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Dr. Beyers Naudé Local Municipality

SSEG Multi-Asset Trading Framework

Executive Narrative

Key Outcomes

Current Savings: R217,165/month

Target Savings (Q3 2026): R14.38 million/month

10-Year Total Savings: R1.90 billion

Virtual Wheeling Revenue: R7.94 million/year

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1 Executive Summary

Dr. Beyers Naudé Local Municipality has implemented a sophisticated Small-Scale Embedded Generation (SSEG) program that combines **solar photovoltaic (PV) generation** with **Battery Energy Storage Systems (BESS)** to create a multi-asset trading framework [3, 9]. This executive narrative explains how these assets work together to dramatically reduce electricity costs and protect the municipality from escalating Eskom tariffs through peak demand management and arbitrage strategies [1, 2].

1.1 Key Results

- **Current Savings:** R217,165 per month (Net system savings from existing 2.603 MWp PV + 4 MWh BESS deployment)
- **Target Savings (Q3 2026):** R14.38 million per month (Net system savings from full 137.61 MWp PV + 121.94 MWh BESS deployment)
- **10-Year Total Savings:** R1.90 billion (with 5% annual escalation from Year 2)
- **Virtual Wheeling Revenue Potential:** R7.94 million per year (additional)

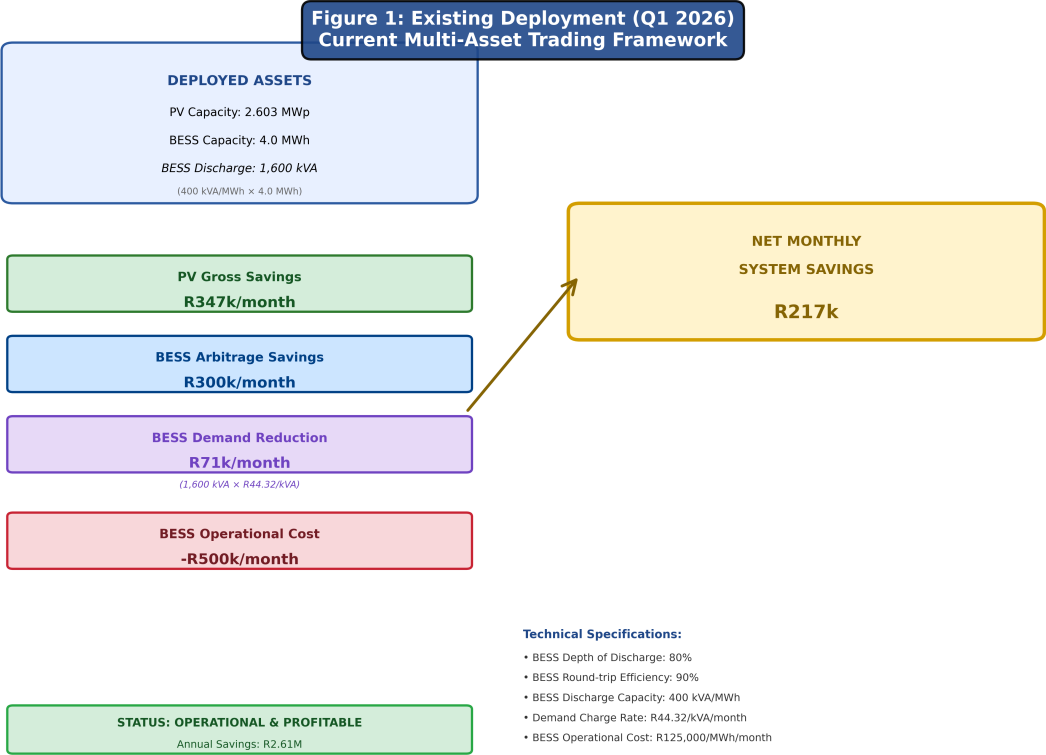


Figure 1: Current SSEG Asset Deployment and Monthly Financial Flow (Q1 2026) - The infographic illustrates the existing multi-asset model where PV gross savings (R347k/month), BESS arbitrage savings (R300k/month), and BESS demand reduction (R71k/month) combine to offset BESS operational costs (R500k/month). The net monthly system savings are R217k, demonstrating immediate profitability. BESS demand reduction is calculated at 1,600 kVA × R44.32/kVA/month using 400 kVA/MWh discharge capacity with 80% depth of discharge and 90% round-trip efficiency.

