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Creating a Coordinated Planning Process – Resource, Transmission & Distribution Planning

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SUMMARY

The convergence of utility planning processes with public policy objectives, (i.e., decarbonization, grid resilience, climate change), while minimizing the total investment required, has brought to light the inefficiencies of traditional, siloed planning practices. To identify the most efficient and effective path forward, increased coordination is required between Utility Scale and Distributed Resource (R), Transmission (T), and Distribution (D, and collectively RTD) planning processes.

The core idea behind Coordinated RTD Planning is simple: the industry cannot continue to plan the grid in a compartmentalized manner. Every utility planning domain, be it utility-scale generation, transmission, distribution, distributed energy resources (DER), and rate design face unique challenges as the push towards more renewable sources and decarbonization intensifies. Effective planning in one domain can only happen with understanding shifts and impacts in the others. The optimum solutions for the evolving issues are increasingly likely to require changes that span multiple planning domains the system now Per the FERC Standards of Conduct, every planning sector should collaborate, setting goals, sharing information, and coordinating efforts. Without this shared knowledge and vision, achieving the best investment strategy for the entire utility system becomes an uphill task.

This paper introduces the concept of Coordinated RTD and discusses its importance in the framework of future grid planning. The paper also describes the primary building blocks and presents use cases to showcase benefits.

KEYWORDS

Coordinated RTD Planning, transmission planning, resource planning, distribution planning, and grid investments.

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1. INTRODUCTION

In many utilities, planning activities for generation, transmission, and distribution are compartmentalized into different departments. Each of these has its own procedures, objectives, and data sources. Moreover, there's a clear divide between operations planning and long-term strategy. Such division serves to narrow the view of potential opportunities and challenges in a rapidly evolving market.

Generation planning usually adopts a long-term perspective (i.e., 20+ years), encompassing comprehensive econometric forecasts of hourly system loads. It evaluates technical alternatives and considers operational, economic, and environmental goals. In contrast, distribution planning tends to have a shorter timeframe, typically 3 to 5 years. It employs load forecasts that generally focus on peak loads at feeder or substation level, often choosing between a short list of technical options. Its planning objectives are usually straightforward, mainly addressing load growth, reliability, regulatory compliance, and cost. Transmission planning sits in between these two. It has a medium-term planning window of generally 5 to 10 years. Its forecasts are typically based on substation-level peak load or generation projections. It evaluates multiple technical and location options and focuses on goals specific to the transmission's operational, economic, and environmental considerations.

Historically, due to consistent load growth, economies of scale in generation plants, and the one way flow of power from the generators to the end user, these traditional planning techniques served the industry and its customers well, even with limited inter-departmental coordination. Any suboptimal planning decisions were often mitigated by adjusting the schedule (either speeding up or postponing) the next planned incremental increase to the R, T or D capacity.

Traditional planning approaches and tools employed by utilities need to be equipped to tackle the complexities arising from changing resources and unique customer load features. The industry grapples with growing uncertainties in technology pricing and capabilities, fluctuating loads due to the rise of distributed solar and electrification, evolving policy and rate structures, fuel cost variations, and several other challenges.

Every planning sector must recognize and adeptly manage uncertainties by integrating scenario-based and probabilistic analyses into their planning strategies. To accommodate the added layers of planning resulting from these approaches, utilities must pivot towards more streamlined and agile methods. The pace at which planning requirements evolve means utilities can't just update their grid plans biennially or triennially. Even yearly updates might become obsolete before they're finalized owing to regulatory shifts, market dynamics, or unforeseen outcomes from another planning domain [1] [2] [3].

