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Energy Audit and Conservation Opportunities in Rwanda's Industrial Sector: A Case Study of SULFO Rwanda Industries Ltd

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Abstract**—** *This study reports an energy audit and conservation assessment of SULFO Rwanda Industries Ltd, covering soap production, PET bottle production, and bottle filling. Data were obtained from on-site measurements and equipment nameplates, supported by historical records and observations, and analyzed using specific electricity consumption (SEC), benchmarking, and scenario simulation. From 2022 to 2024, production declined (soap: 3,760,789 to 1,697,728 kg which is 54.8%; PET bottles: 16,172,980 to 12,743,667 pieces), but electricity use did not fall proportionally, indicating worsening energy intensity. Benchmarking showed SEC above reference values: soap averaged 0.1175 kWh/kg versus 0.1112 kWh/kg (5.66% higher) and PET bottle production averaged 0.0241 kWh/piece versus 0.0125 kWh/piece (92.8% higher). Plant power factor remained high (97-99%), so priority actions focus on end-use efficiency. Opportunities include replacing 229 fluorescent lamps and upgrading outdated or underloaded motors, including a „Crusher for Omega" motor operating at 38% loading. Simulations indicate that these upgrades can save up to 20,317 kWh per year and reduce electricity costs by about 2,499,005 RWF. The results support regular audits, real-time monitoring, and staff training to sustain savings and align with Rwanda's green goals.*

Keywords**—** *Energy audit; Industrial energy efficiency; Specific electricity consumption; Benchmarking; Conservation measures; Rwanda; SULFO Rwanda Industries.*

I. Introduction

Energy is a critical input for industrial production and national economic development. In industrial facilities, electricity is consumed by process equipment (motors, pumps, compressors), heating/cooling systems, and lighting; therefore, efficiency improvements can reduce operating costs while supporting environmental goals [2], [14].

An energy audit is a systematic approach to understand how, where, and how much energy is used in a facility, identify losses, and propose feasible conservation measures with economic justification [6], [7]. Audit approaches range from preliminary walk-through assessments to detailed (investment-grade) studies, and are often structured using frameworks such as ASHRAE levels [14].

In Rwanda, industry is expanding, and managing electricity demand is important for competitiveness. This paper presents an energy audit and conservation assessment for SULFO Rwanda Industries Ltd, focusing on soap production, PET bottle production, and bottle filling lines. The study evaluates historical consumption and production trends, computes specific electricity consumption (SEC), benchmarks performance against reference values, and models selected conservation measures to estimate savings and payback potential.

II. Materials and Methods

The energy audit was conducted at SULFO Rwanda Industries Ltd and covered three main production systems: soap production, PET bottle production, and bottle filling. Data sources included monthly electricity records and bills (2022-2024), plant observations, and selected on-site measurements, complemented by equipment nameplate information.

Specific electricity consumption (SEC) was used as the primary intensity metric to relate electricity use to production output. SEC was computed for each production line as electricity consumption (kWh) divided by production quantity (kg or pieces) for the corresponding period.

Benchmarking compared SULFO's SEC values to reference values reported in the literature and comparable industry benchmarks, to identify performance gaps and prioritize improvement areas.

Potential energy conservation opportunities were identified through end-use reviews (lighting and motor-driven systems) and then evaluated using scenario simulation (RETScreen) to estimate annual energy savings (kWh) and cost reductions (RWF) under base and proposed cases.

III. Result and Discussion

Production decreased between 2022 and 2024 for both soap and PET bottles, while electricity consumption did not decline proportionally in all lines. This pattern indicates worsening energy intensity and justifies the use of SEC rather than total kWh alone when throughput changes.

Plant power factor remained high (approximately 0.97 to 0.99), suggesting that priority actions should focus on end-use efficiency (lighting and motors) rather than power-factor correction alone.

Tables 1-4 summarize (i) production and electricity consumption with SEC indicators, (ii) electricity cost by process, (iii) the lighting inventory used for retrofit planning, and (iv) measured motor loading and operating conditions

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highlighting underloaded motors (e.g., the crusher for Omega motor).

