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Utility Master Planning Guidelines

MINNESOTA STATE

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Introduction to the Guidelines

The Utility Master Planning Guidelines are intended to aid Minnesota State campuses in planning, creating, and communicating their overall strategic plans. This document supplements Minnesota State Comprehensive Facilities Plan, system policy and procedure.

This guidebook is required reading for any college or university campus and its vendors that are developing or updating the campus Utility Master Plan, as it will offer college and university staff, architects, engineers, and other vendors the necessary data, processes and deliverables needed to prepare a successful Plan. Please feel free to contact the system office if you have questions throughout the process.

We gratefully acknowledge the work of LHB Corp. in preparing these guidelines.

When is a utility master plan recommended?

While utility master planning can be useful for all campuses, it is critical for campuses with aging infrastructure that may no longer be able to meet current and future service needs, whether due to problems with the existing systems, anticipated changes in the campus's load profile, or misalignment with sustainability and resilience objectives.

Criteria that trigger the recommendation to complete a utility master plan include, but are not limited to:

New Buildings – A new building or renovation of greater than 50,000 gross square feet to be built in the next five years as identified in the Comprehensive Facilities Plan

Demolition/Mothballing – The decommissioning (either demolition or mothballing) of a building or portion of a building greater than 50,000 gross square feet to take place in the next five years as identified in the Comprehensive Facilities Plan

Temporary Energy/Water System Failures – Energy or water system failures within the last five years resulting in an unplanned loss of heat, power or water for one or more on-campus buildings for a period of greater than one hour

Catastrophic Energy/Water System Failures – Energy or water delivery system failures (e.g. transformer or switchgear failures, tunnel collapses, ruptured pipes) within the last five years resulting in property damage or injury

Equipment/System Condition – Verbal or written acknowledgement within the last five years that key equipment and/or delivery system components are either nearing their end-of-life or are otherwise unsuited to meet the campus's integrated planning, sustainability, environmental health and safety, and resilience goals

Shifting Objectives – Verbal or written conversations within the last five years proposing changes to energy sources, storage and/or delivery (e.g. shifting to cogeneration, shifting from fossil fuels to renewables, adding significant on-site sources of renewable energy, reducing or increasing the number of electrical transformers on campus)

Updates to Utility Master Plans

A five-year updating cycle has been established for comprehensive facilities planning, and the same cycle applies to utility master planning to maintain short-term and long-term vision and planning for campuses in conjunction with the Comprehensive Facilities Plan updates. Campuses are encouraged to complete updates as often as they like within the five-year timeframe, although a Plan is not considered "approved" until presented to system staff and approved by the system's Vice Chancellor/Chief Financial Officer.

Under some circumstances, it may be necessary to defer the Utility Master Planning update process, such as when there is:

- A significant change in institutional leadership (e.g. a new president)
- A significant change in the institution's accreditation, mission or direction
- Insignificant changes to the institution's Comprehensive Facilities Plan
- A major change that is inconsistent with the currently approved Comprehensive Facilities Plan

Overview of Utility Master Planning

The utility master planning process develops a road map to ensure that utility systems can reliably and efficiently serve the campus's current and future service needs. The process includes evaluating existing utility system conditions, understanding future service needs, evaluating options for meeting these future needs, and articulating an implementation plan that can guide capital investment projects.

This process can help campuses:

- determine the capability of existing utility systems to serve future needs
- determine efficient and cost-effective ways to meet expected campus needs
- determine the magnitude, cost, and timing of needed campus utility projects
- develop institutional support for needed projects
- create a capital investment plan for needed improvements to the campus utility infrastructure

The scope of utility master planning efforts at Minnesota State colleges and universities will vary based on campus needs. Each Utility Master Plan will provide a broad overview of each service provided to the campus – including electrical power, heating, cooling, gas, domestic water, fire water, irrigation, sanitary sewer, storm sewer, compressed air, and standby/emergency generation systems. Additionally, each campus will identify systems that would benefit from an in-depth analysis. On a case-by-case basis and for certain utilities, a simplified approach or a limited study may be appropriate; please contact the system office to discuss this option.

