A Digital Platform for Small Scale Embedded Generation: Balancing Customer Service with Grid Integrity.

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Abstract

The City of Cape Town developed and launched an innovative online application platform for Small-Scale Embedded Generation (SSEG) designed to streamline approval processes and enhance customer experience. This digital solution addresses longstanding challenges in managing increasing volumes of SSEG applications - particularly from residential and small commercial customers installing solar photovoltaic (PV) systems. The Energy Online Application System (EOAS) addresses longstanding challenges in managing the exponential growth of SSEG applications - transforming from processing 122 applications monthly to 634 applications monthly (a 420% increase) while reducing processing times from 80+ days to under 10 days for standard systems. This comprehensive digital solution integrates SAP ECC/CRM, e-Services Portal, and GIS systems to create a unified platform. A total number of applications of 29,502, managing 227 MVA of installed capacity.

Previously, the manual submission and tracking of applications led to significant delays, lost documentation, and limited transparency for customers and contractors. The online platform introduced a fully digitised workflow that automates critical steps, including the issuance of Permission to install (PTI) letters, and quote generation for required metering changes to enable energy export and participation in the City's feed-in tariff. The system guides users through each stage, from application to final commissioning approval, ensuring all compliance documentation is correctly submitted and evaluated.

The system demonstrates a 5.2x improvement in processing speed, with the online era (18.5 months) processing 66% of the volume that took the previous system 12+ years to handle. The solution has significantly improved process efficiency, enabling real-time tracking, automated reminders, and improved data accuracy. It reduces the burden on technical teams by validating submissions upfront and providing a clear, auditable trail of each application. Customers benefit from greater convenience, transparency, and quicker feedback, while internal teams can manage workload more effectively and focus on higher-value technical assessments.

The platform successfully supports the City's energy transformation goals, with GIS integration enabling spatial visualisation of installations and technical attribute analysis for network planning. Despite the compliance gap, the system achieves a 56.52% successful completion rate while maintaining grid integrity through standardised processes and City-approved inverter list requirements.

Incorporating principles of openness, fairness, and service excellence, the platform supports the City's broader energy transformation goals, including the uptake of decentralised generation, improved network visibility, and alignment with national regulatory requirements. Since its implementation, the platform has received positive feedback from industry stakeholders and customers, and has contributed to increased compliance rates, reduced processing times, and a more structured approach to managing embedded generation within the municipal network. It stands as a model for digital transformation in local government, aligning customer needs with engineering and regulatory integrity.

1. Introduction

The global energy landscape is rapidly evolving, driven by the need for sustainability, resilience, and customer-centric service delivery. In South Africa, municipalities like the City of Cape Town (CCT) are at the forefront of integrating renewable energy sources into their grids, particularly through SSEG. However, the manual and paper-based processes previously used for SSEG applications were inefficient, prone to errors, and failed to meet growing customer expectations for digital accessibility.

This paper documents the design, implementation, and outcomes of the Energy Online Application System (EOAS) - a digital platform developed under project PN00769 to automate and streamline the application processes for SSEG. The system represents a significant step in the City's digital transformation journey, enhancing operational efficiency, regulatory compliance, and customer satisfaction.

2. Background

2.1 The Need for Digital Transformation

The City of Cape Town has been a leader in SSEG regulation since 2008, introducing guidelines, tariffs, and processes before most municipalities. With falling technology costs and the growing impact of loadshedding, residential solar PV uptake surged.

However, the existing authorisation system became increasingly strained. Applications were complex, involving multiple system configurations, while staff resources were limited. This led to long processing times (up to 80+ days) and high levels of non-compliance, as many installers bypassed the process to speed up sales.

