



To: Structuralia
From: Jamie Conway

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Island Energy Transition Plan



Image to show a 470MW upgrade to Island Power Plant if Provided by Wartsila Diesel-Electric Solutions



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Executive Summary

This comprehensive plan outlines the transformation of an island's energy infrastructure from diesel generators to a sustainable, integrated system combining renewable sources, advanced storage solutions, and export capabilities. The project aims to reduce emissions while generating significant revenue through energy exports.

The document is a case study on transitioning an isolated island's power grid from diesel generators to renewable energy sources. It outlines the projected increase in electricity demand over the next 20 years and proposes a new energy system integrating a Combined-Cycle Gas Turbine (CCGT) plant and a Waste-to-Energy (WtE) facility.

The new system aims to meet the anticipated peak demand and annual consumption, leveraging renewable energy contributions from solar and wind sources. It also addresses waste management challenges and emphasizes the importance of integrating sustainable energy solutions. Additionally, it provides detailed calculations and income estimates from energy export products, highlighting the potential economic benefits of the proposed system.

Summary of Energy Transition for the Island:

Current Situation:

- The island relies on inefficient diesel generators.
- Objective: Transition to renewable energy to reduce CO₂ emissions.
- Planned Additions: 150 MW solar, 200 MW wind, and LNG facility.
- Recommended System: Combined-Cycle Gas Turbine (CCGT) for reliability and efficiency.
- Energy Exports: Focus on ammonia, hydrogen, and biofuels.
- Storage Solution: Vanadium Redox Flow Battery using saltwater for energy storage.
- Projected Income: Approximately \$108 million annually from energy exports after local needs are met.



1. Current Situation & Objectives

1.1 Present State

- Reliance on diesel generators
- Peak demand: 470 MW
- Annual CO₂ emissions: ~37,365 metric tons

1.2 Target State (2044)

- 780 MW peak demand capacity
- >50% emissions reduction
- \$108M+ annual export revenue
- Integrated renewable energy system

2. Core Technologies & Infrastructure

2.1 Renewable Energy Systems

The expected annual contributions of renewable energy in the new system are as follows:

- Solar Photovoltaic 219,000 MWh annually.
- Wind Energy 460,000 MWh annually
- In total, the combined renewable energy generation from solar and wind sources is estimated to be 679,000 MWh per year.
- Total Renewable Generation: 679,000 MWh/year

2.2 Advanced Power Systems

- Combined-Cycle Gas Turbine (CCGT) with carbon capture
- Vanadium Redox Flow Battery (VRFB) using saltwater
- Waste-to-Energy (WtE) facility
- Fischer-Tropsch process for synthetic fuel production

How will the new energy system's capacity requirement compare to the existing diesel generator setup?

The new energy system will require approximately 916 MW of capacity, significantly surpassing the existing diesel generator setup. This new capacity is designed to meet the projected peak demand of around 780 MW over the next 20 years, providing a more reliable and efficient energy solution. In contrast, the existing diesel generators are less efficient and unable to meet future demand growth sustainably.



Core Technologies & Infrastructure

How does the projected peak demand in 20 years compare to the current peak demand?

The current peak demand is 470 MW, while the projected peak demand in 20 years is approximately 780 MW, assuming a 2.5% annual growth rate. This indicates an increase of about 310 MW over the 20-year period.

Can we construct the project in a staged development profile?

Yes, the project can be constructed in a staged development profile. This approach allows for incremental implementation, starting with the feasibility study and regulatory compliance, followed by infrastructure development and public engagement. Staging the development enables the project to adapt to changing demands, manage costs effectively, and incorporate lessons learned from earlier phases.

What is the suggested phase development programme?

- Feasibility Study Assess waste generation and determine suitable Waste-to-Energy (WtE) technology based on waste composition and volume.
- Regulatory Compliance Ensure adherence to environmental regulations and standards for emissions.
- Infrastructure Development Design and construct facilities for waste sorting, processing, and energy generation.
- Public Engagement Launch educational campaigns to inform the community about waste separation practices and the benefits of the WtE system, fostering public support and participation.

