The Putney School Master Plan

May 2019

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Updated from December 2011

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Introduction

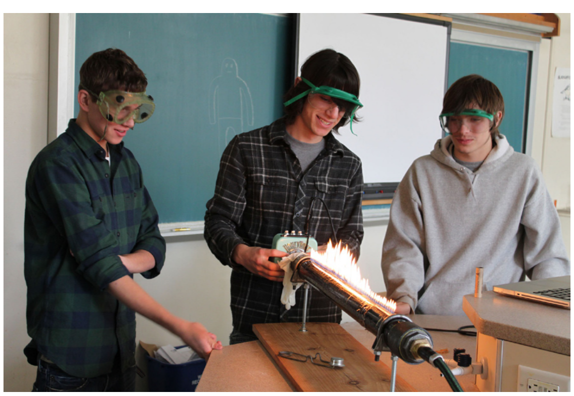
Dear Reader,

Putney's campus is an integral part of the Putney education and way of life. It would be hard to imagine Putney existing without this land, these trees and woods, this wind, and these simple and beautiful buildings. As we work towards making the campus more sustainable, environmentally and financially, we are grateful to those whose work and generosity has brought Putney this far. We have been careful not to build for the sake of building, careful not to incur debt, careful to preserve the rural nature of the campus and the simple and modest nature of the buildings. But the buildings are also wasteful of energy, and many are inadequate for their educational purposes. We built no new buildings for the 20 years before 1998, and deferred much needed maintenance. Today many of our people are living in very poor conditions, and the academic spaces are not well configured for Putney's progressive pedagogy.

This document is about Putney's future, and it embodies all of the values that define this place. It is aspiring not to ostentation, but to meet the moral imperative of reducing our dependence on fossil fuels, and of providing spaces for living and learning that live up to Putney's ideals. Putney is seen as a leader educationally, and is known for the power and agency of our students and their commitment to making things happen. As we move into the future educationally, so we must prove ourselves competent and wise stewards of the place itself. It will take the commitment and generosity of many to make this happen, to keep Putney being the incubator of talent and goodness that it is.

Emily

Emily H. Jones, Head of School



Executive Summary

The 2019 Master Plan is designed to guide The Putney School's decisions over the next decade as it works towards the goal of a net-zero energy campus and mission-appropriate facilities, including new and renovated buildings and attention to land use and the natural beauty of the campus. The Plan builds on the work of the 2011 Master Plan, noting the considerable progress made and incorporating new ideas and changing external circumstances. The school is a leader in environmental education and the natural and built environments are teaching tools as well as resources.

The primary goals of the Plan are to create new student and faculty housing to replace substandard and wasteful spaces, to provide teaching spaces appropriate for learning in a new era, to build a theater on the main campus, and to renovate the Main Building and Reynolds to be energy efficient and useful for current needs. The Plan also continues the work towards a net-zero energy campus, including work on building envelopes, new energy sourcing, and transportation.

Overview of Master Plan Implementation

The success of the Master Plan relies on the enactment of specific recommendations, designed to enable the School to meet the aforementioned goals. The following list provides an overview of the projects and changes identified in the documentation. These items constitute the main components for implementation and are explained in greater detail in the ensuing sections.

Student Housing

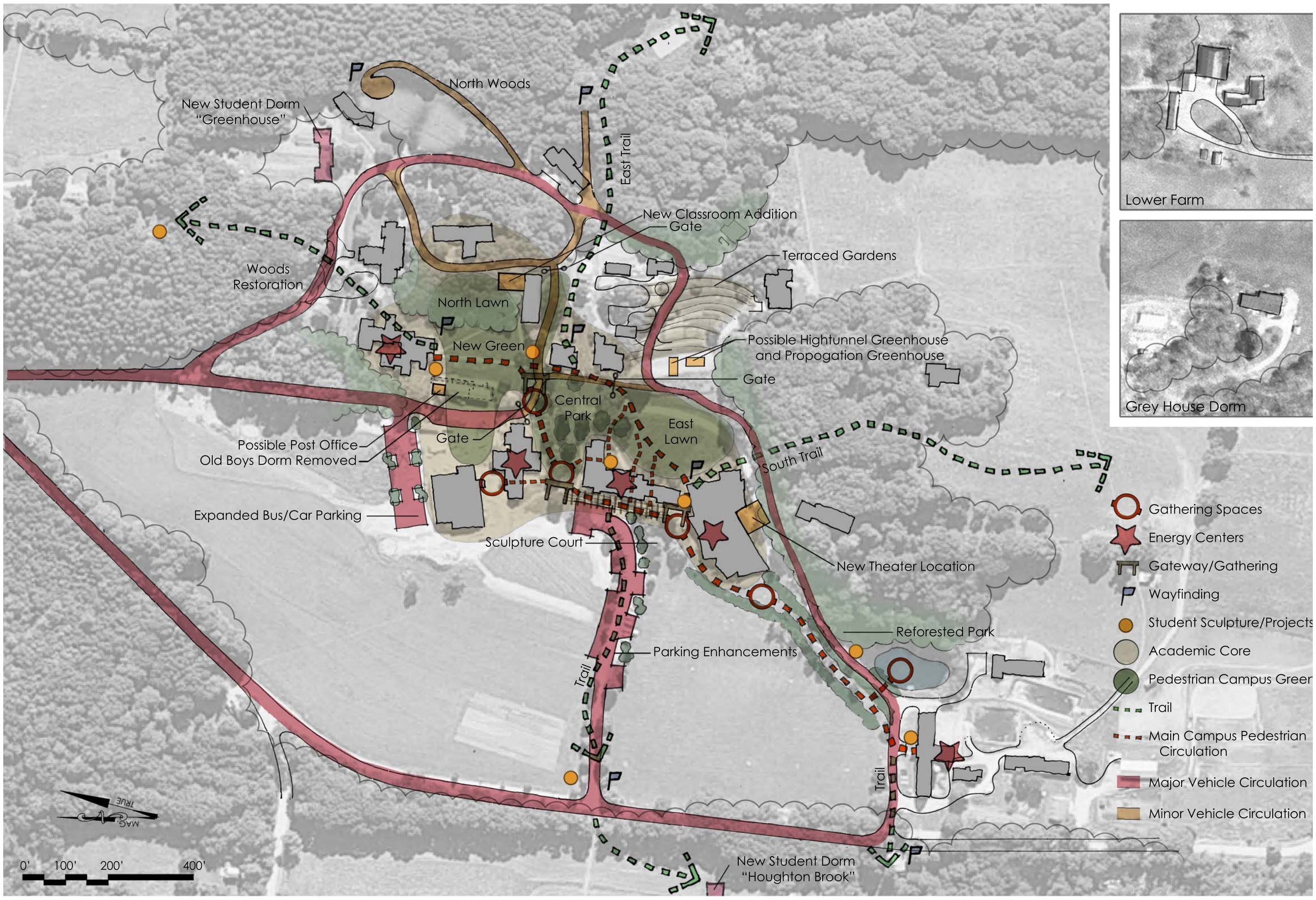
- Provide 7 more student beds long-term
- Remove Old Boys, Old Girls beds, and beds in the basement of Keep
- Provide 2 new dormitories ((11) double occupancy dorm bedrooms, (2) 3-bedroom faculty apartments) on the periphery of campus

Faculty Housing

- Provide 8 additional faculty apartments on campus (3-4 bedroom each), through a mix of dormitory attached and possibly more stand-alone housing on school land

Classroom/Arts Spaces

- Replace Jeffrey Campbell Theater with a modern black box theater adjacent to the Currier Center
- Renovate Reynolds with a new addition containing 3-4 new flexible classrooms and a large workshop space for student projects; redesign substandard / small classrooms in basement
- Add 2 multi-purpose classrooms in current Old Girls dorm space
- Renovate the Main Building and the Library for environmental improvements



The Putney School Master Plan Conceptual Design

- Provide better storage and work area for both the weaving and ceramic studios, and improve accessibility

Vehicular Infrastructure

- Limit access for motor vehicles in the center of campus
- Expand parking away from Main Building

Water and Wastewater Infrastructure

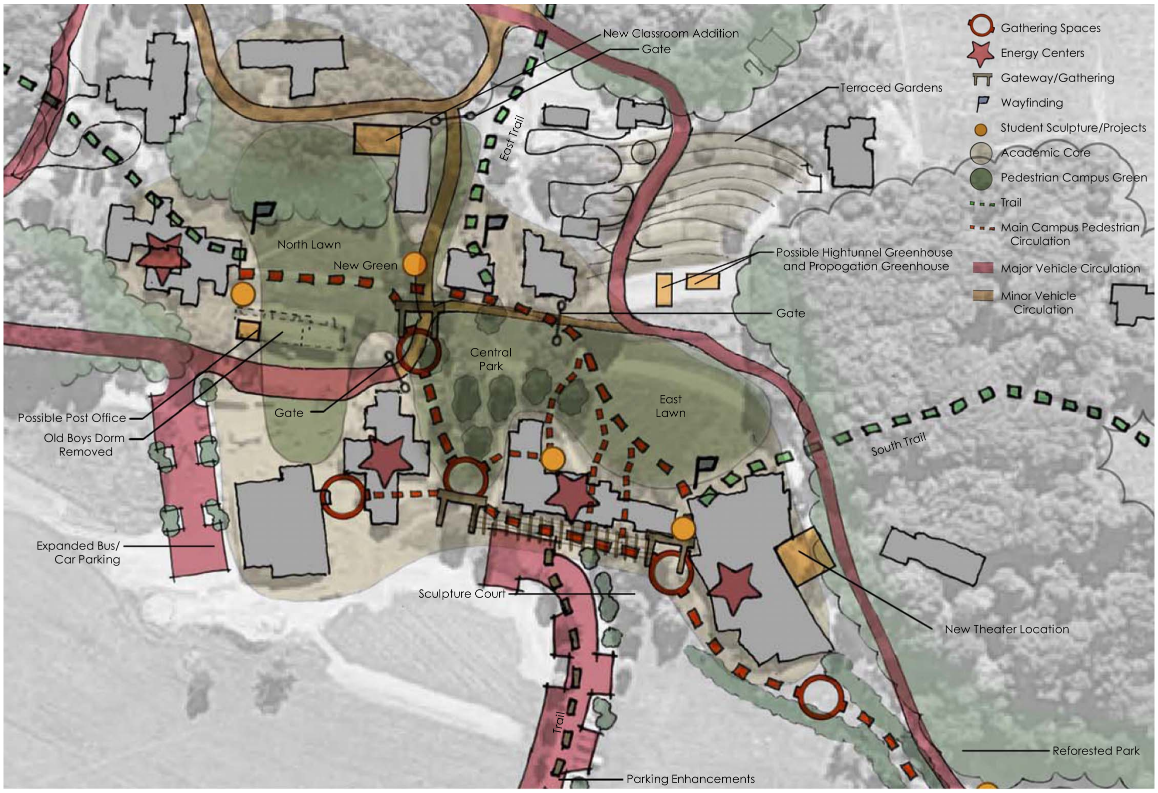
- Separate agricultural water use from the potable system
- Reinstate Noyes well for agricultural use
- Expand wastewater/septic treatment to accommodate additional beds

Landscaping

- Develop campus entrance experience around Main Building
- Enhance pedestrian experience on main campus

Sustainability and the Net-Zero Campus

- Upgrade all building envelopes to net-zero ready energy standards
- Create healthy buildings through moisture remediation and ventilation



The Putney School Master Plan Conceptual Design of the Central Campus

- Install solar photovoltaic (PV) energy production
- Minimize embodied carbon in building materials

To accomplish the sustainability goals, small steps should be taken annually:

- Continue to balance program, maintenance, energy reduction and health needs when choosing future projects
- Implement and annually evaluate strategic projects to pursue through the Prioritization Assessment
- Continue work to finish sub-metering buildings
- Annually assess the energy use of the campus
- Develop a solar photovoltaic strategy

IN SUMMARY: Begin where you can, at the scale you can. Gain experience with new techniques and new technologies incrementally, before embarking on large projects. Be persistent in moving toward the best possible future, retaining flexibility as you go.

1. Master Plan Background

This Master Plan outlines the steps towards an environmentally sustainable campus which will embody the School's mission of progressive education and responsible citizenship. This Plan creates an economically viable model for improving the School's buildings while moving steadily towards the goal of a net-zero energy campus, a campus that will be a beacon and a challenge to the rest of the world. This Plan provides future economic stability by proposing ways to manage current resources and energy consumption into the future.

The goal of The Putney School is to evolve practices on campus in tandem with educational programs so that students learn through experience. This project offers a resource for learning in which students and educators will be involved in the choices that will create the future life and wellbeing of the School.

1.1 Mission & Context

Putney School Mission Statement

The Putney School stands for a way of life. Putney is committed to developing each student's full intellectual, artistic and physical potential. Putney students are encouraged to challenge themselves intellectually, to pursue rigorous learning for its own sake, to actively participate in and appreciate the arts, to contribute meaningfully to the work program that sustains the School community and the farm on which it is located, to engage in vigorous athletics, and to develop a social consciousness and world view that will provide the foundation for life-long moral and intellectual growth.

The Putney School Fundamental Beliefs

To work not for marks, badges, or honors; but to discover truth and to grow in human understanding and knowledge of the universe, to treasure the hard stretching of oneself, to render service.

