Fermilab

2020 Site Sustainability Plan

U.S. DEPARTMENT OF ENERGY | Office of Science

Fermi Research Alliance LLC

Executive Summary

Highlights

Fermi National Accelerator Laboratory is an international hub for particle physics. Fermilab's employees and users drive discovery in particle physics by building and operating world-leading accelerator and detector facilities, performing pioneering research with national and global partners, and developing new technologies for science that support U.S. industrial competitiveness. Fermilab's science strategy for the future delivers on the U.S. particle physics community's goals as outlined in the Particle Physics Project Prioritization Panel's 2014 report. The strategy's primary ten-year focus is a world-leading neutrino science program anchored by the Long Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE).

Fermilab's 6,800-acre site and extensive infrastructure supports the laboratory's current particle physics research program, including the experiments at the Fermilab Accelerator Complex user facility and others located around the world. The laboratory's infrastructure is also evolving to support the significant requirements of the international LBNF/DUNE and PIP-II projects. LBNF and DUNE will be powered by megawatt beams from an upgraded and modernized accelerator complex made possible by the Proton Improvement Plan II (PIP-II). The flagship facility comprised of LBNF, DUNE, and PIP-II will be the first international mega-science project based at a Department of Energy national laboratory.

In FY 2019 Fermilab continued to execute on a sustainability strategy rooted in the Fermilab Site Sustainability Plan, the Fermilab Campus Master Plan, and the Fermilab Annual Laboratory Plan. These plans identify sustainability as a core laboratory value and list specific initiatives to improve sustainability performance in future years. In 2019, Fermilab committed significant resources to plan for capital facility and infrastructure improvements which will have lasting site sustainability performance impacts.

Two infrastructure projects were proposed to the Department of Energy in FY 2019. The first, the Fermilab Utilities Improvement Project ($314M), will recapitalize the heart of the core campus by redeveloping the campus Central Utilities Building, providing a utility interface to the new campus accelerator complex, and replacing all 50-year old supporting utility infrastructure in and supporting the core campus. It will also systematically recapitalize Fermilab's many miles of distributed surface and subsurface site utilities. These projects, once complete, will yield significant improvements to site efficiency, reliability, and longevity. **The Fermilab Utilities Improvement Project reached CD-0 in FY 2019 with the DOE-SLI program concurrence of mission need.**

A second infrastructure project, the Fermilab Core Campus Revitalization Project ($400M), will replace sitewide Accelerator Controls, modernize and recapitalize Wilson Hall, and modernize and streamline processes associated with Fermilab's Technology Campus including accelerator and detector research, development, and production facilities. The accelerator controls upgrade could enable Fermilab's accelerator community to more efficiently perform accelerator operations. The accelerator is the single greatest user of electricity on Fermilab's site, and any minor or incremental improvement to performance will yield significant energy efficiency results. In addition, the wholesale facility improvements planned as part of the Wilson Hall and Technology Campus initiatives carry tremendous potential for increased energy and water efficiency, and potentially opportunities to seek High Performance Sustainable Building status for additional facilities onsite. **The Fermilab Core Campus Revitalization Project completed a Mission Validation Independent Review in FY 2019 and is awaiting CD-0 award.**

These two projects will have significant, long-term impacts to the sustainable operation of Fermilab's site. The laboratory made smaller-scale, immediate investments in FY 2019 to improve site sustainability. The following FY 2019 accomplishments are notable examples of sustainability progress which support Fermilab's ability to deliver on its mission:

- A new facility was completed in FY 2019; the Industrial Center Building Addition includes a high-bay space, adjacent workspaces, and offices and achieved High Performance Sustainable Building status.
- Fermilab completed a "cold and dark" exercise for a former industrial Central Helium Liquifier facility. This exercise eliminated the energy wasted by heating, cooling, and lighting an unused facility, but it also formalized a process to prepare significant industrial buildings for excess.
- A revitalized Campus and Facility Planning Board developed a new process to identify and prioritize capital infrastructure improvement needs. The prioritization process includes consideration for energy and cost savings.

- Food to-go containers in the laboratory's cafeteria were transitioned from polystyrene foam to biodegradable paperboard.
- Fermilab established a new partnership with the natural gas utility provider to conduct audits of several site buildings and identify energy conservation measures.
- Plans were developed for future high-performance sustainable building – existing building improvements.
- For the tenth consecutive year, Fermilab's Grid Computing Center was awarded Energy Star status.
- The Fermilab bicycle sharing program was fully implemented in FY 2019 with additional bicycle rack locations installed. Two bicycle fixit stations were also installed in FY 2019 which provide bicycle commuters with a means to make minor repairs while cycling onsite.

Executive Summary Table available on page 26.

Photos, clockwise from left: Earth Day 2019 plastic water bottle demonstration; Fermilab bikeshare bicycle; bison calf and mother; restored Fermilab prairie interpretive trail sign; PIP II groundbreaking ceremony.

Mission Changes

Fermilab has pivoted toward a five-year program that includes current and near-term neutrino experiments, an R&D platform that serves the wider neutrino physics community, and prototype detectors (ProtoDUNEs) at the European laboratory CERN. This program is driving the development of capabilities and infrastructure planning and bringing together the international community needed for the Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE).

This direction will require new and modernized onsite infrastructure to support the significant requirements of hosting an international flagship experiment. Future upgrades of the accelerator complex enabled by the Proton Improvement Plan II (PIP-II) project will provide megawatts of beam power to LBNF/DUNE. These upgrades will yield an increase in the amount of energy consumed as a site. Minimizing energy consumption for conventional facility operations will be important to provide an offset to required science-driven consumption needs.

In addition to modernized facilities and infrastructure at Fermilab to support the fast-approaching LBNF/DUNE/PIP-II era, DOE has a real-property lease with the South Dakota Science and Technology Authority (SDSTA) at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. Real-property improvements will be necessary at SURF in both leased space and non-leased space in support of the DOE science mission.

Photo 1 Long-Baseline Neutrino Facility Groundbreaking at Fermilab.

Energy Management

Energy Use and Intensity

Energy Intensity

Goal: The latest energy intensity reduction goal, requires a reduction in energy intensity for goal subject facilities by 25 percent by FY 2025 relative to FY 2015 baseline. The prior goal, required a 30 percent reduction by FY 2015 relative to FY 2003 baseline

Interim Target (FY 2019): -10.0%

Current Performance: -9.5%

	FY 2015	FY 2019	% Change
Purchased Utilities (MMBtu)	95,494.3	85,228.3	-10.8%
Purchased Renewables (MMBtu)	0.0	0.0	N/A%
Goal-subject GSF	1,053,588.0	1,039,342.0	-1.4%
Energy Intensity (Btu/GSF)	**90,637.3**	**82,002.2**	**-9.5%**

Photo 2 One strategy for reduction of site energy intensity is to fully decommission end of life facilities. Fermilab's Central Helium Liquefier facility was made 'cold and dark' in FY 2019.

Status

In 2019, Fermilab participated in an energy curtailment program as negotiated with the laboratory's curtailment service provider in FY 2018. The demand reduction exercise yielded $323K in target reduction accomplishment compensation. Fermilab will continue to participate in curtailment programs in the future. PJM, Fermilab's regional transmission organization has a new winter curtailment product offering. Fermilab is currently arranging the contract to utilize this new product. This product will first be offered in the winter of 2020-2021.

Fermilab has one non-excluded facility (a Particle Physics Division Office Building) greater than 5,000 gsf with an EUI greater than 150 kBtu/gsf. This building has been retro-commissioned and an energy model created this year.