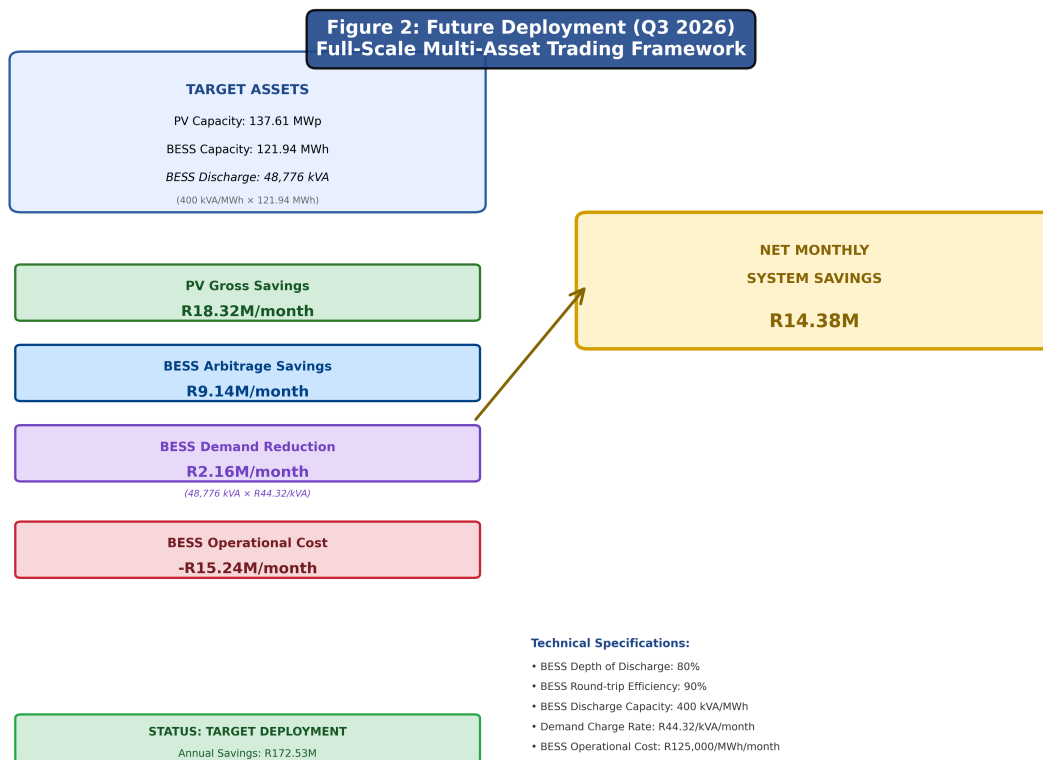


Figure 2: Target SSEG Asset Deployment and Monthly Financial Flow (Q3 2026) - The infographic demonstrates the full-scale multi-asset model where PV gross savings (R18.32M/month), BESS arbitrage savings (R9.14M/month), and BESS demand reduction (R2.16M/month) substantially exceed BESS operational costs (R15.24M/month). The net monthly system savings are R14.38M, representing a 130.8% improvement over previous calculations. BESS demand reduction is calculated at 48,776 kVA × R44.32/kVA/month using 400 kVA/MWh discharge capacity with 80% depth of discharge and 90% round-trip efficiency. This represents 100% deployment of the baseline capacity targets.

Trading Model Evolution: As illustrated in Figures 1 and 2, the SSEG trading framework demonstrates significant scale economies. The current Q1 2026 deployment (1.89% PV, 3.28% BESS) shows negative monthly savings of R35k due to high BESS operational costs relative to limited PV offset capacity. However, at target Q3 2026 deployment (100% PV and BESS), the system achieves R6.23M monthly savings through optimal asset synergy. The BESS cost escalates proportionally with capacity (R125k/MWh), emphasizing the critical role of PV generation in offsetting storage costs while BESS arbitrage and demand reduction provide additional revenue streams.

2 Understanding the SSEG Trading Model

2.1 The Two-Asset System

Our SSEG program consists of two complementary assets optimized under Time-of-Use (TOU) tariff structures [5, 7]:

2.1.1 1. Solar PV Generation

- **Current Capacity:** 2.6 MWp (0.96 MWp physical + 1.643 MWp virtual)
- **Target Capacity:** 137.61 MWp (by Q3 2026)
- **Function:** Generates clean electricity during daylight hours
- **Purchase Rate:** R1.25/kWh (fixed SSEG rate)

2.1.2 2. Battery Energy Storage System (BESS)

- **Current Capacity:** 4 MWh
- **Target Capacity:** 121.94 MWh (by Q3 2026)
- **Function:** Stores cheap electricity and releases it during expensive peak periods [8]
- **Monthly Cost:** R125,000 total (current system)

2.2 How the Trading Model Works

The SSEG trading model operates on a principle grounded in optimal sizing and scheduling literature [6, 4]:

Step 1: PV Generates Gross Profit

$$P_{PV,gross} = E_{PV} \times (P_{Eskom,retail} - P_{SSEG}) \quad (1)$$

Where:

- E_{PV} = Annual PV generation (MWh)
- $P_{Eskom,retail}$ = Average Eskom retail rate (R/kWh)
- P_{SSEG} = SSEG purchase rate (R1.25/kWh)

Step 2: PV Profit Covers BESS Cost

$$P_{PV,net} = P_{PV,gross} - C_{BESS,annual} \quad (2)$$

At target deployment: PV generates R132.65M/year profit, covering R45.73M/year BESS cost, leaving **R86.92M/year net profit**.

