Identifying Grid Needs and Evaluating Investment Options

DOE Clean Energy Innovator Fellows Training

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November 14, 2024

Agenda

Mapping technologies to objectives

Planning objectives

Utility budgets

Investment prioritization

Cost-effectiveness methods

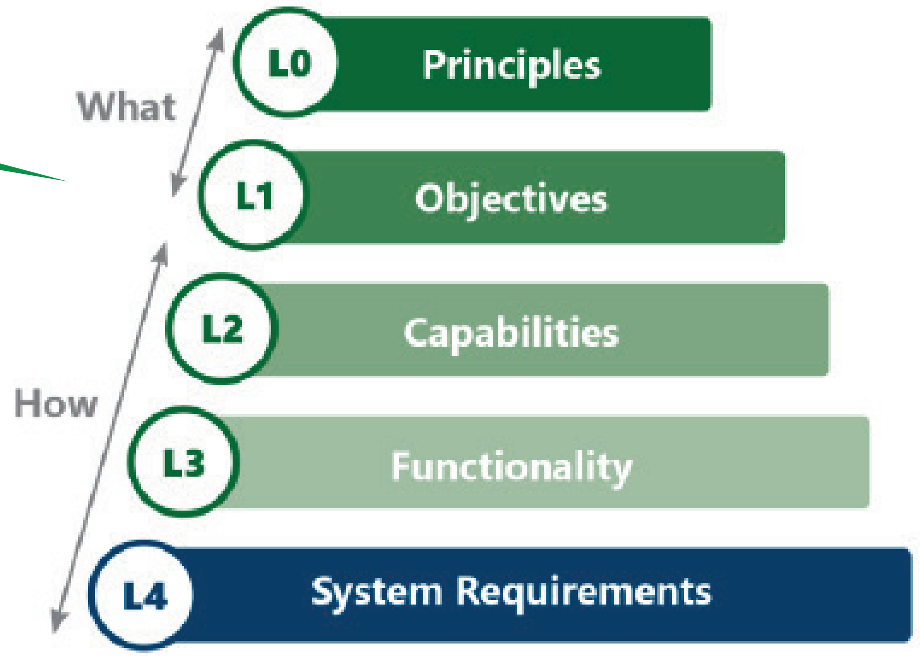
Questions

Grid Modernization Strategy & Implementation Planning

Objective: An envisioned or desired result or outcome

?

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



Source: *Modern Distribution Grid Guidebook, Strategy & Implementation Planning Guidebook*, Version 1.0 Final Draft, DOE Office of Electricity, June 2020; [Modern-Distribution-Grid_Volume_IV_v1_0_draft.pdf (pnnl.gov)]

Mapping Technologies to Objectives: Reliability

Objective	Capability	Function	Technology
Reliability improvement by reducing customer unplanned outage durations Achieve 2nd quartile CAIDI performance by 2025	Improve outage identification and customer service restoration	Fault Identification Fault Location Fault Isolation Service Restoration	Fault Current Indicators Outage Notification from Meters Outage Management System Geospatial Information System Distribution Management System and/or SCADA Automated Switches Work Management System

Source: *Modern Distribution Grid, Volume I: Customer and State Policy Driven Functionality, DOE, 2017;*
https://gridarchitecture.pnnl.gov/media/Modern-Distribution-Grid_Volume-I_v1_1.pdf

Investment Categorization

Cost

- **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)

Poll

Grid technology (modernization, IT, etc.) typically accounts for what fraction of the utility budget?

