1. Introduction

Somalia's energy sector has long been characterized by high costs, limited access, and heavy reliance on diesel generators in the absence of a national grid. In fact, there is currently no unified national grid in Somalia [6]. This resulted in some of the highest electricity prices in the world, formerly around $1.20 per kWh in the mid-2010s [4]. Only about 35% of Somalis had access to electricity by 2018. These conditions underscored an urgent need for a sustainable energy transition. In response, Somalia's leading utility, Banadir Electric Company (BECO), began investing in renewable energy, especially solar, to transform this landscape. BECO's efforts have already made electricity more affordable, with rates falling from $0.49 to $0.36 per kWh after commissioning just an 8 MW solar plant in Mogadishu [1]. By 2020, BECO had cut tariffs to $0.35. These price reductions, coupled with expanding generation capacity, indicate the critical role of solar power in Somalia's sustainable transition, providing relief from the "crippling" costs of diesel-based electricity [7]. Equally important, solar displaces diesel fuel consumption and reduces carbon emissions [5], so each unit of solar energy production avoids significant greenhouse gases. In a country highly vulnerable to climate change, the shift to renewables thus aligns with both economic and environmental sustainability objectives.

The Jabad-Geele solar project is a flagship initiative within this broader transition. Located about 25 km outside Mogadishu, the Jabad-Geele power plant was originally established to move generation out of the crowded city and upgrade transmission to 33 kV [2]. BECO commissioned Phase 1 of Jabad-Geele in 2020 with 5.5 MW of solar PV, which successfully demonstrated the feasibility of large-scale solar by supplying 17% of the plant's energy from clean sources. Following that success, Phase 2 – a 25 MW solar expansion – was launched in 2024 to dramatically scale up renewable capacity. This expansion, when integrated with BECO's existing diesel and battery assets, is poised to make Jabad-Geele one of the largest solar farms in Somalia, substantially increasing the renewable share of Mogadishu's electricity. The project's context in Somalia's energy transition is pivotal: it directly addresses the twin challenges of affordability and sustainability. By adding 25 MW of solar, BECO moves closer to its strategic vision of supplying 75% of Somalia's power with 80% from green energy by 2025 [3]. In essence, the Jabad-Geele project serves as a demonstration of sustainable transition in practice – showcasing how a post-conflict nation can leapfrog to clean energy and more equitable access. The following sections present the portfolio of professional work and learnings from my role as Chief Engineer for Phase 2, highlighting how we applied sustainability principles and course concepts to achieve technical and socio-economic goals.

2. Professional Context

In the capacity of Chief Engineer for BECO's Jabad-Geele Solar Phase 2, I was responsible for overseeing the end-to-end implementation of the 25 MW solar PV expansion and its integration into the existing power system. This role was multifaceted, combining technical management, team leadership, and sustainability governance. On the technical front, my duties included detailed project planning and design review, ensuring the solar plant's layout, inverters, and interconnection met both BECO standards and international best practices. I supervised the procurement and construction process, coordinating with contractors and suppliers to guarantee quality and timely delivery. Given Somalia's fragile infrastructure context, a major focus was on system integration and optimization. This meant designing a control strategy via SCADA (Supervisory Control and Data Acquisition) to balance solar output with diesel plants and storage in real-time. I led the commissioning team in testing this hybrid operation, fine-tuning settings so that solar energy is maximized when available and diesel engines ramp down to save fuel, without compromising grid stability.

As Chief Engineer I also managed a team of engineers and technicians, prioritizing capacity building and knowledge transfer. We recruited and trained local engineers in solar plant O&M and SCADA operations, building local expertise as part of the project's sustainable legacy. Regular safety briefings and adherence to international electrical standards (IEC codes). I was the point of contact for stakeholders such as the project financiers and government regulators. For instance, I coordinated with the Ministry of Energy and Water Resources (MoEWR) to ensure compliance with any emerging energy policies or grid codes. In short, my professional context required bridging technical implementation with socio-environmental considerations: delivering a functional 25 MW solar plant that improves service for customers, upholds safety and environmental standards, and contributes to BECO's broader mission of an affordable, green electricity future for Somalia.

