Agenda

Planning objectives vs criteria
Utility budgets
Investment evaluation
Baseline information on current state of distribution system

• Such as system statistics, reliability performance, equipment condition, historical spending by category

Description of planning process

• Load forecast – projected peak demand for feeders and substations
• Risk analysis for overloads and plans for mitigation
• Budget for planned capacity projects
  • Asset health analysis and system reinforcements
  • Upgrades needed for capacity, reliability, power quality
  • New systems and technologies
  • Ranking criteria (e.g., safety, reliability, compliance, financial)

Distribution operations

• Vegetation management
• Event management

Source: Xcel Energy
Returning to this morning’s discussion...

Baseline information on current state of distribution system

- Such as system statistics, reliability performance, equipment condition, historical spending by category

Description of planning process

- Load forecast – projected peak demand for feeders and substations
- Risk analysis for overloads and plans for mitigation
- Budget for planned capacity projects
  - Asset health analysis and system reinforcements
  - Upgrades needed for capacity, reliability, power quality
  - New systems and technologies
  - Ranking criteria (e.g., safety, reliability, compliance, financial)

Distribution operations

- Vegetation management
- Event management

Source: Xcel Energy
Objective: an envisioned or desired result or attribute

System requirements: technology solutions that can meet specific business and technical requirements

## Mapping Technologies to Objectives (Example)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Capability</th>
<th>Function</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reliability</strong> improvement by reducing customer unplanned outage durations</td>
<td>Improve outage identification and customer service restoration</td>
<td>Fault Identification</td>
<td>Fault Current Indicators</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fault Location</td>
<td>Outage Notification from Meters</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fault Isolation</td>
<td>Outage Management System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Service Restoration</td>
<td>Geospatial Information System</td>
</tr>
<tr>
<td>Achieve 2\textsuperscript{nd} quartile CAIDI performance by 2025</td>
<td></td>
<td></td>
<td>Distribution Management System and/or SCADA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Automated Switches</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Work Management System</td>
</tr>
</tbody>
</table>

Source: *Modern Distribution Grid, Volume I: Customer and State Policy Driven Functionality, DOE, 2017*; Available online at: [https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-I_v1_1.pdf](https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-I_v1_1.pdf)
Translating Objectives into Criteria

**Objectives**: Goals for desirable system characteristics or attributes

**Criteria**: Principles or standards by which system risks or solutions may be evaluated or prioritized

Based on survey of state planning objectives, Schwartz, Berkeley Lab
Planning for Electric Capacity

Normal Operations

“Radial” System

Blue Substation

Transformer 1
- Feeder A
- Feeder B

Transformer 2
- Feeder C
- Feeder D

Residential
(~500 – 1,500 customers)

Commercial and Industrial

DER is analyzed for system normal configuration

Credit: Ameren
https://www2.ameren.com/common/DistributionSystem.aspx
Planning for Capacity
System Flexibility

Feeders broken into three sections by switches
Each section carries 25% of feeder capacity

Feeders are loaded to 75% of capacity at full loading to be capable of carrying section of adjacent feeder

Credit: Ameren
https://www2.ameren.com/common/DistributionSystem.aspx
Planning for Capacity
Contingency Operations

Blue Substation
- Transformer 1
  - Feeder A
  - Feeder B
- Transformer 2
  - Feeder C
  - Feeder D

Orange Substation
- Transformer 1
  - Feeder W
  - Feeder X
- Transformer 2
  - Feeder Y
  - Feeder Z

Feeders would be also be segmented into three sections like Feeder A.

Safety
Reliability

DER may not be studied for abnormal or contingency configurations.
Example: Substation Transformer Outage

Substation is operating under single contingency or “N-1”
Contingency Capacity

Blue Substation
- Transformer 1
  - Feeder A
  - Feeder B
- Transformer 2
  - Feeder C
  - Feeder D

Orange Substation
- Transformer 1
  - Feeder W
  - Feeder X
- Transformer 2
  - Feeder Y
  - Feeder Z

Sections:
- Section 1
- Section 2
- Section 3
Distribution Planning Criteria – Capacity Constraints and EVs

Electric Capacity
- Normal
- Contingency

Voltage
Reliability

Transformer Replacement

Exegol Utility District
When equipment is a candidate for replacement, the utility replaces legacy designs with similar design standards that may become overloaded with incremental EVs.

