Walk-through of long-term utility distribution plans:

Part 1 - Fundamental and grid modernization planning elements

Lavelle Freeman

GE Energy Consulting

Distribution Systems and Planning Training for Southeast Region

March 11-12, 2020
Goal of distribution planning

Provide orderly, economic expansion of equipment and facilities to meet future demand with acceptable system performance

- Deliver power with required frequency (60 Hz)
- Satisfy voltage requirements (within ±5%)
- Deliver adequate availability (<2 hours outage/yr)
- Have capacity to meet instantaneous demand
- Reach all customers wherever they exist

... and do it all for the lowest possible cost
Need to plan because it takes time to build capacity

- Effective minimum-cost planning accounts for lead time to deploy T&D assets in developing reasonable alternatives

<table>
<thead>
<tr>
<th>T&amp;D Level</th>
<th>Lead Time (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation</td>
<td>13</td>
</tr>
<tr>
<td>EHV Transmission</td>
<td>9</td>
</tr>
<tr>
<td>Transmission</td>
<td>8</td>
</tr>
<tr>
<td>Sub-transmission</td>
<td>7</td>
</tr>
<tr>
<td>Substation</td>
<td>6</td>
</tr>
<tr>
<td>Feeder</td>
<td>3</td>
</tr>
<tr>
<td>Lateral</td>
<td>0.5</td>
</tr>
<tr>
<td>Service</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Loads and demand drive distribution planning

- Loads vary over time and space

Typical Feeder Load

Typical Customer Load

Perceived variability depends on level of aggregation and resolution
Example Plan: Xcel Energy’s Integrated Distribution Plan (2020-2029)
Xcel Energy Integrated Distribution Plan (IDP)

Presents a detailed view of the distribution system and plans to meet customers’ current and future needs

► Five-year action plan focused on
  - Providing customers with safe, reliable electric service
  - Advancing the distribution grid with foundational and core capabilities:
    - Advanced Metering Infrastructure (AMI)
    - Field Area Network (FAN)
    - Fault Location, Isolation, and Service Restoration (FLISR)
    - Integrated Volt-Var Optimization (IVVO)
  - Procure and implement Advanced Planning Tool (APT) to facilitate:
    - Non-Wires Alternatives (NWA)
    - Distributed Energy Resources (DER)
    - Load forecast scenario analysis
    - Integrated T&D resource planning

“The backbone of our distribution planning is keeping the lights on ... safely and affordably.”
Xcel Energy Strategic Priorities – Applied to Distribution

Lead the Clean Energy Transition

Enhance the Customer Experience

Keep Bills Low

Distribution Objective: Safe, reliable, affordable electric service – with an eye to the future

Distribution Planning

“strategic priorities ... are embedded in everything that we do – including the way that we plan our distribution system”
Distribution Planning Framework

Work performed by the Distribution Department is essential to ensuring that electric service is safe, reliable, and affordable.

► Extend service to new customers or increase capacity to accommodate growth
► Repair facilities damaged during severe weather to quickly restore service
► Regularly maintain and repair poles, wires, cables, metering, and transformers
► Transform the distribution grid as part of the larger Advanced Grid Intelligence and Security (AGIS) initiative to:
  ■ enhance security, efficiency and reliability
  ■ safely integrate more distributed resources
  ■ support electrification
  ■ enable improved customer products and services
Overall Approach to System Planning

- Proactively identify existing and anticipated capacity deficiencies or constraints that could lead to overloads
  - During *normal* (“system intact” or N-0 operation) operating conditions
  - During *single contingency* (N–1) operating conditions

- Identify corrective actions
  - Traditional distribution expansion
  - Non-wires alternatives

- Develop cost estimates and perform benefit-cost analysis to determine best options based on:
  - Operational requirements
  - Technical feasibility
  - Future year system need

Proposed projects are funded as part of an annual budgeting process, based on a risk ranking methodology.
Annual Distribution Planning Process

Review existing and historical conditions, including:

- Feeder and substation reliability performance
- Equipment condition assessments
- Current load versus previous forecasts
- Quantity and types of DER
- Total system load forecasts
- Previous planning studies
Typical Radial Distribution Circuit Design

