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Innovative Solutions and Approaches Taken by North American Utilities in Leveraging Benefits of DERs and Grid Modernization Technologies

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SUMMARY

Advent of Distributed Energy Resources (DER) and deployment of emerging technologies as parts of grid modernization programs have fundamentally changed distribution systems nature and consequently have imposed the need for introducing new and advanced approaches in distribution planning. The new approaches are considered new tools in the planners' toolboxes based on innovative solutions for capacity and/or reliability enhancement, beyond traditional methods most commonly applied in majority of capital investment projects. The advanced solutions are typically discussed in the context of Non-Wires Alternatives (NWA) with the most familiar examples of all being growing recent interest in energy storage system (ESS) applications and microgrid technologies for grid support, reliability enhancement and resilience improvements.

The key objective of this paper is to highlight the emerging industry trends and strategies in this context based on examples from several major North American distribution utilities. A comprehensive list of NWA solutions that can be used by next generation of distribution planners to enhance system performance and ensure affordable and reliable alternatives is provided. Examples of programs and pilot projects are used to describe the spectrum of solutions and how they are developed, assessed and incorporated in various stages of planning, solution evaluation and implementation.

Furthermore, the paper discusses major challenges and knowledge gained in implementing and utilizing NWA approaches versus conventional wire-based solutions. The examples from current and past projects address the fact that although NWA based projects may reflect a higher level of complexity, they typically offer wider range of applications and benefits.

KEYWORDS

Distributed Energy Resource (DER), Distributed Generation (DG), Non-Wires Alternatives (NWA), Grid Modernization, Demand Response, Energy Efficiency, Energy Storage System (ESS).

1 Introduction

Two recent and rapidly growing trends have changed the shape of electric utility industry, a) growing penetration of renewable and distributed energy resources (DER), driven by decarbonization of the electricity sector [1], and b) greater focus on digitization and further automation of the grid control and operation schemes to achieve higher level of visibility and self-healing [2]. Those trends have initiated the industry and regulators' discussions around identifying and utilizing new services outside of traditional utility planning and project execution methods. Traditional methods primarily promote direct investment in electric utility assets and infrastructure by adding/replacing wires, poles, switchgears and expanding distribution/transmission right of ways for addressing capital grid reliability improvement and system upgrade focused projects.

In contrast to traditional wire-based solutions, Non-Wires Alternatives (NWA) are solutions that are formulated on the promises of introducing optimized ways of using existing infrastructure and defer the upgrade. Building on the two trends recognized earlier, various solutions that incorporate use of locally deployed DERs along with load control schemes and energy efficiency improvement methods can be collectively implemented to address seasonal overload condition, feeder congestion and power quality concerns, or to introduce alternative ways of supplying customers during natural or maintenance related outage events. The solution enablers (assets and resources) may be part of customers' premises, introducing a behind the meter (BTM) application, or deployed/owned by utilities (typically their non-regulated business units) and/or developers in front of meters (FTM). In either way, the approach advocates greater engagement of customers and private sector in electric utility industry.

While conventional wire-based solutions tend to sound simpler in nature and last longer in appearance, they may not necessarily ensure that power is efficiently delivered or that capital investments are effectively allocated. Furthermore, they may not address the need for greater reliability and resilience in modern power systems.

In the following sections of the paper, different types of NWA solutions are described, and examples of on-going or completed projects are discussed; a utility microgrid for reliability and grid support, a MW size energy storage system for capacity deferral and renewable generation shifting under high solar PV penetration, and an enterprise based Distributed Energy Resource Management System (DERMS) platform for increasing using of advanced inverter functionalities and creating a field area communications to manage electric vehicles charging systems and customer engagement in the program.

These examples of grid modernization programs and pilot projects introduce significant value proposition to distribution utilities through deploying advanced automation technologies, integrating DERs, and increasing use of NWA in advanced planning approaches. They also incorporate means of further customer engagement, community outreach and bring in private investments. Furthermore, the paper describes an implementation and evaluation framework for NWA solutions and emphasizes on the importance of performance tracking and potentially program correction during lifetime of the project.

Finally, a successful NWA based on Battery Energy Storage solution is described in more details to discuss the opportunities and challenges associated with implementation process for utilities and lessons learned to adjust utility practices for future implementation.