Tatooine Cooperative
When equipment is a candidate for replacement, either at end of life or when doing things like pole replacement, the utility replaces legacy designs with future-ready solutions.

Smart Charging

Differences in charging assumptions can have a large impact on the cost of distribution upgrades. Smart charging can adjust the charging profile.

Distribution Planning Criteria – Voltage Violations and PV

Electric Capacity
- Normal
- Contingency

Voltage

Reliability

Illustration of Voltage Criteria

Investment categorization

- Distribution investments are frequently lumped together in grid modernization proceedings, but for cost-effectiveness evaluation and cost allocation it’s important to categorize investments according to type and drivers.

- In terms of type, a high-level taxonomy of investments might include:
  - Existing infrastructure replacements and upgrades (e.g., 4 kV to 12 kV upgrades)
  - Line extension and service upgrades (e.g., new service requests, amperage upgrades)
  - Distribution capacity expansion (e.g., substation upgrades)
  - Hardening (e.g., undergrounding, steel/concrete poles, raising equipment)
  - Grid technology (e.g., grid management and monitoring hardware and software)
  - Administrative (e.g., meters and backend software, billing software)

Source: Kahrl (3rd Rail) and de Martini (Newport)
Capacity Planning

Process to plan for adequate system capacity under normal and contingency operations

Capacity Planning is typically an annual process to address load growth or movement of load around the system
System analyzed for normal and contingency conditions
Solutions identified and proposed to address constraints

Asset Health

Programs to plan the replacement of aging assets

Asset health programs contribute to system reliability and the customer experience

Different approaches to asset health

– Corrective Maintenance – replacing failed assets
– Preventative Maintenance – replacing assets prior to failure
– Reliability-Centered Maintenance – replace assets based on historic reliability records
– Condition-based Predictive Maintenance – proactive and situational based
Utility Budgets: Discretionary vs Non-Discretionary

Utility capital and O&M expenditures can be discretionary or non-discretionary.

**Capital**
- Grid Technology, 5%
- System Expansion, 9%
- New Business, 13%
- Resiliency, 7%
- Risk Reduction, 18%
- Municipal Works (Interference), 5%
- Replacement, 22%
- Information Technology, 3%

**Operations and Maintenance**
- Grid Tech & Modernization, 4%
- Planning, 4%
- Other, 3%
- Emergency, 15%
- Required inspections
- Dist. Maint. & Inspection, 26%
- Substation Const. & Maint., 11%
- Trans. Const. & Maint., 7%
- Safety and Training, 10%
- Poles, 7%
- Dist. Const. & Maint., 11%
- Resiliency, 7%
Development of multi-objective distribution plans

Integrated distribution planning should address the development of prioritized and optimized multi-year distribution plans.

**Planning Objectives**

- **Improve Asset Health & Safety**
  - Address asset conditions that lead to failure

- **Improve Reliability**
  - Reduce frequency & duration of outages

- **Increase Capacity**
  - Expand capacity to address load growth & DER adoption

- **Improve Resilience**
  - Address climate threat risks to critical grid infrastructure

- **Promote Equity**
  - Ensure benefits of the grid are fairly distributed

Source: Kahrl (3rd Rail) and de Martini (Newport)
State of the grid and gap analysis

- Determine the status of current tools and capabilities
- Track progress in each area and identify where investment is most needed
- Grid modernization status provides a gap analysis according to functionality and capability
- Next: Prioritize investments delivering joint and interdependent benefits according to objectives

DTE Grid Modernization Status (2023)


Source: DTE DGP 2023
Prioritizing Utility Investments

Goal: develop a list of prioritized solutions given practical constraints, such as budget limitations.

Steps:
1. Ranking planning objectives w/stakeholder input
2. Normalizing the value contribution of each solution in relation to one or more objectives
3. Developing a prioritized list

See example: DTE Electric Company’s 2021 Distribution Grid Plan, pp. 82-90; https://mi-psc.force.com/sfc/servlet.shepherd/version/download/068t000000Uc0pkAAB.