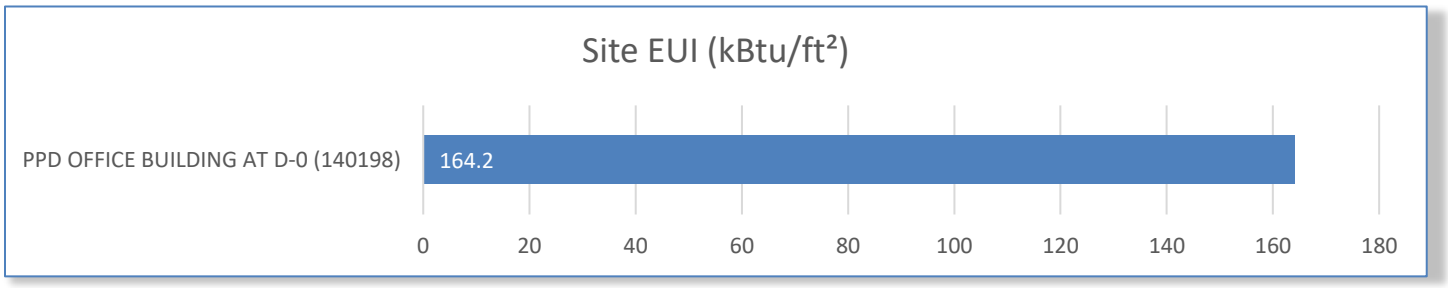
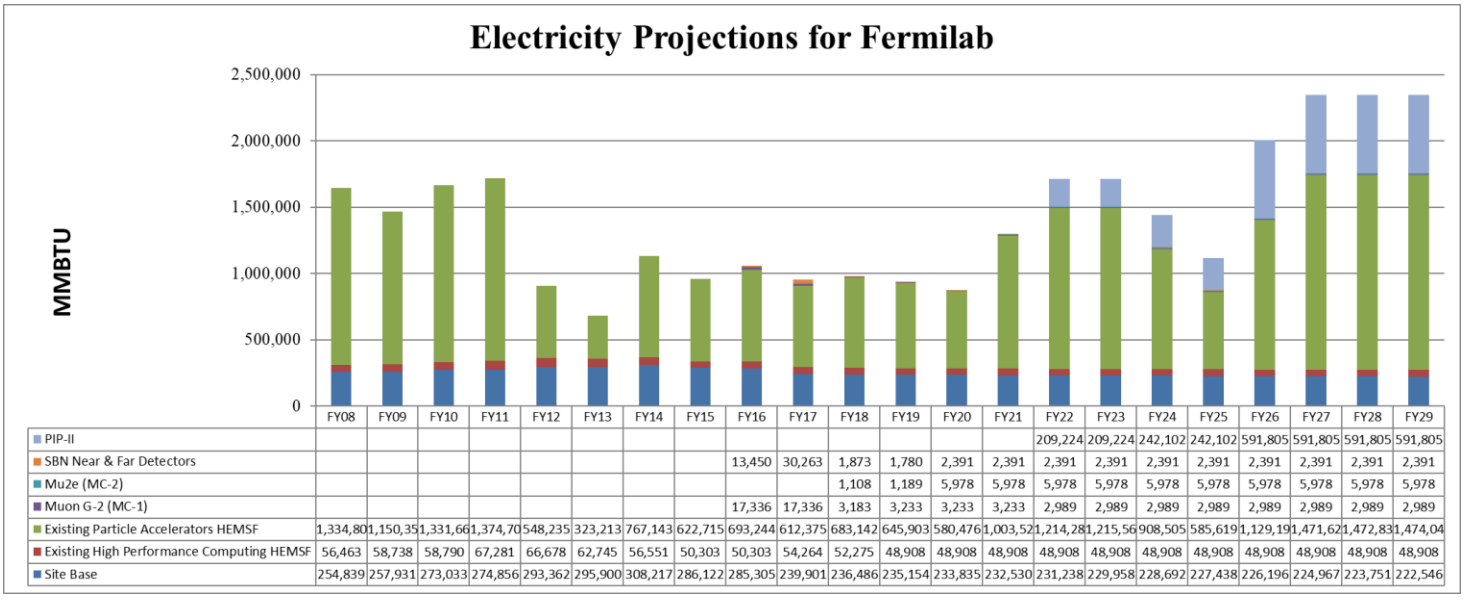


Figure 1 Site EUI (kBtu/ft²)

Plans

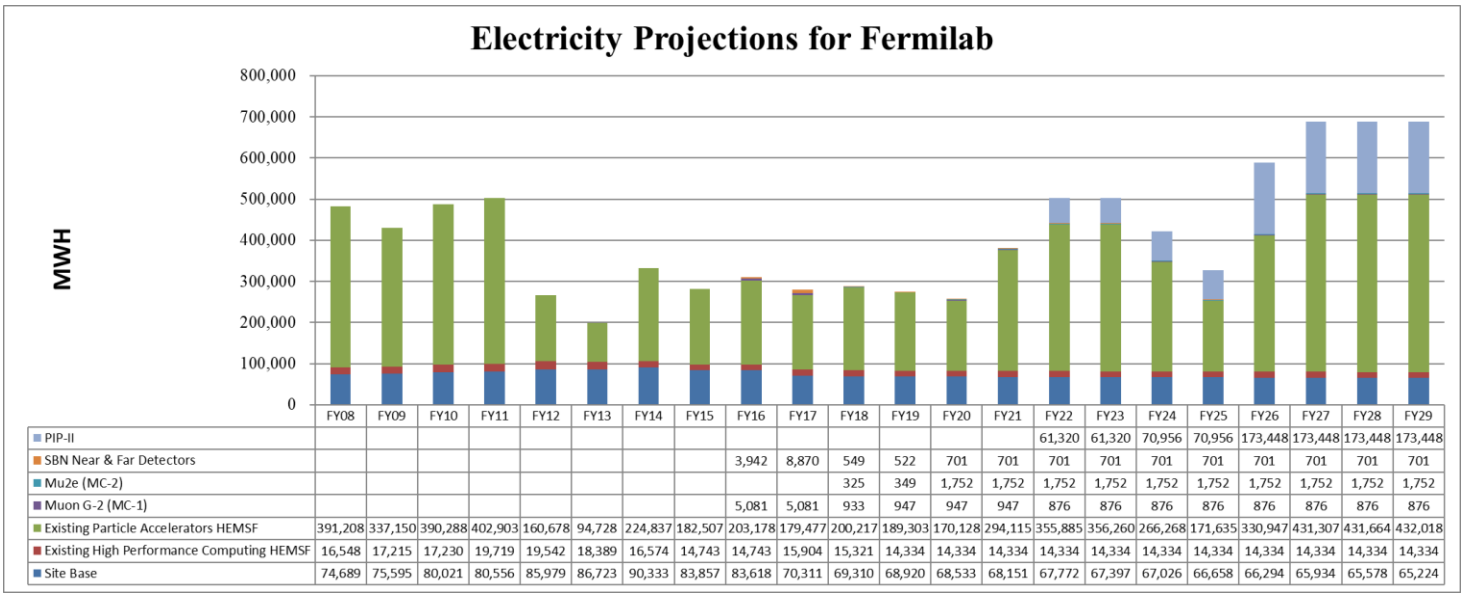
Electricity Use Projections

A significant change to Fermilab's projected energy consumption will occur starting in 2024 when a planned 2-year accelerator shutdown begins and will conclude in 2026 when the new PIP-II accelerator complex is brought online. During the shutdown, the LBNF infrastructure will tie into the existing accelerator campus. The PIP-II accelerator operation is expected to increase Fermilab's overall energy consumption significantly, perhaps by 30% over existing levels.