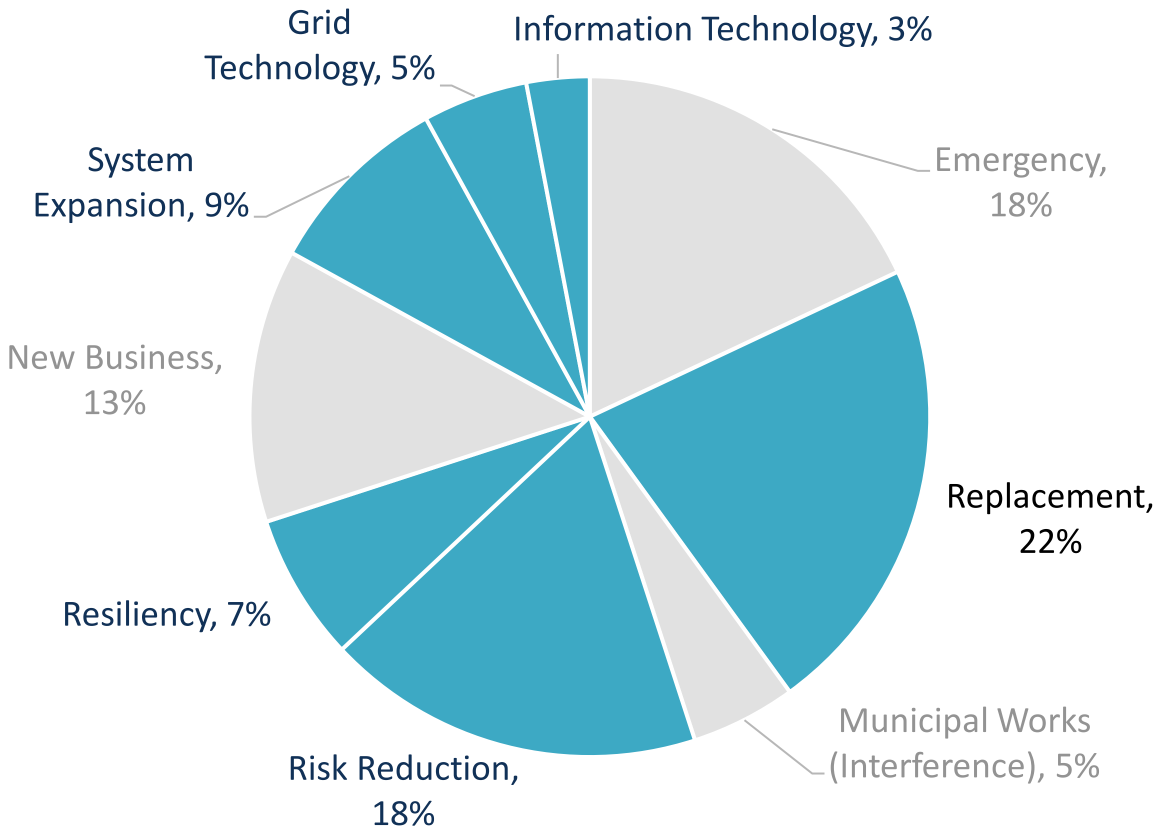
1) 0-3%
2) 3-10%
3) 10-20%
4) 20-40%
5) 40-60%