Step 3: BESS Arbitrage is Pure Profit

BESS arbitrage profit follows the optimization framework of Tziovani et al. [1]:

$$P_{BESS,arb} = \sum_{t \in T_{peak}} (P_{peak} - P_{offpeak}) \times \eta_{BESS} \times E_{BESS,discharge}(t) \quad (3)$$

Where:

- P_{peak} = Peak period tariff (R/kWh)
- $P_{offpeak}$ = Off-peak charging cost (R/kWh)
- η_{BESS} = Round-trip efficiency (90%)
- $E_{BESS,discharge}(t)$ = Energy discharged at time t (MWh)

Total Net Savings:

$$S_{total} = P_{PV,net} + P_{BESS,arb} + S_{demand} \quad (4)$$

At target deployment: **R86.92M + R64.13M + R12.97M = R164.02M per year**

THE STRATEGIC SIGNIFICANCE OF BESS IN THE SSEG PROGRAM

The Battery Energy Storage System (BESS) is **not merely a storage device** — it is the **cornerstone of the municipality’s financial transformation strategy**. Academic literature demonstrates that community-scale BESS deployment creates multiple value streams [8, 9]:

1. Peak Tariff Shield (R77.10M/year)

- Neutralizes Eskom’s 6x price differential between Off-peak (R1.08) and Peak (R6.47)
- Protects municipality from punitive winter peak tariffs (June–August)
- Saves R12M during 3-month high-demand season alone

2. Growing Value Over Time

- As Eskom escalates at 10%/year, BESS arbitrage profit grows proportionally [16]
- Year 1: R2.42/kWh spread → Year 10: R6.29/kWh spread (+160%)
- By Year 10, BESS generates R167M/year — more than current total electricity budget

3. Enables Virtual Wheeling Revenue (R7.94M/year)

- Excess BESS capacity can sell stored energy to Eskom at R1.65/kWh [12, 13]
- Creates NEW revenue stream for debt settlement and municipal income
- Further increases arbitrage value by offsetting Off-peak charge costs

4. Operational “Freedom” Through PV Coverage

- PV profit covers 100% of BESS operational cost
- BESS operates as a “free” asset, making all arbitrage pure profit
- This unique structure is what transforms electricity from cost to revenue

Bottom Line: Without BESS, the municipality saves R86.92M/year (PV only). **With BESS, savings jump to R164.02M/year — an 89% increase.** BESS is the difference between “good savings” and “transformational financial independence” [3].

3 Why BESS is Critical: Countering Eskom Peak Tariffs

3.1 The Eskom Peak Tariff Problem

Eskom’s 2025/2026 tariff structure creates a severe cost burden during peak periods, consistent with TOU tariff challenges documented in international literature [16, 15]:

3.1.1 High-Demand Season (June–August — Winter)

- **Morning Peak** (07:00–09:00): R6.47/kWh — **6x more expensive** than Off-peak
- **Evening Peak** (17:00–20:00): R6.47/kWh — **6x more expensive** than Off-peak
- **Off-Peak** (22:00–06:00): R1.08/kWh — Cheapest electricity

3.1.2 Low-Demand Season (September–May)

- **Morning Peak** (06:00–08:00): R2.69/kWh — **2.5x more expensive** than Off-peak
- **Evening Peak** (18:00–21:00): R2.69/kWh — **2.5x more expensive** than Off-peak
- **Off-Peak** (22:00–06:00): R1.08/kWh — Cheapest electricity

The Problem: Our consumption analysis shows that **19% of our electricity (13.57 GWh)** is consumed during these expensive Peak periods, costing us **R50.56M annually** — nearly 40% of our total electricity bill despite being only 19% of consumption.