System is planned to facilitate single-contingency switching to restore outages within ~1 hour
Planning Criteria and Design Guidelines

- Voltage at the customer meter **within 5%** of nominal
- Voltage imbalance **less than or equal to 3%**
- Balanced phase current phases (as much as possible) to minimize total neutral current at feeder breaker
- Feeder loading under N-0 (normal) conditions **less than 75%**
- Adequate field tie capabilities for first contingency (N-1) restoration
Distribution Planning Process: Load Forecast

- Performed for both feeders and substations
- Focuses on demand, not energy, to ensure loads can be served during system peaks
- Trending method considering:
  - Historical load growth
  - Weather history
  - Customer planned additions
  - Circuit reconfigurations
  - New sources of demand (e.g., EVs)
  - DER applications
  - Planned development or redevelopment in study area

**Tools and Processes:**
- ITRON DAA (Distribution Asset Analysis)
- SCADA (Supervisory Control and Data Acquisition)
- PI Datalink (Excel add-in providing SCADA information)

Generate five-year forecast, aggregate, and compare with system projections.
Example: Feeder Historical and Forecasted Demand

- Summer peak demand forecast for eleven 13.8 kV and two 34.5 kV feeder circuits in focused study area*

*From 2015 Planning Study filed with 2018 IDP; not filed in 2019.
Example: Substation Historical and Forecasted Demand

Summer peak demand forecast for two 13.8 kV substation transformers in focused study area*

*From 2015 Planning Study filed with 2018 IDP; not filed in 2019.
Distribution Planning Process: 
Risk Analysis

Identify feeders and substation transformers for which N-0 or N-1 risk is a concern.

Total number of risks generally exceeds what can be mitigated with available funds.

Strike a balance between
- mitigating risks,
- planning for new customers,
- addressing aging, and
- preparing for the future

Xcel’s planning process identified these risks:
- N-0 normal overloads on 71 feeder circuits
- N-0 normal overloads on 14 substation transformers
- N-1 contingency risks on 498 feeder circuits
- N-1 contingency risks on 112 substation transformers

Tools and Processes:
- ITRON DAA (Distribution Asset Analysis)
- CYMCA (determines circuit ampacity*)
- WorkBook (internal project prioritization tool)

*Ampacity is the maximum current a conductor can carry continuously (safely) before thermal limits are exceeded.
Example: Plymouth and Medina N-0 Risk Assessment: 2016 and 2036

*From 2015 Planning Study filed with 2018 IDP; not filed in 2019.
Example: Plymouth and Medina N-1 Risk Assessment: 2016 and 2036

*From 2015 Planning Study filed with 2018 IDP; not filed in 2019.
Distribution Planning Process: Mitigation Plans

Identify potential solutions to provide additional capacity needed to address identified system deficiencies.

Risk thresholds that trigger mitigation plan:
- N-0 conditions: overload > 106%
- N-1 conditions: load at risk > 3 MVA

Tools and Processes:
- GIS (Geographical Information System)
- Synergi Electric (power flow)
- WorkBook (internal project prioritization tool)

Many mitigation solutions are straightforward, but others require detailed analysis.
Solution Identification Process

Is the problem localized and solution straightforward?

Yes
- Identify the solution
- Quantify the risk
- Estimate costs

No
- Identify the options
- Quantify the risk
- Estimate costs
- Obtain stakeholder input
- Perform planning study
- Select the solution

Enter into the budgeting tool
Distribution Planning Location-Specific Studies to Evaluate Alternatives

Potential Solutions:

- Reinforce existing feeder circuits to address isolated feeder circuit overloads
- Add or extend new feeder circuits
- Expand existing substations to address more widespread overloads
- Evaluate alternatives to bring new distribution sources to the area
- DER not historically considered a viable alternative … changing due to maturing technology, operational experience, and regulatory requirements

1. Identify the study area
2. Project future loads
3. Estimate the saturation of the area
4. Coordinate with transmission planning
5. Generate options
6. Study and compare economics and reliability of the alternatives
Factors used to prioritize investments include:
- Reliability
- Safety
- Environmental
- Legal
- Financial

Each project assessment is ranked against the others.

