Regulation of the Independent Electricity System in Batam City as a Basis for the Development of Energy Science and Technology

Rosa Darman[1*], Huala Adolf[2], Riesa Susanti[3]

[1] Postgraduate Student of the Faculty of Law, Padjajaran University, Indonesia.
[2] Faculty of Law, Padjajaran University, Indonesia.
[3] Vice President of Regulation, Litigation and Permission of PT PLN Nusantara Power, Indonesia.

Abstract: This study examines the regulatory framework of Batam City's independent electricity system as a foundation for the development of energy science and technology. Batam, as a Special Economic Zone, presents a unique case of localized energy governance that integrates legal, technological, and industrial perspectives. Using a qualitative normative–juridical approach, this research analyzes national and regional energy regulations, including Law No. 30 of 2009 on Electricity and Law No. 11 of 2020 on Job Creation, to evaluate their alignment with principles of innovation and sustainability. The research findings indicate that strong regulations supported by policy incentives, research investment, academic-industry collaboration, and optimal system digitalization are essential to promote the effectiveness and independence of Batam's electricity system. This analysis identifies three interrelated stages: (1) driving factors, which include regulation strength and research funding; (2) mediating processes, covering research efficiency and technology adoption; and (3) outcomes, represented by system capacity and technological innovation. This integrative model demonstrates that adaptive, science-based regulation transforms legal frameworks into instruments for innovation, bridging the gap between policy and technological implementation. Strengthening collaboration among legal institutions, research bodies, and industrial actors is essential to advance Batam as a national model for sustainable and knowledge-driven energy governance.

Keywords: Batam electricity system; Energy regulation; Science-based governance; Technological innovation

Introduction

Electrical energy is a vital element in supporting modern social, economic, and industrial activities. The rapid advancement of science and technology demands a stable, efficient, and environmentally sustainable electricity supply. Within this context, the electricity system becomes a strategic infrastructure essential for national development, directly influencing productivity, innovation, and public welfare (Amitayani et al., 2009). Batam City, as one of Indonesia's Special Economic Zones (SEZs), holds a crucial role in facilitating industrial investment and international trade, which requires a reliable and efficient energy infrastructure. To meet this need, Batam has developed an independent electricity system managed by PT PLN Batam, which operates autonomously from the central government while integrating technical, economic, and legal principles in local energy governance (Rosmayati & Maulana, 2024).

The existence of Batam's independent electricity system is rooted in the national regulatory framework established under Law Number 30 of 2009 on Electricity, later refined by Law Number 11 of 2020 on Job Creation. These regulations aim to foster a competitive, efficient, and service-oriented electricity market. However, in

practice, the implementation of this system faces several challenges, including limited legal certainty, technical inefficiencies, and slow adaptation to renewable energy technologies (Prabowo et al., 2018). While regulations function as control mechanisms ensuring compliance with safety and efficiency standards, they must also act as catalysts for scientific innovation and technological advancement. The persistent gap between normative regulation (das sollen) and practical implementation (das sein) illustrates that the regulatory framework has not yet evolved into a fully adaptive and science-driven energy governance system.

From a scientific and technological standpoint, the independent electricity system serves not only as an energy provider but also as a living laboratory for advancing both conventional and renewable energy technologies. Adaptive regulation plays a critical role in facilitating knowledge transfer, applied research, and collaboration among industry, government, and academia (Maulana, 2023b). Who demonstrate how national energy policies and tariff structures affect renewable energy adoption in local contexts, who identify regulatory barriers in the application of solar energy within Batam's maritime sector. Furthermore, emphasize weaknesses in consumer protection laws related to unused electricity billing, revealing broader issues of transparency and accountability in local energy management. Together, these findings highlight that regulation can and should evolve into a science-based policy instrument, enabling the application of research outcomes in renewable energy, distribution efficiency, and digitalized monitoring systems. In Batam, this integration between regulation and science is particularly significant due to its potential to become a national hub for energy research and innovation.

