**INFORMATION ABOUT RESEARCH RESULTS**

Dissertation title: *Efficient energy use, low CO2 emissions for tropical island regions*

Specialization: Electrical Engineering Code: 9520201

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**1. Summary of content**

Amid the global energy crisis and increasingly severe climate change, the search for sustainable energy solutions has become an urgent necessity. Many tropical islands, despite possessing abundant renewable resources, still rely heavily on fossil fuels such as diesel – a costly energy source with high CO₂ emissions. This situation demands greater research efforts and serious investment from scientists and policymakers to develop optimal energy systems that balance economic efficiency, environmental sustainability, and energy security.

In Vietnam, islands such as Phu Quoc, Phu Quy, Con Dao, and Ly Son remain primarily dependent on diesel power, even as electricity demand continues to rise. Although Phú Quốc has been connected to the national grid, future development scenarios indicate a potential supply shortfall, especially as Vietnam commits to reducing CO₂ emissions under COP26 agreements. This presents an urgent challenge in developing sustainable energy models that maximize local resource utilization while minimizing dependence on fossil fuels.

To address this issue, the dissertation focuses on modeling efficient energy utilization for tropical islands in general and Vietnamese islands in particular. To demonstrate the feasibility of this model, the research proposes solutions targeting six key sectors: (1) policy frameworks to support subsidies for technological transitions or increased renewable energy penetration, which provide overarching support for the other five economic sectors: (2) commerce & services, (3) industry, (4) power sector, (5) transportation, and (6) agriculture, forestry, and land use.

The proposed solutions include optimizing power system operation, reducing electricity production costs, and increasing the use of available renewable resources to ensure the sustainable development of island energy systems. Based on the efficient energy utilization model for tropical islands, the dissertation identifies and evaluates five key proposals: waste-to-energy power generation, rooftop solar PV systems, electric vehicles (EVs), a novel operational strategy for diesel-wind hybrid power generation, and natural lighting design for buildings.

To validate the feasibility of these solutions, the dissertation develops and assesses sustainable power system scenarios for Phú Quý Island. Specifically, three power generation scenarios are proposed: BAU (Business As Usual): Continuation of the existing energy structure without changes. GREEN: Increased integration of renewable energy sources and reduced fossil fuel consumption. HIGHER GREEN: Enhanced investment in green power systems such as rooftop solar and wind energy, coupled with an optimized diesel-wind hybrid operation strategy. The CO₂ emission reduction factor is incorporated into the GREEN and HIGHER GREEN scenarios, where renewable energy participation varies at different levels.

The results indicate that, compared to the BAU scenario, the HIGHER GREEN scenario achieves CO₂ emission reductions of 5.2%, 26.97%, and 31.8% across different implementation phases. Additionally, this scenario significantly decreases diesel fuel consumption, reduces electricity production costs, strengthens renewable energy utilization, and enhances energy security for Phú Quý Island.

**2. Novel Contributions of the topic**

**Contribution 1:**

This research proposes a sustainable energy model for tropical islands aimed at energy savings, CO₂ emissions reduction, and optimization of the power generation structure. The proposed model focuses on six key components: (1) policy solutions to support/subsidize technology transitions and increase the penetration rate of renewable energy, which serve as overarching measures supporting (2) power systems, (3) transport, (4) agriculture, forestry, and land use, (5) industry, and (6) residential sectors.

*This contribution has been published in the research article:*

Hoang-Phuong Nguyen, Viet-Cuong Vo, Truong Phuc Khanh Nguyen, Tran Quoc Cuong, "Energy and energy models for tropical islands in Vietnam," *TNU Journal of Science and Technology*, DOI: https://doi.org/10.34238/tnu-jst.

**Contribution 2:**

The dissertation proposes a solution for calculating the power generation potential from solid waste on islands, applied to Phu Quoc for the period 2020–2030. Based on the island's socio-economic development plan, the population is expected to increase during this period, leading to a rise in municipal solid waste. Consequently, the power plant capacity is projected to increase from 4.7 MW to 7.0 MW. The financial indicators include a net present value (NPV) of USD 5.1 million with a discount rate of 7%, an internal rate of return (IRR) of 10.5%, and a payback period of 13.01 years. The total reduction in CO₂ emissions is estimated to range from 23,118 to 34,220 tons of CO₂ per year. With a project lifecycle of approximately 25 years, the project meets the economic criteria for investment feasibility.

*This contribution has been published in the scientific paper:*

Hoang-Phuong Nguyen, Viet-Cuong Vo, Vinh-Nghi Le, Thi-Thanh-Binh Phan, Thanh-Phong Tran, "Feasibility for solid waste power generation at Phu Quoc Island, Vietnam," 2018 4th International Conference on Green Technology and Sustainable Development (GTSD), DOI: 10.1109/GTSD.2018.8595552, pp. 175-180, 2018.

**Contribution 3:**

The dissertation proposes a solution for assessing the development potential of rooftop solar power systems, applied to Phu Quoc until 2030, evaluated under three scenarios. These scenarios are based on the planned building floor area for Phu Quoc during the 2020–2030 period. Accordingly, the total installed capacity is projected to gradually increase to 805 MWp, 1,219 MWp, and 1,931 MWp, respectively. The financial indicators for rooftop solar power systems are as follows: the internal rate of return (IRR) is 10.5%, 11.88%, and 15.41%, with corresponding payback periods of 8, 7.5, and 6 years. The total reduction in CO₂ emissions is estimated at 193,844, 293,287, and 464,473 tons of CO₂ per year, respectively. With a project lifecycle of 20 to 25 years, the project demonstrates strong economic feasibility for investment.