Comparison: Old vs. New Process		
Aspect	**Old Process**	**New Streamlined Process**
System Configurations Allowed	Multiple: Grid-tied (with/without export), Hybrid (with/without export), Standby, Passive standby UPS, Alternative supply, Off-grid, PV Geysers	Only Grid-tied, Grid-tied Hybrid and PV Geysers allowed
Off-grid & Standby Applications	Permitted, often misconfigured, non-approved inverters allowed	No longer accepted where property has a City point of supply
Inverter Requirements	Grid-tied required approved inverters, but standby/off-grid non-approved inverters allowed	All systems must use City-approved inverters (NRS 097-2-1 tested) only
Professional Sign-off	Not required for standby/off-grid	All systems require sign-off by an ECSA Registered professional
Application Complexity	Lengthy checks, spot inspections, average ±80 days turnaround	Simplified process; compliant applications approved within 2–3 days
City Staff Workload	High – manual checks, site visits, correcting incomplete applications	Reduced – staff can focus on complex systems
Customer Experience	Frustrating, delays, encouraged non-compliance	Faster approvals, "future-proofed" for feed-in tariffs and regulation changes
Risk Exposure	Safety risks (incorrect wiring, non-approved inverters), legal liability, fire risk, insurance disputes	Reduced risks through standardisation, approved equipment, and professional accountability

Table 1 Comparison: Old vs. New Process

A particular challenge was standby and off-grid systems. Although intended to be isolated from the grid, many were found to be incorrectly wired and operating as grid-tied, using non-approved inverters and lacking sign-off by qualified professionals. This created significant safety, legal, and technical risks for both the City and customers, while also slowing down approvals for compliant applicants. A comparison is illustrated in Table 1 with the old versus new process.

Against this backdrop, the City undertook to streamline and standardise the authorisation process with an implementation date of Oct 2023. The approach was to simplify system categories, enforce the use of approved inverters, and reduce the administrative burden. This would improve turnaround times, protect network integrity, and ensure compliance with national standards.

National Inverter Approval List

The City of Cape Town Approved Inverter List - based on NRS 097-2-1 type-tested equipment - is used nationwide as the benchmark for compliance. This ensures uniform safety and quality standards across municipalities and underpins confidence in grid-tied solar PV integration.

3. Project Objectives and Scope

3.1 Goals

- Digitise the end-to-end application process for SSEG.
- Enhance customer experience through self-service, real-time tracking, and automated notifications.
- Reduce processing times and manual interventions.
- Improve data accuracy and integration with SAP, GIS, and other corporate systems.
- Support the City's energy transition goals, including feed-in tariffs and grid stability.

4. Solution Design

4.1 Architecture and Integration

The EOAS is built on the following technological foundations:

- **SAP ECC and CRM:** Backend processing, notification management, and billing integration.
- **SAP Fiori and e-Services Portal:** Front-end user interface for applicants.
- **GIS Integration:** Staging tables for geospatial data related to installations.
- **Workflow Automation:** Automated status updates, letters, and task routing.

4.2 Key Features

- **Smart Forms:** Dynamic application forms that pre-populate customer data and validate inputs.
- **Automated Letters:** Permission to install (PTI), commissioning approval, and quotation letters.
- **Real-Time Tracking:** Customers and installers can track application status via email, or on portal.
- **Document Management:** Secure upload and storage of required supporting documentation - IDs, proxy letters, COCs, and design drawings.
- **Proxy, Electrical Contractor and Professional person registration:** Separate registration flows for third-party applicants.

4.3 Integration of GIS with the SSEG Online Application

The introduction of the online SSEG application has created opportunities to leverage Geographic Information Systems (GIS) for both operational and engineering purposes. The data captured during the application process (system size, inverter details, battery details, panel detail, compliance documents, status of application, etc.) can be exported directly into GIS, enabling both spatial and technical visualisation of the embedded generation environment.

In practice, this means that each application can be represented spatially on a GIS platform, where the following is possible:

- **Spatial Visualisation of Applications**: Each SSEG installation is mapped geographically with its current application status (e.g. Busy processing applications, waiting on customer*, waiting on commissioning report,* Commissioning approval issued). This provides a good overview where stakeholders can assess progress and saturation at a glance as illustrated in Figure 1.