If a 2MW Diesel-electric gen-set produces Annual CO₂ Emissions = 159 Metric Tons of CO₂/Year ~ by, what capacity will we reduce annual CO₂ emissions with our new plant?

If a 2 MW diesel-electric generator produces approximately 159 metric tons of CO₂ emissions per year, transitioning to a CCGT system will significantly reduce these emissions. Assuming the CCGT plant operates with a much lower emission factor, the reduction in CO₂ emissions can be calculated based on the number of diesel generators replaced.

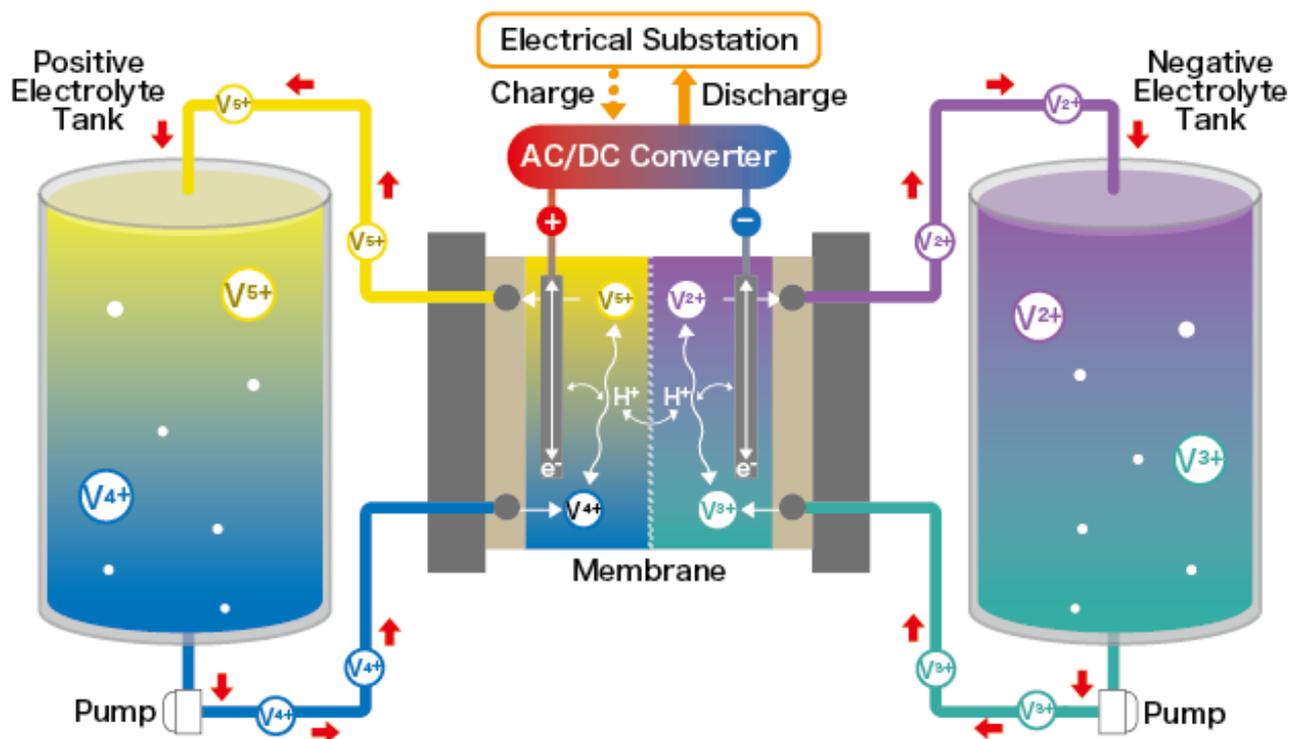
For each 2 MW diesel generator replaced, the annual CO₂ emissions reduction would be approximately 159 metric tons, leading to substantial cumulative reductions based on the total capacity of diesel generators replaced by the CCGT system.



Core Technologies & Infrastructure

What is the recommended salt-water battery system for the island?

