Net Zero Grid Plan Planning Lab

Minutes from Workshop #1:

Distribution Planning to Enable Massachusetts 2050 Decarbonization Roadmap

February 3, 2022

Participant List

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Project overview (slides 1-7)

Dr. Ariel Horowitz, Senior Program Director, MassCEC
Robert Sheridan, Technical Executive Consultant, EPRI

Overarching Goal: Build consensus and strategy around distribution grid challenges to reach Net Zero by 2050

- EPRI (non-profit research institute, retained by MassCEC) will:
  - Highlight barriers and opportunities
  - Use survey results and utility data to forecast customer adoption rates of new tech on a sample of representative feeders then extrapolate results to understand impacts
- Workshop process goals: build consensus, have open discussion, eventually propose solutions for making the Commonwealth's distribution grid 2050-ready
  - Project will also seek to provide ballpark estimate of overall infrastructure investments required to support the electrification objectives
- Electric Distribution Companies (EDCs) will implement and operationalize system upgrades and modifications needed to support electrification, the linchpin of the Decarbonization Roadmap
- First in series of three workshops
  1. Distribution Planning (2/3, 12:00 pm – 2:00 pm)
  2. Identifying Barriers and Opportunities (3/4, 10:00 am – 12:00 pm)
  3. System Costs and Processes to Achieve (5/11, 11:00 am – 1:00 pm)

Today's Agenda:

1. Highlight elements of Decarbonization Pathways that may impact Electric Distribution System (EDS)

2. Review Distribution Planning Processes that drive investment decisions to safely, reliably and cost effectively operate the grid

3. Discuss objectives of next workshop which will focus on barriers and opportunities to achieving 2050 cost effectively

2050 Decarbonization Pathways (slides 8-9)

Robert Sheridan, Technical Executive Consultant, EPRI

- Dec 2020: Commonwealth released *Energy Pathways to Deep Decarbonization*
- Using the "All Options" pathway as the benchmark pathway for this project
- Elements that will impact distribution system:
  - Increasing Electrification of Transportation
    - Substantial increase in Electric Vehicles (EV)
  - Increasing Electrification of Building Heating

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        - While energy efficiency goals will reduce heating energy requirements, increased use of heat pumps means additional heating demand served from electricity rather than pipeline or delivered fossil fuels
    - Increasing Solar Penetration and Grid Flexibility
        - Increased supply of distribution-connected renewables (solar) causes volatility
        - Increased grid flexibility from distributed energy resources (DERs) may help to manage demand needs
        - It was noted that within the "All Options" pathway, the impacts of consumption were measured as an energy value (GWh) while potential contribution from resources were measured as a capacity value (GW). The ability for solar and grid flexibility to be an effective resource for distribution needs will be determined by the ability to leverage available capacity in specific locations at specific times to address local energy needs.
- Key Challenges for the Distribution Grid:
    - Increasing energy requirement and peak demand: distribution planners must consider peak load impacts from an increasingly flexible, volatile, and significantly growing load and generation base and ensure that the distribution system is sized appropriately to meet peak demand
        - As electric heating demand increases, peak may shift to winter season
    - Load profile: how does energy requirement translate to daily/weekly/monthly demand profile?
        - Demand and supply have to be balanced at all times at the regional (ISO-NE) level
    - Intermittency: much of new capacity may be supplied by solar and wind (intermittent sources) which can cause more rapid changes in system voltage and other challenges
    - Location and electrical connectivity
        - Where technologies are adopted will impact local distribution system
    - Flexibility
        - Loads can move, specifically electric vehicle charging loads, forcing the utilities to account for potential capacity needs from the same load (EV) at different locations
        - Flexible loads can be leveraged for multiple use cases. Loads can be managed, both by the EDCs but also by third parties for customer level benefit or participation in wholesale markets (see FERC 2222). Not all use cases will have positive system impacts at the distribution system level, and some may have unintended adverse impacts at some locations. Situational awareness and coordination between aggregators and grid operators will be very important.

<u>Questions:</u>

- Q: Does the graphic provided show distributed solar or all solar?
    - A: behind-the-meter solar and solar connected to primary of the distribution system as well as transmission-sited solar

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Panel Session (slides 10-15)

Moderator: Robert Sheridan, Technical Executive Consultant, EPRI

Panelists:

- Lavelle Freeman, Director, Distribution Planning, Eversource
- Dr. Gerhard Walker, Principal Engineer, System Planning, Eversource
- Domenico Fuda, Director, Electric Strategy Activation, Future of Electric, National Grid
- Balaji Doraibabu, Director, Advanced Data & Analytics, Future of Electric, National Grid