- **Technical Attribute Export:** Detailed technical parameters (system size, inverter rating, installed capacity, compliance status, installation date, etc.) are stored as GIS attributes, ensuring that engineering staff can access both spatial and technical information in one system.

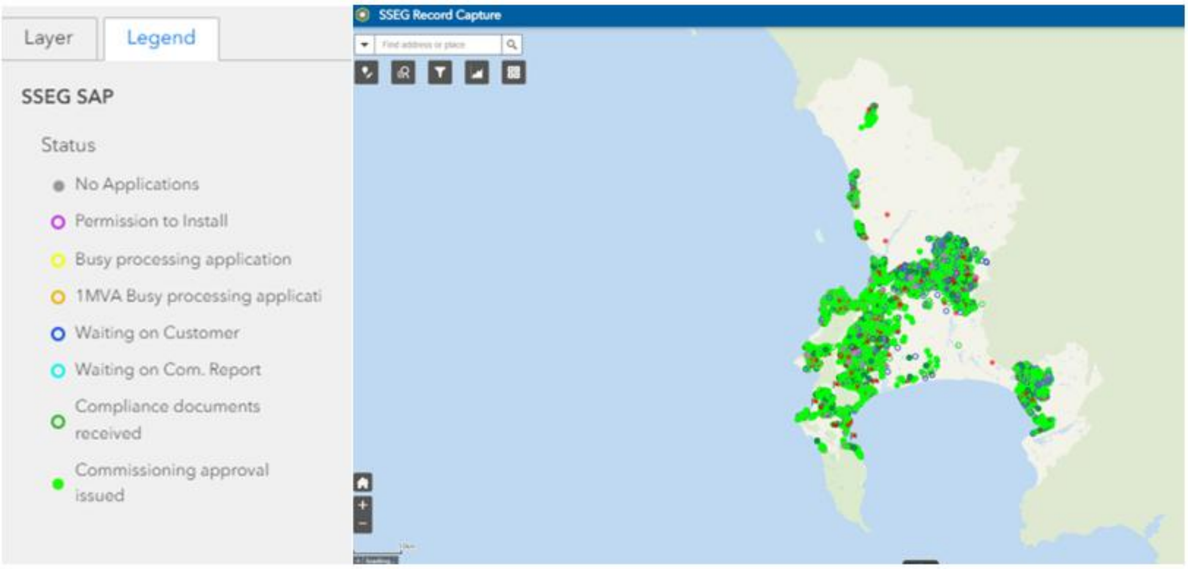

Figure 1 SSEG spatial integration GIS

5. Business Process Re-engineering

5.1 As-Is vs. To-Be Processes

The manual process involved:

- Paper forms submitted via email or hand delivered.
- Manual data entry into SAP.
- Physical document storage.
- No real-time status updates.

The new digital process includes:

- Online form submission with auto-validation.
- Automated Z1, Z9 notification creation in SAP.
- Digital document management via SAP GOS.
- Automated workflow routing based on application type.
- GIS data staging for network planning.

5.2 Process Automation

- **SSEG Applications:** Automated approval for residential and commercial systems up to 100 Ampere; technical checks for complex ones.

- **Payment Integration:** proforma invoices generated automatically.

6. Implementation and Challenges

6.1 Project Governance

A multi-disciplinary team from Energy, IS&T, and external contractors collaborated under a Project Steering Committee chaired by the Business Sponsor. Agile and waterfall methodologies were blended to accommodate evolving requirements.

6.2 Challenges

- **Scope Creep:** Continuous business process improvements required frequent adjustments.
- **Integration Complexity:** Synchronising SAP, GIS and e-Services.
- **Resource Constraints:** Labour broker tender transitions impacted resource availability.
- **Data Quality:** Inconsistent master data required cleansing and validation.