2 NWA versus Conventional Wire-based Solutions

NWA refer to the localized applications of DERs, distribution control and automation schemes or customer sited energy management and efficiency programs to provide services such as load management, reliability and resilience services that are traditionally provided by electric utilities through distribution expansion projects [3]. NWA are evaluated in contrast to wire based solutions such as re-conductoring part of a distribution feeder or installing a new transformer or a brand-new substation to expand number of feeders in an area to resolve reliability and thermal overload concerns. While the conventional wire-based solutions accommodate the demand increase or aging equipment by replacing or upgrading of distribution assets and further capital investment in grid infrastructure expansions, NWA normally seeks out third-party (developers) capacity and reliability services. In addition, NWA also incorporates innovative approaches to incentivize customers participation in various energy efficiency and demand management programs. The NWA focus is to enhance system performance, improve resiliency and efficiency, and deliver cost savings to ratepayers by leveraging functionalities of smarter and more flexible grid-edge technologies.

2.1 NWA challenges

Despite the promising benefits of the NWA solutions, utilities are more inclined to invest in traditional solutions. The reluctancy of pursuing the NWA is due to several barriers; mainly the regulatory environment and utilities operational space limitations. As the advent of the NWA solutions is recent, no comprehensive mechanism is established yet for cost recovery, procurement, and funding of the NWA projects. Hence, the utilities are maintaining their conventional approach of capital expenditure investments which conveniently guarantees the regulator's approval on the rate-based recovery mechanism. In addition, on the operational side, there are not enough expertise and capabilities around the NWA solutions to effectively plan, procure and implement these solutions. As a result, the NWA solution implementation is an unusual practice for utilities which takes extra effort at different stages of planning, integration and operation & maintenance. Unfortunately, the lack of established procedures often leaves utilities with a non-operational system which does not serve the purposes originally designed for.

Figure 1 shows an example of traditional distribution planning approach to accommodate two issues: a) load growth and b) reliability of serving customer with one feeder. Initially, all customers in the area were served by one radial feeder. As the load growth was forecasted to approach 9 MW, the utility planner had proposed adding a second feeder and upgrading the substation transformer (Step 1). However, it should be noted that load growth is a best forecast for certain months and may change due to several factors outside of utility environment. The planning solution for the second issue associated with reliability concern due to serving large number of customers in the area was to further expand the substation by adding a new transformer to split the load (as shown in Step 2 of Figure 1). This expansion eliminates a single point of failure, also enables access to multiple feeders to create feeder ties for transferring customer from one source to another in case of feeder faults.

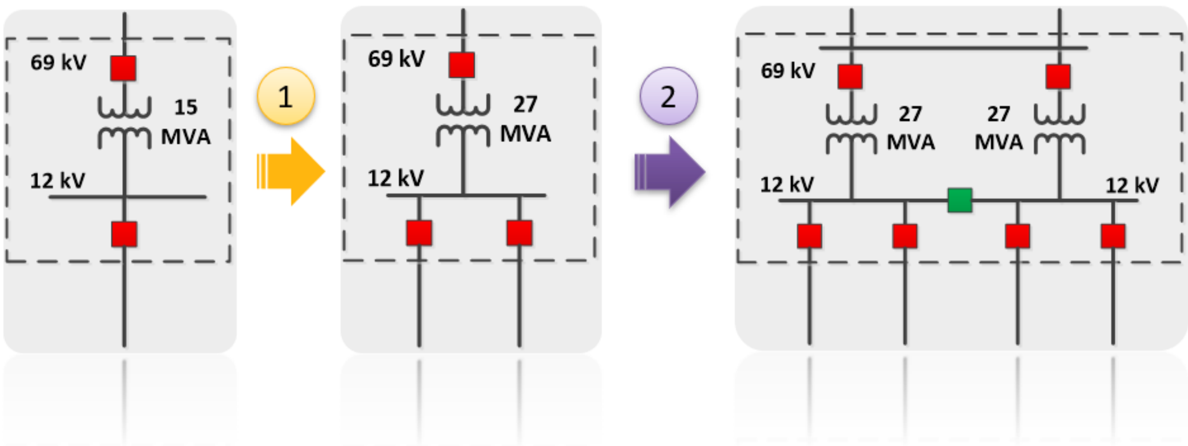

Figure 1 - Example of distribution expansion projects: substation upgrade

As an alternative approach, Figure 2 shows a possible NWA based planning for managing demand growth through a combination of DER and distributed controls locally incorporated at feeder, community and customer levels. The solar plus energy storage systems will be able to serve loads during a few hours of peak demand per year to avoid or delay any expansion projects.