Expected outcomes include documentation of the basic information needed to effectively manage existing utility systems and a proposed implementation plan for future utility projects. In addition to major projects that require capital investment, the implementation plan is expected to include immediately actionable, low-cost strategies that result in operational cost savings.

In addition to protecting mission-critical services, taking a comprehensive and intentional approach to utility planning enables system efficiencies that can minimize operational costs and play a key role in sustainability efforts.

Guiding Principles

The following principles shall be used when preparing a utility master plan.

Integrated Planning:

Colleges and universities shall use an integrated planning approach when establishing a utility master plan, taking into account the academic, technological, facility and financial needs and objectives during utility master planning efforts. According to the Society of College and University Planning, integrated planning is meant “to engage the right people in the right conversations at the right time in the right way” to produce plans that are actionable and realistic.

Additionally, an integrated planning approach optimizes the relationships between systems to achieve greater efficiencies than would be possible by examining each system in isolation.

Sustainability:

Colleges and universities shall prioritize changes that result in improved sustainability, with a focus on energy, carbon, and water reduction. Colleges and universities considering a shift in energy sources shall evaluate and prioritize renewable energy sources and energy storage solutions and should include expected changes to the carbon intensity of electricity generation as a factor in decision-making. Colleges and universities shall include strategies on how they intend to adhere to external sustainability commitments.

Reuse:

Colleges and universities shall prioritize the reuse of existing utility infrastructure before considering any recommendations regarding new infrastructure.

Environmental Health and Safety:

Colleges and universities shall prioritize changes that result in improved environmental health and safety, such as removal of malfunctioning, obsolete, or non-code compliant energy and/or water storage and delivery systems and fixtures.

Resilience:

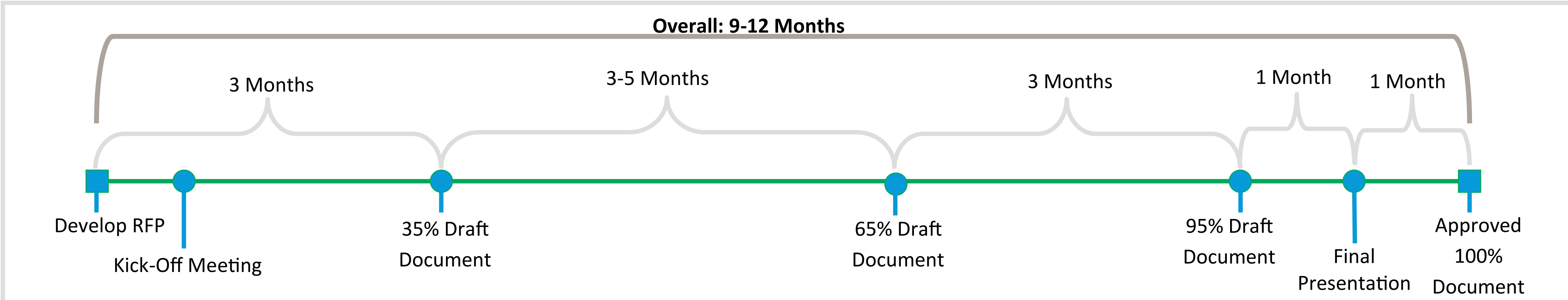
Colleges and universities shall prioritize solutions that can maintain mission-critical system services in the event of short-term shocks (e.g. natural disaster, power outage) and long-term stressors (e.g. increased outdoor temperatures, increase in rain events, fuel cost volatility).

Energy, Carbon and Water Reduction Goals

Campus Utility Master Plans shall include strategies that will contribute to achieving Minnesota State’s energy, carbon, and water reduction goals:

- Energy Consumption: 30% reduction in consumption of energy per square foot by 2027 relative to a 2017 adjusted baseline
- Greenhouse Gas Emissions: 30% reduction of greenhouse gas emissions by 2025 relative to a 2009 calculated baseline
- Water Use: 15% reduction of water use by 2025 relative to a 2017 adjusted baseline

Utility master planning can contribute to these goals through strategies that reduce existing system inefficiencies (e.g. distribution losses), improve system efficiency (e.g. energy storage), improve component efficiency (e.g. low-flow water fixtures), and use less carbon-intensive energy sources (e.g. renewables).



