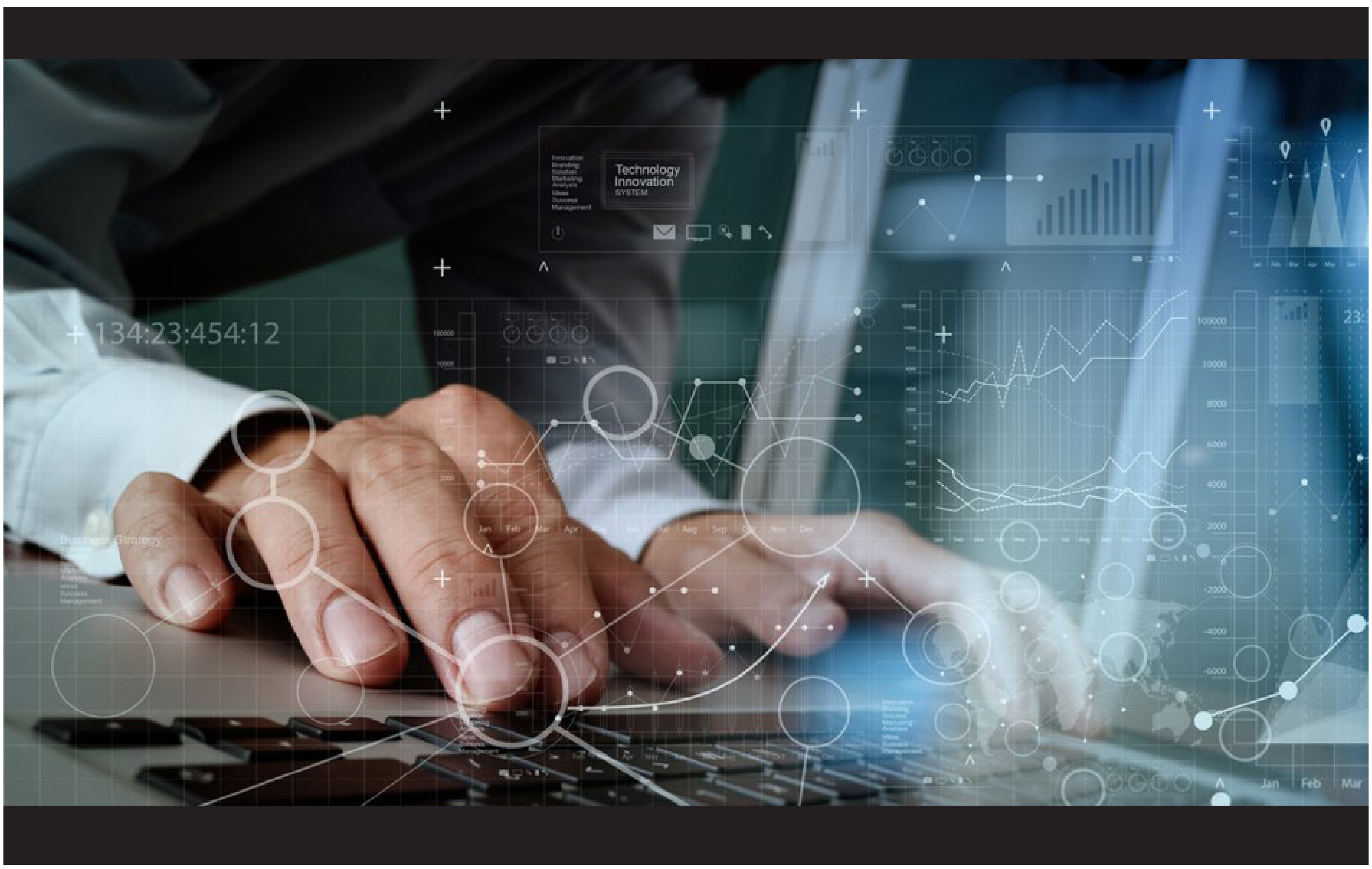
DISTRIBUTION PLANNING EVOLUTION: DEVELOPING A MODERN DISTRIBUTION PLANNING PLATFORM



November 2022

Table of Contents

Introduction

The evolving power distribution system, which comprises new technologies such as variable energy resources, changing load patterns and increased monitoring and control, introduces both new opportunities and additional challenges for distribution utilities. Distribution planning is critical to realizing this modern distribution system. However, traditional planning processes and tools only address a narrow piece of these emerging planning demands. For example, existing studies are geared towards addressing peak demand only and focused on traditional grid upgrade options (transformers, reconductoring, etc.) rather than considering new solutions like Non-Wires Alternatives (NWAs) such as distributed energy resources (DER) and demand-side management programs. The tools are also not equipped to efficiently perform strategic and system-wide studies to support today's integrated resource planning objectives. While current planning tools may have the ability to be used for certain studies within these processes, new capabilities must be developed to comprehensively plan and design a system, factoring in all these complexities, in an efficient manner.

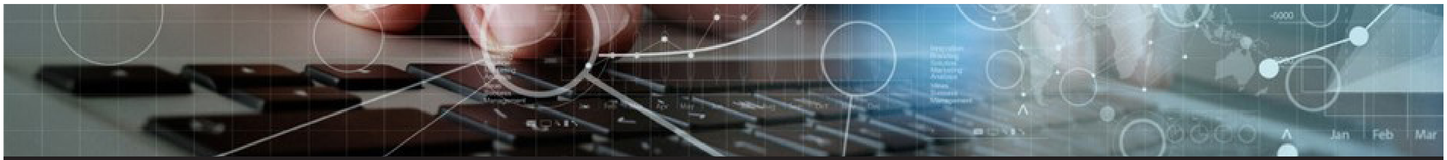
Designing the distribution system to meet future needs, planning processes and tools must evolve. New processes and tools with built-in automation capabilities are necessary to meet the challenges of planning tomorrow's distribution system. Future tools must provide a comprehensive, efficient, flexible, transparent, and integrated approach. Key features and capabilities for a modern distribution system planning process include:

- Holistic evaluation of traditional and non-wires alternatives,
- Flexibility to incorporate changing planning objectives and criteria,
- Engineering analysis that supports effective and efficient system planning,
- Seamless integration of existing and emerging data sources, and
- Supports integrated system planning needs between generation, transmission, distribution, and customers

Figure 1 describes the steps of the planning process that will be required in the future. Some of these steps exist today but may be smaller in scale, while others are new steps required for considerations of new resources. New analytics must be developed to characterize various alternatives, optimize their use, and compare them to traditional alternatives effectively.

Figure 1 – Modern distribution planning steps

This white paper presents the development of the Automated Distribution Assessment & Planning Tools (ADAPT) to face the challenges mentioned above. This EPRI product is intended to work as the vehicle for bridging the gaps in the traditional planning process for designing the modern and future power distribution systems. By combining the technical and economic analysis, ADAPT helps utilities to identify new business models, directions and opportunities when integrating non-traditional technologies into distribution planning.



Overview

To meet the needs of modern and future distribution planning, EPRI has been working to develop, test, and demonstrate new methods to perform complex distribution planning assessments efficiently and effectively. Automation of traditional planning methods and design and evaluation of NWAs and other technologies has been synthesized into an advanced planning framework, employing efficient computing processes. This framework also integrates built-in economic analysis, thus providing an integrated analysis that supports both technical and economic evaluation of planning alternatives. The approach demonstrated with this planning framework addresses today's planning scenarios with changing objectives and criteria, providing a framework for planners to identify the best investment plan which represents utilities and customers' interests for the years ahead.

The advanced planning framework automates the main steps of the planning process, from violation assessment and mitigation alternative identification to economic evaluation of the viable alternatives. This process differs from most traditional planning practices in that it evaluates the system hour-by-hour across multiple years, rather than focusing only on the peak load during the last year of the study. This is done to evaluate potential NWA deferment benefits gained from using different alternative solutions as needed throughout the study period. Planning studies within the framework can also cover a longer-term planning horizon to support integrated system planning.

For covering the needs presented above, the advanced planning framework proposes 5 steps. Shown in Figure 2, these steps comprehend the planning model definition and identifying the goals of the study; the system assessment for each year within the planning horizon for identifying the best group of alternatives and technical features to move into the next planning period to finally, optimize the investment plan selection based on the economic cost of each plan obtained.

The System Assessment and Alternative Identification steps are repeated for every year and for each alternative identified in the previous year. The result is a map of technically viable paths for alternative deployment combinations over time.