However, several barriers continue to hinder the optimal alignment between regulation and scientific advancement in Batam's independent electricity system. These include weak institutional coordination, fragmented policy implementation, and limited incorporation of renewable technologies (Dionysius & Kusuma, 2014). Therefore, this study aims to analyze the regulatory framework of Batam's independent electricity system as a foundation for developing energy science and technology, emphasizing how adaptive regulation can function as both a legal and epistemological tool to foster technological innovation. Kebaruan penelitian ini terletak pada konstruksi model dinamika sistem menggunakan analisis kualitatif, yang mengintegrasikan kekuatan regulasi, investasi riset, dan kolaborasi akademis industri untuk mensimulasikan dampak kolektifnya terhadap kapasitas dan inovasi energi. Studi ini penting karena menyediakan model ilmiah yang menjembatani kesenjangan antara kebijakan hukum dan implementasi teknologi, menawarkan perspektif baru tentang bagaimana tata kelola energi berbasis sains dapat meningkatkan keberlanjutan, efisiensi, dan ketahanan sistem energi lokal di Indonesia.

Method

This study employs a qualitative approach with normative and empirical juridical methods to provide a comprehensive understanding of the regulatory framework governing the independent electricity system in Batam City and its relevance to the development of energy science and technology (Nanlohy et al., 2024). The normative juridical approach focuses on analyzing laws and regulations that form the foundation of Batam's electricity governance, including Law Number 30 of 2009 on Electricity, Law Number 11 of 2020 on Job Creation, Government Regulation Number 25 of 2021 on the Implementation of the Energy and Mineral Resources Sector, and several Ministerial Regulations of Energy and Mineral Resources as well as local energy policies enacted by the Batam City Government and BP Batam. This research aims to find out about 1) Regulatory Structure and Energy Independence in Batam. 2) Regulation as an Instrument for Energy Technology Development 3) Integration of Regulation, Industry, and Natural Science Development 4) Evaluation of the Effectiveness of Regulation and Direction of Energy Science Development

The empirical juridical component was conducted through documentary research and field observation, examining operational practices, policy implementation reports, and administrative documents related to Batam's electricity system (Maulana, 2022). Primary data were drawn from official publications and policy documents issued by PT PLN Batam, BP Batam, and the Riau Islands Provincial Energy and Mineral Resources Office, while secondary data were sourced from scientific journals, policy analyses, and previous studies relevant to renewable energy and energy regulation.

All data were analyzed using descriptive qualitative analysis with an inductive–deductive reasoning framework (Rosmayati & Maulana, 2025). The inductive process identified patterns and relationships between regulatory structures, policy implementation, and scientific development, while the deductive phase interpreted these findings in the context of legal theory and principles of sustainable energy governance. The analysis followed a logical flow beginning from regulatory identification, then implementation assessment, followed by impact analysis on technological and scientific advancement (Maulana, 2023). To ensure validity, data triangulation was applied across legal sources, policy documentation, and

academic literature, ensuring coherence between regulatory analysis and observed outcomes.

Through this method, the study aims to construct an integrative and science-based understanding of how Batam's independent electricity regulation functions not merely as an administrative legal mechanism but also as a policy instrument that promotes innovation, research development, and regional energy independence within the framework of sustainable national energy governance (Valentino et al., 2023).

Results and Discussion

Regulatory Structure and Energy Independence in Batam

The research results show that the electricity system in Batam City has unique legal characteristics compared to other regions in Indonesia (Ichsan et al., 2021). This is due to Batam's status as a Free Trade Zone and Free Port, which allows for the implementation of more flexible and market-oriented energy regulations (Juita et al., 2023). Based on Law Number 11 of 2020 concerning Job Creation, electricity supply can be carried out by state-owned, regional, or private enterprises, provided they meet licensing requirements and service quality standards. In the case of Batam, this role is assumed by PT PLN Batam, a subsidiary of PT PLN (Persero), which operates independently without subsidies from the central government. Regulations applicable at the national and regional levels, including Government Regulation Number 25 of 2021 and the Regulation of the Head of BP Batam concerning Energy Management, serve as the primary legal basis for governing the governance of electricity supply (Ashari et al., 2023). This independence creates a legal ecosystem that demands efficiency and technological innovation in energy management, while also demonstrating how public policy can transform into an adaptive system that supports the development of energy science and environmental sustainability (Qosimah et al., 2023).