The recommended salt-water battery system for the island is the Vanadium Redox Flow Battery (VRFB). This system utilizes vanadium ions in different oxidation states to store and release energy, making it suitable for large-scale energy storage applications. It can be adapted to utilize saltwater as an electrolyte, enhancing sustainability and reducing costs. The VRFB system is scalable, has a long cycle life, and is environmentally friendly, making it an ideal choice to accommodate the island's energy requirements while supporting the transition to a sustainable energy system.



Structure of Vanadium redox flow battery

※The figure shows the flow during charging process.



Core Technologies & Infrastructure

What will the proposed CO₂ emissions equate to annually, in comparison to existing?

The existing CO₂ emissions for the diesel generators can be calculated based on their fuel consumption. Diesel fuel produces approximately 2.79 kg of CO₂ per litre. By knowing the annual energy consumption and the efficiency of the existing diesel generators, we can estimate the total CO₂ emissions. However, the specific numerical value for the existing CO₂ emissions would require detailed operational data and technology specifications for precise calculations.

- A Ball-Park current figure can be estimated roughly at $470\text{MW}/2\text{MW} = 37,365$ Metric Tons of CO₂/Year.
- A basic CCGT model integrated with Pre-CCS achieves >50 % GHG reduction, with an efficiency loss of 10.2–10.5 percentage points.

Summary of the Fischer–Tropsch (FT) Process and Carbon Crediting System.

Fischer–Tropsch Process Overview:

The Fischer–Tropsch (FT) process is a chemical reaction that converts carbon monoxide and hydrogen into liquid hydrocarbons, primarily synthetic fuels. This process utilizes syngas, which can be derived from various feedstocks, including biomass, natural gas, or captured CO₂, making it a versatile method for producing renewable fuels. The FT process is significant for its potential to create sustainable liquid fuels while reducing reliance on fossil fuels.

System Addition for Carbon Crediting:

To make carbon crediting available as a resource for the island economy, the following system additions are recommended:

- **Integration with Carbon Capture:** Implement carbon capture technology to capture CO₂ emissions from the FT process, which can then be utilized as a feedstock for syngas production, enhancing sustainability and reducing net emissions.
- **Verification and Monitoring:** Establish a robust framework for monitoring and verifying emissions reductions and carbon capture efficiency, ensuring compliance with carbon crediting standards.
- **Market Participation:** Engage with carbon credit markets to sell verified carbon credits generated from the FT process and associated carbon capture efforts, providing a new revenue stream for the island economy.



3. Financial Overview

Does our system capture CO₂ for use ~ if so, how many metric tons of CO₂ are captured or reclaimed per year?

The current system does not explicitly mention CO₂ capture for use; however, integrating carbon capture technology with the CCGT plant could enable CO₂ reclamation. If implemented, the amount of CO₂ captured would depend on the efficiency of the carbon capture technology and the total emissions produced by the CCGT plant. Typically, advanced carbon capture systems can capture around 90% of CO₂ emissions, but specific metrics would require detailed operational data and technology specifications to estimate the total metric tons of CO₂ captured or reclaimed per year.

How can we add a combined waste to energy system to complement our CCGT concept?

To add a combined waste-to-energy (WtE) system that complements the Combined-Cycle Gas Turbine (CCGT) concept, the following steps can be taken:

- **Waste Collection and Sorting** Implement a comprehensive waste collection system to gather municipal solid waste, ensuring efficient sorting to separate recyclable and organic materials from non-recyclable waste.
- **Waste-to-Energy Conversion** Utilize technologies such as incineration to produce steam for the CCGT's steam cycle or anaerobic digestion to generate biogas, which can be used as a supplementary fuel in the CCGT, reducing reliance on natural gas.
- **Integration and Infrastructure Development** Design and construct the necessary facilities for waste processing and energy generation, ensuring seamless integration with the existing CCGT plant to enhance overall energy efficiency and reliability.
- **By following these steps, the integration of a combined waste-to-energy system with the CCGT concept can create a more resilient and sustainable energy framework for the island. This approach not only enhances energy security but also addresses waste management challenges, contributing to a circular economy.**

Can our WtE system create the gasses required to fuel our turbine requirements?