6.3 Change Management

Extensive training and communication were conducted for:

- Customers and installers
- Internal staff in Service Connection Planning department
- IT support teams

7. Outcomes and Benefits

7.1 Operational Efficiency

- **Processing Speed**: 5.2x faster (what took ~12 years now happens in 18.5 months)
- **Monthly Average**: ~634 applications in the online era vs. ~122 previously
- **Annual Growth**: 420% increase in processing capacity
- **Efficiency**: The online system processed 66% of the previous 12+ years' volume in just 18.5 months, see SSEG growth analysis in Figure 2.

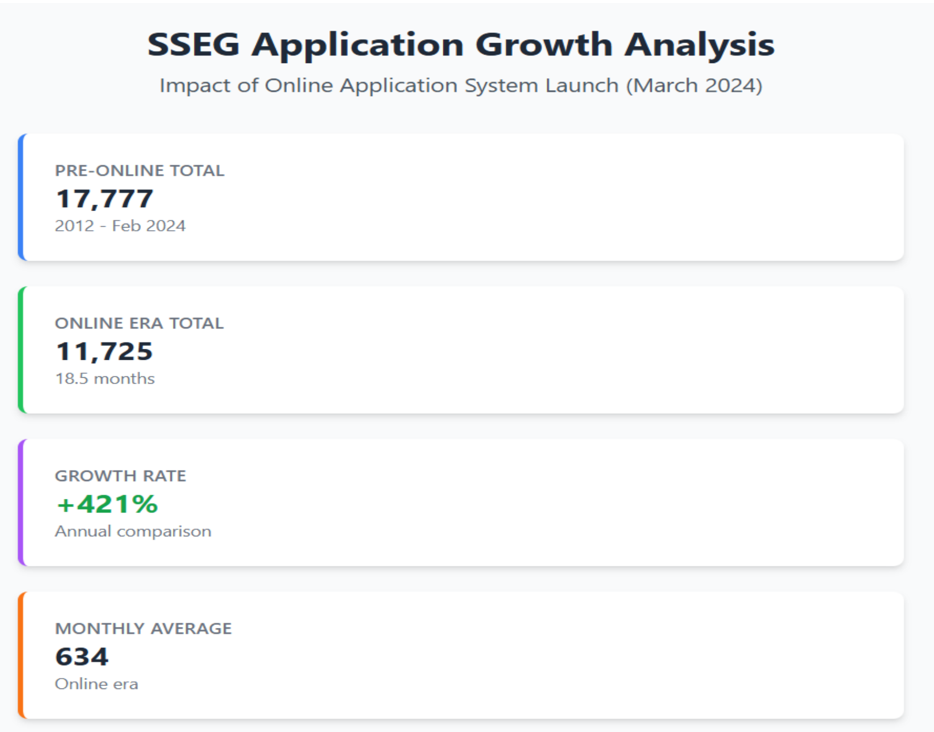

Figure 2 SSEG applications growth analysis

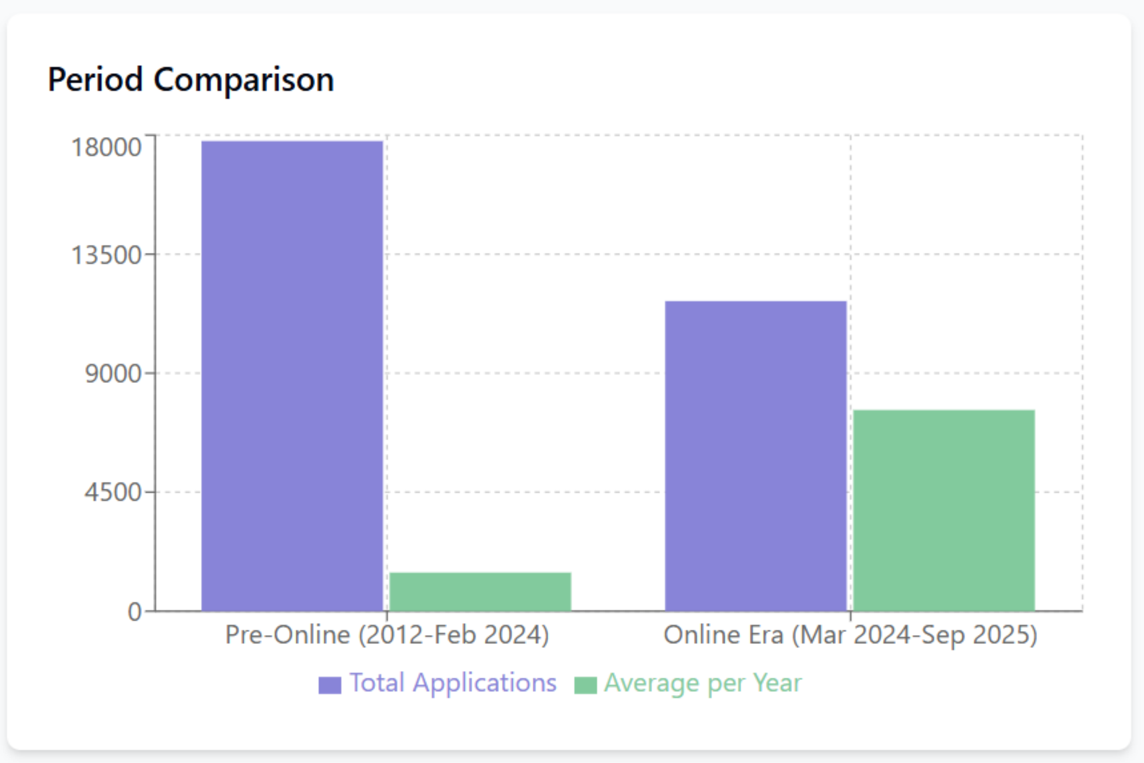

Figure 3 period comparison of pre-online and online era applications

The comparison of pre-online and online era applications is illustrated in Figure 3.

- **Pre-Online Era**: 2012 to February 2024 (12.17 years) - 17,777 applications
  Time period: 12.17 years = 12.17 × 12 = 146.04 months
  Monthly average = 17,777 ÷ 146.04 = 121.73 applications/month

- **Online Era**: March 2024 to September 2025 (18.5 months) - 11,725 applications
  Monthly average = 11,725 ÷ 18.5 = 634.05 applications/month

- **Processing Time:** The graphs' reported growth is directly enabled by a drastic reduction in application processing time from 80+ days to under 10 days for standard systems. This efficiency is the engine behind the ability to handle the 420% increase in monthly volume.

  New Value = 634.05 applications/month
  Original Value = 121.73 applications/month
