The Aruna Initiatives: A Bankable, Dual-Entity IPP Framework to De-risk Community-Based Electrification and Accelerate Indonesia's Blue Economy

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Abstract
An integrated bankable business model is proposed to tackle Gili Ketapang Island's persistent diesel dependence. Two synergistic entities are introduced: the **Renewable & Hydrogen Company (RHC)** delivers renewable electricity through a floating PV system under an IPP/PPA scheme while separately providing hydrogen infrastructure via an IaaS contract. The **Flexible Water Company (FWC)** supplies modular desalinated water for both industrial and community needs. This dual-entity socio-commercial framework, supported by scenario-based techno-economic modelling, enhances stakeholder alignment and local empowerment. The system achieves competitive CEPC compared to diesel benchmarks, avoids over **4,120 tCO_2e** annually, and complies with standard performance ratios for bankable renewables. Results confirm improved reliability, financial viability, and socio-environmental benefits. Our strategy offers an adaptable pathway for Indonesia's archipelagic regions to accelerate their transition to renewables.

Keywords: *Renewable energy, Hybrid Energy System, Hydrogen, Diesel Replacement, Socio-commercial architecture.*

1. Introduction

Small islands across Indonesia still depend on Diesel Based Generators (DBG) for their electricity. In 2024, PLN operated about 5.200 DBG sets spread over 2.130 sites (**DATA: PLN, 2024**). These units are costly and carbon-intensive: fuel alone pushes the Cost of Electricity Production (CEPC) to IDR 3,000–50,000/kWh, or between two and over thirty times the national average (**[11]**). Besides straining public budgets, these plants emit roughly 3 $MtCO_2$ annually and undermine Indonesia's pledge to reach Net Zero Emissions by 2060. To tackle this, the government and PLN launched the "dedieselisasi" programme. This program aims to convert or decommission most isolated diesel units by 2030 with renewable energy power plants while supporting **Presidential Regulation 122/2022** and the next RUPTL roadmap **([2] IESR, 2025)**.

Gili Ketapang, a 68-ha coral-limestone island 9 km off Probolinggo, East Java, hosts **~9,412 residents** with one of Indonesia's densest populations (~13,000 people/km²). Livelihoods rely on ~2,200 fishers and growing marine tourism. Power comes from a 940 kW diesel-based generator (DBG) with CEPC ~IDR 3,142/kWh **([12])**, vulnerable to fuel-supply disruptions. With high solar irradiation (>4.9 kWh/m²-day) and port proximity, the island is primed as a showcase for PLN's DBG replacement program.

Economic ambitions require reliable, affordable power and clean water (see ***Figure 5.1***). Yet diesel-based generation (DBG) drives CEPC costs to nearly double the standard tariff (IDR 1,444/kWh), leaving PLN with both a financial gap and ~0.8 kg CO_2/kWh emissions. Water supply is equally unreliable, as brackish groundwater forces costly imports from Java through undersea pipes. Recognizing this, PLN earmarked the island for an early Hydrogen Fuel-Cell Generator (HFCG) microgrid pilot—signaling the chance to unite renewables, green-H_2 storage, and water treatment into one resilient system. However, most literature still treats micro-grids only from a technical or social lens, seldom integrating technology, finance, and local value-chains into a bankable model, nor addressing water scarcity and local revenue loops. Based on that issue, this paper designs and evaluates an integrated, dual-entity framework:

1. The Renewable & Hydrogen Company (RHC) operates floating PV under an IPP–PPA model, selling power to PLN and providing hydrogen infrastructure via IaaS–BLT with performance-based O&M through blended finance.
2. The Flexible Water Company (FWC) develops renewable-powered SWRO plants, supplying demineralized water for

hydrogen and affordable clean water for the community.

The resulting blueprint offers a replicable template for Indonesia's 2,000 DBG-reliant islands.

2. Setting, Data, and Methodology

2.1. Setting and Data Foundation

Gili Ketapang (7°42′20″ S; 113°12′10″ E), 8 km off Probolinggo, covers 3.8 km² (0–15 m). It hosts 9,412 residents/1,978 households (2,477/km²; avg. 4.8) **[1].** Groups include 12 fisheries associations, three women's cooperatives, and two credit unions under Decree 19/2023 **[2].**

Fisheries dominate: 286 boats and 1,044 fishers landed 3,969 t in 2023, worth IDR 79.4 billion, rising 2.1%/yr since 2020. Tourism adds IDR 18.7 billion, employing 146 guides and 63,180 visitor-days in 2024 **[2,3]**.