Figure 3 illustrates an example of a decision tree produced by the advanced planning framework. This tree maps multiple investment plans for deploying system upgrades over time that mitigate potential impacts under the studied conditions.

In contrast to other decision-tree-based planning techniques, the advanced planning framework generates the investment plans by performing simulations instead of optimization functions. Time-driven simulations enable the tool to predict the actual behavior in time of NWAs when added to the distribution system. By simulating the system operation both before and after each potential alternative is designed, we can create a model-based decision tree which provides realistic investment plans which are nearly as accurate as the base model and input assumptions provided. Even

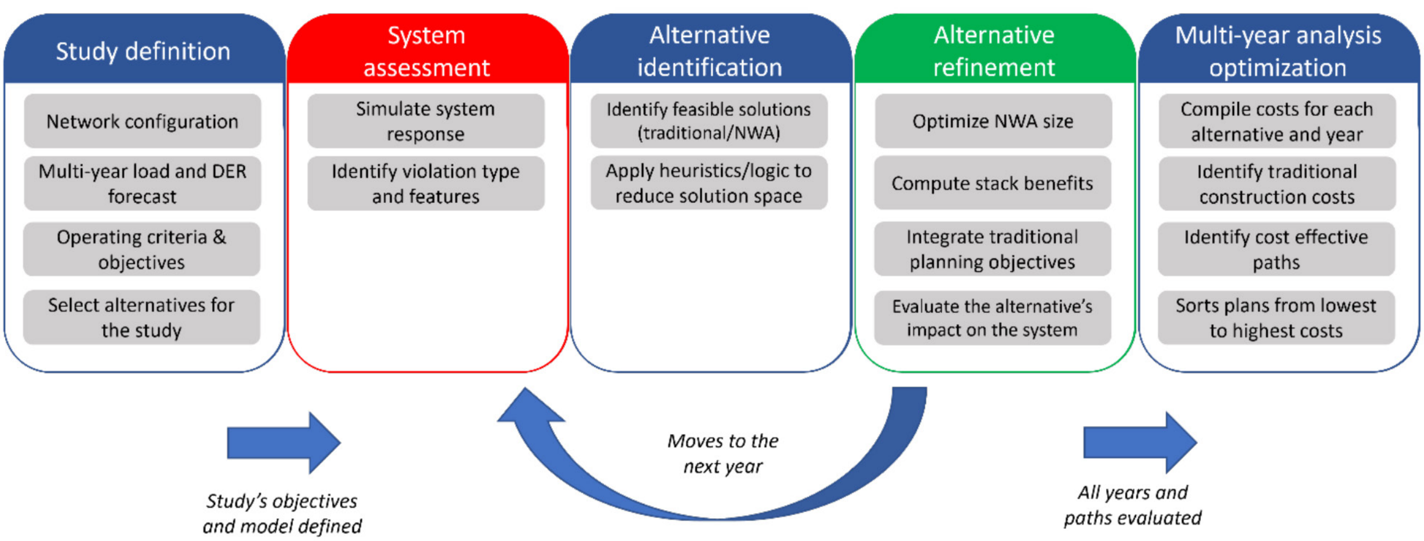


Figure 2 – Advanced planning framework

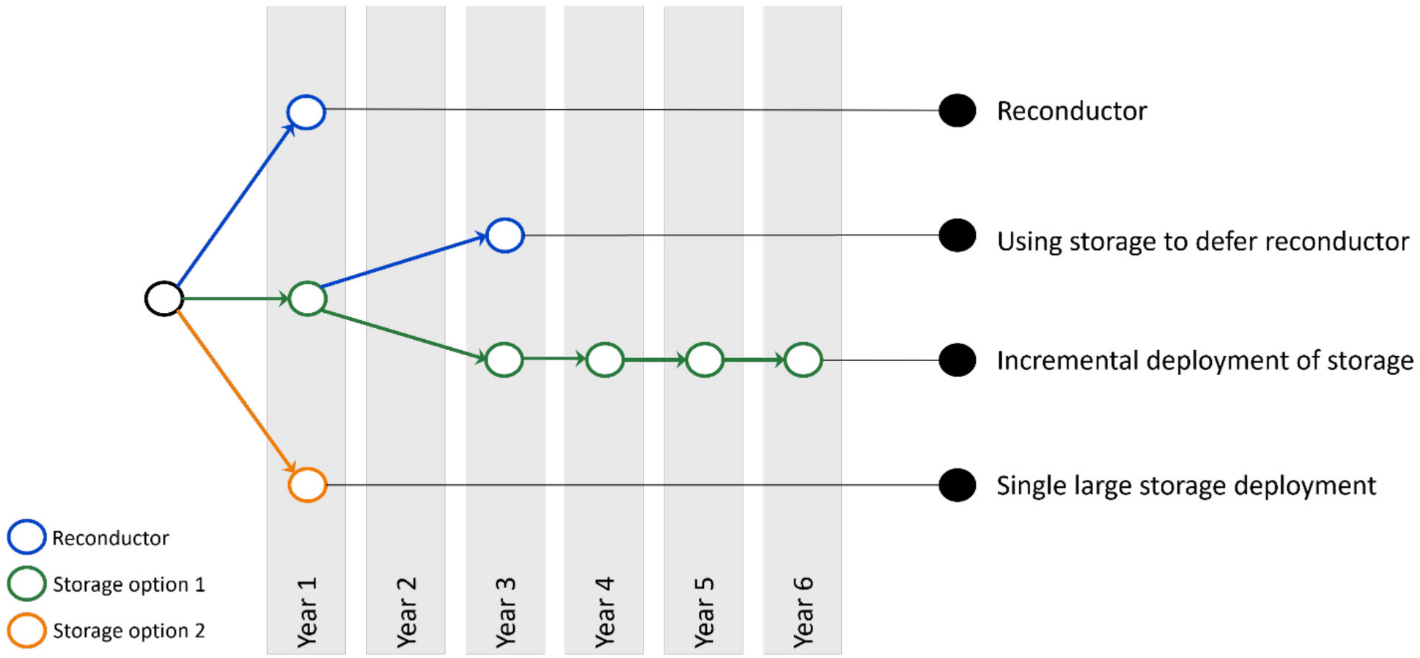


Figure 3 – Decision tree generated in ADAPT

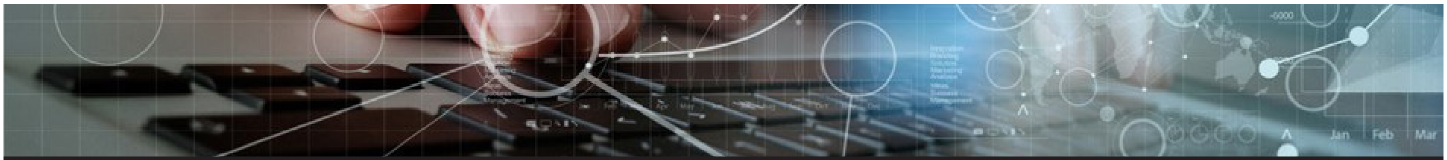
though simulations can be time consuming, by using modern computing features such as parallel processing, our advanced planning framework can perform planning studies and obtain detailed decision trees in a few minutes in a standard computer or laptop. This is in contrast with traditional sequential simulations where obtaining the same results can take several hours or even days.

The final two steps (alternative refinement and multi-year analysis optimization) evaluate each of these paths by computing associated costs and ordering them to identify the lowest-cost solutions. The planner then can determine whether to proceed with the lowest-cost solution or evaluate the options further based on additional decision criteria.

While this framework demonstrates a means to automate much of the overall planning process, it is designed in a fashion that the planner can trace through and visualize the results at each step as well as rerun the underlying simulations manually using the OpenDSS. Furthermore, our framework's modularity allows for less intrusive enhancements and upgrades as well as easier application of custom analytics if desired.

By embracing graphical user interfaces, our advanced planning framework and future tools alike require a user-friendly environment for planners to interact with the complexities that planning studies with NWA represent. Every menu and window must be carefully designed to facilitate planner's input, and to deliver results that can be easily interpreted and analyzed.

While this planning framework can help distribution planners evaluate multiple investment plans, some options will require manual evaluation to correctly capture extraneous information not captured in system models or to address complexities and practices that are not easily automated. Additionally, as with any simulation, the distribution planner needs to ensure all inputs and assumptions are representative of actual system operation and real-world economic conditions to achieve applicable study results.



