GLOBAL COLD CHAIN ALLIANCE®

Strengthening Cold Chain Resilience Amid Rolling Energy Blackouts, aka Load-shedding

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Disclaimer

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Executive Summary

The cold chain sector is crucial to South Africa's economy as it supports the export of perishable goods, creates jobs, ensures food security, and promotes inclusive growth. However, its long-term sustainability is threatened by energy challenges, such as load shedding and an overreliance on ageing coal-fired power plants, as has been the case in South Africa. These issues necessitate policy reforms and significant investment in alternative energy sources to ensure a more sustainable and reliable power supply. Ideally, these alternative sources should be low carbon and renewable for a variety of compelling reasons for private companies – encompassing environmental, financial, regulatory, and reputational factors. Frequent power outages during load shedding strain refrigeration equipment, leading to increased maintenance and breakdowns, ultimately undermining the industry's viability and competitiveness in South Africa.

This report is a product of collaboration, reflecting the input from 15 Global Cold Chain Alliance (GCCA) members and energy experts, capturing qualitative and quantitative data from various stakeholders, including business leaders, technical experts, and researchers. It focuses on the effects of scheduled power outages on operations, equipment reliability, business continuity, and economic impact. The report also outlines the immediate needs of GCCA members to strengthen the sector's resilience and proposes multi-sector solutions to reduce the negative impact on the cold chain industry.

i. Extend Renewable Energy Incentives, provide tax credits for cold chain businesses investing in renewable energy, and establish a funding mechanism for energy-efficient technologies and storage solutions.
ii. Suspend import duties and Value-Added Tax on batteries and solar components for one year. Partner with the South African Photovoltaic Industry Association for lobbying efforts.
iii. Implement intelligent technology for real-time monitoring and data sharing in the cold chain. Foster public-private partnerships to drive innovation and overcome barriers related to temperature management during load shedding.
iv. Optimize trade facilitation to reduce wait times at border posts, enhancing resilience to power disruptions.
v. Use the cold chain sector as an energy storage medium through demand-side management strategies.
vi. Invest in the training and development of cold chain technicians not only for repairs and maintenance, but for technical innovation in the industry. Develop specialised programs aligned with the latest advancements in digital cold chain technology.

1: Overview of the Cold Chain Sector

1.1 Introduction

Load-shedding, the strategy of planned power reductions, is implemented to balance electricity supply and demand and prevent system-wide failures.[1] While often met with resistance, load-shedding is frequently necessary in such circumstances. The effects of load-shedding are acutely detrimental to society, particularly impacting critical industries like South Africa's cold chain industry, which is not just vital for preserving perishable goods and pharmaceuticals, but also for ensuring public health. The intermittent power outages disrupt the continuous refrigeration processes required to maintain product integrity. This leads to spoilage and significant economic losses across the supply chain, especially in sectors that rely on time-sensitive deliveries.[2]

While South Africa is currently experiencing an extended period without load shedding, the severe blackouts of 2023 exposed a critical vulnerability in the country's cold chain infrastructure. The power supply interruption during load shedding significantly impacts refrigeration systems, jeopardising the safety and quality of perishable goods. To survive such shocks, the cold chain sector must urgently implement robust resilience mechanisms. Whether through backup power solutions, improved storage facilities, or adaptive operational practices, fortifying the cold chain against load shedding is not just essential but urgent for food security and public health.

With this understanding, this report aims to illuminate the critical challenges South African Global Cold Chain Alliance (GCCA) members face during load-shedding. It focuses on the effects of scheduled power outages on operations, equipment reliability, business continuity, and economic impact. The report also details the GCCA's members immediate needs to build resilience in the sector. It proposes long-term, multi-sector

[1] Rakotonirainy, R., Durbach, I., & Nyirenda, J. (2019, December 20). Considering fairness in the load shedding scheduling problem. Operations Research Society of South Africa, 35(2), 127-144. https://doi.org/10.5784/35-2-648
[2] Al-Sumaiti, A S., & Salama, M. (2014, January 1). Review on issues related to electric energy demand in distribution systems for developing countries. https://doi.org/10.1049/cp.2014.1511

solutions to mitigate the adverse effects of the cold chain sector. This approach recognises that addressing the issue of load shedding requires collaboration and coordination across various sectors.