To learn to appreciate and participate in the creative arts, where we give expression to our struggle for communication of our inner lives and for beauty, and to grant these arts great prestige.

To believe in manual labor, be glad to do one's share of it and proud of the skills learned in the doing.

To play just as wholeheartedly as one works, but watching out a bit for the competitive angle, remembering that play is for recreation and an increased joy in living.

To want to lend a hand to the community at large, not to live in an "ivory tower."

To combat prejudice and injustice wherever it appears; to strive for a world outlook, putting oneself in others' places, no matter how far away or how remote.

To have old and young work together in a true comradeship relation, stressing the community and its need for the cooperation of all.

To steward and protect the land, to seek ways to live on the earth that are healthy for all beings, and to shape our community as a model of sustainable living.

To wish to live adventurously though not recklessly, willing to take risks, if need be, for moral growth, so that one definitely progresses along the long slow road toward achieving a civilization worthy of the name.

1.2 Master Plan Concept

The Putney School Board prioritized the creation of a Master Plan to address the following current and future campus needs:

- To prepare a road map for the future of the institution that serves as an educational tool to connect students with the broader vision of the School
- To create an accessible document for students to actively participate in the School's vision through educational curriculum alignment
- To proactively anticipate long-range needs and help to meet current needs
- To ensure that dollars are spent wisely for the financial sustainability of the School
- To address the needs of both the academic and co-curricular environments now and in the future, and to optimize the connections between them
- To create a 21st century campus (bring the old up to par with the new)
- To create an engaging environment that builds community and fosters awareness of the Master Plan
- To ensure the campus form embraces the vision of The Putney School
- To build on the place-based identity of the School

1.3 Master Plan Process

In 2009-2011, members of The Putney School community joined together to design a campus Master Plan that would guide the evolution of the campus for years to come. In 2018-2019 The Putney School committee, Maclay Architects, and Energy Balance Inc. collaborated to update the 2011 Master Plan, to document achievements, and set forth an implementation plan for the campus. It is this new plan that will carry The Putney School into the next decade and beyond.

The work to update the plan included goal setting, energy data collection and comparison with 2011 data, and prioritization and implementation options for the future. This document provides a look at where the School is today, accomplishments

Figure 1.3.1 Students Involved in a Charrette During the 2011 Master Planning Process

since 2011, as well as paths forward to implementing the re-envisioned campus.

This updated Master Plan also presents a means for financial planning with focused environmental stewardship. The future reduction of energy use on campus will build the School as a leader in environmental stewardship and protect the School from rising energy costs and price volatility. This evolution of the Master Plan throughout the process was driven by the School's desire to, "Walk their environmental talk," develop a gold standard in environmental campus planning, and develop a financially stable plan far into the future.

1.4 Master Plan Assumptions

The major assumptions underlying the Master Plan are as follows:

- The general nature and organization of the central campus will not change dramatically
- The size of the student body will remain relatively constant, consistent with the nature of the mission and the infrastructure where gatherings occur (KDU and Library)
- There will be a slight increase in the number of boarding students
- Housing will be primarily located on the periphery of campus, and
- The School's focus on sustainability will continue to be a major driving goal

1.5 Master Plan Goals

More Effectively Physically Support the School's Educational

Mission

Most importantly, this Master Plan is poised to facilitate the educational mission of the School. Changes in pedagogy and curriculum have left programs with less than ideal physical spaces. This plan will re-envision the physical structure of the campus and academic buildings to better align with the educational mission of the School into the future. Improved faculty housing will support the hiring and retention of top educators.

Develop a Campus Core which Embodies Community Spirit

The campus character should be read from the campus core itself, the buildings and the landscape. This plan will provide strategies to enhance the campus core, to enliven the buildings and to make a space that students and staff will gravitate towards, allowing for open communication between all levels and a true sense of ownership of place.

Develop Housing that Nurtures and Fosters Connections

Putney's housing and living spaces play an important role in shaping the context of place. Future growth and development of the housing stock should encourage a larger sense of community, developing small neighborhood enclaves which open into the larger academic community. This plan will lay out strategies to approach housing as a campus-wide issue, one that can lead to better relationships and connections between all individuals.

Enhance Natural Connection to the Vermont Environment

The school is privileged to have an extraordinary setting. Future development should capitalize on the magnificent Vermont mountaintop setting and wonderful natural areas while preserving, enhancing and sustaining those environments for future generations.

The plan also needs to promote a clear sense of place, respecting the history and diversity of the School to stimulate the academic and social growth of the School community. The plan will commit to the historic preservation of key buildings and open spaces that make this place a stimulating learning environment.

Develop a Net-Zero, Healthy and Durable Campus

A sustainable campus integrates ecological conservation, economic viability, and social equity through design, planning and operational organization. This Plan will provide strategies to meet current needs without compromising the vitality of future generations of the School community. Sustainability goals must inform decisions on energy sources, reduce embodied carbon of building materials, protect indoor and outdoor environments, and support relationships with the adjoining community. The School strives to become a local, regional and national leader in the application of sustainability practices in the areas of teaching, research and outreach, and the Master Plan aligns with this goal.

Encompass Student Work in the Campus Experience

The Putney School students are known for their engagement with the campus operations, their creativity, art and garden installations, and their footprints on the campus. This plan will provide opportunities for projects on energy and sustainability to be interwoven with the School's academic plan. Student projects will enhance the campus experience and create opportunities for student connection to place.

Develop Roads and Utilities to Support the Campus

A campus, like a town, requires infrastructure to support its mission. The Putney infrastructure is in many ways overused and in need of replacement or redevelopment. This plan will address all of the infrastructure that is needed to make this campus run, evaluate the current stock in terms of future sustainability, and make suggestions that will lead to a better organized, functional campus.

Integrate the Theater into the Campus Experience

The Putney School is recognized for its strong arts program and being a place where artistic expression is held in high regard. The current location of the theater program off-site does not nurture this relationship on the main campus. In order to develop a stronger fraternity among the art programs, the theater program must be re-envisioned as an integral part of the central campus core.

2. The Existing Campus

The Putney School campus is located on a hilltop in Putney, Vermont and is blessed with gorgeous views of Vermont's magnificent mountain ranges. The School's programs function in an eclectic mix of buildings, some inherited farm buildings and some newer buildings built specifically for the School. Before the founding of the School in 1935, a few of today's buildings were part of two neighboring farming operations.

2.1 Community Context

Founded in 1753, the town of Putney, Vermont is a small, rural community located in southern Vermont, just north of Dummerston and Brattleboro. With a population of only 2,898 at the 2000 census, the town supports a diverse community that is well known for its support of the arts.

Sacketts Brook, which once turned a dozen waterwheels powering the small community, flows through the heart of the village and past a small collection of eclectic shops, inns and gourmet delights. Back roads lead from the center of town to the unspoiled country and to hiking, biking and cross-country skiing.

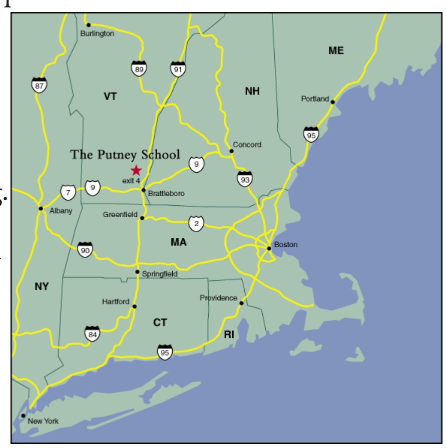


Figure 2.1.1 The Putney School's Location in New England

It is here, in Putney, Vermont, that Carmelita Hinton established The Putney School in 1935 as America's first co educational boarding school. Today, The Putney School lives on as a pioneer in progressive education and continues to thrive as an independent, coeducational boarding and day high school with noteworthy academic, arts, and outdoor programs.

2.2 Historic Growth of the Putney Campus

The Putney School's 75-year history can be seen in its physical plan – over 50 buildings, dating from 1776 to 2008, including both fine and humble examples of the periods. At first glance the core campus of white clapboard and shingle buildings appears fairly uniform in its simple Colonial Revival, New England vernacular style. However, closer inspection and the chronology of the construction reveals the evolution in design from the purely Colonial Revival of the inherited Main Building toward more purely modern as represented by Reynolds Science Building.

The Putney School's founder, Carmelita Hinton, wrote in 1945 that Putney was "a building school" because of the transformation of the campus involving hands-on work by the students and faculty/staff in the School's first decade of operation. The new buildings constructed during this time provided classroom and library space and a dining hall. This trend is emblematic of the School's philosophy of learning by doing. In part, these efforts resulted in more rustic construction than polished effect, but this evidence of hands-on learning is to be honored in the campus buildings. Accompanying this new construction, the initial decade of the School's history included a lot of "making do," and "getting by," particularly with the residential buildings which by 1945 were heavily used, often overcrowded, and in fair repair.

Early in the School's history, a capital campaign was launched to address the need for new dormitories and faculty housing. Initially envisioned to result in 6 new dorms with faculty apartments, the actual donations only allowed one to be built by 1947 (Keep). The slow development of funding resulted in the Alumni House and 3 more new dormitories by 1966 (New Boys, Noyes and John Rogers).

As construction on campus continued through the 1960s, the aesthetic continued to shift. Though a common vocabulary is used for materials and roof lines, the fenestration, asymmetry and modernist massing of joined functional blocks started to evolve through the Library (1936), the Kitchen Dining Unit (KDU, 1941), Leonard's Keep Dormitory (1947), and Reynolds Science Building (1952). More distinctly modern are the three dormitories, New Boys Dormitory (1955), Noyes Dormitory (1961), and John Rogers Dormitory (1966). These were a representation of purely contemporary design adapted to the rural New England landscape. The construction of these buildings also involved the hands-on participation of faculty and students, creating an organic, contemporary, hand-built design.

Concurrent with new construction on campus, the adaptive re-use of existing buildings quietly continued to provide extra space through the acquisition and renovation of small houses on West Hill and Houghton Brook Roads, which continue to be part of the School's inventory. In this part of campus, other simple small houses were constructed. These existing and new smaller houses were converted to faculty housing as the new dormitories were built.

After the construction of the Art Building in 1975-1978, designed and built with the full participation of students and faculty, there was a two-decade hiatus in construction on campus that ended with a capital planning effort that continues to this day.

With this initiative, construction on campus resumed in 1998, and the contemporary architecture tradition continued with the most recent additions. Each of the new buildings exhibits a distinctive design – Huseby dormitory (1999), Currier Center (2002) and the Field House (2006). The last two buildings, located at the forefront of the main school entrance, broke with the traditional appearance and materials of the core campus buildings, adding strong modern design with new materials. The choice of natural finish on Currier and green siding on the Field House allow them to visually recede against the white of

Figure 2.3.1. Elm Lea Farm Cattle Lecture in c. 1910-15, Building with Porch on Right is White Cottage

Figure 2.3.2. 1905-06 View of Construction of Arts & Crafts Building (far Left), Couresy Putney Historical Society

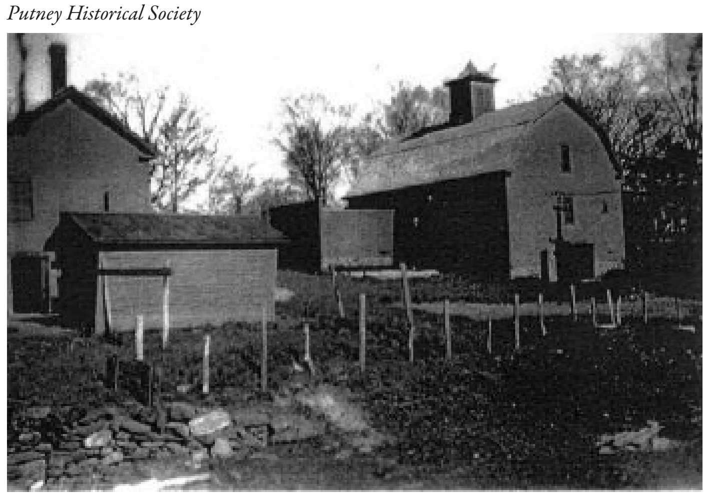


Figure 2.3.3. View of Rear Barnyard with White Cottage on Left and Arts & Crafts Building as a Stable on the Right, c. 1920s-30, Before School, Courtesy Putney School Alumni Office

Figure 2.3.4. Historic View of the Main Building in c. 1935, Courtesy Putney School Alumni Office

