**A PROJECT ON**

**SMART CITY DEVELOPMENT: ENHANCING URBAN PLANNING IN SEATTLE THROUGH ELECTRICAL PERMIT ANALYSIS AND PREDICTIVE MODELING**

**BY**

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**Introduction**

Electrical energy is a vital resource for many different types of businesses, including big, small, residential, and agricultural ones. The persistent technical improvement in the important areas will eventually lead to an increase in the need for electrical energy (Subramani et al., 2024). As a result, electrical energy has come to be seen as essential to daily life.

Every year, the City of Seattle grants a significant number of electrical permits for both residential and non-residential buildings. Regulating and forecasting permit applications, issuances, and completions, however, is a difficult process that is frequently hampered by inefficiencies and erratic swings.

Seattle's sustainable development and public safety depend heavily on the efficient administration and control of electrical licenses. This project is highly relevant to society for several reasons:

* Urban Planning and Development: Improved Resource Allocation, Informed Decision-Making
* Economic Impact: Cost Management, Boosting Efficiency
* Public Safety and Compliance: Ensuring Safety Standards, Timely Inspections
* Environmental Sustainability: Energy Efficiency, Sustainable Urban Growth
* Community Benefits: Transparency and Accountability, Enhanced Quality of Life
* Technological Advancement: Innovation in Public Services, Smart City Initiatives

Electrical permits are required in Seattle to ensure the safety and conformity of electrical installations. The Seattle Department of Construction and Inspections is in charge of these permits, which are required for any electrical work, including installations, alterations, additions, or connections to electrical equipment (SDCI).

In Seattle, there are two different kinds of electrical permits: Over-the-Counter (OTC) permits and Plan Review permits. Online self-issuance is available for Over-the-Counter (OTC) permits, which are typically given for smaller projects. Installations in duplexes or single-family homes, temporary electricity installations for events under 600 amps, fire alarm systems with six or fewer devices, and photovoltaic systems rated less than 7.7 kW are a few examples. On the other hand, more complicated projects need a plan review permit Installations in academic, institutional, or medical settings; projects larger than 5,000 square feet; fire alarm systems including seven or more devices; and renewable energy systems with a rating of 12 kW or above are a few examples. Through the Seattle Services Portal, applicants can submit applications for permits. The application procedure for OTC permits is simple and can be finished online. Applicants seeking plan review permits must provide comprehensive plans for SDCI to review. Depending on their complexity, certain projects may also require pre-application meetings or extra documentation.

The size and complexity of the project, the value of the work, any extra permits needed, the time needed for application and plan reviews, inspection, and technology fees are some of the variables that affect the price of electrical permits in Seattle.

Certain permits, like the Subject-to-Field-Inspection permits, which cost 40% of the plan review price, may only require partial payment; the SDCI offers tools to estimate permit payments.  
Inspections are required following permit acquisition to guarantee adherence to the Seattle Electrical Code. Several inspections may be needed at various phases of the installation, depending on the project. To prevent delays, the SDCI offers comprehensive guidance on what must be prepared for each inspection.  
In order to guarantee the dependability and safety of the electrical systems in homes, businesses, and public spaces, electrical licenses in Seattle are an essential requirement. In order to ensure the safe and sustainable growth of the city, property owners and contractors must adhere to the set procedures and get the relevant licenses.

The development of smart cities and urban planning are crucial for the efficient and sustainable expansion of cities. In cities like Seattle, where population and technology are advancing at a rapid pace, creative solutions are desperately needed to manage urban infrastructure efficiently. The goal of this project is to develop a smart city application that incorporates information from electrical permits that Seattle has issued or is currently processing. This project integrates data analysis, predictive modeling, and application development to offer useful tools and insights to city planners, developers, and citizens.

**Importance of Electrical Permits in Urban Planning**

Electrical permits are necessary to ensure the safety and compliance of electrical installations in residential, commercial, and industrial establishments. These licenses ensure that installations adhere to local building codes, help with routine maintenance, and reduce the likelihood of electrical risks. Analyzing and projecting trends in electrical permit issuance can significantly enhance urban planning projects. This makes it possible to build infrastructure more proactively, make educated decisions, and use resources more effectively (City of Seattle, 2023).

**Project Objectives**

The primary objectives of this project are:

1. Trend Analysis: To analyze historical data on electrical permits to identify seasonal patterns, trends, and significant changes over time.

2. Predictive Modeling: To develop predictive models that can forecast future permit issuance based on historical data and various influencing factors.

3. Geospatial Analysis: To identify hotspots for electrical permits and visualize their spatial distribution within the city.

4. Application Development: To create a user-friendly smart city application that provides interactive maps, dashboards, and search functionalities for users.

**Literature Review**

In order to comprehend previous behaviors and forecast future patterns, it is essential to analyze historical trends in data. Analyzing trends entails spotting cyclical tendencies, seasonal patterns, and any notable departures from projected trends throughout time. In order to identify trends and seasonality in a variety of areas, including construction permits, time series analysis has been widely used in urban planning and infrastructure management. According to research by Chatfield (2004), good forecasting requires a grasp of temporal trends, particularly in industries like construction and electrical licenses that are subject to regulatory changes and economic cycles. With this method, urban planners can forecast times of peak demand and distribute resources appropriately.

Studies have indicated that there are frequently significant seasonal patterns in the issuing of electrical permits and other relevant activities related to building. For instance, Lee et al. (2017) discovered that in temperate regions, building activities typically peak during the warmer months, which has a direct impact on the number of licenses given. Planners must take this seasonality into account when estimating future permit volumes, planning inspections, and resource requirements.