Electric Distribution Systems Overview

- Segmented into Wholesale Generation → The Grid/Transmission System → Local Substations → Distribution System
- **Distribution** comprised of substations that step down high voltage power to primary distribution system
    - Distributes power through smaller transformers to the community
    - Made up of thousands of individual distribution circuits (feeders)
    - Feeders act relatively independently and need to be planned for independently
    - ~4000+ circuits in MA that need to be planned for, each with thousands of pieces of equipment
    - Distribution system is a summation of lots of elements planners will have to consider
- Behind-the-Meter:
    - Customer-generated power
    - Customer loads and end uses

Distribution Planning Process Overview

- Question for Mr. Freeman: Describe the purpose of distribution planning and key objectives you hope to achieve through the planning process?
    - Utility's mission is to provide adequate voltage, reliability and adequate capacity to serve load anywhere that needs it
    - Traditional techniques have evolved to accommodate changes in system demand, but the goal is still the same
    - Assessment of long-term system requirement – develop solutions to ensure sufficient voltage exists in all conceivable areas
    - Eversource plans on a 10-year horizon, to identify when and where criteria violations will occur so the company can develop solutions that work within all applicable lead times
    - Distribution system planning team has to develop substation and feeder solutions (for lines used to transfer load), look at interconnection requirements for DER
        - Plan for load and DER in the same way because both create constraints
        - Look at system over 24h cycle (8,760h annually over the long-term), not just peak time

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- Solutions/upgrades often come with additional headroom to enable more DER and electrification
- Need to develop an advanced load forecasting & modeling team for distribution planning
- In MA, distribution planning is rapidly evolving due to climate goals, policy incentives, tech, penetration of electronic loads, consumer expectations

- Question for Mr. Fuda: Describe the purpose of distribution planning and key objectives you hope to achieve through the planning process?
  - At NG, distribution planning is a cyclical process
  - NG has a 15-year planning horizon
  - Main driver is load forecast for each substation and feeder
    1. System monitoring to gather historical load for each feeder and substation
    2. Use this data to model and forecast
       - Factor in weather, load growth, planned developments (bottom-up)
       - Also conduct a top-down system-level forecasting based on macroeconomic forecasts
    3. Risk assessment
       - Look at load constraints based on forecasts at the feeder level
       - Voltage and reliability criteria
       - Update forecast to look for projected overloads
       - Regional study to evaluate capacity when overloads/risks are identified
       - Develop preferred and alternative solutions for best fit option
    4. Prioritization budgeting
       - Once preferred option is identified, project must be sanctioned then entered into capital budget to ensure each project is prioritized properly
       - Prioritization based on likelihood that the risk will occur
    5. Design and construction

Identifying Upgrade Needs in Distribution Planning Generally

- Question: Dr. Walker, please provide examples of specific issues that you look for? Please relate that to issues a distribution problem would create and the impacts on workforce or customers.
  - In general, System Planning looks for capacity problems (more load or more generation on the system than it is designed to handle – which can manifest itself in a wide variety of problems, such as overloading or voltage issues)
  - We plan for 10 years out to allow sufficient time for larger projects, such as bulk station upgrades, to complete where capacity issues might occur. In addition, we look at the 2050 Decarbonization Roadmap to ensure system upgrades enable future electrification and that we (ES) do not have to revisit the same station with a major project again in short duration
  - Reliability problems: how will the system operate under n-1 criteria (unplanned outage of a critical piece of equipment)?

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        - Ensuring sufficient system redundancy, understanding what would happen if any system asset were to fail
        - Need to pick up all existing load and generation without jeopardizing supply to customers
        - Look at various permutations that can happen on system outages
    - Asset condition-related problems
        - When assets are too old, they need to be upgraded
        - These upgrades are typically merged with upgrades for capacity issues to do all the required work once
    - System Planning does not concern itself with issues caused by single interconnections – those can't be forecasted until the interconnection request is made as precise locations and technology types will be needed

Impact of 2050 Decarbonization Roadmap on Distribution Planning

- Each EDC, please provide
    1. An overview of load and DER forecasts,
    2. How the forecasting process may be impacted by pathways, and
    3. What your plans are to adjust forecasting considering the pathways.
- Mr. Doraibabu:
    - We look across the company, zone, and feeder-level on a 15-year horizon
    - The forecast must address planning for PV systems – National Grid's strategic plan to meet DER policy initiatives – at the distribution level to make sure proper forecasting of load and DER is done at feeder level to evaluate interconnection requests and perform non-wire requests
    - System-level forecast model is purely based on historical customer consumption and future economic variables (does not consider DER impact)
    - Then, we bring in each DER based on deep decarbonization goals
    - Add up system-level + policy initiatives + market drivers
    - Weather scenarios:
        - Normal: 50/50 scenarios
        - Extreme: 90/10 scenario
        - Planning team focuses on extreme scenario case
        - Their study considers 0.7-degree Celsius increase due to climate change
    - Feeder-level forecast
        - Plan for upgrades
        - Scope: 1000 feeders
        - Network flow model from assigned system
        - Take customer load profile and bring it into simulation model
        - Use simulation platform for grid planning, come up with 8760 load profile
    - NG has several "energy initiative" programs with focus in different areas