Electricity comes from PLN diesel (2×470 kW, 2014). Peak load is 317–425 kW, cost USD 0.42/kWh, runtime 17 h/day, availability 98.7%, and emissions 1,170 tCO_2/yr **[4]**. In February 2025, PLN added Indonesia's first Hydrogen Fuel Cell Generator (80 kW), now ~20% of supply with zero CO_2 and noise **[13]**.

Water comes from 143 shallow wells, two RO kiosks (1.2 m³/d each), and cisterns **[6]**. Wells yield ~650 m³/d but salinity (>1,500 µS/cm, Cl^- 450 mg/L) makes them undrinkable **[7]**. A 9 km subsea pipeline (2018, 50 L/s) often ruptures; since 2023 flow is ≤12 L/s with >100 days near-zero **[8,9]**. Households rely on wells, kiosks, or boat water up to IDR 30,000/m³ **[9,10]**.

2.2. Methodology: A Commercially Integrated Development Framework

This study applies a structured business methodology to model the technical and financial feasibility of an integrated solution for Gili Ketapang. The approach maximises bankability and stakeholder value. Two coordinated companies employ innovative contracts with public operators (PLN and PDAM).

The RHC acts as IPP to build **Floating Photovoltaic (FPV)** and sell electricity to PLN through long-term PPA. In parallel, RHC develops hydrogen (H_2) infrastructure under **Build-Lease-Transfer (BLT)** of **Infrastructure-as-a-Service (IaaS)**. This H_2 infrastructure includes electrolyzer, HFCG, and 300-bar pressurized H2 storage. RHC retains asset ownership and leashes the system to PLN with annual Operation & Maintenance (O&M). Asset handover follows contract maturity with clearly defined cost recovery and risk protocols (see ***Figure 5.3***). RHC does not operate hydrogen production itself but ensures system reliability and innovation by supporting O&M throughout the term.

FWC specializes in modular **Sea Water Reverse Osmosis (SWRO)** desalination plants. As shown in ***Figure 5.2***, it integrates operations with RHC and PLN by leveraging HFCG's **Waste Heat Recovery (WHR)**. FWC uses BLT approach with PDAM to ensure its financing, construction, and maintenance of the asset, while PDAM distributes guaranteed clean potable water as a main product. Asset is transferred at lease completion, similar to the approach of H_2's program of BLT-IaaS (see ***Figure 5.3*** & ***Figure 5.4***). The approach used is securing public oversight and minimizing CAPEX risk. It also ensures reliable supply, mitigates technical and institutional risk, and delivers transparent cost predictability for all parties involved.

The methodological backbone integrates scenario-based techno-economic modeling with operational data from asset-leasing and utility partnership schemes. Benchmarks from regulatory frameworks and peer reviewed field study are used to adjust the system tariffs and contract provisions. It also includes the sensitivity analysis to capture variations in demand growth, efficiency gains from WHR, and operational risks such as asset downtime or supply chain interruptions. Stakeholder consultation shapes every stage of the model, especially in both asset lease oversight and management of operational revenues. This approach is taken to prioritize inclusive governance, through formal representation and benefit-sharing mechanisms for local cooperatives and women's groups. This methodology delivers a replicable and scalable partnership that emphasises risk mitigation, community value and measurable social-technical impact. This setting can be a practical template for resilient island green-electrification and water delivery throughout Indonesia, utilizing the Public-Private-Partnership (PPP) framework.

3. Expected Output

The dual entity Aruna business scheme integrates FPV, H2 generation via HFCG, and seawater desalination to meet Gili Ketapang's energy and water needs. RHC installs a 2 MWp FPV system, effectively utilizing an irradiation profile of 2,160 kWh/m²/year with a 0.86 performance ratio to generate 3,714,684 kWh annually. Excess PV drives a 900 kW electrolyzer, producing 40,973 kg H2 yearly and supplying over 52% of night demand via 2 × 80 kW HFCG. The system surpasses 95% uptime, with H2 infrastructure provided through an IaaS model for autonomous island operation and grid offset sales. Electricity is sold to PLN at USD 0.13/kWh under long-term PPA. With 40:60 debt-equity, financials project an NPV of USD 438,937.85, IRR of 9.84%, and an 8.2-year payback.