Highest priority given to regulatory and environmental compliance and projects to connect new customers.

Tools and Processes:
- WorkBook (internal project prioritization tool)

See “Extra Slides: Distribution Budgets”
Distribution Planning Process: Project Initialization

Electric Distribution Planning memos are written to initiate the design and construction part of the project.
- High level, step-by-step description of the project that will mitigate an identified risk

Describes:
- The problem being mitigated
- Any substation design/construction steps to take
- Any distribution line design/construction steps to take

Tools and Processes:
- WorkBook (internal project prioritization tool)
Selected projects are communicated to substation engineering and distribution engineers and designers:

- **Substation Engineering:**
  - Detailed engineering, design and construction for a new feeder bay at an existing substation or a new substation entirely

- **Distribution Design and Construction:**
  - Permitting, design and construction of new feeder circuits or modifications of existing circuits
Planning Tools

- Current forecasting tools only analyze annual peak load for distribution assets — e.g., feeders and transformers
- With increasing DER adoption, distribution system becomes more dynamic and annual peak view is no longer adequate
- Need advanced planning tools and capabilities to:
  - facilitate targeted and granular distribution forecast analyses
  - systematically evaluate NWAs
  - enable better assessment of potential customer-driven DER growth through DER scenario forecasting
  - integrate forecast with other resources and planning processes (AMI, Integrated Resource Planning)

Need more granular load forecasts, in terms of both time intervals and proximity to customer end-points
## Planning Tools Evolution

### Notes:

* New Advanced Planning Tool replaces Distribution Asset Analysis system and adds more functionality

** Planning has larger role in interconnection process

*** Hosting Capacity becomes integrated into planning process

<table>
<thead>
<tr>
<th>Current Tools</th>
<th>Future Planning Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synergi Electric</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Distribution Asset Analysis</strong></td>
<td></td>
</tr>
<tr>
<td><strong>MS Excel</strong></td>
<td></td>
</tr>
<tr>
<td><strong>CYMCAP</strong></td>
<td></td>
</tr>
<tr>
<td><strong>GIS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SCADA</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Workbook (internal)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>DRIVE</strong>*</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expanded Tools</th>
<th>Future Planning Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advanced Planning Tool</strong></td>
<td></td>
</tr>
<tr>
<td><strong>ADMS</strong></td>
<td></td>
</tr>
<tr>
<td><strong>SAP</strong></td>
<td></td>
</tr>
</tbody>
</table>
Non-Wires Alternatives
Non-Wires Alternatives

- Emerging as another advanced distribution planning application
- Significant rise in NWA projects proposed/implemented
- States with high DER penetration and/or regulatory reform measures leading the way
- Decreasing DER costs may present opportunities to address pockets of load growth using DER

- **Traditional buildout solutions:**
  - Fixed capacity at known locations: substations, feeders, laterals, etc.

- **Non-traditional solutions:**
  - Operational characteristics based on technology, location, time of day

Niche applications with potential to quickly become cost-competitive

---

[Link to article: https://www.kqed.org/science/1951005/the-cost-of-battery-storage-plummets-at-the-right-moment-for-california]
Viability of NWAs by Project Type
(Xcel’s View - from 2019 IDP)

► Mandated Projects:
- Relocating infrastructure in public rights-of-way in order to accommodate public projects such as road widenings or realignments.
- Replacing with NWA “…would leave a segment of customers electrically unserved due to having no physical connection to the Xcel system.”
- “Removing interconnectedness takes away .. flexibility and redundancy … and makes [operation] more difficult and less reliable”

► Asset Health Projects:
- Replacing equipment which is reaching the end of life or has failed (pole replacements, storms, underground cables, etc.)
- “Because asset health affects every part of the distribution system and is essential to maintaining reliability, an NWA is not workable”

► Capacity Projects (preferred application for Xcel):
- Better suited for NWA as they are driven by a capacity deficiency that can be offset or deferred by strategically-sited DER
- “… without some external driving need, NWA must be cost-competitive with a traditional solution to be viable in the budget create process”
NWA for Capacity Projects: N-0 overload example

Assuming a $400,000/MWh cost for battery storage, overload could be mitigated with DER for $400,000.

