Facility & Infrastructure Strategic Investment Plan

Infrastructure Services Directorate
Project Management Office

FACILITY & INFRASTRUCTURE

STRATEGIC INVESTMENT PLAN

Infrastructure Services Directorate

Argonne National Laboratory

9700 S Cass Avenue

Building 214

Lemont, Illinois 60439

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Karen Hellman

IS Senior Director

Jason Budd

PMO Division Director

Catherine Hurley

Strategic Planning & Sustainability Program Manager

Jill Ptak

Campus Planner

I. INTRODUCTION

PLAN MISSION

Argonne National Laboratory is a multi-discipline science and engineering research-focused U.S. Department of Energy Office of Science (DOE-SC) laboratory. It is one in the complex of ten national science laboratories and 17 total Department of Energy laboratories across the country. Argonne is managed and operated for the DOE by the University of Chicago under a performance-based contract.

Argonne's mission is to serve the United States as a science and energy laboratory distinguished by the breadth of its R&D capabilities in concert with a powerful suite of experimental and computational facilities.

Argonne serves DOE by advancing the frontiers of knowledge, creating and operating leading edge scientific user facilities and providing innovative and effective tools and solutions to the grand challenges of our time: for sustainable energy, a healthy environment and secure nation.

Argonne's facility and infrastructure vision is shaped by the research goals and service mission of the Laboratory, which guide the physical development of the campus. This plan complements and expands upon the Annual Laboratory Plan content on infrastructure.

Few constraints exist to expanding Argonne's role in twenty-first century research. The physical site at Argonne is relatively unencumbered by serious environmental or contamination legacies and has available land and utilities to support mission adaptation and developmental change. Modernizations of existing facility infrastructure to meet the needs of emerging scientific missions and the mission support operations are key challenges for Argonne.

PLAN GOAL

The Facility and Infrastructure Strategic Investment Plan (Plan) is a structured, ten-year outlook for site modernization and outlines Argonne National Laboratory's strategy to both revitalize existing and construct new facilities and infrastructure that will meet current and emerging scientific needs.

Leveraging the Plan as a resource to guide facility and infrastructure investments will help to prepare for the laboratory of the future. Argonne recognizes that aging facilities and support infrastructure hurt its science competitiveness and impact on the world stage.

Section II of this plan documents the existing conditions of Argonne's facility and infrastructure assets, establishing the baseline for which planned repairs, rehabilitations and modernizations are needed over the next ten plus years. It outlines resources required to achieve the Plan's goals to support the vision of Argonne and DOE. Section III documents prioritized needs, choosing timing and sequencing of actions to align with the mission and leverage resources available for execution.

Update Schedule

This plan builds on and consolidates the former Site Modernization Plan and Ten Year Site Plan. The first edition of the Facility and Infrastructure Strategic Investment Plan was issued in 2016. Subsequent plan updates will be published to the Argonne website as they are made. The Plan is envisioned for an update cycle as necessary, to document changing facility conditions and emerging science priorities.

Our vision for the future is driven by a foundational goal of resilient, sustainable facilities and infrastructure to enable mission readiness.

SUPPORT OF CORE CAPABILITIES

DOE-SC identifies 24 core capability categories that encompass the scientific and technological foundation of its national laboratories. Core capabilities are used to articulate the niche in which Argonne distinguishes itself from other national laboratories in the DOE complex. DOE-SC uses three criteria to define a laboratory's core capabilities: they must a) encompass a substantial combination of facilities and/or teams of people and/or equipment, b) have a unique and/or world-leading component, and c) be relevant to a discussion of DOE missions, as well as those of the Department of Homeland Security and National Nuclear Security Administration.

To maintain Argonne's role as a national leader in these areas of fundamental basic science, applied science and engineering, modern facilities and infrastructure are required.

The DOE-SC has recognized Argonne for having 18 of the 24 possible core capabilities. These include:

- Accelerator Science and Technology
- Advanced Computer Science, Visualization, and Data
- Applied Materials Science and Engineering
- Applied Mathematics
- Biological and Bioprocess Engineering
- Chemical and Molecular Science
- Chemical Engineering
- Climate Change and Atmospheric Science
- Computational Science
- Condensed Matter Physics and Materials Science
- Cyber and Information Sciences
- Decision Science and Analysis
- Large-Scale User Facilities/R&D Facilities/Advanced Instrumentation
- Nuclear and Radio Chemistry
- Nuclear Engineering
- Nuclear Physics
- Particle Physics
- Systems Engineering and Integration

As a multi-programmatic laboratory, a single building may be identified as supporting several Core Capabilities. As represented in the Sankey diagram (Figure 1), this overlap creates challenges as the individual research may have unique facility and/or infrastructure requirements; however, the synergies and potential for discovery created by integrating various research areas are invaluable. As a result, facility and infrastructure investments made now, and in the future, include robust, modular designs that can support changing requirements and facilitate modern science.

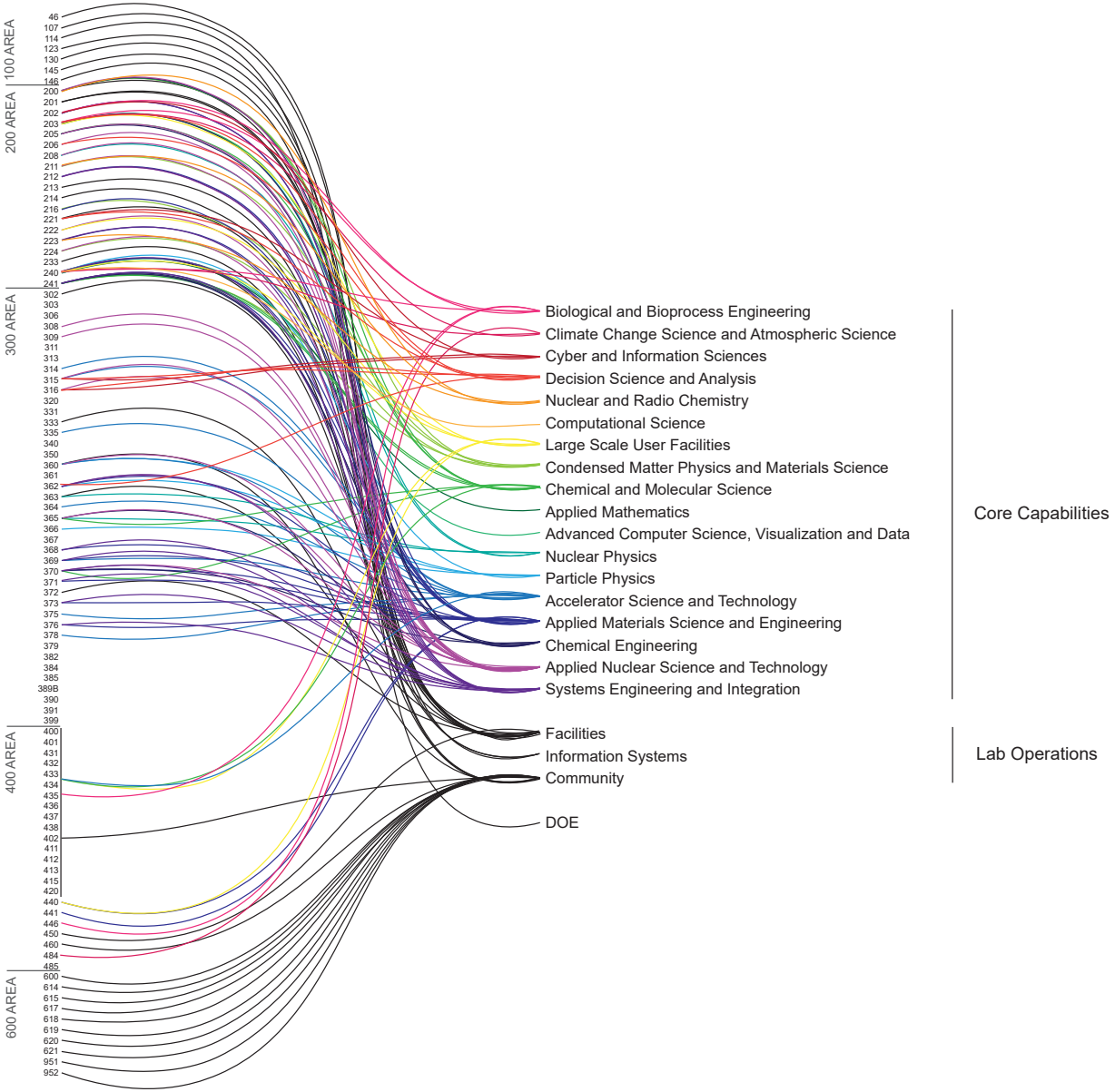


Figure 1. Core Capabilities by Building, FY16

Argonne's 18 core capabilities support vast amounts of research across the basic and applied sciences, from climate research to x-ray imaging and clean energy technologies. Various types of facilities support science from early bench-scale research to prototyping and fabrication. The Annual Laboratory Plan contains a complete description of Argonne's Core Capabilities.

Accelerator Science and Technology

Expertise includes the modeling, design and operation of photon sources in addition to the creation, acceleration and manipulation of high intensity stable and rare isotope ion beams. Key facilities include APS, ATLAS, and in the 300 Area, the Argonne Wakefield Accelerator.

Applied Materials Science and Engineering

Applied materials development and synthesis drives advances in clean energy science and manufacturing processes. Key facilities supporting applied and basic science include APS, CNM, ALCF, ESB, Materials Engineering Research Facility (MERF) and in the 300 Area, MTEM.

Applied Mathematics / Advanced

Computer Science, Visualization and Data / Computational Science

Argonne possesses recognized expertise in mathematical modeling, analysis, and algorithm development, implemented in scalable software for execution on the world's largest computing systems, including leading efforts in exascale

operating systems. Key facilities include ALCF, the Joint Laboratory for System Evaluation, and the Laboratory Computing Resource Center, all located in the 200 Area.

Biological and Bioprocess Engineering

Argonne is pioneering new approaches to biological and bioprocess engineering that combine synthetic biology and synthetic chemistry to create biomaterials with tuned, collaborative functionalities. Key facilities include the CNM, APS, and Advanced Protein Characterization Facility (APCF) in the 400 Area.

Chemical and Molecular Science/ Chemical Engineering

Argonne also possesses expertise in synthesis, characterization and control of molecules and chemical processes, with a focus on energy production and use. Key facilities include the APS, ALCF, the Cell Analysis, Modeling and Prototyping (CAMP) facility, Electrochemical Analysis and Diagnostics Laboratory (EADL), High Throughput Research (HTR) Laboratory and Midwest Transformative Energy Manufacturing (MTEM) Facility.

Climate Change Sciences and Atmospheric Science

Research advances have improved understanding of complex atmospheric and related soil

processes, from the molecular to the global level. Key facilities supporting this capability include the APS and the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) site in Oklahoma.

Condensed Matter Physics and Materials Science

This core capability advances the understanding of the foundational principles that link material complexity to function, tailors this functionality for applications, and designs and creates new materials. Key facilities include the Energy Sciences Building (ESB), APS, CNM, and ALCF.

Cyber and Information Sciences

Cybersecurity research advances the science in data analysis, energy resiliency, intelligent log analysis, authentication, infrastructure risk assessment, moving target defense, vehicle security, power grid cyber susceptibility, and technologies to increase resilience and improve national security. Key facilities include secure data centers and vehicle cybersecurity analysis centers in the 200 Area.

Decision Science and Analysis

Argonne is addressing pressing national challenges through innovative applications of agent-based modeling, complex adaptive system modeling, system dynamics, and complex network analysis. Facilities that support this capability include an immersive decision visualization studio and the ALCF, both in the 200 Area.

Large-Scale User Facilities / Advanced Instrumentation

State-of-the-art user facilities include the APS (Bldg 400-401), ATLAS (in Bldg 203), ALCF (in Bldg 240), and CNM (Bldg 440).

Nuclear and Radio Chemistry

Efforts are focused in chemical separations, nuclear chemical engineering, and the materials science of actinides, radioisotopes and the nuclear fuel cycle. Key facilities include the APS, ATLAS, ALCF, and two radiological facilities in Building 211.

Nuclear Physics

Key efforts supporting theoretical and experimental nuclear physics research work are located at ATLAS, which provides stable and radioactive ion beams at energies up to about 20 megaelectron volts/nucleon.

Nuclear Engineering

Argonne has pioneered nuclear energy systems and continues to advance systems to provide an abundant, sustainable, safe and secure energy source. Key facilities that support this capability include APS, ALCF, ATLAS, the Intermediate Voltage Electron Microscopy Tandem Facility (IVEM), and specialized test laboratories in the 300 Area.

Particle Physics

Particle physics research advances understanding of the properties and interactions of the particles making up the universe and the underlying symmetries of nature. Key facilities are located in the 300 Area of the Laboratory.

Systems Engineering and Integration

This core capability focuses on the development of experimental facilities and analytical tools to advance understanding of transportation, infrastructure, urban, communications, and other large-scale systems. Key facilities include the APS, Advanced Powertrain Research Facility (300 Area), Engine Research Facility (300 Area), and the Electric Vehicle Smart Grid Interoperability Center (300 Area).

PLAN CONTEXT

REGIONAL SETTING

Argonne National Laboratory is located in DuPage County, Illinois, twenty-five miles southwest of the downtown Chicago "Loop" business district. This location offers direct access to Interstate 55 and easy connections to the seven-county Chicago metropolitan area containing more than 8 million residents. Both the University of Chicago (U-Chicago) and Fermi National Accelerator Laboratory (Fermi) are within a 30-mile drive. Argonne is within 30 miles of two international airports, O'Hare and Midway, and is at the hub of the national interstate system (Figure 2). The areas adjacent to Argonne are developed, suburban residential communities (Figure 3).

Argonne leverages its valuable position within the Chicago region for enhanced collaboration with its industry and university partners to drive discoveries supporting the wide range of science performed at the Laboratory. Faculty collaborations with U-Chicago and Northwestern University, amidst other Chicago business partners, enrich the scientific programs, while strong connections with local and national industry partners support the transfer of new technology derived at Argonne to private sector innovation. These partnerships facilitate engagement, mentoring and other support for Argonne staff interested in entrepreneurship and companies interested in engaging with Argonne researchers and scientists.

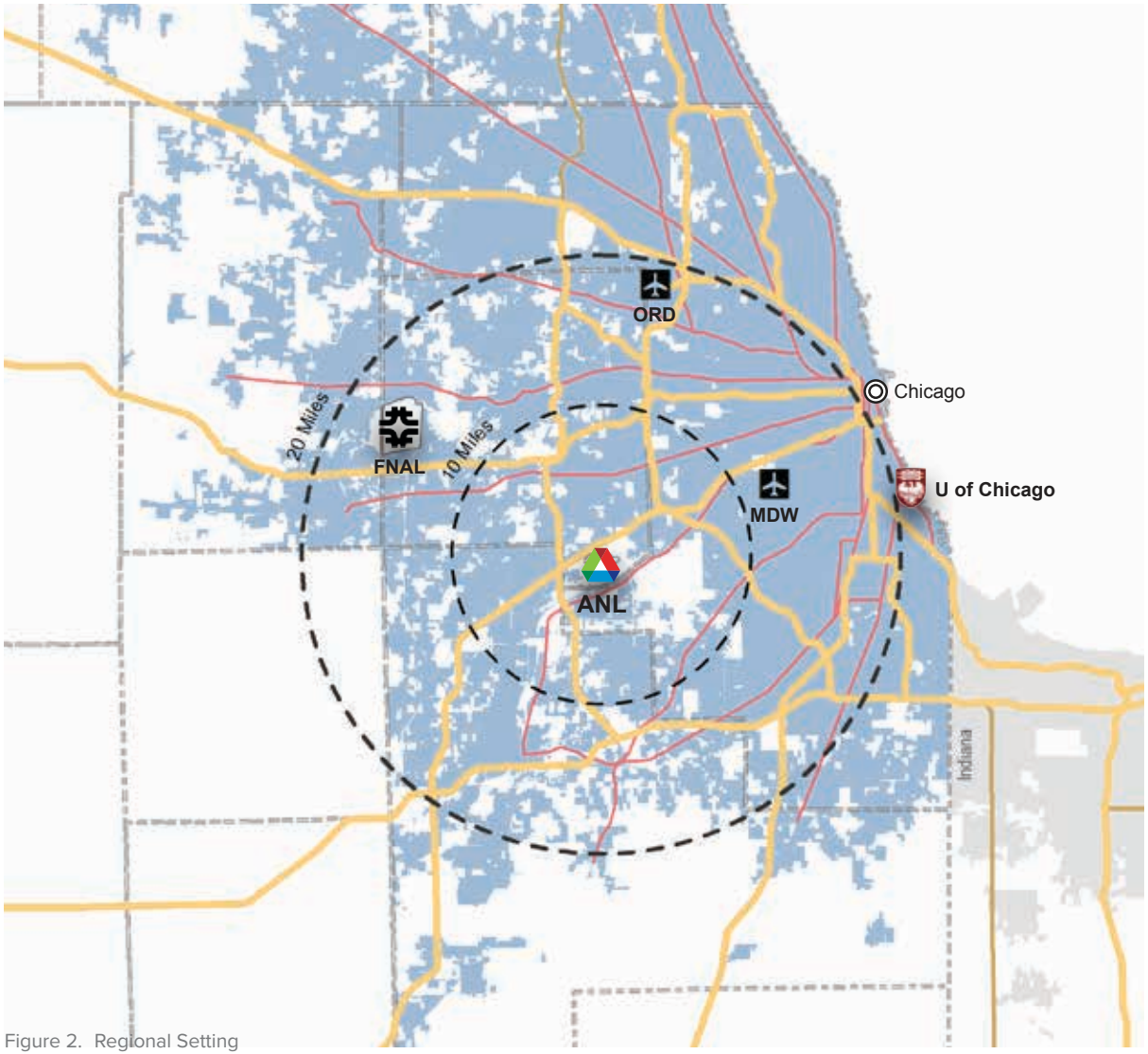


Figure 2. Regional Setting

Figure 3. Argonne Neighbor Communities

PLANNING PROCESS

This Plan draws on several sources of data and information. The primary data comes from various facility and utility condition assessments, performed annually by IS Building Maintenance, Utilities and other system engineers. Facility condition information is reported into the DOE's Condition Assessment and Information System (CAIS). This plan also uses data from the real property portfolio (FIMS) and the sustainability energy audits and retrocommissioning reports.

The Plan incorporates these infrastructure condition assessments with the goals of the Site Sustainability Plan, system reliability and redundancy analysis and scientific program priorities analysis. These items are cross-referenced with the Laboratory's campus strategies for modernization (page 16) to ensure consistency and alignment. Figure 4 provides a graphic representation of the planning process and interrelationship of various planning efforts.