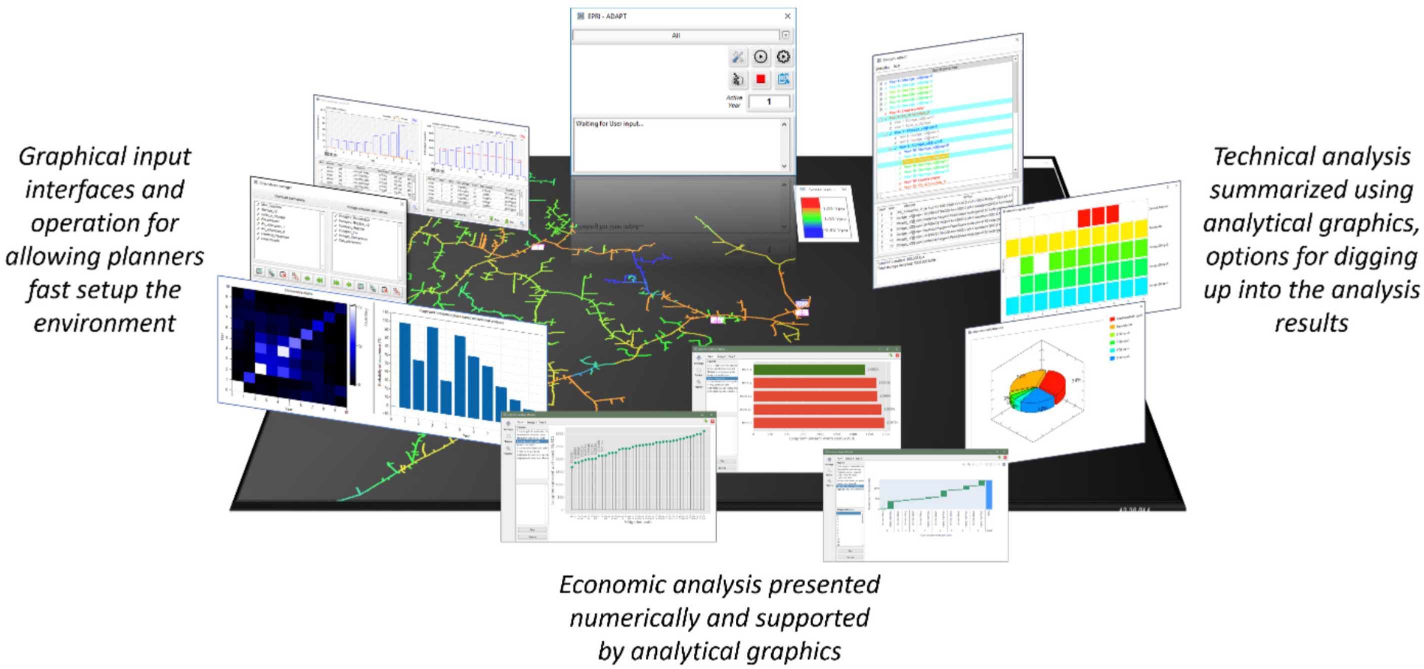


Figure 4 – Graphical environment for modern and future planning tools

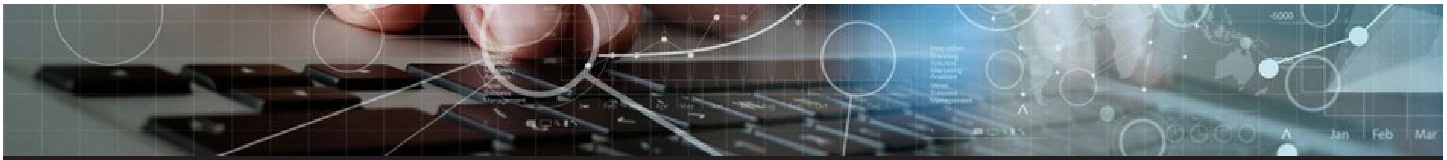
Applications of Advanced Planning Process

As a research and development tool, the advanced planning framework proposed is designed to directly address and inform solutions for many of the challenges of planning the modern distribution system previously described. It can be used directly to perform studies, or its components may be adopted within other tools to advance their capabilities to ensure that the capabilities can be readily employed by system planners.

During a planning study, thermal and voltage violations evolve in time as shown in Figure 5. This evolution is driven by the distribution model forecasted loading for the study's time horizon. Planning studies often forecast an increase in load that can happen yearly or at different rates; thus, voltage and thermal violations will affect different parts of the distribution system in different years.

Using traditional mitigation alternatives such as reconductoring for relieving the violations in time, planners evaluate the length of conductors that need to be upgraded and the years they will have to be replaced. Then, at the end of the study the total number and location of conductors to be replaced are determined, and according to the study aim, the planner will decide what year is the best for aggregating these line upgrades, following the constrains set up by the study's technical and economic guidelines as shown in Figure 5.

On the other hand, applying advanced planning on the same type of study will reveal the impact on the system when introducing other technologies, highlighting the benefits and side-effects within the study's time horizon. For example, using energy storage to mitigate the progressive thermal violations considered in Figure 5 the advanced planning framework will suggest the location for the storage device and the size of this device, which may grow according to the violation expansion in time given that the storage device can be stacked to match the violation advance as shown in Figure 6.



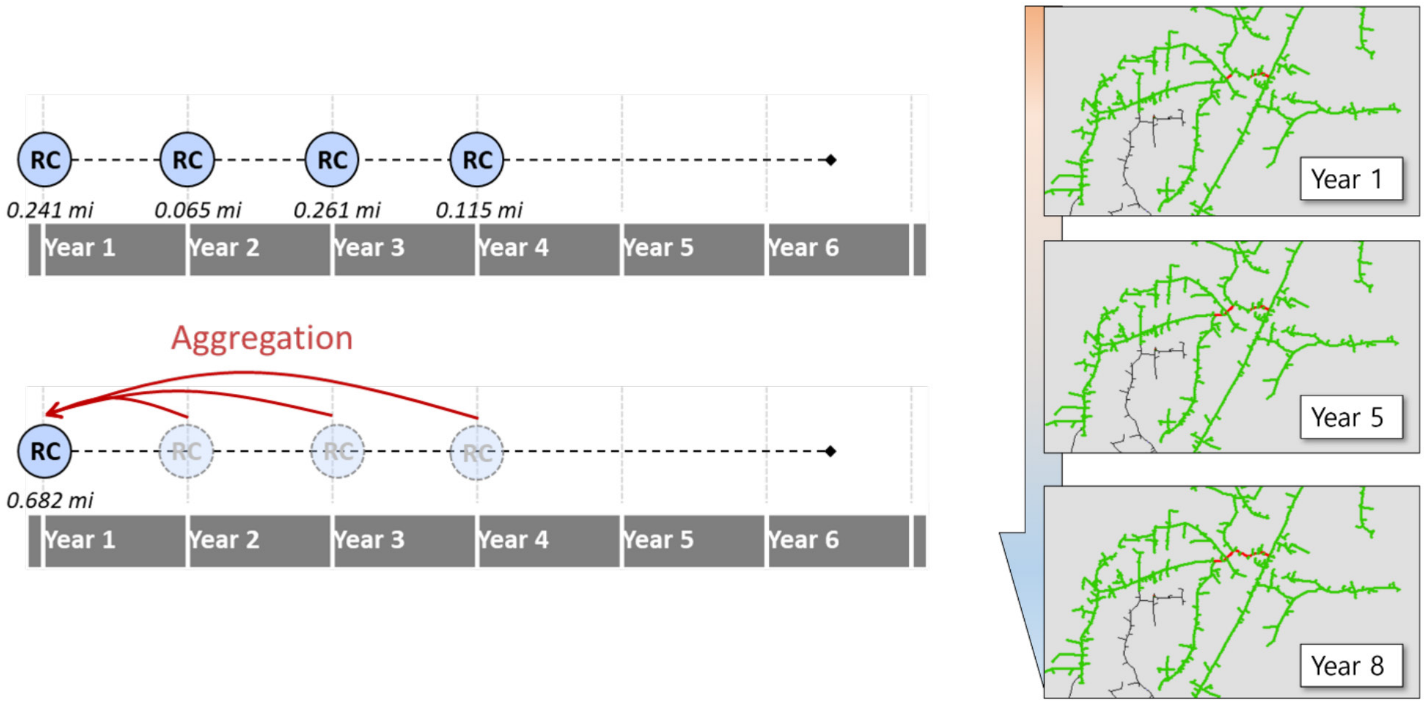


Figure 5 – Evolution of thermal and voltage violations in time and classic planning aggregation