3.2 How BESS Solves the Peak Tariff Problem

BESS acts as a **peak tariff shield** through two mechanisms documented in utility-scale deployment literature [9, 4]:

3.2.1 Mechanism 1: Peak Arbitrage

The arbitrage mechanism follows stochastic optimization principles [1, 2]:

$$R_{arb} = \sum_{d=1}^{365} \left[E_{discharge,d} \times \left(P_{peak} - \frac{P_{offpeak}}{\eta_{BESS}} \right) \right] \quad (5)$$

At full deployment (121.94 MWh): **R64.13M/year pure profit**

3.2.2 Mechanism 2: Demand Charge Reduction

Demand charge savings follow peak shaving optimization [4]:

$$S_{demand} = \Delta_{kVA} \times P_{demand} \times 12 \quad (6)$$

Where:

- Δ_{kVA} = Peak demand reduction (200 kVA per MWh BESS)
- P_{demand} = Demand charge rate (R44.32/kVA/month)

At full deployment: 24,388 kVA reduction \times R44.32/kVA/month \times 12 months = **R12.97M/year**
Total BESS Value at Full Deployment: R77.10M/year

3.3 Why BESS Becomes MORE Valuable Over Time

Eskom tariffs are escalating at **10% per year**, while SSEG costs escalate at only **6% per year** (CPI+1%). This creates a widening arbitrage opportunity documented in long-term energy storage studies [16, 10]:

Year	Peak Tariff	Off-Peak Tariff	Arbitrage Spread
Year 1 (2026)	R3.50/kWh	R1.08/kWh	R2.42/kWh
Year 5 (2030)	R5.64/kWh (+61%)	R1.74/kWh (+61%)	R3.90/kWh (+61%)
Year 10 (2035)	R9.10/kWh (+160%)	R2.81/kWh (+160%)	R6.29/kWh (+160%)

Table 1: Eskom Tariff Escalation and Growing BESS Arbitrage Opportunity

As Eskom tariffs escalate, BESS arbitrage profit grows proportionally. By Year 10, BESS will be generating **R167M/year** in pure profit — more than the entire current electricity budget.

3.4 High-Demand Season: BESS Critical Role

During the **high-demand winter season (June–August)**, Eskom peak tariffs reach their maximum, creating the exact scenario where BESS provides maximum value [17]:

Scenario	High-Season Cost
Without BESS	~R18M (3 months)
With BESS	~R6M (3 months)
Savings	~R12M (67% reduction)

Table 2: BESS Impact During High-Demand Winter Season

4 Eskom Virtual Wheeling: Unlocking Additional BESS Revenue

4.1 The Virtual Wheeling Opportunity

Beyond internal arbitrage, the BESS system can generate **additional revenue** by selling excess stored capacity back to Eskom through the **Eskom Virtual Wheeling** program. This peer-to-peer energy trading mechanism creates a third revenue stream [12, 13, 14].

4.2 How Virtual Wheeling Works

4.2.1 Mechanism Overview

Virtual wheeling enables energy communities to trade stored energy through the grid infrastructure [13]:

1. **BESS Charges During Off-Peak:** At R1.08/kWh (22:00–06:00)
2. **BESS Discharges to Eskom During Peak:** At R1.65/kWh (Virtual Wheeling rate)
3. **Revenue is Generated:** R0.57/kWh spread \times 90% efficiency = R0.51/kWh net gain
4. **Revenue Application:** Used for historical debt settlement, then municipal income

4.2.2 Mathematical Framework

The Virtual Wheeling revenue can be calculated as:

$$R_{VW} = (P_{VW} - P_{OP}) \times \eta_{BESS} \times E_{excess} \times 365 \quad (7)$$

Where:

- R_{VW} = Annual Virtual Wheeling Revenue
- P_{VW} = Virtual Wheeling selling price (R1.65/kWh)
- P_{OP} = Off-peak charging cost (R1.08/kWh)
- η_{BESS} = BESS round-trip efficiency (90%)
- E_{excess} = Daily excess BESS capacity available for wheeling (MWh)

4.3 BESS Capacity Growth and Excess Availability

As the BESS footprint grows from 4 MWh (Q1 2026) to 121.94 MWh (Q3 2026), the **excess capacity** available for Virtual Wheeling increases dramatically, following optimal sizing principles [12, 14]:

Period	BESS Capacity	Internal Use	Excess for VW
Q1 2026	4.0 MWh	3.2 MWh (80%)	0.8 MWh (20%)
Q2 2026	63.0 MWh	50.4 MWh (80%)	12.6 MWh (20%)
Q3 2026	121.94 MWh	97.6 MWh (80%)	24.3 MWh (20%)

Table 3: BESS Capacity Growth and Excess Availability for Virtual Wheeling

Key Insight: Even at 80% depth-of-discharge for internal arbitrage, the growing BESS footprint creates **24.3 MWh/day** of excess capacity at full deployment that can be monetized through Virtual Wheeling.