TABLE 1. Production, electricity consumption, and specific electricity consumption (SEC) (2022-2024)

Item	2022	2023	2024	Average
Soap production (kg)	3,760,789	2,836,797	1,697,728	2,765,105
PET bottle production (pieces)	16,172,980	16,185,737	12,743,667	15,034,128
Bottle filling (pieces)	16,172,980	16,185,737	12,743,667	15,034,128
Electricity consumption - soap (kWh)	434,580	335,096	201,476	323,718
Electricity consumption - PET production (kWh)	157,346	165,897	123,031	148,758
Electricity consumption - bottle filling (kWh)	374,851	386,353	322,373	361,192
SEC - soap (kWh/kg)	0.1156	0.1181	0.1187	0.1175
SEC - PET production (kWh/piece)	0.0232	0.0239	0.0253	0.0241
SEC - bottle filling (kWh/piece)	0.0097	0.0102	0.0097	0.0099

TABLE 2. Cost of electrical energy consumption by process in RWF (2022-2024)

Process	2022 (RWF)	2023 (RWF)	2024 (RWF)
Soap production	45,232,847.90	35,232,093.30	20,923,006.30
PET bottle production	39,038,700.40	40,642,526.60	33,477,997.00
Bottle filling (food + RO)	16,386,786.50	17,443,955.30	12,776,595.00
Total	100,658,334.80	93,318,575.20	67,177,598.30

TABLE 3. Lighting inventory and estimated daily energy use (baseline)

No	Department	Lamps (n)	Lamp W	Total W	Area (m²)	Hours/day	Energy (Wh/day)
1	Generator control room	6	40	240	44	12	2880
2	Administration block	9	160	1400	218	8	11200
3	Engineering Office	8	160	1200	200	24	28800
4	Workshops	3	40	120	100	12	1440
5	Raw material store	15	40	600	180	24	14400
6	Packing & transporting area	40	40	1600	214	12	19200
7	Bleaching/Breaching kettle area	15	40	600	144	12	7200
8	Soap store	10	40	400	135	12	4800
9	Boiler and mixing area	22	40	880	182	12	10560
10	Substation control room	4	40	160	40	24	3840
11	Crushing	10	40	400	82	12	4800
12	Chiller	6	40	240	38	12	2880
13	Confirwa	50	40	2000	420	12	24000
14	Guard room and outside	10	40	400	25	12	4800
15	Pump room	5	40	200	72	12	2400
16	Water treatment area	7	40	280	52	12	3360
17	Water store	10	40	400	140	12	4800
	TOTAL	229		11120			151360

TABLE 4. Motor nameplate and measured operating conditions

No	Motor/equipment	Rated kW	Eff (%)	Speed rpm	Load %	PF	Voltage V	Current A
1	Breaching kettle 1	7.5	90.5	2900	54%	0.98	395	6.1
2	Breaching kettle 2	7.5	87.0	2920	72%	0.96	400	8.2
3	Breaching kettle 3	5.5	75.0	2900	47%	0.95	397	4.0
4	Stapping machine 1	0.55	78.0	1405	59%	0.96	395	0.5
5	Stapping machine 2	5.5	83.4	960	65%	0.92	400	5.7
6	Conveyor belt 1	0.37	76.0	1370	50%	0.9	397	0.3
7	Cutting machine	0.37	76.0	1370	87%	0.95	396	0.5
8	Weber machine	18.5	92.6	1473	80%	0.98	399	21.9
9	Comega machine 1	18.5	92.6	1473	78%	0.98	398	21.6
10	Comega machine 2	18.5	92.6	1473	64%	0.96	400	18.1
11	Vacuum weber	15.0	87.0	1460	60%	0.91	395	14.4
12	Comega machine 3	3.0	80.0	940	54%	0.91	399	2.6
13	Deposit machine	5.5	87.0	2900	46%	0.92	399	4.0
14	Acid mixing	7.5	90.2	2900	50%	0.92	400	6.1
15	Water injection pump	7.5	75.0	2920	45%	0.96	399	5.1
16	Breaching kettle 4	3.7	81.0	2850	50%	0.92	399	2.9
17	Boiler 1	11.0	78.0	2910	64%	0.92	399	11.2
18	Boiler 2	2.2	79.0	1400	64%	0.98	399	2.1
19	Compressor 2	30.0	92.5	1470	57%	0.91	400	27.4
20	Compressor 3	15.0	86.0	1470	66%	0.97	397	14.9
21	Compressor 4	15.0	92.1	1470	62%	0.92	398	14.6
22	Compressor 5	15.0	89.4	1460	60%	0.93	399	14.1
23	Compressor 6	15.0	89.4	1448	62%	0.97	396	14.1
24	Compressor 7	15.0	89.4	1460	63%	0.98	398	14.1
25	Compressor 8	15.0	92.1	1470	65%	0.98	395	14.6
26	Cooling tower 1	11.0	79.0	2900	46%	0.93	398	8.0
27	Cooling tower 2	11.0	79.0	2900	47%	0.96	396	7.9
28	Vccum of comega	18.5	90.5	1460	61%	0.97	399	17.0
29	Conveyor belt 2	1.5	85.3	1430	57%	0.9	397	1.4