Cost-competitive with a typical traditional mitigation project (upgrading feeder cables or conductors, extending a feeder and transferring load, or installing a new feeder)

- Small overload with a peak magnitude of 0.71 MW
- Total overload duration is brief, ~1 MWh overloaded
NWA for Capacity Projects: N-1 overload example

Assuming a $400,000/MWh cost for battery storage, overload could be mitigated with DER for $9,632,000.

- **4 MW overload** (standard for N-1 risks)
- **Duration of the overload** extends to 10 hours, ~24 MWh overloaded

**Orders of magnitude higher** than a typical traditional mitigation project (upgrading feeder cables or conductors, extending a feeder and transferring load, or installing a new feeder)
NWA Screening Process

**Project Types**
- Capacity Projects

**Costs**
- Greater than $2 Million

**Timeline**
- 2022-2024 timeframe

**Risks**
- N-0
- N-1

Reliability Projects

Asset Health Projects
Asset Health and Reliability Management
Electric Distribution Standards

- Develop and maintain a broadly-accepted set of material and construction standards that meet the needs of operating companies and stakeholders

### Some Common Industry Standards Applied in Distribution Engineering

<table>
<thead>
<tr>
<th>Condition</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>National Electric Safety Code (NESC)</td>
</tr>
<tr>
<td></td>
<td>Xcel Energy Safety Manual</td>
</tr>
<tr>
<td>Voltage Limits</td>
<td>ANSI C84.1 – minimum and maximum voltage limits, voltage imbalance limits</td>
</tr>
<tr>
<td></td>
<td>Xcel Energy Standard for Installation and Use – voltage limits and imbalance (same as ANSI C84.1)</td>
</tr>
<tr>
<td>Thermal limits</td>
<td>Xcel Energy Design Manuals (Distribution Standards Engineering)</td>
</tr>
<tr>
<td></td>
<td>Substation Field Engineering (SFE) transformer loading database – based off of IEEE standards</td>
</tr>
<tr>
<td>Distribution Interconnection</td>
<td>IEEE 738 – Overhead conductor ampacity rating</td>
</tr>
<tr>
<td></td>
<td>IEC 287 and IEC 853 – Cable ampacity rating methodology in CYMCP program</td>
</tr>
<tr>
<td></td>
<td>IEEE C57.91 – transformer and regulator loading guide</td>
</tr>
<tr>
<td></td>
<td>IEEE C57.92 – power transformer loading guide</td>
</tr>
<tr>
<td>Harmonics</td>
<td>IEEE 519 – total harmonic distortion and individual harmonic limits</td>
</tr>
<tr>
<td>Voltage Fluctuation</td>
<td>IEEE 1453 – rapid voltage change and flicker limits</td>
</tr>
</tbody>
</table>
Asset Health

Monitor and address the health of distribution assets using a variety of programs and metrics

► Overhead (OH) distribution reliability performance dependent on many factors including vegetation, weather, and health of OH assets
  - E.g. Pole rot at the base of the pole can cause failure, especially in stormy weather
  - Track the fleet age of wood poles, and use age as a proxy for asset health

► Underground distribution reliability performance is heavily influenced by the performance of mainline and tap cable
  - Analyze cable failure rates for both types of cable, and budgets to manage the reliability
  - Era of the cable correlated with its failure rate
  - Tracking allows focused efforts on the cable most likely to fail
Asset Health Programs - Incremental System Investment

Driven by the need to improve reliability on elements of the system closest to customers and to support DER integration

► Overhead (OH) Tap Programs
  ■ Target Undergrounding, Low Cost Reclosers, Pole Top Reinforcements
  ■ Transformer and Secondary Replacements
  ■ High Customer Count Taps, Community Resiliency

► Underground (UG) Programs
  ■ Mainline Cable Replacement, URD Cable Replacement
  ■ Cable Assessment, Network Monitoring, St. Paul Tunnel Rehabilitation
  ■ Feeder Exit Capacity, Purchases / Tooling