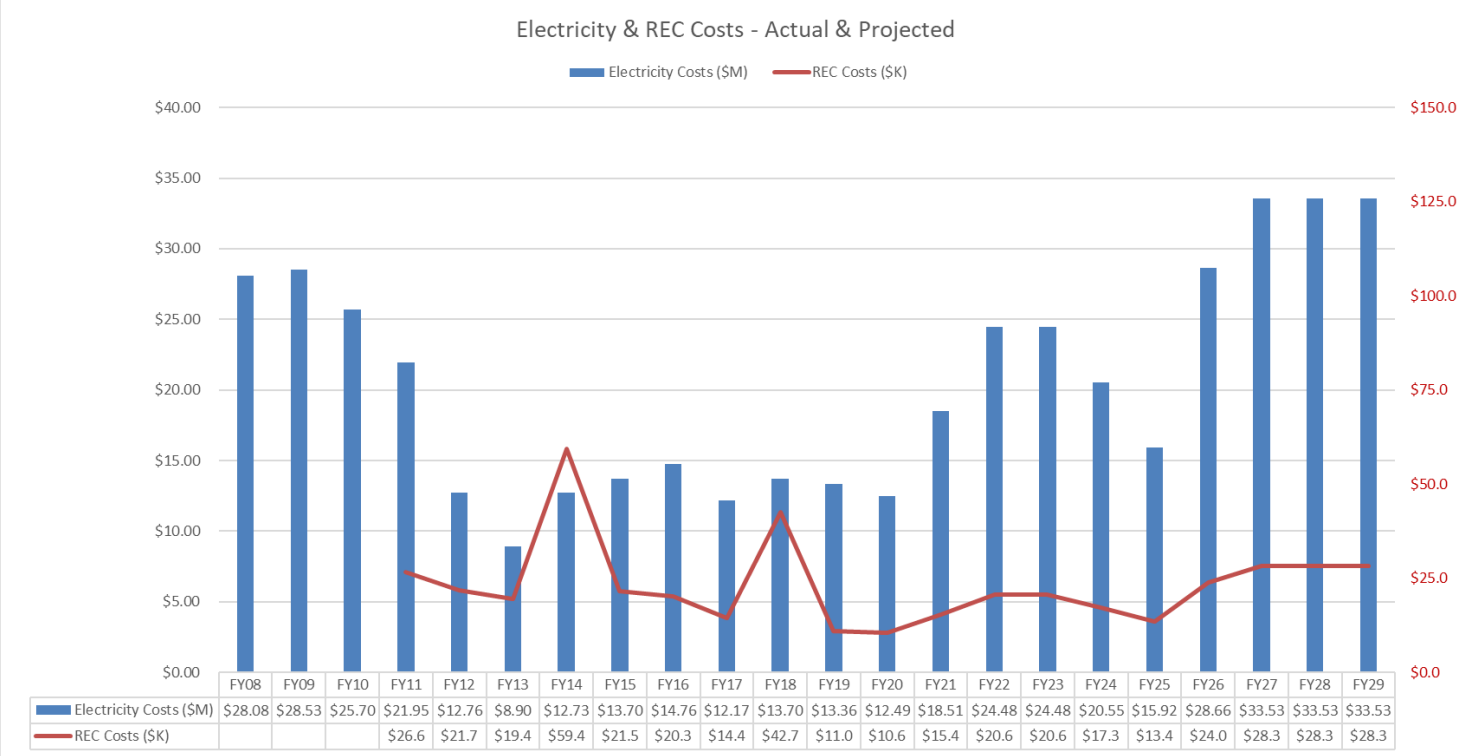
	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
PIP-II															209,224	209,224	242,102	242,102	591,805	591,805	591,805	591,805
SBN Near & Far Detectors									13,450	30,263	1,873	1,780	2,391	2,391	2,391	2,391	2,391	2,391	2,391	2,391	2,391	2,391
Mu2e (MC-2)											1,108	1,189	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978	5,978
Muon G-2 (MC-1)									17,336	17,336	3,183	3,233	3,233	3,233	2,989	2,989	2,989	2,989	2,989	2,989	2,989	2,989
Existing Particle Accelerators HEMSF	1,334,80	1,150,35	1,331,66	1,374,70	548,235	323,213	767,143	622,715	693,244	612,375	683,142	645,903	580,476	1,003,52	1,214,28	1,215,56	908,505	585,619	1,129,19	1,471,62	1,472,83	1,474,04
Existing High Performance Computing HEMSF	56,463	58,738	58,790	67,281	66,678	62,745	56,551	50,303	50,303	54,264	52,275	48,908	48,908	48,908	48,908	48,908	48,908	48,908	48,908	48,908	48,908	48,908
Site Base	254,839	257,931	273,033	274,856	293,362	295,900	308,217	286,122	285,305	239,901	236,486	235,154	233,835	232,530	231,238	229,958	228,692	227,438	226,196	224,967	223,751	222,546

Table 1 Electricity Projections (MMBTU)



	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
PIP-II															61,320	61,320	70,956	70,956	173,448	173,448	173,448	173,448
SBN Near & Far Detectors									3,942	8,870	549	522	701	701	701	701	701	701	701	701	701	701
Mu2e (MC-2)											325	349	1,752	1,752	1,752	1,752	1,752	1,752	1,752	1,752	1,752	1,752
Muon G-2 (MC-1)									5,081	5,081	933	947	947	947	876	876	876	876	876	876	876	876
Existing Particle Accelerators HEMSF	391,208	337,150	390,288	402,903	160,678	94,728	224,837	182,507	203,178	179,477	200,217	189,303	170,128	294,115	355,885	356,260	266,268	171,635	330,947	431,307	431,664	432,018
Existing High Performance Computing HEMSF	16,548	17,215	17,230	19,719	19,542	18,389	16,574	14,743	14,743	15,904	15,321	14,334	14,334	14,334	14,334	14,334	14,334	14,334	14,334	14,334	14,334	14,334
Site Base	74,689	75,595	80,021	80,556	85,979	86,723	90,333	83,857	83,618	70,311	69,310	68,920	68,533	68,151	67,772	67,397	67,026	66,658	66,294	65,934	65,578	65,224

Table 2 Electricity Projections (MWH)



	FY08	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
Electricity Costs ($M)	$28.08	$28.53	$25.70	$21.95	$12.76	$8.90	$12.73	$13.70	$14.76	$12.17	$13.70	$13.36	$12.49	$18.51	$24.48	$24.48	$20.55	$15.92	$28.66	$33.53	$33.53	$33.53
REC Costs ($K)				$26.6	$21.7	$19.4	$59.4	$21.5	$20.3	$14.4	$42.7	$11.0	$10.6	$15.4	$20.6	$20.6	$17.3	$13.4	$24.0	$28.3	$28.3	$28.3

Table 3 Electricity & REC Costs - Actual & Projected

EISA Section 432 Benchmarking and Evaluations

Goal

Evaluate all facilities that constitute at least 75% of Fermilab's total energy use every four years

2019 Actual

In year three out of the four-year Energy Independence and Security Act (EISA) Section 432 schedule, Fermilab has completed energy evaluations on 47% of facilities that consume 75% of Fermilab's total energy use. (1,635,360 gsf complete, 1,794,643 gsf remaining.)

Status

In FY 2018, the State of Illinois discontinued its public-sector retro-commissioning and energy assessment program for electric utility consumers greater than 10MW. However, a natural gas energy efficiency program is now available through the local natural gas utility. Fermilab's emerging centralized facility management program is also conducting condition assessments of facilities included in the program. The resulting data will enable Fermilab's facilities planning teams to more accurately plan for targeted energy assessments.

In FY 2019 Fermilab had ASHRAE Level 2 audits performed at 5 facilities: CUB, OTE, Site 37, Site 38, and Site 39. These audits were performed by the local natural gas utility free of charge. These audits included ECMs specific to natural gas savings.

In effort to increase the number of HPSB facilities, audits and energy models were performed at 3 facilities: Training Center, IB3a, and D-0 Outback. These audits produced a list of ECMs which are required to be completed in order for the facility to earn HPSB status.

Plans

Fermilab will continue to perform energy and water evaluations of goal-subject facilities to complete all facilities every four years. In FY 2020, Fermilab will again partner with the local natural gas utility to complete energy efficiency ASHRAE Level 2 facility assessments.

Facility Metering

Goal
Meter all individual buildings for electricity, natural gas, steam, and water where cost-effective and appropriate.

2019 Actual
100% of new facilities are metered at the building level. Of existing buildings:

- 55% of facilities are individually metered for electricity,
- 61% of facilities are individually metered for natural gas, and
- 7% of facilities are individually metered for domestic water.

Status

Fermilab's new buildings utilize the most current smart meters designed to monitor, track, and assess facility performance and energy consumption. Existing facilities are variably metered either at the building level or at the branch level, giving facilities management staff the ability to monitor energy consumption and identify and mitigate energy consumption issues. The industrial cooling water utility is most comprehensively metered enabling the laboratory to manage ICW to sustain programmatic needs. Electric, natural gas, and domestic water meters are deployed less frequently on existing buildings, but issues are identified as they arise, and consumption is monitored by utilizing branch metering.

A project to replace aged natural gas meters began in FY2019 with the installation of new smart meters at the Central Utilities Building and Warehouse 1. The remainder of the project will be completed in the spring of FY2020.

Plans

As part of Fermilab's campus modernization efforts, aging and failing utility meters will be replaced with smart meters. In FY 2020, the laboratory's metering infrastructure will be further evaluated as part of a Strategic Utilities Assessment. As a result, Fermilab will be able to better plan for metering needs and funding. Fermilab will also conduct an evaluation of meters that will properly interface with the laboratory's supervisory control and data acquisition (SCADA) system.