The effectiveness of an independent electricity system depends on three main variables. To analyze these characteristics, the study uses the Adaptive Regulatory Energy Governance Model, which emphasizes the interaction between legal norms, public policy, and technological innovation in the electricity system (Firdawati et al., 2021). This model views energy independence in Batam as being formed through the process of adapting regulations to the needs of local technology and energy markets. Open and responsive energy regulations enable business entities such as PT PLN Batam to develop efficient electricity management mechanisms, including the implementation of digital-based load monitoring technology and decentralized backup systems. Within this framework, the law serves

not only as a control tool but also as an innovation instrument that encourages energy efficiency and applied research (Hamzah et al., 2023). Observations indicate that the success of Batam's independent electricity system is influenced by the regulation's ability to balance legal certainty with technological flexibility (Witri et al., 2023). Therefore, the adaptive regulatory energy governance model serves as the analytical basis for understanding how public policy in Batam integrates natural science principles into legal practices and energy management.
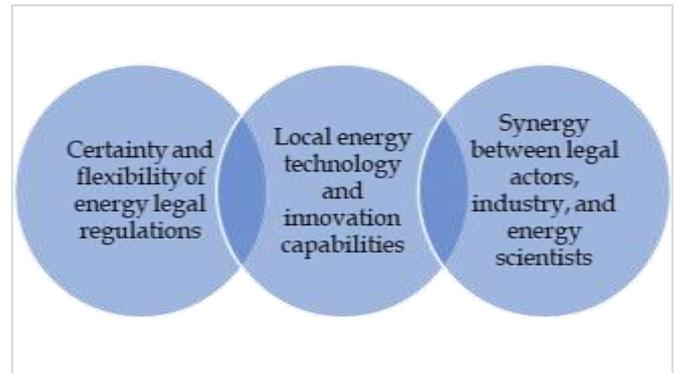

Figure 1. Adaptive Energy Regulation Analysis

Regulation as an Instrument for Energy Technology Development

From a natural science perspective, Batam's independent electricity system regulation serves not only as an administrative tool but also as an energy governance tool that encourages applied research in energy efficiency, renewable energy, and network digitalization (Mukramah et al., 2023). Regulations mandating the implementation of power supply reliability and quality standards (based on Article 42 of the Job Creation Law and Government Regulation No. 14 of 2012) have opened up space for the development of Internet of Things (IoT)-based monitoring technology, smart grids, and predictive maintenance systems in PLN Batam's distribution system (Cahyaningsih & Kharisma, 2023). This policy demands scientific innovation in managing electrical loads, reducing power losses, and improving system stability. Thus, Batam's energy regulation not only regulates but also stimulates interdisciplinary research in energy physics, electrical engineering, and computer science (Silalahi et al., 2023). The existence of an independent electricity system provides a significant opportunity for academics and industry to turn Batam into an open energy lab, where research results can be directly tested on real-world electricity systems (Yanarti et al., 2022).
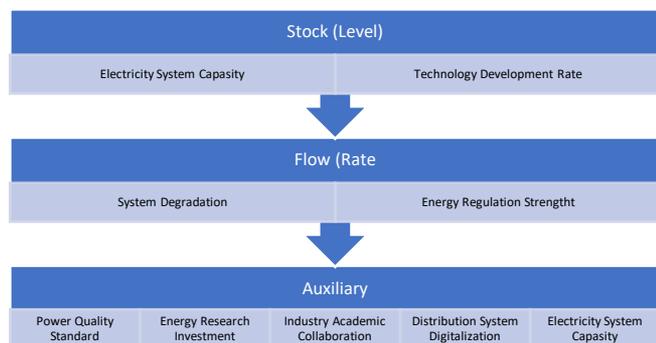
Figure 2. Analysis of the regulation model and innovation of independent energy technology in Batam