To achieve these objectives, the report reviewed relevant literature on the impact of load shedding on the cold chain, focusing on the South African context. The report shares insights from extensive consultations with crucial GCCA industry players. It presents the findings from these consultations on the impact of load shedding on the sector, the sector's immediate needs, and recommendations to strengthen the resilience of this critical industry.

The study began with a comprehensive literature review to understand the existing knowledge on how load-shedding impacts the cold chain sector. This involved examining scholarly articles, industry reports, and expert opinions to gather insights into the effects of load-shedding on various aspects of the sector. This foundational research provided a robust framework for understanding the broader context and identifying key focus areas for our study.

After conducting a literature review, we directly engaged with businesses operating in the cold chain industry to gain firsthand insights into the specific impacts of load-shedding. The report focussed on understanding how load-shedding affects business operations, equipment reliability, business continuity, and the overall economic impact on the sector. We used a long-form survey to gather input from cold chain actors, conducted key informant interviews with industry members and thought leaders, and organised expert group discussions.

The long-form survey consisted of 37 questions and was shared with all the members of the GCCA, with four respondents. Following this, we invited all the GCCA members to participate in a focus group discussion, with six more respondents joining the session. The remaining five individuals were consultations with sector experts in the energy, logistics and research institutions. This engagement allowed us to comprehensively understand the challenges participants face in the cold chain sector due to power disruptions.

Based on the literature review and stakeholder engagement, the report recommends building resilience within the cold chain sector. These include policy interventions to inform the sector's position, business continuity strategies, and equipment reliability measures. Additionally, the report identified key partnerships and alliances that can strengthen the sector's capacity to withstand electricity disruptions. Our recommendations aim to provide actionable insights for stakeholders and support the development of a more resilient and sustainable cold chain sector in the face of ongoing load-shedding challenges.

The report will briefly overview the sector, emphasising its significance to the South African economy. It will then discuss load-shedding's impact on the cold chain sector, outline the urgent requirements to enhance resilience in the sector and conclude with long-term interventions.

1.2 Overview of the Sector

South Africa has a significant cold chain infrastructure comprising over 35 facilities with over 50 million cubic feet of refrigerated space.[3] In recent years, this sector has experienced a notable increase in demand for efficient cold chain logistics, led by the continent's economic growth and the necessity to safeguard the safety

[3] Bonafide Research. (2023). South Africa Cold Chain Logistics Market Overview. Bonafide Research & Marketing. https://www.bonafideresearch.com/product/6401597817/south-africa-cold-chain-logistics-market

and quality of temperature-sensitive products. The South African Cold Chain Logistics market is projected to surpass USD 3 billion by 2029, positioned for growth due to the continent's escalating demand for temperature-controlled goods, the entry of new companies, and government initiatives and programs.

The COVID-19 pandemic exposed Africa's dependence on imported pharmaceuticals, but significant producers such as Moderna and BioNTech have subsequently invested in establishing facilities within the continent. This shift towards domestic pharmaceutical production aligns with the African Union and African Centres for Disease Control and Prevention's objective to fulfil 60% of the continent's vaccine needs locally by 2040. Furthermore, increased health concerns following COVID-19 have resulted in changes in consumption patterns, including a surge in household processed food consumption, further propelling the market's expansion.

South Africa heavily relies on the cold chain logistics sector to preserve the quality of temperature-sensitive agricultural products and pharmaceuticals during transportation. The demand for efficient and reliable cold chain services has significantly increased within the country, driven by the need to maintain the integrity of perishable goods. The pharmaceutical industry has seen a rise in demand for cold chain logistics due to the surge in the healthcare sector and emphasis on public health initiatives, especially for transporting temperature-sensitive medications and vaccines. South Africa's participation in international trade as both an exporter and importer has also contributed to maintaining the quality and safety of perishable products during long-distance transportation, necessitating cold chain logistics. Additionally, the diverse climatic conditions in South Africa further emphasise the critical role of cold chain logistics in preventing the spoilage of temperature-sensitive goods.