  Increase = 634.05 - 121.73 = 512.32 applications/month
  Percentage Increase: (512.32 ÷ 121.73) × 100 = 420%

  Ratio = 634.05 ÷ 121.73 = 5.2
  This means the new system processes 5.2 times more applications per month
  Efficiency ratio: 96 months (legacy) vs. 18.5 months (online) = 5.2x faster.

- **Process Digitisation:** The elimination of paper-based applications and manual data entry removed critical bottlenecks, allowing for the seamless scaling of operations to meet surging demand.

- **Resource Optimisation:** The digital transformation has enabled significant resource
  - Redeployment of staff from manual processing to value-added activities
  - Reduced training requirements for application processing procedures
  - Improved staff productivity through automation.

Figure 4 illustrates the difference between the number of SSEG installations and their contribution to total generation capacity, highlighting a key characteristic of the distributed energy landscape.

Predominance of Residential Adoption: The data reveals that the vast majority (90%) of SSEG installations are residential, indicating broad adoption of technologies like rooftop solar PV by individual homeowners. This suggests successful market penetration at the household level.

Commercial Dominance in Generation: Despite comprising only 10% of the total installations, commercial systems account for 90% of the total installed generation capacity (227 MVA). This underscores that while residential systems are more numerous, individual commercial installations are significantly larger in scale and capacity.

