DISTRIBUTION SYSTEM – ASSET MANAGEMENT APPROACH

This document provides a summary of THESL’s asset management approach. The first two sections introduce the scope of asset management at THESL and relevant regulatory requirements. The next section provides an overview of good asset management practice and THESL’s vision. In later sections, details on the distribution planning process and planning tools are described. The final section elaborates further on THESL’s current work with respect to its asset management approach.

INTRODUCTION

The purpose of THESL’s asset management program is to maximize the value provided to its stakeholders, along the four corporate pillars of employee and public safety, customer service, asset renewal and consistent financial performance. To satisfy these objectives, THESL has developed a tactical approach that sets out to establish specific, actionable goals with clear expectations on strategy and outcomes. Asset management at THESL comprises the system used to evaluate spending decisions, and ultimately the evaluation, justification, prioritization and execution of spending programs. Recognizing that long-term planning cannot be effectively accomplished without considering the requirements and plans of external stakeholders, work programs from the following groups are also considered, and where necessary, integrated into THESL plans: City of Toronto, Toronto Transit Commission ("TTC"), Hydro One Networks Inc. ("HONI"), Ministry of Transportation Ontario ("MTO") and GO Transit.

REGULATORY REQUIREMENTS

THESL’s asset management approach takes into account requirements established in both the Electricity Act, 1998 ("Electricity Act"), and the Distribution System Code ("DSC").
The Electricity Act, in part, is intended:

a) “to ensure the adequacy, safety, sustainability and reliability of electricity supply in Ontario through responsible planning and management of electricity resources, supply and demand” and

b) “to protect the interests of consumers with respect to prices and the adequacy, reliability and quality of electricity service”

The DSC, in part, requires a distributor to follow good utility practices for system planning. It states:

“A distributor shall maintain its distribution system in accordance with good utility practice and performance standards to ensure reliability and quality of electricity service on both a short-term and long-term basis.”

THESL’s asset management approach, results in near-term plans and longer-term forecasts that meet the requirements set out in legislation. However, in addition, THESL is constantly refining its approach and improving its practices to remain compliant with changes to legislation and governing regulations and directives including the Green Energy and Green Economy Act, 2009 (“GEA”), the Ontario Energy Board Act, 1998, THESL’s Distribution Licence, the Affiliate Relationships Code, the Standard Supply Service Code, and other relevant City of Toronto By-laws.

ASSET MANAGEMENT OVERVIEW

The asset management vision at THESL is to become a world-class investment planning organization. The Institute of Asset Management (“IAM”) maturity level scale shown in Figure 1, illustrates a path for asset managers moving along this spectrum, towards PAS55 accreditation. Briefly, PAS55 can be thought of as an asset management standard that provides a framework for good practices in the management of physical assets.

• Holistic in nature and takes into consideration the combined implications of
managing all types of assets including information resources, financial and human capital

- Methodical approaches that promotes repeatable, auditable decision and actions
- Systemic focus on the assets within their operating context and optimizing the value of these asset systems as opposed to individual assets themselves
- Risk-based by focusing resources and expenditures by defining priorities against identified risk areas
- Establishes best value compromise between conflicting factors associated with the assets over their product lifecycles
- Considers long-term consequences of short-term activities and ensures that adequate provisions are made for future needs and obligations
- Integrated approaches that recognize the value of interdependencies and combine effects when managing physical assets

Figure 1: IAM Maturity Level Scale

Organizations that are assessed by endorsed firms through the IAM, as being generally competent, would receive PAS55 accreditation. Due to legislative requirements, all UK organizations overseeing physical assets and infrastructure are mandated to be PAS55 certified, and to date, the majority of PAS55 certified organizations are situated in Europe and Asia. Although meeting PAS55 is not a requirement in Ontario, THESL sees value in the PAS55 framework and has been actively investigating the specification. The final
section of this document contains additional details on THESL’s work to date in this regard.

5 DISTRIBUTION SYSTEM PLANNING

7 System Planning Process
8 Distribution system planning can be thought of as a logical process consisting of field assessments, engineering judgments and system analysis to confirm that specifications and policies are available to determine the most economic strategies to meet system reliability and customer requirements. THESL’s system planning process ensures that system drivers take into account inputs from the corporate business plan, assessments of the external business environment and system performance needs and objectives. The system planning process also ensures that the system plan enters into the project development and prioritization processes appropriately.