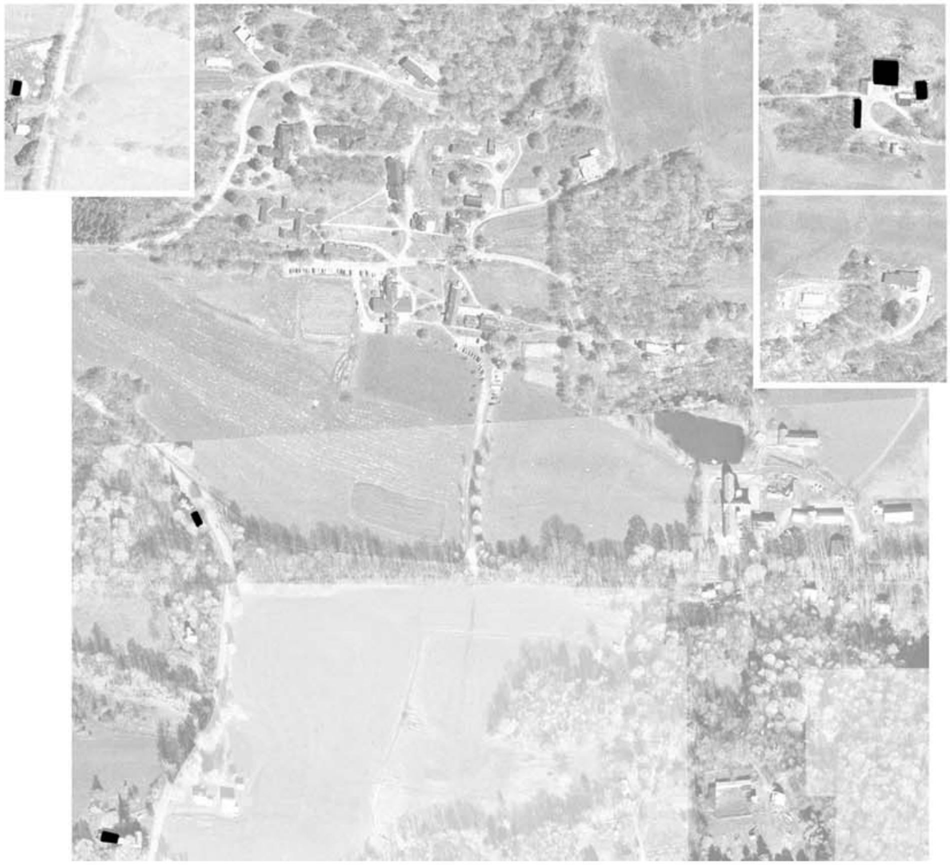


Figure 2.3.5 - The Historic Putney School Campus, pre-1900

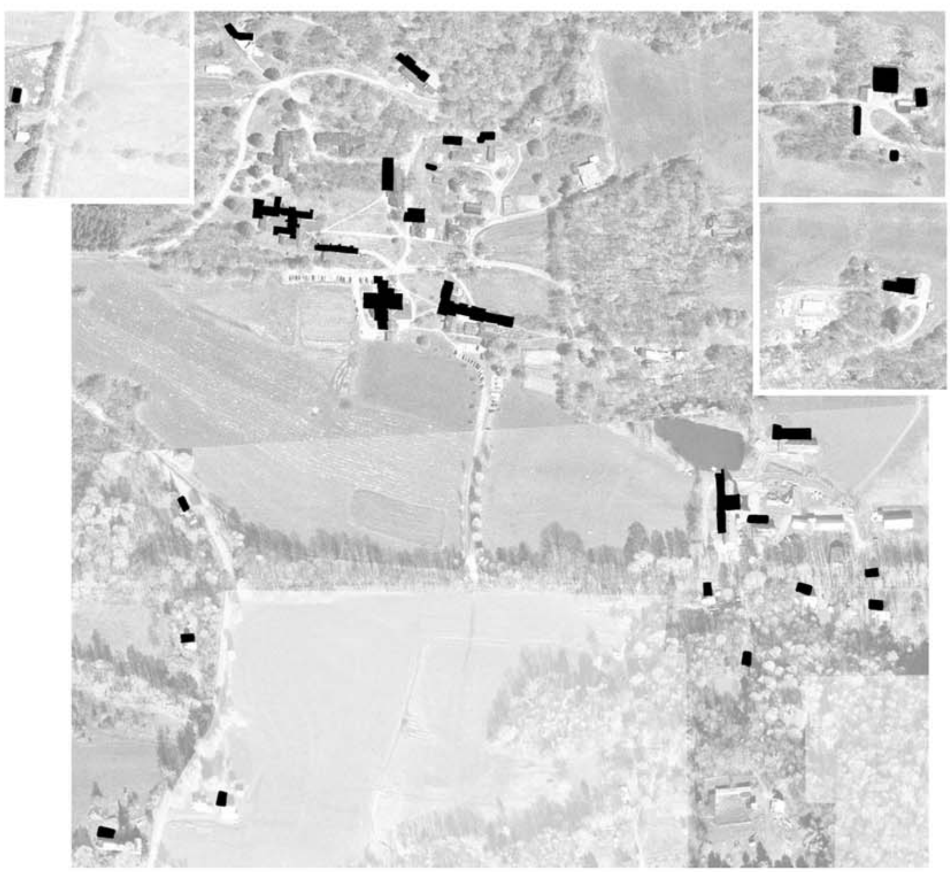


Figure 2.3.6 - The Historic Putney School Campus, 1900 - 1959

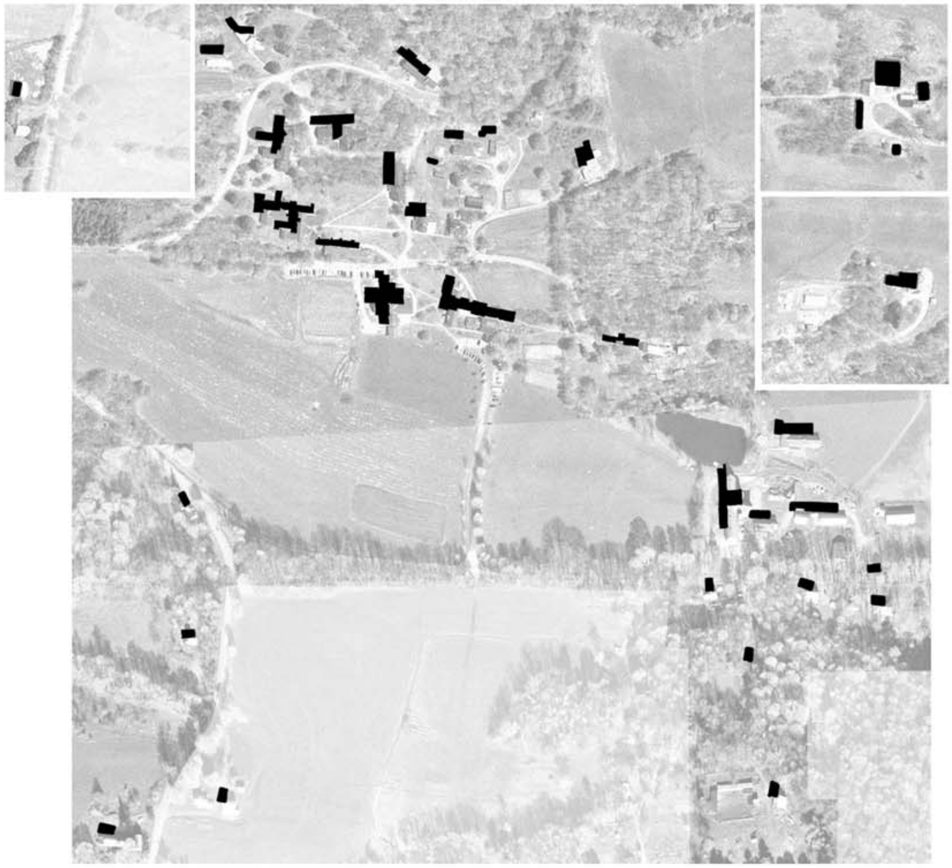


Figure 2.3.7 - The Historic Putney School Campus, 1959 - 1999

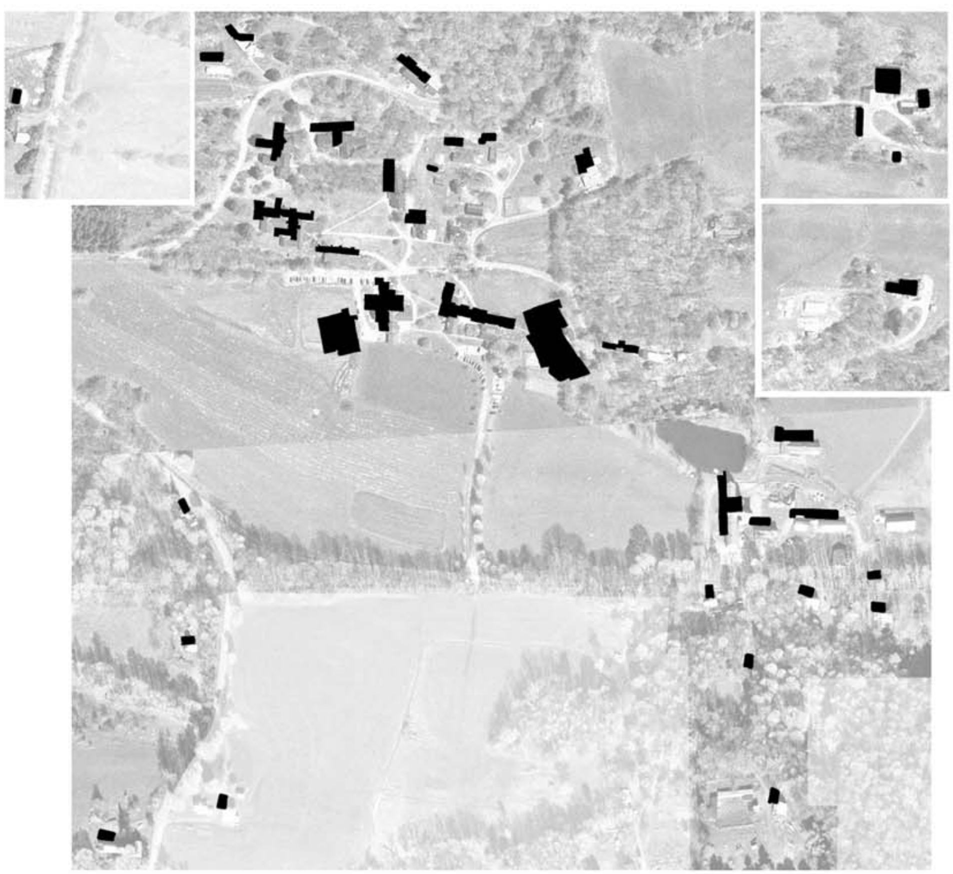


Figure 2.3.8 - The Historic Putney School Campus, post-2000

the neighboring core buildings, primarily the Main Building and KDU. The Currier Center in particular is designed to melt into the landscape. These buildings provide a counterpoint to the older buildings without detracting from their character.

2.3 Campus Character and Community

The sensibility of The Putney School can be read through the form of the physical plant. The campus, dotted with its small buildings, is emblematic of The Putney School's sense of community, a community joined together in small classes and small dormitories with students involved in the daily functions of the School.

The School community learns, works and lives together. Academics feature a student-centered seminar style approach to learning. The 9 dormitories range in size from 10-30 students, and most members of the faculty live on campus. All students participate in a work program that operates the School's dairy and horse farms and provides much of the School's produce, dairy and meat. Putney also offers a wide range of interscholastic athletics.

2. 4 Current Challenges

With a "make it work" attitude through the years, The Putney School adapted existing campus buildings to fit the programs required at any one time. With very few buildings on campus built primarily for their current functions, academic departments long for facilities specifically designed to meet the needs of the various disciplines, with flexibility to continually adapt over time.

- Many classrooms are inadequately sized and do not provide the flexibility required by the various academic programs.
- Offices are either undersized or oversized and use space inefficiently.
- Space issues separate teachers and departments across campus, inhibiting strong collaboration.
- The diverse quality of student dormitories creates inequity among the student body.
- There are too few faculty apartments on campus to house all of the faculty that would like to live on campus, detracting from the community spirit.
- The lack of high-performance building envelopes and prevalence of outdated mechanical systems lead to indoor spaces that are uncomfortable for living and working and are energy inefficient.
- Moisture issues from older, un-drained basements threaten long-term occupant and building health and limit usable space in some buildings.

This Master Plan addresses these issues to ensure that all improvements made will alleviate these challenges over time while enhancing the overall Putney community.

3. The Natural Environment

Land use on The Putney Campus is active and vibrant. The Putney School land is farmed for food, logged for wood and traveled for recreation. The campus is unique because of the beauty of the land, the views toward the mountains and the understanding that through use and time, the land is constantly growing, changing and adapting.

3.1 Existing Site

The main Putney School campus exists in a saddle between two hilltops that flank the campus to the north and south, as illustrated in figure 3.1.1. Broad expanses and corresponding long views open gradually to the west and more grandly to the east. The landscape and topography of the campus create challenges for siting buildings and constructing effective transportation through the campus, but these rolling hills allow for the experience of discovery throughout the campus.