Utility Budgets: Discretionary vs Non-Discretionary

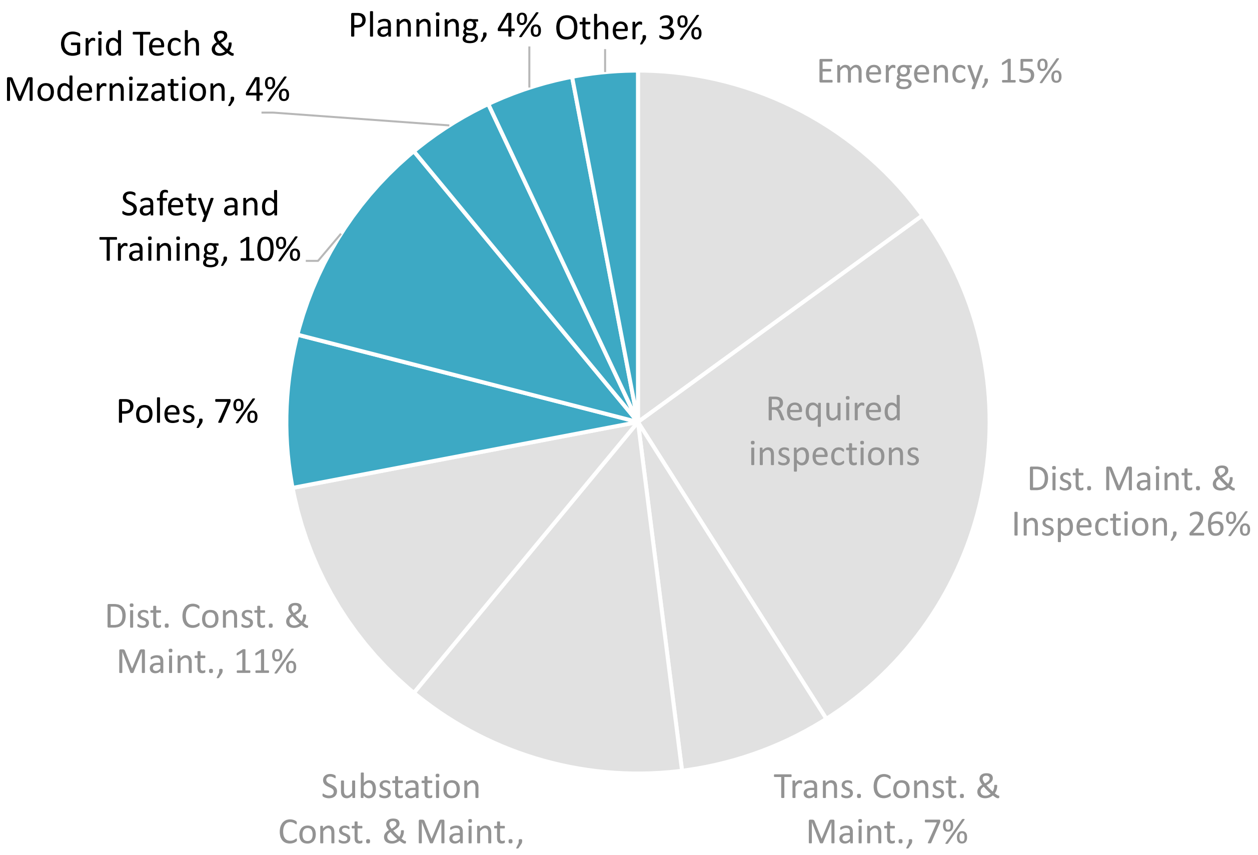
Cost

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

Capital



Operations and Maintenance



Development of Multi-Objective Distribution Plans

Integrated distribution planning develops prioritized and optimized multi-year distribution plans.

Determine Grid Need
Assess grid health, resilience risks, customer load and DER growth needs

Identify Potential Solutions
Develop grid & non-wires solutions that address more than one objective

Evaluate C-E of Potential Solutions
Assess cost-effectiveness of grid & non-wires solutions

Develop Multi-year Plan
Prioritize & optimize expenditures with given financial and resource constraints

Planning Objectives

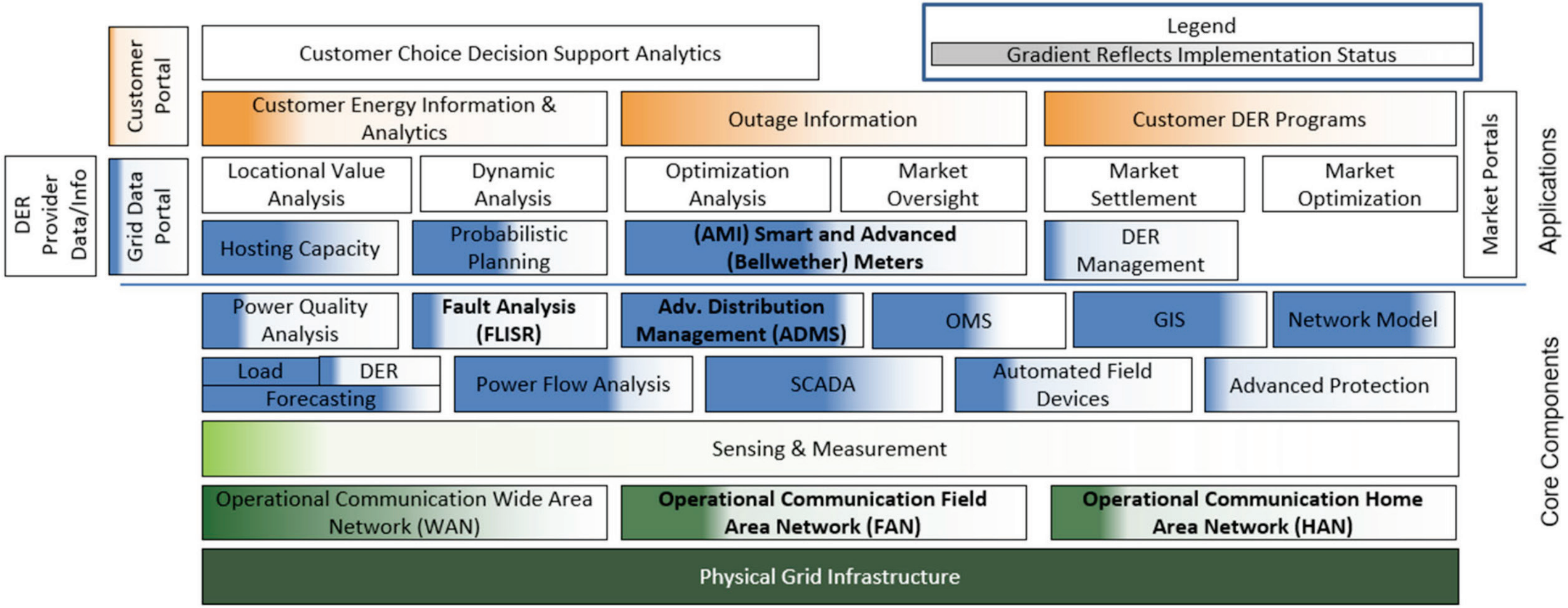
- **Improve Asset Health & Safety**: Address asset conditions that lead to failure
- **Improve Reliability**: Reduce frequency & duration of outages
- **Increase Capacity**: Expand capacity to address load growth & DER adoption
- **Improve Resilience**: Address climate threat risks to critical grid infrastructure
- **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

