



VOLUME 2 · ENGINEERING REPORT

Advanced Energy Audit

Scope, method, data, balances, findings and one sheet per measure.

Demo Foods (Pty) Ltd (fictional)

Food processing: bakery and cold storage · Gauteng, South Africa (fictional site)

FICTIONAL DEMO

Demonstration report. Demo Foods (Pty) Ltd is a fictional company; its site, bills, readings, quotes and rates are invented to show the audit method. It describes no real client.

PREPARED FOR Demo Foods (Pty) Ltd (fictional)	PREPARED BY Thabiso Kali, Certified Energy Manager	AUDIT PERIOD July 2025 to June 2026	REPORT DATE 19 October 2026
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DATA LEVEL SUMMARY · SET PER SYSTEM, NEVER PER SITE

Level 3 Interval data	Refrigeration and chillers	12% of energy
Level 2 Equipment register	Compressed air · Steam and boilers · Process heat · Motors, pumps and fans · Lighting · HVAC and offices	82% of energy
Level 1 Bills	Electrical supply and tariff (demand, power factor, NMD)	all electricity

Standard: ISO 50002-1:2025 detailed audit; ASHRAE Standard 211 Level 2, refrigeration at Level 3.

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STATUS

Demonstration

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Engineering report

The evidence behind Volume 1. Every number carries its quality tag (measured, calculated, estimated or assumed) and, where known, its ±; references in blue link to the node, balance point, system or measure where the number is worked out.

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· DOCUMENT CONTROL

Report	Demo Foods (Pty) Ltd: Advanced Energy Audit (fictional demonstration)
Client	Demo Foods (Pty) Ltd (fictional)
Prepared by	Thabiso Kali, Certified Energy Manager
Audit standard	ISO 50002-1:2025 detailed audit; ASHRAE Standard 211 Level 2, refrigeration at Level 3
Audit period	July 2025 to June 2026
Issue	Revision 0, 19 October 2026: fictional demonstration
Project file	Demo Foods (Pty) Ltd: Advanced Energy Audit (fictional) (schema version 2, updated 2026-10-19)
Confidentiality	Fictional demonstration. Real client data is handled under POPIA and is never stored in this repository.

· HOW TO READ THE TAGS

MEASURED	Read from a meter, bill, nameplate or log.	CALCULATED	Worked out from other figures by the method stated.
ESTIMATED	A reading or judgement made on site, or a quote.	ASSUMED	A typical default, to be replaced with a site figure.
FIRM	Saving from site data, ±20% or better.	INDICATIVE	Rests on an assumed input or a wider ±: confirm first. Never added to firm.

Scope and boundaries

A ISO 50002-1:2025 detailed audit audit of Demo Foods (Pty) Ltd (fictional): every energy carrier that crosses the site boundary, every system that uses it, and the measures that would cut it.

1.1 THE SITE

Site	Demo Foods (Pty) Ltd (fictional) FICTIONAL
Sector and type	Food processing: bakery and cold storage (Food processing)
Location	Gauteng, South Africa (fictional site)
Floor area	9,500 m ² MEAS ±2%
Target data level	Level 2: equipment inventory
Operating hours	6,000 h a year EST ±5% · 24 h, 5.5 days a week, less public holidays
Relevant variables	Production (t, 12 months) MEAS ; Cooling degree-days (18 °C) (degree-days, 12 months) EST

1.2 BOUNDARY AND PERIOD

Objectives: Cut the energy bill by at least 15% with projects that pay back within three years, and set a baseline to track the savings against.

Boundary: Everything behind the utility meter at the fictional Gauteng site: the production halls, two tunnel ovens, the cold stores, the boiler house, offices, canteen and yard lighting. The standby generator is in; delivery vehicles are out. Energy is counted where it is bought, at the utility meter or the fuel delivery: electricity (Eskom account (fictional number)); LPG (Bulk LPG supply (fictional supplier)); diesel (Diesel for the standby generator (fictional supplier)). Energy made on site (steam, compressed air, cooling, heat) is traced inside the boundary from the carrier that makes it.

Period: July 2025 to June 2026, the latest 12 bills of each account. Site work: compressed-air no-load test 15 August 2026; steam-trap survey 20 August 2026; logged data: Refrigeration sub-board, 6 to 12 October 2025 (fictional logger data). The report date is 19 October 2026.

Not in scope: Transport fleet; the tenant's sub-metered packing room.

1.3 SYSTEMS IN SCOPE AND THEIR DATA LEVEL

SYSTEM	LEVEL	DATA BEHIND IT	HOW A NODE'S ENERGY IS ESTIMATED	TYPICAL ±
Electrical supply and tariff		1 12 to 24 months of bills per carrier	The carrier's metered total × a share from the walk-through	±30% or worse
Compressed air		2 Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%
Refrigeration and chillers		3 Half-hourly data, sub-meters or loggers, production	Measured energy annualised; regression baselines	about ±10-15%
Steam and boilers		2 Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%
Process heat		2 Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%
Motors, pumps and fans		2 Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%
Lighting		2 Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%
HVAC and offices		2 Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%

The level is set for each system (and can be overridden for one balance node), never for the whole site, because a site rarely has the same quality of data everywhere. Levels follow the logic of ASHRAE Standard 211-2018 and ISO 50002-1:2025; levels 3 and 4 together correspond to an ASHRAE Level 3 audit.

Method and standards

Each method is written in plain words with its formula and the public source behind it (the audit's method notes). Nothing is forced to agree: estimates are kept as entered and the remainder is shown.

2.1 STANDARDS FOLLOWED

STANDARD	TITLE	USED FOR
ISO 50002-1:2025	Energy audits, Part 1: general requirements	Audit process, scope and boundary, data collection, the energy balance and the report
ASHRAE Standard 211-2018	Commercial Building Energy Audits	Audit levels (walk-through, survey and analysis, detailed analysis) behind the data levels
ISO 50006:2023	Energy performance indicators and energy baselines	EnPIs, relevant variables and the regression baselines
ASHRAE Guideline 14-2014	Measurement of Energy, Demand and Water Savings	Baseline fit statistics: $CV(RMSE) \leq 15\%$ and $ NMBE \leq 5\%$ for monthly data
IPMVP (EVO, Core Concepts); SANS 50010	Measurement and verification of savings	M&V options A to D per measure, non-routine adjustments; SANS 50010 for South African M&V
JCGM 100:2008 (GUM)	Evaluation of measurement data: uncertainty	First-order propagation of the $\pm$ on every estimate
BS 845-1; EN 12953-11; ASME PTC 4	Boiler efficiency testing	Boiler efficiency by losses from a flue-gas test, checked by input and output (confirm editions)

2.2 Units and conversions

One internal unit per quantity: energy in kWh (kWh a year), power in kW, apparent power in kVA, mass in kg, temperature in °C, pressure in bar(g), money in rand. Bills and nameplates are converted once, at the edge, with the factor and its source stored on the account (Appendix A).

2.3 Uncertainty

Every number carries a quality tag and, where known, a $\pm$. Independent relative uncertainties combine in quadrature (GUM, JCGM 100:2008, first order):

$$\begin{aligned} \text{product: } u_{\text{rel}} &= \sqrt{(\sum u_{\text{rel},i}^2)} \\ \text{sum: } u_{\text{abs}} &= \sqrt{(\sum u_{\text{abs},i}^2)} \\ \text{gap a - b: } u_{\text{abs}} &= \sqrt{(u_a^2 + u_b^2)} \end{aligned}$$

Defaults by tag where no $\pm$ is stated: measured $\pm 3\%$, calculated $\pm 10\%$, estimated $\pm 15\%$, assumed $\pm 30\%$. A result is only as good as its weakest input and never better than calculated.

2.4 Bottom-up energy of an item

$$E = n \times P_{\text{rated}} \times \sum (LF \times h) / \eta$$

n is the count, P_{rated} the nameplate (input, or shaft output for motors), the sum runs over the operating modes, and $\eta = 1$ for an input-rated nameplate.

2.5 The energy balance

Top-down: each source's metered total is the sum of its latest 12 bills $\times$ the conversion factor. Bottom-up: an end use takes measured data at level 3 or above, otherwise the system model or the equipment register, otherwise a level-1 share. A conversion node needs input = output / η , and its loss is input – output.

$$\text{gap} = (E_{\text{metered}} - \sum E_i) / E_{\text{metered}}$$

The balance is never forced: the remainder is drawn as an unaccounted flow. Tolerance $\pm 10\%$ ($\pm 5\%$ where every node behind the point is at level 4), after the LEED existing-buildings audit (end uses within 10% of the bills) and the Australian Energy Efficiency Opportunities framework (80% of energy within $\pm 5\%$). Outside tolerance, contributors are ranked by value $\times$ uncertainty for review. Scaling of estimated items is optional, recorded and off for this audit.

2.6 System models and measures

Compressed air (part-load curves by control type, leak test, pressure), steam (Napier trap loss, bare-pipe heat loss, mass and energy balance with condensate and blowdown), refrigeration (constant fraction of Carnot COP), lighting and motors (affinity laws for VSDs, IE classes per IEC 60034-30-1). A measure is a step that turns one plant state into the next, so the balance and the savings always describe the same plant.

2.7 Sequencing

Measures on one system are applied in the order behaviour → controls → maintenance → retrofit → technology → heat recovery, each on the state the earlier ones left (as US DOE MEASUR does for compressed air). Each is also computed on its own, and the overlap removed is reported. Cross-system effects are noted, not netted.

2.8 EnPIs and baselines

Intensities per tonne and per m²; regression baselines following ISO 50006:2023, $E = b_0 + \sum b_j x_j$ by ordinary least squares, with fit statistics from ASHRAE Guideline 14-2014:

$$CV(RMSE) = 100 \times \sqrt{(\sum (y - \hat{y})^2 / (n - p)) / \bar{y}} \leq 15\%$$

$$NMBE = 100 \times \sum (y - \hat{y}) / ((n - p) \bar{y}), |NMBE| \leq 5\%$$

$R^2 \geq 0.75$ is shown as a rule of thumb only. Non-routine adjustments are recorded with month, description and kWh (IPMVP; SANS 50010).

2.11 SIMPLIFICATIONS IN THIS VERSION

- Independent uncertainties; no Monte Carlo.
- Compressors of different sizes averaged into identical units; receivers and pressure bands not modelled.
- Steam: trap steam taken as lost; flash steam and deaerator venting not modelled.

2.9 Rates and the business case

Savings are valued at average rates from the latest 12 bills: energy charges ÷ kWh, demand charges ÷ billed kVA, capacity charges ÷ (NMD × months). Energy savings claim no kVA saving unless the measure targets demand. NPV at 12%, escalation 8% a year, end-of-year cash flows over each measure's life; levelised cost of saved energy (LBNL):

$$LCSE = (\text{capex} \times CRF(r, n) + \Delta \text{opex}) / \text{kWh saved a year}$$

2.10 Firm and indicative savings

A saving is **firm** when its weakest input is measured, calculated or estimated (never assumed) and its ± is within ±20% (the equipment-register band). Otherwise it is **indicative**: it is evaluated as a separate case, never added to the firm case, and given 2 months to confirm before it is built. Screening ranges from the literature are shown for context only and never enter a measure's numbers.

- Refrigeration: constant fraction of Carnot; no part-load or defrost interaction.
- Motors: full-load efficiencies.
- One carrier per balance point; cross-system interactions warned about, not netted.

Data inventory

Every input with its pedigree: where it came from and how good it is. Assumed values are the first to replace with site readings.

3.1 ENERGY ACCOUNTS

ACCOUNT	CARRIER	BILLS	QUANTITY	KWH PER UNIT	ENERGY A YEAR	COST A YEAR	R/KWH	BASIS
Eskom account (fictional number) Megaflex-style time-of-use (fictional rates)	Electricity	12 Jul 25–Jun 26	2,945,004 kWh	1 as billed	2,945 MWh	R4,907,025	R1.67	MEAS ±2%
Bulk LPG supply (fictional supplier)	LPG	12 Jul 25–Jun 26	297,001 kg	13.139 LHV	3,902 MWh	R7,276,525	R1.86	ASSUM ±4%
Diesel for the standby generator (fictional supplier)	Diesel	12 Jul 25–Jun 26	6,500 litre	10.033 LHV	65 MWh	R148,200	R2.27	ASSUM ±6%
Site					6,912 MWh	R12,331,749	R1.78	

3.1.1 Eskom account (fictional number): monthly bills

MONTH	KWH	PEAK	STANDARD	OFF-PEAK	MAX DEMAND KVA	KW AT MD	PF AT MD	ENERGY CHARGE	DEMAND + CAPACITY	TOTAL	READING
Jul 25	237,392	37,983	104,452	94,957	515	443	0.86	R521,789	R37,230	R562,219	MEAS
Aug 25	227,192	36,351	99,964	90,877	493	424	0.86	R499,369	R36,306	R538,875	MEAS
Sep 25	239,492	38,319	105,376	95,797	531	462	0.87	R306,358	R37,902	R347,460	MEAS
Oct 25	246,692	39,471	108,544	98,677	536	461	0.86	R315,568	R38,112	R356,880	MEAS
Nov 25	263,792	42,207	116,068	105,517	599	509	0.85	R337,443	R40,758	R381,401	MEAS
Dec 25	268,892	43,023	118,312	107,557	584	502	0.86	R343,967	R40,128	R387,295	MEAS
Jan 26	248,792	39,807	109,468	99,517	533	464	0.87	R318,255	R37,986	R359,441	MEAS
Feb 26	260,192	41,631	114,484	104,077	626	538	0.86	R332,838	R41,892	R377,930	MEAS
Mar 26	248,192	39,711	109,204	99,277	545	463	0.85	R317,487	R38,490	R359,177	MEAS
Apr 26	240,392	38,463	105,772	96,157	540	464	0.86	R307,510	R38,280	R348,990	MEAS
May 26	231,692	37,071	101,944	92,677	498	433	0.87	R296,380	R36,516	R336,096	MEAS
Jun 26	232,292	37,167	102,208	92,917	521	448	0.86	R510,579	R37,482	R551,261	MEAS

3.1.2 Bulk LPG supply (fictional supplier): monthly bills

MONTH	KG	KWH	ENERGY CHARGE	TOTAL	READING
Jul 25	24,027	315,688	R588,662	R588,662	MEAS
Aug 25	25,397	333,688	R622,227	R622,227	MEAS
Sep 25	24,560	322,691	R601,720	R601,720	MEAS
Oct 25	24,636	323,690	R603,582	R603,582	MEAS
Nov 25	26,462	347,681	R648,319	R648,319	MEAS
Dec 25	26,767	351,689	R655,792	R655,792	MEAS
Jan 26	22,505	295,691	R551,373	R551,373	MEAS
Feb 26	24,179	317,685	R592,386	R592,386	MEAS
Mar 26	24,484	321,693	R599,858	R599,858	MEAS
Apr 26	24,940	327,684	R611,030	R611,030	MEAS

MONTH	KG	KWH	ENERGY CHARGE	TOTAL	READING
May 26	24,408	320,694	R597,996	R597,996	MEAS
Jun 26	24,636	323,690	R603,582	R603,582	MEAS

3.1.3 Diesel for the standby generator (fictional supplier): monthly bills

MONTH	LITRE	KWH	ENERGY CHARGE	TOTAL	READING
Jul 25	0	0	R0	R0	MEAS
Aug 25	3,000	30,100	R68,400	R68,400	MEAS
Sep 25	0	0	R0	R0	MEAS
Oct 25	0	0	R0	R0	MEAS
Nov 25	0	0	R0	R0	MEAS
Dec 25	0	0	R0	R0	MEAS
Jan 26	2,000	20,067	R45,600	R45,600	MEAS
Feb 26	0	0	R0	R0	MEAS
Mar 26	0	0	R0	R0	MEAS
Apr 26	0	0	R0	R0	MEAS
May 26	1,500	15,050	R34,200	R34,200	MEAS
Jun 26	0	0	R0	R0	MEAS

3.2 RELEVANT VARIABLES

VARIABLE	JUL 25	AUG 25	SEP 25	OCT 25	NOV 25	DEC 25	JAN 26	FEB 26	MAR 26	APR 26	MAY 26	JUN 26	YEAR	BASIS
Production t	760	770	740	780	800	860	690	720	770	740	760	750	9,140	MEAS
Cooling degree-days (18 °C) degree-days	1	5	25	55	70	90	100	85	70	30	8	2	541	EST

Production: Monthly production report (fictional). Cooling degree-days (18 °C): Illustrative values, not station data.

3.3 LOGGED AND INTERVAL DATA

PROFILE	INTERVAL	READINGS	ENERGY LOGGED	PEAK	BASIS
Refrigeration sub-board, 6 to 12 October 2025 (fictional logger data) from 2025-10-06 00:00 · Clip-on power logger on the refrigeration sub-board incomer (fictional)	30 min	336	16 MWh	138.5 kW	MEAS

3.4 EQUIPMENT REGISTER

$E = n \times P \times \Sigma(LF \times h) / \eta$ per item. Where a system model owns a node (compressed air, steam), the model's terms replace the item estimates in the balance (§4); the register still records the plant.