FWC's modular SWRO plant supplies 277,400 m³ water yearly with output salinity reduced to 500 mg/L. Integration of WHR from H2 boosts efficiency by 6%, lowering specific energy consumption to 3.19 kWh/m³. BLT contracts undercut regional PPP benchmarks, with PDAM costs at ~USD 0.40/m³. Proactive asset management secures two decades of performance. Financial projection shows NPV USD 135,000, IRR 11.2%, and an eight-year payback.

The scheme couples infrastructure with local empowerment, as both entities commit CSR to support women-led cooperatives in water management and skills programs. Prioritizing local actors strengthens governance and resilience. Reliable clean water improves health for women and children, reduces disease, and alleviates scarcity stress. Families gain hygiene, nutrition, and security. Combining technical resilience with inclusivity mitigates 4,120 tons CO2 annually, preserves marine ecosystems, and enables carbon monetization and green branding. This holistic architecture provides a high-impact template for sustainable independence on Gili Ketapang and similar islands.

4. References

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5. Appendix

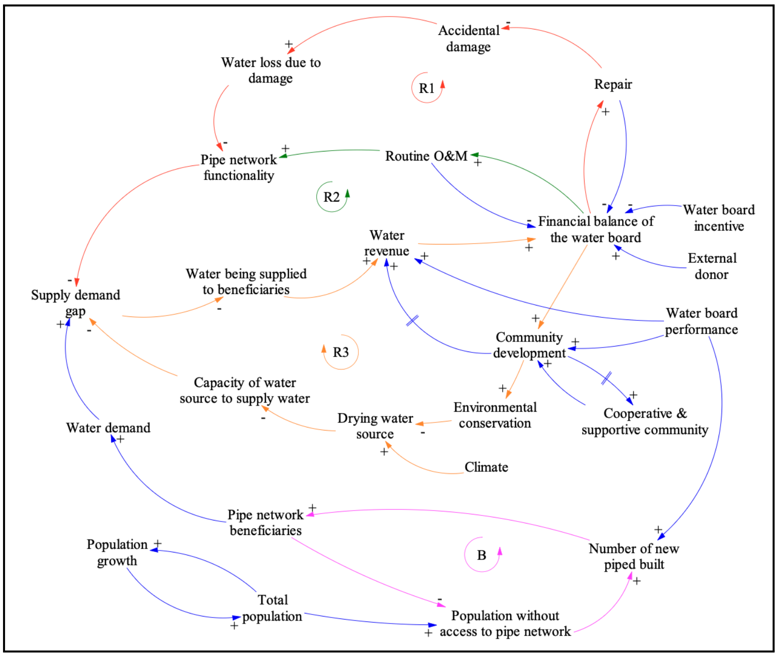

Figure 5.1. Causal loop diagram of the rural water supply network [**5**]; *Copyright: MDPI, 2021*