17 Distribution system planning is an iterative process and entails updating associated documents and actions, as conditions and information change. The most significant change to the asset management approach in recent years has been the evolution of program definition and priority setting as THESL continues to address the age and condition of its assets, and resulting field performance. As such, THESL has introduced improvements that focus on data-driven approaches and emphasize individual assets, whereby engineering staff can identify optimal replacement times for assets based on the following factors: asset condition, risk criticality and lifecycle costs of asset ownership. As THESL constantly looks to maximize the value asset management provides to stakeholders, all relevant parties are considered when evaluating alternatives and setting priorities.
Figure 2 presents the distribution system planning process flowchart and interactions between inputs, planning elements within the scope of the THESL asset management unit, and operational elements.

Figure 2: Distribution System Planning Process Flowchart
SYSTEM PLANNING PROCESS BREAKDOWN

The following section outlines the strategic components that comprise THESL’s distribution planning process.

System Drivers

As discussed earlier, the resulting strategy and plans developed through the asset management approach are intended to reflect the corporate strategic themes of customer service excellence, infrastructure modernization, consistent financial performance and employee and public welfare. Moreover, the asset management approach is also intended to supplement the Enterprise Risk Management framework, and support treatment plans concerning various operational risks. Further details on the key activities and initiatives within Strategic Management and Enterprise Risk Management are provided in Exhibit F2, Tab 1, Schedule 11.

In addition to the strategic themes and enterprise risks that need to be considered generally, there are numerous specific distribution system drivers that impact spending decisions. These factors include, but are not limited to the following: service reliability, employee and public safety, obsolescence, operational and environmental considerations, risk tolerance, integration in support of system expansion needs, and rating limitations due to system additions such as new customer loads and distributed generation.

Long-Term Investment Capital Planning

Capital investments at THESL focus on re-building and sustaining existing distribution plant. Regardless of ongoing maintenance programs, distribution equipment will ultimately fail or become obsolete, eventually reaching a state at which it would no longer be cost-effective to maintain. As such, distribution system projects are intended to address system and operational needs. THESL may also determine it to be economically or operationally beneficial to enhance specific parts of the system. Accordingly,
THESL’s capital investment planning is a systematic process involving current state analysis, assessment of available treatment options, and development of resulting plans. Engineering staff conduct detailed analyses of asset demographics and risks to understand the issues influencing various investment portfolios. The current state analysis entails reviewing and forecasting system performance for applicable investment portfolios, which is facilitated through the maintenance investment strategy as detailed below. Next, engineers identify and examine available treatment options and determine the most appropriate solutions based on operational considerations and system design needs. The end result of this exercise is a series of strategic approaches for sustaining and enhancing the grid, which shapes the development of the Long-Term Electrical Capital Distribution Plan document (see Exhibit D1, Tab 7, Schedule 6), which serves as a reference guide for THESL staff when identifying and scoping projects.

Project Definition and Development

Following the investment planning phase, THESL applies various tools, specifically the Asset Condition Assessment (“ACA”) and Feeder Investment Model (“FIM”) tools, to assist staff in translating engineering analysis and operational data into projects that reflect various investment strategies. The ACA provides staff with a representative understanding of the age demographics for a population of assets captured through the tool via health indices (“HI”), as well as other relevant parameters including asset age, location, manufacturer type, and in-service date that can be used to identify candidate projects. HI results for these assets are used as inputs to the FIM that derives the associated risks for these sets of assets based on defined hazard rate curves. Next, using the concept of “optimal intervention timing”, staff is able to develop projects for individual assets or a grouping of different assets, where deemed appropriate. These tools are discussed in greater detail later on in this document.
Maintenance Planning
Distribution plant maintenance plans are developed through reliability-based methods. At THESL, the Reliability Centered Maintenance (“RCM”) program uses the Aladon RCM II methodology that is designed to establish optimal maintenance programs required to achieve a desired level of operational performance from assets within their current operating contexts. All distribution assets within the THESL RCM model have been analyzed by multi-disciplinary teams. Briefly, the RCM framework establishes asset functions, defines functional failures and identifies potential root causes and failure effects. Through this framework, THESL has the ability to initiate maintenance tasks to address leading indicators that might suggest failure, whether on a reactive basis, or through either proactive or scheduled maintenance cycles. The by-product of this process and the intended analysis is the Annual Distribution Plant Maintenance manual.

Project and Budget Prioritization
After identifying a candidate set of investment projects, THESL analyzes the scope of work and expected value of the projects through the Asset Investment Strategy (“AIS”) tool. In general, the AIS tool provides staff with the opportunity to assess the relative costs and benefits for a diverse set of projects, as well as prioritize these projects against corporate strategic pillars and investment drivers. Then, taking into consideration planned maintenance activities; coordination is done with other appropriate, internal departments to identify spending requirements and constraints to prioritize and set the capital budget.