The Energy Regulatory Innovation Model analysis is designed to simulate the interaction between regulatory strength, technological innovation, and system performance in Batam's independent electricity grid (Muriyati et al., 2023). The model consists of two main factors: Power System Capacity, which represents the accumulated development and efficiency of the electricity system through technologies such as smart grids, IoT, and solar PV, and the Rate of Technology Development, which measures the overall progress of energy innovation in response to policy and research initiatives (Asrizal et al., 2022). The flow factors, System Degradation Rate and Energy Regulatory Strength, capture the opposing processes of system efficiency loss and the regulatory mechanisms that counteract them by stimulating technological adaptation (Napitupulu et al., 2023). Additional factors, Power Quality Standards, Energy Research Investment, Industry-Academic Collaboration, and Distribution System Digitalization, serve as mediating factors that strengthen or moderate the relationship between regulation and innovation (Siregar et al., 2023). Collectively, these components form a dynamic feedback loop in which stronger

regulation increases research investment and collaboration, accelerates technology adoption, improves power quality, and ultimately increases the capacity and resilience of Batam's electricity system (Syakur et al., 2023).

Integration of Regulation, Industry, and Natural Science Development

The implementation of energy policies in Batam shows that there is a positive correlation between legal certainty and the development of science-based energy technology (Annisa et al., 2023). Collaboration between BP Batam, PLN Batam, and educational institutions such as Batam State Polytechnic and Batam International University has resulted in several joint research projects on solar energy, hybrid electrical systems, and the integration of renewable energy into existing grid systems. Regulations supporting clean energy investment and research create an innovative environment that aligns industry needs with academic capacity (Lumi et al., 2022). For example, the implementation of Minister of Energy and Mineral Resources Regulation No. 26 of 2021 concerning Rooftop Solar Power Plants (RSPP) has begun to be piloted in several industrial areas in Batam, and results have shown efficiency increases of up to 12–15% in hybrid power generation systems. This phenomenon demonstrates how legislation can serve as a catalyst for the growth of natural sciences, particularly in the fields of energy conversion (Handayani et al., 2023), power management, and the utilization of new energy sources. With a science-based regulatory approach, Batam's energy policy directly encourages technology transfer from research findings to industrial practice, strengthening Batam's position as a national model for integrated energy development (Zulkifli et al., 2022).

Table 1. Qualitative Model Flow of Energy Regulation and Innovation Development in Batam City

Qualitative Model Stages	Focus of Analysis	Scientific Role or Function
Driving Factors	Energy regulations, incentive policies, academic-industry collaboration, research funding, and system digitalization.	These serve as the primary foundation for determining policy direction, strengthening legal stability, and encouraging investment, research, and the adoption of science-based energy technologies. Strong regulations and appropriate policy support create an innovative environment for the development of energy science and technology in Batam.
Mediating Processes	Efisiensi riset, transfer pengetahuan, kesiapan adopsi teknologi, efektivitas penerapan, dan keberlanjutan pemeliharaan sistem.	Research efficiency, knowledge transfer, technology adoption readiness, implementation effectiveness, and system maintenance sustainability.
Outcome Stage	Technological innovation, increasing the capacity of the electricity system, and strengthening energy research institutions.	Representing the tangible impact of the interaction of all system components. This stage illustrates the success of regulations and policies in improving energy efficiency, promoting regional energy independence, and strengthening the foundation of national energy science and technology.