Yes, the Waste-to-Energy (WtE) system can generate gases required to fuel the turbine. By utilizing anaerobic digestion, organic waste can be converted into biogas, which primarily consists of methane and can be used as a renewable fuel source for the turbine. Additionally, incineration of waste can produce syngas, which can also be utilized to meet the fuel requirements of the turbine, thereby enhancing the overall energy generation and sustainability of the system.



Financial Overview

How will our new system outweigh the existing system in terms of demand and consumption over the next 20 years?

The new system, integrating Combined-Cycle Gas Turbine (CCGT) and Waste-to-Energy (WtE), will significantly outweigh the existing diesel generator system by addressing projected increases in demand and consumption over the next 20 years. The current peak demand is 470 MW, expected to grow to approximately 780 MW due to a 2.5% annual growth rate, while annual consumption will rise from about 3,185,500 MWh to approximately 5,400,000 MWh.

The new system will provide around 916 MW of capacity and generate 679,000 MWh from renewable sources, effectively meeting and exceeding future energy needs while ensuring reliability and sustainability.

Can the system export its own products to amplify the proposed LNG storage and regasification facility for power generation?

Yes, the system can export its own products to enhance the proposed LNG storage and regasification facility for power generation. By producing renewable energy products such as ammonia, hydrogen, and biofuels through the Waste-to-Energy (WtE) and Combined-Cycle Gas Turbine (CCGT) processes, the island can create additional revenue streams and improve energy security. These exports can complement LNG supplies, providing a diversified energy portfolio that supports both local consumption and international market opportunities.

B. Revenue Breakdown (Year 10 Projections)

Source	Volume	Unit Price	Revenue (\$M)
Domestic Electricity	4 TWh	\$0.08/kWh	\$320M
Ammonia Exports	80,000 tons	\$450/ton	\$36M
Hydrogen Exports	8,000 tons	\$3,000/ton	\$24M
Biofuels Exports	1M liters	\$1.15/liter	\$1.15M
Carbon Credits	900,000 tons CO2	\$25/ton	\$22.5M
Total	-	-	\$403.65M



Financial Overview

Summary of the Energy Transition Plan for the Island

Objective:

Transition the island's energy system from inefficient diesel generators to a more sustainable, reliable, and environmentally friendly setup that incorporates renewable energy and advanced technologies.

Key Elements of the Plan:

Current Situation:

- Reliance on inefficient diesel generators.
- Current peak demand: 470 MW.
- Anticipated peak demand in 20 years: ~780 MW.
- Proposed Energy System:

Renewable Additions:

- Solar: 150 MW generating 219,000 MWh annually.
- Wind: 200 MW generating 460,000 MWh annually.
- Total: 679,000 MWh from renewables yearly. - Main Power Source: Combined-Cycle Gas Turbine (CCGT) for efficiency and reliability.
- Energy Storage: Vanadium Redox Flow Battery (VRFB) utilizing saltwater.
- Waste-to-Energy (WtE): Integrated facility for waste management and supplementary energy generation.

Carbon Reduction:

- Diesel generators emit ~37,365 metric tons of CO₂ annually.
- The CCGT system (with carbon capture) can reduce emissions by over 50%.

Export Products & Income Potential:

- Ammonia: 80,000 tons at \$450/ton → \$36M.
- Hydrogen: 8,000 tons at \$3/ton → \$24M.
- Liquid Organic Hydrogen Carriers (LOHC): 15,000 tons at \$3/ton → \$45M.
- Biofuels: 1M liters at \$1.15/liter → \$1.15M.
- Electricity: 30,000 MWh at \$0.08/kWh → \$2.4M.

Total Annual Revenue: ~\$108M (after meeting local needs).