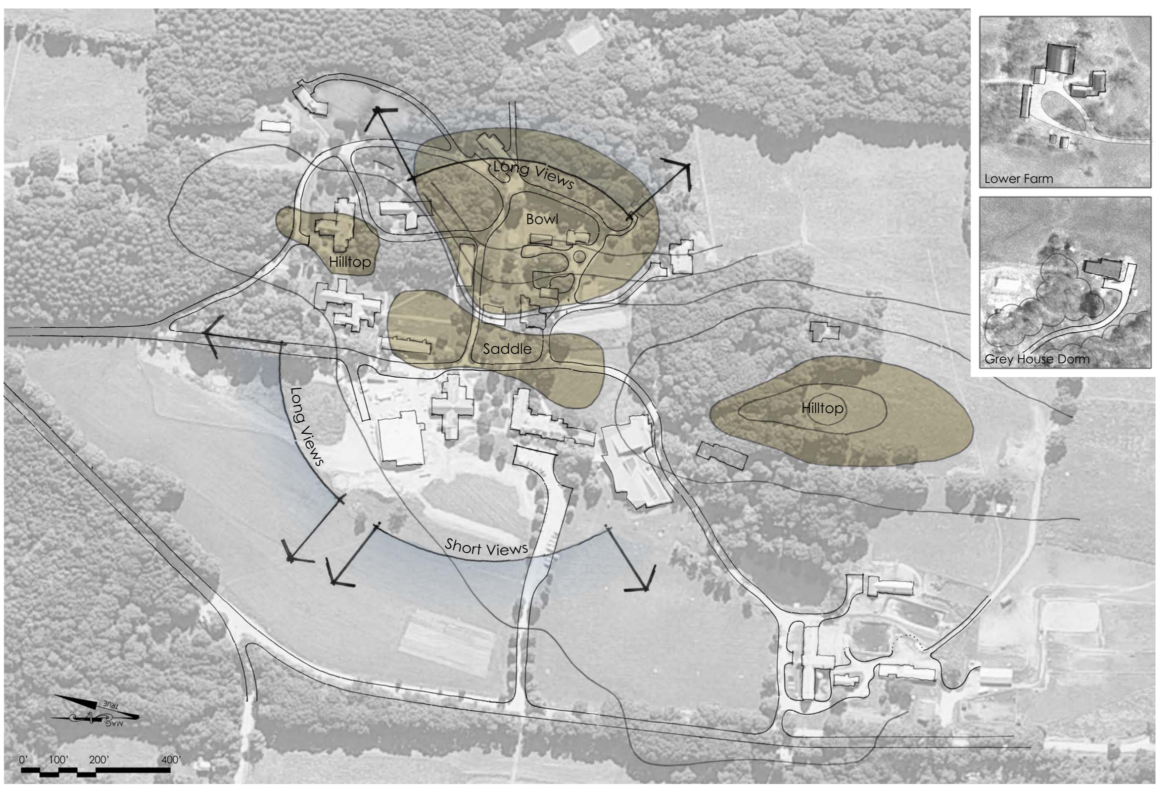


Figure 3.1.1 Existing Site Topography

3.2 Existing Ecosystem/Land Use

The main Putney campus exists within two ecosystems. Woodlands surround the eastern half of the campus, while a meadow covers the western half of the main campus and beyond, as illustrated in figure 3.2.1.

The woodlands are used for recreation and farming activities. Much of The Putney School's woodland habitat is crisscrossed by paths, used by students and faculty of The Putney School as well as the larger Putney community. These tree stands are managed as standing wood lots for the School and are used for construction, heating and cooking. The maples are tapped by the students for sap to produce the maple syrup enjoyed by all on campus.

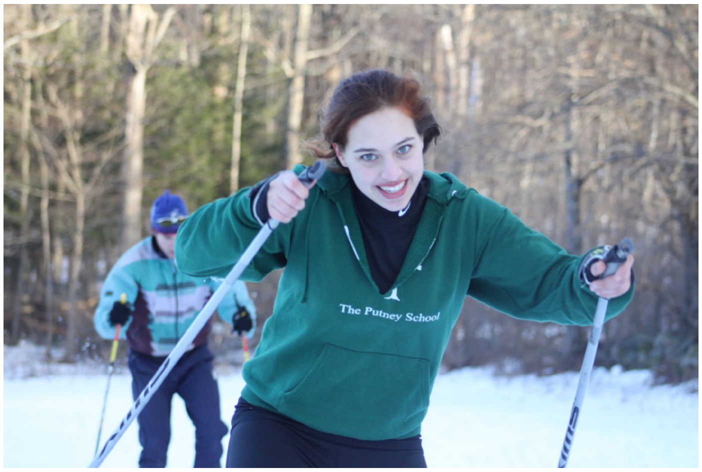


Figure 3.1.2 Recreation Plays a Central Role on the Putney School Natural Landscape

The meadow encompasses the campus core with the majority of the academic buildings and the majority of the farming activities. The meadow spreads from the saddle of the main campus to the west encompassing the playing fields, the gardens, the main barn and the horse farm.

3.3 Campus Lands Overview

Three types of open spaces are present on The Putney School Campus:

- Agricultural: Located mostly at the perimeter of the campus, cornered between West Hill Road and The Putney School Road, this open space is unique to The Putney School. Students are required to participate in farming activities, from which much of the food for The Putney campus is grown. The care of the animals and the upkeep of gardens are central to The Putney School mission and hands-on learning focus.
- Recreation: Located at the perimeter of the campus core, this open space is a campus and community

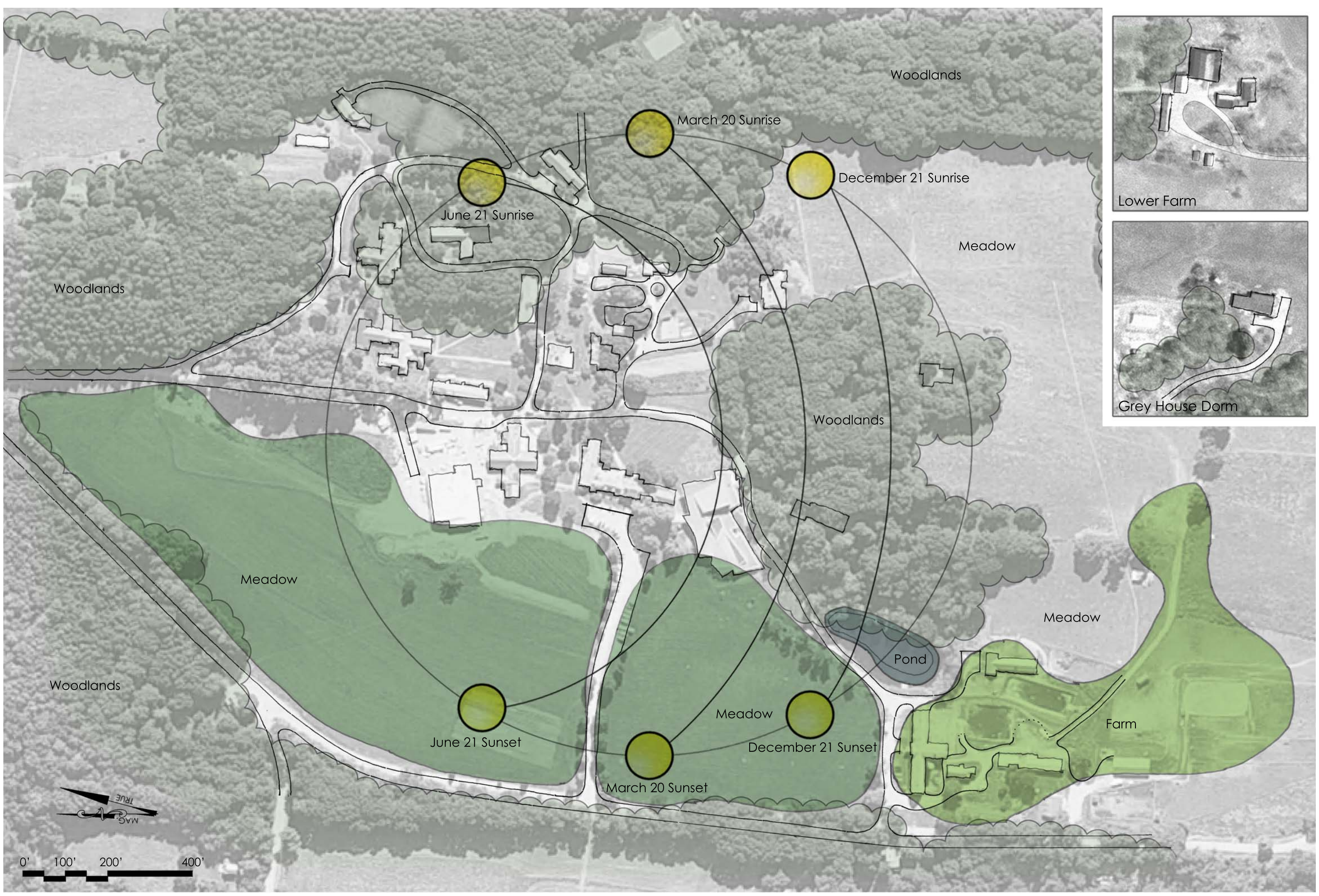


Figure 3.2.1 Existing Ecosystem / Landuse

resource. Managed recreation zones exist on Putney School land and that of adjoining landowners, requiring ongoing respect and care of the land to preserve this open space.

- Outdoor Gathering Space: Outdoor gathering spaces are located at the interior of the campus core and consist of formal and informal areas. The spaces are generally defined by building facades, maintained landscape plantings, and many include outdoor student art. These spaces could be better defined through clarity in entry, edge, size and function to better serve The Putney School community.

3.4 Campus Landscaping

In general, the campus landscape is typical of a rural private school, while containing the character of a New England farm. The old sugar maples, tree lined dirt roads, and mix of architecture support this motif.

The trees and shrubs reflect the old and new. Mature sugar maples populate the perimeter, large black locusts occupy the campus core and lilacs border many of the buildings.

Informal quadrangles enable interaction, allowing people to congregate or meet in passing. These informal spaces are essential to the quality of the School environment.

3.5 New Land Purchased 2011-2018

The Putney School has purchased land as it has become available during the past 8 years. These acquisitions have enabled the School to provide additional faculty housing (Aiken Road House, Pratt House, and Spencer House), as well as to acquire open lands adjacent to the main campus in Spencer/ Paige field and the Houghton Brook parcel. The school will continue to strategically acquire properties that will provide future opportunities for land use that support the School's mission.

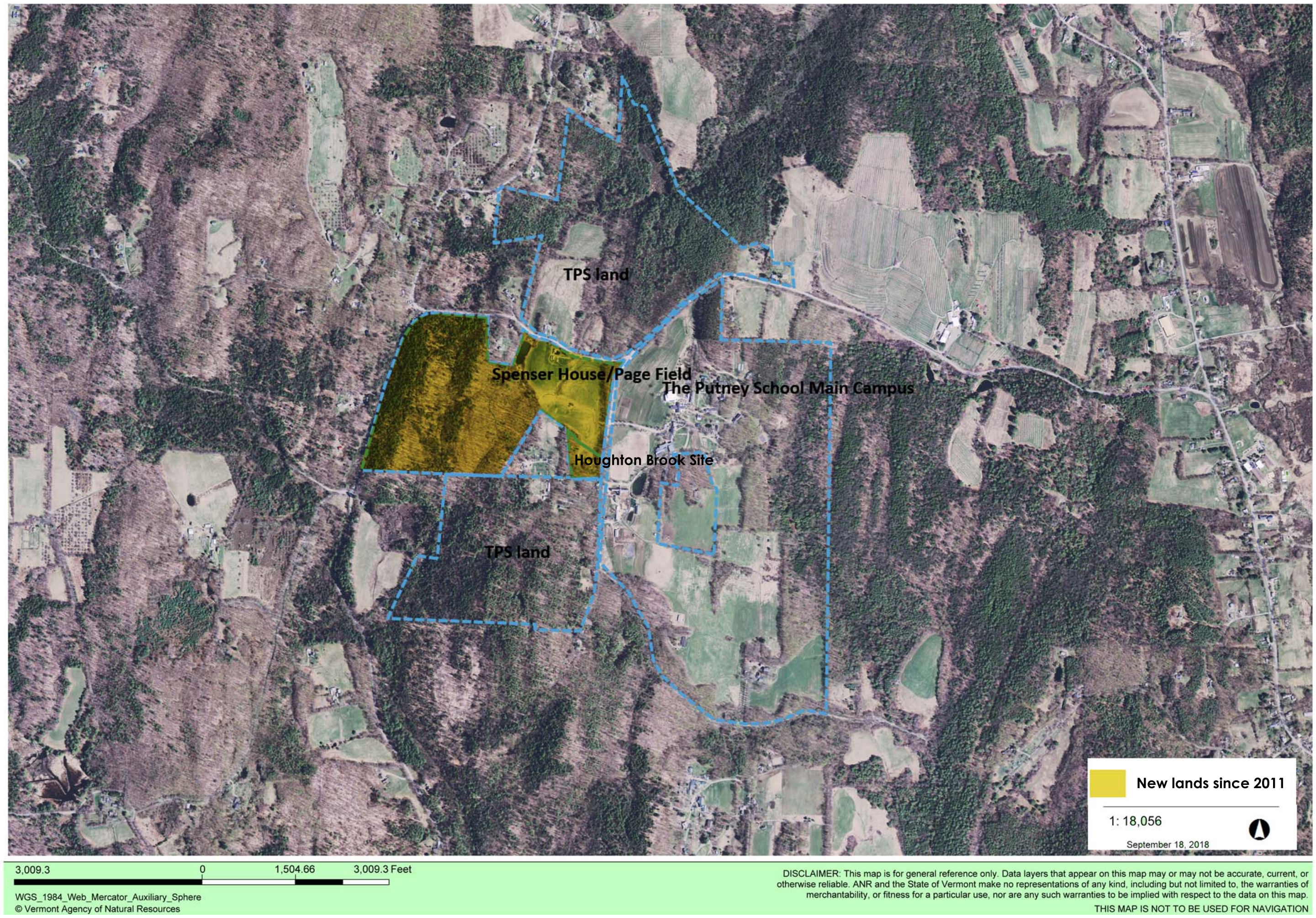


Figure 3.5.1 The Putney School lands, with parcels purchased since 2011

4. The Built Environment

A functional, attractive campus contributes to the ongoing success in the competitive private secondary school environment. To continue to thrive, the facilities must be periodically renovated and remodeled to serve current needs. The continued adapting of The Putney School campus buildings, not primarily built for educational activities, has left the School with many outmoded facilities – built for an obsolete single use, with an emphasis on economy of construction rather than flexibility.