The cold chain industry in South Africa is vital for maintaining the quality of transported products. It includes refrigerated warehouses and transportation. Investments in cold chain infrastructure are driving the expansion of refrigerated transportation services. The pharmaceutical industry depends on refrigerated transportation to distribute temperature-sensitive medications and vaccines. South Africa actively participates in global trade by exporting and importing temperature-sensitive frozen products. The frozen segment of the cold chain logistics sector is essential for facilitating the export of frozen items, such as seafood, meat, and processed foods, to international markets. Frozen temperature-controlled logistics enable efficient distribution and access to diverse frozen products that cater to the country's varied culinary preferences.

South Africa's healthcare sector relies on cold chain logistics and gel packs to transport temperature-sensitive medications and vaccines for emergency and disaster relief efforts. The bakery and confectionery industry also depends on cold chain logistics to export high-quality products while maintaining international standards and regulations.

2. The Impact of Load Shedding on the Cold Chain Sector

In the cold chain sector, businesses depend on a reliable electricity supply. Since 2007, South Africa has been dealing with intentional and temporary electricity supply interruptions. Eskom implemented load shedding to protect its power stations and facilities from power unit breakdowns, leading to total blackouts. These

rolling blackouts disrupt the refrigeration systems necessary for preserving perishable goods and cause significant financial losses, particularly for sectors reliant on a steady power supply, such as pharmaceuticals and food distribution. This exacerbates the challenges already faced by the Cold Chain industry. The impact of load shedding on the cold chain industry in South Africa is significant because it disrupts the temperature-controlled environment required for the storage and transportation of perishable goods.

South Africa has recently experienced an extended period of uninterrupted power supply, with over 140 consecutive days of consistent electricity since 26 March 2024. While the recent period of continuous power supply in South Africa may provide some relief, the underlying challenges of ageing infrastructure and management inefficiencies continue to pose a significant threat to the stability of the power supply. Despite the temporary respite, the sector must remain vigilant and proactive in addressing the impact of these power disruptions, as the long-term reliability of the electricity grid is essential for maintaining the integrity of temperature-sensitive products and ensuring the overall effectiveness of the cold chain.

Load shedding disrupts the power supply to maintain the required temperature levels in cold storage facilities, refrigerated trucks, and containers. Fluctuating temperatures can compromise the quality and safety of perishable goods, leading to spoilage and financial losses. This directly impacts the food manufacturing sector and South African consumers. Furthermore, inadequate temperature control during power outages can result in substantial food waste. This is particularly alarming given the high perishability of fresh products and the urgent need to address food insecurity in the country.

The impact of load shedding on South Africa's cold chain industry has far-reaching consequences for businesses, consumers, and the broader economy. As the cost of maintaining the integrity of the cold chain rises, companies are often forced to pass on these additional expenses to consumers, leading to higher prices for perishable goods.[4] This price increase could further exacerbate food insecurity issues, particularly among lower-income households, as essential items become less affordable. The South African Reserve Bank estimates load shedding has led to a 0.5 percentage inflationary impact.[5] In this context, addressing the root causes of power supply issues and reinforcing the capacity of the energy sector will be crucial in stabilising cold chain logistics and fostering broader economic resilience amidst these ongoing challenges.[6]

The long-form survey respondents were from large and small organisations representing the logistics and food sectors. **Three-quarters of the respondents experienced load shedding several times a week**, with some reporting daily occurrences. **The same proportion (three-quarters) of respondents also stated load shedding affected their ability to maintain required temperature levels** in their cold storage facilities and transportation. Survey respondents indicated that the average monthly costs incurred to keep the temperature controls range **from less than R50,000 to more than R1,000,000.** This shows a significant financial burden on businesses to maintain the cold chain during power outages (see ***Panel A in Figure 1*** for more details.)