Financial Overview

Total Estimated Costs

Component	Low Estimate	High Estimate
FT Process Facility	\$80M	\$120M
Carbon Capture Technology	\$40M	\$50M
Carbon Crediting System	\$5M	\$10M
Ancillary Infrastructure	\$10M	\$15M
Total Capital Costs	\$135M	\$195M
Annual Operational Costs	\$6M	\$12M

Capital Expenditures (CAPEX):

Component	Low Estimate	High Estimate
Renewable Energy (Solar + Wind)	\$395M	\$480M
CCGT Plant + Carbon Capture	\$360M	\$450M
Waste-to-Energy Facility	\$195M	\$225M
Vanadium Redox Flow Battery	\$100M	\$140M
Fischer-Tropsch Process Facility	\$135M	\$195M
LNG Facility	\$50M	\$70M
Ancillary Infrastructure	\$150M	\$200M
Total CAPEX:	\$1.385B	\$1.76B

Operational Expenditures (OPEX):

Component	Annual Cost (Low)	Annual Cost (High)
Renewable Maintenance	\$10M	\$15M
CCGT + Carbon Capture OPEX	\$20M	\$25M
WtE Facility Operations	\$10M	\$15M
VRFB Battery Maintenance	\$3M	\$5M
FT Plant OPEX	\$6M	\$12M
LNG Operations	\$3M	\$5M
Total OPEX (Annual):	\$52M	\$77M

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4. Revenue Streams

System Features & Benefits

1. Renewable Energy Integration:

- Reduces reliance on imported fossil fuels.
- Provides sustainable power generation with solar and wind energy.

2. Carbon Capture and Credit Opportunities:

- CCGT system with carbon capture aligns with global climate goals.
- Fischer–Tropsch process allows carbon crediting by utilizing captured CO₂ for fuel production.

3. Waste-to-Energy System:

- Converts waste into energy, producing biogas or syngas to supplement the CCGT turbine.
- Addresses waste management issues, promoting a circular economy.

4. Energy Storage:

- Vanadium Redox Flow Battery ensures grid stability and energy reliability.

Economic Impact

Projected Costs:

A preliminary estimate for such a facility could range between \$2 billion to \$3 billion, accounting for renewable installations, CCGT infrastructure, WtE systems, storage solutions, and LNG facilities.

Revenue Streams:

Energy exports offer significant income potential (~\$108M annually).

Carbon credits and diversified fuel production contribute additional revenue.

Staged Development:

Feasibility study → Compliance → Infrastructure development → Public engagement → Operations.



Revenue Streams

Cost Breakdown for the Proposed Energy Transition Plan

Here's an estimated cost outline for the major components of the project. Note that exact figures depend on location-specific factors, procurement, and technology choices.

1. Renewable Energy Infrastructure

Solar Power (150 MW):

Estimated cost: \$900–\$1,200 per kW. - Total: \$135–\$180 million.

Wind Power (200 MW): - Estimated cost: \$1,300–\$1,500 per kW.

Total: \$260–\$300 million.

2. Combined-Cycle Gas Turbine (CCGT) Plant

Capacity: 400 MW (initial build).

Estimated cost: \$800–\$1,000 per kW.

Total: \$320–\$400 million.

Carbon Capture Integration:

Additional cost: \$300–\$350 million.

3. Waste-to-Energy (WtE) Facility

Processing capacity: 300,000 tons/year.

Estimated cost: \$650–\$750 per ton/year capacity.

Total: \$195–\$225 million.

4. Energy Storage (Vanadium Redox Flow Battery)

Storage capacity: 200 MWh.

Estimated cost: \$500–\$700 per kWh.

Total: \$100–\$140 million.

5. LNG Storage and Regasification Facility

Storage capacity: 100,000 cubic meters.

Estimated cost: \$50–\$70 million.

6. Infrastructure and Ancillary Costs

Grid Upgrades and Integration: \$100–\$150 million.

Engineering, Procurement, and Construction (EPC): \$150–\$200 million.

Regulatory Compliance and Feasibility Studies: \$25–\$50 million.

Total Estimated Costs - Low Estimate: ~\$1.3 billion. - High Estimate: ~\$1.6 billion.