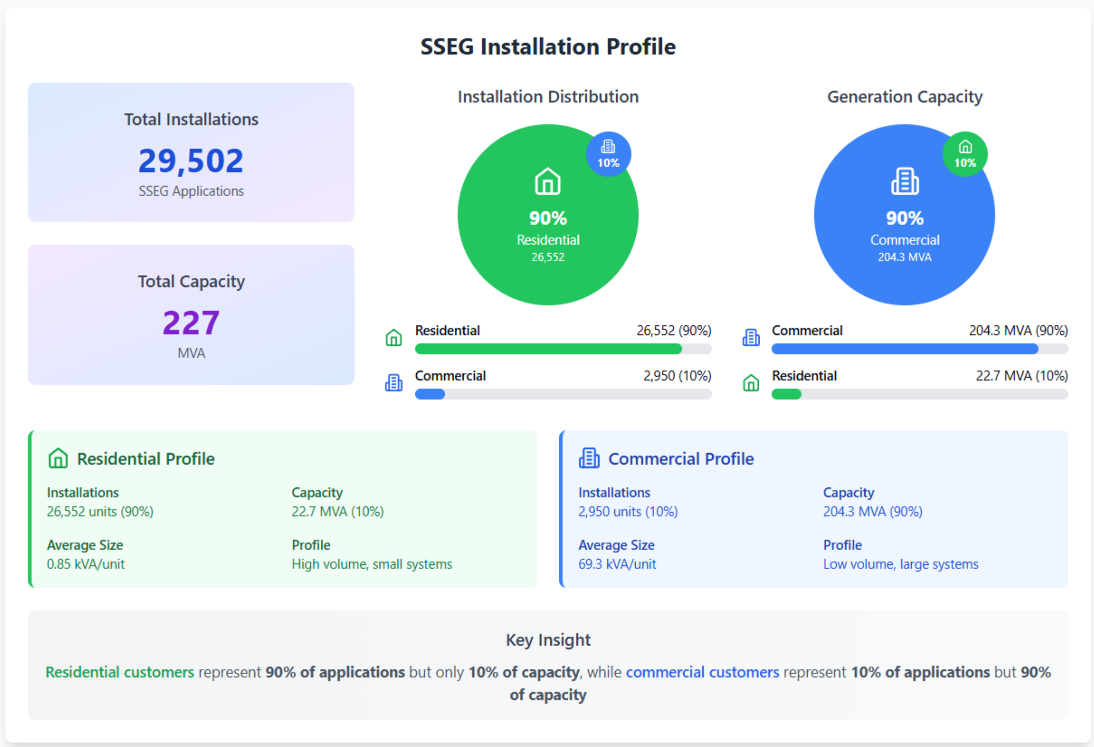

Figure 4 SSEG installation vs. generation capacity

7.2 Customer Experience

- **Accessibility:** The 24/7 application access via computer was a key driver behind the significant growth in residential users (90%), providing convenience that was previously unavailable. Reduced geographical barriers to application submission and streamlined user experience and interface design. Real-time status visibility eliminating uncertainty.
- **Transparency:** Features like real-time tracking, notifications, and a transparent process with clear milestones directly addressed customer pain points, building trust and encouraging application submission.

7.3 Compliance and Safety

- **Standardisation & Risk Mitigation:** The automated enforcement of using only City-approved inverters and treating all systems as grid-tied minimized network risks at scale, ensuring the safety and reliability of the grid despite the massive influx of new systems.
- **Auditability:** Automated compliance checks and digital audit trails ensured that the accelerated growth did not come at the expense of regulatory oversight, maintaining integrity throughout the process.

8. Operational Challenges and Process Optimisation Opportunities

8.1 Residential Customer Compliance Gap Analysis

Despite the significant processing efficiency gains achieved through the online application system, a critical operational challenge has emerged in the post-approval compliance phase, specifically affecting residential customers.