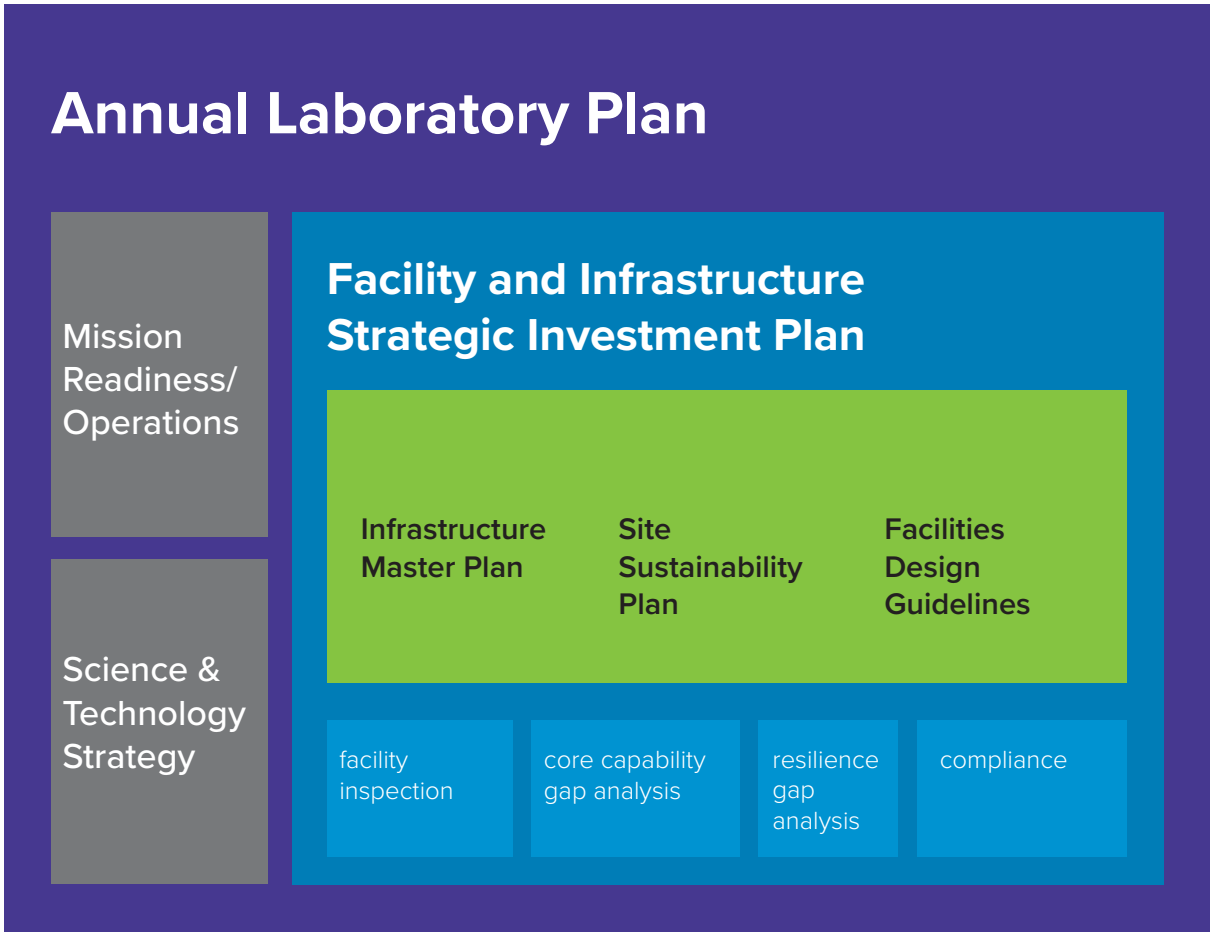


Figure 4. Planning process Inputs and plan relationship

BUDGET AND FUNDING

A successful campus infrastructure planning and modernization process aligns the right type of funding with the right type of investment. Optimizing the limited dollars available for facility improvements can require creative funding strategies and leveraging various sources as applicable. This requires creating a careful balance between laboratory priorities and funding. All financial and accounting practices must comply with the DOE Financial Management Handbook. Figure 5 represents the laboratory funding process.

Direct allocation

- Funded directly by the DOE
- Requires congressional approval
- Total project cost > $20 Million

Indirect allocation

Funded through laboratory overhead funds; facility support projects.

- **IGPP/IGPE:** Institutional General Plant Project / Equipment
  - Total estimated cost > $500,000 ≤ $20 Million
  - Multi-program benefit
- **LGB:** Laboratory General Benefit
- **MR:** Major Repair

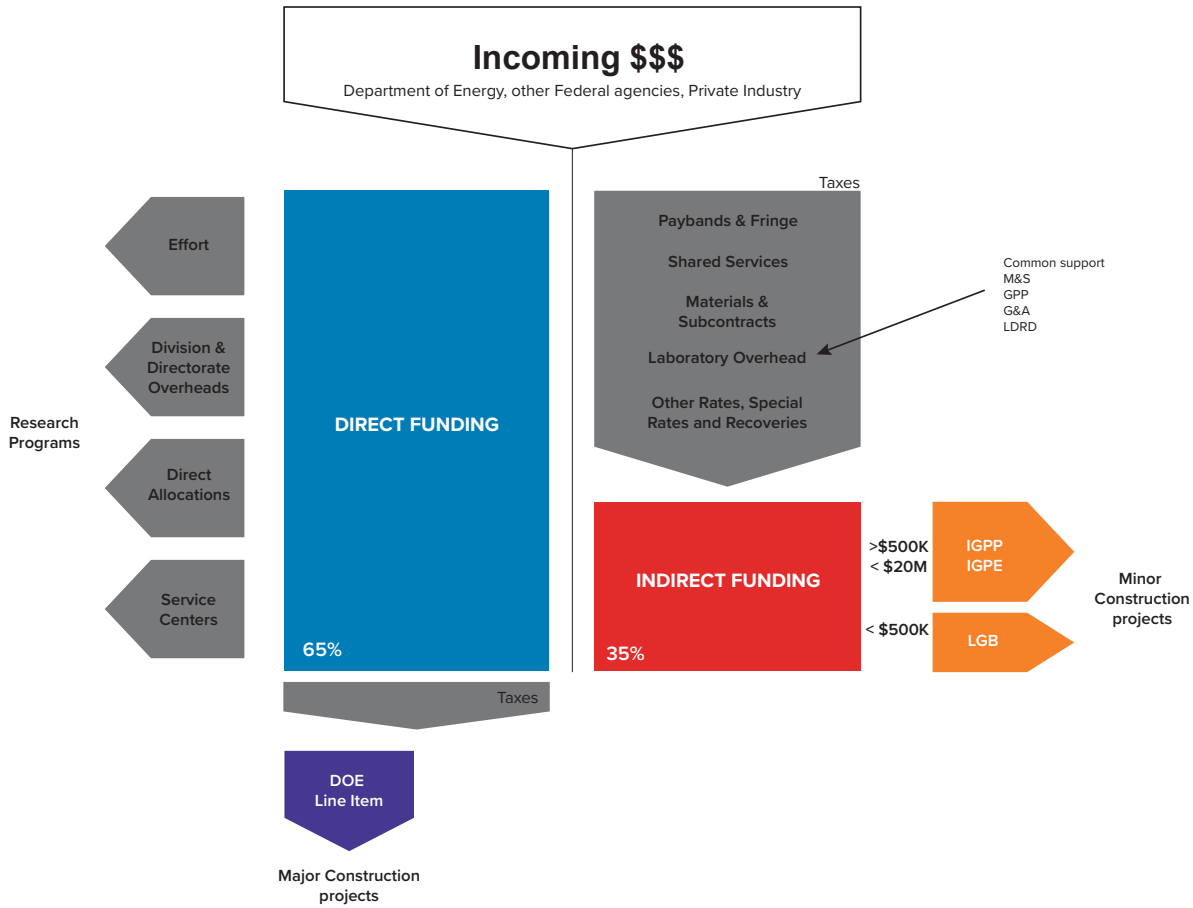


Figure 5. Laboratory funding overview

DEVELOPMENT FRAMEWORK

A development framework is a strategy for future growth and development, indicates a design direction and investment strategies to create a thriving physical campus for the Argonne Community. The framework promotes a process for campus development where decisions may change over time to adapt to the science and research strategy of the laboratory, but are always rooted in the campus strategy for modernization. Rooted in the strategy is data driven decision making to steer investments toward maximum reward.

CAMPUS STRATEGY FOR MODERNIZATION

The vision for the Plan is to provide a premier DOE laboratory that supports the Department of Energy mission and facilitates the advancement of Argonne's research. These goals include producing new fundamental knowledge about the physical and biological world; building on advances in computation and connectivity to meet national goals for sustainability and security; developing large-scale, forefront facilities and systems to support scientists and engineers across all disciplines; and increasing the impact of Argonne research by creating a world-class environment for discovery and innovation.

The emphasis on modernization reflects a comprehensive and executable approach for achieving and maintaining mission need. World-class research is enhanced by world-class work settings in the workplace itself and in the natural surroundings of the Laboratory campus. State of the art facilities strengthen Argonne's ability to attract the best talent available, increasing its capacity for enhanced discovery and innovation.

To achieve the Laboratory vision with respect to facilities and infrastructure, the following four strategies guide the overall infrastructure investment plan. Cross-cutting these four strategies are the foundational pieces of sustainability, resilience, and data-driven decisions.

1. Support Science Initiatives

Targeted investments to support mission-critical programs are a cornerstone of the campus infrastructure strategy. Examples include utility modernizations to meet demand needs for chilled water cooling and/or electrical power required to support upgrades to the Argonne Leadership Computing Facility (ALCF) and the Argonne Tandem Linac Accelerator System (ATLAS).

Other projects include providing support space through reutilization of the existing facilities, aligned with the shutdown schedule for the Advanced Photon Source (APS) upgrade project. New multi-user facilities, including the Argonne Clean Room and the Micro Assembly Facility, support multiple programmatic objectives and core capabilities, such as particle physics, condensed matter physics, and materials and applied materials science and engineering.

2. Replace Facilities And Renovate

Argonne maintains a rigorous process for assessing building and site infrastructure conditions to prioritize and implement repairs and upgrades to meet reliability and redundancy goals. The Laboratory is committed to reducing the identified deferred maintenance backlog, with an ultimate target of achieving the DOE-established Asset Condition Index (ACI) goals for "mission critical" and "mission essential" facilities.

To support modern scientific research, Argonne uses a combination of new facility construction with targeted renovation of existing facilities with favorable characteristics. This approach provides modern, flexible spaces to support today's research while providing the ability to adjust to changing needs as the science evolves. These efforts apply overhead investment to enable reuse of facilities that, although obsolete due to age, retain positive structural and space characteristics that promote modern scientific research. In parallel, new facilities such as the Materials Design Laboratory (MDL), funded by the DOE Scientific Laboratories Infrastructure (SLI) Office provide modern laboratory spaces and allow Argonne to vacate and ultimately demolish inadequate spaces.

3. Repair And Modernize Support Infrastructure

Specific investments include DOE General Plant Project (GPP) funding for electrical reliability upgrades to the 138-kV high voltage system in addition to water and sewer utility upgrades to improve substandard assets. Longer term plans support full electrical infrastructure redundancy and electrical capacity growth for the Argonne site through external power upgrades and construction of a secondary site power supply, both identified as future DOE-SLI line item projects.

4. Eliminate Legacy Waste And Excess Facilities

Removal of legacy waste and excess facilities is consistent with the DOE-SC goal of achieving an asset utilization index ratio of 1:1 for a utilization comparison of justified assets to current real property assets. The ratio also supports complex-wide DOE requirements for overall footprint reductions via space banking.

CAMPUS PLANNING PRINCIPLES

Planning principles are broad statements of a desired outcome that reflect the physical interpretation of the site modernization plan. The following guiding principles support Argonne's core capabilities and mission readiness and promote overall high-quality design.

Each planning principle is supported by objectives that describe specific actions to achieve the desired outcomes. These statements of principle blend both tangible and intangible characteristics to influence Argonne's physical form. Argonne practiced many of these principles in past planning. Continued application of the principles will build on Argonne's existing site modernization momentum and expand the implementation of excellent design solutions.

Development Program

Goal: *Modernize to revitalize and reshape existing and new facilities and infrastructure to meet the current and emerging needs for Argonne's scientific missions.*

Approach:

- Identify key mission-critical renovations and alterations.
- Develop a flexible program for new facilities that:
  - Provides efficient facilities and a safe working environment;
  - Identifies phasing and building disposal time frames, based on anticipated funding cycles;
  - Complements a well-defined move management and staff migration strategy.
- Recognize the holistic impact of supporting new facilities, while addressing infrastructure and utility modernization.

Development Pattern

Goal: *Seek a balance between increased building heights, closer building proximity, simplified but sufficient circulation networks, and open-space preservation to reinforce a range of pedestrian-oriented settings.*

Approach:

- Create a unique design vision and development guidance for each developed area.
- Redevelop and/or expand within previously developed areas.
- Accommodate flexibility and expansion of mission capabilities.
- Position new buildings for the purpose of solar management and energy efficiency and to avoid conflicts with existing utilities.

Visual Character

Goal: *Create well-designed Laboratory facilities that visually reflect leading-edge science.*

Approach:

- Reinforce visual continuity with design guidelines for buildings, site features, landscaping, utility system placement, and building identification.
- Create pedestrian scale open spaces and "hardscape" elements that take into account views and relationships between buildings.
- Create a hierarchy of streets that are visually pleasing, easy to navigate, and can accommodate multiple modes of transportation in a safe and consistent manner.
- Leverage the abundance of Argonne's natural environment by incorporating and encouraging the infusion of natural and indigenous elements into designs.

Circulation, Parking and Access

Goal: *Improve the access and movement of people, emergency vehicles, services and goods.*

Approach:

- Provide safe and efficient access for all able and disabled individuals.
- Create an easily understood wayfinding system that people can use easily to orient themselves and navigate from place to place.
- Develop standard street and road sections that incorporate safety recommendations for vehicular traffic, bicycles, and pedestrian circulation.
- Formulate a consensus for parking standards, addressing maximum walking distances, design, wayfinding, landscaping, and lighting.
- Provide sufficient lighting and landscaping to enhance the quality of the pedestrian experience and to create a safe walking environment.

Environment and Sustainability

Goal: *Implement proactive policies and procedures to achieve energy-efficient and environmentally responsible development and ensure that the requirements of Executive Orders are carried out.*

Approach:

- Achieve DOE's goals for energy and water reduction, renewable energy usage, and Guiding Principles for Federal Leadership in High Performance and Sustainable Buildings (HPSB) certification for construction.
- Minimize new and diminish existing environmental impacts.
- Respect environmentally sensitive areas, especially wetlands.
- Preserve natural open space to benefit biodiversity protection, storm-water management, and scenic value.
- Recognize the oak savanna and other high-quality, high-value vegetation habitats as special, defining characteristics of Argonne.

Safety and Security

Goal: *Protect employees and users, other site personnel, visitors, the public, and the environment from hazards and risks.*

Approach:

- Apply current security best practices related to anti-terrorism, setbacks, cyber security, and safety in all site and facility planning.
- Improve the operational and security functions at the gates and points of access.
- Eliminate points of vulnerability.
- Integrate security measures with mission, functional, and visual goals in mind.

Infrastructure and Utility Systems

Goal: *Continue modernizing Argonne infrastructure that directly supports Argonne's Core Capabilities, is critical to its missions, and will enable reducing deferred maintenance and eliminating excess space while providing a good return on investment.*

Approach:

- Reshape existing infrastructure to be more energy-efficient and sustainable, while meeting current and emerging science needs.
- Execute priority projects to increase capacity and rebuild infrastructure systems.
- Route utilities in a logical manner to avoid environmental impacts and operational disruptions and to allow easy expansion.
- Recycle and reuse utility system by-products and waste streams where advantageous.

II. EXISTING CONDITIONS

SITE

Three secure site entrances provide access to individuals with approved entrance badges. The west site entrance experiences the highest traffic volumes into and out of the Laboratory. The Main Gate, accessed from the north on Northgate Road, is the second most traveled. All visitors use the Main Gate entrance to obtain a visitor access badge from the Argonne Information Center (Bldg 224). Only the Northgate Road guard post is staffed 24 hours/day, 7 days/week. On-site truck traffic was permanently redirected to use the east entrance in 2014 to alleviate traffic backups and site constraints at the main gate.

Argonne total area is 2.37 square miles and is situated between two main thoroughfares with highway access. Argonne's road network incorporates many of the rural roads which pre-date the Laboratory. Pedestrian circulation paths form a mostly complete network in the 200 Area and connect to the 400 Area.

Several site amenities are available, such as restaurants and coffee shops serving the main 200 Area and 400 Area of campus. Argonne offers indoor and outdoor fitness and recreation opportunities across the site.

The microclimate at Argonne can be affected by the surrounding forest preserve and on-site wooded areas provide shade and respite. Buildings oriented in an east-west layout can take advantage of the solar orientation and natural winds for passive heating and cooling measures. Figure 6 summarizes the site analysis.

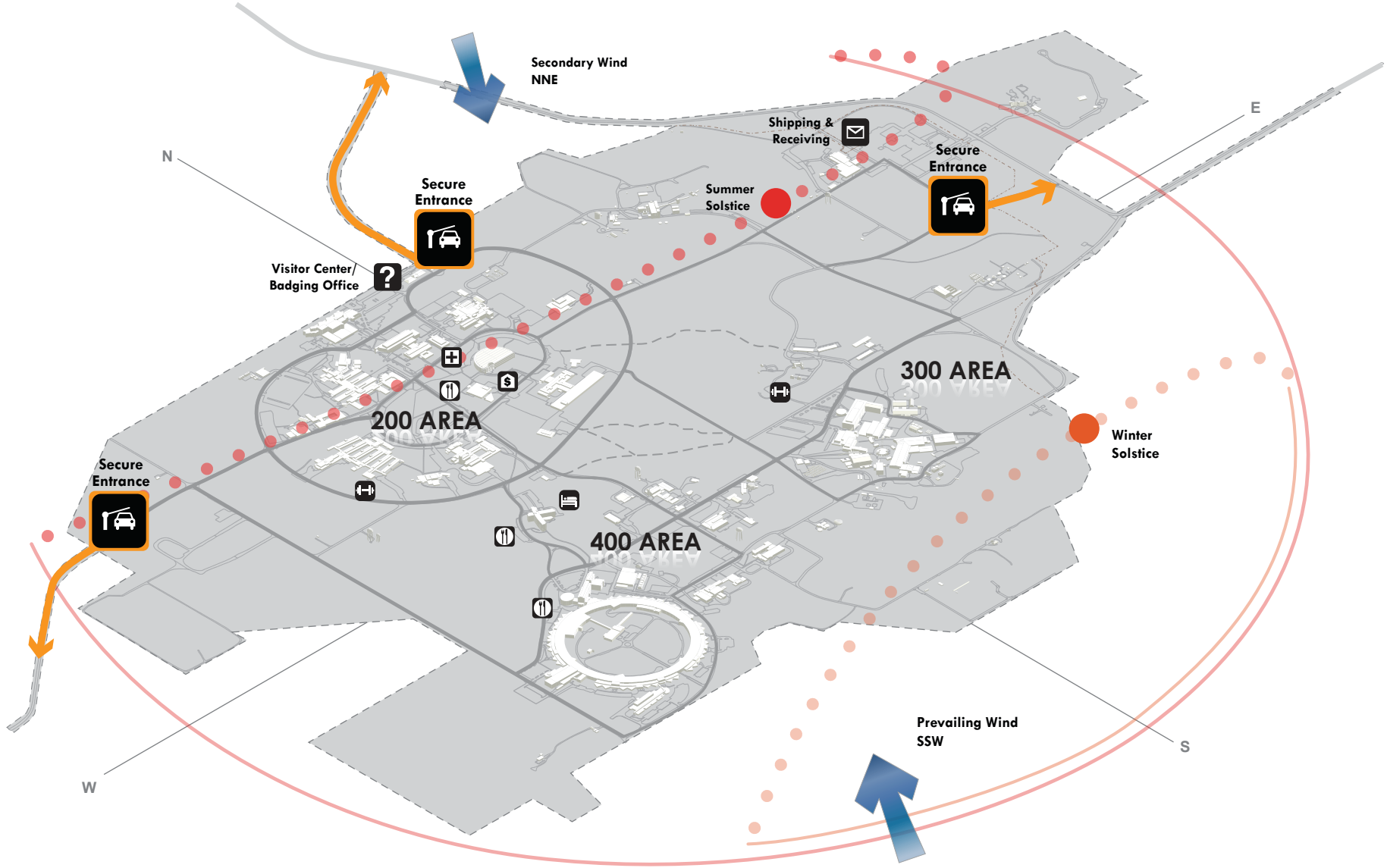


Figure 6. Site Analysis Including Security, Access, Circulation, Micro-climate and Amenities