ITEM	COUNT	RATING	OPERATING MODES (LOAD FACTOR × HOURS)	ENERGY A YEAR	BASIS
COMPRESSED AIR					
Screw compressors, 55 kW fixed speed (fictional make) node Compressed air · electricity	2 MEAS	61.0 kW MEAS	Running: 60% EST × 8,760 h MEAS	641 MWh	EST ±16%

ITEM	COUNT	RATING	OPERATING MODES (LOAD FACTOR × HOURS)	ENERGY A YEAR	BASIS
REFRIGERATION AND CHILLERS					
Freezer plant compressors (−25 °C store and blast freezer) node Refrigeration · electricity	3 MEAS	37.0 kW MEAS	Running: 55% EST × 8,760 h EST	535 MWh	EST ±21%
Chill plant compressors (+2 °C store and dispatch) node Refrigeration · electricity	2 MEAS	22.0 kW MEAS	Running: 50% EST × 8,760 h EST	193 MWh	EST ±21%
Evaporator fans node Refrigeration · electricity	24 MEAS	0.75 kW MEAS	Running: 85% EST × 8,760 h EST	134 MWh	EST ±21%
Electric defrost heaters node Refrigeration · electricity	18 MEAS	4.50 kW MEAS	Defrosting: 100% MEAS × 548 h EST	44 MWh	EST ±16%
STEAM AND BOILERS					
Proofers: humidification and heating node Proofers · steam	2 MEAS	65.0 kW CALC	In use: 60% EST × 6,000 h EST	468 MWh	EST ±23%
Crate and tray washer node Crate washer · steam	1 MEAS	159.0 kW CALC	In use: 50% EST × 4,500 h EST	358 MWh	EST ±23%
Calorifier: hot water for cleaning node Hot water (calorifier) · steam	1 MEAS	101.0 kW CALC	In use: 45% EST × 5,500 h EST	250 MWh	EST ±23%
PROCESS HEAT					
Tunnel oven burners (2 ovens) node Tunnel ovens · lpg	2 MEAS	400.0 kW MEAS	Baking: 42% EST × 5,600 h EST Idle at temperature: 15% EST × 900 h EST	1,990 MWh	EST ±20%
Oven conveyors, recirculation and burner fans node Tunnel ovens · electricity	2 MEAS	18.5 kW MEAS	Running: 75% EST × 6,500 h EST	180 MWh	EST ±21%
MOTORS, PUMPS AND FANS					
Dough mixers node Motors, pumps and fans · electricity	4 MEAS	30.0 kW shaft MEAS η 93.6%	Mixing: 45% EST × 3,000 h EST	173 MWh	EST ±22%
Oven-hall extraction fans node Motors, pumps and fans · electricity	2 MEAS	22.0 kW shaft MEAS η 93.0%	Running: 77% EST × 5,500 h EST	200 MWh	EST ±22%
Cooling-water and process pumps node Motors, pumps and fans · electricity	3 MEAS	11.0 kW shaft MEAS η 91.4%	Running: 70% EST × 6,000 h EST	152 MWh	EST ±22%
Conveyors, dividers and moulders node Motors, pumps and fans · electricity	30 MEAS	1.50 kW shaft MEAS η 82.8%	Running: 55% EST × 6,000 h EST	179 MWh	EST ±22%
Boiler feed pump and burner fan node Motors, pumps and fans · electricity	2 MEAS	7.50 kW shaft MEAS η 90.4%	Running: 60% EST × 6,500 h EST	65 MWh	EST ±22%
LIGHTING					
Production hall: twin 58 W T8 battens node Lighting · electricity	160 MEAS	0.13 kW MEAS	Lit: 100% MEAS × 6,500 h EST	135 MWh	EST ±16%
Warehouse and dispatch: 400 W metal-halide high bays node Lighting · electricity	36 MEAS	0.46 kW MEAS	Lit: 100% MEAS × 6,000 h EST	98 MWh	EST ±16%
Cold stores: twin 58 W T8 battens node Lighting · electricity	40 MEAS	0.13 kW MEAS	Lit: 100% MEAS × 8,760 h EST	46 MWh	EST ±16%
Offices and canteen: 4 × 18 W T8 troffers node Lighting · electricity	90 MEAS	0.08 kW MEAS	Lit: 100% MEAS × 2,800 h EST	20 MWh	EST ±16%
External: 250 W sodium floodlights node Lighting · electricity	18 MEAS	0.28 kW MEAS	Lit: 100% MEAS × 4,200 h EST	21 MWh	EST ±16%

ITEM	COUNT	RATING	OPERATING MODES (LOAD FACTOR × HOURS)	ENERGY A YEAR	BASIS
HVAC AND OFFICES					
Office split units node HVAC and offices · electricity	14 MEAS	3.50 kW MEAS	Cooling: 55% EST × 2,600 h EST	70 MWh	EST ±21%
Servers and IT node HVAC and offices · electricity	1 MEAS	3.00 kW MEAS	Always on: 100% EST × 8,760 h MEAS	26 MWh	EST ±16%
Canteen and office equipment node HVAC and offices · electricity	1 MEAS	25.0 kW MEAS	Office hours: 35% EST × 2,800 h EST	24 MWh	EST ±21%

3.5 SURVEY RECORDS

Compressed air

Generation pressure	7.5 bar(g) MEAS ±2%
Highest end-use need	6.6 bar(g) EST ±5%
Full production	8.6 m³/min for 3,600 h
One line or changeovers	5.0 m³/min for 1,800 h
Cleaning and breaks	2.0 m³/min for 600 h
No production, compressors left on	0.0 m³/min for 2,760 h
No-load leak test	21 s loaded, 44 s unloaded, 1 unit, 2026-08-15
Leak target	10% EST ±20%

Steam and boilers

Steam pressure	8.0 bar(g) MEAS ±2%
Achievable boiler efficiency	84% EST ±3%
Combustion test	300 °C at 8.0% O ₂ , 2026-08-18
Efficiency by losses	81.3% EST ±2%
Efficiency, direct	80.6% ASSUM ±3%
The two methods	agree within their uncertainty
Efficiency in the balance	80.0% EST ±4%
Pressurised hours	6,500 h EST ±5%
Condensate returned	40% EST ±15%
Condensate temperature	85 °C EST ±5%
Blowdown	4% ASSUM ±50%
Traps failed open	6 of 60 (2026-08-20)
Steam leaks	2 small, 0 medium, 0 large (2026-08-20)
Bare pipe	42 m in 3 runs
Water cost	R48/m³ EST ±10%

Electrical supply and tariff

Target power factor	0.98
Capacitor cost	R680/kvar EST ±10%
Supply voltage	400 V

3.6 INTERVAL DATA AND THE LOAD PROFILE

Level 3 data. Each meter's readings are read as confirmed on import (kWh per interval or average kW, the multiplier, whether a timestamp marks the start or the end of its interval, South African Standard Time), put on a regular grid and checked. Gaps stay gaps: every figure below leaves them out, and a short gap is filled only where a cleaning rule says so (flagged, estimated). Baseload: P5 of nights (22:00–05:00), weekends and public holidays. Percentiles interpolate between readings (Excel PERCENTILE.INC).

3.6.1 Data quality

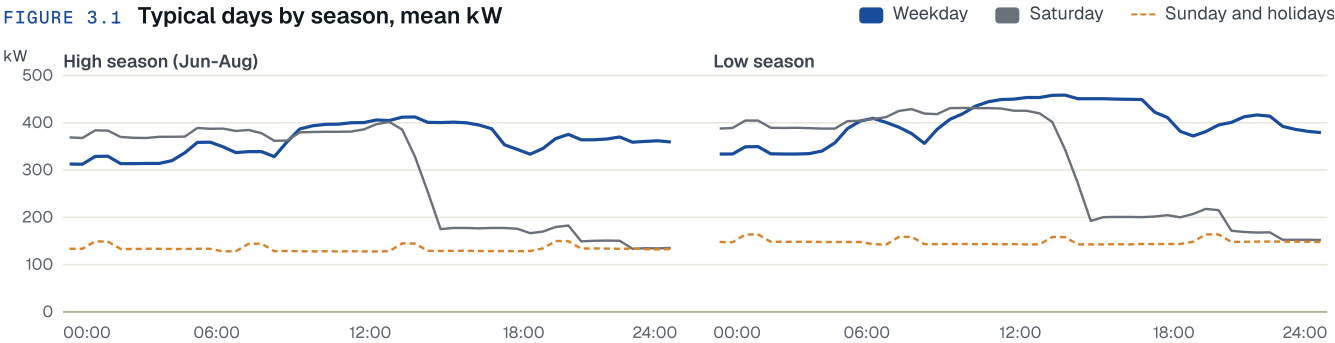
METER	INTERVAL	PERIOD	COMPLETE	GAPS	DUPLICATES	FLAGGED	READ AS	TAG
Main incomer, utility AMR half-hourly (fictional) Utility AMR portal export for the main incomer, July 2025 to June 2026 (fictional, made by a seeded generator)	30 min	2025-07-01 + 365 d	99.98%	1 (2)	0	0	kWh/interval, end-stamped, × 1.000 The columns say kWh and kVArh per half hour.	MEAS

- 1 gap, 2 intervals in all; the longest is 1 h.

3.6.2 The load profile

Energy	2,944 MWh over 365 days
Average and peak demand	336.1 and 541.8 kW (622.8 kVA, power factor 0.87 at the kVA peak; 0.84 on average)
Load factor	62.0% (average ÷ peak); 63.9% on kVA
Baseload	126.0 kW, P5 of nights (22:00–05:00), weekends and public holidays (8,986 readings)
Outside operating hours	333 MWh a year; 71 MWh of it above the baseload. Hours: Production schedule: 24 h Monday to Saturday 13:00, idle on Sundays and public holidays (fictional) (estimated)

FIGURE 3.1 Typical days by season, mean kW



Mean of each 30-minute slot over the days of each type: high season weekdays 65, high season Saturdays 12, high season Sundays 15, low season weekdays 186, low season Saturdays 38, low season Sundays 49.

FIGURE 3.2 Load duration curve

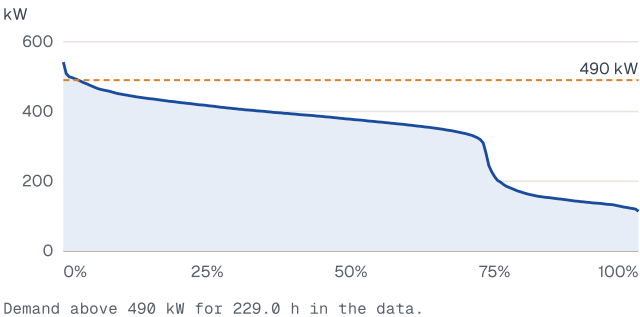
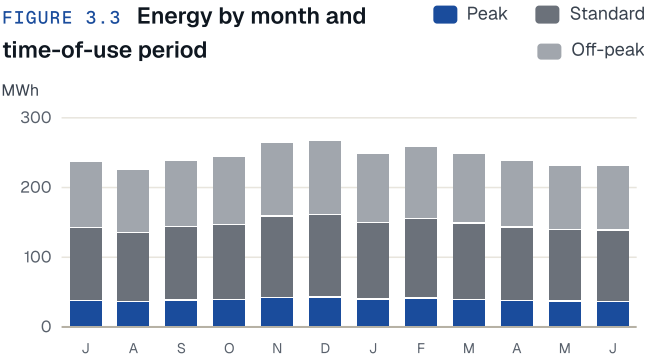
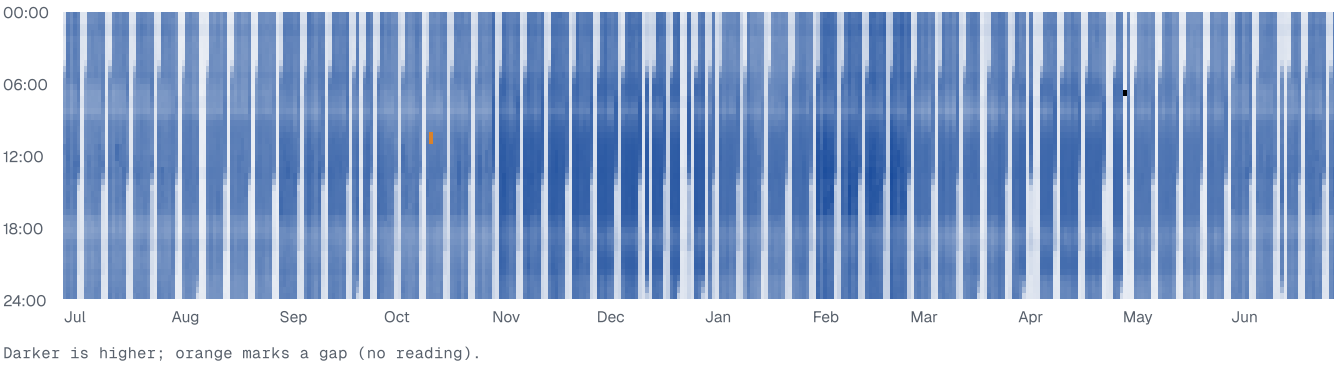


FIGURE 3.3 Energy by month and time-of-use period



Default schedule – verify against the current Eskom tariff book.
Peak 16.0%, standard 44.0%, off-peak 40.0%.

FIGURE 3.4 Heatmap: demand by date (across) and time of day (down), 114 to 542 kW



3.6.3 Check against the bills

12 of 12 months within ±2% of the bill; over 12 whole months the interval data is −0.04% against the bills. Within ±2% with 98% coverage is a match; up to ±5% is close (billing periods rarely follow calendar months).

MONTH	INTERVAL KWH	BILL KWH	DIFFERENCE	COVERAGE	PEAK KWH VS BILL	MAX KVA / BILL	STATUS
July 2025	238,104	237,392	+0.30%	100.0%	+0.3%	516 / 515	match
August 2025	226,283	227,192	−0.40%	100.0%	−0.4%	494 / 493	match
September 2025	239,971	239,492	+0.20%	100.0%	+0.2%	537 / 531	match
October 2025	245,069	246,692	−0.66%	99.9%	−0.5%	530 / 536	match
November 2025	264,847	263,792	+0.40%	100.0%	+0.4%	590 / 599	match
December 2025	268,354	268,892	−0.20%	100.0%	−0.2%	585 / 584	match
January 2026	250,036	248,792	+0.50%	100.0%	+0.5%	536 / 533	match
February 2026	259,411	260,192	−0.30%	100.0%	−0.3%	623 / 626	match
March 2026	248,440	248,192	+0.10%	100.0%	+0.1%	533 / 545	match
April 2026	238,950	240,392	−0.60%	100.0%	−0.6%	547 / 540	match
May 2026	232,387	231,692	+0.30%	100.0%	+0.3%	507 / 498	match
June 2026	231,828	232,292	−0.20%	100.0%	−0.2%	520 / 521	match

3.6.4 Peaks and peak shaving

The ten highest days

WHEN (SAST)	KW	KVA	PERIOD
2026-02-23 13:30	541.8	622.8	standard
2026-02-11 14:30	539.4	619.9	standard
2026-02-04 13:00	534.3	614.1	standard
2026-02-17 13:30	532.3	611.9	standard
2026-02-06 13:00	525.6	604.2	standard
2026-02-02 16:30	523.2	601.4	standard
2026-02-24 13:30	521.3	599.2	standard
2026-02-05 13:00	521.2	599.1	standard
2026-02-18 13:00	520.8	598.6	standard
2026-02-25 12:00	517.9	595.2	standard

Energy above each threshold (what a battery would shave)

HOLD TO	KWH A YEAR	DAYS	WORST DAY	POWER
515 kW	251	10	81 kWh	27 kW
490 kW	2,589	50	257 kWh	52 kW
460 kW	14,965	93	523 kWh	82 kW
435 kW	39,279	170	902 kWh	107 kW

Highest interval 541.8 kW at 2026-02-23 13:30. The peak-shaving rows are the battery sizer's inputs: the worst day's energy above the threshold is the usable capacity before losses, the excess power the inverter rating.

Energy and mass balance

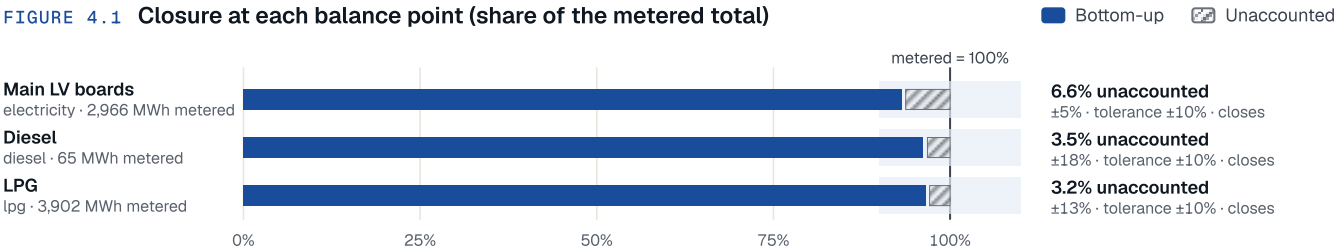
Metered totals (top-down, from bills) against the sum of end-use estimates (bottom-up), node by node.
321 MWh (4.6%) of the site's 6,912 MWh is unaccounted and stays visible as such.

4.1 BALANCE POINTS AND RECONCILIATION

BALANCE POINT	CARRIER	METERED	BOTTOM-UP	GAP	GAP ±	TOLERANCE	LEVEL	RESULT
Main LV boards	electricity	2,966.4 EST ±2%	2,771.8 EST ±5%	194.6 6.6%	±5.3%	±10%	2	CLOSES
Diesel	diesel	65.2 ASSUM ±6%	62.9 EST ±18%	2.3 3.5%	±18.3%	±10%	1	CLOSES
LPG	lpg	3,902.3 ASSUM ±4%	3,778.3 ASSUM ±13%	124.0 3.2%	±12.9%	±10%	2	CLOSES
Site		6,912.5	6,591.6	320.9 4.6%				

Values in MWh a year. Gap ± combines the meter and the bottom-up uncertainties in quadrature.

FIGURE 4.1 Closure at each balance point (share of the metered total)



Shaded band: the tolerance. The balance is never forced: the remainder is drawn as an unaccounted flow.

4.1.1 Largest uncertainties behind each balance point (value × uncertainty)

BALANCE POINT	CONTRIBUTOR	KIND	ENERGY	±	± KWH	BASIS
Main LV boards	Refrigeration (interval data, annualised)	Estimate	858 MWh	±12%	106,097	EST
	Oven-hall extraction fans	Estimate	200 MWh	±22%	43,024	EST
	Compressor plant (2 × 61 kW, part-load model)	Estimate	524 MWh	±7%	38,986	EST
	Oven conveyors, recirculation and burner fans	Estimate	180 MWh	±21%	38,644	EST
Diesel	Standby generator output (Runtime log × average load)	Fixed output	63 MWh	±15%	9,441	EST
	Standby generator efficiency (34%)	Efficiency	63 MWh	±10%	6,294	ASSUM
LPG	Tunnel oven burners (2 ovens)	Estimate	1,990 MWh	±20%	404,236	EST
	Proofers: humidification and heating	Estimate	585 MWh	±26%	151,863	EST
	Crate and tray washer	Estimate	447 MWh	±26%	116,006	EST
	Failed steam traps (6 open, Napier orifice estimate)	Estimate	157 MWh	±64%	100,370	ASSUM

Every point closes within tolerance; the ranking shows which estimate would narrow the gap's ± most. No estimate was scaled.