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        - Want to understand load shape of each DER so they can overlay it on base customer load profiles to understand where they need to focus to mitigate potential issues
        - Solar load and EVs: at base level, National Grid expects MA will meet 2030 Clean Energy and Climate Plan (CECP) goal by 2030
        - Heat pumps: at base level, National Grid expects MA will meet 2030 CECP goal by 2036
- Dr. Walker:
    - 10-year planning horizon to identify constraints, initiate projects
    - Look at available headroom on stations to see how far out stations will last based on a 2050 long range electric demand assessment
    - Project initiation similar to NG
    - Build peak load forecast in two stages
        - Bottom-up: new business, step-loads, econometric model for standard load growth (Temperature normalized)
            - Contractual reserve capacities: for customers who generate their own electricity that can go offline
        - Top-down:
            - ISO state level forecasts for solar adoption, EVs, energy efficiency
            - Break down based on ~100 bulk stations in MA
    - Layer DER models
        - Planning Models for each DER Type (e.g., during peak load days, solar generation is considered at a weather adjusted output to account for worst case weather conditions)
    - Every project has extra headroom, so there's an analysis of how far this headroom gets Eversource in electrification goals? How many years until an upgrade is needed?
    - Break down MA electrification policy goals to determine degree to which projects will enable electrification goals
    - Solar: Decarbonization Pathway calls for 22 GW of new solar; by comparison, ISO-NE currently peaks at 25 GW
    - EVs: transforming entire energy infrastructure (gasoline and diesel) to electric infrastructure (massive increase in charging load)
        - One key problem is on residential feeders, since they tend to have less capacity than commercial, and the EV charging would be expected to be coincident peak in the evenings rather than the mornings in commercial areas (when commuters are tending to charge up at work)
    - Heat pump loads will cause a transition to winter-peaking systems before 2040
        - Electric heating demand in wintertime outstrips the cooling demand in summertime (wide range electrification of heating will also drive-up AC adoption and summer loads)

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        - At colder temperatures, heat pumps become less efficient while houses need more heat, causing even more demand and less flexibility for demand response programs
    - Long-range electric demand assessment – break down state & federal plans by station
        - Technology adoption propensity of customers + socio-economic modelling
    - Convert to 8760 (hourly over the course of the year) models
    - For EVs: Eversource is working with the same company that provides mobility data to MassDOT – helpful tracking data
        - E.g., The Cape, population drastically increases on summer weekends and influx of EVs charging needs to be accommodated
- Audience question (from Ashley Gagnon, MA Office of Attorney General): How do non-wires alternatives play into Eversource's distribution planning process?
    - Under 20-75: Eversource published non-wire alternative framework to screen ever major project (Company has also published this framework in CT and NH and is engaging in stakeholder participation to improve on the Framework)
    - The company has also developed tools that enable engineers to screen NWAs against traditional solutions
    - Variety of solutions to screen against
    - Break down cost of delays to revenue requirement for customers

Electrification-Related Upgrade Needs

- Question for Mr. Fuda: What needs are you anticipating for increase in electrification?
    - Switch to winter-peaking system (natural gas is shifting onto electric supply)
    - 2x load, reliability more important because customers are dependent on electricity for transportation and heating
    - Highways and fleet customers will create hotspots for fast charging stations and require much more capacity than residential charging
    - Local distribution system needs to expand for EV charging
    - Capacity criteria driven by thermal limits, reliability, asset health
    - Overloads = equipment failure, sagging wires, high/low voltages, system protection issues (e.g., live wires on ground)
    - Upgrades likely won't account for 100% of future load need, not zero cost for developers to convert to their system
        - Costs can be equipment, identified during interconnection studies
- Mr. Sheridan: Some growth will happen incrementally, so you have more time to plan for them. Some things like EV charging come in large blocks of demand and require immediate response. Need to be planned for differently?
    - Mr. Fuda: They need to be planned differently, highway hotspots are urgent and need to be planned for now
- Question for Dr. Walker: What types of infrastructure upgrades will be required? Are there feeders for which load flexibility can reduce build-out costs?