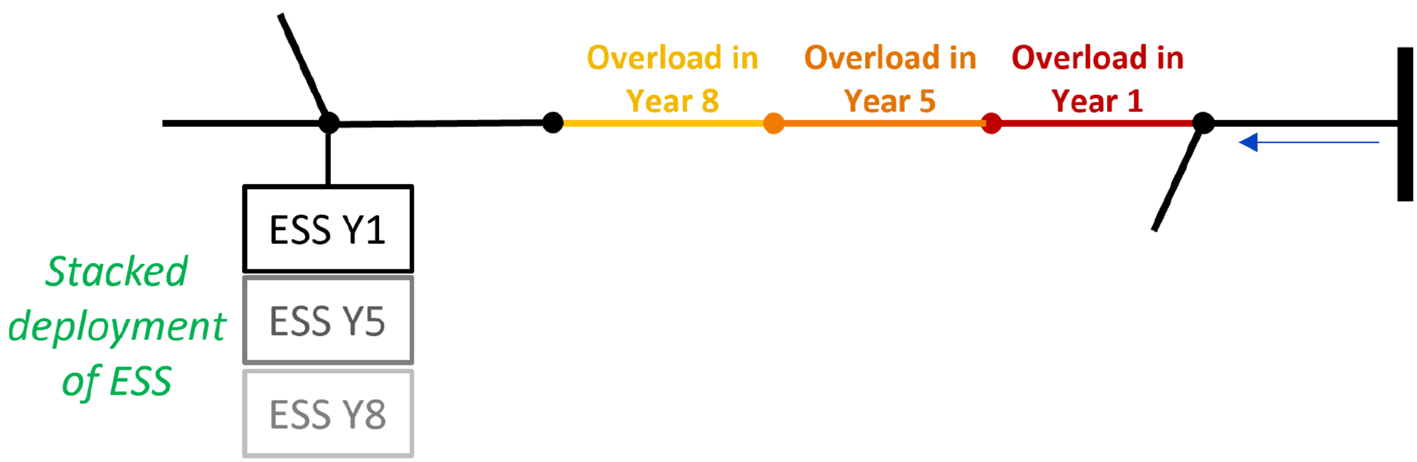


Figure 6 – Stacking Storage in time for matching the thermal violation advance

The same example can be used for integrating other NWA such as demand-side management programs. In this case by managing appliances such as air conditioners/heaters which communicate with the utility through an application of the internet of things (IoT), the utility can set the appliance's set point for relieving thermal violations. Even though the relief offered with this type of alternatives doesn't cover as wide a range of thermal violations as the alternatives mentioned above, this alternative can be useful for deferring upgrades or acquisitions in time, or to relieve short duration violations at a convenient cost as shown in Figure 7.

As can be seen in Figure 7a thermostats for air conditioning units can be set to a temperature a few degrees higher to reduce the demand when it is projected to peak. The relief obtained matches

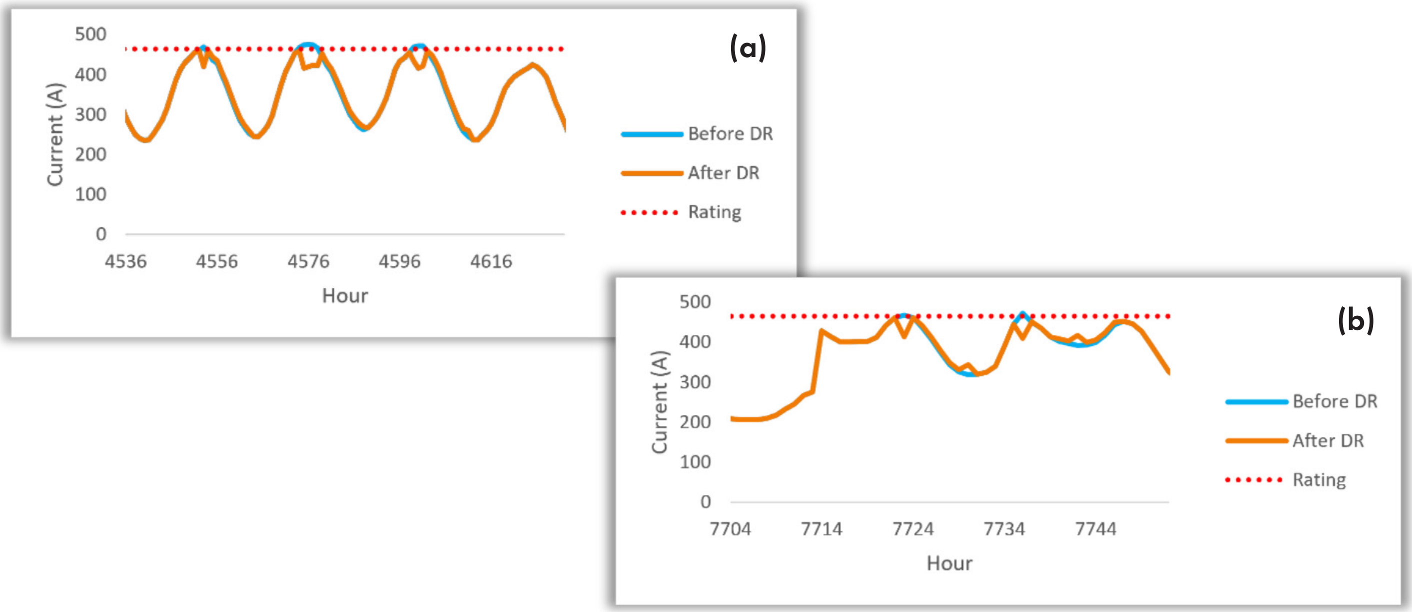


Figure 7 – Thermostats turned up to reduce cooling load (a); thermostats turned down to reduce heating load (b)

with the duration of the peak producing the thermal violation. A similar case is shown in Figure 7b, where the thermostat is set a couple of degrees lower to help relieve thermal violations that may show up during winter demand peaks. This alternative demonstrates a mitigation alternative that can help in scenarios where thermal violations are not long in duration or drastic in terms of the exceeding current.

Demand-side management can also complement other alternatives for relieving the thermal/voltage violations found during a planning study since, after a violation on a feeder's branch is relieved the first-time using NWA, the subsequent violations will probably have a lower magnitude or duration. In cases like this, demand-side management can operate as a cost deferral agent for accomplishing economic and regulatory aims for the years ahead.

The cases presented above can all be part of the same planning study using the advance planning framework, creating investment plans based on each mitigation alternative and combining them to create alternate paths covering the duration of the planning study. This capability allows to quickly perform and compare different planning scenarios and assessments, such as evaluating whether the decreasing costs of emerging NWA over time may result in higher deployments in longer-term planning horizons. This holistic evaluation of traditional and innovative NWA solutions provides quantifiable technical and economic results for the planner, optimizing system investments using multi-year analysis of different alternative deployment strategies considering both short and long-term horizons.

Studies like the one proposed above can be extended to integrated system planning by performing system-wide assessments over the extended timeframes needed to inform generation and transmission planning.

Evaluating emerging NWA applications, accounting for modularity of NWA solutions and potential cost reductions through stacked benefits, allows utilities to identify future study requirements and impacts of changes in planning criteria, through automated evaluation of "what if" scenarios that quantify the impacts to system performance and expected capital expenditures.

The investment plans obtained after conducting a study with the advanced planning framework can be used for evaluating new utility business models; the mitigation alternatives include customer engaging programs as well as innovative technologies as presented above, which can be tailored to specific technology companies working with utilities for a comprehensive NWA procurement. Through this framework, utilities can demonstrate case studies for the forward-moving regulatory environment. Informed by the analysis performed with this framework, utilities can engage in conversation with regulators to facilitate NWA policy development and adoption.

Through the results delivered by advance planning, utilities can identify low-cost NWAs that can complement or replace traditional mitigation alternatives, enabling utilities to benefit from cost-savings provided by emerging NWAs. Identifying potential NWAs and the investment plans generated through advanced planning can lead to inform conversations with stakeholders, enabling collaborative processes for integrating NWA as part of the new standard distribution planning process.

Lessons Learned Through Implementation

Advanced Planning Capabilities Demonstrated through Adapt

The advanced planning framework was implemented in the Automated distribution assessment & planning tools (ADAPT) for further research, application, and refinement of key study components. This section provides further details on the steps and analytics that were implemented and tested across the four steps: the study definition, the system assessment, alternatives identification and design, and economic evaluation. This section also discusses identified gaps, lessons learned, and needs for future research.