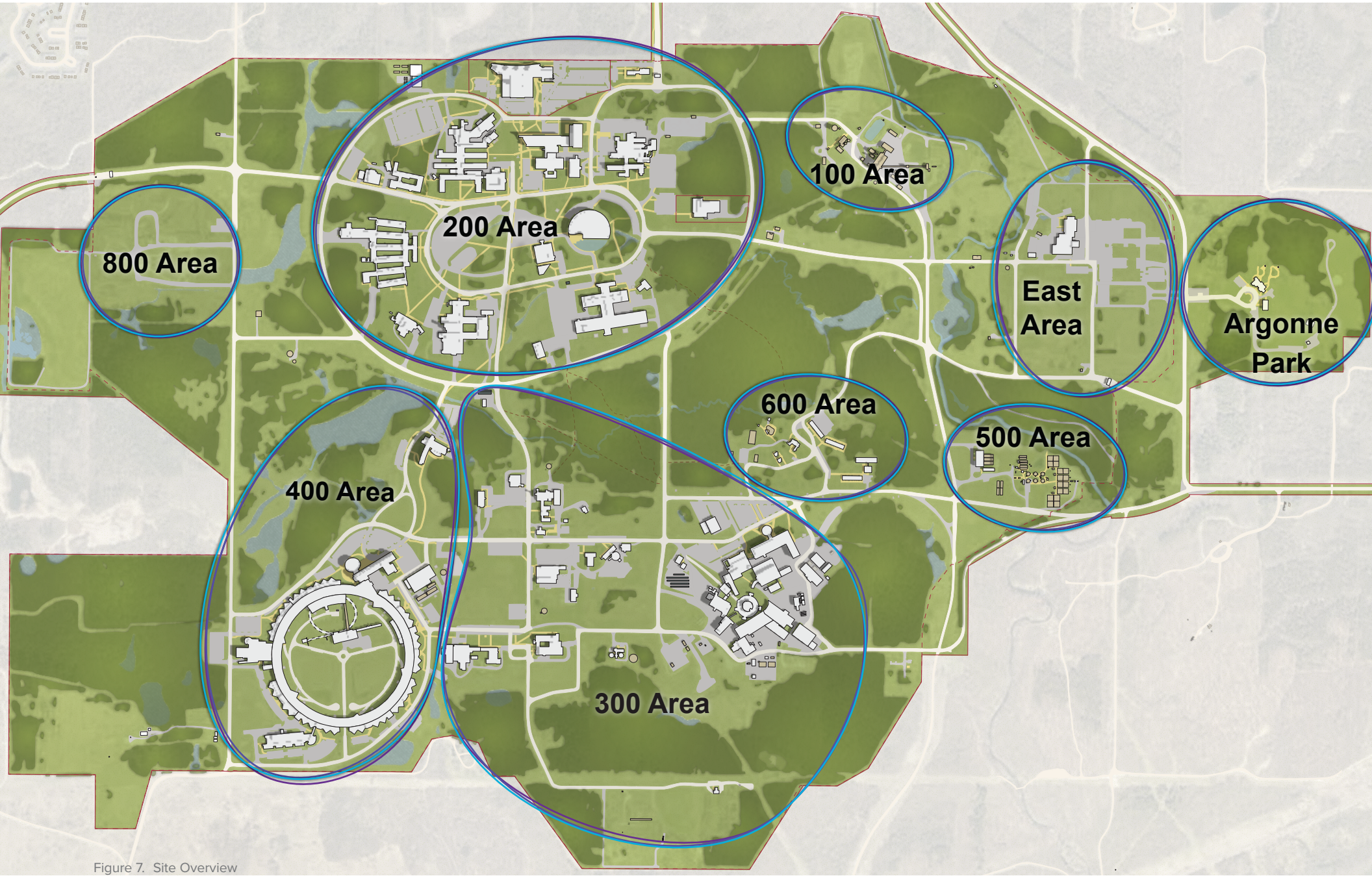


Figure 7. Site Overview

CAMPUS AREAS

The Argonne campus is located on 1,517 acres. The site includes 155 buildings, totaling 5.1 million gross square feet (GSF). The Laboratory is completely surrounded by the 2,470-acre Waterfall Glen Forest Preserve of DuPage County. Much of the Waterfall Glen preserve land was once part of the original Argonne site under the Atomic Energy Commission (the predecessor agency to the DOE) and was donated as excess property to the County in the 1970s.

The Argonne campus can be considered as several unique areas that complete the whole, each of which presents unique challenges for planning, design and infrastructure improvements. The site evolved over the last 75 years since its inception, adapting to changes in the scientific needs and programmatic strategy of the Laboratory. This has resulted in clustering of different research into different site areas (Figure 7).

The average age of Argonne-operated facilities and infrastructure is 51 years, with 64% of the assets being more than 50 years old. Buildings are grouped generally by individual facility number, and campus areas are designated to reflect this numbering.

100 Area, East Area, 500, 800 Areas

These areas primarily consist of laboratory support services, including the site steam generation and sewage treatment plants. The East Area was once home to the original Quonset huts, used to house the Laboratory before permanent structures were built in the 200 and 300 areas of the site. The East Area now houses site services, vehicle fleet maintenance and shipping and receiving. The 800 Area contains a former contractor staging yard, now housing waste and storage containers.

200 Area (Main Campus)

The 200 Area is predominantly office and laboratory space of one- and two-story red brick construction. Designed in the mid-century style, the 200 Area contains some of the earliest permanent facilities built. Recent construction at the "Energy Quad," which includes the Energy Sciences Building (ESB/Bldg 241), and the MDL (Bldg 242), creates approximately 255,000 square feet (sq. ft.) of modern, flexible laboratory space. Two leased facilities, the Theory and Computing Sciences (TCS) Building (Bldg 240) and the Howard T. Ricketts Regional Biocontainment Laboratory (Bldg 204), which is operated by the University of Chicago, are located in the 200 Area.

300 Area

Several buildings in the 300 Area that were completed in 1950 serve specialized functions related to nuclear engineering research, in addition to legacy waste processing and storage. Argonne security and the fire department are also located in the 300 Area.

Buildings 360 through 399 were originally built around a high-energy accelerator the now decommissioned Intense Pulsed Neutron Source (IPNS). The area is more industrial in aesthetic and contains many office, laboratory, and high bay research facilities now dedicated to transportation and vehicle research and high energy physics.

400 Area

The APS and associated facilities, as well as the Center for Nanoscale Materials (CNM), Argonne Guest House, and a few 300-series buildings associated with the APS fill the 400 Area. The APS and CNM are Argonne's two most frequented user facilities. The 400 Area was developed from the mid-1990s to 2010s and consists of modern architecture clad in white or light gray panels.

600 Area

Devoted to recreational and lodging facilities, this area contains the original and historic Erwin Freund Estate and several recreational facilities, including tennis, basketball and Frisbee golf. In 2019, the 1960s era student housing facilities were shutdown.

Argonne Park (900 Area)

Park area outside the perimeter fencing, consisting of the Child Development Center, outdoor picnic structure, and athletic fields.

LAND MANAGEMENT

Land Cover

Land cover data is derived from aerial imagery and reveals characteristics about whether a site is developed with buildings or structures, represented in shades of pink, or is undeveloped and exhibits features such as forest areas, represented in shades of yellow and green (Figure 8).

Land cover provides a quick snapshot of the rough area of open space vs. developed space at Argonne.

- Developed, 763.5 acres 51%
- Forest and Prairie, 25.5 acres 49%

Land cover data can be incorporated into other planning applications and functions to inform studies such as stormwater runoff analysis.

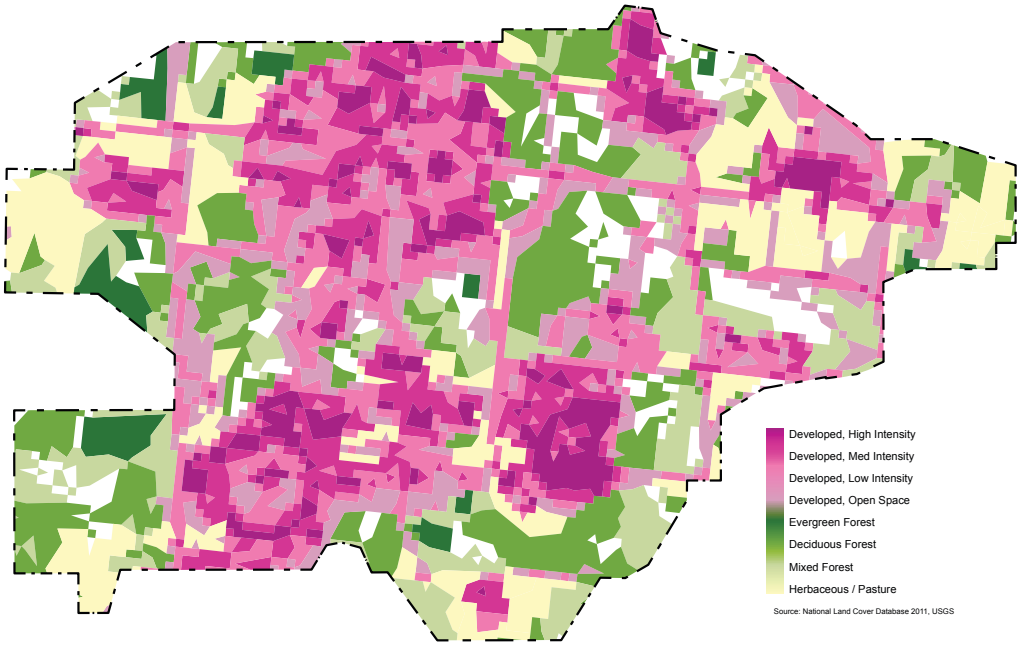


Figure 8. Land Cover

Land Use

Whereas *land cover* tracks land characteristics, *land use* classification tracks the physical activity that occurs on a piece of land at a given time. Land use is a better descriptor for classifying specific activities at Argonne, rather than using land cover data alone. Land use is classified across several dimensions including land activity, economic function, structure type, development character and ownership providing more granularity over the underlying data. Figure 9 shows the site by land use.

Argonne's land use activity on site correlates to the land cover data and shows that roughly 50% of the site has no physical activity occurring, land that is commonly referred to as "vacant space." These areas of no activity are addressed in the Natural Resources Management Plan. Table 1 lists land use activity classifications.

Management

Some locations of the campus are placed under special use restrictions. Restrictions may be in place from a research program requirement, such as a radiation protection area. This could be in the form of an administrative or physical control to limit access to the area. Other controls are in place to comply with a state or federal agency regulatory driver. These are typically administrative controls over land use.

Plan Impact

Any use restrictions are reviewed during a project planning phase or through the facility siting procedure. Development is restricted to previously disturbed locations and directed to areas of existing development.

Table 1. Land Use Activity Classification, FY16

	Acre	%
Residential	9.0	0.6
Office - Lab	176.2	12.0
Office - Mission Support	9.5	0.6
Industrial	138.9	9.5
Social, Assembly	14.1	0.9
Infrastructure - Utilities	120.5	8.2
Infrastructure - Transportation	206.6	14.1
Leisure, Recreation	42.6	2.9
Natural Resources	3.4	0.2
No Activity	742.8	50.8

LANDSCAPE AND NATURAL AREAS

Figure 9. Space typologies

Natural area land management activities at Argonne are driven primarily by two orders: Executive Order 13112, on Invasive Species, and the Migratory Bird Treaty Act of 1918. These policies provide the guidance to increase species diversity and decrease non-native or invasive species populations at Argonne. One-third of the site vegetation is surveyed annually to assess species diversity, habitat quality, and progress of management activities. The following goals and their associated actions, are assigned to sections of the site, depending on the result of the annual assessments.

Goal 1: Preserve existing native remnant plant communities

Goal 2: Identify and control new invasive species introductions/expansions

Goal 3: Re-establish natural plant communities

Activities in natural area management are targeted to address habitat quality levels. Activities to increase habitat quality (Goals 2 and 3) focus on poorer quality areas. Goal 1 is aimed at preserving the quality of areas with already existing, higher quality vegetation. Although the northwest area of the campus is denoted as having a high quality habitat, the health of the area is declining. The pine plantations established when the Laboratory originated are not regenerating and conditions represent an opportunity for future activity.

Increasingly, site natural areas are investigated for their use to advance the Laboratory's sustainability goals to reduce pollution and carbon emissions in support of climate change adaptation.

Habitat management efforts have resulted in increased habitat quality over the past three years. Increases can be tied to the recent habitat management efforts of controlled burns, targeted herbicide applications, and clearing where appropriate.

More information is available in the Argonne Natural Resources Management Plan.

Open Space Framework

Open space, and its relationship to those facilities it frames, is an essential piece of the image, sense of place, educational, social, and recreational experience of the Argonne campus. A principle of effective open space design is to create places that support multiple uses. The following open space typologies are identified in Figure 9:

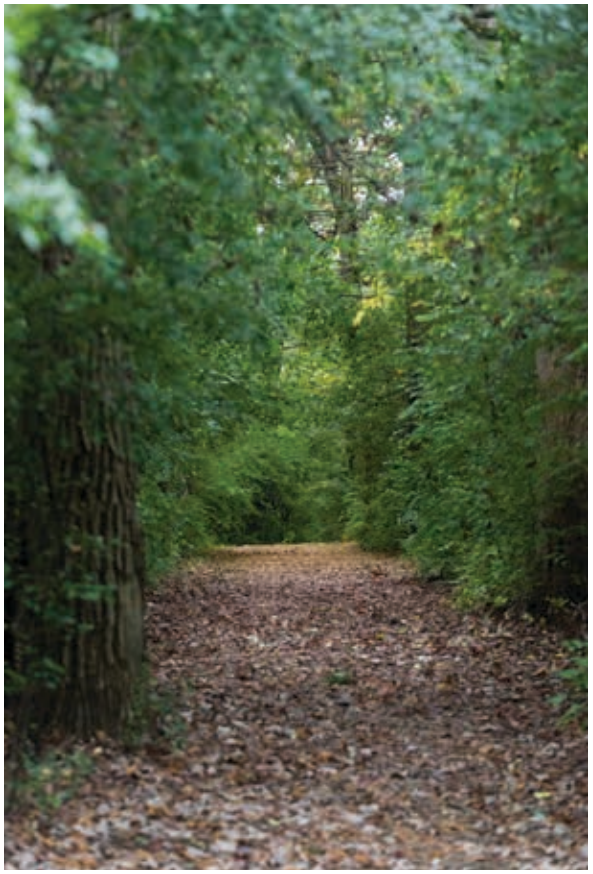
- Preserved landscape (historic front lawns)
- Naturalized landscape (Energy Quad)
- Restored Prairie
- Mowed Field and Recreation
- Courtyard and gardens
- Open woodland

These typologies leave a lasting Impact on the experience of the campus and inform campus planning and development, as well as habitat management plans.

Topography

Argonne is located approximately 150 feet above the nearest large water body and, as a result, is not subject to major flooding. Generally, the site terrain slopes to the east and south, as the site approaches the Des Plaines River and Sanitary and Ship Canal to the south of the Waterfall Glen Forest Preserve. The 100- and 500-year floodplains are limited to low-lying areas of the site near Sawmill Creek, Freund Brook, Wards Creek, and other small streams, associated wetlands and low-lying areas. The floodplain delineations are included in Argonne's site development standards and are generally contained within areas not intended for development. No significant structures are located in these areas. See Figure 10 for site topography.

Figure 10. Site Topography



CIRCULATION

Throughout the entire year, Argonne employees walk, run and cycle around campus for leisure and transportation purposes. Although paved sidewalks are not continuous throughout the entire site, many pedestrian paths were recently created or made continuous in the 200 and 400 Areas. The Infrastructure Services Directorate began paving the existing gravel road shoulders in the last 10 years to add room for pedestrian and bicycle use.

Parking analyses completed for the 200 and 400 Areas of site revealed that each area suffers from both parking oversupply and under-supply. In the 200 Area, ample parking exists for the current number of employees, although it may not be located closest to the need. As the MDL building becomes fully occupied, the site population concentration and associated parking demands will shift farther to the northern half of the main campus. The MDL project added surface parking and the Sustainability Program provided electrical vehicle charging stations, which helps to alleviate parking pressures in the Energy Quad.

In the 400 Area of campus, the parking supply locations do not correspond to the population. Many parking lots are undersized for the amount of associated occupants and visitors. Many of the Lab-Office Module (LOM) facilities around the APS ring do not have adequate parking supply for visiting scientists and sponsors.

Increasing the availability of alternative commute methods and promoting alternate work schedules helps to alleviate the burden on some parking lots. The Site Sustainability Program is analyzing various mobility solutions, such as a Bike Share, for getting around the site without having to use personal vehicles.

The Annual Site Work Improvement Program, funded out of the Major Repair Program, funds infrastructure improvements such as road paving, parking lot reconstruction and sidewalk repairs. IS maintains a list of priority projects, which are evaluated and updated yearly with input from occupants, building managers, and subject matter experts who identify needs or safety concerns.

CIRCULATION NETWORK

The Laboratory maintains a robust vehicle and pedestrian network to accommodate its population across a large campus. Major pedestrian circulation routes are provided and prioritized between the main 200 Area campus and the 400 Area. The many paths provide a variety of experiences, from functional daily movement to passive or leisure use. See Figure 11.

The majority of employees arrive at the Laboratory via personal vehicle and park close to their office in designated parking lots. As a result, the necessary parking spaces to accommodate employee and visitor demand is high.

School buses for educational programs and large delivery trucks frequently enter the site, which requires adequate space for turning movements, loading and parking. Throughout the day, many site users will access different buildings across the site and will walk or travel by personal vehicle, government vehicle, or bicycle. The Laboratory provides a bicycle share program and users are encouraged to “share the road” with other modes of transit, occupying the paved road shoulders.

ACCESS

Argonne's large campus of dispersed development contains varying levels of connectivity depending on the mode of travel. With a commonplace 1/4 mile, or 5-minute walk as the standard rule of thumb, it may take a fully mobile individual as many as 30 minutes to walk from the Visitor Center (Bldg 224) at the main gate entrance to the APS User Facility (Bldg 401), totaling over one mile. The trip was often made longer due to the lack of direct pedestrian connections or construction closures over the last several years. Planned rehabilitation of the Argonne Guest House (Bldg 460) parking lot will also install a sidewalk connection along the road, finalizing the last piece of infrastructure to connect the pedestrian spine across the entire campus.