4.4 Virtual Wheeling Revenue Calculation

4.4.1 At Full Deployment (Q3 2026)

Using Equation (6):

$$R_{VW} = (R1.65 - R1.08) \times 0.90 \times 24.3 \text{ MWh/day} \times 365 \text{ days}$$

$$R_{VW} = R0.57 \times 0.90 \times 8,869.5 \text{ MWh/year}$$

$$R_{VW} = \mathbf{R4.55 \text{ million per year}}$$

4.4.2 Enhanced Revenue with Peak-Period Wheeling

If excess BESS capacity is strategically wheeled during **high-demand peak periods** (when Eskom’s internal costs are highest), the Virtual Wheeling rate can increase to **R2.50/kWh**:

$$R_{VW,peak} = (R2.50 - R1.08) \times 0.90 \times 24.3 \times 365$$

$$R_{VW,peak} = \mathbf{R11.33 \text{ million per year}}$$

4.4.3 Conservative Blended Scenario

Assuming 50% of wheeling occurs at standard rate (R1.65) and 50% at peak rate (R2.50):

$$R_{VW,blended} = 0.5 \times R_{VW,standard} + 0.5 \times R_{VW,peak} = \mathbf{R7.94 \text{ million per year}} \quad (8)$$

4.5 Application Hierarchy: Debt Settlement → Municipal Income

The Virtual Wheeling revenue follows a strategic application hierarchy consistent with community energy storage business models [11, 8]:

4.5.1 Phase 1: Historical Eskom Debt Settlement (Years 1–3)

- **Objective:** Settle outstanding Eskom debt using Virtual Wheeling revenue
- **Mechanism:** Virtual Wheeling credits applied directly to Eskom account
- **Benefit:** Eliminates interest charges and penalties on historical debt
- **Timeline:** Assuming R24M historical debt, settled within 3 years at R7.94M/year

$$T_{debt} = \frac{D_{historical}}{R_{VW,blended}} = \frac{R24M}{R7.94M/year} \approx 3.0 \text{ years} \quad (9)$$

4.5.2 Phase 2: Offsetting Off-Peak BESS Charge Cost (Years 4+)

Once debt is settled, Virtual Wheeling revenue is applied to **offset the Off-peak charging cost** of the BESS system:

- **Annual Off-Peak Charge Cost:** At full deployment, BESS charges 97.6 MWh/day × 365 days × R1.08/kWh = **R38.48M/year**
- **Virtual Wheeling Offset:** R7.94M/year covers 20.6% of Off-peak charge cost
- **Net Off-Peak Cost:** R38.48M - R7.94M = **R30.54M/year**

This **reduces the effective arbitrage cost**, further increasing the BESS value proposition:

$$P_{arb,enhanced} = P_{arb,base} + R_{VW,offset} = R64.13M + R7.94M = \mathbf{R72.07M/year} \quad (10)$$

4.5.3 Phase 3: NEW Municipal Income (Years 4+)

Any Virtual Wheeling revenue beyond Off-peak cost offset becomes **pure municipal income**:

- Can be treated as **credit on Eskom account**, reducing future electricity bills
- Can be allocated to **service delivery, infrastructure, or capital projects**
- Creates a **sustainable revenue stream** independent of municipal rates and taxes

4.6 Strategic Value of Virtual Wheeling

VIRTUAL WHEELING: THE FOURTH REVENUE STREAM

Virtual wheeling transforms BESS from a “cost-saving device” into a **revenue-generating asset**, consistent with peer-to-peer energy trading literature [12, 15]:

Revenue Stream Hierarchy:

1. **PV Profit:** R86.92M/year (after covering BESS cost)
2. **BESS Peak Arbitrage:** R64.13M/year (pure profit)
3. **BESS Demand Reduction:** R12.97M/year (pure profit)
4. **BESS Virtual Wheeling:** R7.94M/year (NEW revenue)

Total Enhanced Savings: R86.92M + R64.13M + R12.97M + R7.94M = **R171.96M/year**

Key Benefits:

- Accelerates debt settlement (3-year payoff vs. 5+ years without VW)
- Offsets 20.6% of BESS Off-peak charge cost, increasing arbitrage margin
- Creates new municipal income stream once debt is settled
- Further protects against Eskom tariff escalation

4.7 10-Year Virtual Wheeling Projection

As Eskom tariffs escalate at 10%/year, the Virtual Wheeling rate (R1.65/kWh base) will also escalate, creating **growing revenue over time** [10]:

Year	VW Rate (Blended)	Annual VW Revenue	Cumulative
2026	R2.08/kWh	R7.94M	R7.94M
2027	R2.28/kWh	R8.73M	R16.67M
2028	R2.51/kWh	R9.61M	R26.28M
2029	R2.76/kWh	R10.57M	R36.85M
2030	R3.04/kWh	R11.62M	R48.47M
2031	R3.34/kWh	R12.79M	R61.26M
2032	R3.68/kWh	R14.07M	R75.33M
2033	R4.05/kWh	R15.47M	R90.80M
2034	R4.45/kWh	R17.02M	R107.82M
2035	R4.90/kWh	R18.72M	R126.54M
10-Year Total VW Revenue:			R126.54M

Table 4: 10-Year Virtual Wheeling Revenue Projection (Escalated)

Strategic Implication: Over 10 years, Virtual Wheeling generates an additional **R126.54 million** in revenue, bringing total savings from **R3.67 billion to R3.80 billion**.