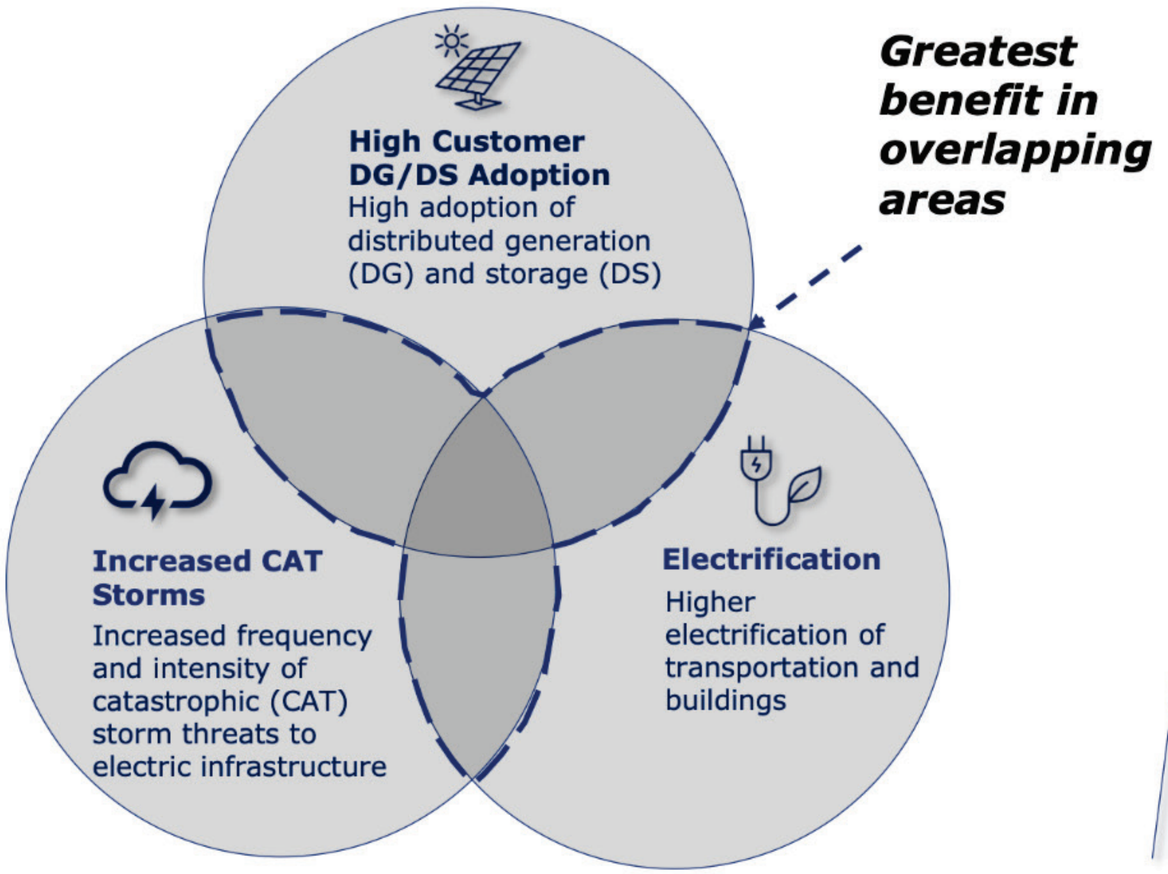
- Determine the status of current tools and capabilities
- Track progress in each area and identify where investment is most needed
- Grid modernization status provides a gap analysis according to functionality and capability
- Next: Prioritize investments delivering joint and interdependent benefits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