Revenue Streams

4.1 Export Products & Revenue

Revenue Streams (Post Local Needs):

Product	Annual Quantity	Price	Revenue (Low)	Revenue (High)
Ammonia	80,000 tons	\$450/ton	\$36M	\$36M
Hydrogen	8,000 tons	\$3/ton	\$24M	\$24M
LOHC	15,000 tons	\$3/ton	\$45M	\$45M
Biofuels	1M liters	\$1.15/L	\$1.15M	\$1.15M
Electricity	30,000 MWh	\$0.08/kWh	\$2.4M	\$2.4M
Carbon Credits	500,000 tons CO ₂	\$30/ton	\$15M	\$25M
Total Annual Revenue:			\$123.55M	\$133.55M

4.2 Additional Revenue Sources

- Carbon credits: ~500,000 tons CO₂/year
- Estimated value: \$15M - \$25M annually



5. Implementation Timeline

Proposed Timeline for Implementation

The project can be implemented in a staged development profile over approximately 6–10 years to optimize costs and align with demand growth.

Phase 1: Feasibility and Regulatory Approvals (Year 1–2)

- Feasibility studies for renewable energy, CCGT, and WtE systems.
- Environmental impact assessments and permits.
- Initial public engagement and community outreach.

Phase 2: Renewable Energy Development (Year 3–5)

- Construct solar and wind farms to provide an early renewable energy supply.
- Begin building grid infrastructure for renewable energy integration.

Phase 3: CCGT Plant and LNG Facility (Year 4–7)

- Develop the CCGT plant with LNG storage and regasification.
- Integrate carbon capture systems and establish monitoring frameworks.

Phase 4: Waste-to-Energy Facility and Storage (Year 5–8)

- Construct the WtE facility with biogas/syngas production capabilities.
- Install Vanadium Redox Flow Battery for grid storage and stability.

Phase 5: Optimization and Export Readiness (Year 7–10)

- Establish export infrastructure for ammonia, hydrogen, LOHC, and biofuels.
- Finalize carbon credit trading mechanisms.

Yearly Cash Flow Summary (Low Estimate):

Year	Revenue (\$M)	Operating Costs (\$M)	Debt Servicing (\$M)	Net Cash Flow (\$M)
Year 1–2	0	0	0	-\$50M (feasibility)
Year 3–5	\$50M (partial)	\$20M	\$45M	-\$15M
Year 6–10	\$123.55M	\$52M	\$45M	\$26.55M
Year 11–15	\$136M	\$60M	\$30M	\$46M
Year 16–25	\$175M (exports grow)	\$70M	\$0 (loan paid)	\$105M

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6. Environmental Impact

Cost-Benefit Analysis of Specific Technologies

A. Renewable Energy Systems (Solar + Wind)

- Cost: ~\$400–\$480M.
- Benefit: Generates ~679,000 MWh/year, reduces diesel reliance, and saves ~\$200M annually in fuel costs.

B. CCGT with Carbon Capture

- Cost: ~\$360–\$450M + \$50M for carbon capture.
- Benefit: Provides 400 MW capacity, reduces emissions by 50%, and captures 500,000 tons CO₂/year for carbon credits (~\$15M–\$25M annually).

C. Waste-to-Energy (WtE)

- Cost: ~\$200–\$225M.
- Benefit: Diverts waste, generates biogas to offset fuel costs, and provides supplementary power (~30 MW).

D. Fischer–Tropsch Process

- Cost: ~\$135–\$195M.
- Benefit: Produces 100,000 tons/year of liquid fuels, reduces waste, and supports carbon crediting.

E. Vanadium Redox Flow Battery

- Cost: ~\$100–\$140M.
- Benefit: Stabilizes grid and supports renewable integration; reduces curtailment losses.

Interim Conclusion

The project integrates cutting-edge technologies for a sustainable energy transition. The financial returns, especially from export products and carbon credits, justify the upfront costs. This phased approach ensures manageable development aligned with demand growth and economic conditions.