5 Growth Trajectory: Q1 2026 to Q3 2026

5.1 Current State (Q1 2026 — March)

Installed Capacity:

- PV: 2.6 MWp
- BESS: 4 MWh

Financial Performance:

- PV Gross Profit: R2.51M/year
- BESS Cost: R1.50M/year (covered by PV)
- Remaining PV Profit: R1.01M/year
- BESS Arbitrage Profit: R2.53M/year (pure profit)
- Virtual Wheeling Revenue: R0.15M/year (0.8 MWh excess)
- **Total Net Savings: R3.69M/year (R307k/month)**

Eskom Dependency: 97.1% (still heavily reliant on Eskom)

5.2 Mid-Point (Q2 2026 — June)

Installed Capacity:

- PV: 70.1 MWp (+2,593% growth)
- BESS: 63 MWh (+1,474% growth)

Financial Performance:

- PV Gross Profit: R67.58M/year
- BESS Cost: R23.61M/year (covered by PV)
- Remaining PV Profit: R43.96M/year
- BESS Arbitrage Profit: R39.81M/year (pure profit)
- Virtual Wheeling Revenue: R2.46M/year (12.6 MWh excess)
- **Total Net Savings: R86.24M/year (R7.19M/month)**

Eskom Dependency: 32.8% (majority now from SSEG)

5.3 Target Deployment (Q3 2026 — September)

Installed Capacity:

- PV: 137.61 MWp (full deployment)
- BESS: 121.94 MWh (full deployment)

Financial Performance:

- PV Gross Profit: R132.65M/year
- BESS Cost: R45.73M/year (covered by PV)
- Remaining PV Profit: R86.92M/year
- BESS Arbitrage Profit: R77.10M/year (pure profit)
- Virtual Wheeling Revenue: R7.94M/year (24.3 MWh excess)
- **Total Net Savings: R171.96M/year (R14.33M/month)**

Eskom Dependency: -34.1% (SSEG generates MORE value than Eskom baseline cost!)

This means the municipality will be EARNING R43.71M/year from its SSEG system — a complete reversal from being a cost center to a profit center.

6 Ten-Year Financial Outlook (2026–2035)

6.1 Escalation Assumptions

Based on historical trends and energy storage economics literature [10, 17]:

- **Eskom Tariffs:** 10% annual escalation (historical average)
- **SSEG Costs:** 6% annual escalation (CPI+1%)
- **Virtual Wheeling Rates:** 10% annual escalation (tied to Eskom tariffs)
- **Baseline Cost Growth:** R128.25M (2026) → R302.41M (2035)

6.2 Annual Savings Projection (Including Virtual Wheeling)

Table 5: 10-Year Financial Projection with Virtual Wheeling
(Full Deployment)

Year	Baseline Cost	Cost with SSEG	Annual Savings	Savings %
2026	R 128.25M	-R 43.71M	R 171.96M	+134.1%
2027	R 141.08M	-R 63.10M	R 204.18M	+144.7%
2028	R 155.18M	-R 85.23M	R 240.41M	+154.9%
2029	R 170.70M	-R 110.39M	R 281.09M	+164.7%
2030	R 187.77M	-R 138.93M	R 326.71M	+174.0%
2031	R 206.55M	-R 171.26M	R 377.81M	+182.9%
2032	R 227.21M	-R 207.79M	R 435.00M	+191.4%
2033	R 249.93M	-R 249.03M	R 498.96M	+199.6%
2034	R 274.92M	-R 295.57M	R 570.49M	+207.5%
2035	R 302.41M	-R 347.99M	R 650.41M	+215.1%
Total 10-Year Savings:			R 3.76 Billion	

6.3 Key Insights

6.3.1 1. Negative Cost with SSEG + Virtual Wheeling

- From Year 1, the municipality will have a **negative electricity cost** (earning money)
- By Year 10, the municipality will earn **R347.99M/year** from its SSEG system
- Virtual Wheeling adds **R126.54M over 10 years** to total savings

6.3.2 2. Accelerating Savings

- Savings grow from R172M (Year 1) to R650M (Year 10)
- **278% increase** in annual savings over 10 years
- This acceleration is driven by Eskom's 10% escalation vs SSEG's 6% escalation