Water Management

Water Use and Management – Potable

Potable Water Intensity

Goal: Reduce water intensity by 36 percent by FY 2025 relative to FY 2007 baseline
Interim Target (FY 2019): -24.0%

Current Performance: 18.4%

	FY 2007	FY 2019	% Change
Water Consumption (million gal)	41.4	50.4	21.7%
Aquifer Recharge (million gal)	0.0	0.0	N/A%
Total GSF	3,398,290.0	3,492,392.0	2.8%
Water Intensity (Gal/GSF)	**12.2**	**14.4**	**18.0%**

Status

Potable water intensity showed a 18.4% increase against the 2007 baseline. This dramatic increase was the result of two large and persistent below ground leaks in primary supply lines. An increase in water use was first noticed in January and the leak persisted until it was found by way of a flooded accelerator tunnel in September. A second significant leak was discovered and repaired near Fermilab's Muon Campus. Fermilab utilizes a continuous domestic water monitoring system to identify water consumption anomalies and excursions. Conventional potable water reduction measures include specifying water efficient fixtures in all new construction and renovation projects.

Facility	kGal	gsf	UI (Gal/gsf)
CMTF	201	27,204	7.39
HAB	80	41,610	1.93
MC-1	564	14,881	37.92
MC-2/Mu2e	136	8,800	15.42
SBN Far	41	14,775	2.77
Wilson Hall	3,719	420,213	8.85
Total	4,741	527,483	8.99

Table 4 FY19 Potable Water Intensity Usage

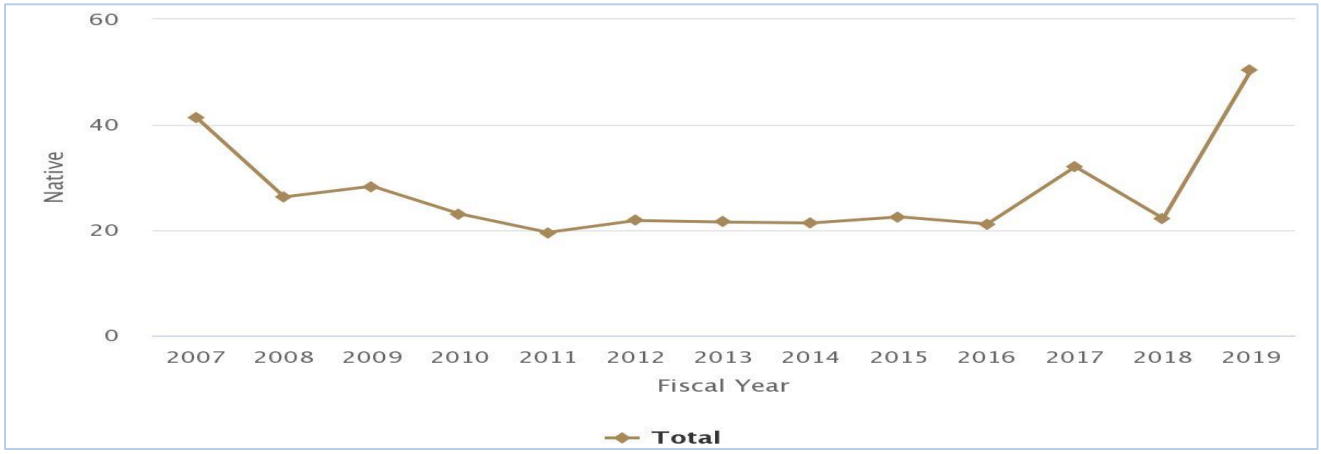


Figure 2 Potable Water Consumption in MGal, 2007-2019

Plans

With the repair of the two major water line breaks complete, Fermilab expects to return to meeting the potable water intensity reduction goals in FY 2020. However, aging site infrastructure, including potable water lines, pose a significant risk to maintaining potable water efficiency. Water main or branch breaks reduce the site's water consumption efficiency and consume staff time to reactively respond to and repair the breaks. The Utilities Improvement Project (UIP), a line item infrastructure funding project, will seek to replace distributed domestic water distribution lines and will further improve site domestic water efficiency.

Water Use and Management – Industrial, Landscape & Agricultural

Non-Potable Water Consumption

Goal: Reduce potable water intensity by 36 percent by FY 2025 relative to FY 2007 baseline.
Interim Target (FY 2019): -18.0%

Current Performance: -36.4%

	FY 2010	FY 2019	% Change
Industrial	81.3	51.7	-36.4%
Landscaping	0.0	0.0	N/A%
Agricultural	0.0	0.0	N/A%
Total Non-Potable Water (million gal)	**81.3**	**51.7**	**-36.4%**

Status

Virtually all ILA water used at Fermilab is contained in a semi closed loop, surface and piped Industrial Cooling Water (ICW) system to provide cooling for the accelerator complex. Water for the ICW system is obtained principally from precipitation that falls on site and is captured in an interconnected network of ponds and ditches. Precipitation is considered an alternative water source and therefore is not subject to efficiency goals. The ICW system is further supplemented by water captured from the bedrock formation associated with the MINOS facility located in an underground tunnel, water pumped from the Fox River, and water pumped from a deep on-site well. These supplemental sources help make up for losses of surface water. In FY 2019, volumes from these three sources were as follows:

Source	Total
MINOS formation water	46.7
Fox River water	0.0
Deep well water	5.3
Total FY 2019	52.0
Total FY 2010	81.3
Difference	(29.3)

Table 5 FY19 ICW System Usage in MGal

As reported in the Dashboard, ILA water usage during FY 2019 is calculated as the sum of these supplemental sources and represents a 36% reduction from the 2010 baseline year.

Fermilab has adopted a site-wide strategy of natural landscaping and native grassland management that requires a minimum amount of landscape watering. Minor amounts of non-potable ICW are used during times of drought to water ornamental trees. There is no use of potable or non-potable water for routine landscaping or the irrigation of row crops at Fermilab.

Plans

In 2020, Fermilab will continue to take measures to increase the efficiency of the system. Nearly all of Fermilab's ILA water is used to support HEMSF operations. The demand for cooling water cannot be met solely by the capture of storm water retained on site. As new facilities come on-line including a new particle accelerator, the volume of cooling water required to meet cooling demands will rise. One source of supplemental cooling water in the past was pumped water from outside the site boundaries at the Fox River. A suspected breach in the line caused the lab to discontinue pumping in FY 2019. However, the line may be reinstated in FY 2020.

Waste Management

Municipal Waste Diversion

Municipal Solid Waste

Goal: Divert at least 50 percent of non-hazardous solid waste (excluding construction and demolition debris)
Interim Target (FY 2019): 50.0%

Current Performance: 53.6%

	FY 2019	%
Off-Site Landfills	258.5	46.2%
On-Site Landfills	0.0	0.0%
Waste to Energy*	1.3	0.2%
Non-diverted Waste	***259.8***	***46.5%***
Diverted Waste	296.3	53.0%
On-Site Composted	0.0	0.0%
Off-Site Composted	2.0	0.4%
Waste to Energy Credit	1.3	0.2%
Total Diverted Waste	***299.5***	***53.5%***
Total Waste (metric tons)	**559.3**	**100.0%**

* For E.O. 13693, waste to energy does not count as diverted waste, but some credit may be applied

Status

Fermilab has an established recycling program and actively seeks out opportunities to expand the program where it is feasible. Nearly 300 metric tons (54%) of Fermilab's waste was diverted from landfills in FY2019. This includes paper, plastic, and aluminum cans as well as scrap metal and other items such as alkaline batteries and polystyrene.

The Fermilab cafeteria contractor has an established compost program for kitchen scraps that generated 1.97 tons of compostable material. Kitchen waste grease totaling 1.26 tons was also gathered and reclaimed as a bio-based fuel. Fermilab's cafeteria contractor has transitioned away from polystyrene to-go containers and moved completely towards recyclable fiberboard material for disposable food containers.

Photo 3 Standard battery recycling station

Plans

Fermilab continues to build an aggressive waste minimization program, including recycling and compost collection in the cafeteria. New signage and bins were deployed in FY 2019 in the cafeteria to assist in refuse sorting.

A small ad hoc group met on a regular basis to work on waste related facilities integration projects. One item for improvement planned for FY19 was to develop a waste management tracking database to simplify and standardize data collection for all types of

non-hazardous waste. Implementation of the database was delayed due to changes in personnel and competing priorities, however plans continue to develop the database.