In an effort to create a comprehensive database of accessible pedestrian features across the

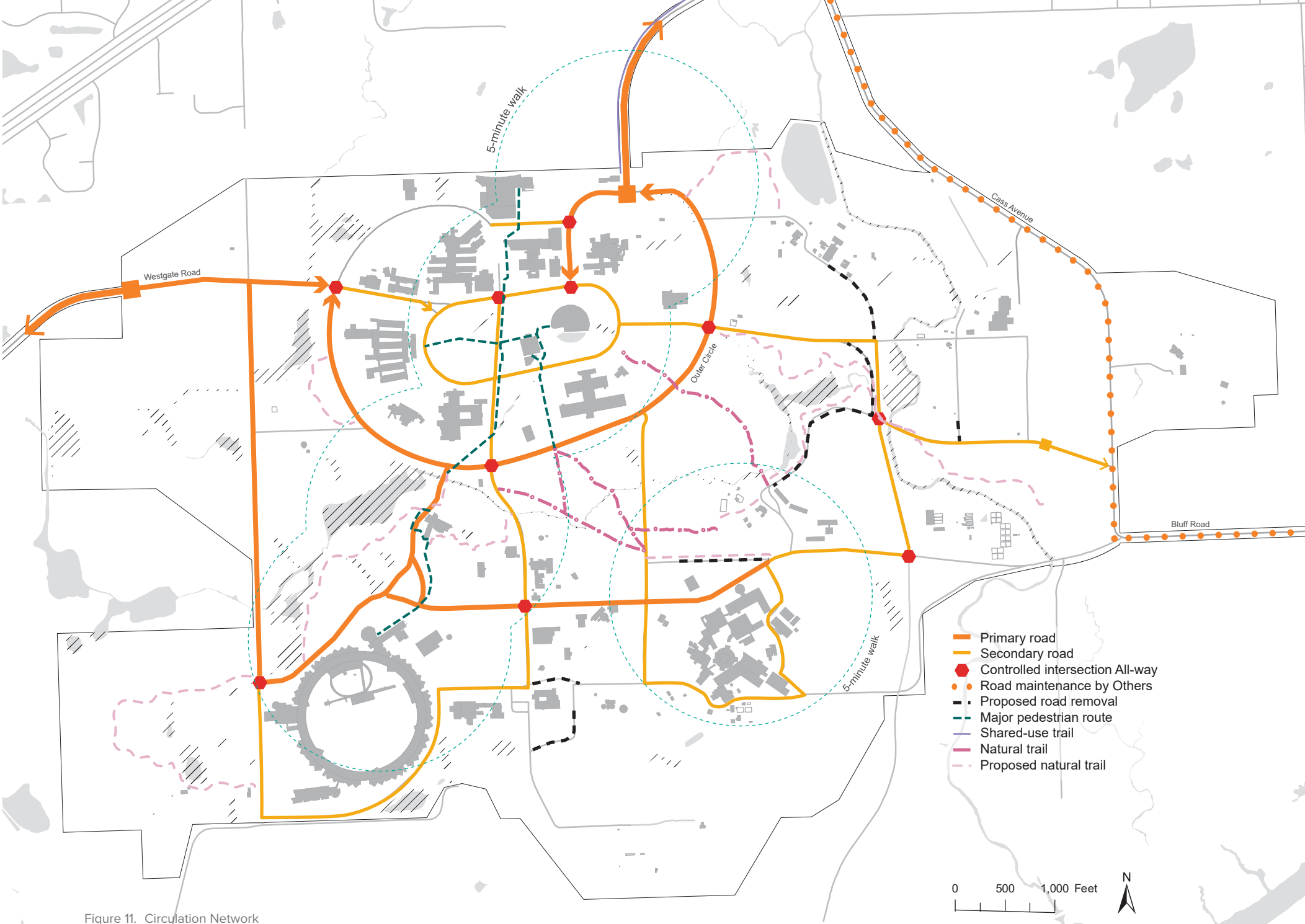


Figure 11. Circulation Network

site, a self-evaluation and compliance inventory was initiated in FY2015. Site data was collected in order to determine compliance with the Architectural Barriers Act and, identify physical barriers that can limit accessibility to programs, services, and activities. This evaluation began in the 200 Area, which is identified as a site priority area with high pedestrian traffic. Future phases will address the remaining portions of the site.

Identified deficiencies are addressed through the Site Work Improvement Program in conjunction with other location-specific repair projects.

PLAN IMPACT

Argonne provides free parking for staff and visitors, but expends its operating and maintenance budget to maintain these facilities in adequate condition. The Laboratory, through the Sustainability Program, is investigating alternative transportation methods to accommodate site visitor and employee access to and within the site.

Site modernization planning has geographically focused site improvements of parking lot reconstruction, road repaving, wayfinding signage and access improvements in the 200 and 400 Areas due to their larger population concentrations. When possible, opportunities to reduce or eliminate redundant roads and parking lots and eliminate extra surface area to reduce maintenance are pursued under the site work repair program.

Other planning goals will concentrate people and programs into existing growth areas of the main campus and 400 Area in appropriately sized facilities for efficiency and collaboration purposes.

DENSITY

Site population is concentrated in the 200 and 400 Areas of campus. An influx of student interns in the summer months and visiting scientists and facility users throughout the year influence the daily population. Various public lectures, events and education programs increase the lab population by nearly 14,000 persons per year. See Table 3 for a breakdown of the Argonne population.

Nearly 60% of the laboratory population works in the 200 Area, concentrated in Buildings 201 and 240. Buildings 400 and 401 house the majority of the second highest concentration on campus, the 400 Area. The 300 Area holds roughly 16% of the total Laboratory population. Remaining areas of the site (East, 100, 600, 500) represent a mere 3% of the lab population.

Site occupant concentrations roughly correspond to facility size in each area. In the 200 Area, 47% of the site's square footage is located across 23 facilities. The 400 Area, with the second highest occupancy, contains 27% of the site's space footprint. The 300 Area rounds out the total square footage of space with 23%.

Argonne's four on-site user facilities are all located in these heavily populated areas of the site (i.e., 200 and 400 Areas), which can contribute to parking issues in already stressed lots and increase use of site infrastructure and amenities. Figure 12 illustrates site population concentrations and distribution across the campus.

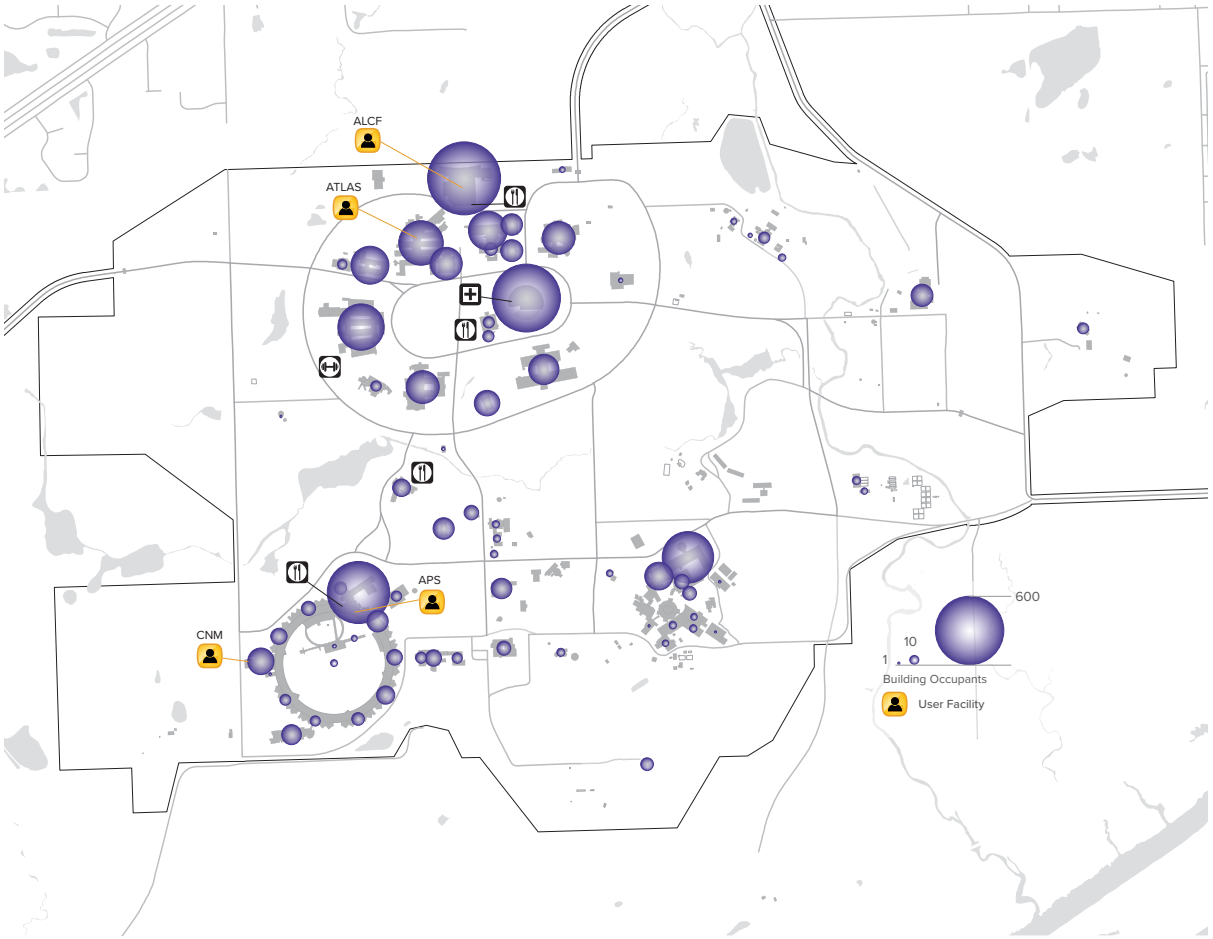


Figure 12. Building Occupants, User Facilities and Amenities Locations, FY20

FACILITY INFRASTRUCTURE

BUILDINGS

Argonne's proposed strategic investments in facility infrastructure are on track to support the Laboratory's research mission. Over the past decade, a combination of new construction (APCF, ESB, MDL) and selective renovation (Buildings 200, 201, and 360) has resulted in substantial improvements to increase the quantity of adequate facilities across the Laboratory. The largest concentration of substandard rated facilities is located in the oldest buildings on site in the 200 and 300 Areas.

The amount of substandard space presents a challenge and is addressed in a two-pronged approach. First, the facilities that are not suitable candidates for reuse are identified and placed on the planned demolition list. Second, those facilities which do possess positive attributes for reuse, and are suitable to the programmatic mission, are adapted with a renovation strategy to modernize for twenty first century science. This reflects the campus strategy for modernization to replace facilities or renovate.

Condition

Facilities identified as substandard or inadequate condition are aligned with proposed renovation, construction, or demolition projects to improve the overall asset condition. Facility age generally aligns with need and building condition, and reinforces the need to invest in the oldest facilities. One standard metric to evaluate facility condition

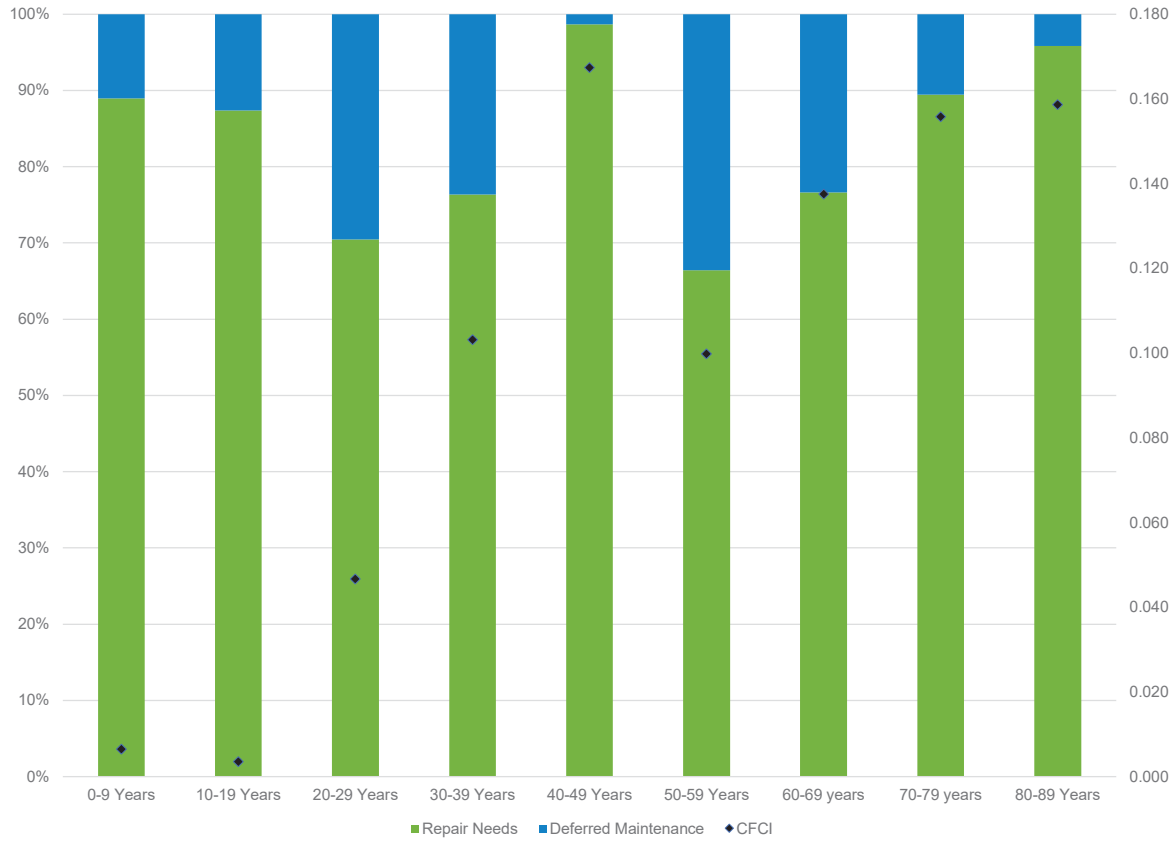


Figure 13. Deferred Maintenance and Repair Need by Age of Facility, FY20

is the comprehensive facility condition index (CFCI). The CFCI rating is a ratio of the amount of repair needs and deferred maintenance to the overall facility replacement value (RPV). Figure 13 shows the relationship of facility age to repair needs and deferred maintenance, along with the total CFCI. Higher ratios of CFCI indicate poor condition assets.

Facility deficiencies are identified and tracked through annual condition assessments. Deficiencies identified, but not performed at the appropriate time as determined by the system engineer or appropriate subject matter expert, are identified as “deferred maintenance,” (DM). Deferred maintenance is often a result of limitations in repair budgets or restrictions related to performing repairs as they may impact mission critical programmatic operations. Deferred maintenance is examined in terms of risk related to functionality and performance of a building or support infrastructure (e.g., utility system). Higher deferred maintenance needs equate to a greater probability of equipment failures, resulting in negative impacts to facility operations.

While deferred maintenance can be representative of operational risk, repair needs are just as important to track. Over time, repair needs can turn into deferred maintenance items. Proactive and preventive measures should be taken to avoid this impact on the overall backlog of maintenance items.

An Infrastructure Services Directorate goal is to focus on deferred maintenance items that pose the greatest risk to continued Laboratory operations and mission critical science, while maintaining a steady downward trend in the total amount of deferred maintenance carried for the Laboratory. A comprehensive analysis of deferred maintenance was performed in FY2019 to identify and prioritize repair projects with the goal to reduce deferred maintenance across the Laboratory. This report outlined a ten-year investment strategy of over $329M of Argonne indirect funds aligned with DOE-SLI and DOE-EM direct funding to project a reduction of 92% of all deferred maintenance.

SPACE MANAGEMENT

Argonne maintains a robust space management program that aids in the identification and planning of office and laboratory facilities to support changing programmatic needs. These include growth or reduction, movement to support consolidation or efficiencies, and/or specialized space needs.

Gross building space at Argonne totaled 5.1M sq. ft. in 2020. FY2016 vacancy rates were at 8%, compared to 10% in FY2017. Vacant space is primarily located in buildings planned for demolition through the excess facilities program or through relocation to newly constructed buildings, such as the MDL (Bldg 242). Recently vacated spaces in the 200 Area are being evaluated for reuse by other programs and/or initiatives and are identified as opportunity areas in the long-term facility renovation plans of the Laboratory. Argonne's goal is to maintain a small amount of vacant space across the site in order to provide for program fluctuations and expansion needs.

Argonne supports various types of research through the different types of spaces on campus: laboratory, office and administrative, and high bay. Figures 14 and 15 show the proportion of each space type across the Laboratory.

The 200 Area contains primarily office and laboratory uses that support basic science, such as dry or wet chemistry laboratories and other bench-scale research. Office and administrative space supports Laboratory operations staff and programmatic research staff.

In the 360 Area, high bay space is used for large-scale experiments and applied engineering research primarily related to manufacturing, transportation and battery testing.

The 400 Area contains the APS and is the Laboratory's largest experimental facility. The APS experiment hall houses ultra-bright, high-energy x-ray beams that are generated in the storage ring and used for research in almost all scientific disciplines. (The APS storage ring is categorized within the laboratory space in Figure 14, but called out separately in Figure 16 to point out the difference in size).

Space is charged to programs or divisions by the type and amount of square foot used. Charges for circulation hallways and common areas are spread across the laboratory evenly. The bar chart in Figure 15 shows the overall building space allocation.

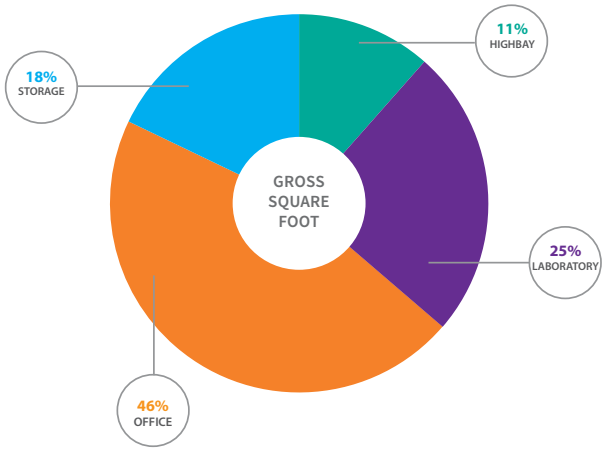


Figure 14. Types of Rented Space, FY 20

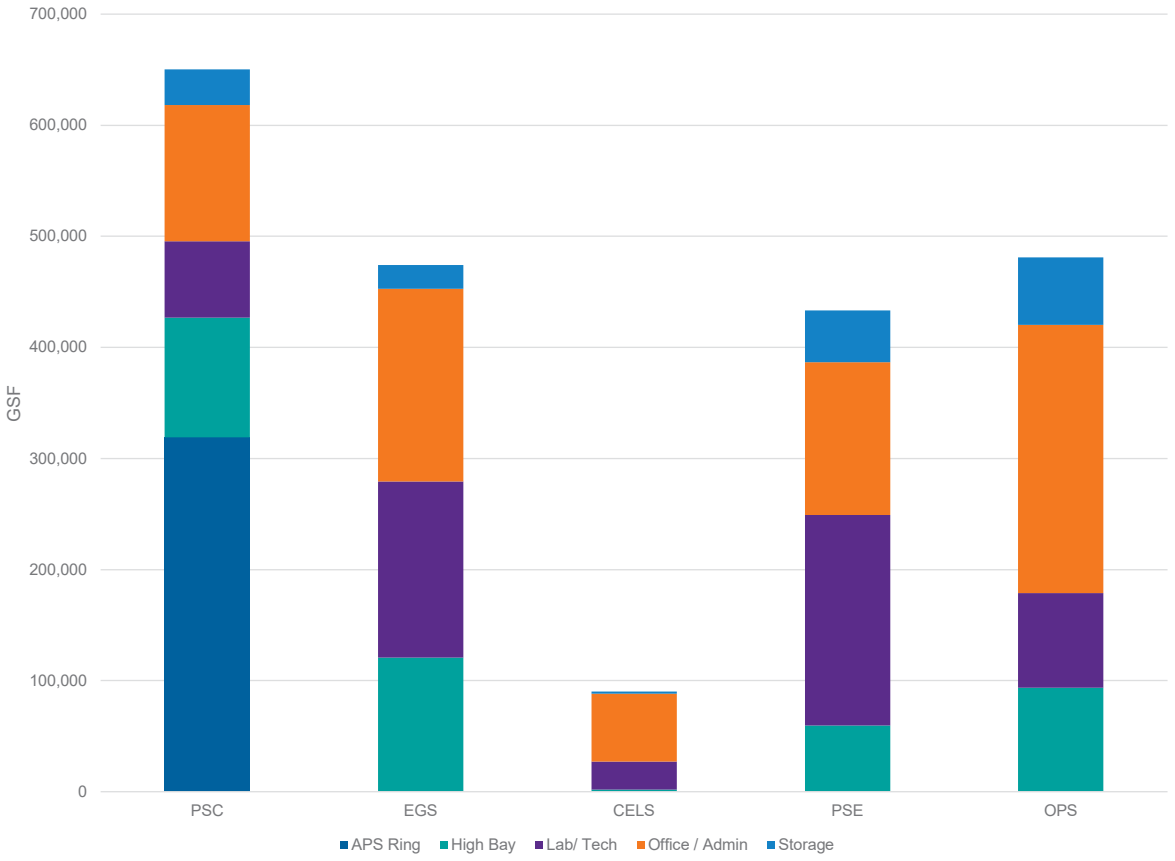


Figure 15. Building Space Allocation in Gross Square Foot, FY20

EXCESS FACILITY MANAGEMENT

Argonne maintains a multi-faceted approach to its excess facilities. The near-term approach focuses on the removal of legacy waste and relocation of staff to permit removal of excess facilities. The relocated staff are placed in renovated space or new facilities designed to accommodate the programmatic research need.