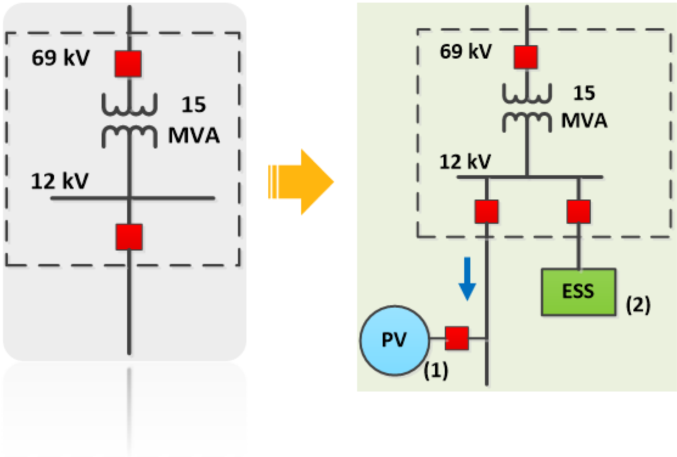

Figure 2 - NWA based on using DER applications for distribution upgrade deferral and reliability service

Because NWA based programs include some components of utilizing clean energy resources, such programs introduce sustainability through reducing carbon emission content and by supporting utilities in meeting their clean energy mandates and environmental targets.

2.2 Examples of NWA technologies

The capacity service in a general term covers methods of managing load growth and responding to high seasonal demand. The potential NWA based planning for capacity service can include a wide range of solutions applied individually or in combination such as distributed generation and energy storage systems along with distribution automation schemes, energy efficiency and demand response programs. On the other hand, the NWA solutions for addressing reliability enhancement services requires hybrid approaches involving distribution automation and multiple DERs locally controlled in the context of microgrid or community energy systems to provide alternative sources for serving customers. Selected technologies commonly considered as part of NWA services are given below.

2.2.1 Energy Storage Systems (ESS)

Energy storage systems are among the most common technologies applied in various NWA projects which can address a wide range of reliability and capacity enhancement services. Utilities infrastructure is always prone to reaching their limits due to overall demand growth, aging and increasing penetration of DERs. Conventional infrastructure upgrade as part of the utility planning is the only feasible solution in many cases; especially over long-term planning horizon. For instance, in an economically growing area with rapid load growth, the addition of a feeder or substation is deemed inevitable. However, when the overloading issue is constrained to parts of the system or a certain timeframe during peak seasonal demand, deploying ESS at a substation or along a feeder can be more efficient, more economic and offering faster in-service time. In this case, ESS is utilized for load management by storing excess energy during low-demand hours and utilizing it during high-demand hour, hence shifting demand. In this respect and depending on the locational aspects of capacity requirement services, an ESS can be installed on the utility side (FTM approach) or on the customer side (BTM), or a combination of both.

The Arizona Public Services Punkin Center Battery ESS project is an example of an NWA with a successful and reliable peak shaving service [4]. The project enabled deferring installation of 20 miles of lines for serving feeder loads during peak-time. The ESS based NWA option was evaluated as the least-cost option to serve load growth in the rural, remote community of Punkin Center, AZ. In addition to feeder-level capacity upgrade deferral, the ESS can provide other services such as energy and ancillary market participation, if required.

2.2.2 Microgrids

Microgrids are key NWA based reliability services. Microgrid is defined by IEEE 2030.7 [5] as a cluster of DER and loads that are operated in a controlled fashion and can operate in parallel or isolated from an area electric power system (Area EPS). As the technology evolves and the change in regulatory frameworks facilitate deployment and operation, utilities continue to implement pilot and production stage Microgrids using private sector investments [6]. The distinguishing feature of a microgrid versus other integrated distributed energy resources (DERs) is its ability to supply local customers within a defined electric boundary in dependent of the main grid in an island mode. Microgrids provide reliability/resiliency services during planned or unplanned outages in the system. Other secondary applications of Microgrids are load management, power quality enhancement for critical facilities and increasing renewable content for fuel saving and emission reduction.

One of the main challenges of Microgrid implementation specifically, and NWA decisions in general from the utility and regulator's perspective, is difficulty in quantifying the values of services which are the basis for financial evaluation and regulatory decision implementing the solutions. Either capacity or reliability services are very time and location sensitive. Trying to only determine the value of a service alone may not reflect the true nature of an NWA project. For instance, a microgrid may operate most of its effective life in normal (non-outage) timeframe connected to an Area EPS. However, during the grid connected mode of operation, a microgrid can deliver other grid supporting services and support utility operation locally that should be evaluated.

Hence, one common way of evaluating NWA project is to compare the cost against the traditional solution for a pre-determined life. Therefore, it is essential for a utility to develop evaluation framework as a systematic approach to investigate Microgrids as a reliability centric NWA in conjunction with other soft benefits.