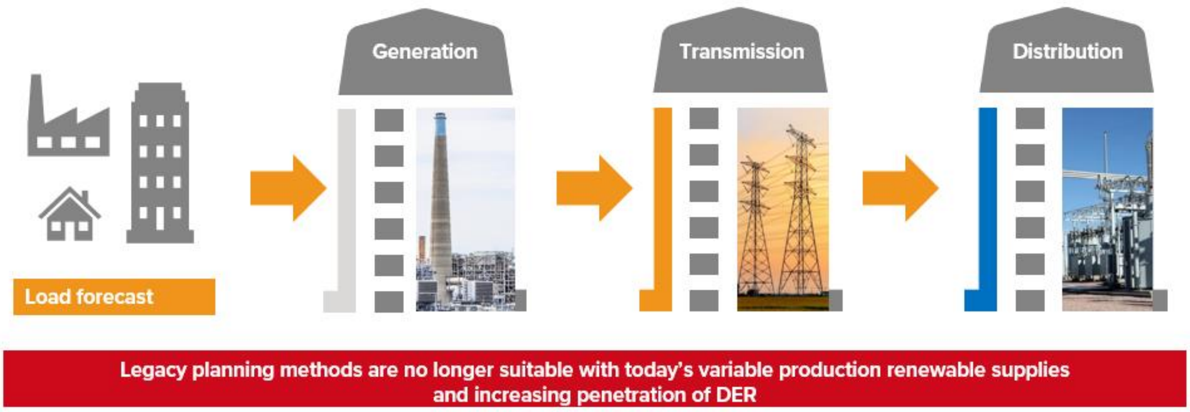

Figure 1: Legacy Structure of RTD planning processes

2. Coordinated RTD Planning

The electric utility sector stands at the crossroads of infrastructure planning, especially as both economies and individual lives grow more reliant on consistent electrical services. The repercussions of climate change, manifested in magnitude and frequency of extreme weather events like hurricanes, droughts, flooding and heatwaves, place enormous strain on electric grids. Public policies aiming at grid decarbonization, enhanced resilience, and the integration of advanced technology, while keeping consumer rates in check, have prompted utilities and regions to introduce a myriad of potentially conflicting or unfeasible policies and plans. Adding to the intricate landscape, each element ushers in a gamut of planning challenges and rising uncertainties that traditional power generation, grids, and planning strategies struggle to address [2].

Utilities strive to harmonize public policy goals with their strategic aims, crafting programs and initiatives that undergo close examination by regulators, resource developers, and various stakeholders. Pursuing carbon-neutral, resilient grids merges the traditionally distinct realms of GTD planning and analysis. In short, policy and strategic goals have catalyzed a merger of planning domains.

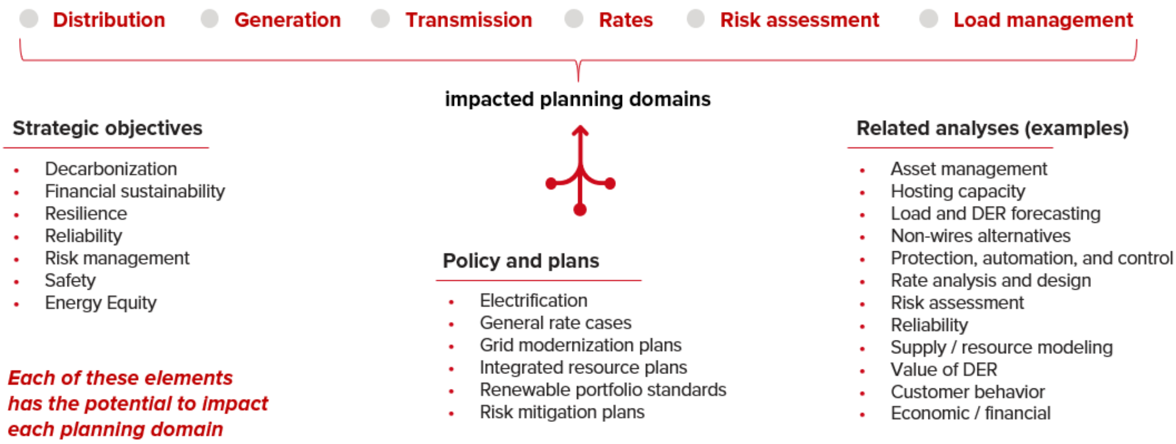

Figure 2: Policy and Strategic Objectives are driving Planning Convergence

The increasing integration of grid planning strategies and analytical methods underscore the growing interdependence of the traditionally compartmentalized RTD planning activities. This interdependence becomes even more evident as renewable resources are introduced at intensified levels and serve as non-wires solutions for grid necessities. An aligned and coordinated evaluation of the worth and effects of renewable resources across different planning domains is vital to ensure their efficient rollout without compromising grid stability and functioning.