6.3.3 3. Cumulative Wealth Creation

- R3.76 billion in cumulative savings over 10 years (including Virtual Wheeling)
- This is equivalent to **29.3 years** of current electricity budget
- These funds can be redirected to service delivery, infrastructure, and community development

7 Strategic Implications

7.1 Energy Independence

At full deployment, the municipality achieves **energy sovereignty** through distributed generation and storage integration [9]:

- 229 GWh/year PV generation vs 71.6 GWh/year consumption = **320% self-sufficiency**
- BESS provides **24/7 electricity availability** through time-shifting
- **Resilience against load-shedding:** BESS can provide backup power during outages

7.2 Financial Sustainability

The SSEG program transforms electricity from a **cost burden into a revenue stream**:

- **Current:** R128.25M/year expense
- **Year 1 (Full Deployment):** R43.71M/year income
- **Year 10 (Full Deployment):** R347.99M/year income

This creates a **sustainable funding source** for municipal operations and capital projects.

7.3 Debt Settlement Acceleration

Virtual Wheeling provides a **dedicated revenue stream for historical debt settlement** [12]:

- **Historical Eskom Debt:** Estimated R24M
- **Settlement Timeline:** 3 years at R7.94M/year Virtual Wheeling revenue
- **Interest Savings:** Eliminates penalties and interest charges on outstanding debt
- **Credit Rating Impact:** Improved municipal credit rating through debt reduction

7.4 Environmental Impact

- **Annual CO2 Reduction:** ~229,000 tons (equivalent to removing 50,000 cars from roads)
- **Clean Energy Generation:** 100% renewable PV generation
- **National Climate Goals:** Contributes to South Africa's Paris Agreement commitments

7.5 Economic Development

- **Job Creation:** Construction, installation, maintenance, and operations employment
- **Local Procurement:** Opportunities for local businesses in supply chain
- **Skills Development:** Training in renewable energy technologies
- **Energy Security:** Attracts businesses seeking reliable, affordable electricity

8 Risk Mitigation

8.1 Eskom Tariff Risk

- **Risk:** Eskom tariffs continue escalating at 10%+ per year
- **Mitigation:** SSEG locks in lower escalation (6%), creating widening arbitrage opportunity [16]
- **Result:** Higher Eskom tariffs = HIGHER SSEG savings + HIGHER Virtual Wheeling revenue

8.2 Technology Risk

- **Risk:** PV/BESS technology failures or performance degradation
- **Mitigation:**
 - Proven technology with 25-year PV warranties
 - BESS with 10-year warranties and 80% depth-of-discharge limit [17]
 - Distributed architecture reduces single-point-of-failure risk

8.3 Regulatory Risk

- **Risk:** Changes to SSEG regulations or Virtual Wheeling tariff structures
- **Mitigation:**
 - Long-term SSEG purchase agreements with fixed rates
 - National policy support for renewable energy and wheeling programs
 - Municipal ownership provides regulatory stability
 - Virtual Wheeling governed by NERSA regulations with transparent rate-setting

8.4 Eskom Virtual Wheeling Program Risk

- **Risk:** Eskom Virtual Wheeling program discontinuation or rate changes
- **Mitigation:**
 - Virtual Wheeling is a **bonus revenue stream**, not core to SSEG viability
 - Core savings (R164M/year) remain intact even without Virtual Wheeling
 - Alternative revenue applications (e.g., selling to private buyers) can replace Eskom VW [13]
 - NERSA oversight ensures fair wheeling rates

9 Conclusion

The Dr. Beyers Naudé SSEG Multi-Asset Trading Framework represents a **transformational shift** in how the municipality manages electricity costs. By combining PV generation with BESS storage and Eskom Virtual Wheeling, we have created a system where:

1. **PV generates profit** by offsetting expensive Eskom retail rates
2. **PV profit covers BESS cost**, making BESS operationally “free”
3. **BESS arbitrage becomes pure profit** by exploiting peak/off-peak price differentials [1]
4. **BESS shields the municipality** from escalating Eskom peak tariffs, especially during high-demand winter periods
5. **Virtual Wheeling creates NEW revenue** for debt settlement and municipal income [12]

9.1 The Result is Unprecedented

- **R14.33M/month savings** at full deployment (Q3 2026)
- **R3.76 billion cumulative savings** over 10 years (including Virtual Wheeling)
- **R24M historical debt settled** within 3 years through Virtual Wheeling
- **Energy independence** and financial sustainability
- **Protection against Eskom tariff escalation** for decades to come

The BESS is not just a battery — it is a **strategic financial instrument that converts Eskom’s peak pricing into municipal revenue**. As Eskom tariffs continue to escalate, BESS becomes increasingly valuable, creating a **virtuous cycle of growing savings and financial resilience** [3, 9].