As an example, the Illinois Commerce Commission (ICC) approved the Bronzeville Community Microgrid, a $25M project that demonstrates a shared utility multi-customer microgrid business model in the U.S [7]. Among other values, the ICC noted community learning benefits as a key factor included in the approval.

2.2.3 Distributed Energy Resources

Distributed Energy Resources (DERs) refers to various generation and energy storage technologies with primary sources that are non-bulk power sources [8]. Presence of DERs on distribution system introduces bi-directional power flow and may face the grid with additional challenges due to variability in resources. Apart from distributed ESS that was covered in an earlier section, distributed solar PV systems are the major technology deployed at small or large scales by residential/commercial customers (e.g. roof-top PV systems) or in utility scale as ground mount systems by developers. Wind energy is more common on transmission systems or may be found scattered around in small amount on distribution systems. There are other DER types such as run-of-river hydro, fuel cell and biomass that may be considered depending on the location and price. The local generation of electricity increases energy efficiency and enhances grid reliability and resiliency.

For DERs to be included in NWA services, they should be directly integrated into a utility control and operation system such as Distribution Management Systems (DMS) where integration is through SCADA, or they need to be part of a microgrid or a community energy system that is locally managed based on utility requests.

In addition to capacity services (which is the primary focus), generation type DER can also provide other grid supporting services such as voltage and reactive power management of the grid. Because majority of DERs use inverter-based resources (IBR) which are power electronic devices used for the power conversion and grid interconnection, the focus of DER standardization effort in recent years have been on enabling Smart Inverter Functions for grid support and ancillary services as added values, grouped and shown in Figure 3, [9]. Smart inverter functions ensure remote communications, monitoring and control of IBRs by utilities in a coordinated fashion with the rest of the grid.

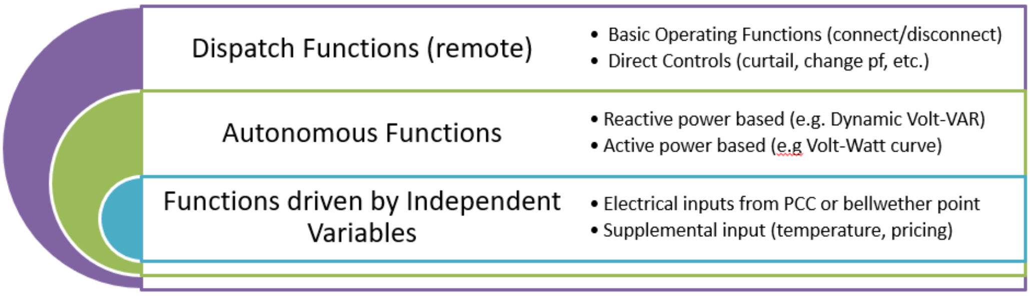

Figure 3 - Smart Inverter Functions enabling NWA

2.2.4 Demand Side Management and Energy Efficiency

Implementation of demand management and energy efficiency programs is a sign of moving from a traditional grid with passive loads on the customer side to a modernized grid where customers take an active role in defining their energy needs and exchange with the grid. The financial incentives and lower electricity bills are the main engagement approaches implemented by utilities and power industries.

As an NWA, Demand side management refers to the changes in the behavior and pattern of the electricity consumption and usage monitoring on the customer side to support the peak-demand periods or unforeseen events in response to time-based rates or incentive payments for lower electricity usage during high wholesale market prices. In demand response programs customers are encouraged to reduce or curtail their electricity consumption during the high demand hours or emergency occurrences. The most famous and successfully implemented demand response and energy efficiency-based NWA project is the Brooklyn Queens Demand Management ("BQDM") program [10]. BQDM uses primarily energy efficiency and customer-sited distributed generation in the form of combined heat and power, fuel cells, and rooftop solar PV systems to achieve more than 50 MWs of peak demand reduction. Additional value propositions and energy saving are also justified with incorporating coordinated voltage and reactive power optimization (VVO), and deployment of utility scale ESS. The total projected program cost for this NWA has been about $200 million, which in contrast, is significantly lower than cost of adding a substation and transmission feeders for achieving same level of 50 MW demand management, which was estimated more than $1 billion.