System Planning Tools
THESL has been managing its assets with a long-term outlook and has focused on moving towards being an industry-leading asset management utility. As part of this cultural change, THESL continually asks questions of its asset management system to ensure that programs and priorities align with system needs. To assist in this transition,
THESL has developed the aforementioned tools to facilitate an integrated investment approach, whereby projects are rationalized through objective and data-driven methods. A high-level graphic of the methodology is included in Figure 3.

![Figure 3: Integration of THESL System Planning Tools](image)

**Figure 3: Integration of THESL System Planning Tools**

**Asset Condition Assessment (“ACA”)**

THESL’s ACA process is based on a common health indexing methodology that has been widely adopted amongst utilities, and addresses a key OEB expectation that states that THESL “[…] must be in a position to provide asset condition studies and other analyses that support its capital strategies and budgets”. The ACA is intended to provide an overall condition for a widely dispersed asset class, and through health indexing, was designed to provide a means of expressing the condition of an asset based on a single number from input provided by subject matter experts. This would ensure that results are quantitative, objective and repeatable. The graphic below, Figure 4, describes the health indexing logic in full. As a result, ACA focuses on condition relative to end-of-life, and condition parameters provide indications on how much longer the asset is expected to remain operational before replacement is required, either on a planned or unplanned basis. This process also ensures that condition assessment information is systematically and formally documented for continual use in the future.
In terms of the budgeting process, the ACA is the first step in translating the raw data into the final budget. As such, the ACA produces three primary outputs that enter into the Feeder Investment Model (“FIM”). First, the ACA defines applicable asset classes, and these definitions are maintained for consistency throughout the development and prioritization process, and subsequently used in FIM. Second, the ACA produces summaries of condition for each asset class. Although this output is not used directly in the FIM, it serves a critical function at THESL in that it is used to verify that the distribution of conditions in a population is not unexpectedly changing. In particular, it is paramount for THESL to know whether the number of assets deemed to be in poor condition, where the potential for failure is imminent, is increasing or whether the average condition is trending downwards suggesting a possible under-investment. Finally, asset health is a strong predictor of failure and is used in the FIM to determine approximations of failure probabilities for each asset. Assets in poor condition have a greater likelihood of failing, and are more likely candidates for replacement than continued maintenance.
**Feeder Investment Model**

The FIM applies a risk-based economic model to assist THESL in identifying an economically, optimal intervention time for aging assets. The basic elements within the FIM are calculations of asset failure probabilities, estimations of asset failure impacts, risk evaluations and determination of optimal asset intervention timing.

To calculate the probability of failure, the FIM first relies on the assets’ Hazard Distribution Function (“HDF”), which represents a conditional probability of an asset failing from the remaining population that has survived up till that time. These functions are validated either directly by THESL or through the assistance of asset life studies from third-party consultants. Then, to quantify the impacts of failure, the FIM would incorporate the direct costs associated with the materials and labour required to replace an asset upon failure, as well as the indirect costs. These indirect costs would include the costs of customer interruptions, emergency repairs and asset replacements. Next, the FIM would evaluate risk using a risk cost that represents the product of a hazard rate function for the given asset and its corresponding impact costs. Lastly, as shown in Figure 5, the computed lifecycle cost represents the total operating costs for a new asset, taking into account the annualized risk and capital over its entire lifecycle. The optimal intervention time would then be the red marker at which the Equivalent Annualized Cost (“EAC”) is at its lowest.
Based on this evaluation, if replacement has been identified as the optimal solution for intervention, the FIM would also account for the replacement of the existing asset. The EAC from the lifecycle cost curve would then need to be cross-referenced against the risk curve of the existing asset to determine optimal replacement timing, as shown by the green marker in Figure 6. This specific point in time would indicate that the existing asset has reached its economic end-of-life at 47 years of age and requires intervention.
Figure 6: Typical Example of Optimal Intervention Time (Existing Assets)

Through this described approach, the primary output from the FIM would be a series of replacement programs for applicable asset classes within a feeder. Concurrently, as the model is able to project failure rates for these asset classes, spending forecasts on replacements due to forced or customer outages can also be identified. For those assets deemed to require immediate replacement, the FIM would be able to support the case for replacement via benefit-to-cost ratios for various projects, and would assist with project prioritization performed through the AIS. In addition to optimizing the replacement timing for aging assets, the FIM can also assist engineering staff in determining the optimal grouping of assets within a project, in terms of the expected replacement periods for those assets of interest. A visualization of these outputs is presented in Figure 7.
Figure 7: Outputs from Individual & Multiple FIM Modules

Asset Investment Strategy

The AIS is a modeling tool used to assist in evaluating and prioritizing capital projects wherein each proposed project is scored on its expected benefits, in terms of the THESL four areas of strategic investment, as summarized below in Figure 8.