Construction & Demolition Waste Diversion

Construction & Demolition

Goal: Divert at least 50 percent of construction and demolition materials and debris

Interim Target (FY 2019): 50.0%

Current Performance: 81.6%

	FY 2019	%
Landfilled C&D Waste	87.6	18.4%
Diverted C&D Waste	388.5	81.6%
Total C&D Waste (metric tons)	**476.0**	**100.0%**

Photo 4 IERC construction site as of 10/15/19

Status

In FY 2019, Fermilab generated 476 metric tons of construction and demolition waste of which 81.6% was ultimately recycled/diverted. For various ongoing small-scale projects, Fermilab has staged at strategic locations C&D recycling collection receptacles. All large scale projects have dedicated recycling dumpsters.

Plans

Fermilab will continue to advocate for best practices in the management of construction and demolition debris. The laboratory maintains a clear set of specifications and related requirements for all new construction projects to include C&D debris recycling. Data collection should be simplified and standardized with the creation of a waste management tracking database expected to be online for FY2021.

Fleet Management

Fuel use data/ scorecards not included due to unavailability of DOE Sustainability Dashboard data

Fleet Management Strategies

Status

Fermilab's approach towards fleet management incorporates the concept of smart fleet utilization to provide mission support. The goal is to partner with the operational units of the lab to provide an optimal blend of vehicles necessary to run the facility. More than half of the motor vehicle fleet is alternatively fueled and Fermilab uses alternative fuels in 100% of the alternatively fueled fleet.

Fermilab maintains a commitment to right sizing its fleet. A Fleet Utilization Committee meets quarterly to discuss/review fleet issues and work collaboratively to ensure the fleet is at the appropriate level for mission need without excess/unnecessary vehicles. There were no major changes to the Fermilab fleet in FY2019. One additional light duty 4-wheel drive truck was added to support a large construction project that involves extensive field work.

An on-site fueling station has been dispensing E85 since 2004 and all fleet vehicles capable of using this fuel source use it exclusively. Recently, a request waiver was needed for two vehicles at Fermilab's leased site in South Dakota because E85 is not available.

Fermilab has been unsuccessful in finding renewable diesel as an alternative fuel for its diesel fleet due to its unavailability in this region of the country. Additionally, until this year, Fermilab had been using biodiesel as the main source of fuel for the diesel fleet. However, severe engine and filter issues have prompted a return to straight diesel. Although the timeline for the procurement of renewable diesel is unknown, Fermilab will continue to pursue a project to first demonstrate, then deploy renewable diesel to replace the laboratory's current biodiesel product.

Photo 5 E85 pump located at the on-site fueling station.

Plans

Fermilab will continue to consider fuel efficient and alternatively fueled vehicles including plug-in electric and hybrids when procuring vehicles in FY2020. As manufactures increase the type and styles of electric vehicles, Fermilab anticipates greater ease in procuring them. When additional plug-in vehicles are purchased, the laboratory will consider installing more electric vehicle charging stations. Electric vehicle charging stations will also be deployed, where possible, in new construction or significant redevelopment projects.

Clean & Renewable Energy

Renewable Energy

Renewable Electricity

Goal: Use 30 percent renewable energy as a percentage of overall facility electricity use by FY 2025
Interim Target (FY 2019): 15%

Current Performance: 9.0%

	FY 2019 Electricity Consumption	FY 2019 Renewable Electricity w/ Bonuses	% of Total
Grid Electricity	274,375	0.0	N/A
On-Site Renewable Energy	0	1,705	0.6%
Purchased Green Electricity	0	0.0	N/A
Renewable Energy Certificates	N/A	23,000	8.4%
Total (MWh)	**274,375**	**24,705**	**9.0%**

Status

Fermilab produced approximately 6 MWH/year of on-site clean and renewable energy. The Office, Technical and Education building (FIMS 328) is heated and cooled by a ground source heat pump network and produced 1,704 MMBTU in FY2019. This is 84.5% the design output of 2,015.5 MMBTU, with the reduction from full output due to a lengthy outage of one of the compressor modules. Fermilab purchased 23,000 MWH of RECs in FY2019, equivalent to 8% of the site's total annual electric energy consumption. Renewables consumption/production did not meet DOE's end of year adjusted renewable energy goal.

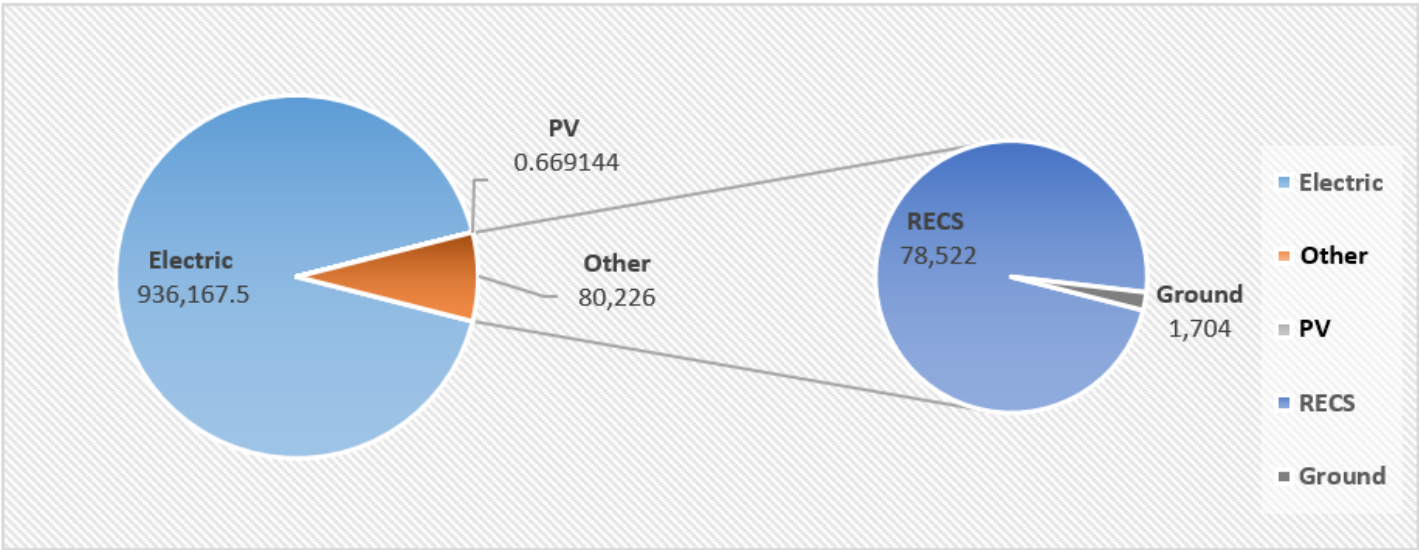


Figure 3 Total Renewable Energy Consumption in MMBtu

Plans

Solar photovoltaic, solar hot water heating and other clean and renewable systems are regularly considered in all construction assessments, but due to Fermilab's very low energy utility rates, have not yet to be found cost effective. Fermilab will continue purchasing Renewable Energy Certificates (RECs) to meet DOE goals each year, until cost effective opportunities for renewable power generation are identified. Fermilab continues to explore renewable energy opportunities including the potential to develop a large-scale solar development.

Sustainable Buildings

Guiding Principles

Sustainable Buildings

Goal: Ensure 17 percent by building count comply with the Guiding Principles for sustainable buildings by FY 2025. Interim Target (FY 2017): 15.0 %
Interim Target (FY 2019): 15.5%

Current Performance: 8.5%

	Building Count	GSF
Guiding Principles Certified	8	141,621
Total Applicable*	94	1,995,071
Performance (%)	**8.51%**	**7.10%**

* Applicable means buildings and trailers that are DOE owned or DOE leased where the gross/rentable SqFt is greater than 5,000.