2.2.5 Advanced controls and distribution automation schemes

Advanced controls of distribution systems by utilizing automated switches and integrating smart inverter functions can increase the level of grid monitoring and self-healing. The integrated and automated controls through centralized DMS approaches or localized feeder automation schemes are key in implementing alternative approaches for alleviating the reliability concerns and deferring capital upgrade investments. Advanced DMS scheme can enable fast restoration and rearrangement of feeders' topologies to ensure continuity of supply to customers in a reliable way. By enabling smart inverters communications and controls to accept external commands and coordinate autonomous applications, utilities can incorporate inverters in the overall day-to-day power forecast and energy balancing (curtail or generate) when approaching feeder limits, or to manage reactive power and voltages to reduce demand.

A well-known NWA solution in this regard is ComEd DG rebate program [11]. To increase DER penetration and to utilize the benefits of smart inverters, ComEd is providing a rebate of $250 per kW of nameplate generating capacity to retail customers. The DG Rebate program motivation for ComEd are provisions for future DER penetration and lack of controllable grid-supporting infrastructure for use during deviations from normal operating voltage and frequency conditions. Through the DG Rebate program, ComEd looks to achieve higher DER (e.g. PV) penetration from nonresidential retail customers with existing infrastructure, by enabling the communications and controls. To qualify for the rebate, the DG installation must include a smart inverter with communication and control capabilities to accept external commands such that ComEd can utilize the inverters for reactive and real power support, voltage and frequency ride-through, ramp rate controls and other functions from the electric utility. The DG Rebate program was also strongly justified on the fact that it takes away investments from traditional infrastructure and instead funds NWA projects through Smart Inverters while also encouraging higher DER penetration, equipped with adverse impact mitigation approached, without the need to expand present infrastructure.

3 Implementation and Evaluation Approach

NWA covers a wide range of solutions on both sides of the meter with focus to shift the ownership to customers or developers in contrast to traditional approaches that were utility centric. The expectation is that, once the implementation and contracting aspects are streamlined, NWA automatically become natural parts of future transmission and distribution infrastructure investment planning and system expansion programs. However, an NWA solution may not be the best fit approach in a particular case as a substitute to the traditional capacity or reliability planning projects.

Figure 4 shows the three main steps that should be followed for 1) identifying all feasible solutions, 2) evaluating solutions, and 3) implementing, monitoring and verifying solution performance. Normally, utility planners and engineers are aware of the methods used for traditional projects. However, a deeper understanding of the available NWA technologies is required to ensure proper assessment of capabilities and fair valuation of benefits and services for various NWA approaches versus traditional solutions.

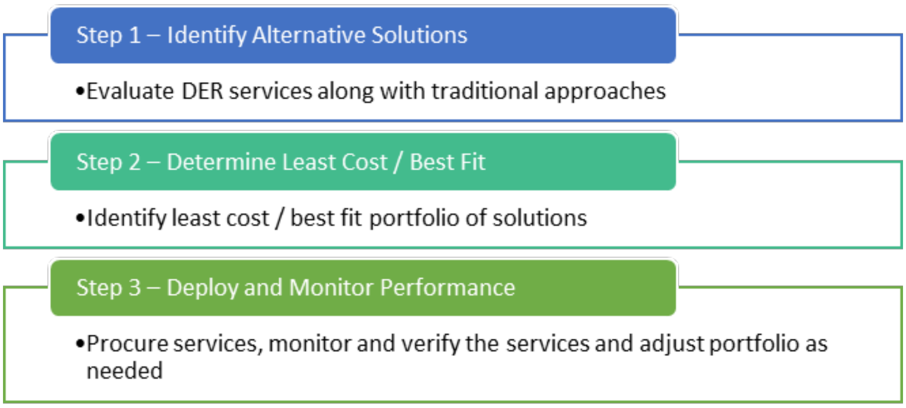

Figure 4 – Typical NWA solution identification and evaluation process

The NWA valuation for the step 2 of the process requires assessments of both the monetary values and soft benefits of the specialized services to determine the least-cost alternative solutions. Utilities normally have a well establish method for evaluating costs of traditional methods using cost of equipment, deployment and maintenance over the life of asset which is typically a minimum 30 years life expectancy for conventional approaches. However, an NWA solution may last shorter, but it can be deployed faster (much shorter ISD) and may deliver higher reliability, safety, and customer satisfaction in contrast. In addition, cost and benefit of an NWA approach may highly vary by location of service and type of the technologies. The locational DER Valuation approach described in [12, 13] has been effective to properly assign quantitative values to the NWA services.

A key step and challenge in the deployment and proper utilization of an NWA is the assessment of quality of services. Because NWA are based on emerging technologies, there may not be enough track record of performance, also there is no or limited national or international standards to be considered as reference and guide for engineering of the solution and to evaluate minimum requirements during project commissioning. Hence, the design specifications are normally agreed upon and they may widely vary from one utility to another one, since there is no common industry practice. As a result, thee is a growing concern with third party solutions may not be able to provide same level of reliability of service that is normally expected from utilities.