Research has shown how regulatory changes and the state of the economy affect the issuing of construction and electrical permits. Examples of these studies are those conducted by Gyourko and Saiz (2006). Building activity and permit applications often rise during times of economic expansion, although they may fall during recessions. Furthermore, modifications to energy efficiency standards or building rules may result in brief spikes and drops in permit applications.

An advanced analytical technique called predictive modeling is used to project future patterns from historical data. These models support resource planning and decision-making by forecasting permit issuance in the context of electrical permits.

Because machine learning approaches can handle big datasets and reveal intricate patterns, they are becoming more and more common in predictive modeling. Time series data in urban contexts have been predicted using methods like ARIMA, SARIMA, and, more recently, machine learning models like Random Forests, Support Vector Machines (SVM), and Neural Networks (Hyndman & Athanasopoulos, 2018).

The study conducted by Hsiao et al. (2020) suggests that machine learning methods can improve the prediction accuracy of construction permit issuing more than traditional statistical models. Their study revealed that combining historical data with external factors like the state of the economy and weather might enhance forecast performance. Given all the external factors that could influence the process, this method is particularly helpful for forecasting when electrical permits will be issued.

Accurate forecasting depends on the incorporation of external factors into predictive models. Research has indicated that a number of factors, including economic expansion, housing market dynamics, and energy laws, have a major impact on the number of permits that are issued (Lütkepohl, 2005). Models that incorporate these variables are able to produce forecasts that are more accurate and better reflect the dynamics of permit issuing.

Urban planning uses geospatial analysis to map and examine the spatial distribution of different operations, such as the granting of electrical licenses. City planners can more efficiently deploy resources and make plans for future growth and development by identifying hotspots.

The spatial distribution of infrastructure projects, particularly electricity permits, is being studied more and more using geospatial analysis. Research like Anselin's (1995) has highlighted the significance of spatial autocorrelation in figuring out where there is a lot of activity and how permits cluster together. Patterns that are not immediately obvious in conventional tabular data can be found using this method.  
Methods for locating spatial hotspots were first presented in research by Getis and Ord (1992), and they have subsequently been frequently used in urban studies. City planners can use hotspot analysis to pinpoint places with concentrated permit activity, which may point to areas experiencing rapid development or higher infrastructure demands. These understandings are essential for designing infrastructure and allocating resources proactively.

Geospatial analysis results must be communicated effectively through visualization. User-friendly methods of presenting spatial data include heat maps, choropleth maps, and interactive dashboards. These visualizations are crucial for helping non-experts, including legislators and city planners, comprehend intricate spatial patterns and make defensible decisions, claims MacEachren (1994).

Modern urban planning requires the creation of smart city applications with interactive dashboards, maps, and search features. Real-time data interaction between users and these applications promotes improved decision-making and public participation.

Applications for "smart cities" have become more popular as cities look to use data to plan and run their operations more effectively. These programs usually combine information from several sources, such as economic, temporal, and geographic data, to give a thorough picture of urban activity. Batty et al. (2012) conducted research that emphasizes how smart city applications might enhance urban planning procedures by increasing the accessibility and actionability of data.

The usability of smart city applications is a key factor in their success. Nielsen (1993) and Shneiderman (2004) conducted studies that highlight the significance of user-centered design in creating apps that work. A user-friendly interface that facilitates data navigation, report generation, and trend visualization is essential for guaranteeing the application's widespread acceptance and efficient use.  
When predictive modeling and geographic analytics are combined into one tool, urban planners can gain a lot of useful information. According to Goodchild (2018), combining these two analytical modalities allows for a more thorough comprehension of temporal and spatial dynamics, facilitating more informed decision-making.

Numerous case studies, including Chicago's "OpenGrid" and New York City's "NYC Planning Labs," show how smart city technologies can be beneficial for urban planning. These programs offer interactive tools for examining many facets of urban infrastructure, such as public safety, transit, and construction permits. The advantages of creating a comparable program for examining electrical permits in Seattle are demonstrated by these case studies.

An effective framework for assessing and projecting electrical permit activities is produced by combining trend analysis, predictive modeling, geospatial analysis, and application development. Through the utilization of these approaches, urban planners can acquire significant knowledge about historical and prospective patterns, pinpoint regions with significant activity, and formulate plans for more effective distribution of resources. The accessibility and usefulness of these insights are further improved by the creation of an intuitive application, which gives decision-makers the capacity to efficiently plan for the expansion and infrastructure requirements of the city.

**Data overview**

The dataset for this project is sourced from the City of Seattle's Open Data Portal, which provides comprehensive data on all electrical permits issued or in process. The dataset includes detailed information on permit number, issue date, permit type, contractor details, project description, project valuation, and location coordinates. This rich dataset allows for in-depth analysis and robust predictive modeling.

**Data source:** Seattle open data

**Link to dataset**: https://data.seattle.gov/Permitting/Electrical-Permits/c4tj-daue/about\_data

The dataset as at the time of this project contained over 442k rows and 20 columns

**Github repository:**

<https://github.com/Chizurumoke/ENHANCING-URBAN-PLANNING-IN-SEATTLE-THROUGH-ELECTRICAL-PERMIT-ANALYSIS-AND-PREDICTIVE-MODELING.git>

**Data overview before cleaning and feature engineering**

A screenshot of a computer

Description automatically generated

A screenshot of a computer

Description automatically generated

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