Approximate timeline for the Utility Master Planning process

The Utility Master Planning Process

Defining the Scope

While a comprehensive Utility Master Plan addresses all the utility systems utilized on a campus, certain systems may benefit from a more detailed evaluation than others due to concerns specific to the campus. Before beginning the utility master planning process, Minnesota State colleges and universities must determine which utility systems would benefit from an in-depth evaluation.
For each service provided to the campus – including electrical power, heating, cooling, gas, domestic water, fire water, irrigation, sanitary sewer, storm sewer, compressed air, and standby/emergency generation systems – the following questions should be answered:

Does this system meet the campus's current needs? Consider the following:

- Have the current program needs placed undue strain on the utility system?
- Have there been system or equipment failures within the last five years?
- Is equipment not compliant with codes or environmental emissions regulations, or does it pose risks to health and safety?
- Is the campus lacking the complete, centralized, accessible, and current information about utility system components, layout, and conditions needed for management, maintenance, and planning purposes?
- Does the campus have concerns about system efficiency, environmental impacts, and/or service reliability?

Is this system expected to meet the campus's future needs, as described in the Comprehensive Facilities Plan, with minimal adjustments? Consider the following:

- Is equipment is nearing its end-of-life or in need of significant repairs or deferred maintenance?
- Is there sufficient capacity to accommodate the expected demand from academic programs?
- Are significant changes needed to bring the system into alignment with changes outlined in the Comprehensive Facilities Plan?
- Does the system support the campus's long-term sustainability and resilience goals?

If the answer to either of these two questions is "no" or "we don't know," a detailed analysis of the system should be included in the scope of the Utility Master Plan.

When defining the planning scope, it is important to also recognize the potential for optimization across different systems. For example, although the responses to the questions above may indicate that the campus heating system is the only one that will not meet future campus needs, looking simultaneously at heating, cooling, and power may reveal opportunities to maximize efficiency – through strategies like cogeneration and energy storage – that would not have been evident when analyzing one system in isolation. Similarly, some campuses may benefit from integrating chilled water and fire protection system planning. On a case-by-case basis and for certain utilities, a simplified approach or a limited study may be appropriate; please contact the system office to discuss this option.

Getting Started

Where practical, a college/university should coordinate the selection process to occur simultaneously with the Comprehensive Facilities Planning process.

- Before beginning the utility master planning process, the campus must establish the funding necessary to hire a consultant.
- Assemble a Utility Master Plan Task Force composed of campus administrative staff, sustainability champions, facilities management staff, and other interested stakeholders. This Task Force will participate fully in the planning process to assist the consultant and campus leadership in developing the plan.
- Develop the Request for Proposals (RFP) to solicit proposals from consultants. All campuses must use the RFP process to select a consultant, regardless of the anticipated consultant fee amount. The RFP should describe the full scope of the campus's expectations for the consultant, including thorough descriptions of any special studies or reports the campus requires as part of the Utility Master Plan.
- The system office will review the RFP prior to its official release and, if desired, provide a list of potential consultant firms for the campus to contact.

Selecting a Consultant

The campus (including the Task Force) and the system office review the consultants' proposals; the campus may opt to conduct on-site interviews with select consultants.

When selecting a consultant, cost remains an important consideration, but campuses are not obligated to select the lowest-cost proposal. We encourage campuses to focus instead on consultants' qualifications; it's important to select a consultant whose proposal demonstrates a willingness to adhere to the schedule established by the campus and whose areas of expertise align with the campus's unique needs or issues.

After the campus has selected a consultant, the system office can aid in finalizing the contract (or purchase order) as necessary.