The findings of this process model indicate that the development of an independent electricity system in Batam City is determined not only by technical and economic factors, but also by the integration of regulations, collaborative processes, and innovative outcomes, as depicted in the qualitative model. The key drivers stage demonstrates that regulatory strength, incentive policies, collaboration between industry and academia, research funding, and system digitalization are the foundations that form a knowledge-based energy ecosystem (Putri et al., 2024). The connecting process stage confirms that research effectiveness, knowledge transfer, readiness for technology adoption, and operational sustainability are mechanisms that bridge policy with actual implementation on the ground (Syamsuni HR et al., 2024). Meanwhile, the final outcome stage shows that the synergy of all these elements results in increased electricity system capacity (Adijaya, 2024), growth in energy technology innovation, and strengthening of research institutions in Batam. Thus, this model emphasizes that effective energy governance requires the integration of science-based regulations, collaborative research processes, and implementable outcomes that support regional energy sustainability and independence (Irmayani et al., 2024).

Evaluation of the Effectiveness of Regulation and Direction of Energy Science Development

The effectiveness of regulations in supporting an independent electricity system in Batam still faces several challenges. Research shows that there is still a gap between legal norms (das sollen) and implementation practices (das sein), particularly in terms of harmonization of central and regional policies, the availability of energy research incentives, and legal protection mechanisms for energy providers and consumers (Syamsudin et al., 2016). From a scientific perspective, the main obstacles lie in the limited availability of industrial-scale energy research facilities and the suboptimal integration of electricity data to support the development of Artificial Intelligence (AI) in distribution systems (Pramono et al., 2024). Therefore, evidence-based regulatory improvements are needed, emphasizing a transdisciplinary approach between law, technology, and energy science (Arsyad et al., 2021). Regulations based on data and scientific research results will not only strengthen legal certainty but also establish Batam as a leading center for smart energy development (smart energy hub) in Indonesia (Aprianti et al., 2010) Strengthening the synergy between the legal framework and natural science, Batam's independent electricity system can become a national model for a just and innovative sustainable energy transition (Tambunan et al., 2024).

Conclusion

The regulatory framework for Batam's independent electricity system serves not only as an administrative legal instrument but also as a scientific driver bridging the gap between law, technology, and sustainable energy management. Strong regulations, supported by policy incentives, research investment, and academic-industry collaboration, play a crucial role in accelerating technological innovation and improving system efficiency. Science-based governance can transform regulatory mechanisms into catalysts for knowledge creation, technology transfer, and renewable energy development. Therefore, strengthening the integration between legal policies, research institutions, and industry players is crucial to achieving energy independence and establishing Batam as a national model for knowledge-based sustainable energy governance.

Author Contributions
Conceptualization, Ahmad Maulana; methodology, Ahmad Maulana; validation, Ahmad Maulana; formal analysis, Ahmad Maulana; investigation, Ahmad Maulana; resources, Ahmad Maulana; data curation, Ahmad Maulana; writing original draft preparation, Ahmad Maulana; writing review and editing, Ahmad Maulana; visualization, Ahmad Maulana; supervision, Siti Rosmayati; project administration, Ahmad Maulana. All authors have read and agreed to the published version of the manuscript.

References

Adijaya, S. (2024). Today's Shifting Cultivation and its Impact on Forest and Environmental Damage in Routa, Konawe, Southeast Sulawesi. *Jurnal*

Penelitian Pendidikan IPA, *10*(5), 2612–2620. https://doi.org/10.29303/jppipa.v10i5.7087

Amitayani, E. S., Finahari, I. N., & Suparman, S. (2009). Studi Pengembangan Sistem Pembangkit Listrik Wilayah Batam dengan Opsi Nuklir. *Jurnal Pengembangan Energi Nuklir*, *11*(2). https://doi.org/10.17146/jpen.2009.11.2.1438

Annisa, N., Samawi, M. F., & Idrus, M. R. (2023). Status of Seaweed K. alvarezii Cultivation Sustainability as a Strategic Direction for Seaweed Management in Baubau City, Southeast Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *9*(2), 931–937. https://doi.org/10.29303/jppipa.v9i2.2874