Xcel Grid Modernization Status (2023)



Source: Xcel Integrated Distribution Plan 2023

Scenario Analysis



- 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

Prioritizing Utility Investments

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

Steps:

1. Ranking planning objectives with 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

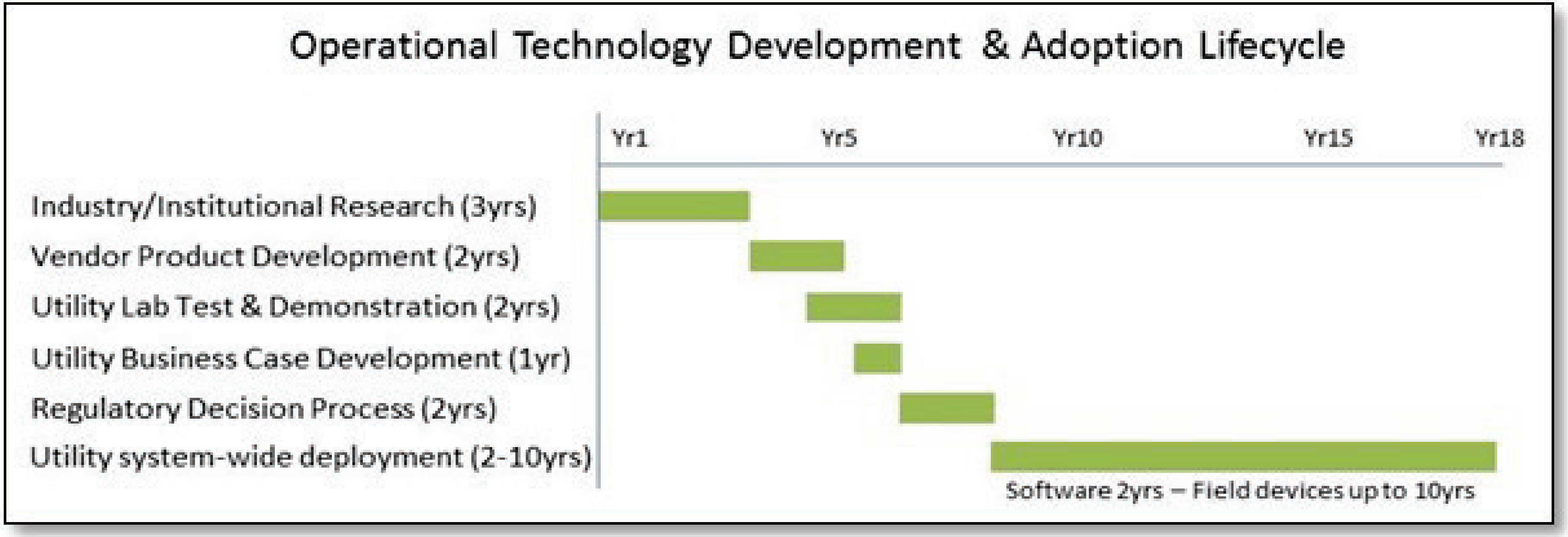
	Planning Objectives Ranked (1-5)									
Specific Projects	Safety (5)	Service Compliance (5)	Reliability (3)	Resilience (4)	Electrification (3)	DG/DS Integration (3)	Equity (4)	Score	Cost ($mm)	Spend Efficiency (S/C)
Tree Trimming[1]	5		3	3				11	$2.5	4.4
Undergrounding[2]	3		3	4	1	1	2	14	$5.0	2.8
Pole/Tower Hardening	2	2	3	4			1	15	$2.0	7.5
4kV Voltage Upgrade Conversions	4	4	2	3	3	3	3	22	$10.0	4.5
Substation Breaker Replacement[2]	5	5	3		1	1		15	$2.0	7.5
ADMS		3	3	3	2	3	1	15	$2.5	6.0
Field Automation[2,3]	3	3	3	3		1	2	15	$3.0	5.0
Advanced Metering	1	2	2	1	1	3	1	11	$2.5	4.4