Kick-Off

When a contract or purchase order is in place with the consultant, the campus should contact Capital Development staff to set up a Kick-Off meeting, which will include Capital Development, the campus's core team, and the consultant. At the Kick-Off meeting, the parties will discuss expectations (especially if it's the first time this particular consultant is working on a Minnesota State Utility Master Plan); discuss how to access the eBuilder and Sharepoint sites; and review forms, lines of communication, and the timeline for the Utility Master Plan document.

After the Kick-Off, the consultant works with the campus to obtain reference documents (see the Reference Materials list), conduct site visits and surveys, and facilitate meetings with the Utility Master Plan Task Force and other stakeholders. Information gathered from these meetings will shape the final Plan.

Developing the Plan

At the 35% and 65% draft stages, the system office reviews the draft Utility Master Plan document and provides feedback to the campus. The guidelines later in this document provide a detailed list of what must be included in the Utility Master Plan document at each draft stage.

Final Steps

The 95% draft document provides the campus and system office the opportunity to review the nearly-complete document and make adjustments prior to the presentation of the Plan at the system office.

Approximately 10 working days before the scheduled final presentation, the consultant and a campus representative review a draft of the presentation with the system office. The campus President, CFO, or other campus representatives (and the consultant, if desired) then present the final Utility Master Plan to the Vice Chancellor–Chief Financial Officer. After the presentation, the Vice Chancellor-CFO, on behalf of the Chancellor, will issue a letter either approving the plan or requesting that revisions be made prior to final approval. A Utility Master Plan is not considered "approved" until presented to system staff and approved by the system's Vice Chancellor/CFO.

The campus and consultant then finalize the Utility Master Plan document and submit the 100% final version to the system office.

Responsibilities

Task	Campus	Consult.	System Office
Getting Started/Selecting a Consultant			
Gather participants/stakeholders; form task force	x		
Create draft RFP	x		
Review RFP	x		x
Send RFP to consultants or release publicly	x		
Review consultant proposals	x		x
Consultant interviews (optional)	x	x	x
Select consultant and sign contract	x		
Developing the Plan			
Participate in kick-off meeting (conf. call)	x	x	x
Provide reference materials	x		x
Site visits, review existing conditions		x	
Meetings w/ committee, stakeholders, community groups	x	x	
Develop document drafts (35%, 65%, 95%)		x	
Review 35% draft	x		x
Review 65% draft	x		x
Final Steps			
Review 95% draft	x		x
Review draft presentation (conference call)	x	x	x
Revise presentation, prepare for final presentation	x	x	
Final presentation to Vice Chancellor/CFO at system	x	x	x
Update/revise document as required, following presentation		x	
Submit final 100% Utility Master Plan	x	x	
Upload final document to system office SharePoint			x
Upload final document to campus website	x		

Utility Master Plan Formatting Requirements

35%, 65% and 95% submittals:

- Submittals of plans at the 35%, 65%, and 95% review stage shall be in electronic (.pdf) form, unless otherwise specified
- Electronic form means a high quality publishable .pdf file that includes all page numbers and relevant exhibits and attachments; photos and illustrations in a high quality, reproducible format are required

For final (100%) submittals:

- 3-ring binder in 8 1/2” x 11” format AND a publishable quality .pdf
- All pages numbered by section (except Front Matter, Tabs/Dividers)
- Sections to be separated by labeled tabs
- Binder to be labeled on front and spine with institution name; Utility Master Plan title; consultant firm name, name of primary contact, address, phone, and email; date of submittal.
- Font size no less than 10 points
- Entire document to be capable of clear black and white reproduction
- Site maps/plans to include campus identification, north arrow, graphic scale, and street names
- Floor plans/building maps to include campus or building identification, north arrow, and graphic scale
- Printing on both sides of the page is encouraged.
- Optional: provide the system office with base files used for creating graphs, diagrams, maps, and the final report (e.g. .indd, .xls, .ai, etc.) on a separate CD or thumb drive.

Utility Master Plan Document Section Descriptions

What follows are detailed descriptions of all sections that must be included in the Utility Master Plan document. For each section, you'll find a summary of the section goals and intent followed by a checklist of items to include in your Plan document.