4.2 NODE BALANCES

NODE	KIND	SYSTEM	LEVEL	BASIS	IN	OUT	IN - OUT	SHARE OF SITE
Grid electricity	Source	Electrical supply and tariff	1	Bills	2,945.0	2,945.0	0.0	42.6%
Diesel	Source	–	1	Bills	65.2	65.2	0.0	0.9%
LPG	Source	–	1	Bills	3,902.3	3,902.3	0.0	56.5%

NODE	KIND	SYSTEM	LEVEL	BASIS	IN	OUT	IN - OUT	SHARE OF SITE
Standby generator	Conversion	Electrical supply and tariff	1	From its flows	62.9	62.9	0.0	0.9%
Generator losses	Loss	Electrical supply and tariff	1	From its flows	41.5	–	sink	0.6%
Main LV boards	Distribution	Electrical supply and tariff	1	From its flows	2,966.4	2,966.4	0.0	42.9%
Compressed air	End use	Compressed air	2	System model	523.7	–	sink	7.6%
Refrigeration register cross-check 906 MWh (+6%)	End use	Refrigeration and chillers	3	Interval data	857.7	–	sink	12.4%
Motors, pumps and fans	End use	Motors, pumps and fans	2	Equipment register	768.7	–	sink	11.1%
Tunnel ovens	End use	Process heat	2	Equipment register	2,170.0	–	sink	31.4%
Lighting	End use	Lighting	2	Equipment register	320.4	–	sink	4.6%
HVAC and offices	End use	HVAC and offices	2	Equipment register	120.9	–	sink	1.7%
Steam boiler	Conversion	Steam and boilers	2	From its flows	1,788.7	1,788.7	0.0	25.9%
Boiler flue and shell losses	Loss	Steam and boilers	2	From its flows	357.7	–	sink	5.2%
Boiler blowdown	Loss	Steam and boilers	2	System model	12.9	–	sink	0.2%
Steam mains	Distribution	Steam and boilers	2	From its flows	1,418.1	1,418.1	0.0	20.5%
Proofers	End use	Steam and boilers	2	System model	467.6	–	sink	6.8%
Crate washer	End use	Steam and boilers	2	System model	357.2	–	sink	5.2%
Hot water (calorifier)	End use	Steam and boilers	2	System model	250.0	–	sink	3.6%
Failed traps and steam leaks	Loss	Steam and boilers	2	System model	178.9	–	sink	2.6%
Bare pipe heat loss	Loss	Steam and boilers	2	System model	164.3	–	sink	2.4%
Unaccounted electricity	Unaccounted	–	2	From its flows	194.6	–	sink	2.8%
Unaccounted diesel	Unaccounted	–	1	From its flows	2.3	–	sink	0.0%
Unaccounted LPG	Unaccounted	–	2	From its flows	124.0	–	sink	1.8%

MWh a year. Sources show their metered total; sinks consume their inflow. Every non-sink node closes (in = out).

4.3 FLOWS

FROM	TO	CARRIER	ORIGIN	ENERGY	SHARE	BASIS
Grid electricity	Main LV boards	electricity	Metered	2,945.0	42.6%	MEAS ±2%
Diesel	Standby generator	diesel	Bottom-up	62.9	0.9%	ASSUM ±18%
Standby generator	Main LV boards	electricity	Fixed output	21.4	0.3%	EST ±15%
Standby generator	Generator losses	heat	Conversion loss	41.5	0.6%	ASSUM ±10%
Main LV boards	Compressed air	electricity	Bottom-up	523.7	7.6%	EST ±7%
Main LV boards	Refrigeration	electricity	Bottom-up	857.7	12.4%	EST ±12%
Main LV boards	Motors, pumps and fans	electricity	Bottom-up	768.7	11.1%	EST ±10%
Main LV boards	Tunnel ovens	electricity	Bottom-up	180.4	2.6%	EST ±21%
Main LV boards	Lighting	electricity	Bottom-up	320.4	4.6%	EST ±9%
Main LV boards	HVAC and offices	electricity	Bottom-up	120.9	1.7%	EST ±14%
LPG	Tunnel ovens	lpg	Bottom-up	1,989.6	28.8%	EST ±20%
LPG	Steam boiler	lpg	Bottom-up	1,788.7	25.9%	ASSUM ±14%

FROM	TO	CARRIER	ORIGIN	ENERGY	SHARE	BASIS
Steam boiler	Steam mains	steam	Bottom-up	1,418.1	20.5%	ASSUM ±14%
Steam boiler	Boiler flue and shell losses	heat	Conversion loss	357.7	5.2%	EST ±4%
Steam boiler	Boiler blowdown	heat	Bottom-up	12.9	0.2%	ASSUM ±50%
Steam mains	Proofers	steam	Bottom-up	467.6	6.8%	EST ±26%
Steam mains	Crate washer	steam	Bottom-up	357.2	5.2%	EST ±26%
Steam mains	Hot water (calorifier)	steam	Bottom-up	250.0	3.6%	EST ±26%
Steam mains	Failed traps and steam leaks	steam	Bottom-up	178.9	2.6%	ASSUM ±46%
Steam mains	Bare pipe heat loss	steam	Bottom-up	164.3	2.4%	EST ±29%
Main LV boards	Unaccounted electricity	electricity	Remainder	194.6	2.8%	CALC ±81%
Diesel	Unaccounted diesel	diesel	Remainder	2.3	0.0%	CALC ±526%
LPG	Unaccounted LPG	lpg	Remainder	124.0	1.8%	CALC ±406%

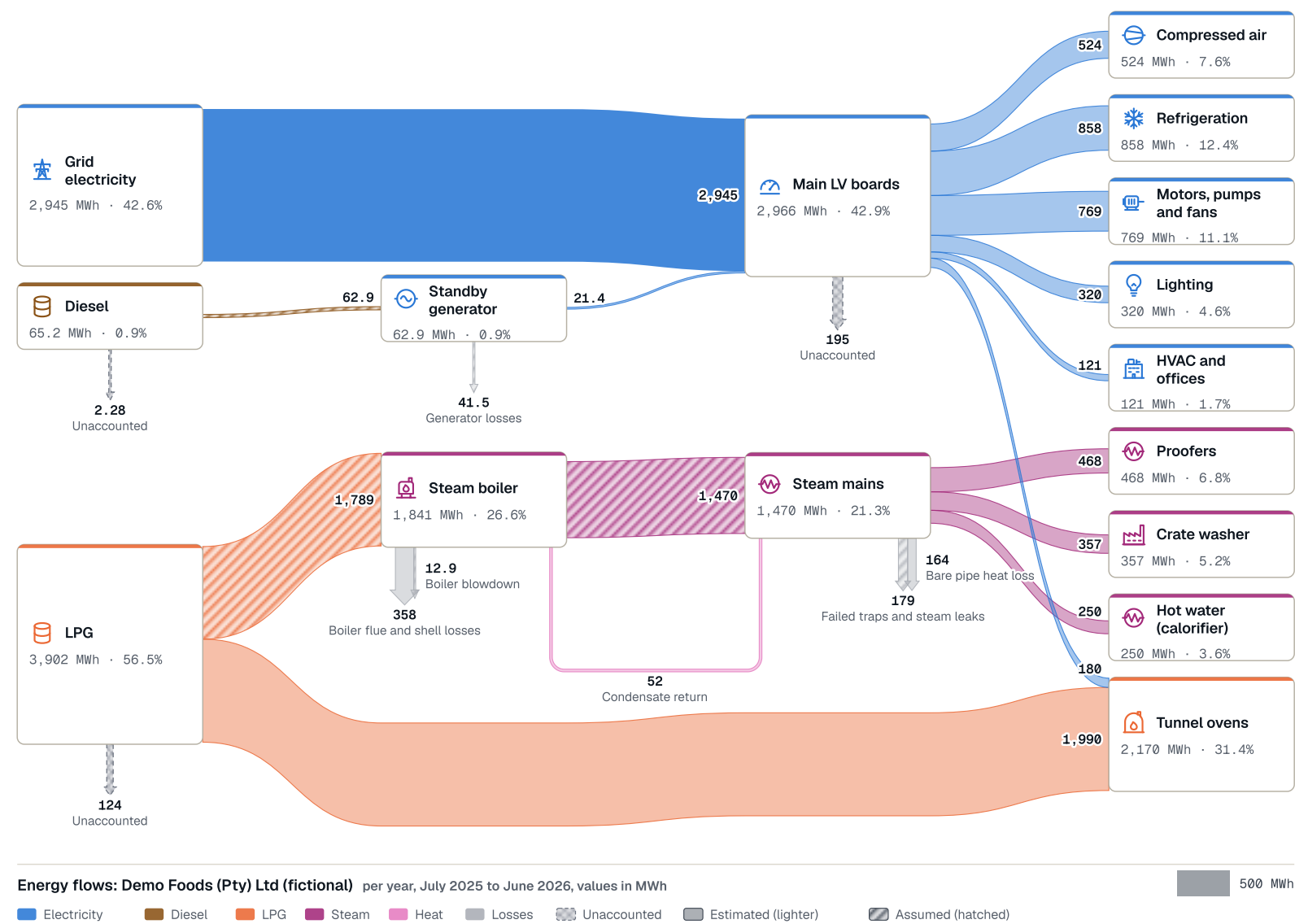
Recirculation, drawn as a loop and left out of the sums above: Condensate return, Steam mains back to Steam boiler: 52.0 MWh a year (Steam model: 687 t a year of condensate returned (40%) at 85 °C, above make-up water at 20 °C). Energy is taken above make-up water, so the loop adds the same energy in and out of each node it passes and changes no balance figure.

4.4 MASS BALANCE

Steam boiler: 1,996.9 t in against 2,047.0 t out a year, a gap of -2.4% (tolerance ±10%): closes. Mass constrains energy: the steam raised and its enthalpy rise fix the boiler's output.

STREAM	DIRECTION	MASS A YEAR	OBTAINED	BASIS
Make-up water (meter)	In	1,310.0 t	Given (meter or record)	MEAS
Condensate returned	In	686.9 t	Steam model (condensate return)	CALC
Steam raised	Out	1,965.1 t	Steam model (steam raised)	CALC
Blowdown	Out	81.9 t	Steam model (blowdown)	CALC

FIGURE 4.2 Energy flow diagram, July 2025 to June 2026



Every flow in §4.3, to one scale. Lighter flows are estimated, hatched flows assumed; dashed outlines are unaccounted. Losses fall from the node that loses them. Condensate return (52.0 MWh) is a loop back upstream: the same energy goes in and out of each node on the way, so the flows carrying it show more than §4.3, which is net of it.

Energy performance indicators and baselines

Intensities say how the site compares month to month; the regression baselines are the yardstick the savings will be measured against (ISO 50006:2023, ASHRAE Guideline 14-2014).

5.1 INTENSITIES

ENPI	CARRIERS	ANNUAL	MONTHLY RANGE	BEST MONTH	AFTER FIRM MEASURES
Electricity per tonne 2,945 MWh ÷ 9,140 t	Electricity	322 kWh/t	295–361	295 (Aug 25)	261 (–19%)
Total energy per tonne 6,912 MWh ÷ 9,140 t	All carriers	756 kWh/t	722–818	722 (Dec 25)	695 (–8%)
Total energy per square metre 6,912 MWh ÷ 9,500 m²	All carriers	728 kWh/m²	–	–	669 (–8%)

The best month of the audit year is an internal benchmark: the site has already run at that intensity. No external sector benchmark is recorded in the project file.

5.2 ELECTRICITY BASELINE: PRODUCTION AND COOLING DEGREE-DAYS

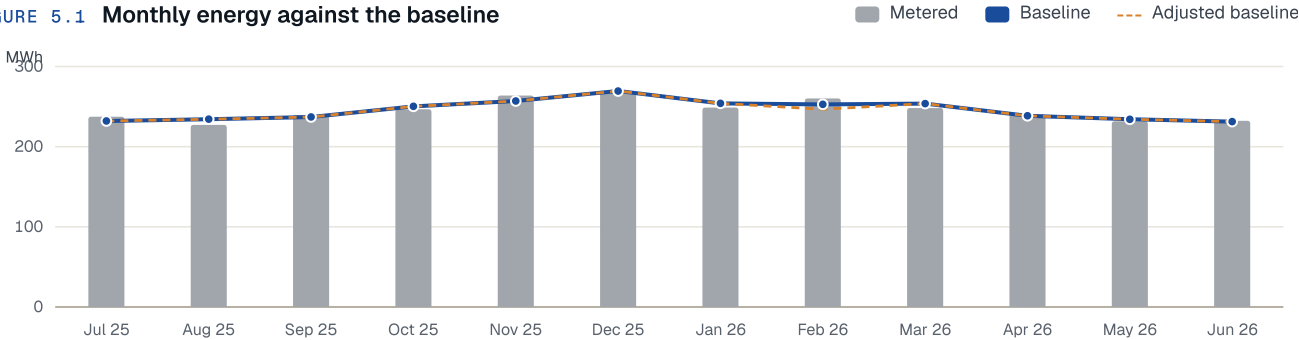
Coefficients ($E = b_0 + \sum b_j x_j$, kWh a month)

TERM	VALUE	STD ERROR	T
Intercept (b_0)	149,830	29,791	5.0
Production	108	39.2	2.8
Cooling degree-days (18 °C)	298	44.2	6.8

Fit against ASHRAE Guideline 14 (monthly data)

STATISTIC	VALUE	LIMIT	RESULT
CV(RMSE)	2.2%	≤ 15%	PASS
NMBE	0.00%	≤ ±5%	PASS
R² (adjusted)	0.862 (0.831)	≥ 0.75	Above (rule of thumb)
Observations, parameters	12, 3		

FIGURE 5.1 Monthly energy against the baseline



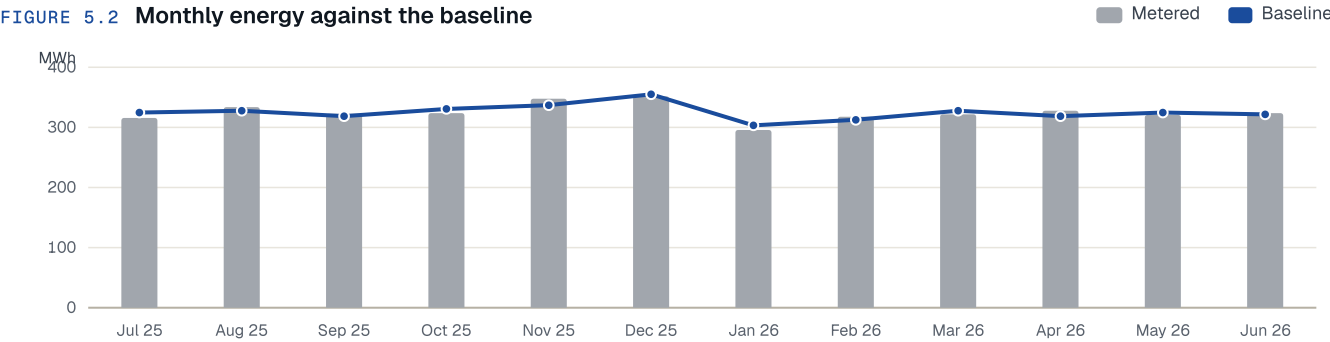
An OLS fit with an intercept has NMBE = 0 on its own months; NMBE matters when the model predicts other months.

Non-routine adjustments

MONTH	EVENT	ADJUSTMENT	BASIS
February 2026	Oven 2 relined: line stopped four days (fictional); baseline reduced for the reporting period	–6,000 kWh	EST ±30%

5.3 LPG BASELINE: PRODUCTION

Coefficients ($E = b_0 + \sum b_j x_j$, kWh a month)				Fit against ASHRAE Guideline 14 (monthly data)			
TERM	VALUE	STD ERROR	T	STATISTIC	VALUE	LIMIT	RESULT
Intercept (b_0)	93,583	39,969	2.3	CV(RMSE)	2.3%	$\leq 15\%$	PASS
Production	304	52.4	5.8	NMBE	0.00%	$\leq \pm 5\%$	PASS
				R ² (adjusted)	0.771 (0.748)	≥ 0.75	Above (rule of thumb)
				Observations, parameters	12, 2		



An OLS fit with an intercept has NMBE = 0 on its own months; NMBE matters when the model predicts other months.

System-by-system findings

For each system: the data behind it, what the survey found, the measures in the order they are applied, and what still needs data.

6.1 ELECTRICAL SUPPLY AND TARIFF

Level 1: bills (typical $\pm 30\%$). Electricity metered: 2,966 MWh a year (42.9% of the site, electricity). Nodes: [Grid electricity](#), [Standby generator](#), [Generator losses](#), [Main LV boards](#).

What the survey found

- Power factor at maximum demand averages 0.86. 12 bills
- 2 transformers energised; the others carry the peak at 63% with Transformer 1 (1,000 kVA, 11 kV/400 V) off. Transformer 1 (1,000 kVA, 11 kV/400 V): 1,000 kVA. Transformer 2 (1,000 kVA, 11 kV/400 V): 1,000 kVA

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M1	Run on fewer transformers at light load	Controls	5,401 kWh	5,401 kWh	R8k	FIRM
M2	Power-factor correction	Retrofit	0 kWh	0 kWh	R35k	FIRM

Electrical supply and tariff: 2 measure(s) have no system model, so their savings are not netted off and may overlap.

Waiting for data

Shift load out of peak periods

Needs shiftable loads and half-hourly data

Half-hourly data for 12 months; the production schedule; the time-of-use rate table.

Rooftop solar PV for own use

Needs the roof and daytime base load

Roof plan and condition; half-hourly data for daytime load; structural sign-off.

Right-size a transformer at replacement

Ask on the walk-through

Is a transformer due for replacement (age, condition, oil tests)?

Switch off loads left running outside operating hours

Interval data shows 70,822 kWh/yr above the 126 kW baseload outside operating hours (Main incomer, utility AMR half-hourly (fictional)); set the electrical supply to level 3 to quantify it

Electrical supply and tariff at data level 3 (Interval data step)

Screened out: Lower the notified maximum demand (NMD) (Peak 626 kVA is close to the NMD 650 kVA).

6.2 COMPRESSED AIR

Level 2: equipment inventory (typical $\pm 20\%$). Energy into the system: 524 MWh a year (7.6% of the site, electricity). Nodes: [Compressed air](#).