► Substation Programs
  ■ Substation Asset Renewal
  ■ Transformer Replacement

► Overhead Mainline Programs
  ■ Lightning Protection Replacement
  ■ Pole Fire Mitigation

**Capital budget:** Over $80 million/year

**O&M Budget:** $1.5 million/year
Distribution Operations Programs

- Vegetation management program – reduce preventable tree-related outages
- Damage prevention program – help public identify/avoid UG infrastructure
- Fleet, tools, and equipment – support the distribution function
- Escalated operations – storm pre-planning and outage restoration
  - Ensure sufficient workforce:
    - Agreements with contractors to supplement field forces when needed
    - Mutual aid agreements with other utilities
  - Prepare for supporting outage restoration crews:
    - Maintain list of hotel accommodations and conference facilities across the service area
    - Maintain lists of available transportation options
    - Ensure ready access to catering to feed crews, restroom availability, etc.
  - Ensure a sufficient storm restoration budget is available

![MN Storm Restoration Totals (Capital and O&M)](chart)
Reliability Management - Indices (SAIDI)

MINNESOTA QSP SAIDI - YTD (Tariff Method/Threshold) 
(Excluding Transmission Line level, Including All Causes)

Xcel Energy

January
February
March
April
May
June
July
August
September
October
November
December

2018 QSP Monthly Actual
2018 QSP YTD Actual
2018 QSP YTD Target
2017 QSP YTD Actual
2016 QSP YTD Actual
2015 QSP YTD Actual
Reliability Management - Indices (SAIFI)

MINNESOTA QSP SAIFI - YTD (Tariff Method/Threshold)
(Excluding Transmission Line level, Including All Causes)
Reliability Management - Cause Analysis

Minnesota Customer Interruptions By Primary Cause - (Tariff Method/Threshold)
Distribution, Substation, & Transmission Level - By Calendar Year

Areas Xcel’s plans are currently focusing on Tree Trimming and Cable Replacement.
Reliability Management - Programs

► Work plans, or programs, target investments after considering common failures and their causes, as well as at-risk equipment.

► Programs on “Star Chart” represent proactive investments to:
  - improve reliability and asset health
  - meet contingency planning requirements

► Investments are made in addition to other capital investments for capacity.

<table>
<thead>
<tr>
<th>Funded Programs</th>
<th>Description</th>
<th>2016 Actuals (k$)</th>
<th>2017 Actuals (k$)</th>
<th>2018 Actuals (k$)</th>
<th>IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder Pert. Improvement Program (OH &amp; UG)</td>
<td>PFIP evaluates and implements improvements for feeder outage based on prior year information.</td>
<td>391</td>
<td>870</td>
<td>1,451</td>
<td></td>
</tr>
<tr>
<td>Outage Exception Reporting Tool (OH &amp; UG)</td>
<td>OERT process provides automatic notification to assets when pointing outage criteria have been met and engineering solutions are implemented to eliminate recurring problems.</td>
<td>637</td>
<td>455</td>
<td>409</td>
<td></td>
</tr>
<tr>
<td>Mainline Cable Replacement, (UG)</td>
<td>Determines &amp; installed cable is failing and causing frequent outages. Preventive and proactive replacement of this cable reduces the outages.</td>
<td>2,194</td>
<td>3,056</td>
<td>1,930</td>
<td></td>
</tr>
<tr>
<td>Tap (URD) Cable, (UG)</td>
<td></td>
<td>16,080</td>
<td>18,320</td>
<td>10,503</td>
<td></td>
</tr>
<tr>
<td>Install Automated Switches</td>
<td>These automation solutions reduce restoration times for long lines with long drive times to bring CAIDI in-line with other distribution lines.</td>
<td>139</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Feeder Infrared Evaluation (OH)</td>
<td>Many pieces of equipment show excess heating prior to failure. The FIRE program provides infrared images of overhead mains which reveal specific equipment that is likely to fail so it can be repaired prior to causing an outage.</td>
<td>20</td>
<td>20</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Vegetation Management (Transmission &amp; Distribution)</td>
<td>Cost benefit prioritized tree trimming in NISP. Continued active &quot;Hot Spot&quot; trimming.</td>
<td>28,247</td>
<td>29,024</td>
<td>29,352</td>
<td></td>
</tr>
<tr>
<td>Program Replacements (transmission)</td>
<td>Replaces end-of-life equipment (i.e. switches, laminated assets, specific insulators, poles) in order to reduce maintenance costs and improve reliability.</td>
<td>666</td>
<td>11</td>
<td>220</td>
<td></td>
</tr>
<tr>
<td>Pole Inspection &amp; Replacement (Distribution)</td>
<td>Pole Inspections include an aboveground visual inspection. Groundline inspections are based on age and environment and may include visual, sound and bore and assessment. Treatment of poles may be included. Based on results, poles may be tagged for replacement.</td>
<td>7,107</td>
<td>7,717</td>
<td>11,035</td>
<td></td>
</tr>
<tr>
<td>Transmission Substation</td>
<td>Replaces end-of-life equipment in order to reduce maintenance costs and improve reliability.</td>
<td>1,472</td>
<td>684</td>
<td>8,228</td>
<td></td>
</tr>
<tr>
<td>Line ELR Work (Transmission)</td>
<td>Identifies lines that have components that have reached their end of life or where significant refurbishment work is needed to enhance system performance and reliability. Project focus is to extend life of existing towers 20+ years to replace and address future capacity upgrade concerns.</td>
<td>2,186</td>
<td>4,824</td>
<td>2,834</td>
<td></td>
</tr>
</tbody>
</table>
Grid Modernization
Technologies to Enable
Advanced Distribution Planning
Utility-Facing and Customer-Facing Grid Modernization Technologies