With over 50 buildings on campus, built at various times and for various uses, many of the historic Vermont farm buildings are now at the functional end of their use and are costly to heat, cool, repair and maintain. To serve the campus' current and future needs, several of these facilities must be updated or replaced. Existing buildings have been evaluated based on their current physical integrity and the condition of their major systems, including HVAC, windows, roofs, walls, exterior finish, electrical, plumbing and code compliance. Existing buildings were also analyzed for their ability to be either downgraded or upgraded from their current use to meet a variety of program needs.

For the purpose of this Master Plan, only structures on the main campus designated for academic or residential use were focused on. A comprehensive study of the various farm and support buildings was not undertaken, as the main campus buildings already require a large amount of deferred maintenance to be addressed. At some point these farm and support buildings will need to be addressed, but in the larger goal of this Master Plan to develop a net-zero campus, the need to address these buildings that did not use energy for heating did not seem urgent.

Faculty housing around the periphery of the campus was also not investigated to a great depth. These structures are only considered in the broadest of brush strokes in terms of planning for the future campus.

The buildings of The Putney School Campus are identified in figure 4.1.1.

The massing, scale and character of campus buildings are crucial to good open space development and contribute to a strong sense of identity. This campus has two distinct scales of buildings – those that define a traditionally, residentially scaled farm campus, and those that house the larger academic programs of a modern educational environment. Regardless of size and function, all campus buildings share the responsibility to create an environment that is human in scale and elegant in detail.

As the demands for building spaces have grown with the campus, functions have been pushed into unlikely locations, developing a campus where specifics of space must be learned and cannot be read from the exterior character of the buildings. While multi-use buildings can help to create a vibrant atmosphere, the mixing of uses should be done strategically so that adjacent functions are compatible, and functions can all operate efficiently.

4.1 Overall Campus Space Use

Putney's current core building infrastructure includes over 190,000 square feet of heated space contained

Figure 4.1.1 Campus Buildings (Numbering Key can be Found in Table 4.1.1)

in 30 buildings. This includes 9 buildings with classrooms or dedicated to academic uses, 10 dormitories or buildings including dormitory functions, twenty attached faculty apartments, and fifteen faculty houses which exist at the periphery of the campus.

The Putney School's academic, administrative and student life functions are primarily located within the main campus core, at the top of the hill. Student dormitories are primarily located at the periphery of this core, although some small dormitories still exist in the central part of the campus. Faculty housing is spread widely, either attached to individual dorms, peripheral to the main campus, at Lower Farm or along the surrounding roads, as illustrated in Figure 4.1.2 and detailed in Figure 4.1.3. This Building Use diagram illustrates the existing campus buildings in terms of building use patterns that currently exist on campus:

Academic: Academic spaces including classrooms, laboratories, art spaces and direct student support such as library, theater and learning center functions.

Administration & Support: Administration and support is made up primarily of office space. This includes both academic offices, such as English or history offices as well as program offices, such as summer programs and college counseling.

Residential - Student: Student residential spaces include all dormitories where students reside.

Residential - Staff: Staff residential spaces include all staff residences including both those attached to student dormitories and those that are free standing.

Community Life / Social: Community Life and Social spaces include those spaces where The Putney community comes together outside of academic spaces. These also include spaces where The Putney School can welcome in visitors.

Recreation / Athletics: Indoor recreation and athletic spaces are contained within the field house, though this space classification extends far beyond any building boundaries.

Farming / Agricultural: Farming and agricultural spaces include all programs that support the farm operation and the growing of plants and animals. This space classification also extends far beyond any building boundaries.

		Net/Programmed Space	Gross Building Area
1	Main Building	12,732	14,079
2	KDU	11,772	12,572
3	Field House	15,322	16,800
4	Old Boys	5,452	6,571
5	Arts & Crafts Building	3,233	5,073
6	White Cottage	5,307	5,741
7	Currier Building	20,884	21,975
8	Reynolds	10,044	10,533
9	Library	8,281	9,128
10	Huseby	14,396	15,484
11	Wender Arts	7,143	7,479
12	Greenhouse		
13	New Boys	4,158	4,601
14	Leonard's Keep	9,369	10,085
15	Woodworking Building		
16	Paint Shop		
17	Noyes	6,401	6,778
18	Kiln		
19	Root Cellar		
20	Old Music Studio		
21	John Rogers	4,200	4,256
30	Main Barn		
31	Small Animal Barn		
32	Horse Barn		
33	Milk House		1,432
34	Titus House/Red Cottage		1,897
35	Arms House		1,450
36	Prefab House		803
37	Hinkle House/Daycare		1,500
38	Cinderblock House		850
39	Sugar House		
40	Goodlatte House		1,650
41	Grey House / Alumni House	6,063	6,084
50	Jeffrey Campbell Theater	7,874	8,306
51	Lower Farm/Innkeeper's 2nd Residence		3,973
52	Innkeeper's House Main Residence		1,673
53	Farm Sheds at Lower Farm		
60	Page Farm		3,623
62	Wirth House		1,802
63	Rogers House		1,457
64	Rockwell House		4,858
65	Pratt House		800
66	Hostel		1,088
67	Spencer House		1,500
68	Aiken Rd House		1,476
		Total Building Area:	197,377

Table 4.1 .1Existing Building Program

Building use here is identified by color: green=academic, red=dormitory, gray=support/farming, purple=faculty housing. It should be noted that building square footages here come from a variety of sources, some measurements are very accurate and others are very loose. More detail on measurements can be found in the appendix document including building plans. As is these numbers should only be used for broad brush, programming understanding.

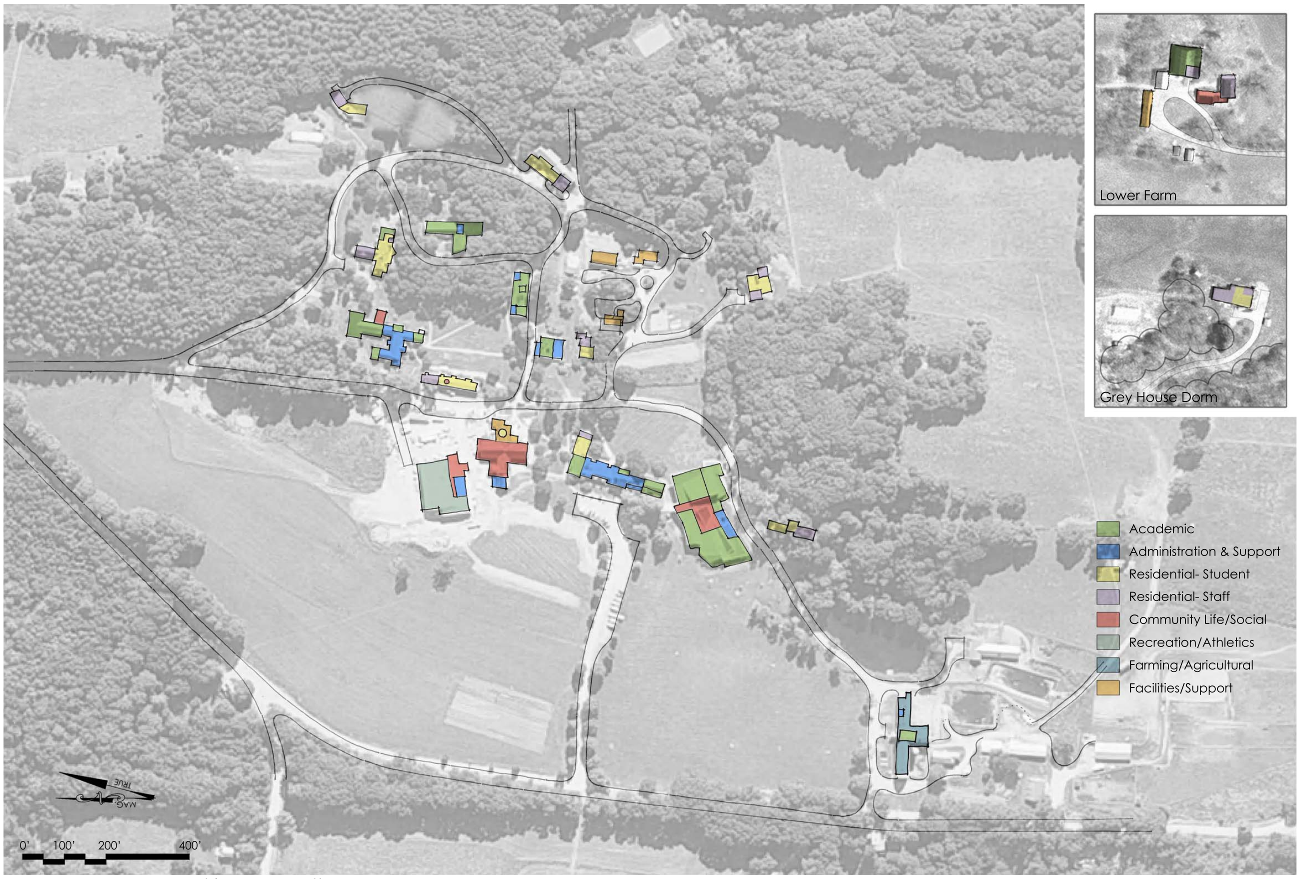


Figure 4.1.2 Existing Building Use - Full Campus

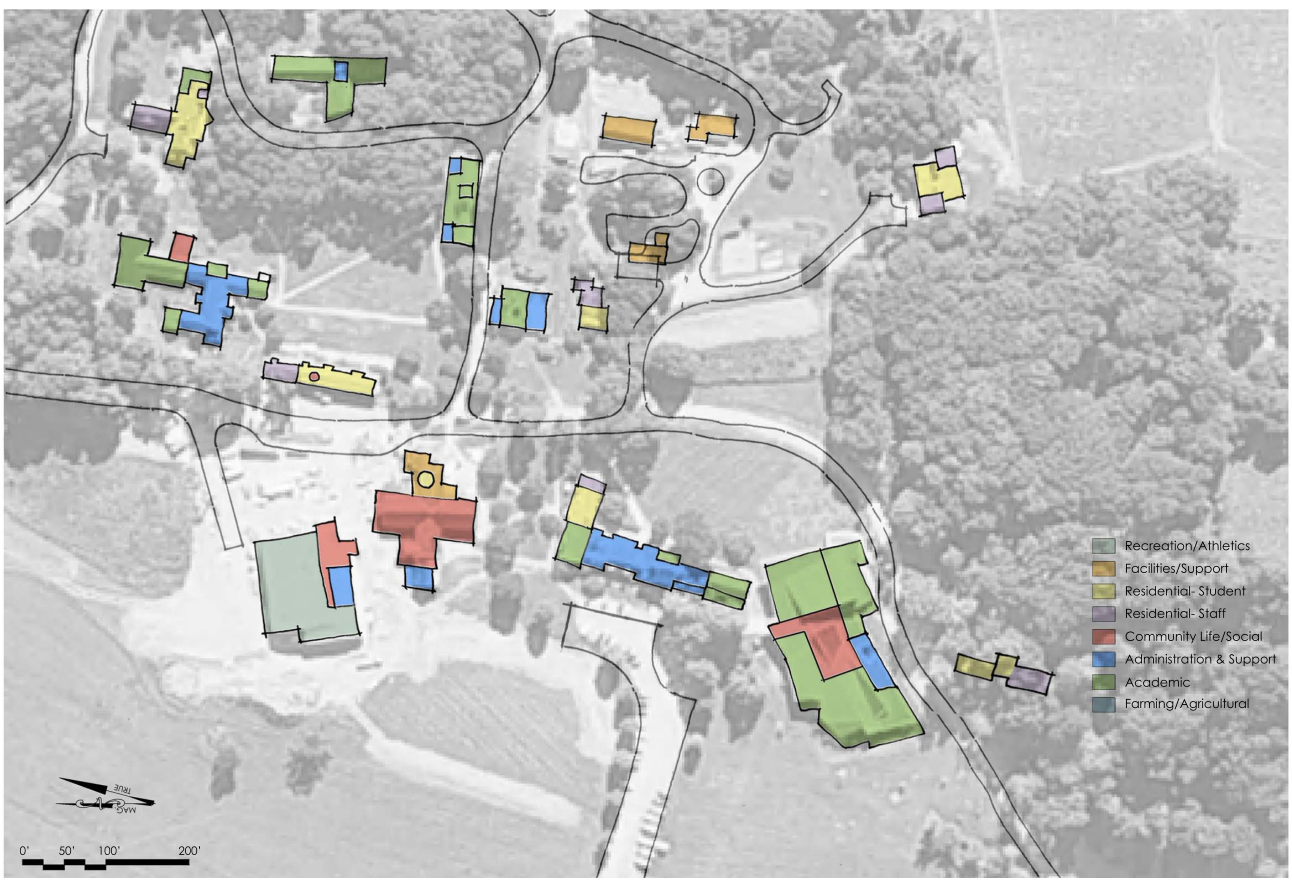


Figure 4.1.3 Existing Building Use - Central Campus

Facilities / Support: Facilities and support is made up of all of the structures that provide support to the Schools systems, to make the facility run. This includes both traditional mechanical support spaces as well as the kitchen.