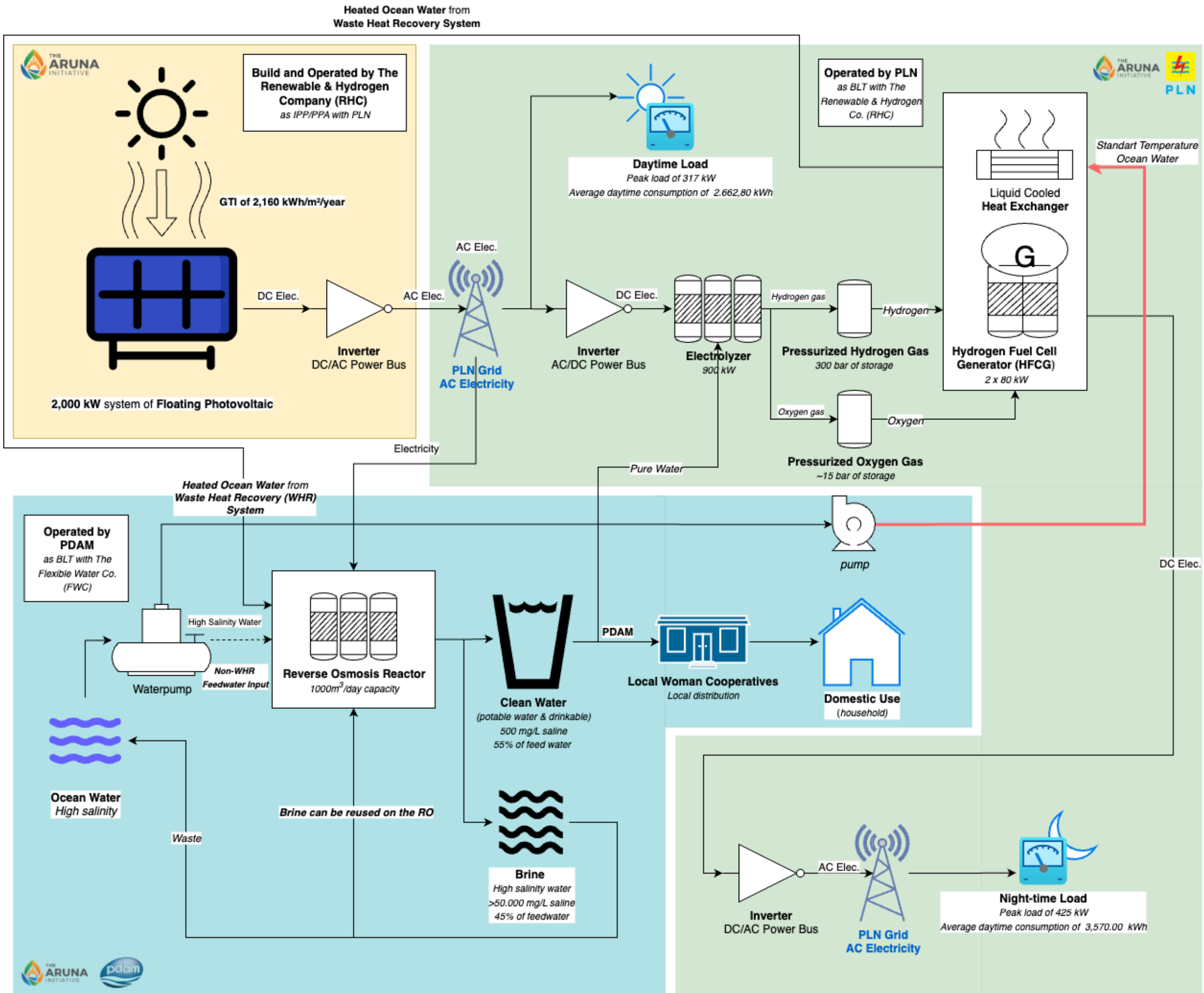

Figure 5.2. Process Engineering Diagram for Aruna Initiatives.

Figure 5.3. Business Model Canvas of The Aruna Initiatives

Key Partners	Key Activities	Value Proposition	Customer Relationships	Customer Segment
• PLN (electricity off-taker and grid partner). • PDAM (water off-taker and distribution partner). • Technology suppliers (PV, electrolyzer, SWRO). • Local government (regulatory facilitation).	• Project development, financing, and construction. • Asset operation, maintenance, and performance monitoring. • Contract management and compliance.	• Bankable, integrated renewable energy and water infrastructure for remote islands. • Reliable, cost-competitive electricity (via floating PV + H_2) and potable water (via SWRO + WHR) delivered under long-term, performance-guaranteed contracts. • De-risked asset ownership and transfer (BLT/IaaS), ensuring utility control and transparent cost recovery. • Measurable decarbonization and resilience, supporting national energy transition goals.	• Long-term, performance-based service agreements (O&M, asset transfer). • Transparent, contractually defined reporting and compliance.	• PLN (State Electricity Utility): Sole buyer of electricity and hydrogen backup services via PPA and IaaS contracts. • PDAM (Regional Water Utility): Sole buyer of potable water via BLT contract.
	Key Resources		**Channels**	
	• Floating PV and hydrogen infrastructure (owned by RHC). • Modular SWRO desalination plant (owned by FWC). • Utility contracts (PPA, BLT, IaaS). • Skilled O&M and project management teams.		• Direct B2B contracting (PPA with PLN, BLT with PDAM). • Formal project handover and reporting processes with utilities.	
Cost Structure			**Revenue Streams**	
• **CAPEX**: PV, H_2, SWRO, pipelines, integration. • **OPEX**: O&M, asset replacement, insurance, compliance. • Financing costs (interest, fees).			• Electricity sales to PLN (PPA). • Hydrogen infrastructure lease/service fees to PLN (IaaS). • Water sales to PDAM (BLT contract).	