Illustrative Value-Spend Efficiency Method

<table>
<thead>
<tr>
<th>Specific Projects</th>
<th>Planning Objectives Ranked (1-5)</th>
<th>Score</th>
<th>Cost ($mm)</th>
<th>Spend Efficiency ($/C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tree Trimming</td>
<td>Safety (5)</td>
<td>5</td>
<td>$2.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Undergrounding</td>
<td>Service Compliance (5)</td>
<td>3</td>
<td>$5.0</td>
<td>2.8</td>
</tr>
<tr>
<td>Pole/Tower Hardening</td>
<td>Reliability (3)</td>
<td>3</td>
<td>$2.0</td>
<td>7.5</td>
</tr>
<tr>
<td>4kV Voltage Upgrade</td>
<td>Resilience (4)</td>
<td>4</td>
<td>$10.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Conversions</td>
<td>Electrification (3)</td>
<td>3</td>
<td>$2.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Substation Breaker</td>
<td>DG/DS Integration (3)</td>
<td>3</td>
<td>$2.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Replacement</td>
<td>Equity (4)</td>
<td>2</td>
<td>$3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>ADMS</td>
<td></td>
<td>1</td>
<td>$2.5</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Technology Adoption Timing Considerations

Required efforts to develop, demonstrate, test, and deploy new technologies are incorporated into an IDSP grid modernization strategy.

Operational Technology Development & Adoption Lifecycle

- Industry/Institutional Research (3yrs)
- Vendor Product Development (2yrs)
- Utility Lab Test & Demonstration (2yrs)
- Utility Business Case Development (1yr)
- Regulatory Decision Process (2yrs)
- Utility system-wide deployment (2-10yrs)

Software 2yrs – Field devices up to 10yrs
Example technology roadmap

<table>
<thead>
<tr>
<th>Project or Initiative</th>
<th>Near-Term (2023-2025)</th>
<th>Medium-Term (2026-2028)</th>
<th>Long-Term (2029-2032)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMI Meter Deployment</td>
<td></td>
<td></td>
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<tr>
<td>AMI Software</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Distributed Intelligence</td>
<td></td>
<td>Distributed Intelligence</td>
<td></td>
</tr>
<tr>
<td>FAN Deployment with Private LTE</td>
<td></td>
<td></td>
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<tr>
<td>FLISR</td>
<td></td>
<td>FLISR Potential Expansion</td>
<td></td>
</tr>
<tr>
<td>ADMS/GIS Model Enhancements</td>
<td></td>
<td>ADMS Upgrade and Enhancements</td>
<td></td>
</tr>
<tr>
<td>Grid Operating Technology Strategy</td>
<td></td>
<td>Integrated Grid Operating Technology Implementation and Integration</td>
<td></td>
</tr>
<tr>
<td>DERMS Strategy and Tech Assessment</td>
<td></td>
<td>DERMS Implementation and Integration</td>
<td></td>
</tr>
<tr>
<td>MDMS Upgrade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop FERC 2222 Deployment and Operations Strategy</td>
<td></td>
<td>FERC 2222 Implementation</td>
<td></td>
</tr>
<tr>
<td>Electric Vehicle Pilots</td>
<td></td>
<td>Electric Vehicle Infrastructure</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Energy Storage</td>
<td></td>
</tr>
<tr>
<td>Customer Experience Enhancements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Substation Upgrades and Additional Distribution Automation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- In Progress
- Potential Future

Source: Xcel Energy (2023)
Investments can be grouped under four key drivers:

1. **Joint and interdependent benefits** — core platform investments that are needed to enable new capabilities and functions in the distribution grid (e.g., distribution management systems)

2. **Standards compliance and policy mandates** — utility investments that are needed to comply with safety and reliability standards or to meet policy mandates for proactive investments to integrate DER (e.g., replacements and upgrades)

3. **Net customer benefits** — utility investments from which some or all customers receive net benefits in the form of bill savings (e.g., advanced metering infrastructure)

4. **Customer choice** — utility investments triggered by customer interconnection, opt-in utility programs, and customer-driven reliability improvements, paid for by individual customers (e.g., line extensions, hardening)

The investment driver points toward an appropriate cost-effectiveness evaluation method (right side of figure).