4.2 Gathering Spaces

Gathering spaces, both formal and informal, inside and outside, are very important places on The Putney School Campus. Because of the identification of community on the campus, and the idea of developing small families through the dormitory system, gathering spaces are incredibly important. Some formal gathering spaces, such as the KDU dining hall, function as very strong meeting places on the campus, but others such as the display hall in Reynolds leave something to be desired. Existing gathering spaces described by quality can be seen in figure 4.2.3.

Dormitories require functional gathering spaces in order to develop the sense of community for the students and faculty that reside in each residence. It is therefore important to ensure that these gathering spaces are encouraged to grow and develop into strong spaces for all of the students.

Figure 4.2.1 and Figure 4.2.2 Gathering spaces come in all shapes and sizes on the Putney School Campus

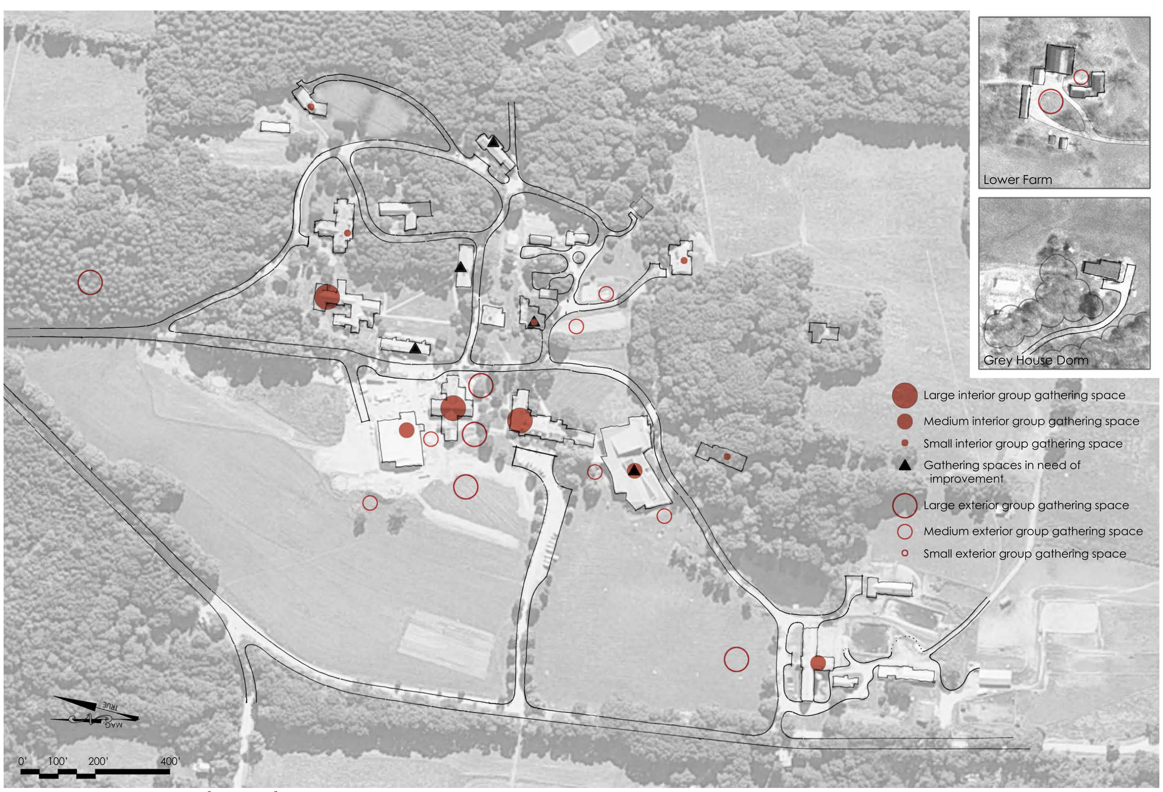


Figure 4.2.3 Existing Gathering Places

4.3 Transportation, Circulation & Parking

Vehicular and pedestrian traffic routes currently overlap on The Putney School campus. With very little delineation between the two functions, both vehicular and pedestrian circulation routes must be better defined for the safety of pedestrians and the accessibility of the vehicles. The main campus circulation path follows The Putney School road and cuts straight through the core campus and through the main green space.

The primary off-road pedestrian ways extend through a variety of campus open spaces. They are not designated pedestrian paths but informal routes that have developed over time. This existing campus network of pedestrian routes is ill-defined. Winter conditions, steep topography and icy paths can create difficult walking conditions.

Dirt roadways make up the existing vehicular structure on The Putney School campus. While vehicles are not necessarily needed to be moved across the core of the campus, many vehicles exist within this space for the use of the faculty and staff. Challenges with the current road system includes the fact that these roadways are steep and often challenging to navigate in winter conditions and that the vehicular routes cut through some of the most important features of the campus. Improvements could be made to this system to both make the vehicular travel system less visible on campus and safer for travel by all residents.

Parking has always been a challenge on The Putney School campus, including faculty and staff parking, visitor parking, and town parking for those individuals who come to use cross-country ski trails on The Putney School campus. Bus parking provides an aesthetic challenge on The Putney campus, because it is the first thing that is seen when visitors come to the main parking lot. Buses need a new location for parking; a designated parking location needs to exist for visitors coming to use the cross-country ski trails; and the main parking lot requires better definition so that it does not spread out into the surrounding fields.

Figure 4.3.1 Existing Pedestrian Circulation

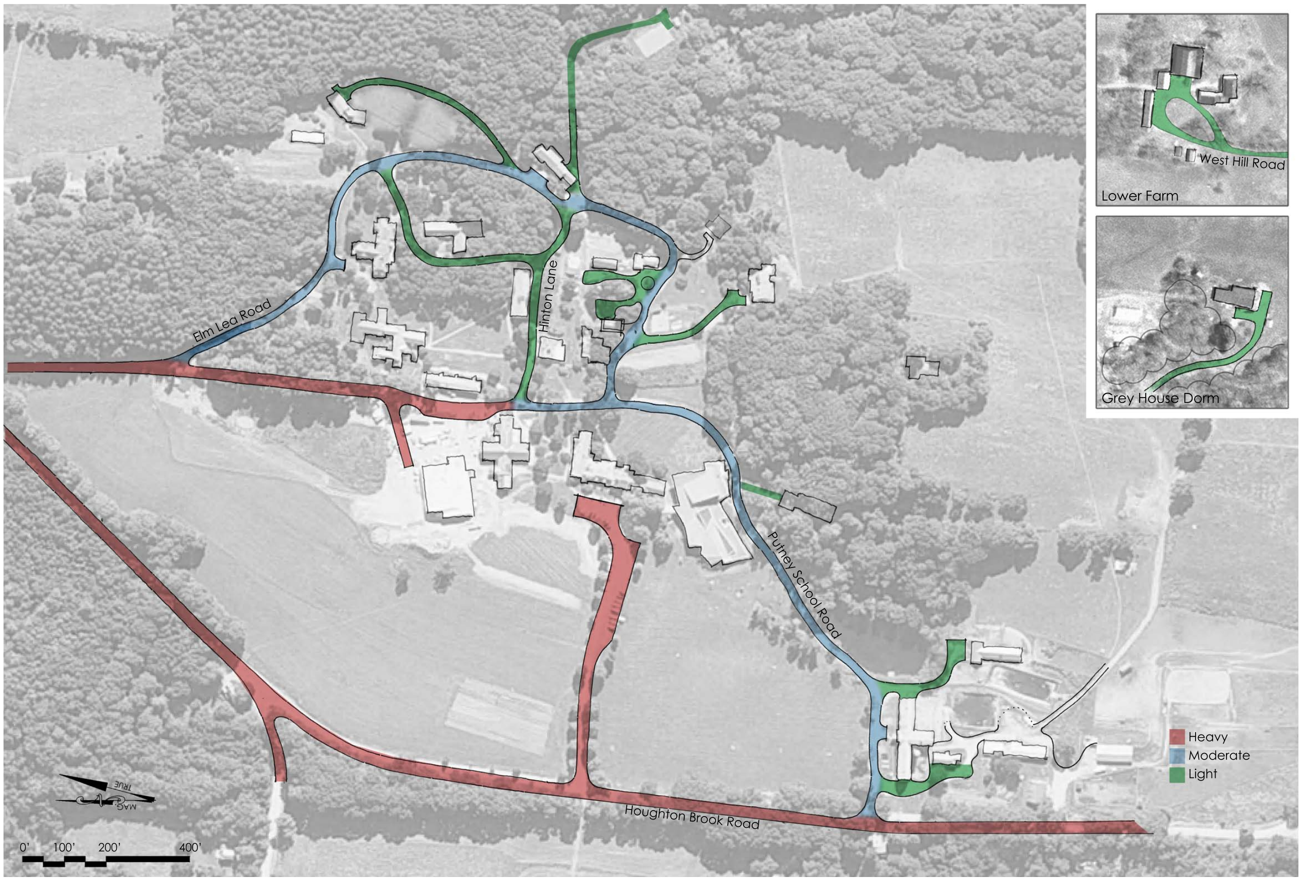


Figure 4.3.2 Existing Vehicular Circulation

5.0 The Campus Plan

The Putney School campus plan is intended as a framework, an outline within which decisions can be made judiciously and positively contribute to the long-term vision of the plan. Prescriptive recommendations have been made in reference to certain buildings and spaces on the campus while other spaces have been left as a broad framework that is meant to guide campus decision making into the future. This campus plan is made up of two parts: this first section refers to program changes, open space structure, circulation systems and infrastructure, while the second section referred to in "The Net-Zero Campus" refers to energy improvements and the installation of renewable energy systems to power the campus.

The goal is to provide a stable framework that enables near-term decisions to be made which continue to uphold the long-term vision for the campus – a vision that produces an efficient and coherent campus while maintaining the intrinsic beauty of the Vermont campus. The following major components of the campus are addressed as locations for improvement, along with sustainability as discussed in the next section.

5.1 Student Housing

Student housing exists in a large variety on The Putney School campus. Though all dormitories are small, maxing out at 30 students, and made up mostly with double rooms, there is drastic disparity between what could be considered the good and bad student rooms on campus. The amount of space per student in each dormitory also varies greatly, where some dormitories see student space at just over 180 square feet and some dormitories seeing student space of close to 300 square feet. In order to better serve the entire student body disparities between dormitories should be corrected and the worst of the student housing should be renovated or replaced with new student accommodations.

Since 2011, creating better housing has been a priority for The Putney School. In 2015-2016 Maclay Architects worked with the School, committees, and students, through conceptual planning and schematic design for new dormitories. The process included presentations at the School assemblies, a campus wide design charrette, and presentations to the board of trustees.

The committee reviewed dorms to be removed, additional bed needs, and locations on campus. The plan to enhance the student dormitory experience is to build two new dorms and remove the following: Old Boys, Old Girls, and the rooms in the basement of Keep, which can be accomplished in a phased implementation plan with three possible scenarios as outlined in Table 5.1.1.

Because of the expectation that more of the student body will be boarding students rather than day students in the future, The Putney School is in need of additional student beds. Past recommendations have been made for the addition of one new dormitory and the expansion of one existing dormitory, but during the 2015 feasibility study, the criteria for dorms to have fewer than 22 students was set in place. This resulted in the following recommendations:

- Build 2 new dorms at once (add 44 beds, (4) 3-bedroom faculty apartments)

	Scenario #1	Scenario #2	Scenario #3
Phase 1	Garden Dorm + Houghton Brook Dorm Old Boys Demo Close Keep Basement Convert Old Girls to classrooms	Garden Dorm Old Boys Demo	Garden Dorm Close Keep Basement Convert Old Girls to classrooms
Phase 2		Houghton Brook Dorm Close Keep Basement Convert Old Girls to classrooms	Houghton Brook Dorm Old Boys Demo
	End Goal: Two new dorms + demo Old Boys + classrooms in Old Girls		

Table 5.1.1 Phasing Scenarios for the 2 Dorm Projects

- Repurpose Old Girls into classrooms (remove 9 beds, (1) 1-bedroom faculty apartment)
- Demo Old Boys (remove 22 beds, (2) 2-bedroom faculty apartments)
- Close basement of Keep dorm (remove 6 beds)

The net change is 7 new dorm beds, and 1 additional and overall larger faculty apartment. The following dormitory additions and conversions can be seen in Figure 5.1.1 with recommended locations for new dorms and renovations of existing dorms. In a campus wide survey about housing, the location and topography of the new dorms were important. The desired location was on the periphery, but not too far from the academic core of the campus, and that the access to the dorm was not steep, as that would provide a mental and physical (for some parts of the year) barrier. Sites chosen were the "Greenhouse" and "Houghton Brook" locations.