Study Definition

Future system conditions and alternative design parameters are defined by the user as inputs into the ADAPT tool. These inputs include:

- System or feeder models representing current configuration.
- Thermal ratings and voltage criteria that will be used to flag violations requiring mitigation. The thermal ratings can be defined by season if required.
- Hourly (8760) load and DER forecasts for every study year to be included in the study. The number of years to be modeled is user specified.
- Selection of mitigation alternatives to be assessed along with the specification of each alternative's design setpoints and criteria.
- Financial assumptions and cost information for each selected alternative type.

System Assessment

As the first analysis step, a pre-screening of the circuit model is performed to identify expected impacts in the "do nothing" case. A quasi-static time-series (QSTS) simulation of each hour of the multi-year study horizon is performed to identify periods resulting in system violations requiring mitigation. This step is shown in Figure 8a. Parallel processing that divides the multi-year simulation across multiple processor cores is employed to speed up this portion of the analysis. While initially time consuming, this pre-screen generally only needs to be run a single time and significantly reduces overall computational requirement by identifying which circuits, devices, years, and specific hours require further detailed analysis.

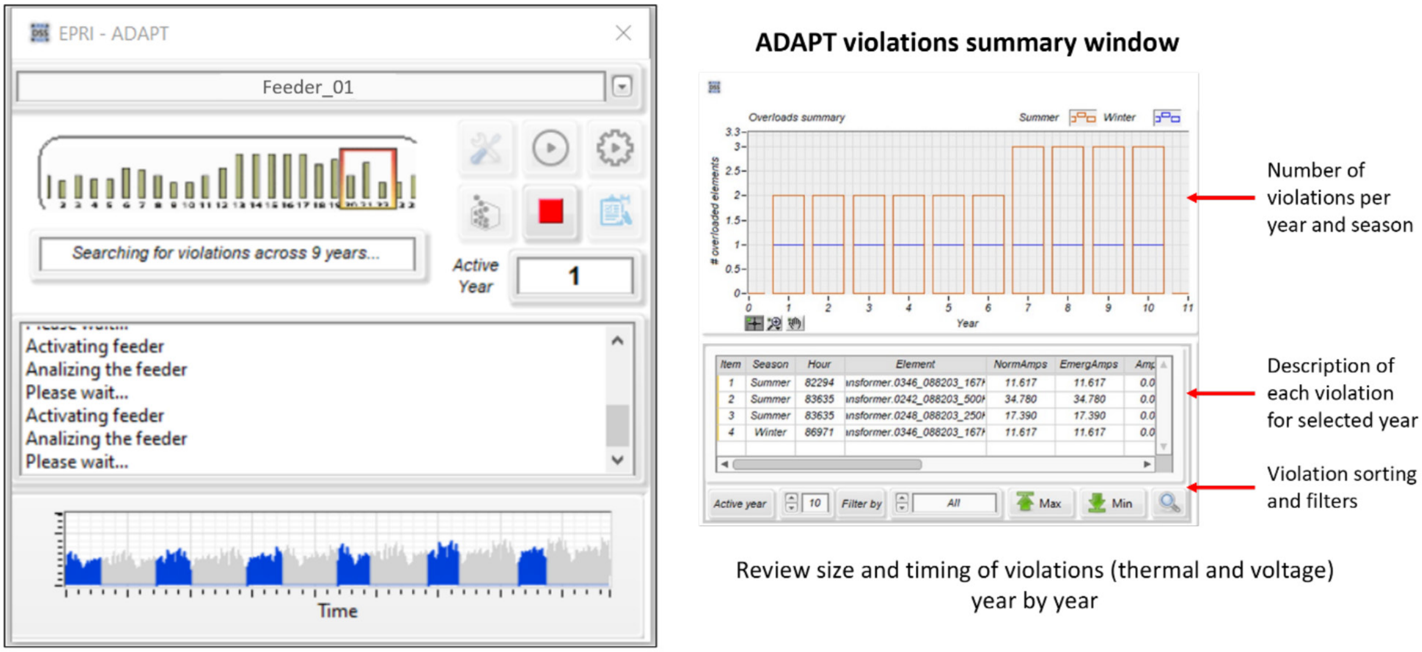
Figure 8b shows a summary report from the ADAPT pre-screening analysis. This report shows when and how study circuit's constraints may evolve over time. When a violation is detected, system information characterizing these impacts are stored and used as the starting point for the "alternative Identification" step.

Through implementation and testing, additional information from the pre-screening analysis has been identified that could expedite analysis of mitigation alternatives. For example, the list of all nodes with voltage violations could be stored to expedite voltage mitigation analysis. As the tool evolves and more valuable results are identified, the amount and type of information chosen to be stored must be prioritized to avoid excessive memory storage requirements while balancing with the computational time needed to re-calculate that information when it is needed.

Automated Alternative Indentification, Design, and Refinement

Automating the design and evaluation of various planning alternatives was a key component of the tool and is expected to be a key area of focus with future advancement in distribution planning capabilities. The current implementations within ADAPT are crucial first steps toward supporting quick and effective assessment of multiple system upgrade and expansion options. The process implemented within ADAPT is designed with a modular framework that allows the alternative design logic to be readily revised and expanded as the needs continue to evolve.

5 A 24-month cycle and a 33-day refueling outage would provide 95.5% availability. Given that the mean capacity factor was 92.5% over this time period, forced outages caused loss of approximately 3% of availability.



(a) (b)

Figure 8 – Prescreening analysis in ADAPT (a); prescreening analysis summary (b)

ADAPT's existing alternative design modules are grouped based on whether they are intended to address a thermal or voltage violation. This grouping is not necessarily a function of the alternative type but instead is driven by different design logic required in meeting different objectives. However, both thermal and voltage violations can occur simultaneously in the planning study. When this occurs, the ADAPT process seeks to first resolve the thermal overloads. If voltage violations still exist following the mitigation of the thermal issues, the voltage mitigation alternatives are designed and introduced in conjunction with the defined thermal mitigation.

An overview of the mitigation alternatives that were developed and implemented in ADAPT for demonstration as part of this project are summarized in the rest of this section. More detailed descriptions of each algorithm are captured in the tool's support documentation.

In ADAPT's modular framework, each design alternative is implemented in a unique module. This allows the alternative design capabilities to be easily expanded or refined without changes to the core toolset. Each module can be activated, deactivated, and edited as needed to study the unique set of alternatives that are of interest in each study. Mitigation alternative modules in ADAPT are user customizable by using Python scripts. The rules for developing scripts compatible with ADAPT are described in the user manual.

Although each alternative is independent, ADAPT allows users to combine alternatives for addressing thermal or voltage violations. For example, assume a planner is looking to relieve thermal violations using a combination of photovoltaic (PV) generation and energy storage solutions in the same year. PV and storage solutions exist as separate modules; however, by using the configuration menus provided in ADAPT, planners can combine them for the study, avoiding the creation of a new module for that purpose.

Table 1 – Modular mitigation alternatives designed for relieving violations in ADAPT

	Alternative	Description
Thermal Violations	Reconductoring/Transformer upgrade	Replaces overloaded conductor or transformer with higher rated asset if available
	Load transfer	Transfers load from one feeder to another if capacity is available to do so
	PV	Determines required PV size and location to resolve overload
	Storage	Determines required storage size and location to resolve overload. Operated to peak-shave based on overloaded element current
	Demand response	Determines required thermostat adjustment for HVAC to provide load reduction to resolve overload
	Voltage conversion	Up-rates voltage on part of a circuit to resolve voltage violations. Voltage converted to the primary side voltage of step transformer if available
Voltage Violations	Regulator setting change	Finds new regulator settings to resolve voltage violations using voltage spread method
	Regulator Line drop compensation	Adds line drop compensation to regulator settings based on feeder impedance to resolve under and overvoltages
	Regulator siting	Adds a new voltage regulator to resolve voltage violations. Settings are the same as those of the existing regulators or LTC
	Capacitor placement	Adds capacitor bank of minimum possible size to the nearest 3-phase location to the lowest voltage bus to resolve voltage violations
	Capacitor control settings	Adds or adjusts control settings on existing capacitors to switch off during times of day when overvoltages may occur
	Voltage conversion	**Up-rates voltage on part of a circuit to resolve voltage violations. Voltage converted to the primary side voltage of step transformer if available**

During the Alternative Identification step, the ADAPT tool automatically designs and tests alternatives which may resolve violations during each year of the study period. For each alternative, the tool automatically selects the locations, sizes, and other parameters for new or upgraded equipment based on the location, magnitude, and duration of violations as well as user-defined parameters. Several alternatives are designed at once using parallel processing to speed up analysis.