Removing programs from obsolete buildings and consolidating them into modern facilities allows the space to be prepared for removal. This drives consolidation of programmatic divisions across the Laboratory.

Removing the obsolete space from the site contains high initial costs for the Laboratory to prepare spaces for removal, and the actual removal cost, but ultimately saves the Laboratory in yearly operations and maintenance costs.

Argonne's excess facilities are classified on the basis of being obsolete due to new construction, being an unlikely candidate for renovation, or having negative environmental impacts. Figure 16 shows the excess facilities on a site plan.

Based on the excess facilities plan, those buildings and structures proposed for demolition, but currently occupied, require a confirmation of the phased relocation and renovation programs needed to support their elimination. The expectation is to assess existing facilities that can be feasibly renovated to support program needs.

LEGACY WASTE

Removing excess equipment, tools and chemical and hazardous wastes from vacant spaces allows Argonne to transfer substandard and inadequate facilities to DOE-Environmental Management (DOE-EM) for demolition, or reuse the space for modern science. DOE-EM has committed to funding the removal of several Argonne excess facilities, including Building 212 and Building 331. Before facilities can be transferred to DOE-EM, they must be prepared for demolition and have completed the deactivation process including waste characterization and waste removal activities. These preparatory actions are funded with Argonne overhead dollars.

The complete removal of contact handled (CH) and remote-handled (RH) transuranic (TRU) waste, from Argonne's legacy nuclear research is projected to be complete by 2025. CH-TRU and RH-TRU removal represents a critical milestone in the de-inventory of waste at the Laboratory and reduction of the overall site hazard categorization.

STRATEGY

The Laboratory's approach to designating facilities as excess, and prioritizing excess facilities for removal, is based on an evaluation of whether a facility meets the following criteria:

- The facility has been, or over the next 10 years will be, replaced by new construction or vacated as a result of program consolidation
- The facility is an unlikely candidate for renovation due to contamination, infrastructure condition, or its general age/deterioration; and/or
- The facility has potential negative impacts to the environment, employee safety, or the surrounding community.

The Laboratory is aggressively consolidating radiological facilities and reducing inventories of radiological materials, while preserving the capability to perform mission-important activities.

The removal of excess facilities will begin with Building 200 M and MA/MB wings, which were vacated by programs that relocated to the MDL facility. A phased clean-out and demolition of Building 212 is planned over several years. The resulting clean-up fully retires the Alpha Gamma Hot Cell Facility in Building 212. Relocation of existing programs that currently reside in Building 212 is under evaluation. Following the elimination of legacy waste, Buildings 331 and 306, which have facilities dedicated to the packaging, storage, and transport of waste, can be demolished. Several vacant IPNS buildings in the 300 Area are planned for removal also.

Figure 16. Current and Planned Excess Facilities Site Plan

Facilities to replace Building 306 for the Waste Management Division are also under evaluation. Argonne's plan to demolish its excess facilities would remove 502,882 GSF of substandard and inadequate space by FY2035. Removing this space represents a reduction in deferred maintenance and reduction of $14.8 M in annual operating cost for maintenance and surveillance. See Figure 17.

Planned deactivation and decommissioning (D&D), along with other associated clean-up activity estimates, are $305 million and are expected to be funded through the DOE-EM program over the next ten years. Without the necessary DOE-EM funding, Argonne projects to carry approximately $95M in total deferred maintenance costs by FY2029. Table 2 shows investments required to remove Building 212.

Further information on the execution and strategy can be found in the Excess Facilities Plan completed in FY2020.

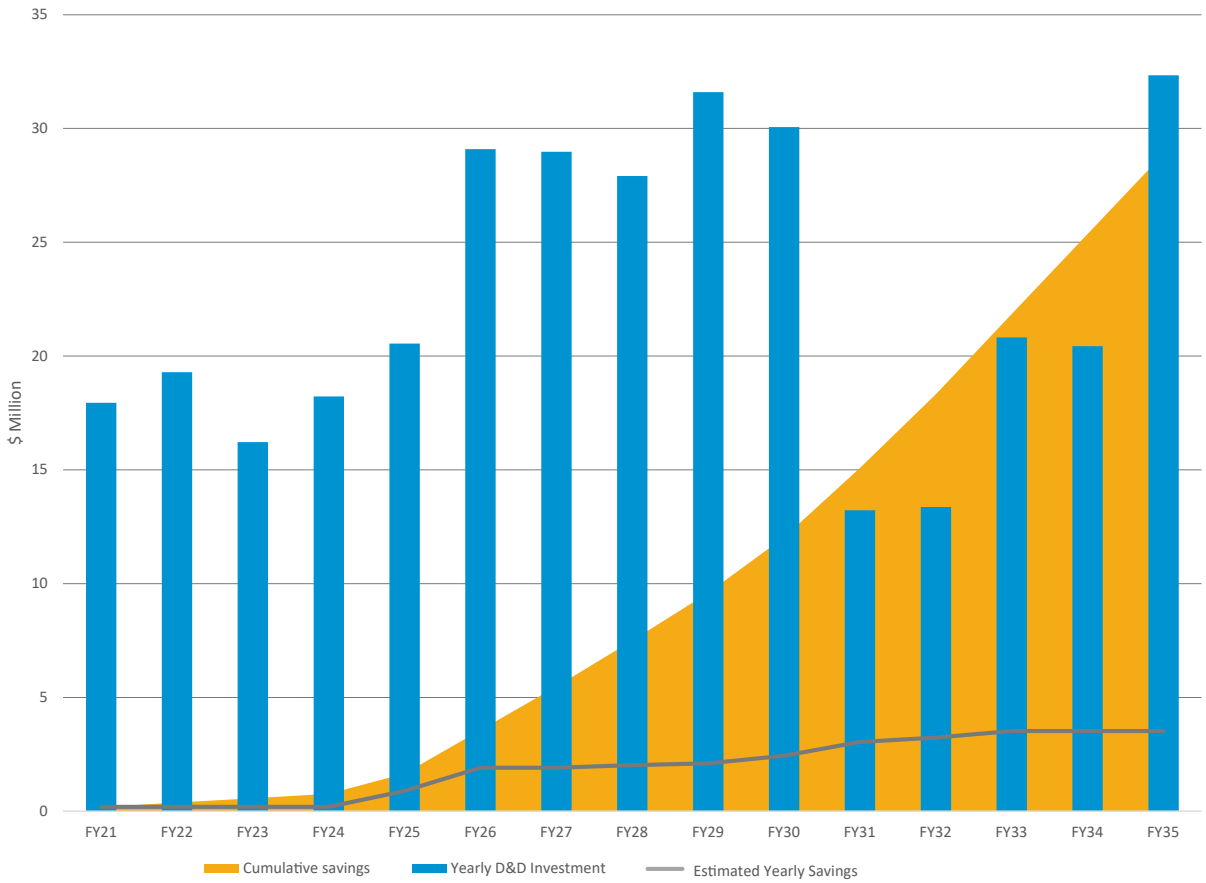
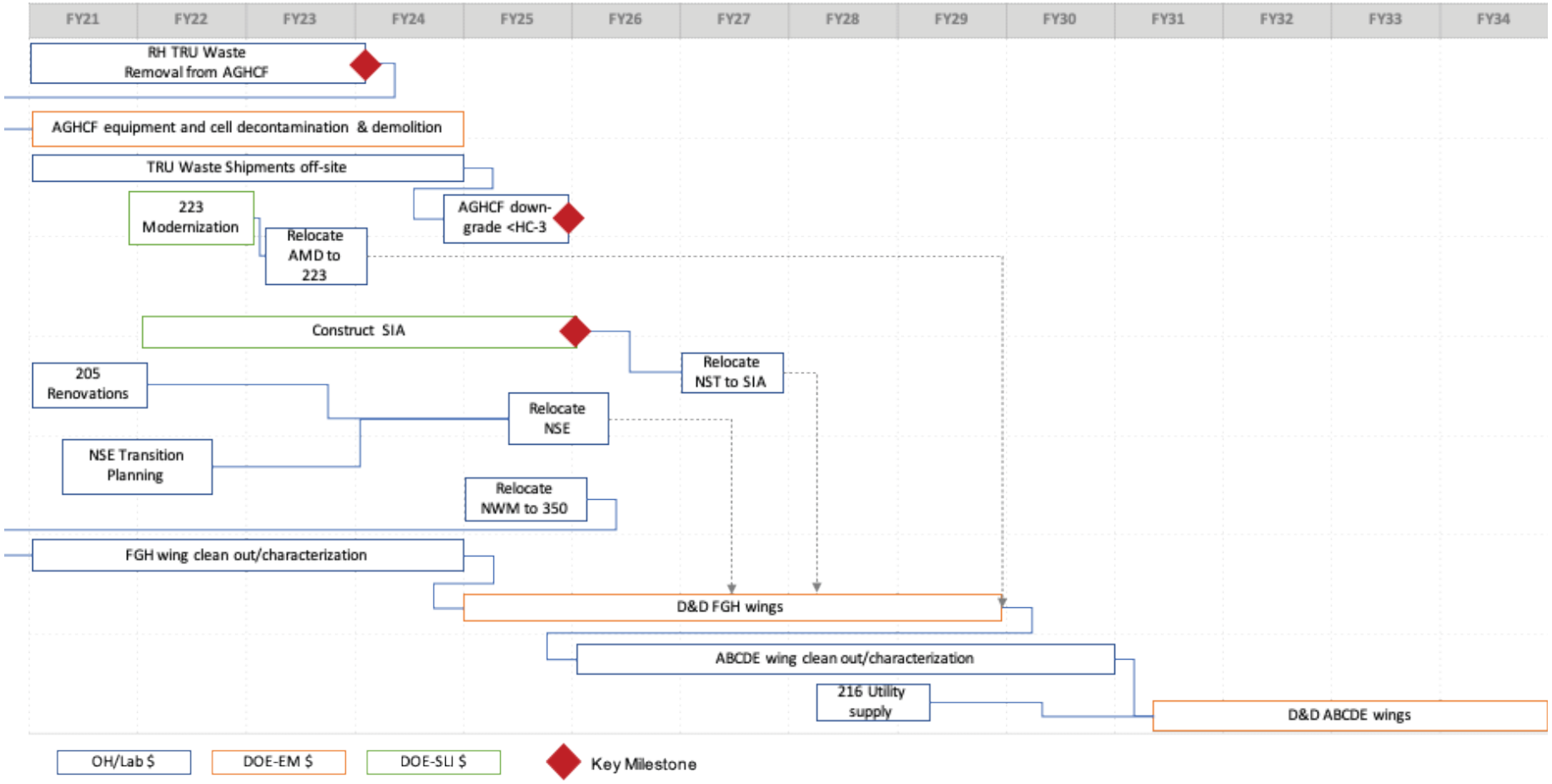


Figure 17. Investment Impact of D&D on Operations, Maintenance and Utilities and Surveillance, FY20

Table 2. Investments required for removal of Building 212



UTILITY AND SUPPORT INFRASTRUCTURE

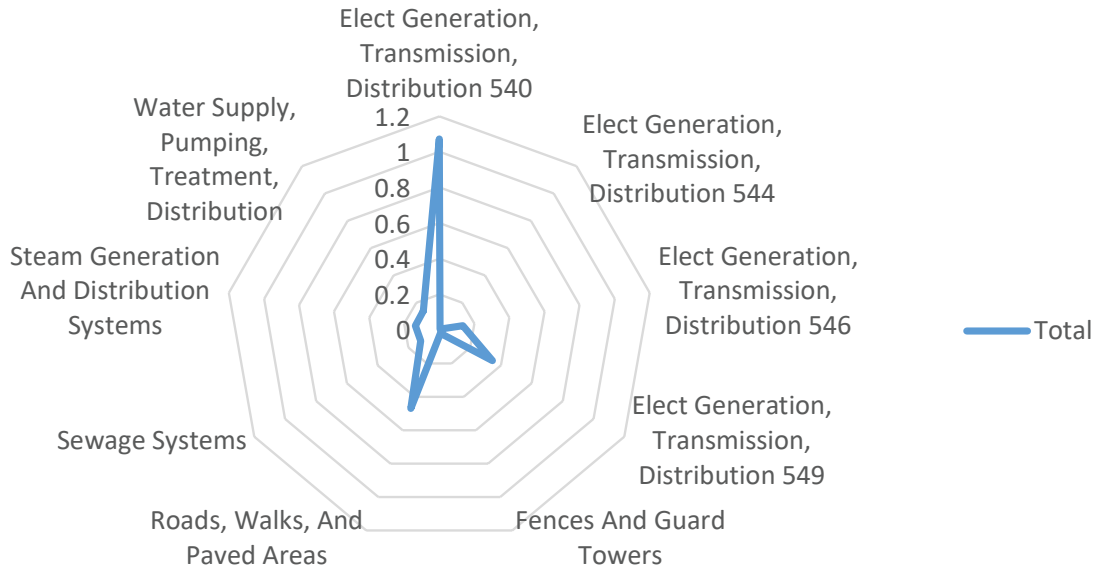


Figure 18. CFCI of Utility Systems

UTILITIES

Results from the condition assessment surveys are used to develop near- and long-term repair and upgrade strategies to ensure proper prioritization of deficiencies that may impact mission critical activities and/or environmental, safety, and health issues.

Utility Master Plan

A planned initiative from FY2017 created a utility master plan for the campus and a master plan for the 400 Area infrastructure. These plans used infrastructure condition data and site growth projections to identify a long-term maintenance, repair, or replacement strategy to guide future infrastructure investments.

The Utility Master Plan was a collaborative effort between Argonne system engineers and a consulting engineering firm to look at the current and future infrastructure requirements and provide a high-level utility road map for Argonne's future. Ten different campus utility systems were investigated to better understand asset condition, maintenance and repair needs and capacity for future site upgrades. See Figure 18 for the CFCI of utility systems site-wide and Figure 19 for condition by utility system.

From this data, 226 projects were identified, totaling over $460 million investment. As a result of the master plan, 132 new projects and studies were identified as feasible. Repair or maintenance needs were reviewed to ensure they were

incorporated onto the site CAIS database and are now tracked under the site maintenance and/or modernization needs. Projects resulting from the utility master plan were identified and prioritized for implementation over the next 25 years.

ECDC

Today, Argonne receives power from a single location that has original 1960-era equipment and installations. This condition increases the risk of an external power outage affecting the site and mission-critical programs, including the Advanced Photon Source (APS), Center for Nanoscale Materials (CNM), Argonne Leadership Computing Facility (ALCF), and Argonne Tandem Linear Accelerator System (ATLAS). An upgrade to Argonne's high-voltage power supply is required to support projected load increases associated with scientific growth and provide a fully redundant power supply to all site research programs, facilities, and systems. The Electrical Capacity and Distribution Capability (ECDC) project was approved by DOE for SLI funding to address these infrastructure gaps. The power upgrade also will provide additional capacity to support increases in electrical usage associated with exascale computing efforts expected in the near future.

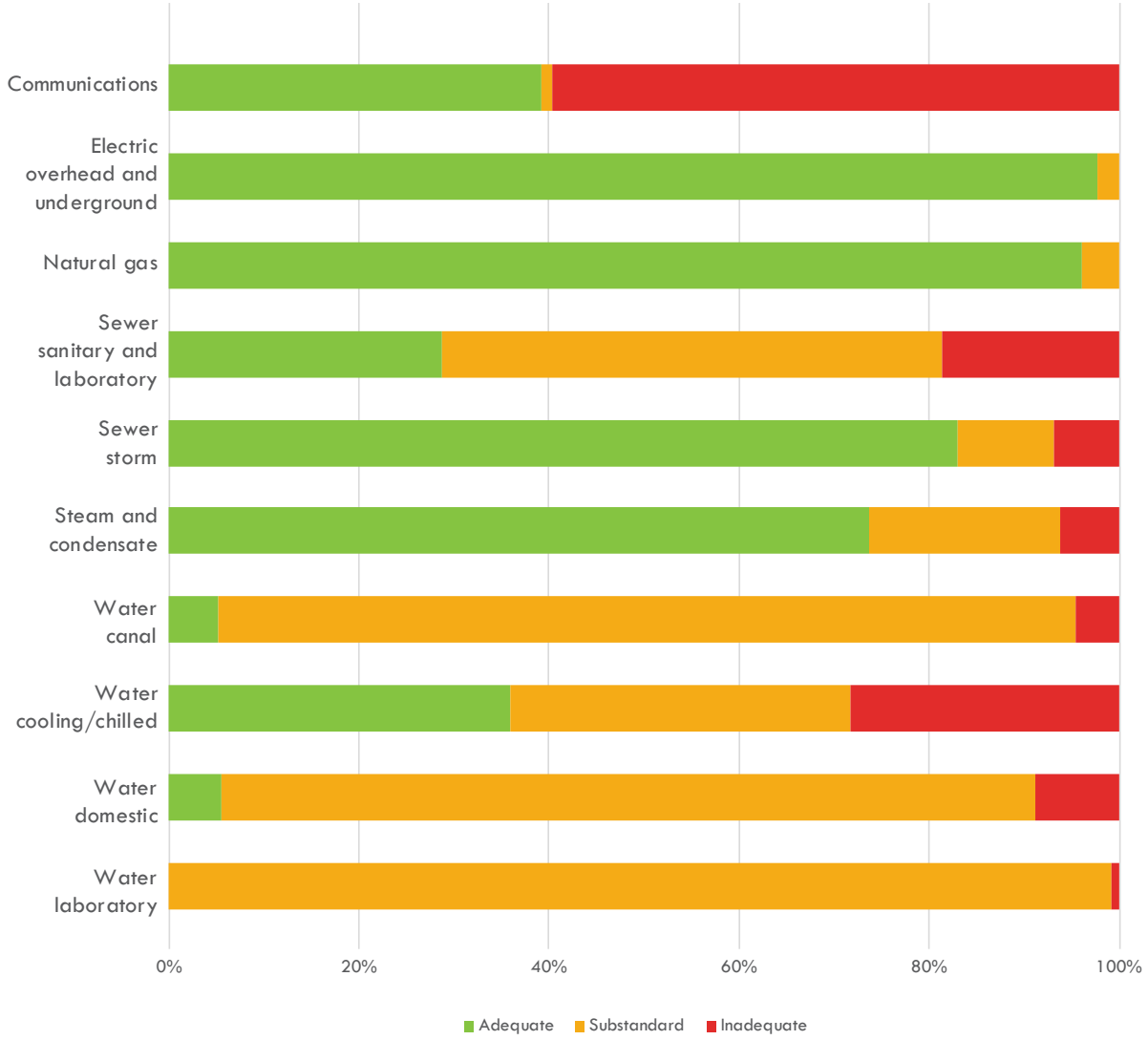


Figure 19. Utility Condition by System, FY17

AU2

Following the ECDC project approval, a second project was approved, the Argonne Utilities Upgrade (AU2). A large percent of the Laboratory's underground water and sewer distribution system are original to the site and are in substandard or inadequate condition. Direct funding from DOE is necessary to complete this large-scale project, which prioritizes critical locations for replacement piping and inadequate support infrastructure, in a multi-year program. The AU2 project will also construct a new central heat and chilled water plant in the 100 Area to accommodate site load increases and replace the aging steam generation plant.

Argonne proposed the AU2 Project for Department of Energy Science Laboratory Infrastructure (SLI) funding, to address numerous deficiencies associated with aging infrastructure. The total project cost is $216M direct funded from DOE-SLI.

IT SUPPORT INFRASTRUCTURE

Site-wide IT infrastructure provides a wide range of services and capabilities to the Laboratory. Outside of the many key business systems and capabilities running on server IT infrastructure, the BIS Directorate provides wired and wireless networking, telecommunications, and outside cable plant services. BIS manages several data centers and networking node rooms while providing broad oversight to other IT facilities on site.