What the survey found

- 2,760 h/yr pressurised with no production. No production, compressors left on: 2,760 h/yr
- Leaks are 31% of production air (target 10%). No-load test 2026-08-15
- Walk-through answer: yes. Intakes draw compressor-room air at about 32 °C; an outside wall is 2 m away (fictional)
- Fixed-speed compressors on load-unload control. Screw compressors, 55 kW fixed speed (fictional make): load-unload

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M3	Switch compressors off outside production	Behaviour and management	73 MWh	73 MWh	R110k	FIRM
M4	Compressed-air leak repair programme	Maintenance	155 MWh	130 MWh	R195k	FIRM

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M5	Duct the compressor intakes to outside air	Retrofit	24 MWh	15 MWh	R22k	INDICATIVE
M6	Variable-speed trim compressor	New technology	59 MWh	12 MWh	R17k	NOT RECOMMENDED

System model: 524 MWh a year before the measures, 294 MWh after all of them (–44%); sequencing removes 82 MWh of overlap the measures would claim on their own.

Waiting for data

Recover compressor heat

Ask on the walk-through

Is there a steady low-temperature heat demand (make-up water, wash water, space heat) near the compressor room?

Screening range (context only, not used in any figure): 40%–84% of compressor electrical input recoverable as useful heat (80–93% becomes heat × 50–90% recoverable); US DOE / Compressed Air Challenge sourcebook, fact sheet 'Heat Recovery with Compressed Air Systems' (confirm edition and page).

Stop inappropriate uses of compressed air

Needs an end-use list

List of open-blow points with nozzle sizes and hours; photos.

Screening range (context only, not used in any figure): 0%–33% of compressed-air electricity, all measures together; Carbon Trust, compressed air guide: savings of up to a third are often possible (confirm edition and page).

Screened out: Lower the compressed-air pressure (Margin 0.9 bar is already modest).

6.3 REFRIGERATION AND CHILLERS



Level 3: interval data (typical ±12.5%). Energy into the system: 858 MWh a year (12.4% of the site, electricity).

Nodes: [Refrigeration](#).

What the survey found

- Fixed head pressure. Freezer plant compressors (–25 °C store and blast freezer): condensing 38 °C fixed. Chill plant compressors (+2 °C store and dispatch): condensing 38 °C fixed
- Walk-through answer: yes. The crate washer's fill water is heated next to the plant room (fictional)

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M7	Floating head pressure on the refrigeration plant	Controls	91 MWh	91 MWh	R136k	FIRM
M8	Refrigeration heat recovery: a desuperheater for hot water	Heat recovery	132 MWh	126 MWh	R236k	INDICATIVE

System model: 689 MWh a year before the measures, 598 MWh after all of them (–13%); sequencing removes 5,690 kWh of overlap the measures would claim on their own.

Waiting for data

Clean condensers and keep them clear

Ask on the walk-through

Are the condenser coils dirty, damaged or recirculating warm air?

Screening range (context only, not used in any figure): 2%–4% of refrigeration compressor energy per kelvin less lift; Carbon Trust refrigeration guide: 2–4% per °C (confirm edition and page).

Raise evaporating temperature where the product allows

Ask on the walk-through

Is any room colder than the product needs, or is the evaporator approach large?

Screening range (context only, not used in any figure): 2%–4% of refrigeration compressor energy per kelvin less lift; Carbon Trust refrigeration guide: 2–4% per °C (confirm edition and page).

Cold-store door discipline and strip curtains

Infiltration needs a door-open log to quantify

Door-open time log (a door switch and logger for a week); photos.

Screened out: Chilled-water set point and condenser-water reset (No chilled-water circuits (evaporating at –2 °C or warmer)); High-efficiency chiller when the old one is due for replacement (No chilled-water circuits (evaporating at –2 °C or warmer)).

6.4 STEAM AND BOILERS



Level 2: equipment inventory (typical ±20%). Energy into the system: 1,789 MWh a year (25.9% of the site, lpg). Nodes:

[Steam boiler](#), [Boiler flue and shell losses](#), [Boiler blowdown](#), [Steam mains](#), [Proofers](#), [Crate washer](#), [Hot water \(calorifier\)](#), [Failed traps and steam leaks](#), [Bare pipe heat loss](#).

What the survey found

- Efficiency 80% against 84% achievable. Combustion test 82% less 2% shell loss
- 6 of 60 traps failed open. Trap survey 2026-08-20
- 2 steam leaks counted (2 small). Leak count 2026-08-20
- 42 m of bare pipe and valve equivalent. DN50 steam main, boiler house to proofer: 16 m. DN25 branches to washer and calorifier: 14 m. Valves and flanges (10), as equivalent DN50 length: 12 m
- 40% returned against 80% achievable. Condensate routes traced on the walk-through
- Flue gas 300 °C against a safe exit of about 140 °C. Combustion test at high fire (fictional report)
- Hot water at 65 °C or less is made with steam. Calorifier: hot water for cleaning: 140 kg/h of steam

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M9	Boiler combustion tuning and O2 trim	Controls	85 MWh	85 MWh	R159k	INDICATIVE
M10	Steam trap survey and repair	Maintenance	148 MWh	141 MWh	R262k	INDICATIVE
M11	Repair steam leaks	Maintenance	63 MWh	60 MWh	R112k	INDICATIVE
M12	Insulate bare steam pipe, valves and flanges	Retrofit	191 MWh	182 MWh	R339k	INDICATIVE
M13	Heat pump instead of steam for hot water	New technology	249 MWh	234 MWh	R460k	INDICATIVE
M14	Return more condensate	Heat recovery	65 MWh	42 MWh	R78k	INDICATIVE
M15	Flue-gas economiser	Heat recovery	195 MWh	79 MWh	R147k	INDICATIVE

System model: 1,789 MWh a year before the measures, 902 MWh after all of them (–50%); sequencing removes 174 MWh of overlap the measures would claim on their own.

Waiting for data

Automatic TDS blowdown control

Ask on the walk-through

Is the boiler blown down by hand or on a timer, without automatic TDS (conductivity) control? Screening range (context only, not used in any figure): 10%–20% of steam-system fuel, all measures together; US DOE Advanced Manufacturing Office / NREL steam system best-practice publications: 10–20% (confirm document and page).

Recover heat from boiler blowdown

Ask on the walk-through

Does the blowdown go to drain hot, with no flash vessel or heat exchanger? Screening range (context only, not used in any figure): 10%–20% of steam-system fuel, all measures together; US DOE Advanced Manufacturing Office / NREL steam system best-practice publications: 10–20% (confirm document and page).

6.5 PROCESS HEAT



Level 2: equipment inventory (typical ±20%). Energy into the system: 2,170 MWh a year (31.4% of the site, electricity and lpg). Nodes: [Tunnel ovens](#).

What the survey found

- Tunnel oven burners (2 ovens): flue O₂ 11.0%. Flue-gas test on oven 1 at high fire (fictional analyser report)
- Walk-through answer: yes. The crate washer's soak tank is open-topped and its walls are bare (fictional)
- Tunnel oven burners (2 ovens): flue gas 260 °C. Flue-gas test on oven 1 at high fire (fictional analyser report); oven 2 is the same model

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M16	Tune the burners on ovens, fryers and dryers: Tunnel oven burners (2 ovens)	Controls	156 MWh	156 MWh	R291k	INDICATIVE
M17	Insulate the crate washer's soak tank and fit a lid	Retrofit	29 MWh	29 MWh	R54k	INDICATIVE
M18	Recover oven flue heat: Tunnel oven burners (2 ovens)	Heat recovery	63 MWh	63 MWh	R118k	INDICATIVE

Process heat: 3 measure(s) have no system model, so their savings are not netted off and may overlap.

Waiting for data

Turn ovens down or off between runs

Ask on the walk-through

Are ovens held at temperature with no product for more than an hour at a time?

Recover heat from one process stream to another

Ask on the walk-through

Is a hot stream sent to drain or cooled while another stream nearby is heated at the same time?

Screened out: Heat pump for hot water now made with elements, LPG or diesel (The hot-water nodes have no electric or fuel-fired heaters in the register).

6.6 MOTORS, PUMPS AND FANS

Level 2: equipment inventory (typical $\pm 20\%$). Energy into the system: 769 MWh a year (11.1% of the site, electricity).

Nodes: [Motors, pumps and fans](#).

What the survey found

- Throttled pumps or fans with long hours. Oven-hall extraction fans: damper
- Throttled or bypassed pumps with long hours. Cooling-water and process pumps: throttle
- Belt drives that a better belt would improve. Oven-hall extraction fans: standard V-belt

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M19	Variable-speed drive on a throttled pump (pump and system curves): Cooling-water and process pumps	Retrofit	50 MWh	50 MWh	R75k	INDICATIVE
M20	VSDs on the oven-hall extraction fans (2 × 22 kW)	Retrofit	88 MWh	88 MWh	R132k	FIRM
M21	Synchronous or cogged belts instead of V-belts: Oven-hall extraction fans	Retrofit	10 MWh	5,715 kWh	R9k	INDICATIVE

System model: 769 MWh a year before the measures, 625 MWh after all of them (–19%); sequencing removes 4,487 kWh of overlap the measures would claim on their own.

Waiting for data

Switch off idle motors, pumps and fans

Ask on the walk-through

Do conveyors, pumps or fans run when the line they serve is stopped?

Screening range (context only, not used in any figure): 20%–30% of motor-system electricity, system optimisation; IEA, Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems (2011): 20-30% (confirm page).

Screened out: Higher-efficiency (IE3/IE4) motor (No IE1, IE2 or unknown-class motors of 5.5 kW+ with 4,000+ hours).

6.7 LIGHTING

Level 2: equipment inventory (typical $\pm 20\%$). Energy into the system: 320 MWh a year (4.6% of the site, electricity).

Nodes: [Lighting](#).

What the survey found

- Intermittently occupied areas on manual switching. Warehouse and dispatch: 400 W metal-halide high bays: 36 fixtures. Cold stores: twin 58 W T8 battens: 40 fixtures
- Non-LED fittings. Production hall: twin 58 W T8 battens: T8-magnetic. Warehouse and dispatch: 400 W metal-halide high bays: metal-halide. Cold stores: twin 58 W T8 battens: T8-magnetic. Offices and canteen: 4 × 18 W T8 troffers: T8-magnetic. External: 250 W sodium floodlights: high-pressure-sodium

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M22	Occupancy sensors in intermittently used areas	Controls	35 MWh	35 MWh	R52k	INDICATIVE
M23	LED lighting retrofit	Retrofit	190 MWh	168 MWh	R252k	FIRM

System model: 320 MWh a year before the measures, 118 MWh after all of them (–63%); sequencing removes 22 MWh of overlap the measures would claim on their own.

Waiting for data

Lights-off campaign Ask on the walk-through	Are lights left on in empty areas or in daylight?
Daylight or photocell control Ask on the walk-through	Do these areas get useful daylight (roof lights, windows), or do outdoor lights burn in daylight? Screening range (context only, not used in any figure): 28%–28% of lighting energy in the daylight areas (average of field studies); Williams, Atkinson, Garbesi, Page and Rubinstein, 'Lighting Controls in Commercial Buildings', LEUKOS 8(3), 2012 (LBNL meta-analysis): daylighting about 28%.
Take fittings out of over-lit areas No lux readings in the register	Lux meter readings at working height across each area, with the lights on and no daylight; the task in each area.

6.8 HVAC AND OFFICES



Level 2: equipment inventory (typical ±20%). Energy into the system: 121 MWh a year (1.7% of the site, electricity). Nodes: HVAC and offices.

What the survey found

- Walk-through answer: yes. Office split remotes found at 19–20 °C cooling on the walk-through (fictional)

Measures, in the order they are applied

REF	MEASURE	CATEGORY	ON ITS OWN	IN SEQUENCE	SAVING A YEAR	CASE
M24	Widen HVAC set points	Behaviour and management	4,204 kWh	4,204 kWh	R6k	INDICATIVE

System model: 70 MWh a year before the measures, 66 MWh after all of them (–6%).

Waiting for data

HVAC time schedules Ask on the walk-through	Does air-conditioning run outside office hours?
High-efficiency air-conditioning when old units are due for replacement Ask on the walk-through	Are air-conditioning units old (about 12 years or more), failing or on R22, so they are due for replacement?

Measure sheets

One sheet per quantified measure, in system order: what it is and the evidence, the baseline it starts from, the method and formula, the savings by tariff component, costs and life with their quality tags, the inputs, the risks and the M&V approach (IPMVP option A, B or C).

REF	MEASURE	CATEGORY	CASE	SAVING A YEAR	CAPEX	NPV	M&V
M1	Run on fewer transformers at light load Electrical supply and tariff	Controls	FIRM	R8k	R15k	R47k	B
M2	Power-factor correction Electrical supply and tariff	Retrofit	FIRM	R35k	R136k	R217k	C
M3	Switch compressors off outside production Compressed air	Behaviour and management	FIRM	R110k	R15k	R441k	B
M4	Compressed-air leak repair programme Compressed air	Maintenance	FIRM	R195k	R45k	R665k	B
M5	Duct the compressor intakes to outside air Compressed air	Retrofit	INDICATIVE	R22k	R36k	R195k	A
M6	Variable-speed trim compressor Compressed air	New technology	NOT RECOMMENDED	R17k	R519k	−R336k	B
M7	Floating head pressure on the refrigeration plant Refrigeration and chillers	Controls	FIRM	R136k	R130k	R909k	B
M8	Refrigeration heat recovery: a desuperheater for hot water Refrigeration and chillers	Heat recovery	INDICATIVE	R236k	R200k	R2.28m	B
M9	Boiler combustion tuning and O2 trim Steam and boilers	Controls	INDICATIVE	R159k	R85k	R1.06m	A
M10	Steam trap survey and repair Steam and boilers	Maintenance	INDICATIVE	R262k	R42k	R985k	A
M11	Repair steam leaks Steam and boilers	Maintenance	INDICATIVE	R112k	R7k	R282k	A
M12	Insulate bare steam pipe, valves and flanges Steam and boilers	Retrofit	INDICATIVE	R339k	R67k	R4.31m	A
M13	Heat pump instead of steam for hot water Steam and boilers	New technology	INDICATIVE	R460k	R770k	R4.06m	B
M14	Return more condensate Steam and boilers	Heat recovery	INDICATIVE	R78k	R250k	R803k	B
M15	Flue-gas economiser Steam and boilers	Heat recovery	INDICATIVE	R147k	R177k	R1.72m	B
M16	Tune the burners on ovens, fryers and dryers: Tunnel oven burners (2 ovens) Process heat	Controls	INDICATIVE	R291k	R13k	R1.16m	A
M17	Insulate the crate washer's soak tank and fit a lid Process heat	Retrofit	INDICATIVE	R54k	R11k	R561k	A
M18	Recover oven flue heat: Tunnel oven burners (2 ovens) Process heat	Heat recovery	INDICATIVE	R118k	R248k	R992k	B
M19	Variable-speed drive on a throttled pump (pump and system curves): Cooling-water and process pumps Motors, pumps and fans	Retrofit	INDICATIVE	R75k	R83k	R480k	B
M20	VSDs on the oven-hall extraction fans (2 × 22 kW) Motors, pumps and fans	Retrofit	FIRM	R132k	R98k	R898k	B
M21	Synchronous or cogged belts instead of V-belts: Oven-hall extraction fans Motors, pumps and fans	Retrofit	INDICATIVE	R9k	R20k	R45k	B
M22	Occupancy sensors in intermittently used areas Lighting	Controls	INDICATIVE	R52k	R14k	R380k	A

REF	MEASURE	CATEGORY	CASE	SAVING A YEAR	CAPEX	NPV	M&V
M23	LED lighting retrofit Lighting	Retrofit	FIRM	R252k	R512k	R1.41m	A
M24	Widen HVAC set points HVAC and offices	Behaviour and management	INDICATIVE	R6k	R6k	R21k	B

Run on fewer transformers at light load

BILL SAVING A YEAR R8k net R8k after running costs	ENERGY SAVED 5,401 kWh Electricity	CAPEX R15k life 10 years · 1 month to build	NPV AT 12% R47k IRR 61%	PAYBACK 1.9 years R0.49 per kWh saved
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Firm: From site data (calculated, ±15%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Where transformers run in parallel well below their rating, switch one off and keep it as a cold standby, so its no-load (core) losses stop.

- Transformer 1 (1,000 kVA, 11 kV/400 V): 1,000 kVA
- Transformer 2 (1,000 kVA, 11 kV/400 V): 1,000 kVA

2 BASELINE

Electrical supply and tariff, data level 1: 2,966 MWh a year in the balance.

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

Transformer losses $P_o + P_k (S/S_r)^2 \times \text{loss factor}$: 39,275 → 33,874 kWh a year with Transformer 1 (1,000 kVA, 11 kV/400 V) off. Tool audit-transformer v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Switched off	Transformer 1 (1,000 kVA, 11 kV/400 V)	
Kept	Transformer 2 (1,000 kVA, 11 kV/400 V)	
Peak (kVA)	626	
Load factor	0.625	
Loss factor	0.461	
Losses before (kWh)	39,275	
Losses after (kWh)	33,874	
Peak loading after	0.626	
Loss factor from the load factor (0.3 LF + 0.7 LF²)	library default	ASSUM
Maximum loading 90%	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R8,083	CALC ±15%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	5.4 MWh	CALC ±15%

6 CAPEX, RUNNING COST AND LIFE

Capex	R15,000	ASSUM ±42%	1 installation × R15,000 (Switching procedure, protection check and interlock to run on fewer transformers: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	10 years	ASSUM	Operating procedure (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Keep the unit switched off as a cold standby: the site keeps a spare, with a changeover time instead of automatic cover. Check protection, earthing and the changeover procedure with the unit isolated.
- These losses are inside the metered energy when the site is metered on the medium-voltage side; on a low-voltage meter the utility carries them and nothing is saved on the bill.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option B: retrofit isolation, all parameter measurement

The system's energy logged before and after, normalised to its driver (production or weather).
Baseline and reporting period: Appendix D.3.

Power-factor correction

BILL SAVING A YEAR R35k net R34k after running costs	ENERGY SAVED — no kWh: a demand saving	CAPEX R136k life 15 years · 2 months to build	NPV AT 12% R217k IRR 31%	PAYBACK 4.0 years not on the MACC (no kWh)
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Firm: From site data (calculated, ±10%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

An automatic capacitor bank lowers the kVA billed for the same kW.

- 12 bills

2 BASELINE

Electrical supply and tariff, data level 1: 2,966 MWh a year in the balance.