Then, the tool runs limited simulations to evaluate whether the designed alternatives successfully resolve all violations. The iterative process to this point results in a "tree" that maps out the potential paths that can be taken in deploying the defined set of mitigation alternatives. This tree branches whenever a system violation is detected, and more than one alternative is technically viable. As this tree represents the potential "future" technical paths that can be taken, the tree is colloquially named in honor of Doc Brown from the Back to the Future movies.

Depending upon the number of alternatives considered and the number of violations over the study period, the number of branches in the tree can grow very large. Thus, viewing and navigating the tree can be a challenge. Figure 9 shows a screenshot of the ADAPT report, which uses color coding for the alternative types as well as pop-up menus and filters to help planners navigate this tree.

In cases where there are a large number of successful paths, navigating the Doc Brown Tree can be especially overwhelming. Some useful summary statistics and plots can be accessed in the statistics menu. These include statistics on the numbers of successful and failed edges and paths, as well as charts showing how often and in which years each mitigation alternative is successful. More work is needed to develop more useful and readable visualizations that can help planners quickly understand the different paths that are feasible. Additionally, analytics could be developed to identify and consolidate identical or very similar paths to simplify the Doc Brown Tree.

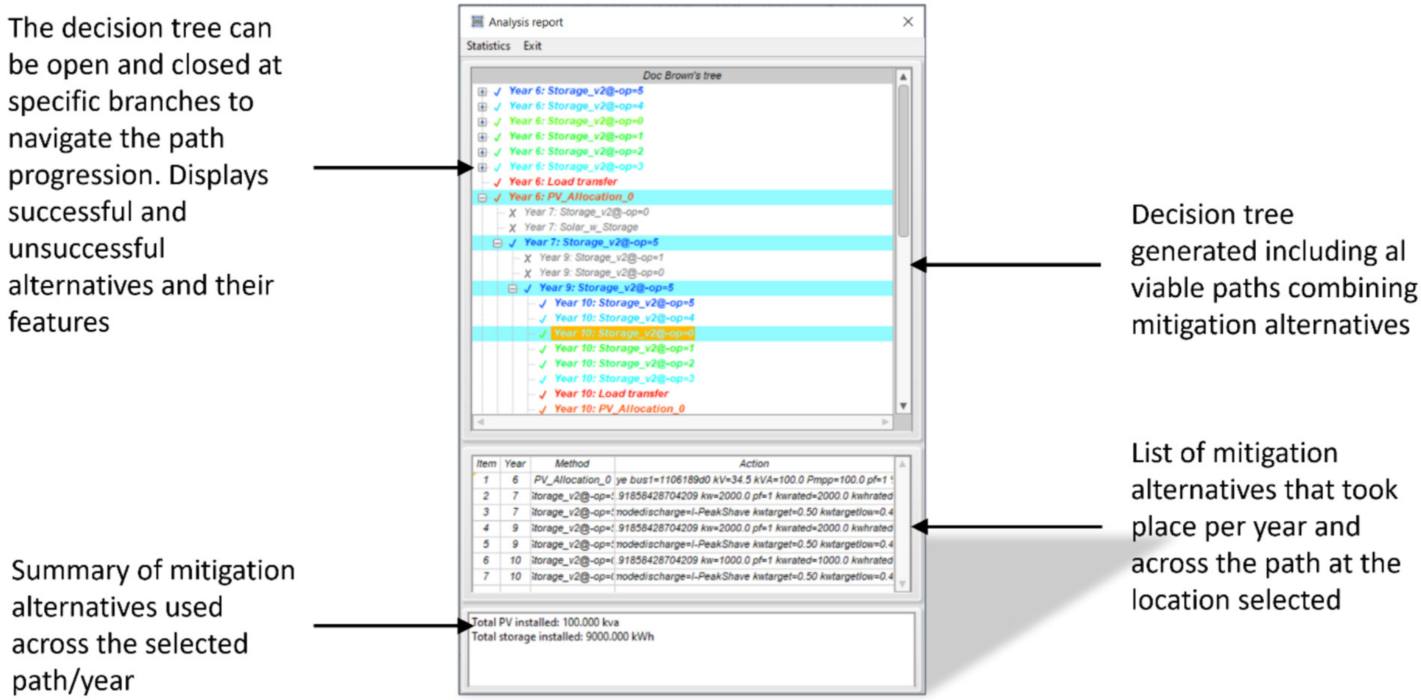


Figure 9 – ADAPT planning study report

Designing mitigation modules and choosing appropriate parameters for them requires a balance between flexibility and computational time. For example, any number of energy storage sizes can be assessed in one study. However, with each storage size considered, the Doc Brown Tree can expand, and the computational time needed for the analysis can increase exponentially. Narrowing down the energy storage options to those that are likely to be applicable for a given circuit can be a time-consuming iterative process using ADAPT's manual analysis feature. A key to reducing both manual and computational analysis time lies in designing mitigation modules that are intelligent enough to design various feasible options without requiring excessive computational time or manual tuning.

Economic Evaluation

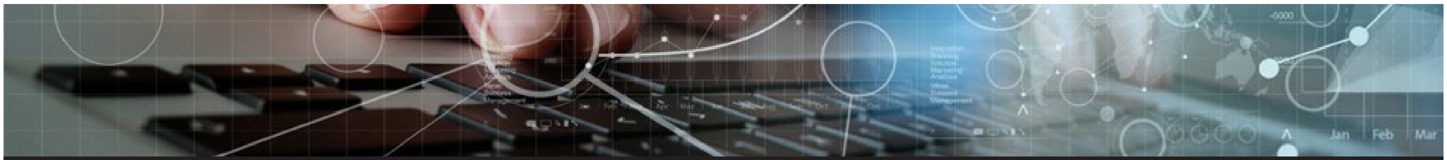
The final step of the analysis is to compute and compare the costs of the different paths represented by the Doc Brown tree (DBT). The economic calculations determine the present worth costs for potential deployments considering:

- Capital costs
- Operational expenditures
- Interest and cost escalation
- Other cost/benefit factors

Results can be accessed using a GUI report shown on Figure 10. There are 4 reports that can be accessed through this GUI displaying the economic features of each path and sorting them out according to their total economic cost. These tables can be exported into common spreadsheet programs such as MS Excel to facilitate further data navigation, analysis, and validation from planners.

The economic analysis interface also includes analytical graphs as the ones shown in Figure 11, these help planners visualize the results obtained and assist with decision making. The interfaces transform data into useful visual information, breaking down the complexity of the DBT and the analysis around it for planners to select the investment plan that fits best with the utility's needs.

Since the future costs of both traditional upgrades and NWAs are uncertain, future work could address the need for sensitivity analysis or risk analysis which could help planners understand how changing costs could impact the relative costs of different paths.