Modernizing the grid to make it “smarter” and more resilient through the use of cutting-edge technologies, equipment, and controls that communicate and work together.

Advanced Distribution Management Systems (ADMS) Integrate Several Components

Core DMS Applications + Optional Applications e.g., FLISR, VVO

- GIS
- OMS
- DSCADA
- FAN

- Detailed network topology
- Outage-Related Restoration Activities
- Monitor, control, optimize and predict operations
- Monitor and Operate the Distribution Network

Manage a variety of interconnected DER Assets

Two-way communication between customer and utilities

Source: Adapted by Tim Woolf from World Bank, Practical Guidance for Defining a Smart Grid Modernization Strategy: The Case of Distribution, 2017
Xcel Energy’s Grid Modernization Goals

Grid mod goals encapsulated in Advanced Grid Intelligence and Security (AGIS) Initiative

► Transformed customer experience
  ■ Provide greater visibility and insight into customer consumption and behavior

► Improved core operations and capabilities
  ■ Smarter networks forming the backbone of operations

► Facilitation of future capabilities
  ■ Support new developments in smart products and services

“The AGIS initiative is our long-term strategic plan to transform our electric distribution system to update system technology and capabilities, meet changing customer demands, enhance transparency into the distribution and to system data, to promote efficiency, and reliability, and to safely integrate more distributed resources.”
Long-term, focus on continuing to provide reliable and safe service and advancing the grid at the “speed of value.”
Evolution in Planning Practices

- Distribution Grid Services
- Locational Value of DER
- Source DER as non-wires alternatives
- Formalized integration with Transmission Planning and Resource Planning
- + Peak Load Variations
- + DER Variations
- + Forecasted DER
- Traditional Peak Forecast Planning
Key Take-Aways

► $2.7 billion in capital and O&M spending projected over 6 years, ~ 25% in grid modernization (AGIS)
► Investments in physical grid infrastructure (poles, wires, relays, transformers, etc.) provide the necessary foundation for upgrading grid capabilities
► Grid modernization goals cannot be fully met if new technology is deployed on existing aging infrastructure
► Must coordinate advanced capabilities with physical grid infrastructure upgrades
► This will allow advanced communications and intelligent applications to manage the grid as a fully integrated bi-directional system
Any Questions?