Status

In FY 2019 Fermilab continued to assess existing buildings to identify potential candidates for which to pursue high performance sustainable building (HPSB) building compliance. Two buildings were selected for assessment. Building IB3a was assessed using energy modeling against ASHRAE 90.1 2016 and resulted in proposed energy conservation measures (ECM) to meet the 30% better than ASHRAE baseline. The D-Zero building was assessed against the FY2015 baseline and resulted in proposed ECMs. Additionally, these two buildings along with Fermilab's Training Center building completed ASHRAE 55 & 62 compliance analysis. Fermilab has further updated from last year the inventory of HPSB baseline buildings to align with Federal Real Property Profile guidance for low energy use, no occupancy, and low or no water use. Including buildings previously identified in 2018, 10 buildings meet the requirements and are reflected in the base eligible building list. Fermilab currently has eight buildings (13.5%) that meet HPBS requirements for buildings over 10,000 gsf. The baseline count of buildings stands at 59.

Facility Name	FIMS Property ID	SqFt	Compliance Year
HDCF - Grid Comp Ctr	628	16,925	2014
Office, Technical and Education (OTE)	328	47,300	2014
Site 37 Shop Roads and Grounds	921	17,500	2015
MC-1	209	14,881	2017
MC-2	270	11,000	2017
SBN Far Detector Building	788	14,775	2017
SBN Near Detector Building	789	5,240	2017
ICB-A	802	14,000	2019
Projected			
Training Center	522	9,565	2020+
IB3-A	808	14,670	2020+
D0-PPD Office	326	10,483	2020+
PIP-II CryoPlant Building (New)	350	28,283	2021
IERC (new)	4	100,000	2020+
PIP-II High Bay Building	351	21,275	2022
PIP-II Linac Gallery	352	32,905	2024

Table 6 GP Compliant Buildings to date and Projections

Plans

If awarded, the Core Campus Revitalization Project (CCRP, HEP line item project) would include significant funds for modernizing Wilson Hall and the Technology Campus. Major renovations would include analysis of strategies to achieve High Performance Sustainable Building guidelines. The engineering design guide and procedure includes the requirement for providing energy modeling to show 30% better than ASHRAE baseline for new building over 5,000 gsf. The submittal of an energy model is included as part of the typical 60% design submittal. Fermilab is updating the lab's engineering design guide's sustainability section to incorporate climate-resilient design and management elements into the design of applicable new or retrofitted buildings.

There are no existing buildings or planned new construction identified for Net Zero energy. The Campus Master Plan noted that the GAC (Global Accelerator Center), known alternately as the Accelerator Science and Technology Center (ASTC), may be the first non-process building to be designed to Net Zero Energy.

New Building Design

Status

Building ICB-A was completed in FY2019 and is HPSB guiding principles (GP) compliant. Fermilab has four buildings that are either at design stage or have just completed design. The Integrated Engineering Research Center is in design stage and currently at approximately 25% compliance. The project will continue to track, evaluate and update guiding principles as design progresses and anticipates full compliance at the end of construction. The design for the PIP II Cryo building was completed this year. The GP checklist was updated from 15% predesign to 55% compliant after final design and is expected to be fully compliant up completion of construction. The Linac Complex phase of PIP-II includes two buildings, High Bay and Linac Gallery which will start design in 2020. This project anticipates 50 – 70% compliance at the end of design.

Photo 6 Completed ICB-A building

Plans

All new buildings that meet square foot threshold for HPSB eligibility will be designed to meet the HPSB guiding principles and the 30% building energy over ASHRAE 90.1 baseline. Fermilab has a procedure in place, as well as updated design guides, and design reviews to ensure the HPSB guiding principles are met.

Acquisition & Procurement

Status

In 2019 Fermilab applied sustainable acquisition requirements to all eligible contracts per Department of Energy Acquisition regulations. An established eMarketplace system helps the laboratory reduce the amount of paper requisitions by allowing employees the ability to place orders from the point of need.

FY 2019 Sustainable Acquisition (SA) Progress	
Metric	**Total**
Eligible Contract Actions	179
Contract Actions w/ SA Clauses	179
Percentage of Contract Actions w/SA Clauses	100%
Eligible Contract Dollars	$ 102.9M
Contract Dollars ($) w/ SA Clauses	$ 102.9M
Percent of Contract Dollars w/ SA Clauses	100%

Table 7 Sustainable Acquisition Progress

Plans

In FY 2020 Fermilab will continue to explore opportunities to improve sustainable acquisition.

Measurements, Funding & Training

Status

Over the last 18 years, Fermilab has completed 6 utility energy service contracts (UESCs, formerly called UIP) and energy savings performance contracts (ESPCs) valued at nearly $60 million. In 2014, Fermilab conducted an investment grade audit, but a viable ESPC project was not pursued. Measurement and verification (M&V) is performed annually by Ameresco for a 15-year ESPC begun in 2011. The M&V reports verify that the projected energy savings are all being met. The ESPC included a new central plant boiler, various lighting upgrades, and disconnection of unused transformers.

Summary of Sustainability Funding ($K)			
Category	**FY19 Actual**	**FY20 Planned/ Requested**	**FY21 Projected**
Sustainability Projects	0.0	0.0	0.0
Sustainability Activities other than projects	0.0	0.0	0.0
SPO Funded Projects (SPO funding portion only)	0.0	0.0	0.0
Site Contribution to SPO Funded Project	0.0	0.0	0.0
ESPC/UESC Contract Payments	206.3	216.4	226.2
Renewable Energy Credits (REC) Purchase Costs	11.0	15.4	15.4
Total	217.3	231.8	241.6

Table 8 Fermilab Sustainability Funding and Projections, FY 2019 – FY 2021

Plans

Fermilab will continue to assess future opportunities including technology specific measures. Recent state legislation has removed Fermilab and other high energy-consuming customers from its public energy efficiency incentive program. However, Nicor, the local natural gas utility, has recently begun offering rebates and energy audits for its high gas use customers. In FY2019, Fermilab has used this service on several buildings. Since Nicor is a natural gas utility, their audits cover ECMs that benefit natural gas consumption only.

While Fermilab is working towards the goal of more HPSB buildings, we have coupled the HPSB audits to also include EISA audits. These have been performed on 3 facilities in FY2019: The Training Center, IB3A, and PPD Office Building at D-0.

Fermilab is also investigating the development of an in-house program to reinvest and incentivize energy efficiency projects. The laboratory is benchmarking with other facilities to identify best practices and developing a coordinated approach to enhancing Fermilab's energy management program.

Travel & Commuting

Status

As noted in previous SSPs, mileage associated with airline travel has changed over the past several years. The increase in medium haul flights continues to increase in support of the Deep Underground Neutrino Experiment located in the Sanford Underground Research Facility in Lead, South Dakota. Fermilab expects this travel to continue for the foreseeable future.

Fermilab's site wide bicycle sharing program, initiated in the spring of 2018, has been successful and expanded to accommodate the additional users. The program grew in 2019 with the installation of bike stations at additional locations to accommodate an increased demand by riders.

Plans

As Fermilab has continued ramping up the DUNE effort in FY2019, there has been an increase in management related travel. The development of the far site in South Dakota has required additional medium distance air travel (see figure). The oversight of this effort is expected to continue for some time, and we expect the medium distance air travel will be higher than pre-DUNE years.