Aprianti, N. A., Fathona, I. W., Suprijadi, S., Budiman, M., & Khairurrijal, K. (2010). Sistem Kontrol Otomatik Pembatasan Daya Listrik Berbasis Mikrokontroler PIC18F4520. *Jurnal Otomasi Kontrol Dan Instrumentasi*, *2*(2). https://doi.org/10.5614/joki.2010.2.2.6

Arsyad, M., Alghifari, R. M., Susanto, A., Palloan, P., & Sulistiawaty. (2021). Analysis of Radiation Intensity and Sunshine Duration in the Karst Area of Maros TN Bantimurung Bulusaraung South Sulawesi During Solstice Phenomenon. *Jurnal Penelitian Pendidikan IPA*, *7*(SpecialIssue), 199–204. https://doi.org/10.29303/jppipa.v7ispecialissue.1068

Ashari, A., Anwar, S., & Sumarna, O. (2023). Environmental Literacy of Students at SMA Negeri 6 Wajo, South Sulawesi Province. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4517–4522. https://doi.org/10.29303/jppipa.v9i6.3295

Asrizal, A., Ayu, D. F., Mardian, V., & Festiyed, F. (2022). Electronic Learning Material of Newton's Laws with Kvisoft Flipbook Maker to Improve Learning Outcomes of Students. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 489–498. https://doi.org/10.29303/jppipa.v8i2.1222

Cahyaningsih, D. T., & Kharisma, D. B. (2023). Role of Intellectual Property Law in Increasing Science Education Capacity in Indonesia. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5731–5736. https://doi.org/10.29303/jppipa.v9i7.4565

Dionysius, D., & Kusuma, I. R. (2014). Perancangan Power Management System Pada Kapal Penumpang. *Jurnal Teknik ITS*, *3*(1). https://doi.org/10.12962/j23373539.v3i1.5769

Firdawati, R., Maison, M., & Nazarudin, N. (2021). Development of Mobile Learning Media on Newton's Laws Using the Appy Pie Application. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 202–206. https://doi.org/10.29303/jppipa.v7i2.599

Hamzah, A. H. P., Nurhasanah, Harijati, S., Pangerapan, S. B., & Suriani, C. (2023). Ethnobotanical Identification of Medicinal Plants Used by the Sangihe Tribe in Sangihe Archipelago District, North Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5765–5772. https://doi.org/10.29303/jppipa.v9i7.3924

Handayani, S., Gazali, I. M. U., Yaurwarin, W., Raodiah, R., & Idrus, W. (2023). Validity and Effectiveness of Customary Law-Based Environmental Management for The Sustainability of Natural Resources. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2350–2356. https://doi.org/10.29303/jppipa.v9i5.3642

Ichsan, M., Yusrizal, Y., & Mursal, M. (2021). Development of Student Worksheets Based on React Model to Increase Student Motivation in Newton's Law Materials. *Jurnal Penelitian Pendidikan IPA*, *7*(3), 364–369. https://doi.org/10.29303/jppipa.v7i3.710

Irmayani, Mokoginta, M. M., Seelagama, P. K., Abdullah, Azis, D. A., Mukhlis, & Masnur. (2024). Strategy Analysis for Implementing Rice Transplanter Planting Machine Technology in Rice Farming Using the Interpretive Structural Modeling (ISM) Method in South Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1827–1836. https://doi.org/10.29303/jppipa.v10i4.7124

Juita, Z., Sundari, P. D., Sari, S. Y., & Rahim, F. R. (2023). Identification of Physics Misconceptions Using Five-tier Diagnostic Test: Newton's Law of Gravitation Context. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 5954–5963. https://doi.org/10.29303/jppipa.v9i8.3147

Lumi, Y. R., Budiarto, R., & Kusnanto, K. (2022). Analisis Kebutuhan dan Strategi Penyediaan Energi Listrik di Provinsi Sulawesi Utara. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 759–766. https://doi.org/10.29303/jppipa.v8i2.1441