*This contribution has been published in the following scientific papers:*

[1] Hoang-Phuong Nguyen, Viet-Cuong Vo, Van-Quan Vo, Thi-Thanh-Binh Phan, Thanh-Phong Tran, "A feasible proposal for small capacity solar power generation at Phu Quoc, Viet Nam," 2019 Innovations in Power and Advanced Computing Technologies, DOI: 10.1109/i-PACT44901.2019.8960125, pp. 1-6, 2019.

[2] Nguyễn Hoàng Phương, Nguyễn Phước Tín, Võ Viết Cường, Trần Thanh Phong, Võ Văn Quân, "Hiệu quả kinh tế hệ thống điện mặt trời áp mái," Proceedings of the 2019 National Conference on Natural Resources and Environment in the New Situation, Climate Change, Science and Technology Publishing House, ISBN 978-604-67-1585-6, pp. 80-93, 2020.

**Contribution 4:**

The dissertation proposes a feasibility assessment for CO₂ emission reduction by replacing internal combustion engine vehicles with electric vehicles. The study is applied to Phu Quoc Island with three scenarios of gradually increasing replacement rates of traditional vehicles with electric vehicles at 5%, 10%, and 15%, respectively. These scenarios are entirely feasible, particularly in the context of Vietnam’s rapidly growing electric vehicle market. The research findings indicate that by 2030, the CO₂ emission reduction rates corresponding to the three scenarios are approximately 17%, 18%, and 21%, respectively.

*This contribution has been published in the scientific paper:*

Hoang-Phuong Nguyen, Viet-Cuong Vo, Tan-Dong Le, Thi-Thanh-Binh Phan, Thanh-Phong Tran, Le-Duy-Luan Nguyen, "CO₂ reduction potential by putting electric vehicles into operation in Phu Quoc Island, Vietnam," 2019 International Conference on System Science and Engineering (ICSSE), DOI: 10.1109/ICSSE.2019.8823377, pp. 229-234, 2019.

**Contribution 5**:

Optimization of Diesel-Wind Hybrid Power System at Phu Quy Island The dissertation proposes an innovative operational strategy for the existing diesel-wind hybrid power system on Phu Quy Island. The results indicate significant improvements in efficiency, including an 81.69% reduction in diesel fuel consumption and a corresponding CO₂ emissions reduction. Even if the proposed strategy achieves only 70% of its projected efficiency, fuel cost savings of approximately 12.5 billion VND per year can still be achieved.

*This contribution has been published in the research article:*

Nguyen Hoang Phuong, Vo Viet Cuong, Nguyen Ngoc Au, Tran Thai An, "A new operation strategy for diesel-wind hybrid power system on Phu Quy island," *The University of Danang - Journal of Science and Technology*, vol. 19, no. 5.1, pp. 29-34, 2021.

**Contribution 6:**

Natural Lighting Utilization for Energy Reduction The dissertation proposes a novel approach for optimizing natural lighting utilization to enhance energy efficiency and reduce CO₂ emissions. The study is applied to a single-story building with dimensions of 80m × 32m × 14m, demonstrating significant energy-saving potential. The primary outcomes indicate an annual energy savings potential of up to 34%, with CO₂ emissions reductions ranging between 23,118 and 34,220 tons per year. Over the estimated 25-year project lifespan, this approach meets the economic viability criteria for investment.

*This contribution has been published in the research article:*

Nguyen H. Phuong, Luan D. L. Nguyen, Vu H. M. Nguyen, Vo. V. Cuong, Tran M. Tuan, Pham A. Tuan, "A new approach to natural lighting utilization for energy-efficient building design," *ETC Journal of Renewable Energy Applications*, 2024.

**Contribution 7:**

The dissertation proposes a method for determining the optimal power generation structure for islands and demonstrates its feasibility through a case study on Phu Quy Island. The primary objective of this method is to optimize the island’s power generation mix to minimize electricity production costs while enhancing the integration of renewable energy sources.

The optimization model incorporates key constraints related to power system planning, including the maximum and minimum capacity limits of each power source, the combination of different generation types, the allowable power variation between consecutive hours, the maximum hourly solar power generation, and the charge/discharge capacity limits of the energy storage system. These constraints ensure stable system operation while achieving the highest economic efficiency.

When applied to Phu Quy Island, the dissertation develops three green power generation scenarios. Specifically, the BAU (Business As Usual) scenario maintains the existing system, while the Higher Green and Green scenarios increase the share of renewable energy sources, integrating rooftop solar power to reduce dependence on fossil fuels. The results indicate that the electricity generation cost in the Higher Green scenario is 30% to 40% lower than in the BAU scenario, corresponding to a reduction of 3 to 6 US cents/kWh. Furthermore, the Higher Green scenario achieves the highest CO₂ emission reductions, decreasing by 5%, 73.03%, and 68.20% compared to the BAU scenario in 2030, 2035, and 2040, respectively. Although some diesel power capacity is still required, reducing fossil fuel dependence significantly lowers electricity costs while contributing to substantial CO₂ emission reductions for Phu Quy Island.

*This contribution has been published in the scientific paper:*

Hoang Phuong Nguyen, Le Duy Luan Nguyen, Hoang Minh Vu Nguyen, Truong Phuc Khanh Nguyen, Viet Cuong Vo, Thi Thanh Binh Phan, "Green Power Generation for Phu Quy Island to 2040," *GMSARN International Journal*, vol. 19, pp. 540-552, 2025.

*Ho Chi Minh City, March 14, 2025*

PhD Candidate

NGUYEN HOANG PHUONG