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No	Motor/equipment	Rated kW	Eff (%)	Speed rpm	Load %	PF	Voltage V	Current A
30	Crusher for omega	90.0	85.0	1450	38%	0.94	396	53.4
31	Crusher for Weber	37.0	75.0	1000	68%	0.91	398	40.3

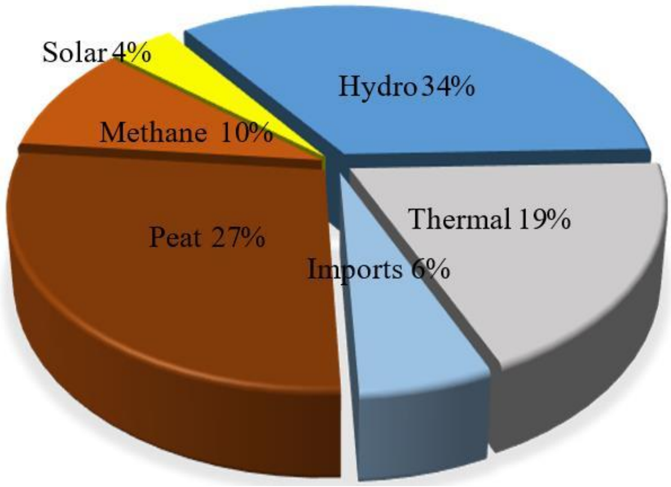

Figure 1. Rwanda electricity generation mix (context).

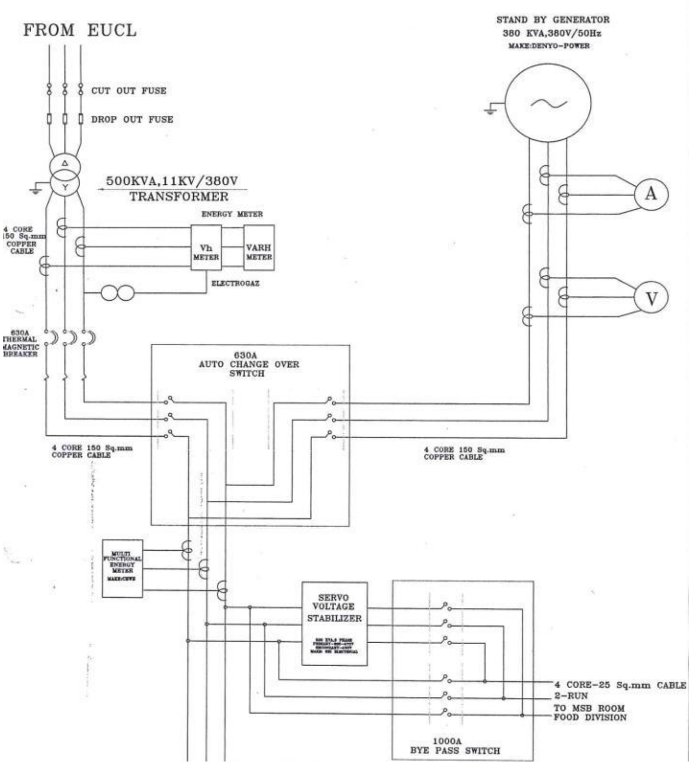

Figure 2. Power supply configuration at SULFO (REG supply and standby generator).