1. Improved reliability & resilience supports greater consumer reliance on electrification
2. If program involves using larger conductor or higher capacity equipment
3. Improved reliability and resilience of grid improves the availability for DER to provide bulk power & grid services

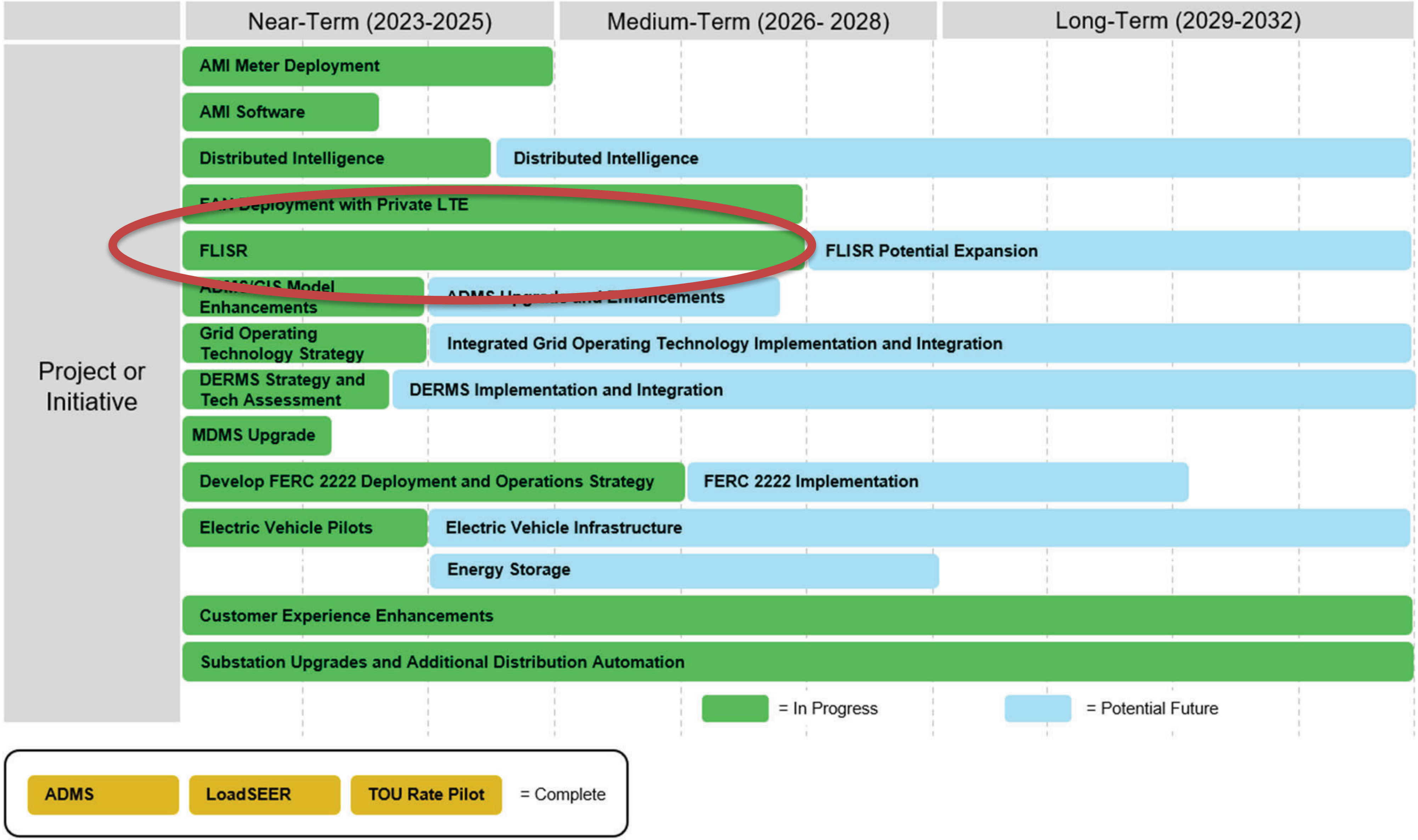
Source: Integrated Resilient Distribution Planning, by P. De Martini, J. Taft, A. De Martini, and M. Hall, PNNL-32883, May 2022. Available at: https://gridarchitecture.pnnl.gov/media/advanced/Integrated_Resilient_Distibution_Planning.pdf.