When asked about the operational challenges their respective companies faced due to load shedding, the most common response was that **logistical challenges in coordinating and organising the power disruptions**

[4] Aung, M M., & Chang, Y. (2014, June 1). Temperature management for the quality assurance of a perishable food supply chain. Elsevier BV, 40, 198-207. https://doi.org/10.1016/j.foodcont.2013.11.016

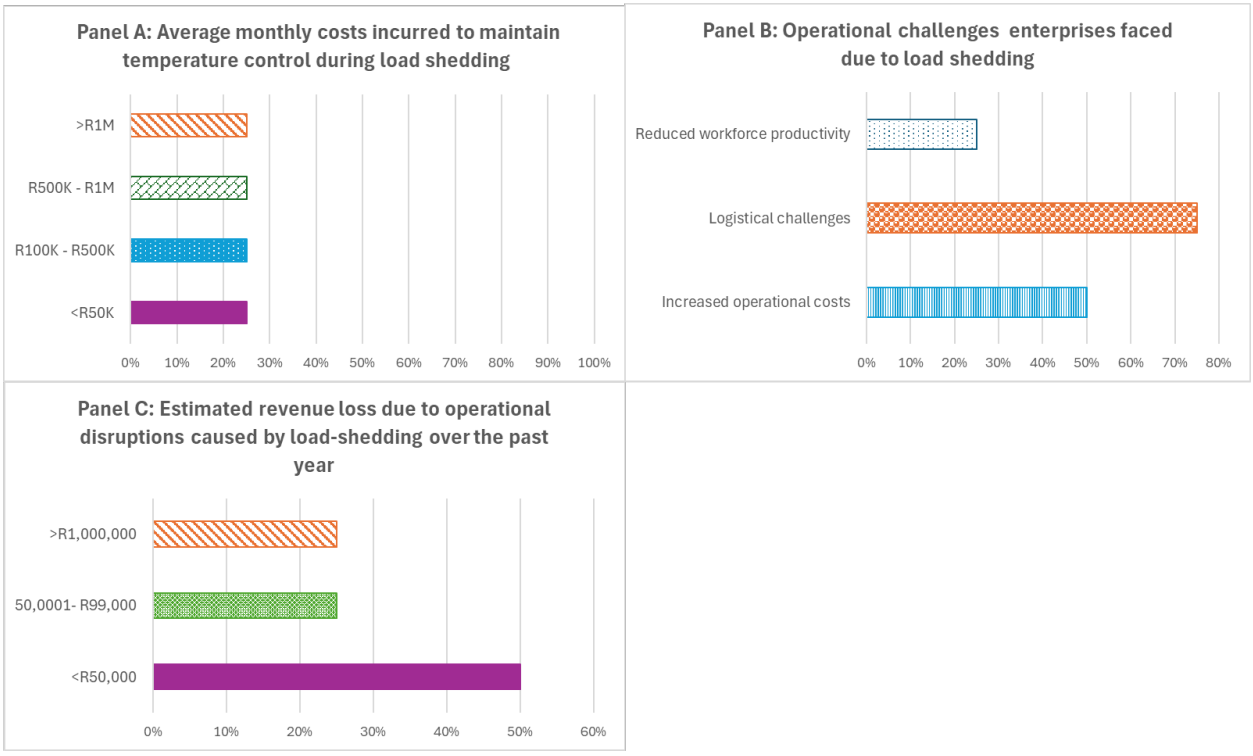
[5] BusinessTech. (2023, April 27). Reserve Bank explains how load shedding is ruining the economy. *Finance*. https://businesstech.co.za/news/finance/683425/reserve-bank-explains-how-load-shedding-is-ruining-the-economy/

[6] Gorjão, L R., & Maritz, J. (2022, January 1). The stochastic nature of power-grid frequency in South Africa. Cornell University. https://doi.org/10.48550/arxiv.2211.05582

were the central issue across all respondents. The second most common response was that **load-shedding had led to increased operational costs**, with some respondents attributing this to **costs associated with running diesel generators**. Respondents in the long-form survey indicated that load-shedding **had led to a reduction in workforce productivity**. Respondents also indicated that load-shedding led to quality breaches.

Respondents indicated that the reported **revenue losses ranged from under R50,000 to over R1,000,000**. The most significant losses were in the R50,000 to R500,000 category, underscoring the substantial economic impact of load shedding on business revenues.