3. Application Examples

The following examples illustrate how I applied concepts from the Sustainability in Energy Transition (SET) course in my work, through concrete initiatives in Demand-Side Management, System Optimization, and Energy Auditing. Each example outlines the situation or challenge faced, the relevant course principles or concepts applied, the approach I took, and the measurable outcomes achieved.

3.1. Demand-Side Management (DSM)

With the commissioning of Phase 2's 25 MW solar array, a new challenge emerged: aligning customer demand with the variable renewable supply. Prior to the expansion, Mogadishu's peak demand occurred in the evenings when solar production is zero, forcing heavy diesel generation. Our customer base, now over 300,000 users in the capital, had little awareness of energy efficiency or peak load impacts. From the SET course, I recognized that behavioral change and consumer engagement are critical for sustainable energy transitions. The concept of demand-side management emphasizes altering energy use patterns as a complement to adding supply. This was highly relevant: without DSM, the benefits of the solar project would be limited to daylight hours, and expensive diesel would still meet the evening peak. Moreover, any wasted energy or unnecessary peak load would translate to higher fuel consumption and emissions. Backed by course principles on energy efficiency and social behavior, I framed a DSM program to encourage efficient use and maximize utilization of solar generation.

I spearheaded a comprehensive DSM campaign targeting both technological upgrades and user behavior. Key components of the approach included:

- Energy Awareness Outreach: We launched community workshops and radio info-spots to educate customers on the cost difference between solar vs diesel power and simple ways to conserve energy and reduce peak usage. We collaborated with local leaders and the Ministry of Energy's public education efforts to amplify our message.

- Time-of-Use Incentives: We implemented a pilot time-of-use tariff for large commercial customers, offering lower rates during midday when solar generation is abundant and higher rates during the evening peak. This pricing signal incentivized businesses to shift some operations to daylight hours. For residential users with prepaid meters, we introduced discounts in solar hours to encourage daytime usage.

Outcomes: The DSM initiatives yielded tangible benefits for both the grid and consumers. Within six months of rollout, evening peak demand dropped by roughly 5% as many customers shifted discretionary usage to daylight hours. As a result, BECO was able to shut off an extra diesel generator during midday and delay ramp-ups in the evening, saving an estimated 1,500 liters of diesel fuel per day. Residential consumers benefited from efficiency measures through lower bills. Importantly, these changes improved the utilization of the solar plant: much of the 25 MW solar output is now absorbed by daytime loads, minimizing solar curtailment and maximizing green energy usage. This cultural shift towards energy-conscious behavior, though gradual, represents a foundational step in Somalia's sustainable transition, lasting energy transitions require not just new infrastructure but also new consumption norms. BECO's DSM program thus became a model of aligning demand-side behavior with supply-side innovation, contributing to both immediate operational efficiency and long-term sustainability through an informed customer base.

3.2. System Optimization (Hybrid Integration and Reliability)

The introduction of 25 MW of intermittent solar power into BECO's grid required significant system optimization to maintain reliability and efficiency. Somalia's grid context is essentially a large microgrid so integrating a high percentage of solar came with challenges of balancing supply and demand. Initially, during Phase 1, solar provided only 17% of energy and system control was largely manual. With Phase 2, solar capacity increased almost fivefold, theoretically capable of supplying a major share of midday demand. However, without proper optimization, this could cause issues: solar output varies with clouds, and a sudden drop could trigger outages if diesel generators didn't ramp up in time. Conversely, running diesel generators at high load while solar is also at peak could waste fuel or force solar curtailment. The course's systems thinking perspective underlined that a power system must be viewed holistically. A key concept applied was the hybrid power system optimization: effectively combining solar PV, battery storage, and diesel gensets with intelligent controls (SCADA) to achieve reliability akin to a conventional grid. The course had stressed the role of modern smart grid technologies and optimization algorithms in integrating renewables. Additionally, BECO's own strategy recognized the need for batteries and automation, "unless we have batteries to store electricity, we can't stop using fossil fuels" at night, underscoring storage's importance in cost and reliability. Thus, the situation called for upgrading our control infrastructure and operational strategy to fully leverage the new solar capacity while maintaining a stable 24/7 supply.