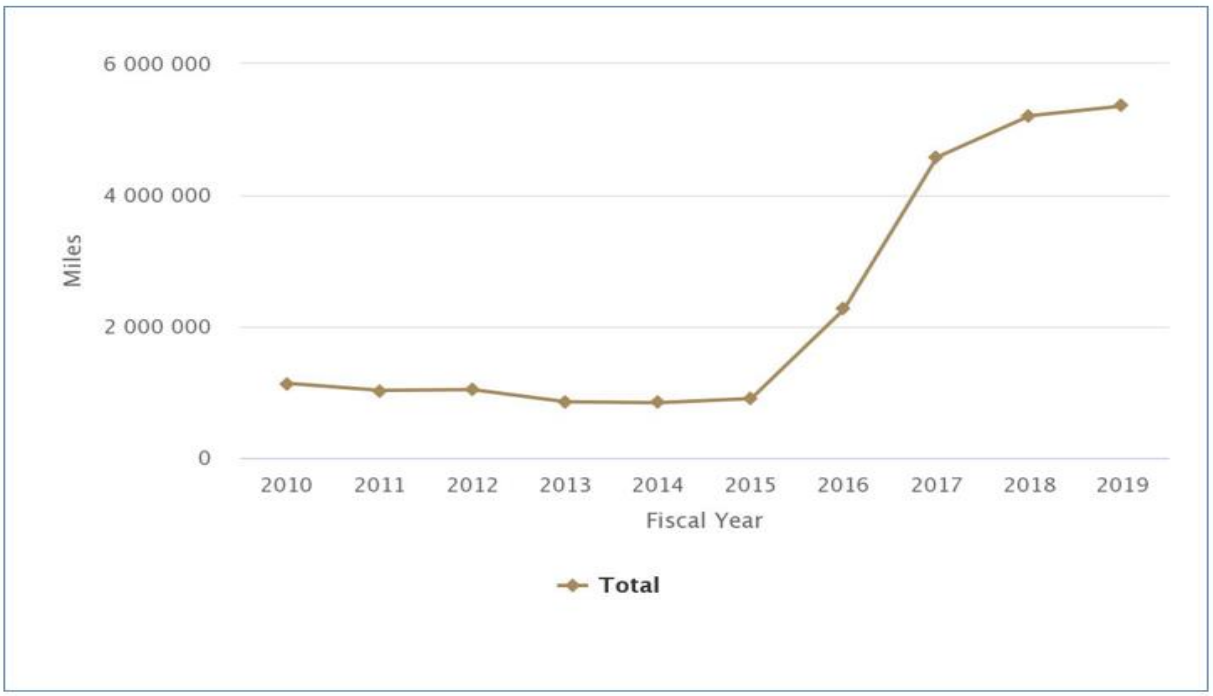


Figure 4 Medium haul flights

Fugitives & Refrigerants

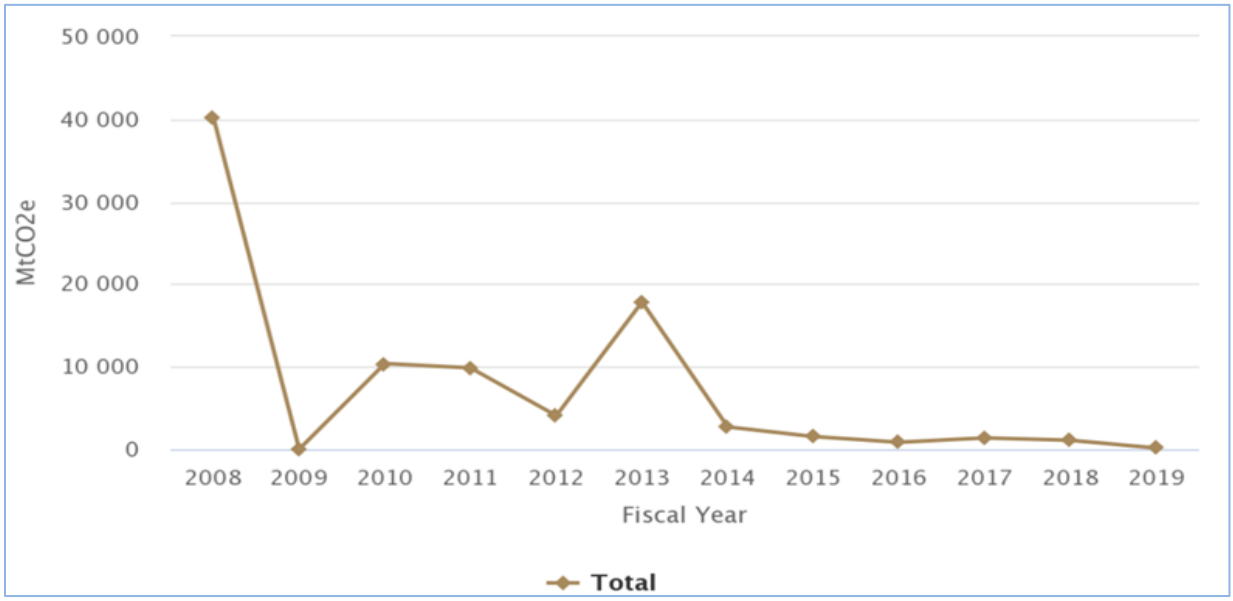


Figure 5 Fugitives and Refrigerants Emissions, MtCO2e, 2008-2019

Status

Fugitive emissions continue to trend lower and are well below 2008 baseline releases. Fermilab uses an in-house refrigerant management system based on regulatory refrigerant use protocols to minimize losses. This centralized system uses a database based on refrigerant mass balance accounting to track the use (and release) of refrigerants used across the site. Fermilab uses very little sulfur hexafluoride (SF_6), and inventories are managed by groups who use it.

In 2019, Fermilab provided enhanced third-party training to laboratory staff involved with the management of refrigerants. The training involved a review of relevant regulations, including a focus on recent changes, data management and reporting, guidance on self-assessing the program, and lessons learned from different industries. Members of the Logistics and Property Control Group (LPC) and the Environmental Protection Group participated to ensure an understanding of the requirements from both a compliance and reporting standpoint as well as from operations.

Plans

Fermilab will continue to track the release of fugitive emissions. A near term challenge will be to address a transition away from R22 refrigerant still used in cooling systems across the facility.

Electronic Stewardship

Electronics Acquisition

Goal: 100 percent of eligible electronics procurements must be environmentally sustainable (e.g. EPEAT)
Interim Target (FY 2019): 95.0%

Current Performance: 99.5%

	EPEAT Acquired	Total Acquired	%
Monitors	291	291	100.0%
Computers	461	461	100.0%
Imaging Equipment	3	3	100.0%
Televisions	2	2	100.0%
Total Acquired	**806**	**810**	**99.5%**

Electronics Recycling

Goal: Dispose of 100 percent of electronics through government programs and certified recyclers
Interim Target (FY 2019): 100.0%

Current Performance: 100.0%

	Amount	%
Transferred or Donated	1.470	7.2%
Recycled by Certified Recycler	18.926	92.8%
Recycled by non-Certified Recycler	0.000	0.0%
Amount disposed (e.g. landfill)	0.000	0.0%
Total Electronics Waste (metric tons)	**20.396**	**100.0%**

Power Management

Goal: Implement and actively use power management features on 100 percent of eligible computers (PCs & laptops) and monitors
Interim Target (FY 2019): 100.0%

Current Performance: 97.0%

	Total Owned	PM Enabled	Exempt	%
Monitors	0	0	0	N/A%
Computers	5,200	3,903	1,175	97.0%
Total Items	**5,200**	**3,903**	**1,175**	**97.0%**

Duplex Printing

Goal: Implement and actively use duplex printing features of 100 percent of eligible printers
Interim Target (FY 2019): 100.0%

Current Performance: 100.0%

	Total Owned	Duplex Enabled	Incapable	%
Total Printers	**259**	**255**	**4**	**100.0%**

Status

Fermilab is committed to meeting the prescribed federal acquisition goals for electronic assets by purchasing qualified computing equipment which meet the Electronic Product Environmental Assessment Tool (EPEAT) registration requirements. Requisitioners must provide justification for any acquisitions that are not EPEAT registered. These justifications must be reviewed and approved by a designated approver. Purchases that may cause the failure to meet these goals may be denied.

Fermilab requires that all eligible desktops and laptops be centrally managed. Central management systems enforce power management settings as defined in the respective operating system baseline.

A user must submit a Power Management Exemption request for any monitor, laptop or desktop that cannot meet the Power Management settings. That request will be reviewed to determine if the provided business case is sufficient. If approved, the device will be added to the appropriate power management exemption group.

Figure 6 Fermilab was awarded the Energy Star award for the Grid Computing Center in each of the last ten consecutive years.

Fermilab lists all electronics on the federal General Services Administration (GSA) excess system that are condition code 1 (unused), 4 (used, working) or 7 (repairs required). If an asset does not get reused through the GSA excess system, it is disposed of by sending to a R2 recycler.

Office Lighting Conversion to Motion Detection Switches

Figure 7 Motion Detection Switch

In 2019, Fermilab continued an initiative at the Feynman Computing Center to replace office lighting with motion detection switches. 11 offices were reconfigured in FY2019 bring the total from 30 to 41. The estimated annual energy savings for all 41 offices is 70,069 kWh or $3,075/year.

HEPCloud Project

Fermilab's Scientific Computing Division HEPCloud project has demonstrated the ability to burst into commercial cloud and High-Performance Computing (HPC) resources at a level matching the entirety of global resources allocated for the Compact Muon Solenoid (CMS) experiment. HEPCloud received Authority to Operate status in early 2019 and is now an operational service. Through HEPCloud, Fermilab has heavily utilized the HPC facilities at the National Energy Research Scientific Computing Center (NERSC) for CMS and executing scientific workflows for the Intensity Frontier NOvA experiment at scales orders of magnitude larger than resources available at Fermilab. The HEPCloud project is extending its reach into other DOE HPC facilities at Argonne and Oak Ridge.