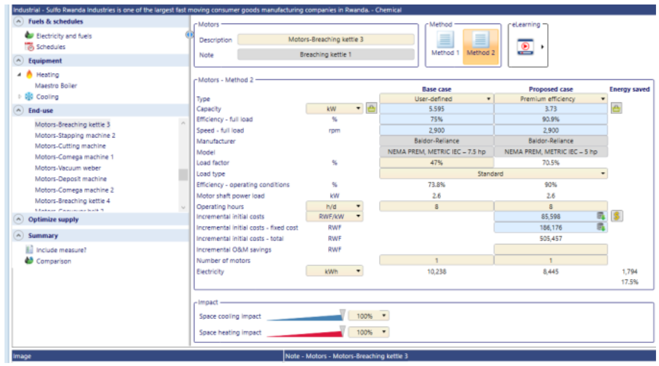

Figure 3. Example RETScreen motor upgrade scenario (base case vs proposed case).

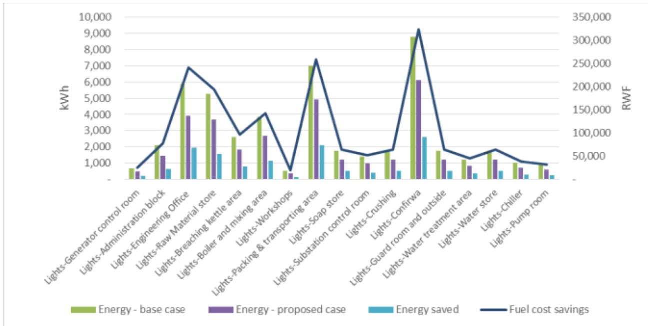

Figure 4. Lighting retrofit scenario results: base vs proposed energy and estimated savings.

IV. CONCLUSIONS

This case study indicates that declines in production between 2022 and 2024 were not matched by proportional declines in electricity use, leading to increased SEC for key lines. Benchmarking showed that SULFO's SEC exceeded reference values for both soap and PET bottle production, indicating significant efficiency improvement potential.

Given the high power factor (approximately 0.97-0.99), the most promising opportunities are end-use measures: lighting retrofits (replacing 229 fluorescent lamps) and motor system improvements (replacing or resizing underloaded/inefficient motors). RETScreen simulations suggest a potential saving of up to 20,317 kWh/year and approximately 2,499,005 RWF/year in electricity cost reductions, depending on implementation scope and operating hours.

Recommended next steps include institutionalizing periodic audits, embedding energy KPIs (SEC by line), implementing sub-metering for major loads, and strengthening maintenance planning and staff training to sustain savings.

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REFERENCES

[1] M. Shradha, C. Deshmukh, and A. Patil, "Energy Conservation and Audit," International Journal of Scientific and Research Publications, vol. 3, no. 8, 2013, [Online]. Available: www.ijsrp.org

[2] V. Thakur, B. Kumari, and K. Pallav, "Energy Conservation Using Energy Audit", [Online]. Available:www.ijstm.com