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    - The majority of upgrades will be capacity related, either through more capable conductors or by addressing voltage issues caused through overloading with regulators, capacitors, LTCs or the use of smart inverters
    - Load flexibility will be able to reduce built out cost. It will not be able to replace it, and the question how much it will reduce it by depends significantly on the area and application
    - HOWEVER: Load flexibility can also cause an increase in build out costs: FERC 2222 has the potential for DERs to participate in energy markets through aggregators (3rd party). Aggregators not in-tune with local system conditions can drive demand on a very local level that EDC's will have to either build to match the system, OR have an approach to congestion management with a bilateral information exchange between aggregators and the EDCs (See Eversource's proposal under "congestion management" MA DPU 21-80)
    - How does system planning team plan for optimized system 10 years down the road to understand what customers and the market are going to do will be the big challenge?
        - Utility system needs to collaborate with stakeholders while planning for the worst conditions
        - Some resources will be used to offer flexibility – but who controls the flexibility?
        - If utility isn't included, then demand will be driven up and utilities will have to build up to accommodate demand
- Mr. Freeman: build-out to accommodate group study demand in SEMA can accommodate another 1.3 GW
    - Potential for high reverse flow during low load hours creating thermal and steady-state voltage issues
    - Can also create transient overvoltage issues leading to voltage spikes of 1.7 per unit
    - Solutions are varied – investment in electrical infrastructure (the foundation for solutions) is needed to move energy from where it's produced to where it's consumed
    - Now: building up technology but will have to deal with more issues that come with this
    - Utilities well-positioned for these challenges. Foundation is there, need to execute
- Dr. Walker: national trend to electrify is shifting industry into electric
    - The development to electrify is changing industries and if the electric distribution system does not keep pace up upgrade its capacity, the timelines required to build major capacity projects in combination with significant demand increases can derail the entire 2050 decarbonatization roadmap
        - GM pledged to not make more combustion engines – can't backtrack if necessary, upgrades and funds were not approved
    - No room for error because if the system isn't ready for electrification, we hit a brick wall.

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Attendee Q&A

- Question: Are there feeder typologies for which load flexibility can deliver greater value/reduce initial build out costs?
    - Dr. Walker: Hard to plan generically for specific feeder types/geographic areas. All will depend on what happens on the ground in that specific location.
    - Planning Lab has identified 15 feeders to examine what the impact will mean
    - Only works on high-level, not specific locations.
    - Critical: Capacity upgrades can guarantee their capacity, flexibility projects would need to deliver the same guarantee
- Follow-up question: Can it be somewhat predicted because zoning – won't have heavy industry in suburb?
    - Dr. Walker: commercial areas have peak during day, residential in evening
        - Can make some assumptions but can't pinpoint specifics and their impacts
    - Mr. Freeman: zoning & restrictions drive impact of feeders more than characteristics
        - Seeing DER show up at already congested feeders
        - Western MA: hydroponic farming requesting interconnection – new demand on feeders, takes a couple years
        - Infrastructure build-outs take time, need to have a line of sight to them. Utilities need to work with communities to understand industry trends to feed back into forecasting
    - Mr. Doraibabu: critical to understand knowledge in local regions – understand bylaws
        - Engaging with other stakeholders to view from their lens
- Question: Would the EDCs find feeder-specific dynamic storage incentives helpful?
    - Short answer: yes, they already have these programs. Would offset issue but not prevent every upgrade
    - Unclear how customers can or should be compensated for avoiding distribution system upgrades.
- Question: Eversource short-term and long-term forecasts talk about drivers of chance and anticipation of needs and how much headroom they build to? How granular is the level (substation? feeders?)? You talked about what you consider, but what do they actually do?
    - Dr. Walker: Headroom specific to each substation/feeder – currently not much headroom because previously the mandate was to avoid stranded assets. Was designed to meet demand, not more.
    - Now need to upgrade system to meet demand ahead of time.
    - Electric heating adoption can, in most cases, use existing winter head room for the next couple of years. Eversource expects that between 2030 and 2040 that winter head room will be used up.
    - Switch from summer- to winter-peaking system will depend on adoption rates of heat pumps
        - Looking only at electric heating, system has some near-term headroom to absorb a portion of that because it is built for the existing summer peak

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(example from a recent study has 23MW difference between summer and winter, and 68MW total increase in winter demand due to heating electrification potential).
        - Building heating profiles peak in the morning; to the extent that coincides with EV charging will drive system needs and pose challenges
    - Heat pump flexibility and efficiency decrease in cold snaps because they have to run more
        - What if electric heat pump systems fail? Some will fall back to electric resistance, which creates capacity challenges
        - Eventually, winter peak will overtake the summer peak capacity and EV charging will increase more
- Question: What % of system at any time is in N-1 state? How common is it?
    - Dr. Walker: N-1 condition can take weeks or months to rectify so, when it happens, it's not something easy to fix. So, it is not a question of how long, but of the expected value of the impact, which is likelihood multiplied by potential impact.
    - Mr. Freeman: Every day, there is a feeder that is in an N-1 condition. Systems are very connected so distribution feeders can move customers during emergencies
        - At substation level, N-1 is rarer but still happens
        - Design for N -1 is insurance like seat belts or airbags: you hope you don't have to use them, but you're grateful they are there. System is designed to have capacity to move load from one transformer/station to another for when it does occur