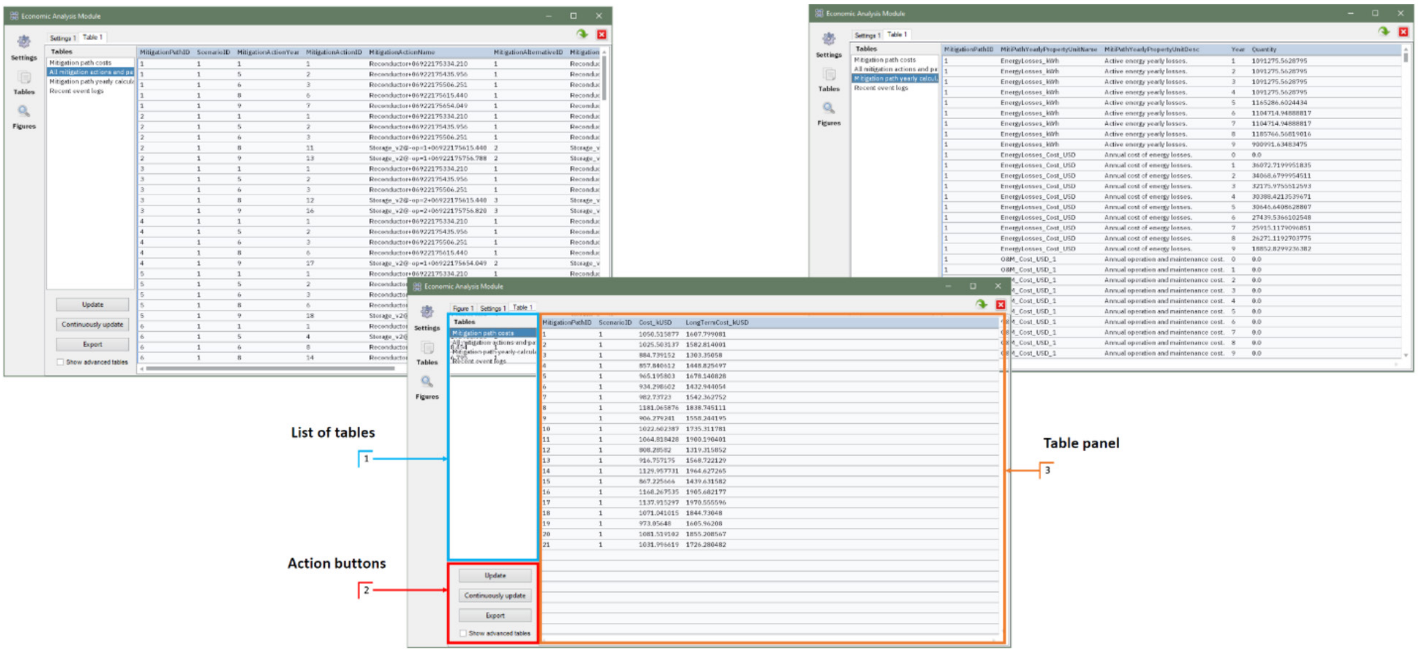


Figure 10 – Economic analysis interface

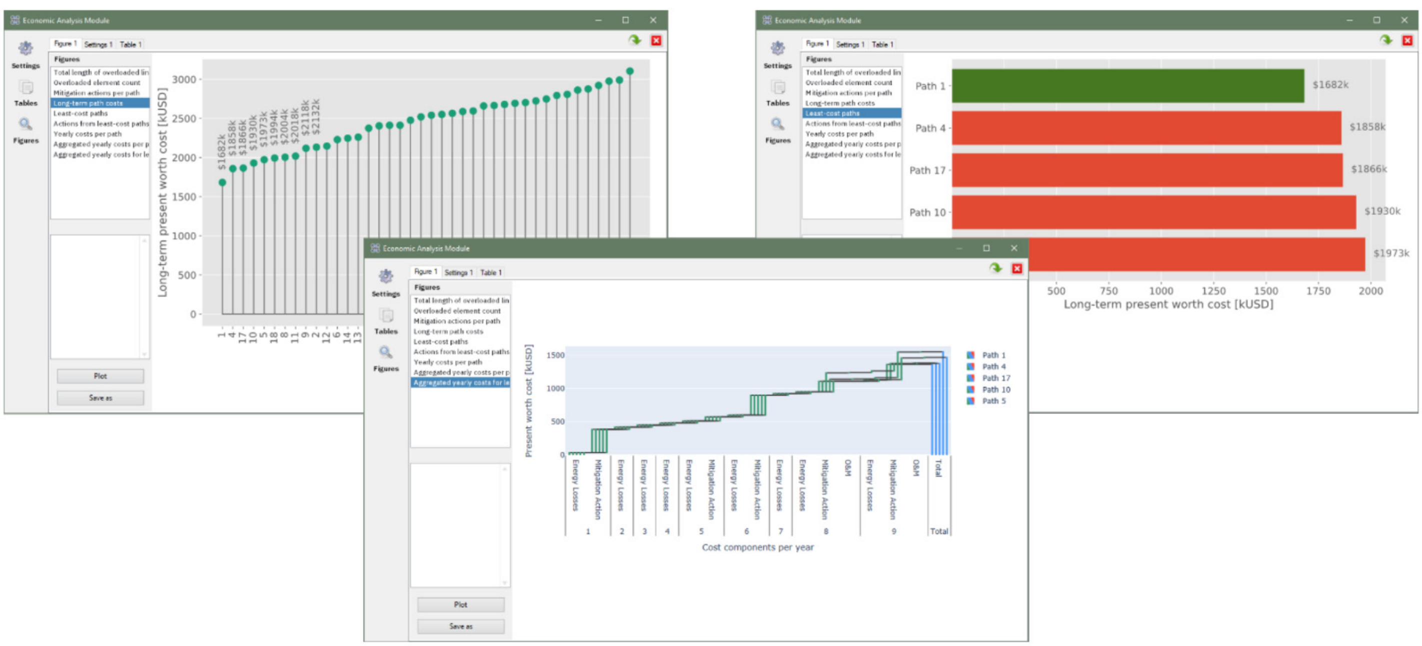


Figure 11 – Reports and visualization aids for navigating the study results

Refinements to Process through Implementation

In implementing these new methods and applying them on utility feeders, numerous gaps were identified and refinements to the methods were made. These utility demonstrations enabled application and testing to ensure advanced planning tools are applicable and accessible to distribution planners.

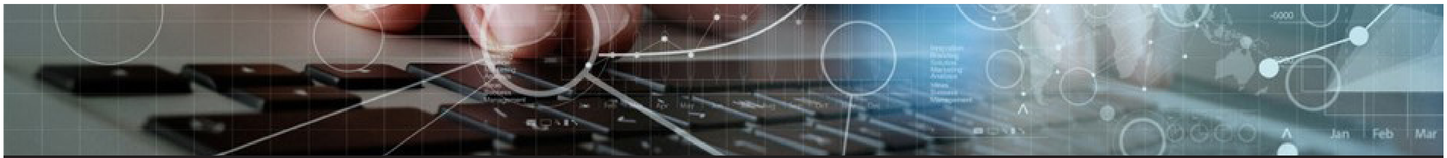
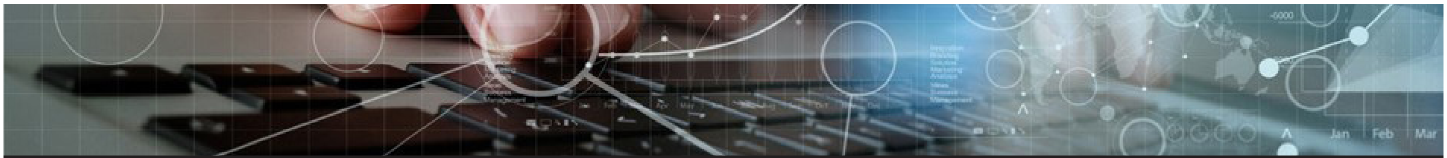