A close assessment of current approaches has found that each planning domain shares common steps, including data input, forecasting, needs assessment, solution development, investment analysis, and prioritization. In addition, much of the input data accumulation and forecasting are performed independently within or for each planning domain. The Coordinated RTD Planning methodology is structured around these common planning steps that are applied within each domain. To these common elements that we find under different names in almost every utility planning department, we integrate the coordination elements, of a common, shared source of data inputs and forecasts, exchange of results across domains and common uncertainty analyses methods applied within each domain.

These common process elements are then integrated into a continuous and coordinated planning cycle for which each planning domain draws upon the latest input data, forecasts, and results from other domains [1].

Figure 3 presents the overall process structured on planning steps across RT&D and DER planning domain via convergence of data, tools and methods.

3. Components of a Coordinated RTD Planning

The growing complexities and uncertainties of utility planning requires a new planning methodology that enables the identification of optimal solutions, regardless of where they lay, ultimately bridging the traditional boundaries of the transmission and distribution planning domains.

All planning domains share common planning steps.

1. **Develop** shared forecasts and planning scenarios as an initial step
2. **Define and assess** the needs of the system and of potential mitigation options
3. **Assess and prioritize** potential mitigation options
4. **Address uncertainty, resilience** and **decarbonization** (future proof solutions)