The Laboratory's outside cable plant (fiber and copper), networking and telecommunications services underpin IT across the site. Year-to-year investments in these areas resulted in a state-of-the-art, reliable, high-performing set of communications capabilities. With modern fiber connecting the distributed campus, yearly investment in networking equipment has positioned the Laboratory very well to meet the needs of science and business.

Finally, our partnership with ALD IT leaders (the "IT Advisory Board – Executive" group) provides an opportunity for regular discussion, strategy building and roadmap alignment for short and long-term IT infrastructure needs.

Data centers

Mission-critical IT hardware is encouraged to be housed in the Laboratory's Enterprise Data Center, Building 386. Designed to meet federal data center efficiency guidelines, this purpose-built facility provides redundancy in networking, power, and cooling to provide high levels of system reliability. Additionally, Buildings 221 and 541B provide critical core networking service redundancy to the site.

In 2015, Argonne maintained over 21 different "data centers" across campus. Since 2015, seven of those were closed and/or consolidated. Long-term, the BIS goal is to consolidate onsite data centers down to 10 facilities at most. The data center facilities that will remain longterm include those supporting the research programs of APS (Bldg 401), LCF (Bldg 240). NST (Bldg 440) and potentially PSE, as well as those managed by BIS at Building 221 and 386.

BIS provides broad oversight or reporting and metrics for the remaining data centers via DCOI and our centralized DCIM (data center infrastructure management) software and service.

Communications

New fiber work will be performed as-needed when new buildings, major facility changes, or capacity growth prompt the update. In-ground fiber conduit system allows additional fiber to be added as needed to facilitate growth and expansion of the system. Multi-year major investments in the outside fiber and copper plant are planned to end by FY2021; the project will then enter the maintenance phase. We anticipate moving the Laboratory's primary Internet connection from 100Gb/s to 400Gb/s in the next 18 months.

5G and on site wireless

The outside cable plant investment has laid the foundation for upgrade to the fifth generation wireless network technology, 5G. The ultra-high speeds and densities of 5G networks ultimately require extensive fiber-based network distribution and connectivity. Because 5G signals do not penetrate well into buildings, fiber distribution of 5G networks will be required. Once the fiber signal reaches a building, it needs to be distributed within the building. This conversion and distribution from a high-speed, fiber data connection to a radio signal is performed by a "distributed antenna system" (DAS). Argonne has invested in a DAS in key high-density buildings throughout the campus, with additional investments planned in the coming years.

Preparing the infrastructure for the lab of the future will allow for researchers and operations to benefit from the high speed, low latency, and ubiquitous wireless network connectivity 5G offers.

OPERATIONS AND MAINTENANCE

DEFERRED MAINTENANCE, REPAIR NEED AND MODERNIZATION

The DOE Order 430.1C, Real Property Asset Management, requires performing a condition assessment on all DOE assets at least once during a five-year period. Argonne system engineers and subject matter experts inspect 20% of all facility and infrastructure assets each year to identify the current condition. Facility engineers determine estimated time to facility or system failure, optimal period to perform maintenance actions, and estimated costs to correct identified deficiencies.

Beginning in FY2016, a multi-lab initiative re-evaluated the deferred maintenance categorization, significantly impacting total deferred maintenance and repair need funding profiles. Total deferred maintenance for the Laboratory reduced by $46M from FY2015 to FY2017 as a result. FY2017 deferred maintenance totaled $73.567M. After that, the Laboratory has tracked an annual increase to the total annual deferred maintenance and repair need estimates, despite steady Laboratory overhead investment. The vast majority of deferred maintenance is located in the oldest campus facilities, aged over 50 years, which account for 61% of the site's total building square footage.

In contrast to deferred maintenance, repair needs are categorized by the estimated amount to bring a facility back to optimal operating condition. As a result of the re-categorization in FY2016, total Laboratory repair needs increased to $276M. The

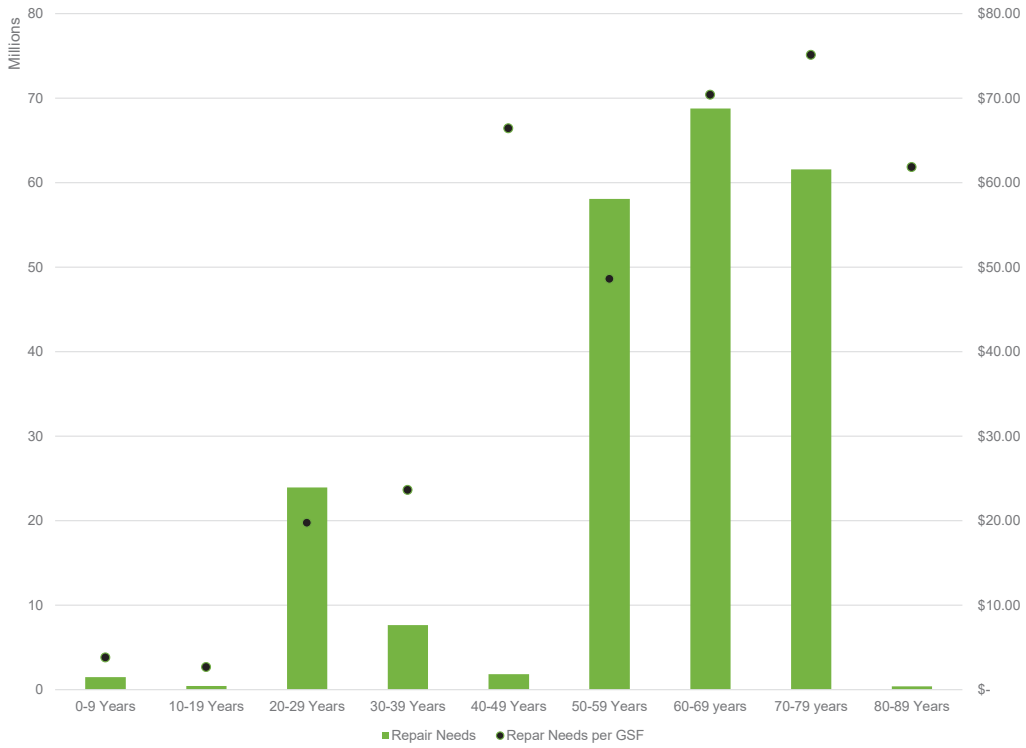


Figure 20. Facility repair needs by age of building, FY20

200 Area had the highest amount of repair needs in FY2017. Total repair needs have increased annually since then.

Modernization is the last category of need resulting from condition inspections. The modernization cost is considered a need that keeps existing facilities relevant and fresh in a setting with ever-changing standards and emerging science needs. Modernization includes activities that improve quality, increase capacity, extend an asset's useful life, or enhance an asset's value. Argonne's modernization needs were $223M in FY2017. These needs most significantly occur in the Laboratory support facilities of the 100 Area and secondarily in the 300 Area.

COST OF FACILITY MANAGEMENT

Figure 20 highlights the amount of repair needs per gross square foot of facility, by age of building. This highlights the variety of repairs needed to maintain the aging facilities. Often, the amount of needs identified are beyond the limits of the internal budgets and capabilities of Facilities Division. Overhead funding to support minor construction is targeted toward the highest risk from identified facility needs and lowering the overall deferred maintenance.

Notable in Figure 21, is the projected increase and overall upward trend of the cost to operate and manage facilities at Argonne. While the amount of physical space (GSF) to maintain has reduced since over the past five years, the total effort by the Facilities Division has not experienced similar results. This can be attributed to the age of facilities requiring more and more repair as failures compound.

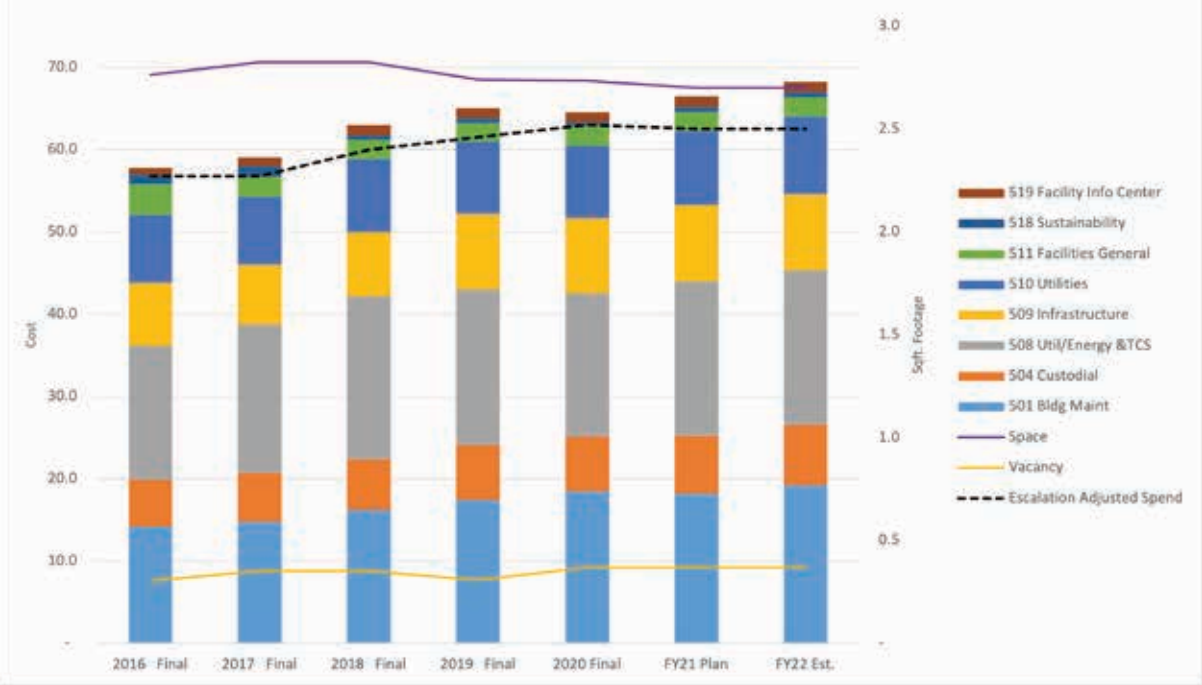


Figure 21. Building and Utilities (B&U) Rate Trends

FAULT DETECTION AND DATA ANALYTICS

Asset commissioning involves testing, adjusting and maintaining building systems to optimize performance. Commissioning provides energy and water saving benefits and improves building occupant comfort. Argonne is implementing a full life-cycle approach to commission assets that addresses the Laboratory's wide range of building age, conditions and needs. The long-term goal is to achieve continuous asset commissioning by leveraging technology to continuously ensure buildings are operating as efficiently as possible.

Fault detection and diagnostics (FDD) is a process that uses software to analyze building system data, automatically identify faults, and prioritize opportunities (see Figure 22). Opportunities can be in the form of actual energy savings, maintenance prioritization, and/or predictive equipment failure. FDD is complementary to a Building Automation System (BAS) (such as Johnson Controls' Metasys) rather than a replacement. Fault detection and diagnostic software application is a core benefit of the broader categories of facility metering, building controls and retrocommissioning.

The Building Controls and Analytics group in the Facilities Division receives all faults identified through the FDD software, analyzes the faults and performs the first step in basic triage, where faults are categorized based on priority. A "fault" occurs when a piece of equipment is not operating to specification and is identified based on a "rule" composed of several parameters. When this rule is broken, the software immediately triggers the fault along with associated data (frequency of occurrence, length of occurrence, and visual graphs) to alert users to further diagnose.

A fault is deemed valid when the equipment is found to indeed be operating outside of its specified parameters. It is then checked through diagnostics (the last "D" of "FDD"). Diagnostics currently requires human intervention. The future of the industry would be for the issue to auto-correct itself through Artificial Intelligence (assuming it's a software or programming fix that is needed). However, the typical process used to diagnose the issue is to

cross-reference the BAS, as that is what controls the equipment. The next step, if that doesn't solve the issue, is to physically inspect the equipment or controls and troubleshoot with a controls technician or building maintenance personnel. If the fault rule is considered valid, the BCA group will determine if the fault is a simple fault that can be easily corrected or if the fault requires more in-depth follow up and a work order. If a work order is needed, the fault is reviewed with the area maintenance foreman and work follows the standard building maintenance workflow. For longer-term needs or capital issues, the faults will enter into the infrastructure planning process and follow

that workflow for funding and repair through a work project.

Benefits to implementation of FDD is threefold. First, more efficient commissioning, retro commissioning and energy auditing across the Laboratory's facilities, more findings with improve confidence in the findings and, finally, ongoing automated retro commissioning.

Argonne has a traditional existing building commissioning program that physically tests equipment. Performing commissioning is a slow, arduous process for a campus of our scale. FDD software will supplement that commissioning process through “monitoring-based commissioning” (MBCx), sometimes referred to as on-going or continuous commissioning. Once a building is tuned-up and verified to be working correctly, we can overlay the FDD software to ensure it continues operating correctly and efficiently. This addresses the persistence of energy savings which is often shown to diminish quickly after a building tune-up.

Another benefit to implementation is the ability to leverage big data. With a facility portfolio of Argonne's scale, the Metasys streams in large amounts of data, which are stored in a database. The volume of data points makes it difficult to stay current with this data, analyze and make sense of it. The FDD software aids in the analytics process.

Further, the FDD software implementation will help the Laboratory meet legislative requirements. The EISA 2007 legislation includes a commissioning requirement for major use buildings on a four year cycle. The Energy Act of 2020 states sites can forego re-commissioning every four years if the building is under "ongoing commissioning” through a MBCx process, that is, FDD software.

FDD can be used as a tool to identify or verify savings in implemented projects or Energy Savings Performance Contracts (ESPCs). It gives us direct visibility into the equipment performance data. In the past, contractors had to install their own software to monitor equipment performance. Moving forward we could consider using this platform. Argonne plans to investigate the potential use of the Facilities Investment, Renovation and Modernization (FIRM) Program, sponsored by the DOE-Sustainability Performance Office. The program focuses on strategies to leverage alternative financing measures such as ESPCs or utility energy service contracts. These funding outlets would allow Argonne to implement deep energy retrofits to achieve a 40% or more reduction in energy use.

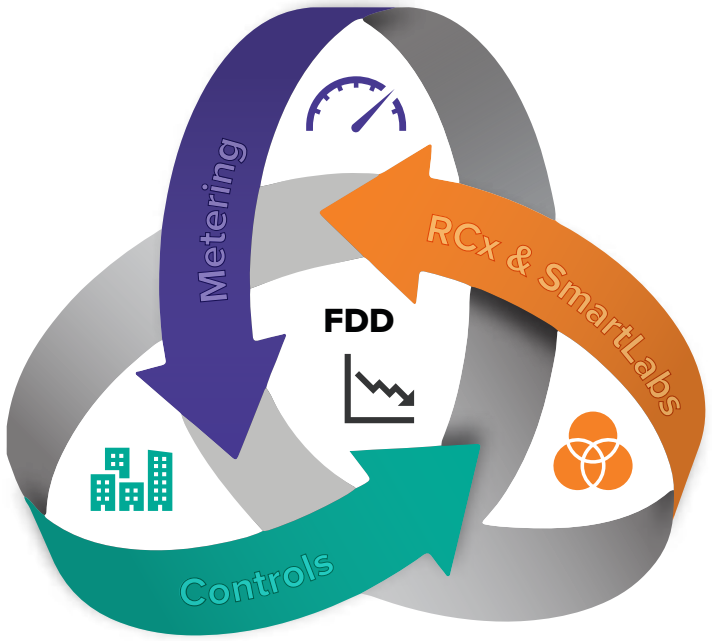


Figure 22. Fault Detection

SUSTAINABILITY AND RESILIENCE

Argonne's Sustainability Program supports world-class science and engineering research through infrastructure modernization and site occupant engagement. The program's goal is to deliver cost savings by addressing deferred maintenance and improving operations, while reducing Argonne's environmental impact.

Gains in energy savings and performance inherent to a modern facility can be realized by coordinating facility and infrastructure maintenance programs with sustainability focused actions. Laboratory-wide integration of DOE and Argonne sustainability program goals, with ongoing projects funded to reduce deferred maintenance and modernize aging facilities, results in a greater benefit to the Laboratory. By integrating the Sustainability goals into existing operations and maintenance activities, projects are able to meet multiple Laboratory goals.

RESILIENCE

The Strategic Planning and Sustainability Program is leading organizational resilience planning efforts. The collaboration between the Strategic Planning and Sustainability programs integrates adaptation strategies into ongoing work to ensure overall mission readiness through Laboratory-wide facility and infrastructure strategic planning.

In FY2021, planning for energy and water infrastructure resilience commenced. The project team will analyze electric, natural gas and water facility infrastructure gaps and operations for risk reduction opportunities. Reducing risk to the Laboratory facilities enables Argonne to better prepare for and respond to an interruption in operations. Figure 23 illustrates Argonne's resilient campus vision.

Climate Assessment

To determine potential risks associated with climate-related impacts on its mission, scientific programs, site operations and personnel, Argonne began a study on Climate Change Vulnerability Assessment in FY17. This will be updated according to the DOE Climate Action and Resilience Plan and related guidance issued in 2021.

Based on hazards identified in the climate change vulnerability assessment (e.g., extreme precipitation, severe hot or cold cycles), future facility and infrastructure designs incorporate the associated projected load increases to the systems. Specifically, the Electrical Capacity and Distribution Capability (ECDC) project, incorporates needed reliability and redundancy to the site to address power grid vulnerabilities. Providing resiliency to critical infrastructure at the Laboratory ensures mission-critical scientific programs remain operational.

Argonne will analyze flood risks identified as part of extreme weather events and incorporate them into the site's modernization plan for stormwater distribution, flood retention, and flood mitigation (e.g. bioswales, natural resource management) investments on site to reduce runoff and flooding.

To protect its employees, Argonne continues to implement and update safety procedures and protocols for working in extreme weather conditions, including extreme heat events. Argonne will also leverage existing activities and expertise of the Security, Travel, and Emergency Services Division during adaptation planning activities to further support ongoing efforts to maintain operational resilience at the Laboratory.

The Sustainability Program collaborates with Laboratory operations groups to update processes to incorporate sustainability for improved efficiency and cost savings. Sustainability Program goals have been incorporated into the Facilities Design Guide, general construction specifications, procurement actions and the business case template.

More information is available in the Site Sustainability Plan, located at www.anl.gov.