Step 2 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$S = P / PF; \Delta kVA = P / PF_1 - P / PF_2; \text{saving} = \Delta kVA \times \text{demand charge (R/kVA/month)} \times 12$$

69.5 kVA × R42.00/kVA/month × 12 months. Tool power-factor-correction v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Real power (kW)	467.6
Power factor before	0.861
Power factor target	0.980
Capacitor step (kvar)	25
Demand charge (R/kVAmonth)	42
Months per year	12
Capacitor cost (R/kvar)	680
Supply voltage (V)	400
Capacitor step (kvar)	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Demand (kVA) charges	R35,011	CALC
Energy (kWh) charges, Capacity (NMD) charges, Fixed charges	not counted	
Demand reduction	69 kVA	CALC

6 CAPEX, RUNNING COST AND LIFE

Capex	R136,000	EST	200 kvar × R680/kvar (power-factor tool)
Running cost change	R1,400/yr	ASSUM	Default: 1% of capex a year
Life	15 years	ASSUM	Default life for a capacitor bank
Lead time	2 months	ASSUM	Default lead time

7 RISKS

- Counts kVA-based charges only; reactive energy (kvarh) charges and lower cable losses are not added.
- Assumes the kW and power factor at maximum demand are similar every month.

8 MEASUREMENT AND VERIFICATION



IPMVP Option C: whole facility

Utility bills: kVA and kW at maximum demand for 12 months before and after; the saving is the billed kVA avoided.

Baseline and reporting period: Appendix D.3.

Switch compressors off outside production

BILL SAVING A YEAR R110k net R110k after running costs	ENERGY SAVED 73 MWh Electricity	CAPEX R15k life 5 years · 1 month to build	NPV AT 12% R441k IRR above 500%	PAYBACK 2 months R0.06 per kWh saved
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Firm: From site data (estimated, ±17%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Compressors left running at night and weekends only feed leaks. Isolate and switch off, with a timer or sequencer.

- No production, compressors left on: 2,760 h/yr

2 BASELINE

Compressed air, data level 2: 524 MWh a year before any measure (system model).

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$\Delta E = \sum \text{idle hours} \times \text{share switched off} \times \text{plant kW feeding leaks only}$$

Plant part-load model: non-production hours × 15%. Tool audit-compressed-air v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Share off	0.850
Idle hours	2,760

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R109,789	EST ±17%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	73.4 MWh	EST ±17%

6 CAPEX, RUNNING COST AND LIFE

Capex	R15,000	ASSUM ±33%	1 installation × R15,000 (Compressor timer or sequencer setting and an isolation valve: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	5 years	ASSUM	Behaviour change held by a timer (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- A sanitation or maintenance crew may still need air on some idle days; the share switched off allows for it.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Log compressor kW (or read the hour meters) over four non-production weekends before and after; the saving is the idle-hour energy avoided.

Baseline and reporting period: Appendix D.3.

Compressed-air leak repair programme

BILL SAVING A YEAR R195k net R171k after running costs	ENERGY SAVED 130 MWh Electricity	CAPEX R45k life 5 years · 2 months to build	NPV AT 12% R665k IRR 387%	PAYBACK 3 months R0.28 per kWh saved
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Firm: From site data (estimated, ±17%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Find leaks with an ultrasonic survey, tag and repair them, and repeat the survey every quarter so they stay fixed.

- No-load test 2026-08-15

2 BASELINE

Compressed air, data level 2: 524 MWh a year before any measure (system model).

Step 2 in the system's sequence. On its own it would save 155 MWh; after the earlier measures it saves 130 MWh (–16%).

3 METHOD AND FORMULA

$$\text{Leak flow} = \text{capacity running} \times T_{\text{loaded}} / (T_{\text{loaded}} + T_{\text{unloaded}}); \Delta E = \Sigma \text{ hours} \times [P(\text{demand} + \text{leak now}) - P(\text{demand} + \text{leak target})]$$

Plant part-load model with leaks 3.10 → 0.76 m³/min (No-load test: loaded 21 s, unloaded 44 s, 1 unit(s) running). Tool audit-compressed-air v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Leak before (m³/min)	3.10
Leak after (m³/min)	0.762
Leak share before	0.311
Leak share target	0.100
Average production demand (m³/min)	6.86

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R194,759	EST ±17%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	130.1 MWh	EST ±17%

6 CAPEX, RUNNING COST AND LIFE

Capex	R45,000	ASSUM ±26%	1 installation × R45,000 (Ultrasonic leak survey, tags, fittings and labour for the first repair round: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R24,000/yr	ASSUM ±25%	1 programme a year × R24,000 (Quarterly ultrasonic leak survey and repairs: assumed placeholder 2026 budget — replace with supplier quotes)
Life	5 years	ASSUM	Programme horizon (assumed)
Lead time	2 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Leaks come back: the quarterly survey in the running cost keeps the rate at the target.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Repeat the no-load leak test after the repairs and log compressor kW for two weeks; normalise to the audit's demand blocks.

Baseline and reporting period: Appendix D.3.

Duct the compressor intakes to outside air

BILL SAVING A YEAR R22k net R22k after running costs	ENERGY SAVED 15 MWh Electricity	CAPEX R36k life 15 years · 2 months to build	NPV AT 12% R195k IRR 69%	PAYBACK 1.6 years R0.36 per kWh saved
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Indicative: Rests on an assumed input (±39%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Duct the compressors' intakes to outside air, with a filter and a weather hood, instead of drawing the warm compressor-room air: cooler, denser air takes less power to compress.

- Intakes draw compressor-room air at about 32 °C; an outside wall is 2 m away (fictional)

2 BASELINE

Compressed air, data level 2: [524 MWh](#) a year before any measure (system model).

Step 3 in the system's sequence. On its own it would save 24 MWh; after the earlier measures it saves 15 MWh (–39%).

3 METHOD AND FORMULA

Same air, same pressure ratio: $\text{power} \propto T_{\text{intake}}$ (kelvin); $\Delta E = E (1 - T_{\text{new}} / T_{\text{now}})$

Plant power $\times T_{\text{new}} / T_{\text{now}} = (18.0 + 273.15) / (32.0 + 273.15)$: 4.6% less for the same air. Tool audit-compressed-air v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Intake now (°C)	32
Intake new (°C)	18
Saving share	0.046
Compressors	2
Outside air 18 °C on average over the year (use the nearest weather station's annual mean)	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R21,988	ASSUM ±39%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	14.7 MWh	ASSUM ±39%

6 CAPEX, RUNNING COST AND LIFE

Capex	R36,000	ASSUM ±43%	2 compressors $\times$ R18,000 (Intake duct from a compressor to outside air, with a filter, weather hood and damper: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	15 years	ASSUM	Ductwork life (assumed)
Lead time	2 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Use the year's average at the intake and outside (a week of logging at both, set against the weather station), not one hot afternoon.
- Keep the duct short and fit a filter and a weather hood; a damper can switch back to room air if the room needs the heat.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option A: retrofit isolation, key parameter measurement

Log the air temperature at the intakes before and after for a week (the key parameter), against outside; plant kWh is stipulated from the audit model.

Baseline and reporting period: Appendix D.3.

Variable-speed trim compressor

BILL SAVING A YEAR R17k net R17k after running costs	ENERGY SAVED 12 MWh Electricity	CAPEX R519k life 15 years · 4 months to build	NPV AT 12% −R336k IRR −1%	PAYBACK 29.9 years R6.57 per kWh saved
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Indicative: Rests on an assumed input (±21%): confirm it on site first. Negative NPV at 12% once the earlier measures on the system are in. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Replace the part-loaded (trim) compressor with a variable-speed unit so the plant follows demand without running unloaded.

- Screw compressors, 55 kW fixed speed (fictional make): load-unload

2 BASELINE

Compressed air, data level 2: [524 MWh](#) a year before any measure (system model).

Step 4 in the system's sequence. On its own it would save 59 MWh; after the earlier measures it saves 12 MWh (−80%).

3 METHOD AND FORMULA

Trim unit: $\text{load-unload } u + (1 - u)C \rightarrow \text{VSD } (v_0 + (1 - v_0)C)(1 + \delta)$; [D] − 1 units loaded, one trim unit

Plant part-load model: trim unit on a VSD curve instead of load-unload. Tool audit-compressed-air v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS

	TOOL INPUTS, MODEL UNITS
Trim unit (kW)	61
Units	2
Before	load-unload
After	vsd
VSD part-load curve (typical)	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R17,329	ASSUM ±21%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	11.6 MWh	ASSUM ±21%

6 CAPEX, RUNNING COST AND LIFE

Capex	R518,500	ASSUM ±15%	61 kW of compressor input × R8,500 (Variable-speed screw compressor (trim unit), installed: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	15 years	ASSUM	Compressor life (assumed)
Lead time	4 months	ASSUM	Typical lead time (assumed)

7 RISKS

- VSD curve: typical shape (assumed); the maker's CAGI data sheet replaces it.
- Right-size the trim unit after leaks are fixed: a smaller VSD may do.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Log plant kW and pressure for two weeks before and after at like production; normalise to air demand or production.

Baseline and reporting period: Appendix D.3.

Floating head pressure on the refrigeration plant

BILL SAVING A YEAR R136k net R136k after running costs	ENERGY SAVED 91 MWh Electricity	CAPEX R130k life 10 years · 3 months to build	NPV AT 12% R909k IRR 113%	PAYBACK 11 months R0.25 per kWh saved
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Firm: From site data (estimated, ±19%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Let the condensing pressure follow the weather instead of holding it fixed; fit electronic expansion valves where needed.

- Freezer plant compressors (−25 °C store and blast freezer): condensing 38 °C fixed
- Chill plant compressors (+2 °C store and dispatch): condensing 38 °C fixed

2 BASELINE

Refrigeration and chillers, data level 3: 689 MWh a year before any measure (system model).

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$\text{COP} \propto T_e / (T_c - T_e) \text{ (kelvin)}; E_{\text{new}} / E_{\text{old}} = \text{COP}_{\text{old}} / \text{COP}_{\text{new}} \text{ for the same cooling load}$$

Carnot COP ratio per circuit on measured energy. Tool audit-refrigeration v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Circuits Freezer plant compressors (−25 °C store and blast freezer): −32/38 → 30 °C; Chill plant compressors (+2 °C store and dispatch): −6/38 → 30 °C

Basis measured

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R136,259	EST ±20%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	91.0 MWh	EST ±19%

6 CAPEX, RUNNING COST AND LIFE

Capex	R130,000	ASSUM ±27%	2 circuits × R65,000 (Floating head pressure: controller changes and electronic expansion valves: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	10 years	ASSUM	Controls life (assumed)
Lead time	3 months	ASSUM	Typical lead time (assumed)

7 RISKS

- The achievable condensing temperature depends on ambient and the condenser approach; a year of weather data firms it up.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

The refrigeration sub-board meter, regressed against ambient temperature before and after.

Baseline and reporting period: Appendix D.3.

Refrigeration heat recovery: a desuperheater for hot water

BILL SAVING A YEAR R236k net R236k after running costs	ENERGY SAVED 126 MWh LPG	CAPEX R200k life 15 years · 3 months to build	NPV AT 12% R2.28m IRR 126%	PAYBACK 10 months R0.23 per kWh saved
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Indicative: Rests on an assumed input (±44%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Take the hot discharge gas from the refrigeration compressors through a desuperheater before the condensers, to preheat wash, cleaning or boiler make-up water.

- The crate washer's fill water is heated next to the plant room (fictional)

2 BASELINE

Refrigeration and chillers, data level 3: **689 MWh** a year before any measure (system model).

Step 2 in the system's sequence. On its own it would save 132 MWh; after the earlier measures it saves 126 MWh (−4%).

3 METHOD AND FORMULA

$$Q_c = E (1 + COP), COP = 0.5 \times Carnot; recovered = s Q_c u; fuel = recovered / \eta_{heater}$$

Condenser heat $E (1 + COP) = 2,023,906 \text{ kWh} \times 10\% \text{ superheat} \times 50\% \text{ used} = 101,195 \text{ kWh}$ of hot water ÷ 80% (steam from the LPG boiler at 80%) = 126,494 kWh/yr. Tool audit-heat-exchange v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Compressor (kWh)	597,776	
Condenser (kWh)	2,023,906	
Superheat share	0.100	
Use share	0.500	
Carnot fraction	0.500	
Recovered (kWh)	101,195	
Heater carrier	lpg	
Heater efficiency	0.800	
Design (kW)	53.4	
Superheat 10% of the condenser heat	library default	ASSUM
Half of it meets a hot-water demand at the time	library default	ASSUM
COP half of the Carnot COP	library default	ASSUM
Heated by steam from the boiler	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R235,873	ASSUM ±44%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	126.5 MWh	ASSUM ±44%

6 CAPEX, RUNNING COST AND LIFE

Capex	R200,297	ASSUM ±29%	53.4 kW of desuperheat duty × R3,750 (Desuperheater on the compressor discharge, with water piping, pump and controls, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	15 years	ASSUM	Exchanger life (assumed)
Lead time	3 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Floating head pressure lowers the discharge temperature: confirm the water temperature the desuperheater can reach.
- Not netted against other measures that make the same hot water: count one of them.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Heat meter on the desuperheater's water circuit; fuel displaced = heat ÷ heater efficiency.

Baseline and reporting period: Appendix D.3.

Boiler combustion tuning and O2 trim

BILL SAVING A YEAR R159k net R151k after running costs	ENERGY SAVED 85 MWh LPG	CAPEX R85k life 10 years · 2 months to build	NPV AT 12% R1.06m IRR 185%	PAYBACK 7 months R0.27 per kWh saved
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Indicative: Rests on an assumed input (±26%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Set the burner's air-fuel ratio across the firing range and hold it with oxygen trim.

- Combustion test 82% less 2% shell loss

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$\Delta F = F (1 - \eta_1 / \eta_2) \text{ for the same heat}$$

Steam model: fuel × (1 – 0.800 / 0.840). Tool audit-steam v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Efficiency before	0.800
Efficiency after	0.840

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R158,829	ASSUM ±26%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	85.2 MWh	ASSUM ±26%

6 CAPEX, RUNNING COST AND LIFE

Capex	R85,000	ASSUM ±24%	1 boiler × R85,000 (O ₂ trim kit, commissioning and burner tuning: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R8,000/yr	ASSUM ±25%	1 boiler a year × R8,000 (Annual combustion test and re-tune: assumed placeholder 2026 budget — replace with supplier quotes)
Life	10 years	ASSUM	Controls life (assumed)
Lead time	2 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option A: retrofit isolation, key parameter measurement

Combustion test before and after (efficiency is the key parameter); fuel is stipulated from the LPG bills.

Baseline and reporting period: Appendix D.3.

Steam trap survey and repair

BILL SAVING A YEAR R262k net R247k after running costs	ENERGY SAVED 141 MWh LPG	CAPEX R42k life 5 years · 1 month to build	NPV AT 12% R985k IRR above 500%	PAYBACK 2 months R0.19 per kWh saved
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Indicative: Rests on an assumed input (±67%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Replace traps that have failed open and survey every year.

- Trap survey 2026-08-20

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 2 in the system's sequence. On its own it would save 148 MWh; after the earlier measures it saves 141 MWh (−5%).

3 METHOD AND FORMULA

Napier: $W \text{ (lb/h)} = 24.24 \times P \text{ (psia)} \times D^2 \text{ (in}^2\text{)} \times \text{severity}$; $\text{fuel} = \text{steam} \times (h_g - h_{fw}) / \eta$

Napier (DOE Steam Tip Sheet #1): 173.8 t steam a year through 6 failed traps. Tool audit-steam v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Failed open	6	
Orifice (mm)	2	
Severity	0.500	
Trap loss before (kg)	173,775	
Residual share	0.100	
10% of the loss returns between annual surveys	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R261,999	ASSUM ±67%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	140.5 MWh	ASSUM ±67%

6 CAPEX, RUNNING COST AND LIFE

Capex	R42,000	ASSUM ±25%	1 survey × R15,000 (Steam trap survey (first): assumed placeholder 2026 budget — replace with supplier quotes) + 6 traps × R4,500 (Steam trap replaced, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R15,000/yr	ASSUM ±29%	1 programme a year × R15,000 (Annual steam trap survey: assumed placeholder 2026 budget — replace with supplier quotes)
Life	5 years	ASSUM	Trap life with an annual survey (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

A IPMVP Option A: retrofit isolation, key parameter measurement

Trap survey before and after (the failed-open count is the key parameter); the loss per trap is stipulated by Napier's formula.

Baseline and reporting period: Appendix D.3.

Repair steam leaks

BILL SAVING A YEAR R112k net R112k after running costs	ENERGY SAVED 60 MWh LPG	CAPEX R7k life 3 years · 1 month to build	NPV AT 12% R282k IRR above 500%	PAYBACK 1 months R0.05 per kWh saved
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Indicative: Rests on an assumed input (±46%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Repack leaking valve glands, renew flange gaskets and repair unions and pipe; tag new leaks on every walk-round.

- Leak count 2026-08-20

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 3 in the system's sequence. On its own it would save 63 MWh; after the earlier measures it saves 60 MWh (−5%).

3 METHOD AND FORMULA

Napier: $W \text{ (lb/h)} = 24.24 \times P \text{ (psia)} \times D^2 \text{ (in}^2\text{)}$, $D = 1.6, 3.2 \text{ or } 6.4 \text{ mm by size}$; $\text{fuel} = \text{steam} \times (h_g - h_{fw}) / \eta$

Napier (as for traps): 74.1 t steam a year through 2 small leaks at 8.0 bar(g). Tool audit-steam v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Leaks	2 small	
Leak loss before (kg)	74,144	
Residual share	0.100	
Pressure bar g	8	
Hours	6,500	
10% of the leak loss is back by the next walk-round	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R111,786	ASSUM ±46%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	59.9 MWh	ASSUM ±46%

6 CAPEX, RUNNING COST AND LIFE

Capex	R7,000	ASSUM ±87%	2 leaks × R3,500 (Steam leak repair: gland repacking, gasket or union, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	3 years	ASSUM	Repairs hold about three years before glands and gaskets need doing again (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Leak sizes are judged by eye: a small wisp is taken as a 1.6 mm hole, a medium plume 3.2 mm and a large jet 6.4 mm. An ultrasonic survey firms them up.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option A: retrofit isolation, key parameter measurement

Leak count by size before and after the repairs (the key parameter); the loss per leak is stipulated by Napier's formula.

Baseline and reporting period: Appendix D.3.

Insulate bare steam pipe, valves and flanges

BILL SAVING A YEAR R339k net R339k after running costs	ENERGY SAVED 182 MWh LPG	CAPEX R67k life 20 years · 1 month to build	NPV AT 12% R4.31m IRR above 500%	PAYBACK 2 months R0.05 per kWh saved
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Indicative: Rests on an assumed input (±37%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Lag bare pipe and fit removable jackets on valves and flanges.