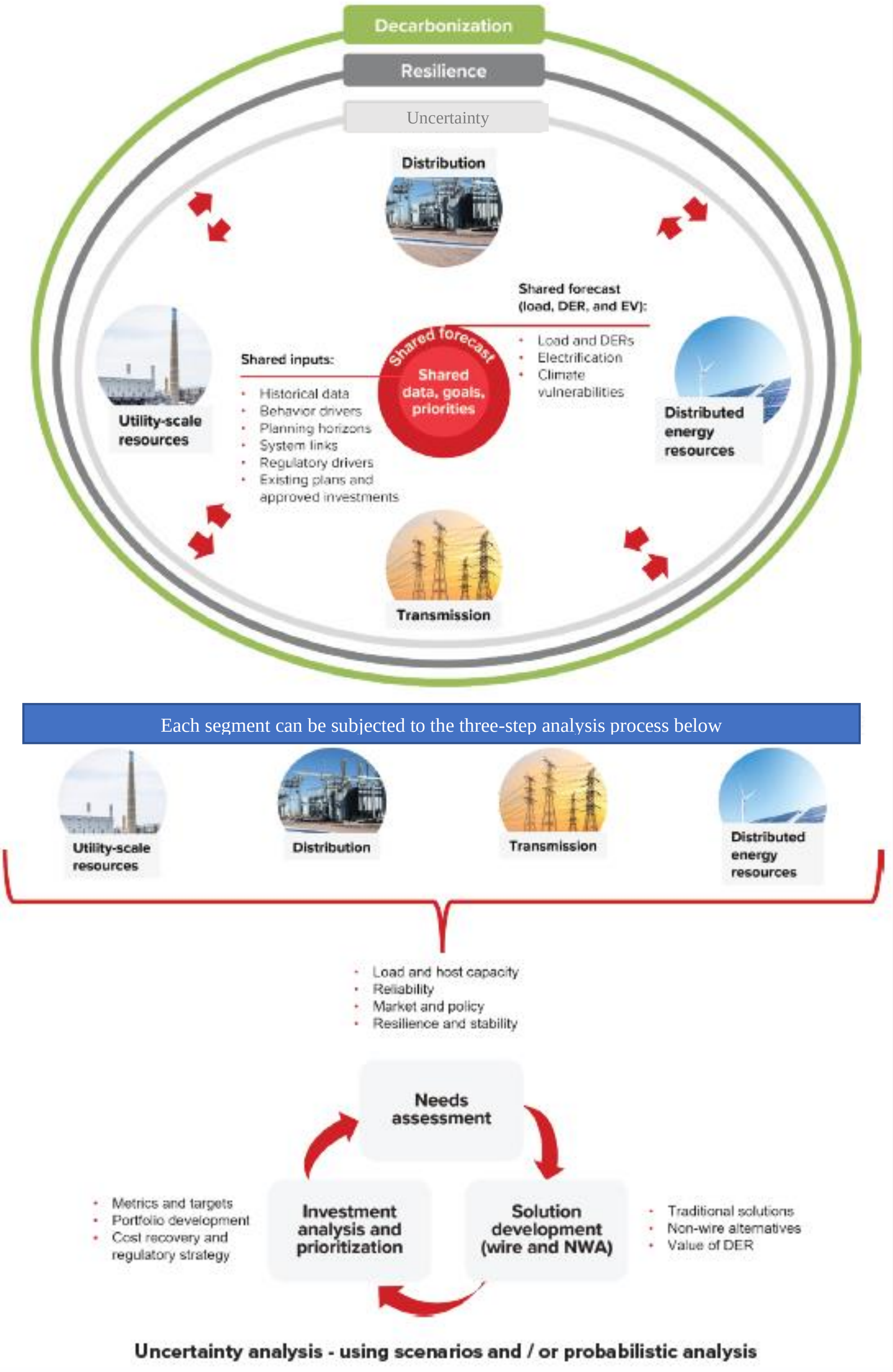

Figure 3: Commonality and Themes across all Planning Domains and Coordinated RTD Planning framework.

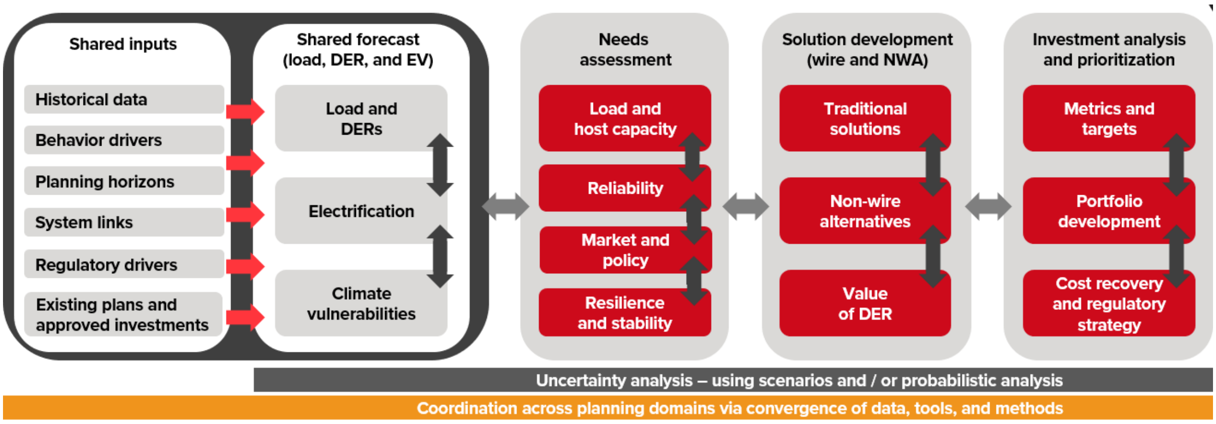

Figure 4: Components of a Coordinated RTD Planning Process

a. Develop Shared Forecasts and Planning Scenarios

Shared forecasts form the foundational step in the Coordinate RTD Planning© process. This stage involves merging multiple data sets from the generation, transmission, distribution and distributed resources sectors to create common forecasts for load, DERs, electrification, climate vulnerabilities and other planning inputs.