Figure 5.4. Lean Canvas of the *Flexible Water* Co. (FWC)

Unfair Advantage	Key Metric	Unique Value Proposition	Customer Segments	Problem
• Dual-purpose water system. • Tech integration (RO + WHR). • Women-led governance. • Strategic alignment with PLN & Net Zero targets..	• Ultrapure water to PLN. • Diesel/water import reduction. • Water output (m³/day). • Households served. • % women engaged.	• Dual water output: potable + ultrapure. • WHR-powered RO = lower cost & greener. • Empowers women cooperatives. • Supports hydrogen transition & Net Zero.	• PLN / IPP (hydrogen off-takers). • Households (domestic use). • Local women cooperatives. • PDAM (regional water utility). • Local industries (fisheries, tourism).	• Hydrogen production needs ultrapure water. • High cost & scarcity of clean water. • Diesel-based desalination → expensive & polluting. • Inefficient RO without Waste Heat Recovery (WHR). • Limited community involvement in water management.
	Solution		**Channels**	
	• RO + WHR desalination. • Potable water for the community. • Ultrapure water for hydrogen. • Tiered pricing (subsidy for homes, premium for PLN/industry).		• Direct supply contracts with PLN and local industries. • PDAM as formal water distributor. • Community channels via women cooperatives.	
Cost Structure			**Revenue Streams**	
• **CAPEX:** RO facility installation, distribution pipelines, integration with WHR. • **OPEX:** Energy costs (from floating PV, hydrogen, or PLN), RO maintenance, cooperative workforce. • Training and capacity building for cooperatives. • Quality monitoring for potable and ultrapure water.			• Sale of ultrapure water to PLN/IPP for hydrogen. • Supply contracts with PDAM. • Sale of clean water to households. • Sale of water to local industries (fisheries, culinary, tourism). • Grants, subsidies, and impact financing.	

Figure 5.5. Integrated Financial-Technical Summary Table.

Category	KPI / Metric	RHC: Renewable & Hydrogen Co.	FWC: Flexible Water Co.
Location	Project Island	Gili Ketapang	Gili Ketapang
Technology	Main Asset/Capacity	2,000 kWp Floating PV, 900 kW Electrolyzer, HFCG (176 kW total), H2 storage	800 m³/day SWRO (modular), Waste Heat Recovery (WHR)
Yield	Annual Output	3,714,684 kWh (AC)	277,400 m³ water, 880,320 kWh use
	Hydrogen Produced/yr	45,249 kg H_2	--
Performance	System Uptime	>95%	95%
	Specific Yield	1,857 kWh/kWp/yr	3.17 kWh/m³ (with WHR)
	Nighttime Load Coverage	58% by HFCG	--
Financials	CAPEX (initial)	$3,961,000	$539,044
	OPEX (annual, average)	$81,000–$118,000	$12,937–$20,682
	NPV (20-yr, 8% DR)	$438,938	$135,377
	IRR	9.85%	11.2%
	Payback Period	9.8 years	7.4 years
	Tariff to PLN/PDAM	$0.13/kWh (PLN)	~$0.40/m³ (PDAM)
Environment	CO_2 Emissions Avoided/yr	3,529 tCO_2e	836 tCO_2e
	Total Combined CO_2 Reduction	4,365 tCO_2e/yr	—
Outputs & Impact	Electricity for grid (PLN)	Yes	—
	Water for community / process	—	Yes
	Hydrogen for backup/grid	Yes	—
	Women's Coop Impact	CSR and O&M support	Water management, coop governance
Innovation	Asset Ownership Model	BLT, IaaS to PLN, O&M performance	BLT to PDAM, O&M performance
	Efficiency Enhancements	Optimized H_2, floating PV	WHR integrated to SWRO
Bankability	Main Customer (Revenue)	PLN (Electricity, H_2 infra)	PDAM (Water)
	Contract Models	PPA, IaaS, O&M, Carbon	BLT, O&M, Performance Fee
Social	Jobs Created (direct)	At least 15+ (energy+water)	Included in O&M/coop

The detailed financial model can be seen in this file below:

YEH 2025_Calculations.xlsx