Source: Kahrl (3rd Rail) and de Martini (Newport)
Least-cost best-fit (LCFB) and benefit-cost analysis (BCA) are used in different situations and answer different questions.

**LCBF** – used for most distribution infrastructure investments and platform software investments

- Given that we want some functionality/capability on the distribution system or that we want to meet some safety, reliability, or regulatory goal, what is the lowest cost way to do so?

**BCA** – used for investments in advanced meters (often but not always), non-wires alternatives, utility resource procurement and programs

- Will an investment enhance welfare (benefits > costs) for all or a subset of customers?

There may be an overlap between BCA and self-supporting investments, which historically have been addressed through cost-sharing mechanisms (e.g., free footage allowances in line extension).

Source: Kahrl (3rd Rail) and de Martini (Newport)
Project vs. portfolio cost-effectiveness

Project cost-effectiveness is the first step to evaluate an overall distribution plan.

However evaluation of individual grid modernization projects is insufficient to determine whether an overall distribution expenditure plan is reasonable.

It is also necessary to consider whether the proposed portfolio of expenditures:

– Clearly addresses more than one identified statutory or regulatory objective
– Represents an integrated set of projects that are complementary
– Represents a set of projects that are part of a series of expenditures to address identified statutory or regulatory objectives
– Represents a prioritized set of expenditures given the urgency of grid needs that address identified statutory or regulatory objectives and utility financial and resource constraints
– Represents an optimized set of expenditures respecting customer affordability and equity considerations

Distribution expenditure plans require a multi-objective decision-making framework to evaluate these considerations.

The objective is to achieve the highest value per dollar expended – “value-spend efficiency”

Source: Kahrl (3rd Rail) and de Martini (Newport)
DTE: Objectives, Scenarios, Investments

Planning Objectives:
- Safe
- Reliable and Resilient
- Affordable
- Customer Accessibility and Community Focus
- Clean

Scenario Planning:
- Electrification
- Increasing CAT Storms
- DG/DS Adoption

Grid Investments:
- Analytics and Computing Platforms
- Observability and Controls
- Communications
- Infrastructure

Source: DTE DGP 2023
Scenario Analysis: DTE Distribution Grid Plan

Three scenarios were developed to analyze the range of potential impacts to the grid if one or multiple scenarios materialize.

Scenarios are driven by unique sets of drivers that are expected to impact the grid over the next 15 years and beyond.

Each scenario includes three components to determine the potential investments needed for the grid:
1. Plausible forecasts
2. Grid impacts
3. Signposts

While the Company invests in projects and programs that support individual scenarios, the greatest benefit is achieved by identifying investment opportunities across multiple scenarios.

Source: DTE DGP 2023
Grid Modernization Cost-Effectiveness Framework

Cost-effectiveness Methods for Typical Grid Projects

**Best-Fit, Most-Reasonable-Cost** for core grid platform and grid expenditures required to maintain or reliable operations as well as integrate distributed resources connected behind and in front of the customer meter that may be socialized across all customers.

**Benefit-Cost Analysis** for grid expenditures proposed to enable public policy and/or incremental system and societal benefits to be paid by all customers. Grid expenditures are the cost to implement the rate, program or NWA. Various methods for BCA may be used.

**Customer Self-supporting** costs for projects that only benefit a single or self-selected number of customers and do not require regulatory benefit-cost justification. For example, DER interconnection costs not socialized to all customers. Also, undergrounding wires at customers’ request.

Volume IV of the guide includes an economic evaluation framework for grid modernization investments.

- Aims to inform approaches to evaluating economics and managing costs and risks of grid modernization investments

No textbook approach — multiple reasonable paths to achieving the same broad goals
Questions to Ask

Have clear objectives been established in policy or regulation, or proposed by the utility?

What are the appropriate planning objectives and criteria for your distribution systems?

What is the utility’s grid modernization strategy and roadmap, and how will they meet state objectives?

What is the appropriate investment prioritization model recognizing multiple objectives and multiple benefits?

What level of oversight and transparency is required to facilitate stakeholder buy-in and ensure objectives are achieved?

How does the plan address uncertainty in the pace and scope of change — e.g., in technologies and policies — over the planning period, and how do the grid mod strategy and roadmap address the needs?
Contact

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