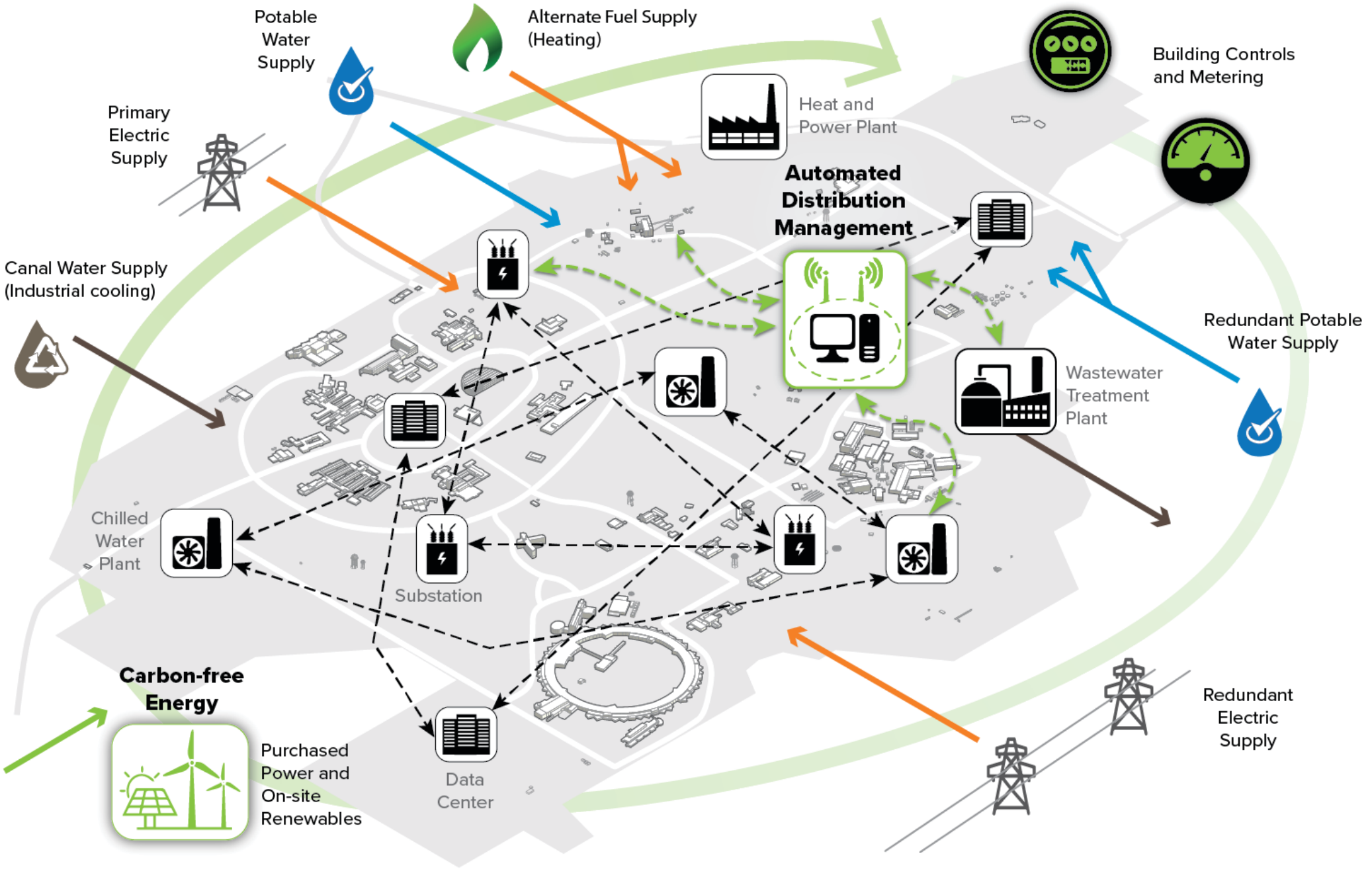


Figure 23. Argonne resilient campus vision

III. VISION

FUTURE TRENDS

LAB OF THE FUTURE

Argonne 2050 is the Laboratory's initiative to envision and evaluate possible long-term futures for Argonne National Laboratory. The entire Lab community was invited to contribute to shape the vision for Argonne 2050 through collaborative visioning sessions, an open house, small conversations and interactive blog.

Through this process, the Laboratory developed a vision for the future science we seek to pursue, and the ways in which the lab may change over the next three decades through its physical campus and its workforce.

The Infrastructure Services Directorate outlined the strategic initiatives in Figure 24 on the road map to constructing the lab of the future.

These decadal marches mirror the campus infrastructure objectives in this plan and the Annual Laboratory Plan.

Universal Access

As hybrid work and telework shifts the way we work and operate the laboratory, Argonne will become more universally accessible no matter one's location. With hybrid work and virtual connections more routine, researchers could access the lab from outside the lab or outside the country, with ease. Setting up the network communications and security networks to allow for these connections will be an important implementation measure over the next 10 to 20 years.

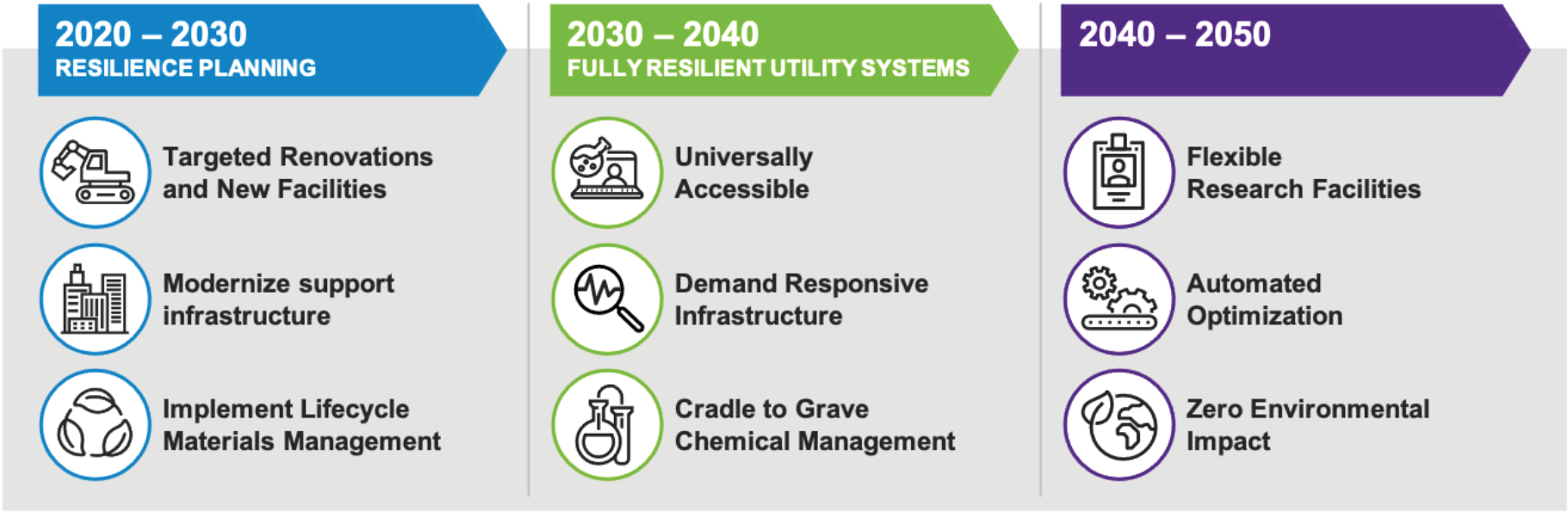


Figure 24. Strategic Initiatives for laboratory of the future

Flexible Facilities

As science and technology change, so too should the research environment to accommodate the evolving workplace needs. In 20 years, Argonne envisions that facilities must be flexible and adaptable to swiftly accommodate different research needs. Large, modular open plan space that can be easily transitioned for multiple users to perform many different types of experiments will allow research to thrive at Argonne. Future building construction will be adaptable and accommodating for whatever research may require.

AI FOR OPERATIONS

The continuum of Artificial Intelligence for Operations (AIOPS) begins with intelligent machines and programs, such as the smart meter and building controls. Argonne started deploying smart meters across buildings in 2010. The next phase is analytic systems that can use machine learning algorithms. Finally, automated optimization of AI allows for deep learning algorithms to automate systems.

The following areas are identified for potential AI use cases across the support organizations of the Laboratory.

Energy monitoring, measurement and verification (M&V). M&V takes what can be a very complex set of calculations to create a building's performance model, and automates them. Adding new variables, such as weather and occupants, can provide energy consumption estimates using the same building model. Provided enough data to observe a correlation between energy, weather and occupancy, an accurate model can calculate one of these variables if the others are available. In the case of M&V, actual weather and building occupancy can be used to estimate energy use under a pre-retrofit scenario, which can be compared to the actual energy consumption after a facility retrofit. The difference between actual and predicted energy is a more accurate way to track energy savings as compared to examining energy bills before and after a retrofit.

Demand management: in front of or behind the meter. Understanding current energy demand is very important for grid reliability. Utility providers have to know how much power they will need to supply and avoid generating too much. More data on energy consumption and the characteristics that drive its use (such as weather and occupancy) can translate into better predictions about how the grid will behave. With this knowledge, it's possible to reduce energy demand, save money and increase grid reliability.

HVAC optimization. In terms of facility demand management, understanding the performance of subsystems, like heating, ventilation and cooling (HVAC), is important. In the summer, cooling demands in an office can be the difference between setting a new, costly demand peak, or avoiding a hefty energy consumption charge. AI can provide cost savings by pre-cooling a building in the early mornings based on calendar schedules for meetings and historic occupancy data. The building's HVAC system would start early in the morning when energy is less expensive, and begin cooling space for the day ahead, all without human intervention. Moreover, if a building has used a pre-cooling strategy in the past, AI may help improve future pre-cooling efforts.

Equipment predictive analysis. Data pulled from complex machines found in buildings, like chillers and boilers, can be overwhelming to facility managers. But, when these data streams are analyzed by a software solution, trends may appear. This analysis may indicate a high likelihood of failure in the near term, based on the condition of the equipment and reasonable estimates about how it is used (such as expected operating times). The additional insight, which may help a facility team plan upcoming maintenance, can reduce unexpected equipment outages, add predictability to the budget, and keep occupants comfortable.

Space planning. As more offices move to open plan designs and more flexible work arrangements become the norm, a risk of space shortage exists, especially at peak times. Offering too much space is very costly for operations to heat and condition for no occupants. With a rise in indoor space sensors, it is possible to predict demand at different times — both when planning a new open office and for day-to-day management. AI helps by pulling in the data from these space sensors and providing estimates of occupancy, plus information that can help to resolve potential issues.

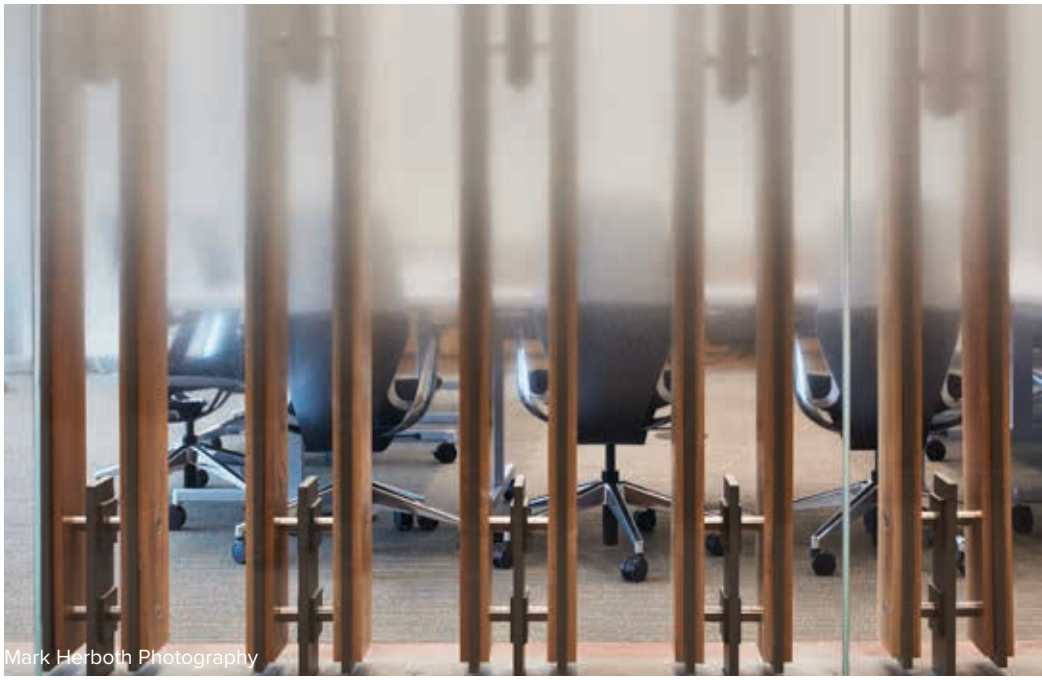
Predict facility cleaning needs. Custodial staff typically clean all occupied spaces regularly. This schedule-based approach is appropriate for busy spaces that are consistently used. But, with more flexibility in how occupants interact with spaces, it is likely that some spaces will be used more than others. There is an opportunity for spaces to be cleaned only when needed and based on actual use. Today, this cleaning schedule may be based on sensors that track occupancy, but AI can help to predict cleaning demands and even generate a schedule for service providers. Moreover, AI can optimize supply by automatically ordering various materials and products for the office space, based on actual and predicted occupancy trends.

WORK TRENDS

Employment remained steady over the previous five years (2020-2015), averaging 3,620 Argonne employees per year. Employee hiring did not slow during the COVID-19 Pandemic, as the laboratory was able to smoothly transition to a fully remote work posture and continue to on-board new staff virtually and provide safe access to laboratory facilities as needed. The expected shift to a hybrid workforce of the future will incorporate many of these telework themes that were accelerated due to the pandemic.

Pandemic Impact

While the laboratory began visioning the campus of the future, the reality of the global SARS-CoV-2 (the virus that causes COVID-19) pandemic accelerated several future themes into actual practice. We saw the positive impact of our infrastructure planning during the COVID-19 pandemic, as we smoothly transitioned from minimum safe operations in March 2020 to limited site operations in June 2020 and continued construction projects without interruption. The unprecedented levels of telecommuting in the Laboratory workforce since March 2020 led to investigations of the interest in and potential campus impacts of, long-term telework by a significant portion of the Laboratory population. Changing operations resulting from permanent


Mark Herboth Photography

telework are being analyzed for potential cost savings.

Our 30-year planning efforts include considering expanded technology platforms to accommodate remote work and the impacts on facilities. Any potential reduction in on-site work creates a need to identify modern space planning opportunities within buildings and further evaluate vacant and inadequate facilities for shutdown, removal, or reuse. Increased telecommuting accelerated campus wide discussions of the long-term impacts from telework on the laboratory community and its physical infrastructure.

Hybrid workspaces

We are also seeing workforce changes emerge and are responding with hybrid workspace options. Adjustments in on-site personnel, as well as long term and short term telecommuting impact how facilities will be used going forward.

Facility Renovation

Lastly, we are focusing our facility renovation investments on science space – prioritizing quality laboratory and research spaces over office type spaces. The future of work shapes Argonne's plans for its facilities and infrastructure.

AI Optimized Facility and Utility Operations

The future impact on Argonne's work force will be profound. We are planning now for the changes and opportunities that will emerge in staffing, in skill sets and in responsibilities for our teams. The impact of these changes and enhancements to our facilities doesn't stop with energy efficiency or building functionality. AI and Machine Learning systems provide immense information that our operations staff can use in day to day decision making, as well as driving long term investments.

Table 3. Argonne Site Occupants. Source: FY21 Annual Laboratory Plan; HRS

Human Capital	
3,442	Full Time Employees
424	Joint Faculty
324	Post-Doctoral Researchers
276	Undergraduate Students
200	Graduate Students
6,715	Facility Users
825	Visiting Scientists
214	Department of Energy

DEVELOPMENT FRAMEWORK

PLANNING ZONES

Each Argonne campus area has a unique character, based on the programming each contains and its growth over time. Campus planing and development enhances that unique character with context sensitive design and thoughtful space programming strategies.

The 200 Area, consisting of the main or central campus, contains some of the first permanent facilities of Argonne. The main campus is anchored by the social functions provided by the Building 213 Cafeteria, Building 200 Fitness Center and Building 201 Medical Center. The site design reflects this, with ample walking paths, seating areas and connections to enhance social collaboration.

The pedestrian spine bridges the 200 and 400 Areas of campus and encourages socialization and informal meetings with its broad sidewalks and rest areas for conversation or quiet reflection. The 400 Area is defined by accelerator science, imaging and microscopy research activities and promotes social interaction at the 401 Grill and education at the APS Auditorium.

Pilot scale demonstration science takes place in the 300 Area. Opportunities to further enhance the pedestrian connections between the 300 Area and the rest of the site abound. The architecture of the 300 area reflects the larger scale use of the facilities for science and maintains an industrial style.

Continued site and facility development aligned with the campus planning zones in Figure 25 will ensure a cohesive social, natural and built environment for the current and future lab community to thrive.

Argonne's Core Capabilities are broadly aligned with the site planning zones. Theory and laboratory bench-top research connected with chemistry and materials science, and nuclear engineering and physics in the 200 Area may use traditional laboratory-based research facilities. When these theories are ready to be proven, the scale of application jumps and requires larger facilities that may be found in the 300 or 400 Areas. Here, high bay space is used for large scale-up of research and production of material for industry partners.

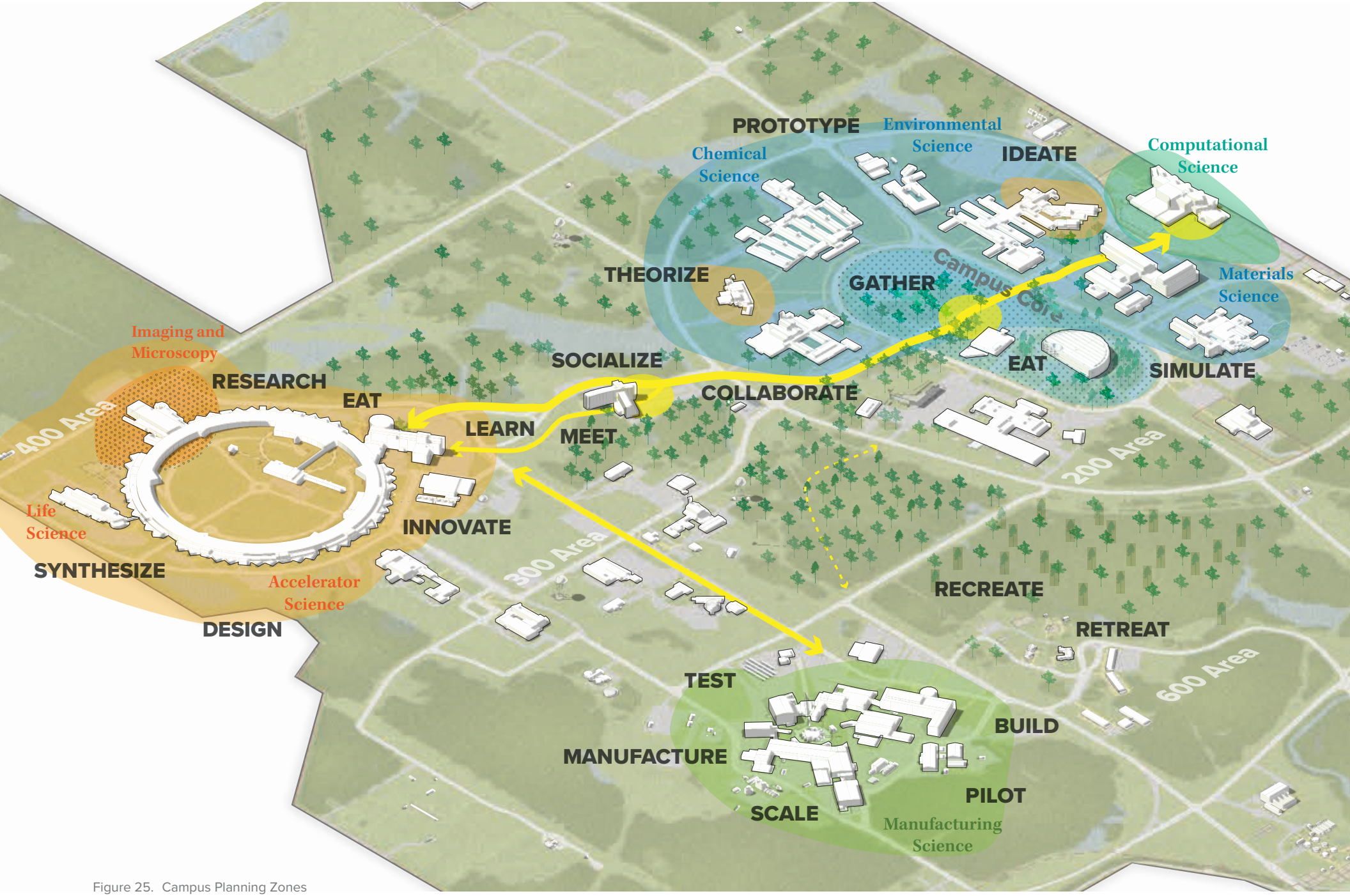


Figure 25. Campus Planning Zones

Figure 26. Future Development Sites. Graphics are for illustrative purposes only.

DEVELOPABLE AREA

The natural topography and features of the site influenced its development pattern over time, preserving significant tracts of oak groves and natural areas. Although 50% of the Argonne site area does not currently have a land use activity, several natural environmental constraints reduce future development potential. The main campus is circled by a substantial area of streams and wetlands and varying degrees of quality vegetation.