- DN50 steam main, boiler house to roofers: 16 m
- DN25 branches to washer and calorifier: 14 m
- Valves and flanges (10), as equivalent DN50 length: 12 m

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 4 in the system's sequence. On its own it would save 191 MWh; after the earlier measures it saves 182 MWh (−5%).

3 METHOD AND FORMULA

$$q' = \pi D (h_c + h_r)(T_s - T_a); h_c = 1.32 (\Delta T / D)^{0.25}; \text{insulated: } 2\pi k(T_{\text{pipe}} - T_s) / \ln(r_2/r_1)$$

= jacket loss

Bare and insulated pipe heat loss (convection + radiation): 128,386 → 9,544 kWh/yr. Tool audit-steam v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Metres	42
Thickness (mm)	50
Conductivity	0.045
Pipe loss before (kWh)	128,386
Pipe loss after (kWh)	9,544

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R338,870	ASSUM ±37%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	181.7 MWh	ASSUM ±37%

6 CAPEX, RUNNING COST AND LIFE

Capex	R67,200	ASSUM ±27%	42 m of pipe × R1,600 (Pipe insulation with cladding, installed (DN25–DN50; valves as equivalent length): assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	20 years	ASSUM	Insulation life (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option A: retrofit isolation, key parameter measurement

Surface-temperature survey before and after (the key parameter); hours and ambient are stipulated. Baseline and reporting period: Appendix D.3.

Heat pump instead of steam for hot water

BILL SAVING A YEAR R460k net R460k after running costs	ENERGY SAVED 234 MWh Electricity, LPG	CAPEX R770k life 15 years · 4 months to build	NPV AT 12% R4.06m IRR 68%	PAYBACK 1.7 years R0.48 per kWh saved
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Indicative: Rests on an assumed input (±47%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Make hot water up to about 65 °C with an air-to-water heat pump instead of a steam calorifier: the steam to that user, and the boiler fuel and losses behind it, go; the heat pump's electricity comes in.

- Calorifier: hot water for cleaning: 140 kg/h of steam

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 5 in the system's sequence. On its own it would save 249 MWh; after the earlier measures it saves 234 MWh (–6%).

3 METHOD AND FORMULA

346.5 t/yr of steam to Calorifier: hot water for cleaning replaced (195,406 kWh of heat at h_fg): boiler fuel from the steam model; heat pump 195,406 ÷ COP 3.0 = 65,135 kWh of electricity; 346.5 t/yr of steam to Calorifier: hot water for cleaning replaced (195,406 kWh of heat at h_fg): boiler fuel from the steam model; heat pump 195,406 ÷ COP 3.0 = 65,135 kWh of electricity. Tool audit-heat-pump v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Item ids	st-calorifier	
Steam (kg/year)	346,500	
Heat (kWh)	195,406	
COP	3	
Coverage fraction	1	
Heat pump (kWh)	65,135	
Heating capacity (kW)	79.0	
Heat pump SCOP 3.0 (air source, about 60 °C water)	library default	ASSUM
Heat pump takes all of the hot water	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R459,702	ASSUM ±47%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	–65.1 MWh	ASSUM ±47%
LPG saved	298.8 MWh	ASSUM ±47%

6 CAPEX, RUNNING COST AND LIFE

Capex	R769,781	ASSUM ±20%	79.0 kW of heating capacity × R9,750 (Air-to-water heat pump for hot water up to about 65 °C, with storage, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	15 years	ASSUM	Heat pump life (assumed)
Lead time	4 months	ASSUM	Typical lead time (assumed)

7 RISKS

- The heat pump adds about 26 kW of electrical load; if it runs at the time of the monthly maximum demand, the demand charge rises (not counted).
- Confirm the hot-water temperature: above about 65 °C use a high-temperature heat pump or keep steam for the top-up (coverage below 100%).
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B IPMVP Option B: retrofit isolation, all parameter measurement

The system's energy logged before and after at like load.

Baseline and reporting period: Appendix D.3.

Return more condensate

BILL SAVING A YEAR R78k net R100k after running costs	ENERGY SAVED 42 MWh LPG	CAPEX R250k life 15 years · 4 months to build	NPV AT 12% R803k IRR 48%	PAYBACK 2.5 years R0.35 per kWh saved
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Indicative: Rests on an assumed input (±29%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Pipe condensate from the users that drain to sewer back to the hotwell, with a pump set where needed.

- Condensate routes traced on the walk-through

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 6 in the system's sequence. On its own it would save 65 MWh; after the earlier measures it saves 42 MWh (~36%).

3 METHOD AND FORMULA

$$F = S / (1 - b); M = F - R; T_{fw} \text{ from mixing } R \text{ at } T_c \text{ with } M \text{ at } T_m; Q = S(h_g - h_{fw}) + B(h_f - h_{fw}); fuel = Q / \eta$$

Steam model: feedwater 44.4 → 68.9 °C. Tool audit-steam v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Return before	0.400
Return after	0.800
Feedwater before (°C)	44.4
Feedwater after (°C)	68.9
Makeup saved (m³)	464.0

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R77,919	ASSUM ±30%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	41.8 MWh	ASSUM ±29%

6 CAPEX, RUNNING COST AND LIFE

Capex	R250,000	ASSUM ±29%	1 installation × R250,000 (Condensate pump set, flash vessel and return piping: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	–R22,271/yr	EST	464 m³ less make-up water × R48/m³ (water, effluent and treatment)
Life	15 years	ASSUM	Pumps and piping life (assumed)
Lead time	4 months	ASSUM	Typical lead time (assumed)

7 RISKS

- The condensate pump's electricity is not deducted (small next to the fuel saved).
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Make-up water meter and feedwater temperature, logged before and after; fuel follows from the steam model.

Baseline and reporting period: Appendix D.3.

Flue-gas economiser

BILL SAVING A YEAR R147k net R147k after running costs	ENERGY SAVED 79 MWh LPG	CAPEX R177k life 20 years · 4 months to build	NPV AT 12% R1.72m IRR 91%	PAYBACK 1.2 years R0.30 per kWh saved
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Indicative: Rests on an assumed input (±26%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Preheat boiler feedwater with the flue gas, down to a safe exit temperature above the acid dew point.

- Combustion test at high fire (fictional report)

2 BASELINE

Steam and boilers, data level 2: 1,789 MWh a year before any measure (system model).

Step 7 in the system's sequence. On its own it would save 195 MWh; after the earlier measures it saves 79 MWh (–60%).

3 METHOD AND FORMULA

$$Q = \dot{m}_{fw} c_p \Delta T_{fw}; \text{ fuel} = Q / \eta$$

Economiser: flue gas 300 → 140 °C at 3.0% O₂ (19.3 kg of flue gas per kg of fuel): boiler efficiency 84.0% → 91.3%. Tool audit-economiser v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Fuel	lpg	
Flue in (°C)	300	
Flue out (°C)	140	
Flue O ₂ (%)	3	
Excess air	0.168	
Flue gas (kg/kgfuel)	19.3	
Recovered kj per (kgfuel)	3,464	
Efficiency before	0.840	
Efficiency after	0.913	
Recovered (kWh)	66,058	
Flue O ₂ 3% after O ₂ trim	library default	ASSUM
Flue exit 140 °C (the fuel's minimum + 20 K)	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R146,640	ASSUM ±26%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	78.6 MWh	ASSUM ±26%

6 CAPEX, RUNNING COST AND LIFE

Capex	R176,635	ASSUM ±28%	22.1 kW of design heat recovery × R7,980 (Feedwater economiser with bypass and controls, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	20 years	ASSUM	Economiser life (assumed)
Lead time	4 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Worked out on the flue gas after O₂ trim (less excess air, so less flue gas to cool).
- Feedwater leaves the economiser at about 115 °C (in at 69 °C).
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Feedwater temperature and flow across the economiser.

Baseline and reporting period: Appendix D.3.

Tune the burners on ovens, fryers and dryers: Tunnel oven burners (2 ovens)

BILL SAVING A YEAR R291k net R283k after running costs	ENERGY SAVED 156 MWh LPG	CAPEX R13k life 5 years · 1 month to build	NPV AT 12% R1.16m IRR above 500%	PAYBACK 1 months R0.07 per kWh saved
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Indicative: Rests on an assumed input (±26%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Set each burner's air-fuel ratio with a combustion analyser so it runs with no more excess air than it needs, and check it every year.

- Flue-gas test on oven 1 at high fire (fictional analyser report)

2 BASELINE

Process heat, data level 2: 2,170 MWh a year in the balance.

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$\eta = 1 - \text{dry flue-gas loss} - \text{moisture loss at each } O_2; \Delta F = F (1 - \eta_{\text{now}} / \eta_{\text{tuned}})$$

Fuel × (1 - $\eta_{\text{now}} / \eta_{\text{tuned}}$) = 1,989,600 × (1 - 81.9% / 88.9%): flue gas 260 °C at 11.0% → 4.0% O₂ (losses method). Tool audit-burner-tuning v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS

TOOL INPUTS, MODEL UNITS		
Fuel (kWh/year)	1,989,600	
Flue gas (°C)	260	
Flue O ₂ (%)	11	
Target O ₂ (%)	4	
Efficiency now	0.819	
Efficiency tuned	0.889	
Tuned to 4% O ₂ (typical for LPG)	library default	ASSUM
Combustion air 25 °C	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R290,782	ASSUM ±26%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	155.9 MWh	ASSUM ±26%

6 CAPEX, RUNNING COST AND LIFE

Capex	R13,000	ASSUM ±36%	2 burners × R6,500 (Burner tuning with a combustion analyser: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R8,000/yr	ASSUM ±25%	2 burner a year × R4,000 (Yearly re-tune: assumed placeholder 2026 budget — replace with supplier quotes)
Life	5 years	ASSUM	Held by a yearly re-tune (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Agree the target O₂ with the burner's maker (some oven burners need more air); keep CO below about 100 ppm.
- Tuning leaves 40% less flue gas per kg of fuel; a flue heat recovery on this oven is worked out after the tuning, so the two do not overlap.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option A: retrofit isolation, key parameter measurement

Combustion test before and after tuning (flue O₂ and temperature, the key parameters); fuel is stipulated from the register or the gas meter.

Baseline and reporting period: Appendix D.3.

Insulate the crate washer's soak tank and fit a lid

BILL SAVING A YEAR R54k net R54k after running costs	ENERGY SAVED 29 MWh LPG	CAPEX R11k life 15 years · 1 month to build	NPV AT 12% R561k IRR above 500%	PAYBACK 2 months R0.06 per kWh saved
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Indicative: Rests on an assumed input (±33%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Lag bare hot tanks, vessels and equipment, and fit insulated lids to open tanks of hot water or wash liquor, which lose heat by evaporation as well.

- The crate washer's soak tank is open-topped and its walls are bare (fictional)

2 BASELINE

Process heat, data level 2: 2,170 MWh a year in the balance.

Step 2 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$q = (h_c + h_r)(T_s - T_a), \quad h_c = 1.31 \Delta T^{(1/3)};$$
$$\text{evaporation } (p_w - p_a)(0.089 + 0.0782 V) \text{ kW/m}^2;$$
$$\text{fuel} = \text{heat} / \eta_{\text{heater}}$$

6.0 m² bare at 60 °C: 1.50 → 0.15 kW; 1.5 m² open water at 65 °C: 3.88 kW (3.15 kW evaporation) → 0.04 kW with a lid. 5.19 kW × 4,500 h = 23,361 kWh of heat ÷ 80% (steam from the LPG boiler at 80%) = 29,201 kWh/yr. Tool audit-hot-surfaces v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Bare area (m²)	6	
Surface (°C)	60	
Open area (m²)	1.50	
Liquid (°C)	65	
Hours per year	4,500	
Emissivity	0.400	
Heater carrier	lpg	
Heater efficiency	0.800	
Saved (kW)	5.19	
Saved heat (kWh)	23,361	
Air around it 25 °C	library default	ASSUM
Air over the water at 50% relative humidity and still	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R54,451	ASSUM ±33%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	29.2 MWh	ASSUM ±33%

6 CAPEX, RUNNING COST AND LIFE

Capex	R10,950	ASSUM ±29%	6 m² of surface × R1,200 (Insulation with cladding on hot tanks and equipment, installed: assumed placeholder 2026 budget — replace with supplier quotes) + 1.50 m² of open surface × R2,500 (Insulated lid or cover for an open hot tank, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	15 years	ASSUM	Insulation and lids (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Bare areas are taken as walls; a top loses about 15% more by convection, so the saving there is a little understated.
- Evaporation is from the pool equation (ASHRAE), fitted to pools: confirm on a hot tank by the fall in level, or the make-up water, with the lid off and on.
- Not netted against the steam measures (they change the boiler fuel behind each kWh of steam heat): noted, not counted twice.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

A

IPMVP Option A: retrofit isolation, key parameter measurement

Surface temperatures before and after (the key parameter), and the tank's make-up water with the lid off and on; hours stipulated.

Baseline and reporting period: Appendix D.3.

Recover oven flue heat: Tunnel oven burners (2 ovens)

BILL SAVING A YEAR R118k net R118k after running costs	ENERGY SAVED 63 MWh LPG	CAPEX R248k life 15 years · 4 months to build	NPV AT 12% R992k IRR 55%	PAYBACK 2.1 years R0.58 per kWh saved
---	--------------------------------------	--	---------------------------------------	--

Indicative: Rests on an assumed input (±49%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Cool the oven or dryer flue gas in an exchanger to make hot water or preheat air, down to a safe exit above the acid dew point.

- Flue-gas test on oven 1 at high fire (fictional analyser report); oven 2 is the same model

2 BASELINE

[Process heat](#), data level 2: 2,170 MWh a year in the balance.

Step 3 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$m = \text{fuel kg} \times \text{flue products per kg (at the flue } O_2); Q = m c_p (T_{\text{flue}} - T_{\text{exit}}) \varepsilon u; \text{fuel} = Q / \eta_{\text{heater}}$$

2,846 t/yr of flue gas (20.4 kg per kg of fuel at 11% O₂) cooled 260 → 140 °C × 0.6 × 0.8 = 50,611 kWh/yr recovered ÷ 0.8 = 63,264 kWh/yr of LPG. Tool audit-oven-heat-recovery v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS

TOOL INPUTS, MODEL UNITS	
Item id	ph-burners
Fuel (kWh/year)	1,989,600
Fuel from	register
Flue gas (°C)	260
Flue O2 (%)	11
Flue exit (°C)	140
Effectiveness	0.600
Use share	0.800
Heater efficiency	0.800
Flue gas (kg/year)	2,845,755
Flue exit 140 °C (the fuel's minimum + 20 K)	library default ASSUM
Exchanger recovers 60% of the heat above the exit temperature	library default ASSUM
80% of the recovered heat has a use while the oven fires	library default ASSUM
Displaced heater 80% efficient	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R117,968	ASSUM ±49%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
LPG saved	63.3 MWh	ASSUM ±49%

6 CAPEX, RUNNING COST AND LIFE

Capex	R248,411	ASSUM ±29%	27.6 kW of design heat recovery × R9,000 (Oven or dryer flue-gas heat recovery: cleanable exchanger, ducting, bypass damper and controls, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	15 years	ASSUM	Exchanger and ducting life (assumed)
Lead time	4 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Sized for 27.6 kW at full firing. Oven flue gas carries baking vapour and fat: specify a bypass and cleaning access.
- Displaces the oven's own fuel by default; if the hot water would otherwise come from steam or a heat pump, the saving overlaps with those measures: count one of them.
- Worked out after the burner tuning on this oven (4.0% O₂, 1,833,659 kWh/yr of fuel), so the two measures do not count the same fuel twice.
- The flue test (2026-08-20) is applied to all 2 units of this register line: test each before sizing.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option B: retrofit isolation, all parameter measurement

Heat meter on the recovery circuit.

Baseline and reporting period: Appendix D.3.

M19 · Motors, pumps and fans · Retrofit

INDICATIVE

RECOMMENDED · RANK 11

Variable-speed drive on a throttled pump (pump and system curves): Cooling-water and process pumps

BILL SAVING A YEAR R75k net R74k after running costs	ENERGY SAVED 50 MWh Electricity	CAPEX R83k life 10 years · 2 months to build	NPV AT 12% R480k IRR 97%	PAYBACK 1.1 years R0.31 per kWh saved
---	--	---	---------------------------------------	--

Indicative: Rests on an assumed input (±23%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Replace a throttle valve or bypass on a centrifugal pump with speed control, worked out on the pump curve, the system curve with its static head, and the pump's efficiency curve.

- Cooling-water and process pumps: throttle

2 BASELINE

Motors, pumps and fans, data level 2: 769 MWh a year before any measure (system model).

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

Pump and system curves: 151,641 kWh throttled → 101,822 kWh on a VSD (33% less). Tool audit-pump-system v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Rated (kW)	11	
Count	3	
Control	throttle	
Static head fraction	0.350	
Shutoff head ratio	1.25	
Design head margin	1.10	
Bep flow ratio	1	
Design shaft (kW)	25.3	
Motor efficiency	0.914	
VSD efficiency	0.970	
Shut-off head 1.25 × head at design flow (radial pump)	library default	ASSUM
Pump makes 10% more head than the system needs at design flow	library default	ASSUM
Best efficiency point at design flow	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R74,561	ASSUM ±23%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	49.8 MWh	ASSUM ±23%

6 CAPEX, RUNNING COST AND LIFE

Capex	R82,500	ASSUM ±20%	33 kW of motor rating × R2,500 (Variable-speed drive for a pump or fan, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R825/yr	ASSUM	Drive upkeep: 1% of capex a year (as the VSD tool)
Life	10 years	ASSUM	Drive life (assumed, as the VSD tool)
Lead time	2 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Motor efficiency is held at its full-load value; the drive's own losses are included.
- The pump's curve from the maker, and suction and discharge pressures at two flows, firm up the static head and the margin the valve burns.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B IPMVP Option B: retrofit isolation, all parameter measurement

The system's energy logged before and after at like load.

Baseline and reporting period: Appendix D.3.

VSDs on the oven-hall extraction fans (2 × 22 kW)

BILL SAVING A YEAR R132k net R131k after running costs	ENERGY SAVED 88 MWh Electricity	CAPEX R98k life 10 years · 2 months to build	NPV AT 12% R898k IRR 141%	PAYBACK 9 months R0.21 per kWh saved
---	--	---	--	---

Firm: From site data (calculated, ±10%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Replace throttling, dampers or bypass with speed control (affinity laws). Throttled and bypassed pumps go through the pump and system curves instead (mo-pump-vsd).