Figure 1: GCCA Long Form survey responses to Load-shedding impact on operations

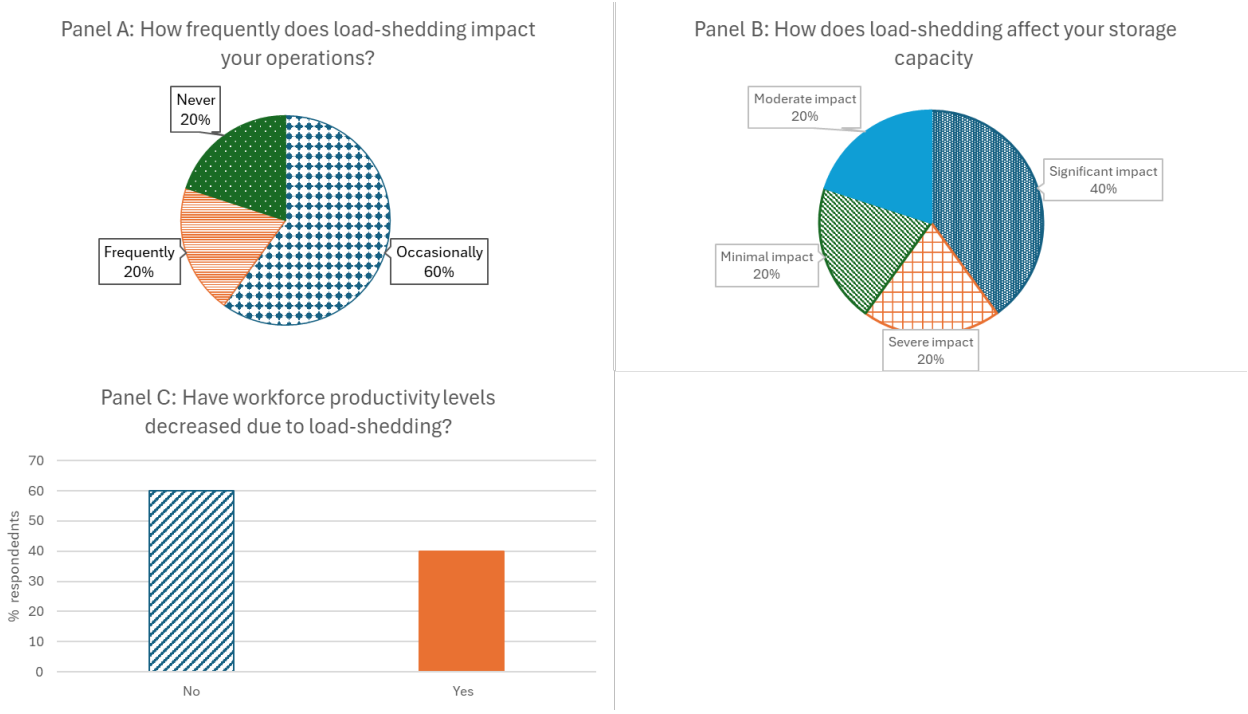


Source: Consultant's analysis of survey data

The survey revealed that all respondents experienced operational disruption, which impacted their revenues and led to an increase in maintenance costs. Additionally, all respondents reported that they had switched to backup power sources. Furthermore, 60% of respondents also implemented energy optimisation approaches alongside setting up backup power sources. 40% indicated that they adjusted their work hours to operate outside load-shedding hours in addition to backup power sources and energy optimisation approaches. Lastly, 20% of the respondents took all the aforementioned mitigation measures and adjusted their prices to counter the revenue losses. Backup generators and solar solutions were identified as the preferred alternate power sources. Interestingly, respondents indicated that the Enhanced Renewable Energy incentive introduced in 2023 to encourage clean electricity generation did not influence the decision.[7]

[7] South Africa's Enhanced Renewable Energy Incentive encourages businesses to invest in clean energy. Eligible assets include photovoltaic solar energy, concentrated solar energy, wind power, and hydropower. Businesses can claim a 12,5% tax deduction in the first year for qualifying capital expenditure on renewable energy projects. This incentive is available from March 1, 2023, until February 28, 2025, with the aim of alleviating the energy crisis and promoting sustainable practices.