Front Matter

A. Cover Letter #1 - Campus to the Associate Vice Chancellor

Addressed to the Associate Vice Chancellor for Facilities, from the Campus President. This letter outlines the major points and highlights of the Utility Master Plan.

B. Cover Letter #2 - Consultant to Campus

Addressed to the Campus President from the consultant, this letter verifies that the Utility Master Plan document meets Minnesota State Utility Master Planning Guidelines, and briefly describes the consultant's scope of work. This letter must be signed by a Minnesota-registered architect/engineer with accompanying registration number.

Checklist for Front Matter:

- Title/Cover Page
- Cover letter from campus
- Cover letter from consultant
- Table of Contents

Executive Summary

The executive summary provides a clear and concise summary of the document capturing the highlights from each section. It identifies the current state of the campus utility systems and describes the proposed capital investment. **This section should be written last.**

Checklist for Executive Summary:

- Summarize the plan's objectives and scope from Section 1.
- For each utility system included in the plan, summarize existing conditions, future needs, and recommended solutions described in Sections 2-4.
- Summarize the short-, medium-, and long-term projects identified in the implementation plan in Section 5.
- Highlight key impacts of the plan from Section 6.

Section 1: Objectives and Scope

This section defines the Plan's scope and objectives and provides an overview of relevant campus goals that will shape and inform the Utility Master Plan.

Checklist for Section 1: Objectives and Scope

- Describe the conditions that triggered the need for a Utility Master Plan.
- Describe the objectives for the Plan and define its scope.
- Identify campus goals that are relevant to utility master planning (e.g. energy and carbon goals as set forth in Board of Trustees Policy 5.17 and State of Minnesota Executive Order 17-12, goals set forth in campus Climate Action Plan, energy use intensity targets, renewable energy goals, etc.).

Section 2: Existing Conditions

This section provides an overview of the existing conditions of the campus's utility systems and assets. In addition to general descriptions of each utility service, it includes detailed studies of one or more specific utility systems, as defined in the Plan's scope. These detailed studies are informed by reviewing documentation of system components, site inspections, staff and utility provider interviews, and usage and utility bills and records. The section highlights issues to be addressed in the potential solutions analysis and implementation plan in Sections 4 and 5.

A. Campus Energy Profile

This subsection provides a comprehensive view of the energy used on campus. This can be used to identify areas with the greatest potential for improvement, whether through efficiency or decarbonization efforts. This section should present:

1. A breakdown of the percentage of total energy (MMBtu), energy costs ($), and energy-related carbon dioxide emissions (lbs CO_2) for each of the energy sources used on campus (e.g. electricity, steam, natural gas, etc.) for the last five complete calendar years
2. A table or graph of potential savings by energy source (in kBtu/year and $/year, as identified in B3 Benchmarking)
3. A comparison of the campus's total energy use intensity to that of other Minnesota State campuses. This can include all campuses or a self-identified peer group of 6 or more.
4. Current compliance with SB2030/B3 Guidelines (for applicable buildings), including metering requirements
5. Progress toward State of Minnesota ener-

gy goals

B. Campus Water Profile

This subsection provides a comprehensive view of the water used on campus, which can be used to identify areas with the greatest potential for improvement. This section should present:

1. A breakdown of the percentage of total water (gallons) and water costs ($) for each of the water uses on campus (e.g. indoor water, irrigation, etc.) for the last five complete calendar years
2. A comparison of the campus's total reduction in water use to that of other Minnesota State campuses of the same institution type
3. Current compliance with B3 Guidelines (for applicable buildings), including metering requirements
4. Progress toward State of Minnesota water conservation goals

C. Existing Campus Assets

This subsection identifies assets currently available to the campus that could be leveraged in the utility master plan. Assets may include components of the existing utility systems that have expansion potential, on-site or nearby energy sources (e.g. solar, wind, biomass, geothermal, waste heat), and even regulatory or financial conditions that incentivize certain strategies. Applicable assets from this section should be incorporated into the potential solutions analyzed in Section 4 as part of an integrated planning approach.