Investing time and resources during the initial phase of operation (early in-service time) is crucial to monitor, analyze and correct any performance deficit. In addition, for successful deployment of the project it is important to continue rigorous monitoring and tracking the service quality associated with the selected technology.

3.1 Case Study – An Energy Storage based Microgrid Solution for NWA

In this section a case study based on a project design and deployed by a north American utility is used to further clarify the approach shown in Figure 4. The project involves a rural town located in the middle of a natural forest and served by a very long radial distribution feeder about 50 miles. The community economy is centered around seasonal tourist attractions which during late winter and spring for 2-3 months can see sharp increase in load, while having very light loading in other months, about one fifth of the peak season. Community has been experiencing multiple outages for several time per year with durations in range of 40 to 85 minutes. This is mainly because rough trains along the right of way of the distribution line passing through forest typically causes delays with line inspection (patrolling of utility crew) before a tie-line can be permitted to close to switch the source to another feeder. Because the sustained outages were adversely impacting the town economy due to loss of business, the utility was mandated to implement a mitigation solution.

Figure 5 shows the two steps associated with identifying all possible solution (traditional and nontraditional) and evaluating the solutions to arrive at a least cost / best fit solution. The final evaluation was narrowed down in three solutions: two traditional and one NWA based. Traditional solution 1 follows the conventional wire and pole solution based on adding a new feeder as an alternative supply path for the community. This approach has the highest cost among all three. Solution 2 has the least cost and utility personnel are very comfortable with this approach; however, it was considered as the least fit method, since involves increase in emission level of a protected community and natural forest. The NWA solution has very acceptable cost compare to the other viable solution and offers the best fit, since it is based on using battery ESS in a microgrid approach.

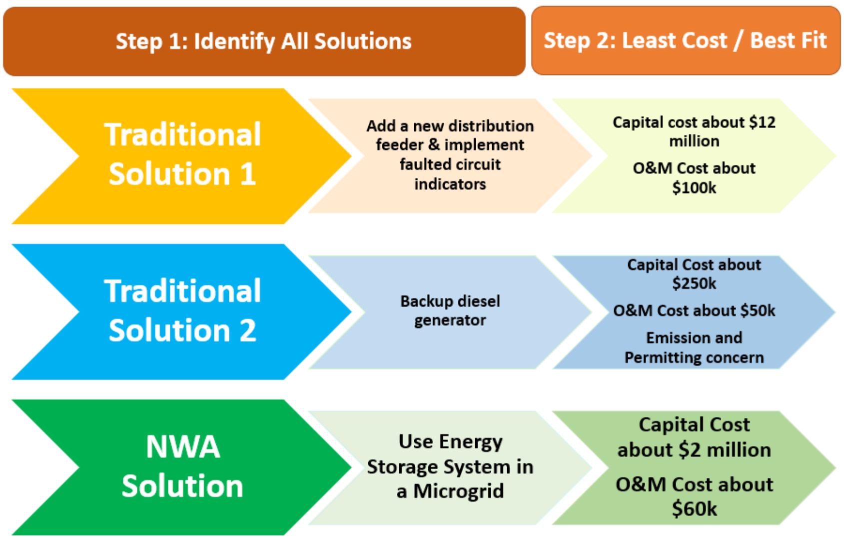

Figure 5 - NWA case study: microgrid justification

A challenge with the microgrid solution was the lack of enough experience and technological knowledge about deployment of such systems. However, the utility decided to embark on the solution by engaging an experienced company to serve as owner's engineering to support using this opportunity to gain more knowledge and experience throughout the project stages, including: detailed analysis and design of the solution, engineering and technology evaluation - finally, successful implementation and commissioning. The project design incorporated provisions for extensive level of monitoring, reporting and data analytics to facilitate performance evaluation through defining several key performance indices (KPI); some of which are described in the following section.

4 Performance-based Verification and Correction

Throughout the operational stage of an NWA solution, an elaborate and ongoing performance-based verification and correction procedure is required to ensure the successful implementation of the project/program. This procedure defines the measures for evaluation of the NWA performance and the approach to track the technical viability of the NWA solution in meeting the grid needs and the cost-effectiveness of the solution.