Process Flow and Compliance Requirements

The current SSEG application process follows a streamlined workflow as indicated in Figure 5:

1. **Initial Application Submission**: Customers submit applications through the online portal
2. **Automated Permission to install Granted**: System automatically issues permission to install upon successful application validation
3. **Installation Phase**: Customers proceed with SSEG installation
4. **Compliance Documentation**: Customers must submit outstanding compliance documents post-installation
5. **City Verification:** City staff verify compliance documents
6. **Final Registration**: System automatically issues commissioning approval upon successful verification of compliance documents.

Figure 5 SSEG application process workflow

8.2 Identified Compliance Challenge

Problem Statement: A significant proportion of residential customers fail to complete the registration process by submitting required post-installation compliance documents. Despite these dramatic improvements, a critical bottleneck was identified not in the system's processing capability, but in the final customer-dependent stage.

Process Breakdown Characteristics:

The automated system grants permission to install immediately upon application validation. However, customers must submit compliance documents within a 3-month period after installation. Analysis reveals a systemic failure at this stage see Figure 6:

Application Status Distribution Analysis (Total Applications: 11,725)

- Waiting on Customer: 2,150 applications (18.34% of total) are pending customer action.
- Cancelled: 1,891 applications (16.13%) were terminated due to customer non-response.
- Combined, 34.47% (n=4,041) of all applications are stalled or failed due to customer-related non-compliance.

Impact on Effective System Performance

This bottleneck severely impacts the system's effective performance:

- **Successful Completion Rate:** Only 56.52% (n=6,627) of applications reached full completion.
- **Administrative Burden:** Significant resources are allocated to managing pending applications and processing cancellations.
- **Legal and Reputational Risk:** Applications exceeding the 3-month deadline are classified as illegal installations, triggering complex enforcement procedures and potential customer dissatisfaction.

This represents a critical bottleneck where technical system efficiency (5.2x improvement) is undermined by customer behaviour patterns.

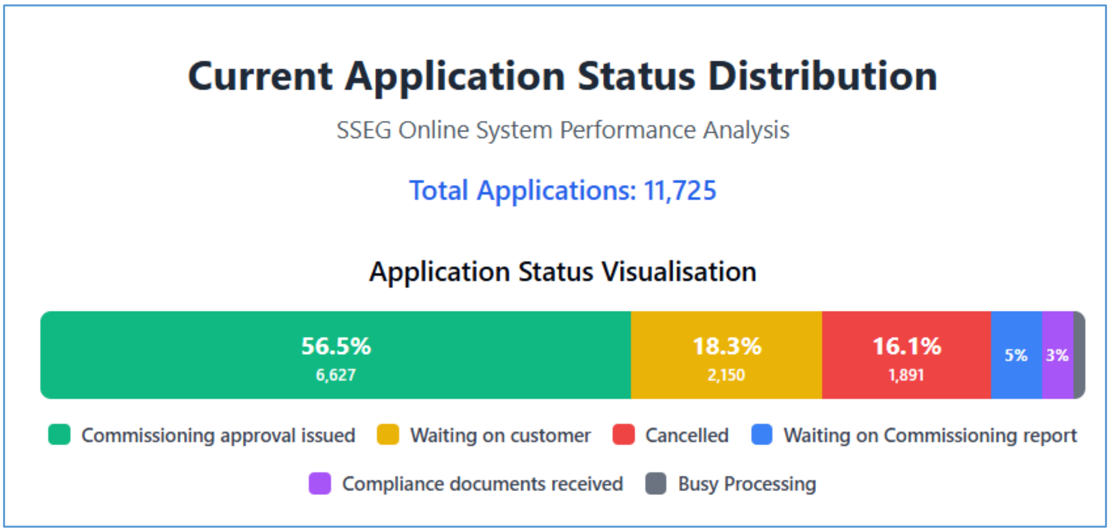

Figure 6 Application Status Distribution Analysis

8.3 Key Findings

The empirical analysis of the SSEG online application system's implementation yields several paramount conclusions. Primarily, the digital transformation has delivered transformational efficiency gains, manifesting as a 5.2-fold improvement in processing speed compared to the legacy system. This acceleration is directly linked to a substantial capacity enhancement, with the system achieving a 420% increase in monthly throughput, demonstrating its ability to handle significantly higher application volumes. Furthermore, the system has exhibited sustainable performance, maintaining these high-level, consistent operational metrics throughout the entire 18.5-month observation period. This robust performance effectively establishes a strategic platform capable of supporting anticipated future growth within the renewable energy sector.