Leveraging course principles of technology integration and grid modernization, I led a set of optimization measures focused on hybrid system control, infrastructure upgrades, and storage utilization:

- SCADA Implementation: We deployed a state-of-the-art SCADA system across the generation fleet. This digital platform allows real-time monitoring and automatic control of solar inverters, battery inverters, and diesel gensets from a central control room. We programmed SCADA with load-following algorithms: for example, during sunny hours, the control system prioritizes solar output and signals diesel generators to throttled low or standby mode. If a cloud transient occurs, the SCADA triggers instantaneous response from the battery and fast-acting diesel ramping to fill the gap. This closed-loop control significantly improves grid stability.

- Battery Energy Storage Optimization: We integrated a new battery energy storage system (BESS) expanding storage capacity to total of 20 MWh, aimed at peak shaving and smoothing. The BESS charges each day when solar output is high and load is lower, and then discharges during the critical evening peak to delay and reduce the need for diesel ramp-up. This not only cuts fuel use but also mitigates frequency and voltage fluctuations.

- Grid Infrastructure Upgrades: Anticipating higher power flows, we upgraded the transmission line to Mogadishu to 33 kV, minimizing losses and improving voltage regulation for the city. We also installed automated capacitor banks at substations to maintain power factor and voltage stability as the solar injection varies. These hardware optimizations ensured the distribution network could safely handle the solar influx and deliver quality power to customers.

- Generator Dispatch and Maintenance Optimization: Using data from SCADA, we revised the diesel generator commitment strategy. Instead of running many units at partial load, we now operate fewer generators at optimal load points (around 70–80% capacity) during the day, and turn off excess units entirely when solar is sufficient. The SCADA alarms and logs also improved maintenance scheduling. This predictive maintenance and smarter dispatch extended generator lifespans and cut O&M costs.

Outcomes: The system optimization efforts have substantially improved both the efficiency and reliability of BECO's power supply. One year into Phase 2 operation, statistics show that renewable penetration (solar) increased, thanks to optimal use of the new solar capacity. Correspondingly, diesel fuel consumption has dropped. Reliability metrics also improved markedly. The frequency of outages decreased, because the automated controls react faster than human operators could to disturbances. Power quality (voltage levels) remained within ±5% on even the remotest feeders, as verified by recordings, a benefit of the voltage support strategies. The hybrid system is now robust: even if a diesel generator fails, the battery can kick in to cover the gap for critical minutes while a standby unit starts, meaning no loss of power to consumers. These outcomes illustrate the systems thinking approach advocated in the SET course: by treating generation, storage, and network as an integrated whole, we achieved performance gains greater than the sum of parts. More immediately, the project's success in reliability and cost reduction strengthens the case for further renewable investments in Somalia, showing that clean energy can be integrated without compromising service quality.

3.3. Energy Auditing and Continuous Improvement

After the Phase 2 expansion and initial operation period, I led a systematic energy auditing initiative to evaluate the performance of the new systems and identify any inefficiencies or areas for improvement. The motivation came from both our internal commitment to continuous improvement and principles from the SET course on monitoring and evaluation. We wanted to ensure that the solar plant and hybrid system were operating at peak performance and that any energy losses or wastage in the system were minimized. Key questions drove this effort: Were we realizing the expected output from the 25 MW solar array? Could we reduce losses in the distribution network? Were customers getting the full benefit of the efficiency measures?. The course had underscored that "you can't manage what you don't measure". In Somalia's context, technical losses can creep up due to factors like dust on panels, heat affecting equipment, or outdated infrastructure. There was also no regulatory mandate for audits, but as a professional exercise, we treated it akin to implementing an ISO 50001 energy management practice within BECO. The situation set the stage for applying energy auditing techniques learned in class: conducting a thorough assessment of energy flows, from generation to end-use, to pinpoint inefficiencies and improve overall system efficiency.