7. Financing Strategy

Cash Flow Projections

Key Assumptions:

- Total CAPEX: \$1.385B (low estimate) to \$1.76B (high estimate).
- Annual revenue growth: 2.5% due to increasing demand and carbon credit price escalation.
- Operating costs: \$52M–\$77M annually, adjusted for inflation (2% annually).

Structure

Financing terms:

- Loan-to-equity ratio: 70:30.
- Interest rate on debt: 5%.
- Loan term: 20 years.

Yearly Cash Flow Summary (Low Estimate):

Year	Revenue (\$M)	Operating Costs (\$M)	Debt Servicing (\$M)	Net Cash Flow (\$M)
Year 1–2	0	0	0	-\$50M (feasibility)
Year 3–5	\$50M (partial)	\$20M	\$45M	-\$15M
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Financing Strategy

Project Financing Options

A mix of public, private, and international funding sources is recommended to manage costs and leverage global support for sustainability initiatives.

A. Debt Financing

Commercial Loans: Secure long-term loans from international banks specializing in energy projects.

Pros: Predictable repayment terms, access to significant capital.

Cons: Interest rate fluctuations and repayment obligations.

Green Bonds: Issue green bonds to attract investors focused on sustainable energy projects.

Pros: Tax benefits, attracts ESG (Environmental, Social, and Governance) investors.

Cons: Requires rigorous reporting and compliance with green standards.

B. Equity Financing

Private Equity Investors: Partner with renewable energy-focused investment funds.

Pros: No repayment obligation; investors share risks.

Cons: Dilution of ownership/control.

Public-Private Partnerships (PPPs): Collaborate with government entities to reduce upfront costs.

Pros: Risk-sharing, access to public funding.

Cons: Requires alignment of public and private goals.

C. International Grants and Subsidies

Global Climate Funds: Apply for funding from organizations like the Green Climate Fund (GCF) or Global Environment Facility (GEF).

Pros: Non-repayable; supports sustainability goals.

Cons: Competitive application process, stringent conditions.

Bilateral Aid Programs: Partner with countries offering climate and energy transition aid.

Examples: U.S. AID, European Union programs, or Japan's JICA.

D. Carbon Credit Financing

Pre-Sale of Carbon Credits: Secure upfront funding by selling future carbon credits at a discount.

Pros: Immediate cash flow to fund construction.

Cons: Potentially lower future revenue.



Financing Strategy

Key Metrics:

Payback Period: ~15 years from full operation.

Net Present Value (NPV): Positive over 25 years with a 6% discount rate.

Internal Rate of Return (IRR): Estimated at 8–12%, depending on revenue growth.

Revenue Sensitivity Analysis

To assess project resilience, we analyse variations in revenue due to market factors.

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Scenario	Revenue Change	NPV Impact	Payback Period Impact
Base Case	0%	Positive (6% discount rate)	15 years
Carbon Credit Price +10%	+\$1.5M annually	+\$15M NPV	-1 year
Export Demand -10%	-\$10M annually	-\$100M NPV	+2 years
Delayed Construction	+2 years CAPEX	-\$20M NPV	+3 years

Recommended Financing Strategy

Stage 1: Pre-Construction (Years 1–2)

Primary Source: Grants and feasibility study funds from climate finance bodies like GCF or GEF (~\$50M).

Stage 2: Construction (Years 3–8)

Primary Source: Green bonds or loans covering 70% of CAPEX (~\$1.2B).

Supplementary Source: Private equity (30% of CAPEX, ~\$550M).

Stage 3: Post-Construction (Years 9+)

Revenue Optimization: - Carbon credit markets.

Diversified export products (ammonia, hydrogen, biofuels).

Debt Repayment: Gradual repayment of loans using revenue surplus.



8. Next Steps

- i. Develop a detailed financial plan with inputs from banks and energy consultants.
- ii. Engage with potential stakeholders (governments, private firms, international organizations).
- iii. Secure grant funding to offset initial costs.