However, the analysis also identifies a critical operational challenge that threatens to undermine these efficiencies. A significant post-approval compliance gap has emerged, wherein a substantial proportion of residential customers fail to complete the registration process by submitting required compliance documentation within the mandatory 3-month deadline. This failure induces a critical process inefficiency, as applications transition from a "waiting on customer" status to a "cancelled" status due to non-compliance. This dynamic not only creates a considerable administrative backlog but also necessitates the initiation of resource-intensive enforcement procedures. Consequently, this situation introduces a layer of legal complexity, as installations that exceed the compliance period are legally classified as illegal, requiring customers to restart the entire application process from the beginning. While the quantitative performance metrics demonstrate unprecedented success, qualitative analysis reveals nuanced operational challenges that require strategic intervention.

9. Conclusion and Future Directions

The SSEG Online Application System is a resounding success story in municipal digital transformation. The project successfully translated technological innovation into tangible, measurable outcomes; unprecedented growth, radical efficiency, enhanced safety, and superior customer service. The lessons learned provide a valuable blueprint for future digital initiatives within the City, demonstrating that with the right approach, technology can dramatically improve public service delivery.

The findings necessitate a strategic pivot from merely informing customers to engineering the process for compliance. The failure of a one-time communication of penalties to ensure compliance underscores the need for a more robust, behaviourally informed approach. Resource optimisation has been achieved through the redeployment of staff to higher value-added activities, improving overall efficiency. In addition, scalability has been demonstrated, with the platform now capable of handling 5.2 times the previous volume without the need for additional infrastructure.

System Enhancement Priorities

9.1. Process Re-engineering: Evaluate a staged approval model to replace the immediate permission to install letter. A provisional approval, with final authorisation contingent upon compliance submission, creates a direct and tangible incentive for customers to complete the process. This aligns the cognitive "completion" milestone with the actual regulatory requirement.

9.2 Advanced Nudge-Based Communication: Implement a behaviourally informed, escalating communication campaign that reinforces the initial letter. This system would send proactive reminders at 30, 60, and 75-day intervals, progressively highlighting the growing risk and explicitly restating the consequences outlined in the original letter (e.g., "Your installation will become illegal in 15 days, requiring a new application and potential enforcement").

9.3 Engineering Compliance Checks: The next phase involves linking SSEG data to the existing network layer in GIS (MV lines, distribution transformers, LV feeders, meter kiosk, meters). This integration will allow engineers to:

- Assess cumulative penetration levels at transformer and feeder level.
- Verify compliance with network hosting capacity limits.
- Run load-flow and voltage rise simulations directly on the GIS platform by overlaying SSEG data onto network assets.
- Automate compliance checks such as transformer loading, phase balancing, and reverse power flow risks.

9.4 Decision Support and Planning: With SSEG data linked spatially in GIS to electrical network infrastructure, planners can make evidence-based decisions regarding network upgrades, reinforcement, and long-term distributed energy resource (DER) strategies.

9.5 Real-Time Application Tracking Dashboard

- Live status updates with progress indicators
- Next step notifications with clear action items
- Countdown timers for compliance deadlines (3-month warning)

9.6 Proactive Communication System

- WhatsApp integration - reaches customers where they are
- Automated reminders at 30, 60, 75 days
- Escalating notifications - email → phone call

9.7 Integrated Help & Support

- Live chat support during business hours
- AI chatbot for 24/7 basic queries (FAQs)
- Screen sharing capability for technical assistance
- Callback scheduling for complex issues during business hours

10. References

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