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[3] "No. Ministry of energy and mineral resources republic of Indonesia the study on energy conservation and efficiency Improvement in the republic of Indonesia final report energy efficiency improvement and conservation guideline," 2009.
[4] M. J. Panchal, V. Vyas Dwivedi, and R. Aparnathi, "The Case study of Energy Conservation & Audit in Industry Sector," 2014. [Online]. Available: www.ijecs.in
[5] M. J. Panchal, V. Vyas Dwivedi, and R. Aparnathi, "The Case study of Energy Conservation & Audit in Industry Sector," 2014. [Online]. Available: www.ijecs.in
[6] O. Oyelaran, O. A. Oyelaran, Y. Y. Twada, and O. M. Sanusi, "Energy Audit of an Industry: A Case Study of Fabrication Company," Aceh International Journal of Science and Technology, vol. 5, no. 2, pp. 45–53, Aug. 2016, doi: 10.13170/aijst.5.2.4838.
[7] I. Bosu, H. Mahmoud, and H. Hassan, "Energy audit and management of an industrial site based on energy efficiency,Economic and environmental analysis," Appl Energy, vol. 333, p. 120619, Mar. 2023, doi: 10.1016/J.APENERGY.2022.120619.
[8] N. Kumar and J. Singh, "Energy Audit Of A College Campus," Online, 2017. [Online]. Available:www.arseam.com
[9] V. J. Dwivedi, M. J. Panchal, V. Vyas Dwivedi, and R. Aparnathi, "Energy Audit of an Industry The Case study of Energy Conservation & Audit in Industry Sector," 2014. [Online]. Available: https://www.researchgate.net/publication/270275846
[10] V. J. Dwivedi, R. R. Aparnathi, M. J. Panchal, V. Vyas Dwivedi, and R. Aparnathi, "The Case study of Energy Conservation & Audit in Industry Sector," 2014. [Online]. Available: www.ijecs.in
[11] V. J. Dwivedi, M. J. Panchal, V. Vyas Dwivedi, and R. Aparnathi, "Energy Audit of an Industry The Case study of Energy Conservation & Audit in Industry Sector," 2014. [Online]. Available: https://www.researchgate.net/publication/270275846
[12] V. J. Dwivedi, M. J. Panchal, V. Vyas Dwivedi, and R. Aparnathi, "Energy Audit of an Industry The Case study of Energy Conservation & Audit in Industry Sector," 2014. [Online]. Available: https://www.researchgate.net/publication/270275846
[13] M. Sharma, "Energy Audit: Case Study of A Wheel Manufacturing Industry Highligting the Energy Conservation Opportunities in the Manufacturing Sector." [Online]. Available: www.ijert.org
[14] R. P. K, V. Jadhav, V. Bhandankar, and J. Priolkar, "Energy Audit of an Industry for Energy Conservation and Economical Operations," IJIRST-International Journal for Innovative Research in Science & Technology|, vol. 2, no. 10, 2016, [Online]. Available: www.ijirst.org
[15] A. Hasanbeigi and L. Price, "Industrial Energy Audit Guidebook: Guidelines for Conducting an Energy Audit in Industrial Facilities," 2010.
[16] S. Gusta, "Energy audit method for industrial plants," 2013.
[17] G. / Egziabher and G. / Meskel, "Energy auditing and conservation in Dire Dawa National Cement Plant Energy Auditing And Conservation In Cement Plant (Case Study: Diredawa National Cement PLC)."
[18] "Updated_Rwanda_LCPDP_Plan_2023-2050_-_June_2023".
[19] "Updated_Rwanda_Electricity_Distribution_Development_Plan_-_June_2023".
[20] Eaton, "Power factor correction: A guide for the plant engineer."
[21] U.S. Department of Energy, "Determining Electric Motor Load And Efficiency Load Ranges: Acceptable Short-Period Acceptable Operating Optimum," 2022.
[22] D. Kaya, E. A. Yagmur, K. S. Yigit, F. C. Kilic, A. S. Eren, and C. Celik, "Energy efficiency in pumps," Energy Convers Manag, vol. 49, no. 6, pp. 1662–1673, Jun. 2008, doi: 10.1016/J.ENCONMAN.2007.11.010.
[23] "Water Pump Electricity Usage: Capacity and Factors." Accessed: Nov. 05, 2024. [Online]. Available:https://famcocorp.ae/blog/pumps-articles/water-pump-electricity-usage-capacity-and-factors/
[24] M. S. Islam, "Plastic Waste and Carbon Footprint Generation Due to the Consumption of Bottled Waters in Saudi Arabia," Research & Development in Material Science, vol. 5, no. 1, Mar. 2018, doi: 10.31031/RDMS.2018.05.000604.
[25] H. Marczak, "Energy Inputs on the Production of Plastic Products," Journal of Ecological Engineering, vol. 23, no. 9, pp.146–156, Sep. 2022, doi: 10.12911/22998993/151815.
[26] I. A. Osterroth and T. Voigt, "Energy Consumption of Beverage-Bottling Machines," Sustainability 2021, Vol. 13, Page 9880, vol. 13, no. 17, p. 9880, Sep. 2021, doi: 10.3390/SU13179880.