Checklist for Section 2: Existing Conditions

- Briefly describe how each of the following services are provided on campus: electrical power, heating, cooling, gas, domestic water, fire water, irrigation, sanitary sewer, storm sewer, compressed air, standby/emergency generation systems. Address proximity and connections to external utility services and include any relevant background information on campus history that led to the current configuration of utility systems. Note whether or not each service is expected to meet current and future campus needs.
- Site plan showing existing utility infrastructure. This site plan is also a requirement of the Comprehensive Facilities Plan.
- Campus Energy Profile
- Campus Water Profile
- List existing campus assets.
- Utility System Analyses – As applicable, include the following detailed analysis for each utility system defined in the Plan scope:
    - An overview of the utility system that documents: system type, service provided, extent, components, capacity, history, access, and metering infrastructure
    - A site plan showing system components
    - Current load profiles showing demand versus capacity for an average day in each season and under peak load conditions, broken down by building/area served to the extent possible.
    - Annual consumption, cost, and carbon emissions (if applicable), broken down by building/area served to the extent possible for the past five years or since the most recent Utility Master Plan.
    - A system evaluation that includes (as applicable): a configuration and condition assessment, a capacity/flow analysis, an assessment of system expansion or consolidation opportunities, an analysis of load reduction opportunities, and an analysis of system longevity, efficiency, fuel availability, resilience, sustainability, and maintainability.
    - A summary of utility system issues to be addressed in the potential solutions analysis and implementation plan in Sections 4 and 5.

Examples of Campus Assets

- Buildings with year-round cooling needs
- Room around a chiller plant for thermal storage
- A hill above the campus
- Gas below the campus
- Roofs for solar panel installations
- Waste heat recovery opportunities
- Waste paper obtained on the campus (as an energy source)
- An abandoned water reservoir
- A lake on campus
- Good wells on campus
- A river or canal nearby
- Perfected water rights
- An existing utility tunnel

From APPA, Campus Utility Systems Master Planning, 2017.

Section 3: Future Needs

This section describes future campus utility needs based on the projects identified in the campus's Comprehensive Facilities Plan.

Checklist for Section 3: Future Needs

- Summarize campus changes identified in the Comprehensive Facilities Plan.
- Provide a building load analysis by building and subsystems with a range of capacities (low-high) taking into account planned changes.
- Provide a prioritization matrix showing systems that need replacement due to anticipated obsolescence and other risk factors.
- Provide an analysis of the impact of anticipated campus changes on existing utilities, such as changes in load profiles and relocation requirements due to changes in academic programming, space conflicts, or expected alterations of campus space.
- Highlight issues to be addressed in the potential solutions analysis and implementation plan in Sections 4 and 5.

Section 4: System Options Analysis and Recommendations

This section describes and evaluates potential solutions to the issues identified in Sections 2 and 3. This should include an analysis of multiple options that considers life-cycle costs, environmental health and safety, resilience, sustainability, and other relevant topics. To the extent possible, rather than evaluating strategies in isolation, this analysis should reflect an integrated approach. For example, leveraging freely available resources such as solar energy or waste heat may cause a less efficient system to be the better option in terms of life-cycle costs and greenhouse gas emissions.

Common Issues

Common utility system issues include:

- Poor or trapped central plant location
- Inadequate distribution system for expansion needs
- Failing central plant or distribution mains
- Air emissions constraints
- Systems and/or distribution unsuited to current technology
- Deteriorating or undersized systems and equipment
- Inefficient plant or utility service with remaining useful life

From APPA, Campus Utility Systems Master Planning, 2017.

Proposed solutions should reflect the Guiding Principles of integrated planning, sustainability, reuse, environmental health and safety, and resilience. They should support the campus goals identified in Section 1 and, when applicable, incorporate the existing campus assets identified in Section 2. To the extent possible, the proposed solutions should include no/low-cost strategies that can be immediately implemented.

To provide a point of comparison, this section should also include an analysis of a "do nothing" scenario.