Identification of project KPIs should mainly happen during the procurement stages of the technology as part of technology specification, RFP preparation and technology evaluation. This is to ensure the most viable technology is selected. Once the relevant KPIs are defined, they should be incorporated into the contract terms and performance guarantees as well as acceptance test procedures. Usually a third-party acceptance testing of technology is performed to guarantee a comprehensive and independent evaluation of the solution provider. This critical stage help identify and correct any solution issues in comparison to the initial design and expected level of services. For instance, during the acceptance testing of an ESS, several KPIs will be used to ensure the technology can meet technical requirements of the project; such as: usable capacity, maximum active/reactive power delivery, round-trip efficiency, and power quality indices associated with reliability or capacity projects.

Once commissioned, operation specific KPIs should be monitored and tracked to assess the performance of the delivered services and readiness during project lifetime. For the example of an ESS base NWA, the operation KPIs may include annual throughput, battery degradation, partial/full number of cycle charges, availability and utilization factor, or any other application specific parameters.

For performance-based rate basing (PBR) of NWA projects, tracking and reporting of defined measures is done based on measurement and verification (M&V) protocols developed by the utility and/or independent third-party consultant engagement. The common KPI in this case is the success rate of providing services to evaluate if it is well-aligned with the target of the program. Another KPI for evaluation of the customer-sided services (BTM) such as demand side management and smart inverters in DER grid support is the customer participation rate. For instance, an NWA program may require showing customers participating in a project were able to reduce load requirements below 80% maximum summer peak based on the average of last 2 years [14]. If the project does not achieve its goal based on M&V process, corrective action will be needed.

Different risk mitigation strategies can be implemented to increase the success rates of NWA projects. For instance, the risk of technology operation not meeting the planned needs of the grid can be mitigated by deploying technologies in stages and measuring progress during deployment to identify issues and enable course-correction. In Demand Response programs, the expected customer participation level can be achieved by setting penalties for non-participation and including compulsory direct control elements in the technology deployment to mitigate the risk of non-participation [15].

Table 1 shows examples of KPIs utilized normally in industry to track the performance of NWA solution.

Table 1 - Sample KPIs for Performance Evaluation of NWA Solutions

NWA Technology	Sample KPIs
Energy Storage Systems	Success rate (for targeted applications such as peak shaving, demand management) State of Health (SOH) Energy efficiency (%) Number of full and partial cycles Battery degradation

NWA Technology	Sample KPIs
	Cumulative charge/discharge (kWh) Annual throughput (%) Mean Time to Repair Mean Down Time
Microgrids	Success rate (for targeted applications such as islanding, load serving, peak shaving, etc.) Carbon emission reduction SAIFI reduction SAIDI reduction
Distributed Energy Resource	Production ratio Plant availability Maximum power rating Mean Time to Repair
Demand Response and Energy Efficiency	Customer participation percentage Success rate
Advanced controls and distribution automation schemes	Success rate (for targeted applications such as grid-connected support, energy management, etc.) Energy loss reduction and efficiency improvement

5 Survey of NWA Projects

This section provides a summary of selected NWA projects in North America with successful performance and outcome. Table 2 summarizes key information about four selected NWA projects. Additional information about each project and implementation approach.

Table 2 - NWA Case Studies across North America

No.	Example NWA Projects	State/Utility	Goals	NWA Technology
1	Brooklyn Queens Demand Management Program	Consolidated Edison	Load Reduction Maintain reliability	Demand Response Energy efficiency Energy storage system
2	ComEd Energy Infrastructure Modernization Act	ComEd	Outage management Reliability	Advanced Control: Distribution Automation Smart Meters
3	Power Your Drive	San Diego Gas and Electric (SDG&E)	Shift load curves during high load Increase penetration of DERs	Demand Response: Electrical vehicles Rate design for charging EVs
4	Distributed Generation Rebate Program	ComEd	Provisions for future DER penetration Lack of controllable grid-supporting infrastructure	Advanced Control (Distribution automation) Distribution generation

Project 1: Brooklyn Queen Demand Management Program

The prime objective and motivation for Con Edison to submit a petition for BQDM program [16] is the rising electricity demand in Brooklyn and Queens would lead to capacity constraints on a portion of its grid as early as 2018. Con Edison projected 69 MW of demand growth above existing distribution capacities that could overload existing infrastructure and lead to reliability concerns.
The proposed solutions are a combination of the customer-side and utility-side solutions.