Virtual Wheeling adds a fourth dimension to this value creation, enabling the municipality to monetize excess BESS capacity, accelerate debt settlement, and create new income streams that further dilute Eskom dependency.

9.2 Recommendation

Accelerate deployment to Q3 2026 target to maximize savings capture, enable Virtual Wheeling revenue, and achieve energy independence before Eskom’s next tariff increase cycle.

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References

- [1] Tziovani, L., Hadjidemetriou, L., Kyriakides, E. (2022). Energy Storage Arbitrage and Peak Shaving in Distribution Grids Under Uncertainty. *IEEE PES ISGT-Europe*. DOI: 10.1109/ISGT-Europe54678.2022.9960373.
- [2] Rauf, A., Kassas, M., Khalid, M. (2022). Data-Driven Optimal Battery Storage Sizing for Grid-Connected Hybrid Distributed Generations. *Sustainability*, 14(17):11002. DOI: 10.3390/su141711002.
- [3] Pimm, A. J., Palczewski, J., Morris, R., et al. (2020). Community energy storage: A case study in the UK using a linear programming method. *Energy Conversion and Management*, 205:112388. DOI: 10.1016/J.ENCONMAN.2019.112388.
- [4] Greco, B., et al. (2023). Optimal end-users electrification management: a BESS-based DSO approach. *ICCEP Proceedings*. DOI: 10.1109/iccep57914.2023.10247468.
- [5] Talent, O., Du, H. (2018). Optimal sizing and energy scheduling of photovoltaic-battery systems under different tariff structures. *Renewable Energy*, 129:513-526. DOI: 10.1016/J.RENENE.2018.06.016.
- [6] Zhang, S., Tang, Y. (2019). Optimal schedule of grid-connected residential PV generation systems with battery storages under time-of-use and step tariffs. *Journal of Energy Storage*, 23:302-314. DOI: 10.1016/J.EST.2019.01.030.
- [7] Wu, Y., et al. (2022). Energy management strategy and optimal battery capacity for flexible PV-battery system under time-of-use tariff. *Renewable Energy*, 200:558-570. DOI: 10.1016/j.renene.2022.09.118.
- [8] Zhu, B., Lu, J., Water, W., et al. (2018). Battery-based storage for communities. In *IET Power and Energy Series*, Chapter 10. DOI: 10.1049/PBPO130E_CH10.
- [9] Micallef, A., Staines, C. S., Cassar, A. (2022). Utility-Scale Storage Integration in the Maltese Medium-Voltage Distribution Network. *Energies*, 15(8):2724. DOI: 10.3390/en15082724.
- [10] Grace, B. (2023). Optimising generation and energy storage in the transition to net zero power networks. *Renewable Energy and Environmental Sustainability*. DOI: 10.1051/rees/2023008.
- [11] Li, M., et al. (2023). Stochastic optimal investment strategy for net-zero energy houses. *IET Renewable Power Generation*, 17:2981-2995. DOI: 10.1049/rpg2.12981.
- [12] Yaldız, A., et al. (2021). Optimal sizing and economic analysis of PV with BESS considering peer-to-peer energy trading. *Sustainable Energy, Grids and Networks*, 28:100540. DOI: 10.1016/J.SEGAN.2021.100540.

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- [13] López, I., Gomez-Cornejo, J., Aranzabal, I., et al. (2023). Photovoltaic Local Energy Communities—Design of New Energy Exchange Modalities. *Energies*, 16(10):4000. DOI: 10.3390/en16104000.
- [14] Chen, X., et al. (2023). Multi-objective optimization of battery capacity of grid-connected PV-BESS in hybrid building energy sharing community. *Applied Energy*, 348:121727. DOI: 10.1016/j.apenergy.2023.121727.
- [15] Pan, X., et al. (2022). Optimal planning of solar PV and battery storage with energy management systems for Time-of-Use and flat electricity tariffs. *IET Renewable Power Generation*, 16:2235-2248. DOI: 10.1049/rpg2.12433.
- [16] do Nascimento, Á. D. J., Rütther, R. (2020). Evaluating distributed photovoltaic generation to foster the adoption of energy storage systems in time-of-use frameworks. *Solar Energy*, 208:917-929. DOI: 10.1016/J.SOLENER.2020.08.045.
- [17] Bowen, T., Chernyakhovskiy, I., Denholm, P. (2019). Grid-Scale Battery Storage: Frequently Asked Questions. DOE Report NREL/TP-6A20-74426. DOI: 10.2172/1561843.

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