These different forecasts and can then be combined to create plausible scenarios deserving of further exploration. Given the unpredictability of future conditions, an integral part of a Coordinated RTD Planning approach is to analyze various scenarios. Each scenario is based on cohesive set of reasonable projections of the future conditions of exogenous characteristics that could materially impact planning decisions (e.g., growth of DER, policy changes, technology costs, etc.). Insights obtained from analyzing grid requirements across a range of possible scenarios and their respective solutions guide planners to pinpoint the most efficient, low-risk solution for a region, considering the uncertainties in the future conditions under which the solution will need to operate.

b. Define and assess the needs of the system and identify potential mitigation options

The goal of Coordinated RTD Planning is to identify the optimum portfolio of solutions for the collective needs of the system, assessing both needs and solution options in each of the planning domains. Both the system needs and potential mitigation options are dependent on the characteristics of the scenarios defined. Generally, the potential solutions will vary across the futures conditions defined by each scenario.

During this stage, the focus is to identify potential mitigation options to address the combined RTD needs driven by each scenario. The mitigation options might be operational (like load transfers), traditional infrastructure changes (such as the addition of generation or substation transformation), or DER-based solutions (like demand management programs). Planners should strive to identify mitigation options that can serve to address the different needs of multiple RTD planning domains with a single solution. An example of this is a potential mitigation option like virtual power plant (VPP) flexible demand management program that uses customer owned distributed storage to either charge or discharge the storage capacity at the discretion of the utility. These mitigation solutions that solve multiple needs can at times seem like a panacea, but would not be fully appreciated or possible even considered without the wider perspective gained with implementation of Coordinated RTD Planning. If there are sufficient subscribers to the VPP connected to the same bus in a substation, these programs can serve to:

- Increase distributed solar PV (DPV) hosting capacity on all feeders connected to the bus
- Avoid or reduce potential upgrades to the feeders connected to the bus to enable greater amounts of DPV
- Avoid or reduce potential transformation upgrades to service transformers on the feeders and to the substation transformation to accommodate increased peak load
- Avoid or reduce potential transmission line upgrades to accommodate increase peak loads
- Avoid or reduce potential interruption of utility scale renewables.
- Provide an emergency resource to address system events where the VPP discharge or charge could mitigation an emergency event on the system.

c. Assess and prioritize potential mitigation options including resilience and decarbonization performance

During this phase, mitigation options are evaluated to identify the preferred set of solutions that can best address the collective RTD needs for each scenario. The assessment and prioritization of solution options are based on the financial and performance objectives and their associated metrics defined by the company to assess investment options. The performance metrics should ideally include objectives and metrics to assess the resilience and decarbonization performance of mitigation options. The process of selecting the best set of mitigation options can become iterative as the planners find that adjustments to the mitigation options originally identify can provide improved performance results. Generally, each scenario will result in a different portfolio of mitigation solutions (i.e., Scenario-Specific Portfolio. The analysis will typically result in common elements of potential mitigation solutions across the different portfolios of mitigation solutions for each scenario.

d. Address uncertainty (Future Proofing Solutions)

This stage of the process begins after the Scenario-Specific Portfolios have been identified. The purpose of this stage is to assess the flexibility of the Scenario-Specific Portfolios to perform well across the range of future conditions defined by scenarios. This stage assists in identify the strengths, weaknesses and gaps for each Scenario-Specific Portfolios. During The preferred portfolio of solutions is generally the one that provides a balance of cost efficiency and flexibility. To arrive at a final recommended portfolio of solutions, the planner may need to adjust the elements of a Scenario-Specific Portfolio to expand its flexibility to address a wider range of future conditions.

4. Example 1 of Outcomes from Coordinated RTD Planning

The problem involved a 60-mile 12kV feeder receiving >10 MW of load interconnection requests. The underlying 35kV sub-transmission system is capacity constrained. The primary challenges include identifying how much new load can be added without any feeder upgrades or new substations. Additionally, quantifying the amount of storage that would be needed along with associated costs for incremental levels of load interconnection.

Initial analysis identified that up to 4.5 MW of new loads can be added without additional feeder or transmission upgrades. Additional load would create thermal overloads in the underlying system.