Customer-side solutions:

- Commercial direct install
- Multi-family, residential and commercial energy efficiency programs
- CHP solutions

- Solar photovoltaics units

Utility-side solutions:

- BESS installations of 4.3 MW, 4 MW and 300 kW (customer site)
- Conservation voltage optimization schemes on the 27kV system and 4kV overhead system to provide load reduction

Opportunity:

- Community benefit from energy conservation and electricity bill savings
- Deferral of the Glendale substation project from 2014 to 2026 or beyond

Project 2: ComEd Energy Infrastructure Modernization Act

The prime objective and motivation for ComEd to file an application for the EIMA program [17] is in response to the Illinois General Assembly's goals and objectives which include:

- Regulatory reform
- Reliability performance metrics
- Infrastructure modernization
- Smart Grid investment

ComEd project includes advanced controls as well as traditional solutions.

- Distribution automation:
    - installed 6300 smart switches to automatically isolate and re-route power around problem areas, using distributed FLISR scheme.
    - installed more than 4 million smart meters by end of 2018.
- Substation micro-processor relay upgrades
- Associated cyber-secure data communication network

Opportunity:

- From 2012 - 2017, ComEd avoided more than 7.6 million customer interruptions with smart switches.
- ComEd achieved an overall reliability rate of 99.97% and 60% reduction in outage duration
- Average residential monthly usage was 608 kWh in 2018, down from 694 kWh in 2008

Project 3: SDG&E Power Your Drive

The SDG&E Power Your Drive program [18] enables Electric Vehicle (EV) adoption in apartments and workplaces, with a focus on disadvantaged communities. SDG&E facilitates an EV site installation by reviewing the customer's application for feasibility metrics such as nearby transformer capacity, distance between transformer and new service point and site conditions related to ease of construction. The program also offers an innovative hourly charging rate mechanism which requires customers to submit a load management plan which includes customizations like shutting off charging during high priced intervals and only allowing charging during certain times.

Opportunity:

- CPUC approves the program as a pilot in January 2016.
- As of July 31st, 2019, 253 sites with 3,015 charging ports have been energized
- 39% of sites are at multi-family buildings and 35% of sites are at disadvantaged communities

Project 4: DG Rebate Program

The DG Rebate program [19] motivation for ComEd are provisions for future DER penetration and Lack of controllable grid-supporting infrastructure for use during deviations from normal operating voltage and frequency conditions. Through the DG Rebate program, ComEd looks to achieve higher DER (e.g. PV) penetration from nonresidential retail customers with existing infrastructure, by enabling the communications and controls. To qualify for the rebate, the DG installation must include a smart inverter with communication and control capabilities to accept external commands such that

ComEd can utilize the inverters for reactive and real power support, voltage and frequency ride-through, ramp rate controls and other functions from the electric utility. The DG Rebate program is also strongly justified since it takes away investments from traditional infrastructure and instead funds NWA projects such as Smart Inverters which also enables a higher DER penetration, without the need to spend on infrastructure

Opportunity:

- Illinois Commerce Commission (ICC) approves the DG rebate program effective December 10th, 2018
- ComEd projects to issue $30,271,000 in rebates in 2019 (121,084kW of installed capacity)

6 Summary and Conclusion

In this paper, different type of technologies and applications have been discussed to illustrate the path utilities have taken in terms of planning, evaluating and implementing NWA projects. The paper describes industry trends in grid modernization programs and the upcoming changes to advanced distribution planning. It is expected that NWA will become key components of planning portfolio for addressing distribution system needs in a modernized grid. That is due to the various benefits NWA offer to the utilities, ratepayers and society in general; the most evident of all, is the economic savings of infrastructure upgrade deferral for utilities. Utilities make significant investments on distribution infrastructures; especially as they are entitled to earn regulator approved rate of return on capital expenditures included in their rate base. Reallocating the significant amount of infrastructure capital investment towards less costly NWA solutions in an adjusted regulatory environment provides substantial economic benefits. Furthermore, NWA solutions incorporate automation, monitoring and control elements which leads to a more interactive energy exchange with the grid. That in turn leads to a more efficient and flexible customer-side energy behavior and eventually cost savings for the ratepayers. For instance, a battery energy storage system installed either at utility or customer side can manage to reduce the peak demand by shifting the energy consumption from high-demand to low-demand hours and flatten out the demand curve; indirectly contributing to the cost-savings for ratepayers.

Key components of developing a successful NWA project are outlined below:

- Identification of value streams and NWA valuation,
- Designing compensation methods, including:
    - Benefit distribution among rate payers,
    - Timeframe methods are applied,
    - Certainty of effectiveness and acceptance by customers
- Establishing performance requirements and measurements and verifications (M&V) to assess outcome and quantify benefits, penalties, etc.,
- Operation considerations for enabling stacked benefits such as reliability and market applications.

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