Contact Lavelle Freeman at 518-385-3335
Lavelle.freeman@ge.com
Extra Slides:
Distribution Budgets
NSPM* Actual Historical Distribution Capital Investments by IDP Category (2014-2018)

MN Jurisdiction - Capital Profile 2014-2018
IDP Categories (excludes CIAC and Solar)

- $269.4 Age-Related Replacements and Asset Renewal
- $175.7 New Customer Projects and New Revenue
- $109.4 System Expansion or Upgrades for Capacity
- $107.4 Projects related to Local (or other) Government-Requirements
- $97.4 System Expansion or Upgrades for Reliability and Power Quality
- $107.4 Other
- $162.8 Metering
- $27.7 Grid Modernization and Pilot Projects
- $0.4 Grid Mod & Pilots

*Northern States Power Company-Minnesota (Xcel Energy subsidiary)

Note: excludes non-investment amounts.
NSPM Budgeted Distribution Capital Investments by IDP Category (2019-2024)

~$2B over six years (2019-2024)

Note: excludes non-investment/CLAC amounts.
NSPM Actual Historical Distribution O&M Costs by Cost Element (2014-2018)

Capital and O&M expenditures associated with the advanced grid initiative are presented separately as a holistic initiative. The average Contract Outside Vendor annual expense related to Vegetation Management and Damage Prevention are $27.9M and $7.4M, respectively. Misc. Other: Includes bad debt, use costs, office supplies, janitorial, dues, donations, permits, etc.
NSPM Budgeted Distribution O&M Costs by Cost Element (2019-2024)

~$0.7B over six years (2019-2024)

Capital and O&M expenditures associated with the advanced grid initiative are presented separately as a holistic initiative. The average Contract Outside Vendor annual expense related to Vegetation Management and Damage Prevention are $30.5M and $8.6M, respectively; Misc. Other: Includes bad debt, use costs, office supplies, janitorial, dues, donations, permits, etc.
### Grid Modernization (AGIS) Investments

#### Capital Expenditures

<table>
<thead>
<tr>
<th>Component</th>
<th>MYRP Case Period</th>
<th>5-Year Period</th>
<th>10-Year Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2021</td>
<td>2022</td>
</tr>
<tr>
<td>ADMS&lt;sup&gt;3&lt;/sup&gt;</td>
<td>$6.5</td>
<td>$1.0</td>
<td>$3.0</td>
</tr>
<tr>
<td>AMI&lt;sup&gt;4&lt;/sup&gt;</td>
<td>$14.0</td>
<td>$28.9</td>
<td>$144.0</td>
</tr>
<tr>
<td>FAN&lt;sup&gt;5&lt;/sup&gt;</td>
<td>$14.7</td>
<td>$37.3</td>
<td>$36.8</td>
</tr>
<tr>
<td>FLISR</td>
<td>$3.5</td>
<td>$8.6</td>
<td>$6.6</td>
</tr>
<tr>
<td>IVVO</td>
<td>$0.1</td>
<td>$6.5</td>
<td>$9.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$38.8</td>
<td>$82.3</td>
<td>$200.2</td>
</tr>
</tbody>
</table>

$600M over 10 years

#### O&M Expenditures

<table>
<thead>
<tr>
<th>Component</th>
<th>Rate Case Period</th>
<th>5-Year Period</th>
<th>10-Year Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2020</td>
<td>2021</td>
<td>2022</td>
</tr>
<tr>
<td>ADMS&lt;sup&gt;8&lt;/sup&gt;</td>
<td>$1.9</td>
<td>$2.5</td>
<td>$2.5</td>
</tr>
<tr>
<td>AMI&lt;sup&gt;9&lt;/sup&gt;</td>
<td>$6.6</td>
<td>$16.4</td>
<td>$14.1</td>
</tr>
<tr>
<td>FAN&lt;sup&gt;10&lt;/sup&gt;</td>
<td>$0.1</td>
<td>$2.3</td>
<td>$1.5</td>
</tr>
<tr>
<td>FLISR</td>
<td>$0.2</td>
<td>$0.4</td>
<td>$0.3</td>
</tr>
<tr>
<td>IVVO</td>
<td>$0.0</td>
<td>$0.4</td>
<td>$0.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$8.8</td>
<td>$22.0</td>
<td>$19.2</td>
</tr>
</tbody>
</table>

$170M over 10 years