New Dormitory Northwest of New Boys – "Greenhouse Site"

Currently there exists a flat open space with two existing greenhouses that would be an ideal location for a new dormitory. This location places the dormitory at the periphery of the main campus strengthening the organization that is being developed of academics at the core and living spaces in a

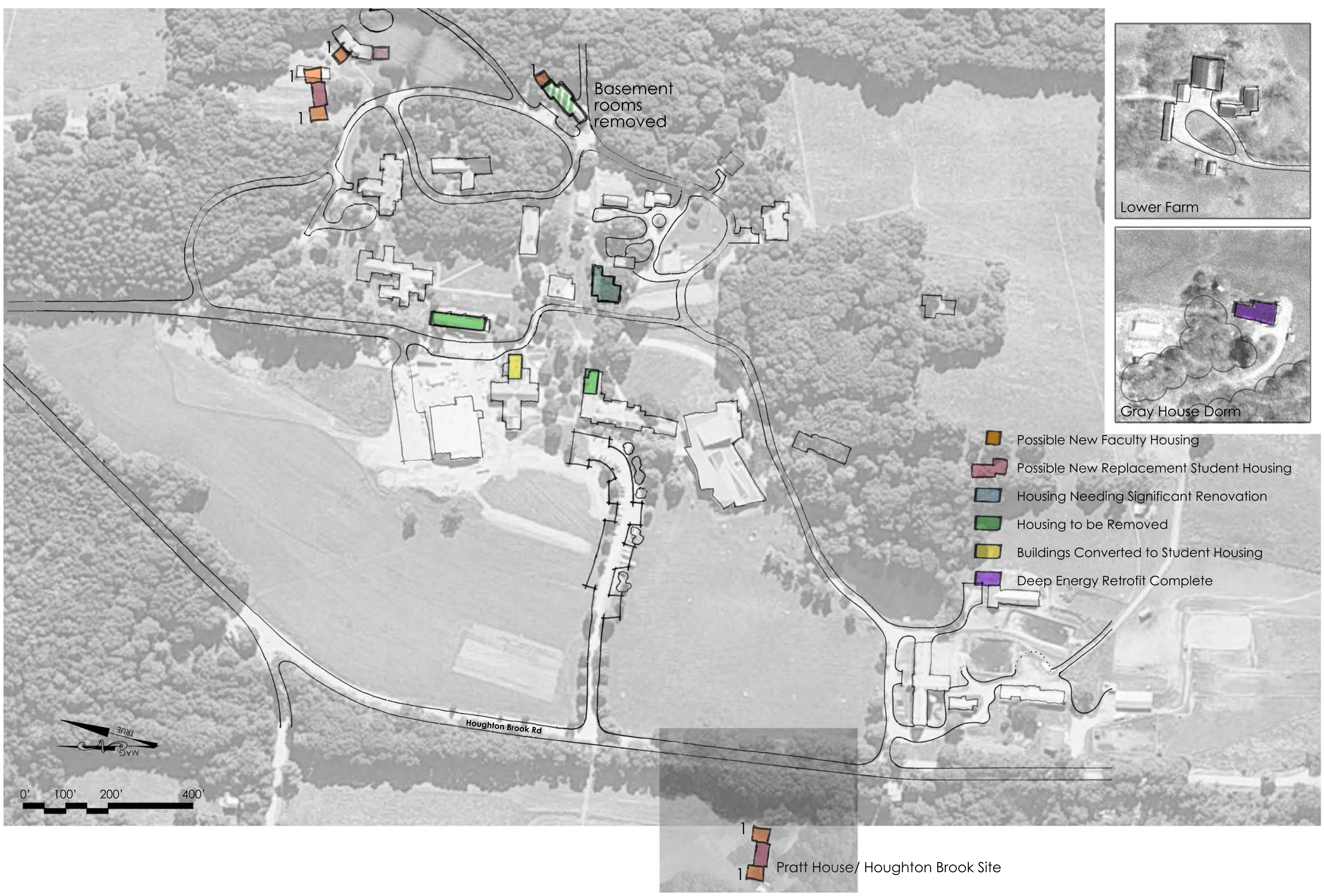


Figure 5.1.1 Recommended Locations for New Dorms and Renovations of Existing Dorms

				Existing		
				SF	Pop	SF/Pop
Student Housing						
1001	1152		*Main Building*	2208	11	201
2302			*KDU*	901	6	150
4102	4202		*Old Boys*	4405	24	184
6102	6202		*White Cottage*	2255	11	205
10102	10202	10302	*Huseby*	8670	29	299
13102	13202		*New Boys*	2315	14	165
14101	14202	14302	*Leonard's Keep*	6540	28	234
17101	17201		*Noyes*	5246	16	328
21102	21202		*John Rogers*	2524	10	252
41100	41200		*Grey House*	6063	8	758

Table 5.1.2 - Student Housing on the Putney School Campus

ring around the exterior. This location would also allow for good solar access and a courtyard space to the north for student outdoor gathering, and side yards to the east and west for faculty. The close proximity between this new dormitory and New Boys and Huseby will help to develop a community relationship. This site also has potential for some additional septic capacity to be built in the vicinity that will relieve the existing system.

New Dormitory on Pratt Property – "Houghton Brook Site"

In 2012 Putney purchased the Pratt House property across Houghton Brook Road from the main campus. This property has a small residence that is beyond its useful life and would be removed. Although this location is slightly further from the campus core, it is an ideal location for a large dorm, as it is flat, has good solar access, a beautiful view, and potential for septic nearby. It is close to the main barn and free-standing faculty houses.

Future expansion of New Boys has been shown in conceptual plans and included in the appendix.

Though almost all student dormitories do need some renovation, the spaces in need of the most attention are Old Boys, Old Girls and White Cottage. Old Boys has an incredibly leaky envelope which leads to comfort issues for the occupants. It has a small amount of space per dormitory occupant and because of many past renovations it has an ugly and disjointed organization.

Old Boys will be torn down upon completion of the new dorms to create an open green space on campus. Old Girls is awkwardly located, connected to an academic building and stranded in the center of campus, and will also be retired as dorm rooms when the new dorms are completed. The lower level of this wing will be turned into two classrooms. The 6 beds in the basement of Keep will also be retired upon completion of the new dorms.

White Cottage is in need of a better organization and better functioning social space. Also fit into an older building, this dormitory could use a face lift to better fit into the function that is required of it today. In 2012, Maclay Architects provided a drawing packet with reconfiguration and addition to White Cottage. The Putney School has decided to not expand White Cottage as this is in conflict with the overall goal to have housing on the periphery of campus, and money would be better spent toward the two new dormitories. When the time comes to renovate White Cottage, a new plan will be drawn up.

Keep or John Rogers would be the next dorms for a deep energy retrofit project as the buildings would benefit greatly from exterior applied insulation and air sealing.

5.2 Faculty Housing

Faculty housing exists on The Putney School campus in two different varieties: apartments attached to dormitories and stand-alone homes at the periphery of the campus. The current challenge on The Putney School campus is that there is not enough, especially of the larger apartments/houses, to accommodate all of the faculty and their families who would like to live on campus or near. In 2011, recommendations were made to provide 8 additional faculty apartments on campus, which would be a mix of dormitory attached and stand-alone housing. Since that time the School has purchased three stand-alone houses,

		Existing		Proposed	
		SF	Pop	SF	Pop
		Existing		Proposed	
		SF	Pop	SF	Pop
		14211		18258	
1107	Classroom	420	12	420	
1113	Classroom	330	15	330	
1114	Classroom	340	15	340	
1115	Classroom	340	15	340	
1209	Classroom	225	10	331	
7111	Classroom	520	10	520	
7113	Classroom	1100	25	1100	
7140	Auditorium	5276	330	5276	
8101	Laboratory	775	15	775	
8105	Classroom	270	10		
8106	Classroom	200	8		
8107	Classroom	200	8		
8109	Classroom	350	10		
8201	Laboratory	775	15	923	
8204	Laboratory	740	15	796	
8207	Laboratory	610	15	1110	
8302	Classroom	300	4		
8303	Classroom	580	12		
9111	Classroom	420	15	420	
9121	Classroom	440	15	440	
1170*	Classroom			362	
1172*	Classroom			391	
1230*	Classroom			313	
4124*	Classroom			491	
4125*	Classroom			491	
4129*	Classroom			491	
4130*	Classroom			491	
8120*	Classroom			511	
8121*	Classroom			595	
9130*	Computer Lab / Teaching Space			577	
9135*	Classroom			424	

Table 5.3.1 - Classroom spaces on the Putney School Campus

Spencer, Pratt and Aiken, which has relieved some of the pressure for more faculty housing. Only Spencer House is likely to remain part of the housing stock in the long run; Pratt will be torn down, and Aiken will be sold when there is sufficient housing on school land.

The priority for faculty housing is to build the 2 new dorms described in section 5.1, each of which will include two family sized faculty apartments.

Opportunities for additional dormitory-attached faculty housing exist at the middle of New Boys as well as at the northeast end of Leonard's Keep. Both of these dormitories have 2 attached faculty apartments at one end, but providing additional faculty housing here would provide more adult support for the dormitory residents. These attached housing structures would make the most sense to add as other upgrades and renovations are being completed on these individual dormitories.

One long term option is to locate new faculty housing on campus. Location around the periphery of central campus would be recommended for stand alone faculty housing, close enough to the dining hall that faculty might choose to have dinner there rather than at home, but far enough away that faculty members could have some privacy. The recommendation is that these 4-6 additional faculty housing units would be built as 4-bedroom, duplex apartments that can work for larger families. These new housing units would be clustered in such a way as to create a small community, with a courtyard, in order to encourage a sense of community between the families. Possible locations to examine are at the Shaw lot or behind the sugar shack.

Along with the need for more faculty housing on campus, there is quite a disparity across campus of the quality of faculty accommodations. Existing housing ranges from studio apartments that can barely house a single individual to beautiful 4-bedroom homes. Revisiting and removing or renovating existing faculty housing should be a priority in the future, in order to create enjoyable places to live. Faculty housing that is in need of review includes the apartments attached to White Cottage, though others are also in need of renovation.

5.3 Classroom/Art Spaces

As pedagogy changes, the requirements for teaching spaces changes. Flexibility in class size and room configuration is increasingly important. At the same time, having different disciplines in contiguous spaces creates interesting synergy. For this reason, the main additional teaching space is proposed to be attached to Reynolds, which already houses math, science, fiber arts and photography. The expansion can be done with minimal disruption to the center of campus while keeping the academic core intact.

The Main Building and Library also require improvements to their programmed academic spaces. These buildings need to be addressed for classrooms size, office functionality and efficient use of space.

As illustrated in Table 5.3.1, currently 20 classroom spaces, with an average size of 435 square feet per classroom, exist on The Putney School campus. All together our recommendations will increase the number of classroom spaces to 21, with an average classroom size of 500 square feet per classroom.

The school has identified three main goals for academic spaces:

- 4-6 new classrooms of adequate size and flexible configuration. (The existing classroom stock includes limits scheduling options, which in turn may limit the optimal deployment of teaching faculty. Several classrooms only fit very small classes, which exacerbates this problem further.)

- At least one larger academic space which can be used for combined classes or larger groups. (There is often a need for a space which can hold 40-50 people. This allows for varied group sizes for different kinds of teaching practice.)
- Increased space for the fiber arts program, which is much constrained by its current location.

Recommendations (See Figure 5.3.1 through 5.3.4):

- A possible classroom expansion to make a "L" on Reynolds, which would contain the following elements:
  - Ground level workshop for students' projects, opening to the road to the west of Wender
  - Four large classrooms on the middle level, two of which would be divided by a flexible partition so that one large room could be created
  - Additional space for the fiber arts studio on the upper level
  - A renovation and reconfiguration of the western end of the current lower level of Reynolds, to make the classrooms there more usable. This expansion would also be a prudent time to renovate all of Reynolds to the net-zero ready standards.
- Main Building - The lower level of Old Girls will be renovated into two new classrooms when the new dorms are completed and Old Girls beds are removed.

