

## ABSTRAK

Tingginya minat global terhadap sumber energi terbarukan telah mendorong penelitian ini, yang difokuskan pada investigasi dampak penetrasi pembangkit energi terbarukan intermiten (*intermittent renewable energy generators* - IREGs) khususnya fotovoltaik (*photovoltaic* - PV) dan pembangkit turbin angin (*wind turbin generators* - WTG) terhadap harmonisa dan stabilitas sistem distribusi. Studi ini mengidentifikasi bahwa gardu hubung Lamno dan gardu hubung Calang mengalami penurunan tegangan yang menyebabkan rugi-rugi daya. Oleh karena itu, studi ini menyoroti pentingnya penelitian dampak energi terbarukan dalam skala besar sebagai alternatif. Pertumbuhan penetrasi kapasitas PV dan WTG dapat mempengaruhi sistem tenaga dan stabilitasnya. Metode penelitian melibatkan analisis menggunakan perangkat lunak ETAP versi 19.0.1, dengan memodelkan sistem distribusi penyulang dari gardu induk Meulaboh Kota. Penelitian ini secara ekstensif mengeksplorasi tantangan teknis terkait integrasi IREGs pada analisis aliran daya, harmonisa dan stabilitas transien. Penetrasi IREGs dilakukan secara bertahap pada tingkat 25%, 50%, 75%, dan 100%. Hasil penelitian menunjukkan kontribusi positif paling signifikan terjadi saat penetrasi IREGs 100%. Nilai rata-rata kenaikan tegangan keseluruhan saat penetrasi maksimum sebesar 3,69%, nilai peningkatan total mencapai 2,67 kV. Selain itu, kehilangan rugi-rugi daya aktif juga mengalami penurunan sebesar 634,5 kW, sementara rugi-rugi daya reaktif sebesar -1058,6 kVar. Rata-rata keseluruhan peningkatan distorsi harmonik total ( $THD_v$ ) selama penetrasi maksimum adalah 7,41%, dengan peningkatan total sebesar 0,92%. Rata-rata keseluruhan peningkatan distorsi harmonik total arus ( $THD_I$ ) selama penetrasi maksimum adalah 49,76%, dengan peningkatan total sebesar 7,55%. Analisis transien keseluruhan menunjukkan bahwa sistem mengalami fluktuasi tegangan dan frekuensi selama periode gangguan hubung singkat. Namun, sistem berhasil pulih ke kondisi operasional yang stabil setelah gangguan diatasi.

*Kata Kunci* : IREGs, Harmonisa, Stabilitas Sistem Distribusi, ETAP

## ABSTRACT

*The global interest in renewable energy sources has propelled this research, which focuses on investigating the impacts of intermittent renewable energy generators (IREGs), specifically photovoltaic (PV) and wind turbine generator (WTG), on the harmonization and stability of distribution systems. This study identifies voltage drops occurring at the Lamno and Calang substations, resulting in power losses. Therefore, this study underscores the importance of large-scale research on the impacts of renewable energy as an alternative. The growth in PV and WTG capacity penetration can affect the power system and its stability. The research methodology involves analysis using ETAP software version 19.0.1, modeling the distribution feeder system from the Meulaboh Kota substation. This study extensively explores technical challenges related to integrating IREGs in power flow analysis, harmonization, and transient stability. IREG penetration is phased at levels of 25%, 50%, 75%, and 100%. The research findings indicate the most significant positive contribution occurs at 100% IREG penetration. The overall average voltage increase during maximum penetration is 3.69%, with a total increase reaching 2.67 kV. Additionally, active power loss decreases by 634.5 kW, while reactive power loss decreases by -1058.6 kVar. The overall average total harmonic distortion (THD<sub>V</sub>) increase during maximum penetration is 7.41%, with a total increase of 0.92%. The overall average current total harmonic distortion (THD<sub>I</sub>) increase during maximum penetration is 49.76%, with a total increase of 7.55%. Overall transient analysis indicates voltage and frequency fluctuations during short-circuit disturbance periods. However, the system successfully recovers to stable operational conditions after overcoming disturbances.*

*Keywords: IREGs, Harmonics, Distribution System Stability, ETAP.*