Figure 2: GCCA Member's Key informant survey responses to Load-shedding impact on operations



Source: Consultant's analysis of survey data

The disruptions caused by load-shedding have affected the functioning of cold chain facilities, resulting in delays in storing, handling, and transporting goods. This leads to inefficiencies in operations, logistical difficulties, and higher costs for cold chain operators. Additionally, the cumulative impact of these operational disruptions can strain relationships with suppliers and customers, leading to pronounced delays and inconsistencies. Thus, it intensifies the challenges faced within the cold chain logistics framework and increases the risk of financial instability for the operators.

When asked to categorise significant incidents related to equipment failure caused by load shedding, respondents primarily attributed these issues to power fluctuations affecting sensitive refrigeration control equipment and power spikes, causing Programmable Logic Controllers[8] (PLC) and electronics to fail. Additionally, the prolonged use of generators increased the frequency of breakdowns, requiring premature repairs and increased strain on generators due to prolonged outages. In a climate where refrigerated systems must constantly adapt to power fluctuations, the reliability of these critical pieces of equipment decreases. This undermines the overall viability and competitiveness of the cold chain industry in South Africa.

All respondents indicated that **load-shedding significantly impacted the reliability of their equipment**, leading to an increased breakdown frequency and reduced equipment lifespans. Conversations revealed that power surges damaged sensitive components in refrigeration units, compressors, and control systems. This cascading effect not only exacerbates maintenance costs, with **67% of respondents indicating that the financial burden** resulting from the maintenance is a significant cost that is impacting their operational performance.

[8] The PLCs monitor and control temperatures of storage facilities to keep perishable goods within the required range. They automate refrigeration cycles, defrosting, and alarm systems to maintain product integrity. PLCs log data on temperature and other conditions for compliance and quality assurance. They also enable remote monitoring and control from a central location.

Two-thirds of respondents indicated a **lack of skilled technicians who could promptly repair machinery**, while 50% indicated that **ageing equipment contributed to the increased maintenance costs**.

Cold chain companies have taken comprehensive steps to ensure their operations continue smoothly during power outages. These steps include installing extra diesel generators with on-site fuel storage, investing in solar power systems, and using harmonic filters to prevent power surges. In addition, they have technicians on standby around the clock, at considerable expense. The companies have also installed Uninterruptible Power Supply (UPS) systems to provide backup power for crucial electronic equipment. Furthermore, there has been a coordinated effort to improve operations through collaboration among the companies within the cold chain. This collaboration aims to enhance performance, improve responsiveness, reduce food wastage, and overall enhance the efficiency of the supply chain. These integrated efforts bolster these enterprises' resilience and minimise the disruptive impacts of load-shedding.

3. Urgent Imperative: Strengthening Cold Chain Resilience in the Face of Load Shedding

Through strategic planning, investment in resilient infrastructure, and adopting advanced monitoring technologies, stakeholders can better navigate these challenges and enhance the overall stability and efficiency of the cold chain, safeguarding food quality and consumer trust in a constantly evolving energy landscape.

Furthermore, addressing these challenges necessitates collaborative efforts among stakeholders in the food supply chain. Improved coordination and communication can significantly mitigate the detrimental effects of load shedding on perishable goods, thereby preserving product quality and minimising losses throughout the supply chain.[9]

3.1 Incentives for renewable energy initiatives to address the impact of load shedding on the cold chain industry

There are opportunities to leverage renewable energy initiatives to address these issues. Investing in renewable energy sources mitigates the risks associated with power disruptions. It aligns with the global trend towards sustainable practices, which are increasingly essential for operational resilience and market competitiveness. By prioritising investments in solar, wind, and other renewable technologies, stakeholders can enhance their energy security while reducing dependence on fluctuating conventional power sources. This strategy is critical in a market that increasingly favours low-carbon solutions.[10] Through effective policy measures and supportive frameworks, businesses can be incentivised to adopt these renewable energy solutions, ultimately transforming the cold chain industry into a more resilient and sustainable sector capable of withstanding the ongoing challenges posed by load shedding.[11] In addition to fostering an environment