Figure 8: Focus Areas of Strategic Investment

Accordingly, a key component of the AIS is the Project Equivalence Matrix, which guides engineering staff through examples on how to evaluate tradeoffs amongst the aforementioned focus areas. For instance, the matrix would show that for a given project,
the replacement of eight obsolete remote terminal units ("RTUs") is thought to be equivalent to the replacement of a single, obsolete transformer station. Similarly, the equivalency matrix would detail other examples of this kind, and serves as the foundation for the scoring system. The result would ensure that all projects are rated on a systematic and objective basis, regardless of the unique benefits offered by the different projects evaluated. Moreover, this approach would also ensure that capital projects are prioritized in a consistent manner.

Once appropriate comparisons and scoring is done amongst projects in the various portfolios, the AIS guides engineering staff in forming an initial budget estimate that would be reviewed and modified, where appropriate, to correspond with the THESL system drivers, strategic plans and other external requirements. To prepare the initial budget forecast, the AIS has two points of interface with the FIM. Firstly, the projects produced through the FIM are catalogued into the AIS project library. Conversely, any tradeoffs identified between the different areas of strategic investment are captured to quantify the cost consequence of failure in the FIM. This allows THESL to conduct scenario analyses via the AIS when prioritizing and evaluating projects. The interdependencies between these two tools are shown below in Figure 9.

Figure 9: Nature of Interdependencies between FIM and AIS
CURRENT WORK

THESL has conducted continuous reviews of the ACA tool since it was first introduced in 2006. Notable progress has been made in addressing the recommendations put forth from the 2006 ACA report, and in 2009, THESL undertook a third-party audit of the program. As a result of that audit, health index formulations were updated and revised to reflect latest industry practices and newly available data. Last year, THESL again used the third-party group to review and update asset populations, sample sizes and condition distributions. A separate assessment was also released last year on THESL network assets, wherein the formulations were revisited and adjusted to capture the civil elements and equipment associated with these assets.

With respect to the current ACA, THESL continues to improve on its data collection techniques and build on the work done through the web-based Health Index Calculator that now allows staff to receive near real-time updates on asset conditions. Moreover, the transition to a web-based application allowed for easier remote access to the tool. In terms of data collection improvements, THESL deployed a mobile inspection program that uses handheld devices to conduct and record inspections. Leveraging on this technology, THESL analyzed and re-engineered internal maintenance processes to ensure that all mandatory data fields for the ACA are addressed during inspections. Lastly, resources have also been committed to determine those asset classes that have available data in the THESL asset registry, and identify dominant factors or critical condition parameters to include in health index calculations.

As data and health index calculations become more complete on a system-wide basis, statistical analyses are being performed with a greater degree of confidence.

With regard to the FIM, the application was created in 2010 and implemented for the following asset classes: underground cable, vault transformers, underground switches.
and network units. However, substantial work has since been done to extend the FIM methodology to several other asset classes, including select overhead distribution and station equipment.

Similarly, the AIS system was built and implemented in 2010, and has since undergone reviews and been updated to reflect current system requirements. These updates included upgrading the software, renewing and aligning focus areas for strategic investment and further evaluating the Project Equivalency Matrix. In the last year, the framework has remained relatively unchanged and greater focus was spent on refining the metrics used to evaluate projects and changes to the template used to assist staff when entering their respective projects for evaluation.

Lastly, THESL is aware that the OEB and other stakeholders are interested as to how utilities manage their assets, and to what degree utilities employ standards or structured methods for effective asset management. In 2008, the OEB undertook an informal survey of utility asset management practices. At the time, THESL was already reviewing the PAS55 asset management specification and had been exploring opportunities to enhance its asset management approach, in line with the key management elements of PAS55 shown in Figure 10.
As PAS 55 is a global, cross-industry specification with established auditing and certification measures, THESL decided to investigate it further and conducted an internal gap assessment to compare current practices against the requirements of the specification. The assessment highlighted two key areas where practices could be improved upon: overall risk management system (particularly risk assessment) and strategy and policy development (both medium and long-term). Over the past few years, THESL has responded and addressed these areas, largely through the implementation of FIM and AIS. More recently, THESL conducted another gap assessment across a broader range of organization functions that have an influence on the above system structure. Based on the assessment, system documentation and information management were key areas that were identified for further development. Subsequently, THESL is presently analyzing the findings of the assessment in greater detail to establish an improvement plan, and has committed resources to develop a business case to progress towards the PAS55 specification.