Plans

In FY 2020, Fermilab's data center efficiency is expected to improve. Most new services typically start on Virtual Machines (VM's) allowing the laboratory to avoid purchasing single purpose physical machines to run those workloads. The savings estimate for migrating workloads from single purpose physical systems to VM's is more than $2.6M or about 90% over approximately 8 years.

Organizational Resilience

Status

Fermilab continued to improve operational resilience in 2019. Improvements to date are as follows:

Photo 7 Seasonal flooding near Fermilab's central building, Wilson Hall.

- Construction of 4 miles of new ICW backbone piping ranging in size from 6” to 30” diameter pipe. Installed from Casey’s Pond to Main Injector and includes new network Loop piping to improve working pressures and fire protection flows.
- A new standalone pump station for the Cryogenic Test Module Facility at Andy’s Pond to reduce ICW demands on Casey’s Pumphouse.
- 100 horse power ICW pond pump motors raised 1.25 feet to reduce flooding potential.
- Two new strainer vaults at Casey’s Pond Pumphouse installed to improve efficiency in ICW flow control and monitoring.
- New Pump station at Swan Lake for more efficient return of water to ICW system.
- New Well 4 Pumphouse piping to improve means for adding makeup water to Swan Lake.
- Installation of Main Ring Pond A-0 makeup water piping. Used to return ICW flows from A-0 Pond back to Swan Lake and the Swan Lake Pump Station.
- Casey’s Pond electrical room addition. New space provides for relocated power supplies for four (4) 100 horsepower pumps previously exposed to flooding during heavy rain events.
- Reconstruction of the Kidney Pond parking lot, including a complete reroute of stormwater piping to alleviate chronic flooding problems.
- One mile of aging 6” diameter ductile iron domestic water line replaced with 4” diameter PVC pipe.

Plans

Fermilab intends to update its Engineering Design Guide to include an element to address climate resilient design. This would be applied to all applicable new or retrofitted buildings.

Executive Summary Table

Green; goal met, Yellow; cautionary, Red; goal not met

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
Multiple Categories				
50% Scope 1 & 2 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	62.5% reduction	Investigations into onsite renewables (building-level or utility scale) and continued focus on procurement of alternative fueled vehicles will carry Fermilab's Scope 1 & 2 reduction trend in the next 10 years.		
25% Scope 3 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	51.1% reduction	Fermilab's Scope 3 is dominated by transmission and distribution losses. Reduced electrical power consumption equates to reduced losses.		
Energy Management				
25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2025 from a FY 2015 baseline.	9.5%	Fermilab will work to reduce energy intensity of goal-subject buildings; Fermilab will continue to work towards previously established DOE targets. The lab will implement measures described in this Site Sustainability Plan.		
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	In compliance	In FY 2020 and beyond Fermilab will continue to work with State of Illinois -funded programs to pursue energy assessments where economically feasible.		
Meter all individual buildings for electricity, natural gas, steam and water, where cost-effective and appropriate.	100% new buildings at the building level; Existing Bldgs. 55% electricity 61% natural gas 7% water (no steam)	Previously Fermilab counted facilities metered by group feeder lines as 'individually metered.' Current data reflects only those metered at the unique facility location. Metering plan to implement meters at individual existing buildings as resources allow.		
Water Management				
36% potable water intensity (Gal per gross square foot) reduction by FY 2025 from a FY 2007 baseline.	18.4% increase	Fermilab will continue to specify low-water use fixtures in new construction or remodeling projects. Ongoing potable water system utility repairs will also help the reduction of potable water use onsite.		
30% water consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 from a FY 2010 baseline.	36.4% reduction	The makeup water which supplies Fermilab's site industrial cooling water will continue to fluctuate annually based on precipitation levels. However, Fermilab's overall ILA consumption (including precipitation-fed system) will continue to hold steady as repairs to branch lines continue.		
Waste Management				
Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris.	53.6% diverted	Fermilab strives to continue to meet and exceed the 50% diversion target, and overall totals may increase with continued focus on improved management of recyclable material.		
Divert at least 50% of construction and demolition materials and debris.	81.6% diverted	Onsite construction will continue to divert construction and demolition debris into reuse or recycling streams and will yield continued success in meeting and exceeding the 50% diversion rate target.		
Fleet Management				

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline.	Data not yet available in Dashboard	No data available.		
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; maintain 20% reduction thereafter.	Data not yet available in Dashboard	As electric and hybrid vehicle offerings grow, Fermilab's use of alternative fuels will continue to grow and offset petroleum consumption.		
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.	Data not yet available in Dashboard	As electric and hybrid vehicle offerings grow, Fermilab's use of alternative fuels will continue to increase relative to annual acquired vehicles.		
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV).	Data not yet available in Dashboard	As electric and hybrid vehicle offerings grow, Fermilab's acquisition of AFVs will increase.		
50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025.	Data not yet available in Dashboard	As electric and hybrid vehicle offerings grow, Fermilab's acquisition of AFVs will increase.		
Clean & Renewable Energy				
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than 25% by FY 2025 and each year thereafter.	8.0% From Renewable Energy Credits	Fermilab will continue to purchase Renewable Energy Credits to meet renewable energy targets. The laboratory will also explore opportunities for building-level or utility-scale renewable installations in conjunction with other energy saving projects.		
"Renewable Electric Energy" requires that renewable electric energy account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter.	9.0% From Renewable Energy Credits	Fermilab will continue to purchase Renewable Energy Credits to meet renewable energy targets. The laboratory will also explore opportunities for building-level or utility-scale renewable installations in conjunction with other energy saving projects.		
Green Buildings				
At least 17% (by building count) of existing buildings greater than 5,000 gross square feet to be compliant with the *revised* Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter.	8.5% Meet HBSB criteria	New facilities in planning and design stages will be designed and constructed to meet HPSB guiding principles. Fermilab will also pursue projects to modify existing buildings to bring additional existing buildings into compliance with HPSB guiding principles.		
Net Zero Buildings: 1% of the site's existing buildings above 5,000 gross square feet intended to be energy, waste, or water net-zero buildings by FY 2025.	No Data	No net NZB are currently planned.		

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
Net Zero Buildings: All new buildings (>5,000 GSF) entering the planning process designed to achieve energy net-zero beginning in FY 2020.	No Data	No net NZB are currently planned.		
Increase regional and local planning coordination and involvement.	Ongoing	Fermilab regularly engages with local communities via a community advisory board. Longstanding relationships exist with public works departments for surrounding communities that continue to evolve to meet common needs		
Acquisition & Procurement				
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts.	Meeting DOE's Goal	Fermilab will continue to include requirements for sustainable acquisition and procurement in contract terms and will seek opportunities to improve opportunities for requisitioners to choose sustainable alternatives.		
Measures, Funding, & Training				
Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section 14 of E.O. 13693.	Fermilab continues to consider opportunities for ESPC/UESC and other financing methods.	In FY 2020 and beyond, Fermilab will continue to consider opportunities for ESPC/UESC and other financing methods to support sustainability performance in the areas of energy efficiency, high performance sustainable buildings, and renewable energy.		
Electronic Stewardship				
Purchases – 95% of eligible acquisitions each year are EPEAT-registered products.	99.5% EPEAT Registered	Fermilab will continue to procure only EPEAT-registered products, with granted exceptions only for products with no registered alternative.		
Power management – 100% of eligible PCs, laptops, and monitors have power management enabled.	97% Enabled	Fermilab will continue to support lab wide computing power management.		
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	100% Enabled	Fermilab will continue to support and deploy automatic duplexing of all eligible computers and imaging equipment.		
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	100% Environmentally Sound Methods	Fermilab will continue to dispose of all end of life electronics through certified reuse or recycling programs/facilities.		
Data Center Efficiency. Establish a power usage effectiveness target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers.	1.6 PUE	Feynman Computing Center and the Grid Computing Center PUE is 1.6. The Grid Computing Center has achieved Energy Star rating for 10 consecutive years.		

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
Organizational Resilience				
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	Ongoing	Fermilab will continue to develop methods for integrating climate resilience techniques into emergency response, site planning, facility development and renovation processes.		