Using Integrated T&D models, the analysis found that distribution connected BESS of 10.5 MW/58MWh and 17 MW PV were ideal candidates for consideration. At the transmission level, 6.6 MW/55 MWh batteries were found to be economically infeasible.

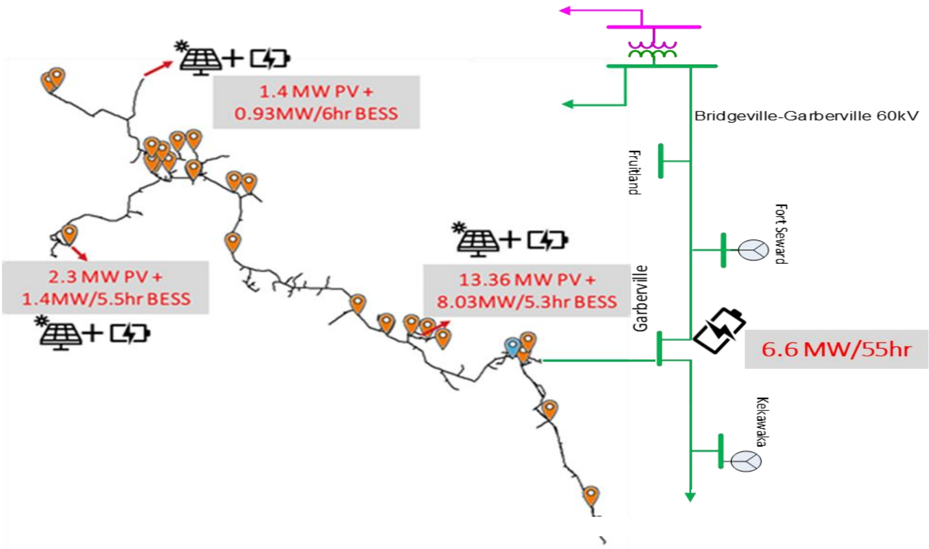

Figure 5 : Study Area for Integrated Planning with solutions

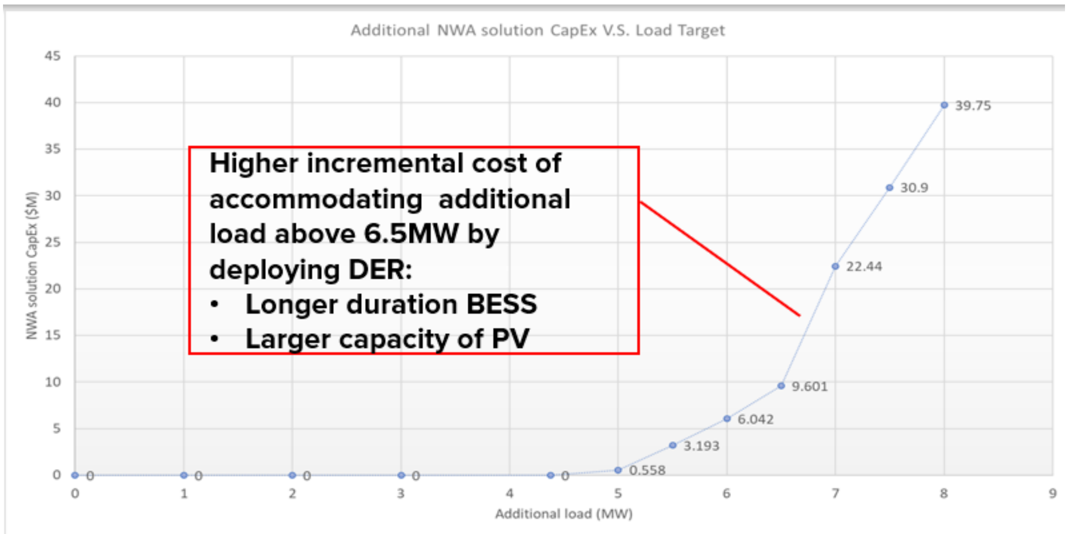

Figure 6: Cost of Incremental Non Wire solutions vs Load growth

5. Example 2 of Outcomes from Coordinated RTD Planning process

Combined Transmission and Distribution power flow studies were performed for a system in Central California. The analysis indicated that across multiple scenarios there were thermal violations identified on sub-transmission facilities. The scenarios reflected the impacts of varying local generation, load growth and DERs.