I organized the energy audit as a multi-faceted project, covering generation performance, network losses, and end-user consumption patterns:

- Data Collection: Over several weeks, we gathered detailed operational data using SCADA logs and field measurements. This included solar panel output, inverter efficiency readings, diesel generator fuel consumption vs. output records, and feeder load profiles on the distribution network. On the demand side, we sampled data from smart meters installed at large customers and some households to gauge changes in consumption.

- Performance Analysis: Using the collected data, we computed performance indicators. For the solar plant, we calculated the performance ratio (PR) and found it was around 78% slightly below the expected 80–82% for our conditions indicating some losses but still can be considered as high efficient. Diesel generator efficiency was analyzed by comparing fuel in vs. kWh out; most units were operating near their optimal efficiency, but one older generator showed abnormally high fuel consumption per kWh, flagging it for maintenance or retirement. For the grid, we performed a load flow analysis which estimated technical line losses at about 14% on average. We also audited energy use at BECO's own facilities (offices, workshops) as a sample for energy-saving opportunities.

- Findings and Interventions: The audit findings were compiled and translated into an action plan. For the solar farm, we introduced a panel cleaning schedule and installed additional temperature-controlled ventilation in inverter rooms. These steps were low-cost and expected to boost the solar PR by a few percentage points. In the distribution network, we prioritized the worst-loss feeder for an upgrade: reconductoring a section with a larger gauge wire and adding a mid-point voltage regulator. We also added remote metering and monitoring for feeders to continuously track losses. For the inefficient generator identified, we scheduled an overhaul. On the demand side, the audit data validated the success of our DSM efforts but also highlighted that some customers reverted to old habits over time. In response, we planned periodic reinforcement of DSM messaging and an annual energy "check-up" for large consumers, offering them advice on sustaining efficiency gains.

- Measurement of Improvements: After implementing several of these measures, we set up a process to measure the improvements over the following months, essentially creating a feedback loop for continuous improvement.

Outcomes: The energy audit and subsequent optimizations led to measurable improvements in system performance. This translates to additional clean energy for the grid at virtually no operating cost. The problematic diesel generator, after maintenance, showed a 5% fuel efficiency improvement (kWh per liter) and is now used sparingly until retirement. In the distribution network, the feeder upgrade reduced overall system technical losses from 14% to 12%. While Somalia's grids often tolerate high losses, this improvement means more of the generated electricity actually reaches customers, effectively enabling us to serve additional load without increasing generation. It also enhances revenue capture for BECO and lowers strain on generators. Engineers are now routinely checking SCADA analytics for anomalies and addressing them proactively. This kind of continuous monitoring and adjustment has become part of our standard operating procedure, an outcome very much influenced by the systematic approach taught in the course. On the customer side, our follow-up with large users through the "energy check-ups" was well received. Such success stories have reinforced the value of energy audits as a tool not just for internal optimization but also for community outreach and trust-building. Overall, the auditing exercise confirmed that the Phase 2 project's benefits were being realized and improved upon: every percentage point of efficiency gained translates to tangible fuel savings, cost reduction, and emissions avoided. This exemplifies the SET course principle that sustainability is an ongoing process, we ensure the project continues to deliver on economic, environmental, and social goals beyond its initial commissioning.

4. Reflection and Analysis

Reflecting on the Jabad-Geele Phase 2 project and the strategies above, it's clear that our approach was effective in advancing a sustainable energy transition in Somalia, though not without challenges and lessons learned. Each initiative contributed to the project's success, and their effectiveness can be understood in light of key SET course pillars: socio-economic impact, policy and governance context, systems thinking, and energy justice.