Technology Adoption Timing Considerations

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



Example Technology Roadmap



Source: Xcel Energy (2023)

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Example: Fault Location Isolation and System Restoration (FLISR)

Benefits

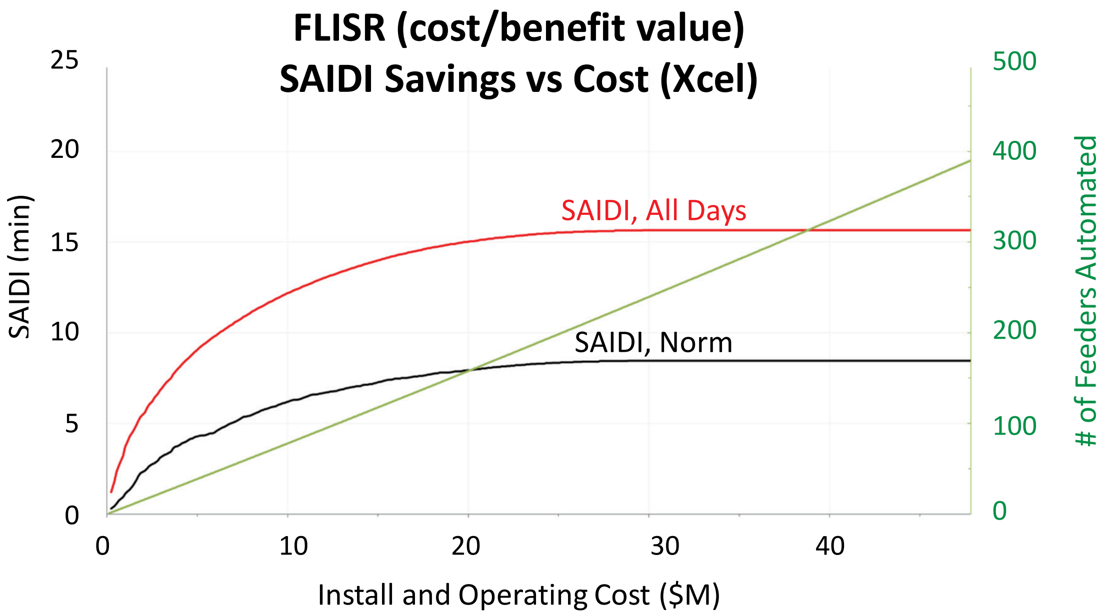
- Improve reliability - Two-thirds reduction in the number of customers who experience a sustained outage because of a fault

Phased Deployment

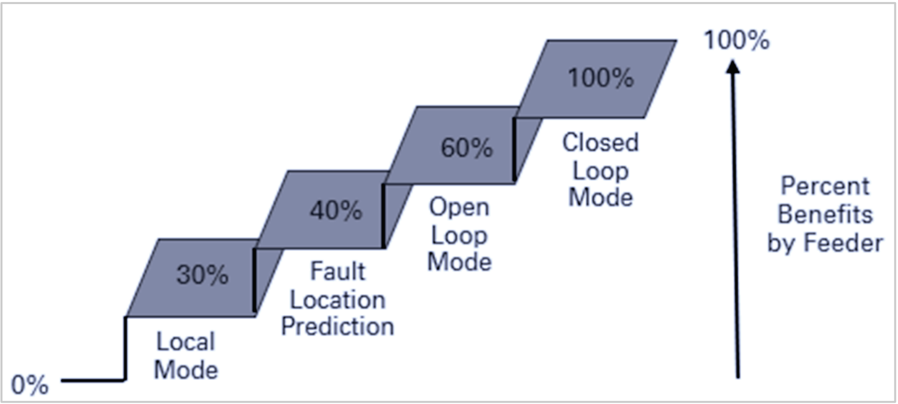
- Deployed on ~200 feeders over 5 years, focusing on lower reliability performance and/or circuits with existing field devices
- Phased functionality: Local mode, fault location prediction, open loop, closed loop