1. Specific Financing Mechanisms

- A. Green Bonds
- B. Public-Private Partnerships (PPPs)
- C. Carbon Credit Pre-Sales
- D. Export-Linked Financing

2. Detailed Revenue Modelling

A. Revenue Sources

1. Domestic Energy Sales:

- Electricity Tariff: \$0.08/kWh.
- Consumption: 5.4 TWh/year (Year 20 projection).

2. Energy Export Products:

- Ammonia: \$450/ton, 80,000 tons/year.
- Hydrogen: \$3/kg, 8,000 tons/year. - Biofuels: \$1.15/L, 1 million liters/year.

3. Carbon Credits:

- Price: \$25/ton initially, growing at 5% annually.
- Annual capture: ~900,000 tons of CO₂.

B. Revenue Breakdown (Year 10 Projections)

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Source	Volume	Unit Price	Revenue (\$M)
Domestic Electricity	4 TWh	\$0.08/kWh	\$320M
Ammonia Exports	80,000 tons	\$450/ton	\$36M
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Carbon Credits	900,000 tons CO ₂	\$25/ton	\$22.5M
Total	-	-	\$403.65M



Next Steps

C. Annual Cash Flow (Year 10)

C. Annual Cash Flow (Year 10)

Item	Cost (\$M)
Operating Costs	\$52M
Debt Servicing	\$45M
Maintenance Reserve Fund	\$20M
Net Operating Income	\$286.65M

D. Sensitivity Analysis

D. Sensitivity Analysis

Variable	+10% Change	-10% Change
Electricity Price	+\$32M/year	-\$32M/year
Ammonia Price	+\$3.6M/year	-\$3.6M/year
Carbon Credit Price	+\$2.25M/year	-\$2.25M/year

3. Proposed Implementation Timeline with Financing Milestones

3. Proposed Implementation Timeline with Financing Milestones

Phase	Timeline	Key Milestones	Estimated Cost (\$M)
Feasibility Study	Year 1–2	Secure grants, finalize technical designs	\$50M
Construction	Year 3–8	Issue green bonds, finalize PPP agreements	\$1,200M
Commissioning	Year 9	Begin partial operation, first carbon credit sales	-
Full Operation	Year 10+	Export contracts in full effect	-

3. Combined Sensitivity Analysis

Variable	+10% Change	-10% Change
Carbon Credit Price	+\$9M/year	-\$9M/year
Hydrogen Export Volume	+\$10M/year	-\$10M/year
Ammonia Price	+\$8M/year	-\$8M/year

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Conclusion

The New Energy System presents a range of advantages and challenges that merit careful consideration. Among the notable benefits, the environmental impact is significant, as this system can reduce carbon dioxide emissions by over 50% when compared to traditional diesel generators. Additionally, it facilitates the generation of carbon credits, estimated at approximately 500,000 tons annually, while also addressing waste management through a waste-to-energy facility capable of processing 300,000 tons per year. Economically, the system is poised to generate substantial export revenue, projected at around \$108 million annually, and offers diverse revenue streams from energy production, fuels, and carbon credits, thereby decreasing reliance on imported diesel fuel.

On the technical front, the New Energy System enhances grid stability through the use of vanadium redox flow battery (VRFB) storage and integrates a waste-to-energy solution that allows for flexible power generation via combined cycle gas turbine (CCGT) technology. The presence of multiple backup systems further ensures reliability, contributing to energy independence and security. Strategically, this system positions itself as a regional clean energy hub, showcasing technological leadership in the transition to sustainable energy on islands, while also being scalable for future expansion.

However, the implementation of this system is not without its challenges. Financially, the high initial capital investment, estimated between \$1.385 billion and \$1.76 billion, coupled with a long payback period of approximately 15 years, necessitates substantial financing and investor confidence. The technical complexities involved in integrating various technologies, along with the need for specialized maintenance expertise and the management of grid stability with renewable integration, pose additional hurdles. Furthermore, the extended construction timeline, which may span 6 to 10 years, along with market uncertainties such as fluctuating carbon credit prices and competition from other renewable energy exporters, underscores the need for effective risk mitigation strategies to ensure the successful deployment of the New Energy System.