Maulana, A. (2022). Analisis Pelatihan dan Pengembangan Sumber Daya Manusia Pada Perusahaan Jasa. *Coopetition : Jurnal Ilmiah Manajemen*, *13*(2), 345–352. https://doi.org/10.32670/coopetition.v13i2.2219

Maulana, A. (2023a). Kebebasan Dan Tanggung Jawab Bisnis: Sebuah Penelitian Filsafat Bisnis. *EKBIS (Ekonomi & Bisnis)*, *11*(2), 59–74. https://doi.org/10.56689/ekbis.v11i2.1162

Maulana, A. (2023b). Peran Pelatihan Konvensional dalam Pengembangan Organisasi dan Dunia Industri. *Coopetition : Jurnal Ilmiah Manajemen*, *14*(2), 199–206. https://doi.org/10.32670/coopetition.v14i2.3160

Mukramah, W. A. N., Halim, A., Winarni, S., Yusrizal, Safrida, Jannah, M., & Wahyuni, A. (2023). Effect of Using Comic-based E-Module Assisted by the Flipbook Maker for Remediation of Newton's Law Misconceptions. *Jurnal Penelitian Pendidikan IPA*,

9(8), 6384–6392. https://doi.org/10.29303/jppipa.v9i8.4389

Muriyati, M., Hamdana, H., Asri, A., Safruddin, S., & Asnidar. (2023). Fat and Carbohydrates as Causative Factors of Obesity of Youths at Bulukumba City, South Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 2726–2731. https://doi.org/10.29303/jppipa.v9i5.3467

Nanlohy, F. N., Moko, E. M., Ngangi, J., Ngangi, C. M. ., & Roring, V. I. Y. (2024). Composition and Diversity of Forestry Plant Species in Forest Areas Manado State University, North Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *10*(1), 12–18. https://doi.org/10.29303/jppipa.v10i1.4794

Napitupulu, N. D., Ratu, B., Walanda, D. K., & Napitupulu, M. (2023). Challenges Faced by Science Teachers in Implementing Differentiated Learning in Junior High School Palu Central Sulawesi Indonesia. *Jurnal Penelitian Pendidikan IPA*, *9*(SpecialIssue), 960–966. https://doi.org/10.29303/jppipa.v9ispecialissue.6383

Prabowo, Y., B., S., Nazori, N., & Gata, G. (2018). Studi Kelayakan Pembangkit Listrik Tenaga Mikrohidro (Pmlth) pada Saluran Irigasi Gunung Bunder Pamijahan Bogor. *Jurnal Ilmiah Fifo*, *10*(1), 41–52. https://doi.org/10.22441/fifo.v10i1.2939

Pramono, T. B., Marnani, S., Putra, J. J., Saprudin, & Islamy, R. A. (2024). The First Record of Atractosteus spatula (Lacepède, 1803) (Actinopterygii: Lepisosteiformes: Lepisosteidae) in the Klawing River, Central Java, Indonesia. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 193–198. https://doi.org/10.29303/jppipa.v10ispecialissue.7882

Putri, V. A., Sundari, P. D., Mufit, F., & Dewi, W. S. (2024). Analysis of Students' Physics Conceptual Understanding using Five-Tier Multiple Choice Questions: the Newton's Law of Motion Context. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 2275–2285. https://doi.org/10.29303/jppipa.v10i5.5847

Qosimah, D., Laminem, Mandasari, C., & Setyawati, D. (2023). Review of the Role of Probiotic and Herbal Supplements as Antibacterial, Antioxidant, and Immunomodulatory Against Aeromonas hydrophila). *Jurnal Penelitian Pendidikan IPA*, *9*(6), 178–189. https://doi.org/10.29303/jppipa.v9i6.3621

Rosmayati, S., & Maulana, A. (2024). Peluang Dan Tantangan Ekonomi Bisnis Dan Kesehatan Di Era Society 5.0. *Coopetition : Jurnal Ilmiah Manajemen*, *15*(1), 113–130. https://doi.org/10.32670/coopetition.v15i1.4124