- Oven-hall extraction fans: damper

2 BASELINE

Motors, pumps and fans, data level 2: 769 MWh a year before any measure (system model).

Step 2 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

Affinity laws over the duty profile (power ∝ flow³ with no static head), against the damper or throttle curve

199,949 kWh today – 112,005 kWh with a VSD (affinity laws). Tool motor-vsd-savings v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Motor rated (kW)	44
Load fraction at full flow	0.850
Motor efficiency	0.930
VSD efficiency	0.970
Operating hours per year	5,500
Static head fraction	0
Baseline power at zero flow fraction	0.600
Duty	100% flow for 20% of hours; 80% flow for 40% of hours; 60% flow for 40% of hours
Tariff (R/kWh)	1.50
VSD cost (R/kW)	2,227
VSD efficiency (tool default)	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R131,619	CALC
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	87.9 MWh	CALC

6 CAPEX, RUNNING COST AND LIFE

Capex	R98,000	EST ±10%	Installer quote for two 22 kW drives, fitted (fictional)
Running cost change	R1,000/yr	ASSUM	Default: 1% of capex a year
Life	10 years	ASSUM	Default life for a drive
Lead time	2 months	ASSUM	Default lead time

7 RISKS

- Screening estimate: motor part-load efficiency, minimum speed and pump-curve shifts are ignored.

8 MEASUREMENT AND VERIFICATION

B

IPMVP Option B: retrofit isolation, all parameter measurement

Log drive kW for two weeks before (damper or throttle) and after (VSD) over the same duty; annualise with the duty profile.

Baseline and reporting period: Appendix D.3.

M21 · Motors, pumps and fans · Retrofit

INDICATIVE

RECOMMENDED · RANK 15

Synchronous or cogged belts instead of V-belts: Oven-hall extraction fans

BILL SAVING A YEAR R9k net R9k after running costs	ENERGY SAVED 5,715 kWh Electricity	CAPEX R20k life 10 years · 1 month to build	NPV AT 12% R45k IRR 50%	PAYBACK 2.3 years R0.61 per kWh saved
---	---	--	--------------------------------------	--

Indicative: Rests on an assumed input (±37%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Fit synchronous (toothed) belts and sprockets on steady loads such as fans and pumps, or cogged V-belts on shock loads, so less of the motor's output is lost to slip and flexing.

- Oven-hall extraction fans: standard V-belt

2 BASELINE

Motors, pumps and fans, data level 2: 769 MWh a year before any measure (system model).

Step 3 in the system's sequence. On its own it would save 10 MWh; after the earlier measures it saves 5,715 kWh (–44%).

3 METHOD AND FORMULA

$E \times (1 - 93\% / 98\%)$: standard V-belt to synchronous (toothed) belt. Tool audit-belt-drive v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS

TOOL INPUTS, MODEL UNITS		
Rated (kW)	22	
Count	2	
From	v-belt	
To	synchronous-belt	
Efficiency before	0.930	
Efficiency after	0.980	
standard V-belt 93% (DOE tip sheet)	library default	ASSUM
synchronous (toothed) belt 98% (DOE tip sheet)	library default	ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R8,552	ASSUM ±37%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	5.7 MWh	ASSUM ±37%

6 CAPEX, RUNNING COST AND LIFE

Capex	R19,800	ASSUM ±26%	44 kW of motor rating × R450 (Synchronous belt and sprockets, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	10 years	ASSUM	Sprockets last; replacement belts cost about the same as V-belts (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- A synchronous belt does not slip, so the fan or pump runs a little faster on the same pulleys and can use more power: change the pulley ratio, or trim the speed on its VSD, to hold the old speed.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B IPMVP Option B: retrofit isolation, all parameter measurement

The system's energy logged before and after at like load.

Baseline and reporting period: Appendix D.3.

Occupancy sensors in intermittently used areas

BILL SAVING A YEAR R52k net R52k after running costs	ENERGY SAVED 35 MWh Electricity	CAPEX R14k life 10 years · 1 month to build	NPV AT 12% R380k IRR 377%	PAYBACK 3 months R0.07 per kWh saved
---	--	--	--	---

Indicative: Rests on an assumed input (±34%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Presence detection in warehouses, stores, cold rooms and corridors.

- Warehouse and dispatch: 400 W metal-halide high bays: 36 fixtures
- Cold stores: twin 58 W T8 battens: 40 fixtures

2 BASELINE

Lighting, data level 2: 320 MWh a year before any measure (system model).

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

$$\Delta E = E_{\text{lighting}} \times r, \quad r = 24\% \text{ (Williams et al., 2012) in the controlled areas}$$

Lighting energy × 0.24 in 2 area(s). Tool audit-lighting v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS

Item ids	TOOL INPUTS, MODEL UNITS
lt-warehouse,lt-coldstore	
Reduction	0.240
Sensors	10
On-time cut by 24% (LBNL meta-analysis average)	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R51,663	ASSUM ±34%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	34.5 MWh	ASSUM ±34%

6 CAPEX, RUNNING COST AND LIFE

Capex	R14,000	ASSUM ±27%	10 sensors × R1,400 (Occupancy sensor, installed (one per 8 fittings): assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	10 years	ASSUM	Sensor life (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- LED fittings tolerate frequent switching; with discharge lamps fit the sensors after the LED retrofit.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION



IPMVP Option A: retrofit isolation, key parameter measurement

Light loggers in the controlled areas for two weeks before and after (hours are the key parameter); watts are stipulated.

Baseline and reporting period: Appendix D.3.

LED lighting retrofit

BILL SAVING A YEAR R252k net R252k after running costs	ENERGY SAVED 168 MWh Electricity	CAPEX R512k life 10 years · 2 months to build	NPV AT 12% R1.41m IRR 56%	PAYBACK 2.0 years R0.54 per kWh saved
---	---	--	--	--

Firm: From site data (estimated, ±19%). Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Replace fluorescent and discharge fittings with LED fittings for the same light level.

- Production hall: twin 58 W T8 battens: T8-magnetic
- Warehouse and dispatch: 400 W metal-halide high bays: metal-halide
- Cold stores: twin 58 W T8 battens: T8-magnetic
- Offices and canteen: 4 × 18 W T8 troffers: T8-magnetic

2 BASELINE

Lighting, data level 2: 320 MWh a year before any measure (system model).

Step 2 in the system's sequence. On its own it would save 190 MWh; after the earlier measures it saves 168 MWh (−11%).

3 METHOD AND FORMULA

$$\Delta E = n \times (W_{old} - W_{LED}) \times h \times f_{on} / 1000$$

$n \times (W_{old} - W_{LED}) \times h \times on$ -share. Tool audit-lighting v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Fixtures 344

Groups Production hall: twin 58 W T8 battens: 130 → 56 W; Warehouse and dispatch: 400 W metal-halide high bays: 455 → 170 W; Cold stores: twin 58 W T8 battens: 130 → 50 W; Offices and canteen: 4 × 18 W T8 troffers: 80 → 36 W; External: 250 W sodium floodlights: 280 → 120 W

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R251,782	EST ±19%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	168.2 MWh	EST ±19%

6 CAPEX, RUNNING COST AND LIFE

Capex	R511,600	ASSUM ±10%	160 luminaires × R1,100 (LED batten or troffer replacing fluorescent, fitted: assumed placeholder 2026 budget — replace with supplier quotes) + 36 luminaires × R3,450 (LED high bay replacing metal-halide or sodium, fitted: quote, Fictional Lighting Supplies (Pty) Ltd, 2026-09-15) + 40 luminaires × R1,100 (LED batten or troffer replacing fluorescent, fitted: assumed placeholder 2026 budget — replace with supplier quotes) + 90 luminaires × R1,100 (LED batten or troffer replacing fluorescent, fitted: assumed placeholder 2026 budget — replace with supplier quotes) + 18 luminaires × R3,800 (LED floodlight replacing metal-halide or sodium outdoors, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
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Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	10 years	ASSUM	50,000 h rated life (L70) at each area's hours, capped at 15 years (assumed)
Lead time	2 months	ASSUM	Typical lead time (assumed)

7 RISKS

- Same light level assumed; confirm with a lighting design for high bays.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

A**IPMVP Option A: retrofit isolation, key parameter measurement**

Measure input watts on a sample of old and new fittings (the key parameter); hours are stipulated from the audit.

Baseline and reporting period: Appendix D.3.

Widen HVAC set points

BILL SAVING A YEAR R6k net R6k after running costs	ENERGY SAVED 4,204 kWh Electricity	CAPEX R6k life 5 years · 1 month to build	NPV AT 12% R21k IRR 117%	PAYBACK 11 months R0.37 per kWh saved
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Indicative: Rests on an assumed input (±37%): confirm it on site first. Weakest number on the sheet: **ASSUM** (a cost, life or input still at a default: replace it with a quote or a site figure).

1 WHAT IT IS AND THE EVIDENCE

Cooling set points of 23-24 °C with a dead band instead of 18-21 °C (heating 19-20 °C), held by limits on the controllers.

- Office split remotes found at 19-20 °C cooling on the walk-through (fictional)

2 BASELINE

HVAC and offices, data level 2: 70 MWh a year before any measure (system model).

Step 1 in the system's sequence. It is quantified on the baseline plant.

3 METHOD AND FORMULA

HVAC unit energy × 6.0% (cooling: 3.0% per K × 2.0 K). Tool audit-hvac v1.0.0; method notes, Volume 2 §2.

4 INPUTS AND ASSUMPTIONS TOOL INPUTS, MODEL UNITS

Item ids	hv-splits
Mode	cooling
Setpoint change k	2
Saving share	0.060
Set point 2 K closer to outdoors	library default ASSUM
3% per K (About 3% of air-conditioning electricity per °C warmer (Hong Kong EMSD indoor set-point guidance; confirm document))	library default ASSUM

5 SAVINGS BY TARIFF COMPONENT

COMPONENT	YEAR 1	BASIS
Energy (kWh) charges	R6,292	ASSUM ±37%
Demand (kVA) charges, Capacity (NMD) charges, Fixed charges	not counted	
Electricity saved	4.2 MWh	ASSUM ±37%

6 CAPEX, RUNNING COST AND LIFE

Capex	R5,600	ASSUM ±94%	14 units × R400 (Set-point limits on the unit controllers (lock-out or BMS), per unit: assumed placeholder 2026 budget — replace with supplier quotes)
Running cost change	R0/yr	ASSUM	No change in running costs (assumed)
Life	5 years	ASSUM	Behaviour change held by controller limits (assumed)
Lead time	1 month	ASSUM	Typical lead time (assumed)

7 RISKS

- Agree the new set points with the occupants and hold them with controller limits, or the saving drifts back.
- Any fall in the billed maximum demand is not counted.

8 MEASUREMENT AND VERIFICATION

B IPMVP Option B: retrofit isolation, all parameter measurement

kW or run-time logging of the units, normalised to cooling degree-days.

Baseline and reporting period: Appendix D.3.

■ §8 · ENGINEERING REPORT

Financing view (for lenders)

The firm measures as a bank's credit committee would read them if a term loan paid for them: the loan the savings can carry, the yearly repayment, and how well each year's net saving covers it. Indicative measures are left out: a lender sizes on savings it can verify.

8.1 TERMS AND RESULT

Capex of the firm measures	R950,600
Loan	R665,420 (70% of capex; the 70% debt share binds)
Interest rate	11.5% nominal, all-in: an assumed prime-linked rate; replace it with the bank's quote
Tenor and repayment	5 years, annuity (level payments in arrears), R182,313 a year
DSCR: minimum, average	4.61× (year 1), 5.41×; target 1.30×
Equity	R285,180 in; equity IRR 240.9%, equity NPV R4.59m at 12%

Meets a 1.30× cover in every year: a bank can lend R665k (70% of capex) over 5 years. The weakest year, year 1, covers 4.61×.

8.2 DEBT SCHEDULE BY YEAR (NOMINAL RAND)

YEAR	NET SAVING (CFADS)	INTEREST	PRINCIPAL	DEBT SERVICE	BALANCE AT YEAR END	DSCR	EQUITY CASH FLOW
0	Loan drawn R665,420				R665,420		–R285,180
1	R840,903	R76,523	R105,790	R182,313	R559,630	4.61×	R658,590
2	R908,175	R64,357	R117,955	R182,313	R441,675	4.98×	R725,862
3	R980,829	R50,793	R131,520	R182,313	R310,155	5.38×	R798,516
4	R1,059,295	R35,668	R146,645	R182,313	R163,509	5.81×	R876,982
5	R1,144,039	R18,804	R163,509	R182,313	R0	6.28×	R961,726

After year 5 the loan is repaid and the whole net saving goes to equity, to year 15 (the longest measure life).

8.3 METHOD

Cash flow available for debt service (CFADS) in year t is the firm measures' net saving that year, as in the business case (savings less running costs, escalated with the tariff). The repayment is an annuity: $A = D \times i (1 + i)^n \div ((1 + i)^n - 1)$, with interest on the opening balance and the rest of A repaying principal. $DSCR_t = CFADS_t \div A$.

The loan is the smaller of the debt share $\times$ capex and the loan the target cover allows. With level payments the weakest year binds: $A_{\max} = \min_t CFADS_t \div DSCR_{\text{target}}$, $D_{\max} = A_{\max} \div$ the capital recovery factor. Lenders test the minimum DSCR, not the average, because a loan defaults in its worst year: a good average can hide a year the savings do not cover the payment. Equity cash flow = net saving – debt service (year 0: capex – loan), with IRR and NPV as in the business case.

A sizing sketch, not a term sheet: no tax, fees, grace period, construction interest or debt service reserve account. Sources: Yescombe, Principles of Project Finance (cover ratios and debt sizing); the debt-sizing tool's sources (Bodmer). METHODS.md section 9.

Conversion factors

CARRIER	UNIT	BASIS	KWH PER UNIT	SOURCE	USED
Electricity	kWh	n/a	1	Billed in kWh	Yes
Diesel	litre	LHV	10.033	43.0 MJ/kg net (IPCC 2006, Vol. 2, Table 1.2) × 0.84 kg/l (typical; use the delivery note)	Yes
Diesel	kg	LHV	11.944	43.0 MJ/kg net (IPCC 2006, Vol. 2, Table 1.2)	
LPG	kg	LHV	13.139	47.3 MJ/kg net (IPCC 2006, Vol. 2, Table 1.2)	Yes
LPG	kg	HHV	14.273	47.3 MJ/kg net × 1.086 gross/net (propane, NIST Chemistry WebBook)	
Natural gas	GJ	HHV	277.778	1 GJ = 277.78 kWh (billed on gross heating value)	
Coal	t	LHV	7,166.667	25.8 MJ/kg net, other bituminous coal (IPCC 2006, Vol. 2, Table 1.2); SA coals vary: use the supplier's analysis	

Saturated steam properties from IAPWS-IF97 values (1 to 20 bar(a)) with linear interpolation; liquid water below 100 °C uses $h \approx 4.19 \times T$ kJ/kg. 1 kWh = 3.6 MJ; 1 GJ = 277.78 kWh.

■ B · APPENDIX

Standards and sources

B.1 STANDARDS

ISO 50002-1:2025	Energy audits, Part 1: general requirements
ASHRAE Standard 211-2018	Commercial Building Energy Audits
ISO 50006:2023	Energy performance indicators and energy baselines
ASHRAE Guideline 14-2014	Measurement of Energy, Demand and Water Savings
IPMVP (EVO, Core Concepts); SANS 50010	Measurement and verification of savings
JCGM 100:2008 (GUM)	Evaluation of measurement data: uncertainty
BS 845-1; EN 12953-11; ASME PTC 4	Boiler efficiency testing

B.2 SOURCES BEHIND THE METHODS

SOURCE	USED FOR	STATUS
ISO 50002-1:2025, Energy audits, Part 1: general requirements	audit process, data collection, energy balance	confirm clauses
ASHRAE Standard 211-2018, Commercial Building Energy Audits	audit levels	confirm section
ISO 50006:2023, EnPIs and energy baselines	regression baselines, relevant variables	confirm clauses
ASHRAE Guideline 14-2014, Measurement of Energy, Demand and Water Savings	CV(RMSE), NMBE and their thresholds	confirm section and table
EVO, IPMVP Core Concepts; SANS 50010	M&V, non-routine adjustments	confirm edition
LEED existing buildings (O+M) energy audit requirement	10% end-use reconciliation benchmark	as summarised in the design spec; confirm
Australian Energy Efficiency Opportunities, assessment framework	80% within $\pm 5\%$ benchmark	as summarised in the design spec; confirm
JCGM 100:2008 (GUM)	uncertainty propagation	section 5.1
IPCC 2006 Guidelines, Vol. 2, ch. 1, Table 1.2	net calorific values	confirm table values
NIST Chemistry WebBook	propane gross/net ratio	—
IAPWS-IF97 (via standard steam tables)	saturated steam properties	—
US DOE / Compressed Air Challenge, Improving Compressed Air System Performance (sourcebook)	part-load curves, leak test, heat recovery	confirm edition and pages
US DOE MEASUR	ordered evaluation of measures	—
Carbon Trust compressed air and refrigeration guides	screening ranges	confirm edition and pages
British Compressed Air Society (BCAS)	leakage screening range	confirm document
US DOE Steam Tip Sheet #1; DOE/NREL Improving Steam System Performance sourcebook	trap losses, steam system	confirm pages
J. P. Holman, Heat Transfer	simplified free-convection correlation	confirm edition and table
IEC 60034-30-1:2014; Regulation (EU) 2019/1781, Annex I	IE minimum efficiencies	check the table values before client use
IEA (2011), Energy-Efficiency Policy Opportunities for Electric Motor-Driven Systems	motor-system screening range	confirm page
Williams et al. (2012), Lighting Controls in Commercial Buildings, LEUKOS 8(3)	occupancy-sensor saving	—
LBNL: Meier (1982); Hoffman et al., The Cost of Saving Electricity	cost of saved energy	—
E. R. Yescombe, Principles of Project Finance (2nd ed., 2014)	cover ratios (DSCR), debt sizing to a target cover, annuity repayment	confirm chapter and pages

SOURCE	USED FOR	STATUS
Edward Bodmer, project finance debt sizing and sculpting (edbodmer.com)	annuity debt sized by the weakest year's cover (as in the debt-sizing tool)	—

Where a status says “confirm”, the clause or page is checked against the copy in the reference library before a client report quotes it. Every method is written in the audit's own words from these published sources.