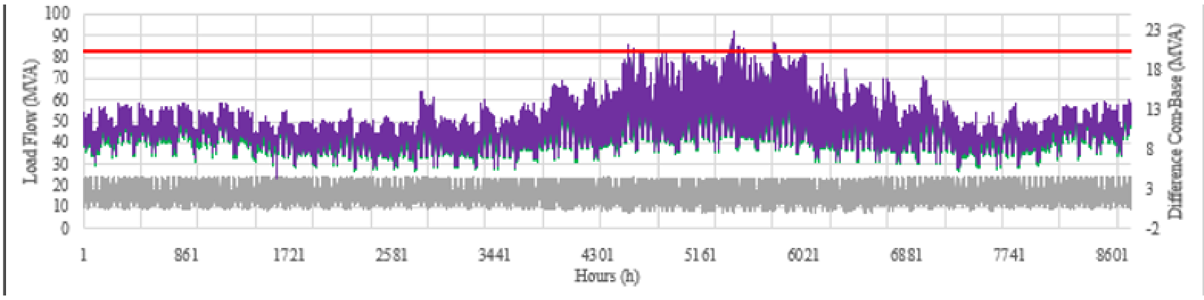

Figure 7: 8760 Power flows on overloaded facility

		2027	2028	2029	2030	2031
Scenario A	Magnitude (%)	1.03	5.81	7.11	8.83	10.68
	Frequency	2	7	7	9	10
	Duration	2	4	5	6	6
Scenario B	Magnitude (%)	0.48	5.20	6.76	8.43	10.84
	Frequency	1	6	8	9	11
	Duration	3	5	5	6	6

A combination of solutions was evaluated to address the needs – ranging from traditional investments (Reconductor, New line) and Non wire alternatives (Sub-transmission and Distribution substation BESS and Demand Response).

Scope	Solution	Cost ($M)
Reconductor	Segment 1	12.5
Reconductor	Segment 2	10.6
Reconductor	Segment 3	9.8
New line	From Substation A to B	20

	At Location A	At Location B	At Location C
Size (MW/MWh) BESS	10.62/24.89	12.47/32.200	3.28/6.74
Demand Response (MW)	6.44	7.94	1.06
Cost ($)	16.09M	19.61M	4.64M

The analysis identified that a combination of Demand Response and BESS at Location C on distribution substation "C", addressed overloads on the sub-transmission network – while enhancing the reliability and resilience of the distribution system.

6. Conclusion

This paper outlines the advantages and requirements of Coordinated RTD Planning . For effective planning and prioritizing investments, it is crucial to define overall objectives and metrics of success to guide a unified planning process. At the heart of this coordinated process is a value framework, which assesses how solutions impact the agreed-upon success metrics guiding the plan. Once the potential solutions' values are discerned, a coordinated optimization analysis across the RTD planning domains help pinpoint investment portfolios. The culmination of this process is the identification of an optimum solution portfolio that addresses the combined RTD needs. Ultimately the implementation of the Coordinated RTD Planning should include the initiation of a continuous planning culture incorporating a mechanism to gauge ongoing progress and re-evaluation of planning objectives and metrics as insights emerge.

BIBLIOGRAPHY

[1] Quanta Technology, “Coordinated Resource Transmission and Distribution Planning”, Advanced Grid Planning, 2021.

[2] D. Elizondo, “Coordinated GT&D Planning and Investment Prioritization – An Introduction to our Industry Needs”, IEEE PES General Meeting, July 2021.

[3] NARUC, “ AMBER COHORT ROADMAP”, NARUC-NASEO TASK FORCE ON COMPREHENSIVE ELECTRIC PLANNING, February 2021