Rosmayati, S., & Maulana, A. (2025). Human Resource Management in National Defense Policy : Reserve Component Management Strategy. *Coopetition: Jurnal Ilmiah Manajemen*, *16*(1), 45-58. https://doi.org/10.32670/coopetition.v16i1.5105

Silalahi, M. T., Dahrin, D., Abdurrahman, D., & Tohari, A. (2023). Identification Of Liquefaction-Potential Zones Using The Gravity Method In Lolu Village, Central Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6206–6212. https://doi.org/10.29303/jppipa.v9i8.4830

Siregar, F. M. H., Zainul, R., Andromeda, Oktavia, B., & Lubis, A. P. (2023). Module Development on Basic Laws of Chemistry Based on the 5E Instructional Model to Improve Science Process Skills in Senior High School. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 5420–5428. https://doi.org/10.29303/jppipa.v9i7.4343

Syakur, R., Musaidah, M. M., & Handayani, N. (2023). Risk Factors for Stunting in Toddlers in the Public Health Center Working Area Embo Jeneponto, South Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7685–7690. https://doi.org/10.29303/jppipa.v9i9.5266

Syamsudin, Z., Makkulau, A., & Nizar, L. (2016). Evaluasi Perencanaan Kelistrikan. *Sutet*, *6*(1), 28–34. https://doi.org/10.33322/sutet.v6i1.576

Syamsuni HR, S., Jumadi, J., Nursyam, A., & Kafilawaty, B. N. (2024). Implementation of Digital Scientific Literacy in Family Education (Gender Study in Remote Areas of South Sulawesi). *Jurnal Penelitian Pendidikan IPA*, *10*(4), 2176–2185. https://doi.org/10.29303/jppipa.v10i4.7005

Syarqiy, D., Yuliati, L., & Taufiq, A. (2023). Exploration of Argumentation and Scientific Reasoning Ability in Phenomenon-Based Argument-Driven Inquiry Learning in Newton's Law Material. *Jurnal Penelitian Pendidikan IPA*, *9*(9), 7264–7272. https://doi.org/10.29303/jppipa.v9i9.4589

Tambunan, A. A., Adi, T. B., & Tukijan, T. (2024). The Role of Creative Economics in Sei Nagalawan Mangrove Ecotourism Sector. *Jurnal Penelitian Pendidikan IPA*, *10*(SpecialIssue), 505–513. https://doi.org/10.29303/jppipa.v10ispecialissue.6146

Valentino, N., Prasetyo, A. R., & Hadi, M. A. (2023). Preliminary Study of Mangrove Eco-Structures and Natural Regeneration at Gili Lawang, East Lombok, West Nusa Tenggara). *Jurnal Penelitian Pendidikan IPA*, *9*(1), 590–601. https://doi.org/10.29303/jppipa.v9i1.4451

Witri, R. E., Hardeli, Kurniawati, D., & Yerimadesi. (2023). Integrated Green Chemistry Problem-Based Learning Module Development to Improve Science Process Skills Senior High School Students on Basic Chemicals Law. *Jurnal Penelitian*

Pendidikan   IPA,   *9*(8),   6188–6196. https://doi.org/10.29303/jppipa.v9i8.4380

Yanarti, Y., Jumadi, J., Lelita, I., & Rosiningtias, W. (2022). Development of Archimedes Law Material E-Module on Motion Systems to Improve Student's Concept Understanding. *Jurnal Penelitian Pendidikan   IPA*,   *8*(4),   2439–2447. https://doi.org/10.29303/jppipa.v8i4.1905

Zulkifli, Z., Azhar, A., & Syaflita, D. (2022). Application Effect of PhET Virtual Laboratory and Real Laboratory on the Learning Outcomes of Class XI Students on Elasticity and Hooke's Law. *Jurnal Penelitian   Pendidikan   IPA*,   *8*(1),   401–407. https://doi.org/10.29303/jppipa.v8i1.1274