Assumptions register

C.1 THE DEMONSTRATION SITE

TOPIC	ASSUMPTION
General	Demo Foods (Pty) Ltd, its site, bills, readings, quotes and rates are invented for demonstration.
General	Audit year July 2025 to June 2026; 12 monthly bills per carrier.
Site	Production about 6,000 h a year (24 h, 5.5 days, less holidays); 2,760 h a year with no production.
Site	9,140 t a year of product, 690 to 860 t a month (December peak, January low).
Site	Cooling degree-days (base 18 °C) are illustrative values for an inland Gauteng site, 541 a year.
Electricity	Megaflex-style time-of-use rates (fictional): high season (Jun-Aug) peak R6.10, standard R1.85, off-peak R1.02 per kWh; low season R2.00, R1.38, R0.88; network demand charge R42/kVA a month on the month's maximum demand; network access charge R24/kVA a month on the 650 kVA NMD; service and administration R3,200 a month.
Electricity	Energy split 16% peak, 44% standard, 40% off-peak every month.
Electricity	Monthly grid kWh = base + 120 kWh/t × production + 300 kWh per cooling degree-day + a fixed month-to-month scatter of a few percent; the base sets the annual total.
Electricity	Maximum demand: average kW of the month ÷ 0.72 load factor; power factor at maximum demand 0.85 to 0.87 (no correction installed).
Diesel	500 kVA standby generator: about 21,400 kWh a year (62 h of outages at about 320 kW and 12 one-hour tests at 130 kW, from its runtime log), at 34% efficiency (assumed). Deliveries 6,500 litres in the year; tank level about the same at both ends.
LPG	LPG from a bulk tank with supplier telemetry (monthly kg measured); R24.50/kg delivered (fictional); 47.3 MJ/kg net (IPCC default). Monthly use = base + 300 kWh/t × production + scatter.
Compressed air	Two 55 kW fixed-speed screw compressors, 61 kW package input, 9.6 m³/min each at 7.5 bar(g), load-unload; 28% of full-load power unloaded (controller reading). End uses need 6.6 bar(g).
Compressed air	Air demand excluding leaks: 8.6 m³/min for 3,600 h, 5.0 for 1,800 h, 2.0 for 600 h; compressors left on with no production for 2,760 h.
Compressed air	No-load test (one unit running, production stopped): loaded 21 s, unloaded 44 s, so leaks are about 3.1 m³/min, 31% of production air. Target after a repair programme: 10%.
Refrigeration	Freezer plant 3 × 37 kW (−32 °C evaporating) and chill plant 2 × 22 kW (−6 °C), both condensing at a fixed 38 °C; floating head pressure could average 30 °C. 24 evaporator fans of 0.75 kW and 18 defrost heaters of 4.5 kW.
Refrigeration	Level 3: a clip-on logger on the refrigeration sub-board recorded 6 to 12 October 2025 at 30-minute intervals; annualised × 365/7 with no seasonal correction (estimated ±12%).
Process heat	Two LPG tunnel ovens, 400 kW burner input each, average firing 42% over 5,600 baking hours and 15% over 900 idle hours; 2 × 18.5 kW of conveyor, recirculation and burner-fan motors.
Steam	LPG steam boiler at 8 bar(g), 80% efficiency (combustion test 82% less 2% shell loss), 84% achievable with O2 trim; 6,500 pressurised hours; 4% blowdown.
Steam	Two proofers 90 kg/h each at 60% for 6,000 h; crate washer 220 kg/h at 50% for 4,500 h; hot-water calorifier 140 kg/h at 45% for 5,500 h.
Steam	40% of condensate returns at 85 °C (the washer drains to sewer); 80% achievable; make-up water at 20 °C costs R48/m³ with effluent and treatment.
Steam	Trap survey: 6 of 60 traps failed open, 2.0 mm orifice, passing half a full orifice on average.
Steam	Bare pipe: 16 m of DN50 main, 14 m of DN25 branches and 12 m equivalent for 10 valves and flanges; 50 mm mineral wool (0.045 W/(m·K)) with aluminium cladding proposed.
Steam	Make-up water meter: 1,310 m³ in the year (cross-checks the steam mass balance).
Motors	Four 30 kW IE3 mixers; two 22 kW IE3 oven-hall extraction fans on damper control (duty 20% at full flow, 40% at 80%, 40% at 60%); three 11 kW IE3 pumps; thirty 1.5 kW IE2 conveyor and make-up motors; two 7.5 kW IE3 boiler-house motors.
Lighting	160 twin-58 W T8 battens (130 W with magnetic ballast) in production; 36 × 400 W metal-halide high bays (455 W) in the warehouse; 40 twin-58 W T8 in the cold stores; 90 × 4 × 18 W troffers (80 W) in offices; 18 × 250 W sodium floodlights (280 W) outside.
HVAC and offices	Fourteen 3.5 kW (input) office split units at 55% for 2,600 h; 3 kW of IT running all year; 25 kW of canteen and office equipment at 35% for 2,800 h.

TOPIC	ASSUMPTION
Measures	Measure costs come from the cost library's placeholder 2026 budget figures (fictional rand, excl. VAT) unless a quote is shown; lives are assumed. Three quotes are fictional too: the fan VSDs (on the opportunity), the capacitor bank (on the electrical survey) and the LED high bays (R3,450 each, in the project's cost library).
Steam	Combustion test at high fire: flue gas 300 °C at 8% O ₂ (an older two-pass boiler, tubes due for cleaning); an economiser could take it to about 140 °C, above the acid dew point for LPG.
Steam	The calorifier makes cleaning water used at 60 °C, which an air-source heat pump (SCOP about 3) can make instead of steam.
Motors	The cooling-water and process pumps are throttled by hand valves (duty 30% at full flow, 40% at 80%, 30% at 60%; static head about 35% of the design head); the extraction fans run on standard V-belts; mixers and conveyors drive through gearboxes.
Electricity	Two 1,000 kVA 11 kV/400 V transformers (2009) run in parallel, metered on the 11 kV side; test certificates give 1.7 kW no-load and 12 kW load losses each.
HVAC and offices	Office split units found set to 19–20 °C cooling; 22–23 °C is the target.
Steam	The combustion test's detail: air at 24 °C at the burner intake and a 2% casing loss (maker's figure). The losses method gives about 81% (net); the balance keeps the 80% estimate until the tested figure is chosen. A four-hour direct test at high fire read 1.95 m ³ on the feedwater meter at 45 °C and 128 kg of LPG on the boiler's sub-meter.
Process heat	Flue-gas test on oven 1 at high fire (20 August 2026): 260 °C at 11% O ₂ ; oven 2 is the same model and taken as the same. Both ovens are indirect-fired: radiant tubes with their own flue (maker's manual). The crate washer and the cleaning-water tank could take the recovered heat as hot water.
Compressed air	The compressors draw their air from the compressor room, 32 °C on average over the walk-through week (a logger, fictional), about 14 K above outside; an outside wall is 2 m from the intakes.
Steam	Two small steam leaks (valve glands, a wisp each) counted on the walk-round of 20 August 2026; none medium or large.
Steam	The crate washer's soak tank is open-topped: 1.5 m ² of water at 65 °C and 6 m ² of bare stainless-steel wall (emissivity about 0.4) at about 60 °C, hot for the washer's 4,500 hours. A lid and 50 mm of clad insulation are proposed.
Refrigeration	The plant room is next to the crate washer, whose fill and rinse water (heated with steam today) a desuperheater on the refrigeration compressors could preheat while the washer runs.
Electricity	Level-3 data on the main incomer: a year of half-hourly kWh and kVArh (fictional, made by a seeded generator from these assumptions). Each month is within 1% of its bill, with the bill's peak, standard and off-peak split and its maximum demand to within a few percent; one hour is missing on 14 October 2025 (a communications drop-out). Daily production and degree-days sum to the monthly figures.

C.2 ASSUMED VALUES IN THE MEASURES (REPLACE FIRST)

REF	WHAT	VALUE	SOURCE
M1	Capex	R15,000	1 installation × R15,000 (Switching procedure, protection check and interlock to run on fewer transformers: assumed placeholder 2026 budget — replace with supplier quotes)
M1	Life	10 years	Operating procedure (assumed)
M1	Input at default	Loss factor from the load factor (0.3 LF + 0.7 LF ²)	Library default
M1	Input at default	Maximum loading 90%	Library default
M2	Life	15 years	Default life for a capacitor bank
M2	Input at default	capacitorStepKvar	Library default
M3	Capex	R15,000	1 installation × R15,000 (Compressor timer or sequencer setting and an isolation valve: assumed placeholder 2026 budget — replace with supplier quotes)
M3	Life	5 years	Behaviour change held by a timer (assumed)
M4	Capex	R45,000	1 installation × R45,000 (Ultrasonic leak survey, tags, fittings and labour for the first repair round: assumed placeholder 2026 budget — replace with supplier quotes)
M4	Life	5 years	Programme horizon (assumed)
M5	Capex	R36,000	2 compressors × R18,000 (Intake duct from a compressor to outside air, with a filter, weather hood and damper: assumed placeholder 2026 budget — replace with supplier quotes)
M5	Life	15 years	Ductwork life (assumed)

REF	WHAT	VALUE	SOURCE
M5	Input at default	Outside air 18 °C on average over the year (use the nearest weather station's annual mean)	Library default
M6	Capex	R518,500	61 kW of compressor input × R8,500 (Variable-speed screw compressor (trim unit), installed: assumed placeholder 2026 budget — replace with supplier quotes)
M6	Life	15 years	Compressor life (assumed)
M6	Input at default	VSD part-load curve (typical)	Library default
M7	Capex	R130,000	2 circuits × R65,000 (Floating head pressure: controller changes and electronic expansion valves: assumed placeholder 2026 budget — replace with supplier quotes)
M7	Life	10 years	Controls life (assumed)
M8	Capex	R200,297	53.4 kW of desuperheat duty × R3,750 (Desuperheater on the compressor discharge, with water piping, pump and controls, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
M8	Life	15 years	Exchanger life (assumed)
M8	Input at default	Superheat 10% of the condenser heat	Library default
M8	Input at default	Half of it meets a hot-water demand at the time	Library default
M8	Input at default	COP half of the Carnot COP	Library default
M8	Input at default	Heated by steam from the boiler	Library default
M9	Capex	R85,000	1 boiler × R85,000 (O ₂ trim kit, commissioning and burner tuning: assumed placeholder 2026 budget — replace with supplier quotes)
M9	Life	10 years	Controls life (assumed)
M10	Capex	R42,000	1 survey × R15,000 (Steam trap survey (first): assumed placeholder 2026 budget — replace with supplier quotes) + 6 traps × R4,500 (Steam trap replaced, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
M10	Life	5 years	Trap life with an annual survey (assumed)
M10	Input at default	10% of the loss returns between annual surveys	Library default
M11	Capex	R7,000	2 leaks × R3,500 (Steam leak repair: gland repacking, gasket or union, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
M11	Life	3 years	Repairs hold about three years before glands and gaskets need doing again (assumed)
M11	Input at default	10% of the leak loss is back by the next walk-round	Library default
M12	Capex	R67,200	42 m of pipe × R1,600 (Pipe insulation with cladding, installed (DN25-DN50; valves as equivalent length): assumed placeholder 2026 budget — replace with supplier quotes)
M12	Life	20 years	Insulation life (assumed)
M13	Capex	R769,781	79.0 kW of heating capacity × R9,750 (Air-to-water heat pump for hot water up to about 65 °C, with storage, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
M13	Life	15 years	Heat pump life (assumed)
M13	Input at default	Heat pump SCOP 3.0 (air source, about 60 °C water)	Library default
M13	Input at default	Heat pump takes all of the hot water	Library default
M14	Capex	R250,000	1 installation × R250,000 (Condensate pump set, flash vessel and return piping: assumed placeholder 2026 budget — replace with supplier quotes)
M14	Life	15 years	Pumps and piping life (assumed)
M15	Capex	R176,635	22.1 kW of design heat recovery × R7,980 (Feedwater economiser with bypass and controls, supplied: assumed placeholder 2026 budget — replace with supplier quotes)

REF	WHAT	VALUE	SOURCE
M15	Life	20 years	Economiser life (assumed)
M15	Input at default	Flue O ₂ 3% after O ₂ trim	Library default
M15	Input at default	Flue exit 140 °C (the fuel's minimum + 20 K)	Library default
M16	Capex	R13,000	2 burners × R6,500 (Burner tuning with a combustion analyser: assumed placeholder 2026 budget — replace with supplier quotes)
M16	Life	5 years	Held by a yearly re-tune (assumed)
M16	Input at default	Tuned to 4% O ₂ (typical for LPG)	Library default
M16	Input at default	Combustion air 25 °C	Library default
M17	Capex	R10,950	6 m ² of surface × R1,200 (Insulation with cladding on hot tanks and equipment, installed: assumed placeholder 2026 budget — replace with supplier quotes) + 1.50 m ² of open surface × R2,500 (Insulated lid or cover for an open hot tank, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
M17	Life	15 years	Insulation and lids (assumed)
M17	Input at default	Air around it 25 °C	Library default
M17	Input at default	Air over the water at 50% relative humidity and still	Library default
M18	Capex	R248,411	27.6 kW of design heat recovery × R9,000 (Oven or dryer flue-gas heat recovery: cleanable exchanger, ducting, bypass damper and controls, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
M18	Life	15 years	Exchanger and ducting life (assumed)
M18	Input at default	Flue exit 140 °C (the fuel's minimum + 20 K)	Library default
M18	Input at default	Exchanger recovers 60% of the heat above the exit temperature	Library default
M18	Input at default	80% of the recovered heat has a use while the oven fires	Library default
M18	Input at default	Displaced heater 80% efficient	Library default
M19	Capex	R82,500	33 kW of motor rating × R2,500 (Variable-speed drive for a pump or fan, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
M19	Life	10 years	Drive life (assumed, as the VSD tool)
M19	Input at default	Shut-off head 1.25 × head at design flow (radial pump)	Library default
M19	Input at default	Pump makes 10% more head than the system needs at design flow	Library default
M19	Input at default	Best efficiency point at design flow	Library default
M20	Life	10 years	Default life for a drive
M20	Input at default	VSD efficiency (tool default)	Library default
M21	Capex	R19,800	44 kW of motor rating × R450 (Synchronous belt and sprockets, supplied: assumed placeholder 2026 budget — replace with supplier quotes)
M21	Life	10 years	Sprockets last; replacement belts cost about the same as V-belts (assumed)
M21	Input at default	standard V-belt 93% (DOE tip sheet)	Library default

REF	WHAT	VALUE	SOURCE
M21	Input at default	synchronous (toothed) belt 98% (DOE tip sheet)	Library default
M22	Capex	R14,000	10 sensors × R1,400 (Occupancy sensor, installed (one per 8 fittings): assumed placeholder 2026 budget — replace with supplier quotes)
M22	Life	10 years	Sensor life (assumed)
M22	Input at default	On-time cut by 24% (LBNL meta-analysis average)	Library default
M23	Capex	R511,600	160 luminaires × R1,100 (LED batten or troffer replacing fluorescent, fitted: assumed placeholder 2026 budget — replace with supplier quotes) + 36 luminaires × R3,450 (LED high bay replacing metal-halide or sodium, fitted: quote, Fictional Lighting Supplies (Pty) Ltd, 2026-09-15) + 40 luminaires × R1,100 (LED batten or troffer replacing fluorescent, fitted: assumed placeholder 2026 budget — replace with supplier quotes) + 90 luminaires × R1,100 (LED batten or troffer replacing fluorescent, fitted: assumed placeholder 2026 budget — replace with supplier quotes) + 18 luminaires × R3,800 (LED floodlight replacing metal-halide or sodium outdoors, fitted: assumed placeholder 2026 budget — replace with supplier quotes)
M23	Life	10 years	50,000 h rated life (L70) at each area's hours, capped at 15 years (assumed)
M24	Capex	R5,600	14 units × R400 (Set-point limits on the unit controllers (lock-out or BMS), per unit: assumed placeholder 2026 budget — replace with supplier quotes)
M24	Life	5 years	Behaviour change held by controller limits (assumed)
M24	Input at default	Set point 2 K closer to outdoors	Library default
M24	Input at default	3% per K (About 3% of air-conditioning electricity per °C warmer (Hong Kong EMSD indoor set-point guidance; confirm document))	Library default

Quality tags, data levels and terms

D.1 QUALITY TAGS

MEASURED	Measured. Read from a meter, bill, nameplate or log.
CALCULATED	Calculated. Worked out from other figures by the method stated.
ESTIMATED	Estimated. A reading or judgement made on site, or a quote.
ASSUMED	Assumed. A typical default, to be replaced with a site figure.

D.2 DATA LEVELS

LEVEL	DATA	ESTIMATE	TYPICAL ±
Bills	12 to 24 months of bills per carrier	The carrier's metered total × a share from the walk-through	±30% or worse
Equipment inventory	Equipment register: nameplate, load factor, hours, efficiency	Bottom-up $E = n \times P \times LF \times h / \eta$, checked against the bills	about ±20%
Interval data	Half-hourly data, sub-meters or loggers, production	Measured energy annualised; regression baselines	about ±10-15%
Process measurements	Mass flows, temperatures, pressures, historian	Energy and mass balance per process unit	about ±5-10%

D.3 M&V OPTIONS (IPMVP)

Option A: retrofit isolation, key parameter measurement	The parameter the saving turns on is measured before and after; the others are stipulated from the audit.
Option B: retrofit isolation, all parameter measurement	The energy of the system the measure acts on is metered or logged before and after.
Option C: whole facility	Utility meters or bills, against a baseline adjusted for the relevant variables.
Option D: calibrated simulation	A model calibrated to measured data, where the other options cannot isolate the saving.

For every measure: the baseline is the audit year (July 2025 to June 2026); the reporting period is the 12 months from completion; non-routine adjustments follow SANS 50010.

D.4 TERMS

Firm saving	Weakest input measured, calculated or estimated, and ±20% or better.
Indicative saving	Rests on an assumed input or a wider ±; evaluated separately and never added to the firm case.
Balance point	Where a metered supply meets estimated demand (a source feeding several nodes, or the board it feeds).
Unaccounted	Metered energy the bottom-up estimates do not explain; drawn, never forced into an end use.
LCSE	Levelised cost of saved energy: $(\text{capex} \times \text{CRF} + \Delta \text{ running cost}) \div \text{kWh saved a year}$.
NMD	Notified maximum demand: the capacity the utility reserves for the site, billed per kVA.