Checklist for Section 4: Potential Solutions

- Describe each issue to be addressed and include an analysis of one or more solutions. Each analysis should include:
  - Capital cost to implement and anticipated sources of funding
  - Life-cycle costs, using the guidance document provided by the Department of Energy Federal Energy Management Program and future fuel cost projections from the Energy Information Agency
  - Environmental health and safety
  - Resilience and reliability
  - Sustainability (including energy, carbon, and water goals)
  - Any other relevant topics (e.g. system longevity, system flexibility, maintenance requirements vs. campus maintenance availability and knowledge, current and projected fuel costs, fuel availability/curtailment, cost and availability of replacement parts, etc.)

Section 5: Implementation Plan

This section recommends solutions based on the analysis of the alternatives presented in Section 4, identifying and prioritizing which projects should be addressed in the short-term (0-5 years), medium-term (6-10 years) and long-term (10+ years) in order to best meet current and future campus needs and goals.

Checklist for Section 5: Implementation Plan

- Table or matrix listing and prioritizing all proposed projects by funding source. Include:
  - Project name
  - Timeframe (short-, medium-, or long-term)
  - Estimated project cost

        - Funding source (capital budget, campus R&R, HEAPR, revenue fund, GESP, other)
- Description of each proposed project, including:
    - Project description/scope
    - Narrative explaining rationale and campus impacts
    - Optional: conceptual design narrative

Section 6: Impacts

This section describes the expected impacts of the implementation plan presented in Section 5, and compares these impacts to a "do nothing" scenario.

Checklist for Section 6: Impacts

- Describe how the proposed implementation plan leverages integrated planning and reuse.
- In comparison to a "do nothing" scenario, describe the impacts of the overall implementation plan on:
    - Initial capital costs
    - Life-cycle costs
    - Environmental health and safety
    - Resilience and reliability
    - Sustainability (including energy, carbon, and water savings)
    - Any other relevant topics (e.g. maintenance requirements, fuel availability/volatility)

Solutions to Consider

Efficiency and conservation

Whether for energy or water, reducing demand through efficiency and conservation strategies is typically the most cost-effective and sustainable way to meet service needs. Focusing these strategies on peak demand – not just overall consumption – may offset the need for new peak capacity. Efficiency measures can be implemented at both the buildings scale (e.g. high-efficiency lighting) and the system scale (e.g. reducing the delta T of a district heating or cooling system).

Heat recovery

Waste heat is produced by equipment as a byproduct of doing work. Examples of equipment that generate waste heat include: electrical generators, servers, chillers, boilers, and kitchen equipment. Cogeneration, or combined heat and power, is one example of a heat recovery strategy. District heating and cooling systems can capture and redistribute much of this waste heat to help serve space or water heating needs. Understanding the heating and cooling profile of the campus will help uncover opportunities to move thermal energy to where it is needed.

Energy storage

By allowing energy to be used at a different time than it was generated, energy storage can more efficiently match supply to demand. Using thermal energy storage for district cooling systems is often a cost-effective option, since it can reduce the need for additional chiller capacity and lower the cost of generating chilled water, which can be done at off-peak hours. Energy storage can also increase the flexibility and reliability of systems using variable renewable energy sources such as wind and solar.

Hot water district heating

Hot water-based district heating systems are more efficient than steam-based systems. The lower temperatures of water-based systems result in cheaper heat generation, lower distribution losses, greater flexibility to integrate diverse energy sources and technologies, lower operations and maintenance costs, and greater flexibility for future changes. It is possible to convert steam-based systems into hot water systems without completely replacing the distribution infrastructure.

Solar

Solar energy can be used as a carbon-free source of electricity and thermal energy. In combination with energy storage elements, off-grid or islandable solar photovoltaic systems can contribute to system resilience by operating when the electric grid is down.

Heat pumps

Heat pumps exchange thermal energy with available air, water, or ground-based sources. This energy can be used for direct or pre-heating and cooling. This process is much more efficient than other options since it involves moving thermal energy rather than generating it.