Argonne's development strategy is to reduce site impacts as best as possible when siting a new facility or expansion. Goals include concentrating development in existing facilities through renovation and rehabilitation, and siting new facilities in locations which leverage existing infrastructure and satisfy program and mission needs. See pages 18-19.

Considering these environmental features, as well as floodplain areas and contaminated and previously disturbed sites, Argonne's potential development spaces are revealed. Areas with opportunity for future development represent 254 acres of the site, or 17% of total acreage. Figure 26 shows future development sites.

The scale and amount of available land for development and/or redevelopment provide an advantage for Argonne's campus. Considerable tracts of land adjacent to Cass Avenue and the west site entrance off Lemont Road are suitable for large-scale development, where the interior of the site provides opportunity for smaller-scale infill development.

The large-scale development tracts on the east and west borders of the site are prime locations for establishing commercial partner engagement areas. Quick, direct access to the Interstate 55 highway interchange from both Cass Avenue and Lemont Road, with expansive development potential offer unlimited opportunity. These sites also offer a lower development impact, as they are predominantly gray-field sites, where past development occurred and much of the site infrastructure remains. These areas are prime targets for use in technology commercialization and development with Argonne's industry partners.

Remaining primary development sites are better suited for smaller scale, infill type development. Growth in existing programs or expansions to satisfy emerging scientific needs would expand into these areas, as best determined by program and space needs.

GROWTH POTENTIAL

113.3 acres	Primary Development Laboratory/Office
140.9 acres	Primary Development Tech/Manufacturing

IV. MODERNIZATION PLAN

TEN-YEAR PLANS

The ANL Annual Laboratory Plan lays out a path to encourage and focus bold and visionary efforts from basic science to deployed technology. To expedite these strategies and ensure a successful outcome, key facility and infrastructure investments are required. Infrastructure Services Directorate aims to provide adequate and modern facilities and infrastructure to support science needs and the Laboratory's Core Capabilities (pages 8-11).

Investments are planned across all four campus strategy areas for modernization (page 16-17). Critical path investments for the site include expansion to the crucial campus utility systems of chilled water and high voltage electrical power, which will repair and modernize the Laboratory support infrastructure for the laboratory of the future.

Focused building renovations and program relocations or moves allow for the consolidation of distributed organizations or new teaming structures. One successful example of the interdependencies of construction, moves, and renovations is modeled in the sequencing of activities for the MDL. The planned strategic moves and space rehabilitations planned for post MDL construction will allow demolition of the Building 200 M wing and MA/MB wings, thereby reducing deferred maintenance, risk, and operating costs for the Laboratory. The strategies of replacing and renovating facilities overlaps and relies on the strategy to eliminate legacy waste and excess facilities in this case.

Construction of new, modern facilities often supports the execution of the strategy to support major science initiatives. The APS-Upgrade Long Beamline Building and others will provide state of the art facilities to enable the world class science that Argonne provides.

See the Site Modernization Plan Vision, Figure 27, to envision the long-term realization of these efforts.

SITE-WIDE INFRASTRUCTURE ENHANCEMENT PROJECTS

- Argonne Utilities Upgrade (AU2) project
- Consolidated space initiative
- Electrical Capacity and Distribution Capability (ECDC) project
- Electrical Modernization Program
- Elevator Replacement Program
- Enterprise data center (network)
- Major Repair Program
- Out-Year IGPP Investments
- Roof Renovation Program
- Site chilled water capacity upgrades
- Site helium recovery system
- 100 Area physical plant modernization

Figure 27. Argonne Site Modernization Plan vision

200 AREA

Major investments to support Argonne's near-term scientific strategy over the next ten years are identified in the Annual Laboratory Plan. While preparing the laboratory for longer-term success, these investments support Argonne's major scientific initiatives through new construction, renovations and upgrades to critical infrastructure.

A major building project, the Materials Design Laboratory (MDL), funded by the DOE Science Laboratories Infrastructure (DOE-SLI) Program, is complete. Occupants began to move into the building in FY2020. The MDL currently accommodates roughly 100 employees in 115,000 GSF of new state of the art laboratory and office space, including new low-level radiological facilities. The space supports scientific theory and simulation, materials discovery, characterization and the application of new energy-related materials and processes. The MDL enhances the 200-Area and completes the vision for the modern "Energy Quad" at Argonne. MDL, following on the construction of ESB, consolidates research space that supports three core capabilities into the Energy Quad.

Additional new laboratory and office construction in the 200 Area will include the Energy Innovation Center (EIC), a State of Illinois-funded building estimated for completion in 2025. In preparation for the Aurora 21 Exascale high performance computer, the TCS Building 240, is expanding its data center and utility support space.

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Table 4. 200 Area Investments. Funding profiles and schedule are notional and subject to change.

Planned Capital Investments	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	Funding Program	Project Type
Electrical Capacity Distribution Capability (ECDC) Project												DOE-SLI	Utility
ATLAS CARIBU Facility Relocation												DOE-NP	Bldg Renov/Modernizatior
Building 222 Lab Renovations												Argonne	Bldg Renov/Modernizatior
Building 205 K Wing Hot-Cell Refurbishment												DOE-IP	Bldg Renov/Modernizatior
Building 221 Renovations												Argonne	Bldg Renov/Modernizatior
Space Renovation Program - Building 208												Argonne	Bldg Renov/Modernizatior
Building 223 Facility Modernization												DOE-SLI	Bldg Renov/Modernizatior
Building Envelope Enhancements												DOE-SLI	Bldg Renov/Modernizatior
Energy Innovation Center												Other	New Building
Elevator Improvement and Safety Program												DOE-SLI	Bldg Renov/Modernizatior
Space Renovation Program - Building 200 A, B Wings												Argonne	Bldg Renov/Modernizatior
Out-year IGPP Investments												Argonne	Other
Lab renovations - Building 223												Argonne	Bldg Renov/Modernizatior
Smart Labs Program - Heating and Cooling Optimization												Argonne	Bldg Renov/Modernizatior
Fiber Optic Cabling Plant Upgrade - E/W Lab												Argonne	Utility
Water & Sewer Utilities Modernization												DOE-SLI	Utility
Site Security Upgrades – North Gate												Argonne	Bldg Renov/Modernizatior
Site Security Upgrades – West Gate												Argonne	Bldg Renov/Modernizatior
Site Chilled Water Capacity Upgrades												Argonne	Utility
Helium Recovery System Expansion												Argonne	Utility
Picoprobe Lab												Argonne	Bldg Renov/Modernizatior
Argonne Utilities Upgrade (AU2) Project												DOE-SLI	Utility
Road & Parking Surface Repairs												DOE-SLI	Other
Building Operations, Maintenance & Repair												Argonne	Other
Major Repair Program												Argonne	Other
Electrical Modernization Program												Argonne	Utility
200 Area Waste Heat Recovery System												DOE-SLI	Utility
D&D Building 202 XY Wing												DOE-EM	Demolition
D&D of Bldg 212 FGH Wing												DOE-EM	Demolition
Building 200 MA, MB Wing Demolition												DOE-EM	Demolition
Building 200 M Wing Demolition												DOE-EM	Demolition

Investment in the Building 200 laboratory and office facility continues with both planned demolition of M and MA/MB wings and future renovation to A and B wings.

A Micro Assembly Facility was completed at Building 223, which focuses on the assembly and testing of micro-scale devices for large area detectors. The facility provides approximately 4,200 sq. ft. of clean assembly space and test bays, with the flexibility to adapt to changing and future project needs. The assembly space is intended to meet the needs of future experiments, including silicon sensors for the APS Upgrade, the Cosmic Microwave Background Stage 4, (CMB-S4), Electron Ion Collider (EIC) and ATLAS. Multiple scientific divisions will benefit from the space.

The Building 528 chilled water plant and Building 551 electrical substation, both located in the 200 Area, will complete planned capacity expansions to support campus-wide power and cooling needs. Utility infrastructure upgrades are necessary to support projected load increases associated with scientific program growth. The Electrical Capacity and Distribution Capability (ECDC) project also will provide a fully redundant power source to the site, limiting potential single-point failures. Table 4 summarizes the planned 200 Area investments.

300 AREA

In anticipation of the APS Upgrade project, space in the 300 Area is being used for preparatory activities prior to the beamline shutdown. High bay space in Buildings 361 and 375 will be cleaned out through decontamination and demolition (D&D), then reused to create 21,000 sq. ft. of preparation space to support APS Upgrade operations. Facade improvements to Building 384 were completed to provide further preparatory space for the upgrade.

Space at Building 370 was renovated for the Midwest Transformative Energy Manufacturing Facility (MTEM), a unique research environment to accelerate the progression of future energy technologies from discovery to applied research and scalable manufacturing.

Argonne took over operational responsibilities of Building 350 from the DOE in FY17. To make the facility usable for future research activities, Argonne initiated an SLI-funded project to de-inventory nuclear reference materials, clean out hazardous materials and characterize the residual contamination. Renovations are now ongoing to allow for reuse by programmatic divisions starting in FY2020. With the building occupancy increasing, Argonne is planning for site improvements to parking and road circulation in the area to improve capacity and safety.

Planned renovations to Building 362 will commence with a planning analysis for space needs to accommodate a newly hybrid workforce. The third floor was renovated for the ES Division, which created more collaborative breakout space.

Table 5 summarizes the planned 300 Area investments.

Table 5. 300 Area Investments. Funding profiles and schedule are notional and subject to change.

Planned Capital Investments	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	g Progra m	Project Type
Electrical Capacity Distribution Capability (ECDC) Project												DOE-SLI	Utility
Building 375 High Bay Reutilization												Argonne	Other
Building 350 Legacy Project												DOE-SLI	Other
Space Renovation Program - Building 370												Argonne	Bldg Renov/Modernizatior
Space Renovation Program - Building 368												Argonne	Bldg Renov/Modernizatior
Building Envelope Enhancements												DOE-SLI	Bldg Renov/Modernizatior
Building 362 Facility Modernization												DOE-SLI	Bldg Renov/Modernizatior
Elevator Improvement and Safety Program												DOE-SLI	Bldg Renov/Modernizatior
Out-year IGPP Investments												Argonne	Other
Smart Labs Program - Heating and Cooling Optimization												Argonne	Bldg Renov/Modernizatior
Fiber Optic Cabling Plant Upgrade - E/W Lab												Argonne	Utility
Water & Sewer Utilities Modernization												DOE-SLI	Utility
Site Chilled Water Capacity Upgrades												Argonne	Utility
Helium Recovery System Expansion												Argonne	Utility
Argonne Utilities Upgrade (AU2) Project												DOE-SLI	Utility
Enterprise Data Center Hall #2 Build-out												Argonne	Bldg Renov/Modernizatior
Road and Parking Surface Repairs												DOE-SLI	Other
Building Operations, Maintenance & Repair												Argonne	Other
Major Repair Program												Argonne	Other
Electrical Modernization Program												Argonne	Utility
IPNS Rapid Cycling Synchrotron (391 and 391A), Experimental Apparatus and Facilities D&D 384, 385, 399												DOE-EM	Demolition
D&D 600 Area Lodging												Argonne	Demolition
D&D OSFs 603, 604, 606, 607												Argonne	Demolition

400 AREA

The largest facility in the 400 Area is the Advanced Photon Source (APS), which was completed in 1996. The main facilities and systems have now reached their expected end of life and are deteriorating. Major investments for this area are planned to coincide with the APS-Upgrade project.

The APS Upgrade project will increase the brightness of the APS' high-energy (hard) X-ray beams. Shutdown of the beamline to upgrade the facility is planned for 2022 - 2023. The planned upgrade includes the construction of long beamline end stations, which will be located north of Building 446 (Figure 28).

Infrastructure Master Plan

Building on the valuable information collected in the Utility Master Plan effort, Argonne initiated an APS Infrastructure Master Plan in FY17. The purpose of the study, which was prepared by a consulting engineer, is to identify future needs and repair investments in the 400 Area that must be addressed to support the upgrade project. Identification of needs and programming repairs will ensure continued operations at not only the APS but at CNM and APCF facilities, also.

A majority of the APS support facilities and utility distribution infrastructure are original to the APS construction, dating to 1992. Much of the equipment has reached end of life and emergency repairs are increasing in frequency. Underground cooling and electric piping were not constructed in duct banks, but are direct-buried, causing accelerated deterioration. Direct funding from DOE is required to replace these systems and construct utility tunnels to avoid future failures. Argonne internal repair funds would be used to replace roofs in coordination with the APS Upgrade shutdown time frame. Table 6 summarizes the 400 Area investments.

SENSING AND IMAGING AT ARGONNE

A proposed 40,000 - 60,000 GSF experimental and computational imaging facility would be constructed in the 400 Area by the end of FY2025. The Sensing and Imaging at Argonne (SIA) facility would aim to solve pressing scientific challenges across a wide range of DOE applications. The building is proposed for DOE-SLI funding, with DOE Critical Decision (CD-0) still to be awarded.

The SIA construction facilitates the consolidation of microscopy research on site and supports the shut down and demolition strategy for Building 212.

Advanced electron microscopy research requires extreme vibration, humidity and temperature restrictions that would be accommodated in the new facility. This allows Argonne to consolidate

Figure 28. APS-Upgrade Long Beamline Building rendering
Credit: HDR

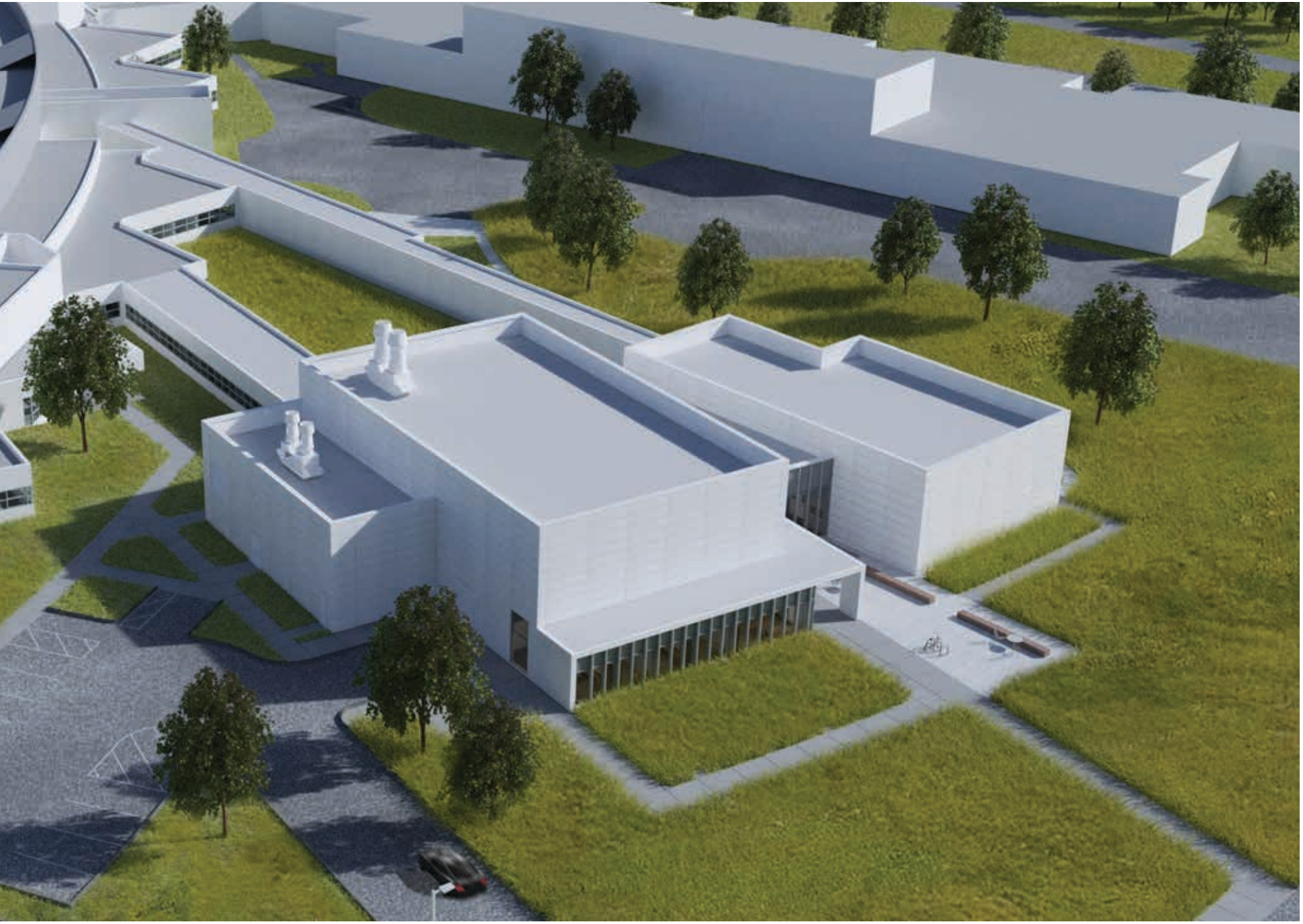

Table 6. 400 Area Investments. Funding profiles and schedule are notional and subject to change.

Planned Capital Investments	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026	FY 2027	FY 2028	FY 2029	FY 2030	Funding Program	Project Type
APS-U Long Beamline Building												DOE-BES	New Bldg
Electrical Capacity Distribution Capability (ECDC) Project												DOE-SLI	Utility
Sensing and Imaging at Argonne												DOE-SLI	New Bldg
LOM 437 Lab Build out												DOE-BES	Bldg Renov/Modernization
Building Envelope Enhancements												DOE-SLI	Bldg Renov/Modernization
Elevator Improvement and Safety Program												DOE-SLI	Bldg Renov/Modernization
Out-year IGPP Investments												Argonne	Other
Smart Labs Program - Heating and Cooling Optimization												Argonne	Bldg Renov/Modernization
Fiber Optic Cabling Plant Upgrade - E/W Lab												Argonne	Utility
Water & Sewer Utilities Modernization												DOE-SLI	Utility
Site Chilled Water Capacity Upgrades												Argonne	Utility
Helium Recovery System Expansion												Argonne	Utility
Argonne Utilities Upgrade (AU2) Project												DOE-SLI	Utility
Road and Parking Surface Repairs												DOE-SLI	Other
Building Operations, Maintenance & Repair												Argonne	Other
Major Repair Program												Argonne	Other
Electrical Modernization Program												Argonne	Utility
400 Area Waste Heat Recovery System												DOE-SLI	Utility

the imaging research currently being conducted in aging facilities and support next generation equipment requirements. See Figure 29 for a conceptual view of the SIA facility.

Figure 29. Conceptual View of 400 Area Improvements, Sensing and Imaging at Argonne Facility and APS Long Beamline Building in Background

MISSION SUPPORT

The Argonne Utilities Project, AU2, will update the 100 Area to help support science and realize the vision of a modern laboratory infrastructure. The AU2 Project will replace, repair, and upgrade several critical utility systems to eliminate deferred maintenance and reduce the risk of unplanned service outages, safety concerns, and other impacts to operations. These utility projects will allow for the continued support of mission critical program growth, increase site resiliency, and integration of data analytics/machine learning measures.

To maintain the current building loads of the chilled water system with the addition of the Exascale expansion project, additional chilled water capacity is required. Installation of additional underground piping runs outside the 100 Area will improve the efficiency of chilled water distribution.

The existing boiler house infrastructure in Building 108 is reaching the end of its useful service life. With the addition of several new buildings to the campus, the campus will require additional steam capacity in the future to maintain year-round operations.

Based on the results of a life cycle cost analysis performed as part of the AU2 project, a combined chilled water and steam plant provides the largest savings over a 50-year life cycle. The project will proceed with design and engineering for a new combined plant with this assumption. Figure 30 provides a conceptual image of the Area 100 Modernization.

Figure 30. Conceptual image of 100 Area Modernization including a new combined utility plant. Photo credit: Jacobs and Argonne

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