[9] Nair, S., & Lau, K H A. (2013, November 1). Postharvest Food Wastage Reduction In Fruit And Vegetables Through Cold Chain Collaboration: A Theoretical Framework. International Society for Horticultural Science, 1311-1315. https://doi.org/10.17660/actahortic.2013.1012.176

[10] Pegels, A. (2010, September 1). Renewable energy in South Africa: Potentials, barriers and options for support. Elsevier BV, 38(9), 4945-4954. https://doi.org/10.1016/j.enpol.2010.03.077

[11] Uhunamure, S E., & Shale, K. (2021, April 2). A SWOT Analysis Approach for a Sustainable Transition to Renewable Energy in South Africa. Multidisciplinary Digital Publishing Institute, 13(7), 3933-3933. https://doi.org/10.3390/su13073933

conducive to investment in renewable energy, it is also vital that the government implements targeted incentives that promote energy efficiency and storage solutions tailored to the needs of the cold chain industry, as this would not only enhance operational stability but also contribute to the overall sustainability of the sector.[12]

Recommendation 1: Extend the Enhanced Renewable Energy Incentive, provide tax credits for cold chain businesses investing in renewable energy, and establish a dedicated funding mechanism to support the adoption of energy-efficient technologies and storage solutions within the cold chain industry.

Recommendation 2: 1 Year suspension of import duties and Value Added Tax for batteries and other solar components. The GCCA can partner with the South African Photovoltaic Industry Association on their lobbying efforts.

3.2 Enhancing Cold Chain Efficiency with Digital Tools

Improving coordination and communication among stakeholders in the food supply chain is crucial. Doing so can significantly reduce the adverse effects of load shedding on perishable goods. This is particularly important at border crossings like Beitbridge, where delays and disruptions can worsen the impact on perishable goods. To enhance the resilience of the cold chain industry, it is essential to streamline customs processing and logistics coordination. These improvements can notably decrease spoilage rates and maintain product integrity during transit, especially with robust temperature management practices. Collaborative frameworks among logistics providers, customs authorities, and cold chain operators can enhance efficiency and responsiveness in cross-border trade. This ensures that temperature-sensitive products are transported safely and quickly through critical checkpoints, mitigating the adverse effects of load shedding on the cold chain industry. Moreover, improving communication and information sharing among stakeholders in the cold chain ecosystem can facilitate smoother operations at border crossings, significantly reducing transit times and the risk of product degradation due to temperature excursions. This is increasingly crucial given the frequent disruptions caused by load shedding in South Africa.

Stakeholders should consider implementing intelligent technology solutions that enable real-time monitoring and data sharing. This will allow quicker response times during power outages and reduce losses associated with temperature fluctuations. Fostering partnerships between private and public entities can also drive innovation and investment in cold chain technologies. This will enable the development of robust systems resilient to energy disruptions while ensuring compliance with health and safety standards. Establishing collaborative frameworks among different players in the cold chain ecosystem can enhance the sharing of best practices and resources, ultimately leading to a more agile and responsive supply chain capable of adapting to the challenges posed by load shedding. Integrating advanced digital tools streamlines operations and facilitates proactive risk management and decision-making in response to unpredictable energy conditions. This reinforces the cold chain's capacity to maintain product integrity and quality under adverse circumstances.

Recommendation 3: Explore the implementation of intelligent technology solutions for real-time monitoring and data sharing among cold chain stakeholders. This involves fostering public-private partnerships to drive innovation in resilient cold chain technologies. While these technologies can provide substantial benefits,

[12] Amir, M., & Khan, S. (2021). Assessment of renewable energy: Status, challenges, COVID-19 impacts, opportunities, and sustainable energy solutions in Africa. Energy and Built Environment, 3. https://doi.org/10.1016/j.enbenv.2021.03.002

their successful adoption depends on overcoming barriers such as cost, limited technical expertise, and infrastructure challenges related to temperature management throughout the supply chain. This is critical for preserving food quality and reducing waste during load-shedding events. Research into innovative technologies and operational practices is vital in addressing the challenges posed by load shedding in South Africa's cold chain industry.

