wall Ratio* (WWR) masif 60-75%. Untuk menetralisir penalti termal akibat WWR tersebut, konfigurasi Pareto Optimal hanya tercapai pada kombinasi WWR 60%, kaca *Low-E Sputtered* (SC=0,23), dan sirip peneduh 1,5m yang menghasilkan OTTV 33,85 W/m². Memaksakan desain ini agar patuh SNI menyebabkan pembengkakan Biaya Modal (CAPEX) kaca hingga 165% dibandingkan *baseline*, dengan kenaikan RAB fasad total sebesar 12,01%. Hasil ini tidak hanya menghadirkan kerangka kerja 5D (OTTV–RTTV–BOQ–JSON–Web) pertama untuk Indonesia, melainkan juga membuktikan secara kritis bahwa ambang batas SNI 35 W/m² masih terlalu permisif terhadap estetika "kotak kaca", yang secara operasional bertentangan dengan konsensus termal global.

Kata Kunci: *Building Information Modeling*, *Visual Programming Language*, OTTV, RTTV, SNI 6389:2020, *Bill of Quantities*, Selubung Bangunan, Iklim Tropis

INTEGRATION OF THERMAL TRANSFER VALUE CALCULATION AND BUILDING ENVELOPE COST ESTIMATION BASED ON BUILDING INFORMATION MODELING-VISUAL PROGRAMMING LANGUAGE FOR RENTAL OFFICE BUILDINGS IN TROPICAL CLIMATES

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ABSTRACT

The global building sector contributes 35-40% of world carbon emissions, situating the energy efficiency of building envelopes as an architectural imperative in tropical climates. This study develops and validates a Building Information Modeling (BIM) and Visual Programming Language (VPL) automation algorithm utilizing Autodesk Revit and Dynamo to calculate OTTV, RTTV, and Bill of Quantities (BOQ) estimations in real-time for premium high-rise rental offices, complying with SNI 6389:2020. This algorithm dismantles the isolation of conventional BIM data by exporting JSON formats into a cloud-based analytical dashboard (Streamlit). Computational validation demonstrates extreme reliability, yielding a mean absolute percentage error (MAPE) of <1.5% against manual formulas, confirming the system's precision. Parametric simulations of 80 scenarios reveal that property market demands prioritizing high rental yields (flight to quality) necessitate a massive Window-to-Wall Ratio (WWR) of 60-75%. To neutralize the subsequent thermal penalties, the Pareto Optimal configuration is solely achieved through a combination of 60% WWR, Low-E Sputtered glass (SC=0.23), and 1.5m shading fins, resulting in an OTTV of 33.85 W/m². Forcing this design into SNI compliance triggers a Capital Expenditure (CAPEX) inflation for glass by 165% compared to the baseline, reflecting a 12.01% increase in total façade BOQ. These findings not only introduce Indonesia's first 5D framework (OTTV–RTTV–BOQ–JSON–Web) but also critically prove that the SNI threshold of 35 W/m² remains excessively permissive towards "glass box" aesthetics, operationally contradicting the global thermal consensus.

Keyword: *Building Information Modeling, Visual Programming Language, OTTV, RTTV, SNI 6389:2020, Bill of Quantities, Building Envelope, Tropical Climates*