Table 2 – Features implemented and evaluated through ADAPT

Feature Evaluated	**Implementation in ADAPT**
Computational Efficiencies through Parallel Processing	Simulating every possible option and path over multiple years can be computationally intensive. A novel parallel processing technique was leveraged that directs multiple cores in simulating the different deployment paths in parallel, significantly reducing computation times.
Time Series Simulation Screening and Reduction	A marked reduction in overall computational time and effort was achieved through a screening process that simulates power flows across the user-provided 8760 profiles and identifies key time segments when thermal or voltage violations occur.
Annual Loss Estimates under Different System Changes	Novel techniques using adaptive filtering were developed to accurate estimate annual loss totals - needed to inform O&M costs – that accurately capture the impact of dispatched energy sources without needing to simulate the system for every hour of the year. This estimate dramatically reduces overall computational requirements.
Mitigation of Coincident Thermal and Voltage Violations	Addressing more than one violation/objective requires additional logic to appropriately design and evaluate potential mitigation alternatives. The logic employed first evaluates potential solutions to mitigate thermal issues. If voltage issues remain unsolved after thermal mitigation solutions are implemented, the analysis then examines additional mitigation focused on the voltage issues. This additional dimension to the automation required significant expansion to the management and navigation of the decision tree. More work is needed to address cases where implementing a voltage mitigation causes new thermal violations which could be solved by expanding the thermal mitigation solutions already identified.
Seasonal Ratings with Time-Series Simulation	Reflect the ratings considered by utilities when operating throughout the year under different weather conditions. Summer and winter ratings for transformers and lines are fed into the simulation model for the analysis. This allows for considerations of different equipment ratings during two or more seasons each year as required for representing the utility's operational limits.
Load Shape Aggregation Algorithms	For detailed models where each load has its own load shape, include algorithms for simplifying the amount of data available. This option was developed before adding memory mapping (see below) which significantly reduces processing time for detailed models. The functionality for aggregating load shapes was kept in case such reduction is necessary in the future.
Enabling Detailed Models with Large Data Sets	Improvements on memory management for speeding up detailed simulation models was included. Having a unique load shape to represent each load's behavior within a circuit model can be computationally exhausting. However, thanks to a modern computing technology called memory mapping, simulating detailed models can be simpler and computationally efficient.
Interactive Feedback	Graphical User Interfaces that provide an intuitive and comprehensive graphical environment, including circuit visualizations, for the user to navigate, explore and validate the technical results delivered by the analysis: • Circuit heat maps show the locations of thermal violations during any hour when violations occur. • Voltage profiles and circuit heat maps illustrate circuit behavior and highlight voltage violation locations during any hour when voltage violations occur. • Automatically visualize the chosen location of alternatives selected from the Doc Brown Tree report on the circuit map. • Model export capabilities for allowing planners to validate and investigate in detail the results proposed by ADAPT. This capability allows users to use multiple validation tools for recreating scenarios and move the planning study results into other domains. • Graphical reports used for transforming data into information, facilitating the planer's decision making when selecting planning paths for covering the utility's objectives. • The interface offers an explorer like experience to the user, where the user can navigate and check all the aspects of the process. However, this design is always subject to feedback to address the needs of the modern planning process and the people involved in it.
Improved Reporting	Additional reports to better summarize the outputs, these include: • Yearly occurrence reports which show the years in which an alternative has been used during the analysis • Alternative utilization rate report which aggregates how much each alternative was used during the entire study • Investment year probability report which considers all technical results to provide a probability of investment for each year • Financial reports which compare the capital and O&M expenditures each year for different mitigation paths on the Doc Brown Tree • The OpenDSS model associated with any path on the Doc Brown Tree can be exported for further analysis or as the final planning model with planned improvements.
Automated Alternative Designs	Automating the design of alternatives is a key component in efficiently evaluating the both the technical and economic viability of multiple options. ADAPT uses a modular framework that permits the various alternative types or implementation to be specified in a unique module, allowing the alternative design capabilities to be easily expanded or refined without changes to the core toolset. Additionally, the project derived novel approaches for identifying solutions to coincident locational impacts or in the case of both thermal and voltage violations.



Next Steps

Advancing the advanced planning framework and its implementation through ADAPT comprehends several fronts. Among the additional input required to keep advancing distribution planning are the future configurations and planned upgrades and projects . These add an important degree of uncertainty for the study and can represent a decisive factor when analyzing the value of investment when costing valid planning paths. Future projects can also alter the shape of the resulting decision tree when using ADAPT, adding or removing violations for a feasible planning path. This topic is under study to be included in future versions of ADAPT.

Additionally, there is a clear need to keep improving our tools to facilitate model conversion between distribution modeling and simulation platforms. The integration of these types of tools is a topic of constant improvement within ADAPT and for future implementations, it is expected that the user will have access to this conversion at high level, using a couple of click to make it happen without abandoning the graphical interfaces domain. Another solution is to integrate ADAPT's or other similar analytical tools into existing widely used vendor software.

Vendor engagement is an important component of EPRI's research. The R&D derived through the project as well as future enhancements to ADAPT are intended to inform planning software vendors on expand capabilities needed and desired by the industry. This goal is planned to achieve through a triad of activities:

1. **Show** – EPRI will share information and insights on the algorithms and processes derived from the R&D, permitting vendors to incorporate, emulate, or adapt these capabilities within the planning toolsets.
2. **Tell** – Inform vendors on industry needs and experiences through collaborative engagements between utilities, researchers, and vendors. As the vendors customer, active utility participation in this step is crucial to its effectiveness.
3. **Do** – Continue to advance and demonstrate the benefits derived through the R&D efforts as well as look for opportunities to directly collaborate with the vendors on related future R&D. Additionally, the ADAPT tool will continue to be advanced, through follow-on efforts, to inform the industry and provide stop-gap capabilities as applications and study needs continue to evolve.

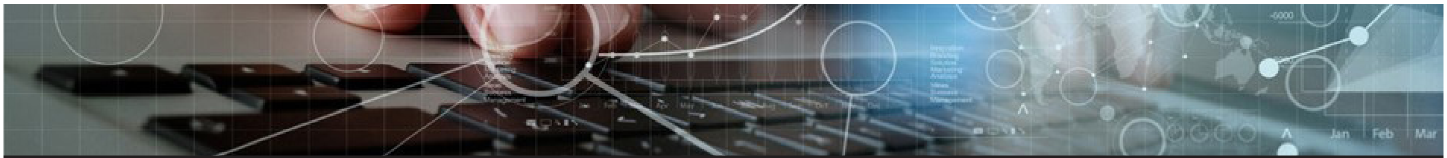
Conclusion

Advancing distribution planning is an interdisciplinary effort toward automating various steps of the planning process. As noted previously, the complexities introduced by a more modern distribution system are not easily addressed using traditional planning approaches and tools. However, this does not equate to the automation of the entire planning process. On the contrary, many aspects of the planning process cannot be reasonably automated. Furthermore, automation cannot replace the experience and knowledge of the planner nor consider extraneous factors not captured by simulations or analytics. Instead, the planner should have full visibility of each step in the planning process and the ability to engineer the appropriate automated analytics and simulations to more effectively and efficiently answer planning study needs and objectives.

At its present state, ADAPT covers aspects of traditional distribution planning and complements them with the introduction of NWA, creating a decision tree which encapsulates all technically feasible investment alternatives within a planning horizon. This tree, called the DBT, is the critical link between technical and economic analysis, providing advanced information to the planner to determine the best investment plan representing the aims of the study.

The analysis demonstrated through ADAPT is aimed to provide a space for evolving processes for modernizing power distribution planning. These processes include non-traditional mitigation alternatives for upgrading distribution feeders, which, when combined among themselves and with traditional mitigation alternatives, provide a wider panorama of options a utility can implement for moving forward in time with a secure power system. The planning options provided by this type of modern planning study each have varying technical and economic features, opening the door for utilities to identify which if these options represent the best business model in the years ahead while tackling several objectives.

The next steps for ADAPT are to continue integrating distribution planning elements. Among these are circuit model conversion capability, substation upgrade and evaluation, assessing dynamic models by considering scheduled projects within the planning study, and hosting capacity integration. The modular architecture of ADAPT enables rapid expansion into these areas and more to keep advancing the tool following members' feedback.



Continued feedback from the industry is critical to the future advancement of the modern planning process and ADAPT platform. These interactions with members ensure that continued improvements to the tool will meet more member needs, thus facilitating adoption of the tool as well as vendor engagement. EPRI aims to advance the ADAPT platform such that its capabilities can be seamlessly integrated into utilities' existing planning processes using existing vendor tools that are already widely used in distribution planning.

ADAPT is developed as vehicle for demonstrating and gathering the utilities needs for modernizing distribution planning. Through demonstrations ADAPT provides a closer look into the modern planning process, displaying different approaches for implementing the tools that future planners need for facilitating vendor adoption and engagement.

Further Reading

Defining a Distribution Planning Framework for Resilience: Moving Beyond Wires and Poles to Prepare for Future Events. EPRI, Palo Alto, CA, 2022. 30002023951

Modernizing Distribution Planning: Collaborative Report on System Cases and Protype Tool Advancements. EPRI, Palo Alto, CA: 2021. 3002023006.

Modernizing Distribution Planning: Economic Cost-Benefit Assessment for Distribution Operations and Planning. EPRI, Palo Alto, CA: 2021. 3002022345.

Modernizing Distribution Planning: Drivers and Future Vision. EPRI, Palo Alto, CA: 2021. 3002019874.

EPRI prepared this report.

Note

For further information about EPRI, call the EPRI Customer Assistance Center at 800.313.3774 or e-mail askepri@epri.com.

About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

EPRI RESOURCES

Lindsey Rogers, *Program Manager*
865.218.8092, lirogers@epri.com

Davis Montenegro, *Technical Leader*
865.347.4418, dmmartinez@epri.com

Catie McEntee, *Engineer/Scientist II*
980.495.7421, cmcentee@epri.com

Matt Rylander, *Project Manager*
512.731.9780, mrylander@epri.com

Distribution Operations and Planning

3002025662 November 2022

EPRI
3420 Hillview Avenue, Palo Alto, California 94304-1338 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com