Integrating advanced digital tools streamlines operations and facilitates proactive risk management and decision-making in response to unpredictable energy conditions, reinforcing the cold chain's capacity to maintain product integrity and quality under adverse circumstances. This includes adopting real-time temperature monitoring systems that allow for timely interventions in case of equipment failures or power outages, ensuring compliance with safety standards and reducing potential food waste.

Furthermore, fostering collaboration among stakeholders within the supply chain can enhance the implementation of these technologies while ensuring adherence to temperature management protocols, which is vital in mitigating food spoilage and waste during load-shedding events. The exploration and adoption of innovative technologies, such as blockchain for data transparency and automated temperature control systems, can provide a significant edge in preserving the quality of perishable goods as they navigate the challenges posed by frequent load shedding, ultimately contributing to the long-term sustainability and resilience of the cold chain industry in South Africa.

Accessing funding from institutions such as the Citrus Trust at the National Agricultural Marketing Council, which has funds dedicated to research into the citrus sector, is crucial for successfully implementing such technologies. This requires financial investment and a commitment to training personnel in best temperature management and equipment handling practices, as ineffective practices can lead to significant losses in product quality and increased food waste during load-shedding periods.

Recommendation 4: Optimise trade facilitation to reduce wait times at border posts through collaborative frameworks between logistics providers, customs authorities, and cold chain operators, thereby enhancing the cold chain sector's resilience to power disruptions.

3.3 Effective demand side management with the Cold Chain Sector

Collaboration between industry stakeholders and policymakers can enable the cold chain sector to effectively manage power demand and mitigate the impact of power outages. One innovative approach is to leverage the cold chain as an energy storage medium. This entails adjusting refrigeration temperatures during periods of surplus power and minimising energy use when shortages occur. This strategy can improve grid stability and resilience, aligning with demand-side management and smart grid technologies. However, implementing this idea necessitates meticulous coordination, monitoring, and robust control systems to ensure food safety and product quality within the cold chain. In addition, establishing clear guidelines and protocols for temperature management during energy fluctuations is essential to avoid food safety risks and ensure compliance with regulatory standards, highlighting the need for continuous improvement in operational practices within the cold chain sector to adapt to the new energy landscape. Furthermore, the application of rigorous temperature management protocols within this framework is critical, as improper temperature control can exacerbate food loss and waste, undermining the overall efficacy of the cold chain during periods of load shedding, which emphasises the urgency of adopting comprehensive strategies to enhance resilience and sustainability in the face of energy disruptions.

Recommendation 5: Explore the potential for the cold chain sector to serve as an energy storage medium through demand-side management strategies that involve adjusting refrigeration temperatures during periods of surplus power and minimising energy use when the grid is under strain.

3.4 Training cold chain technicians to support critical cold chain equipment maintenance.

The training is crucial to ensure that technicians are well-equipped to maintain and troubleshoot critical cold chain equipment. This helps minimise disruptions during load-shedding events, which can lead to spoilage and increased waste of perishable goods. It also shows the importance of skilled personnel and the resilience of the cold chain industry. Investing in the ongoing education and skill development of cold chain technicians empowers them to effectively address equipment failures and implement best practices in temperature management. This ultimately contributes to enhanced operational efficiency and reduced spoilage during energy crises, as evidenced by numerous studies highlighting the critical role of human capital in the efficacy of cold chain systems. Therefore, a systematic approach to training encompassing theoretical knowledge and hands-on experience is vital for improving the preparedness of cold chain technicians, reinforcing the industry's ability to withstand the adverse consequences of load shedding, and maintaining high standards of food safety and quality.

Recommendation 6: Invest in the training and development of cold chain technicians to ensure they are well-equipped to maintain and troubleshoot critical cold chain equipment, thereby minimising disruptions and reducing food spoilage during load-shedding. Furthermore, specialised training programs must be developed aligned with the latest advancements in cold chain technology and practices to ensure technicians stay abreast of emerging challenges, particularly those exacerbated by power supply issues, thus enhancing their capacity. The GCCA will need to partner with the FoodBev SETA to explore the best way to ensure that the right skills are imparted to technicians responsible for maintenance of machinery and equipment in the cold chain.