Challenges in quantifying benefits

- Sustained outage indices (SAIDI, SAIFI) might improve while performance of momentary outages (MAIFI) declines
- Customer average interruption duration index (CAIDI) performance might decline as shorter interruptions are mitigated



Phases of FLISR Functionality and Benefits (Xcel)

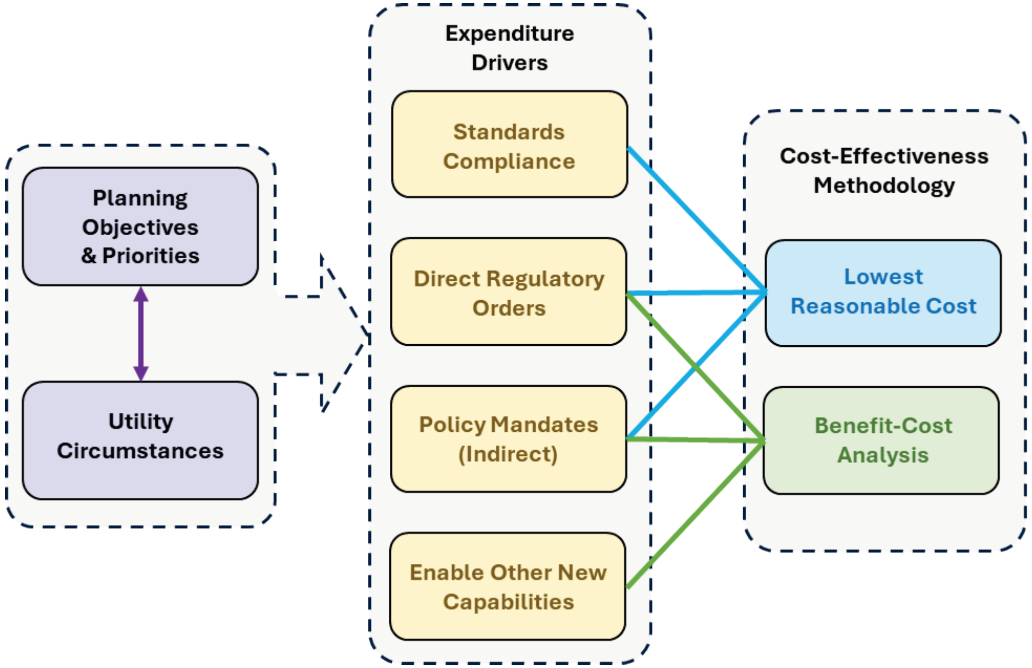


Source: Xcel Energy (2023), Xcel Energy (2023)

Drivers and Cost-Effectiveness Evaluation Methods

Lowest reasonable cost

- A quantitatively focused method based on engineering or technology architectural analysis, or both, to discern the necessity and cost of a solution based on compliance with statutory requirements and explicit and implicit regulatory requirements identified in the distribution planning process
- Answers the question, *What is the lowest reasonable cost to meet a safety, reliability, or other statutory or regulatory requirement?*
- Requires clear alignment and supporting engineering rationale for meeting statutory and regulatory requirements
- Also applied to individual expenditures with interdependent relationships in which the full value is only realized when the interdependent components are all deployed



Benefit-cost analysis

- A quantitatively focused method based on monetizing the benefits and costs of distribution modernization expenditures over a defined time period
- Best used when the dollar value of the benefits of a distribution modernization solution is discrete and assignable, quantitatively measurable, and does not materially change with increasing or decreasing usage
- Answers the question, *Will a specific or interrelated group of grid expenditures enhance welfare (i.e., benefits > costs) for all or a subset of customers?*

Source: De Martini, Ball and Schwartz (forthcoming), *Economic Evaluation of Distribution Grid Modernization Expenditures: A Guide for Utility Regulators*

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)

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 state's 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?

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