Biomass

Fuel derived from biomass can be used to generate electricity, produce thermal energy, and fuel combustion engines or fuel cells. Common sources include: solid waste, agricultural byproducts, and other sources of organic waste. Biomass is a renewable energy resource and serves as both waste management and energy generation method when waste products are used.

Life-cycle Costs

When calculating life-cycle cost, consider:

First costs

In addition to the cost of the materials and labor, first costs should include ancillary costs such as engineering and commissioning fees and administration by campus staff. First costs should account for the ability of existing building components to interface with revised campus systems.

Maintenance and labor costs

The costs incurred over the lifetime of the installation should account for ongoing maintenance and labor, including any specialized maintenance requirements and the cost of replacement parts.

Fuel costs

Future fuel costs should be considered based on historic and projected future trends. Multiple scenarios should be tested for fuels that are subject to high price volatility.

Anticipated load profiles

Calculating the average system efficiency rather than using peak efficiency data will produce more realistic results.

System efficiency over time

Some types of equipment, such as photovoltaic panels, are expected to decrease in efficiency over time, so a degradation factor should be included in the life-cycle cost analysis.

Technological improvements

When periodic replacement of system components is included in the time horizon being evaluated, anticipated technological improvements should be considered. This is especially applicable for technologies that are experiencing rapid improvements (like photovoltaics).

Campus Resilience

Utility system design should be coordinated with overall campus resilience and emergency preparedness efforts. System resilience can be increased through redundancies, building designs that support passive survivability, and systems with the flexibility to incorporate different energy sources and technologies based on future needs and conditions. Examples of questions to ask when evaluating the resilience of potential systems include:

How will the system…

- Minimize service down-time due to the failure of any single component?
- Provide emergency services in the event of a crisis?
- Provide mission-critical services in the event of an external utility system failure?
- Adapt to changing energy and water economics, availability, climate conditions, and programmatic needs?

Section 7: Appendix

This appendix to the Plan includes supplementary information that supports the information presented in Sections 1-6 and allows others to accurately evaluate the master plan and its recommendations. Example appendices include: a glossary of definitions, B3 reports, meeting notes, utility records, utility rates, costs estimates, life-cycle cost calculations, a summary of system capacities, manufacturer information, quotations from vendors, etc.

Glossary

Campus: Throughout this document, campus will refer to the institution (college or university). Physical campus or campus site will be used to refer to an institution's individual campus locations, where applicable.

Cogeneration: Cogeneration, also known as combined heat and power (CHP), involves the generation of electricity and other energy jointly, typically capturing thermal energy that would otherwise be wasted.

Community solar gardens: Solar is the source of producing electricity. The garden is an array of solar panels owned by a developer who shares the saving with customer credit issued by a utility company. The gardens are also sustainable and can be looked at in your goals in energy production.

Passive survivability: Passive survivability refers to a building's ability to maintain critical life-support conditions in the event of an extended loss of power, heating fuel, or water.

Second Nature Climate Commitment: Presidents signing Second Nature's Commitment are pledging their institution to eliminate its contribution to global warming over time. This includes establishing an institutional structure to oversee the development and implementation of the school's program; completing an emissions inventory within a year and annually thereafter; establishing a climate neutrality action plan; taking some immediate steps to reduce greenhouse gas emissions; integrating sustainability into the curriculum; and making their climate action plan, inventory, and progress reports publicly available.

Renewable energy: Renewable energy is derived from sources that are replenished over short periods of time. Examples include: solar, wind, hydro, geothermal, biogenic fuels, and municipal solid waste. Using renewable energy sources can reduce carbon emissions and increase system resilience to external forces.

Useful life: Useful life presents the expected longevity of key utility system components, and is a key characteristic when calculating backlog and renewal forecasts. The useful life of a utility system component (such as distribution pipes, boilers, pumps) may have lapsed, indicating that it may need a replacement. fixed equipment, such as boilers, pumps, and other building systems. Under current system procedures, campuses are required to invest at least $1.00 per square foot annually for repair and replacement.