Effectiveness and Course Pillars: Overall, the combination of technical and engagement strategies proved highly effective. The DSM program was instrumental in securing community buy-in and ensuring that the new solar supply translated into real benefits for end-users. This underscores the socio-economic pillar of sustainability: technology alone doesn't guarantee improvement unless coupled with changes in user behavior and equitable access. By involving consumers in the solution, the project improved not just kilowatt-hours but quality of life. The policy and governance dimension played a more subtle role. Somalia's formal regulatory framework is still nascent, which meant our initiatives were largely voluntary and driven by corporate leadership and stakeholder pressure rather than compliance. This relative lack of policy mandates gave us flexibility but also posed challenges. We navigated this by aligning with the government's informal goals. A lesson here is that in a low-governance environment, the company had to self-regulate and innovate. Going forward, stronger policy support could amplify these efforts. From a systems thinking perspective, one of the greatest successes was recognizing interdependencies: we treated technical upgrades, human behavior, and institutional support as interconnected pieces of the energy transition puzzle. This integrative approach reflects the holistic mindset encouraged by the SET course.

Challenges and Energy Justice: Not all strategies worked perfectly from the start, and we faced challenges that taught us valuable lessons. One major challenge was behavioral inertia, given Somalia's history of inconsistent utility service. We learned that building trust requires consistent engagement and demonstrating results. Another challenge was technical teething issues: This highlighted the importance of robust testing and also having skilled local personnel to maintain advanced systems. We invested more in training and even developed a partnership with a local university to prepare future engineers in renewable energy management, addressing the human capital aspect of sustainability. In terms of energy justice, our project made strides in improving equity. We also ensured that reliability improvements were felt across all served districts, not just commercial centers. One reflection is that as we extend the grid or mini-grids to new communities, we must continue this inclusive approach, prioritizing connections for underserved areas. A just transition also means mitigating any negative impacts: we had to ensure that the land used for the solar farm did not displace local livelihoods. We coordinated with local authorities so that the site selection avoided grazing areas, and the ESIA confirmed no communities were forcibly resettled. Fair distribution of benefits was a guiding principle. These actions align with the course's emphasis on energy justice, ensuring that the transition not only reduces carbon but also improves social equity.

Lessons Learned and Improvements: Through these experiences, I learned several key lessons that will inform future projects. First, engaging stakeholders early and often is crucial. For instance, initially we had not fully included large industrial customers in our planning; once we brought them in to discuss scheduling flexibility, we found many were willing to cooperate if it meant more stable power, which enhanced the DSM outcome. Second, data is your friend: the success of our energy audit demonstrated that investing time in measurement and analysis can yield high returns in performance. Going forward, establishing a continuous monitoring framework will help catch issues early and optimize new expansions from day one. Third, I recognized the importance of flexibility and adaptation. Our original plan had assumed a certain solar output and load forecast, we had to adapt by accelerating some diesel genset upgrades and adjusting our DSM targets. Adaptive management, a concept reinforced in the course, proved essential in this dynamic post-conflict environment.

If I were to refine our strategies further, I would aim to integrate even more with the national policy framework and leverage any international support. For example, Somalia's government and donors (World Bank, etc.) have initiatives like the Electricity Sector Recovery Project; aligning our project's next phases with those could provide additional resources for things like smart meters or community solar kits for those not yet connected. I would also explore innovative business models on the demand side, such as pay-as-you-go efficient appliances or solar home systems for remote customers, extending the sustainability impact beyond the grid. Technically, as battery costs fall, a lesson is to invest more in storage. Planning for that scalability, perhaps in modular increments, will be important. Finally, the project underscored that sustainable energy transition is not a one-off project but a continuous journey. It requires institutionalizing practices like DSM and audits so they persist beyond individual champions. We have thus begun embedding these into BECO's standard operating procedures and KPIs. In conclusion, the Jabad-Geele Phase 2 project reflects a microcosm of sustainable energy transition in a challenging context. By balancing technical innovation with social engagement, and immediate needs with long-term system thinking, we achieved notable improvements in access, affordability, and sustainability of energy for Somali communities. The experience reinforced course principles at every step – proving that even in Somalia's post-conflict, diesel-dependent environment, with the right mix of technology, human-centric strategies, and supportive governance, a cleaner and more equitable energy future is attainable. The lessons learned here will inform not only future expansions at BECO but can also guide other developing regions embarking on their own sustainable energy transitions.

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