Figure 5.3.1 Possible View Toward Reynolds from the Library

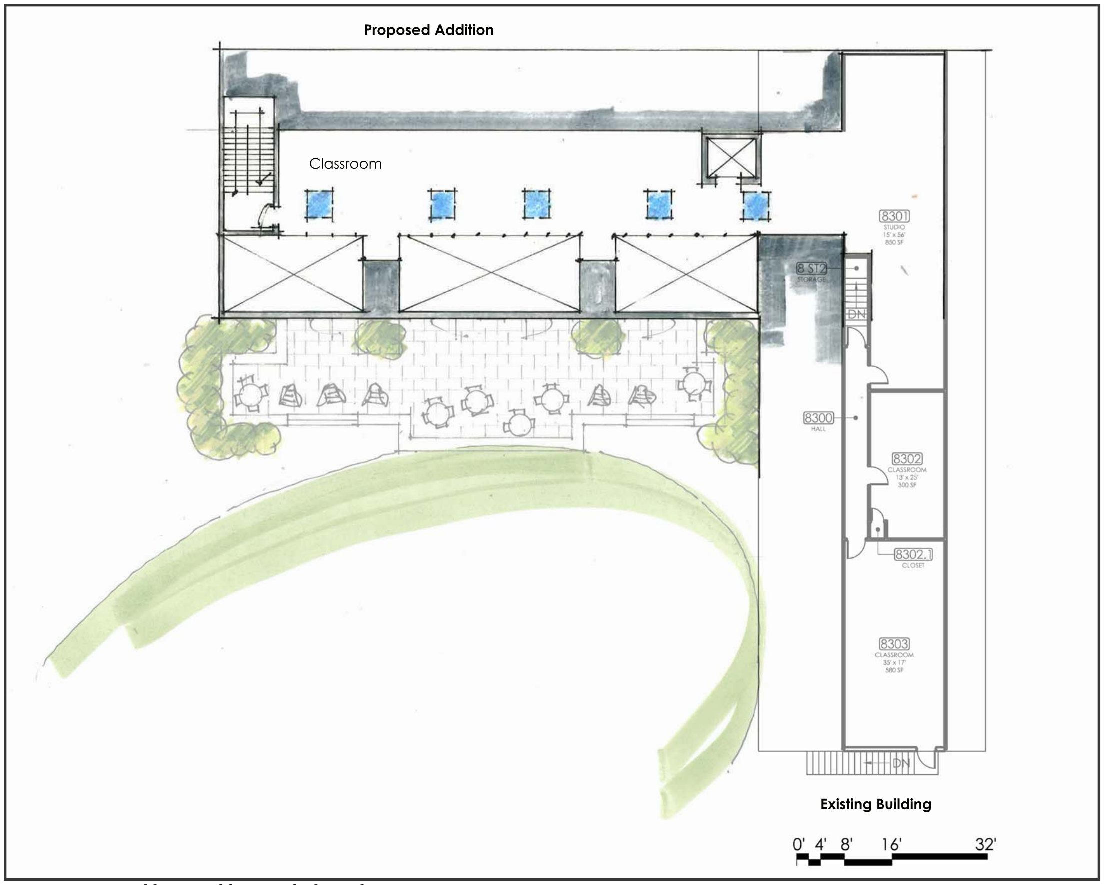


Figure 5.3.2 Possible Reynolds Second Floor Plan

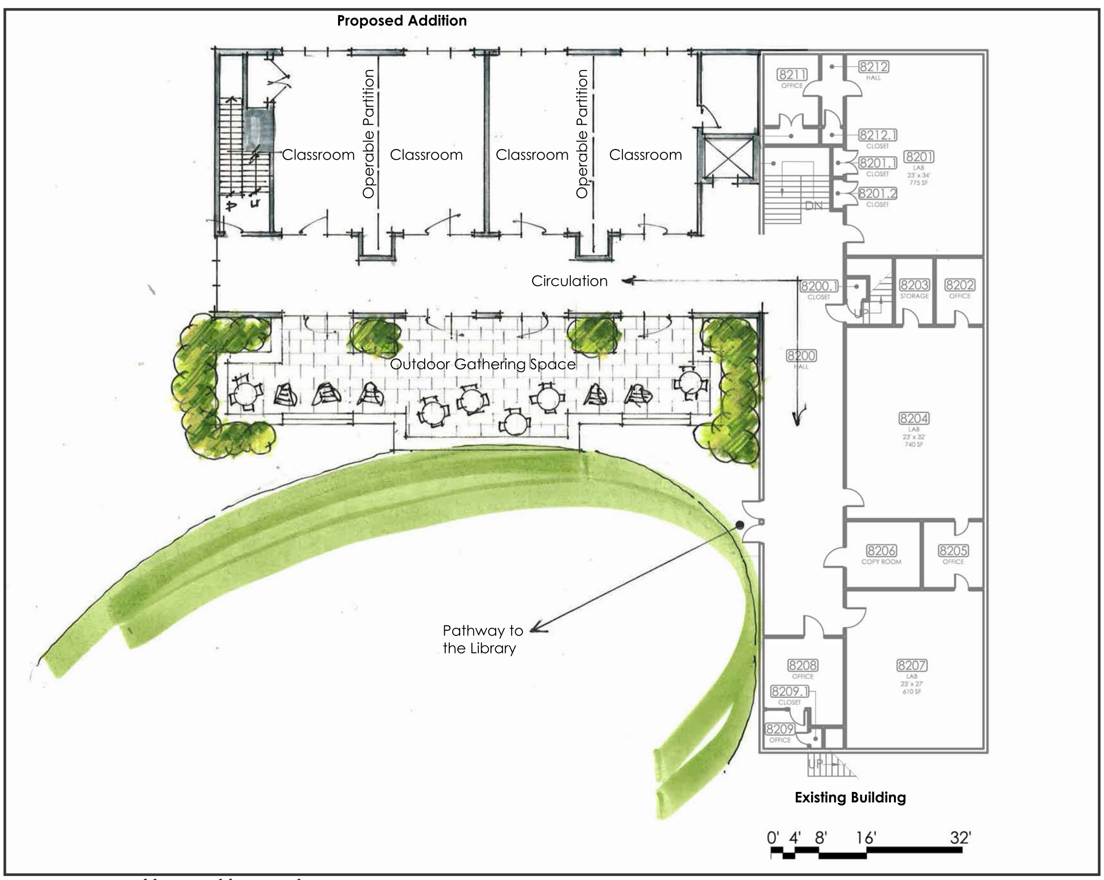


Figure 5.3.3 Possible Reynolds First Plan

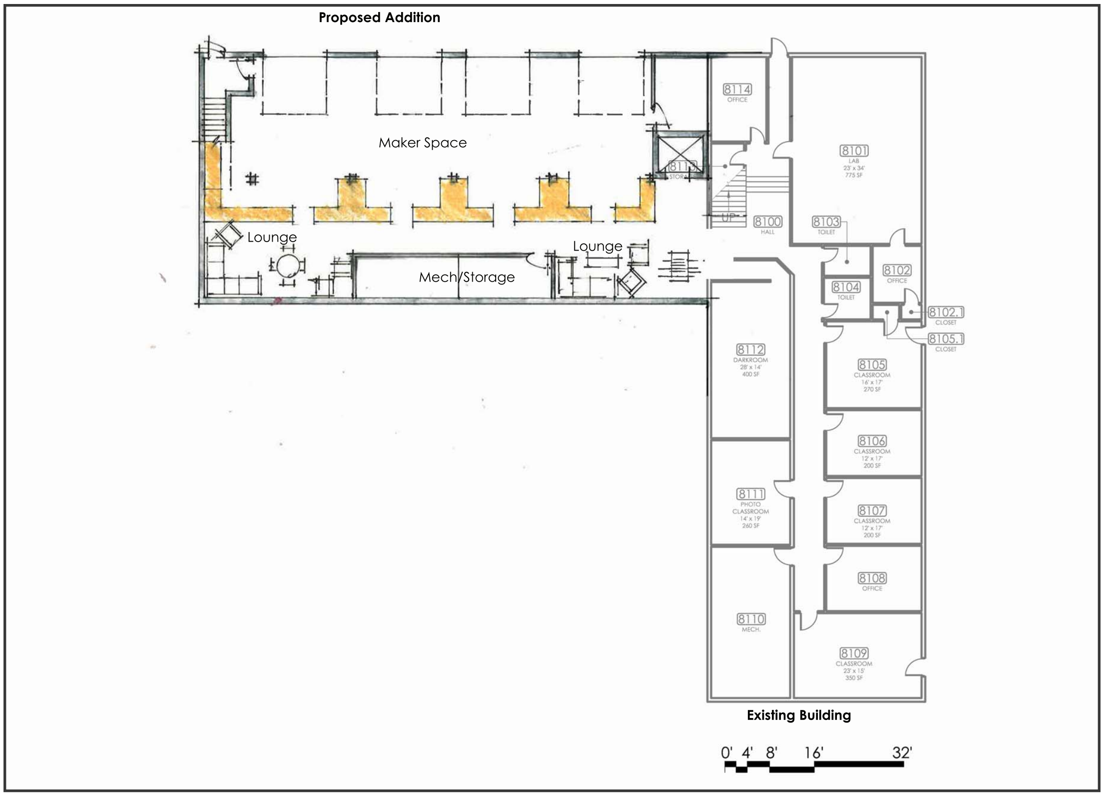
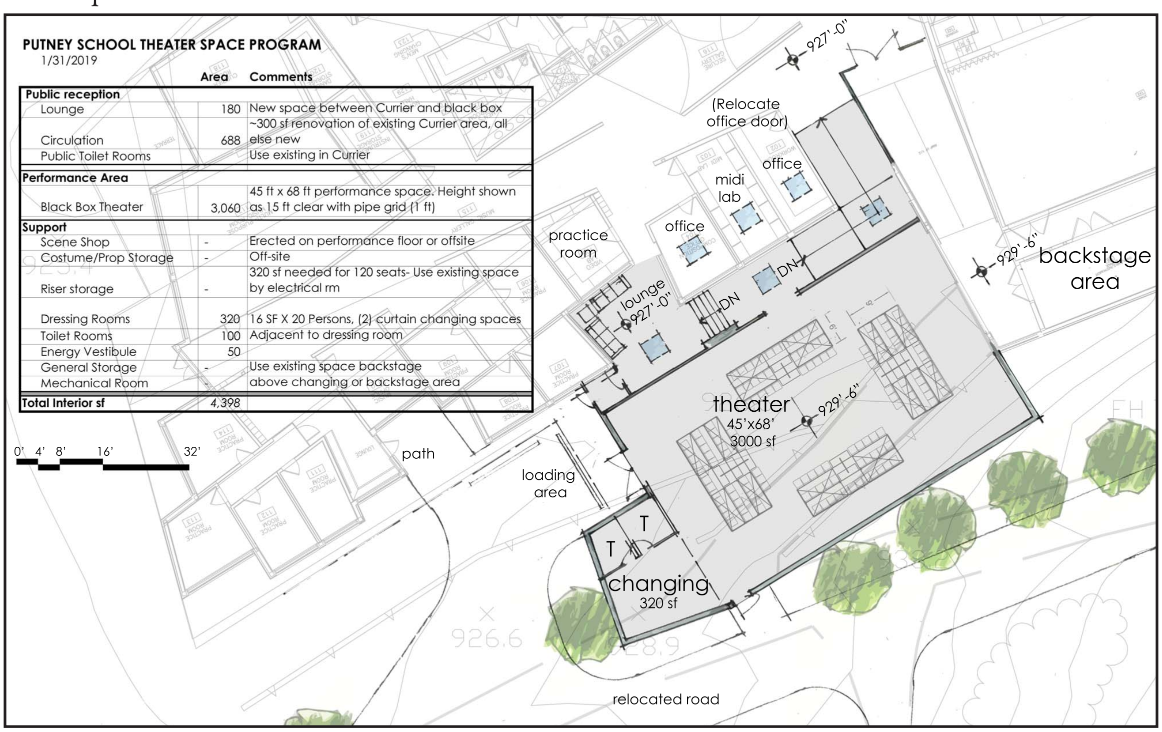


Figure 5.3.4 Possible Reynolds Basement Floor Plan

The arts have always been one of the reasons that students choose to come to The Putney School. The buildings on campus house an eclectic mix of student artwork displayed in a variety of locations. This same experience is not felt walking through the campus grounds, except around the Wender Arts building. There exists an opportunity to develop an even stronger feeling of the arts on campus by creatively inserting locations to display student artwork as features within the landscape. All future landscaping changes should be addressed with the possibility of displaying student artwork throughout the campus.



PUTNEY SCHOOL THEATER SPACE PROGRAM
1/31/2019

	Area	Comments
Public reception		
Lounge	180	New space between Currier and black box
Circulation	688	~300 sf renovation of existing Currier area, all else new
Public Toilet Rooms		Use existing in Currier
Performance Area		
Black Box Theater	3,060	45 ft x 68 ft performance space. Height shown as 15 ft clear with pipe grid (1 ft)
Support		
Scene Shop	-	Erected on performance floor or offsite
Costume/Prop Storage	-	Off-site
Riser storage	-	320 sf needed for 120 seats- Use existing space by electrical rm
Dressing Rooms	320	16 SF X 20 Persons, (2) curtain changing spaces
Toilet Rooms	100	Adjacent to dressing room
Energy Vestibule	50	
General Storage	-	Use existing space backstage
Mechanical Room	-	above changing or backstage area
Total Interior sf	4,398	

Figure 5.3.5 Theater Plan and Program

While many of the art programs are located in some of the best academic square footage on campus, there are some programs which are in need of significant building improvements. The Jeffrey Campbell Theater has outlived its current purpose, and without a major investment in the building it will not be able to fulfill the requirements of theater program for much longer. This building is in constant danger of failing to meet fire code regulations and therefore must be addressed as a needed program improvement. The current theater program was assessed, and a recommendation was given as to the size and requirements for a new theater to support the School's program.

Throughout the first Master Planning process, multiple locations were documented for this new theater location, all on the main campus, in order to connect the theater program more closely with other campus activities as well as being able to take advantage of infrastructure and parking already developed within the main campus core. In 2015, these sites were walked with a building committee and it was decided to attach the theater to the south side of Currier. Conceptual design was rekindled in 2018, with a building program revised and layout developed attached to the south side of Currier, as shown in Figure 5.3.5, also see the appendix for elevations and a conceptual cost estimate.

This location utilizes the infrastructure of Currier and would allow the addition to be smaller than if it were a stand-alone building. The south side of Currier currently is the loading dock and "back of house" so would not impact the elevation of Currier from Houghton Brook or the main campus drive.

5.4 Post Office and Store

When Old Boys dorm is demolished, the current Post Office and School Store will go with it. The critical determiners of location for a new Post Office/Store are the need for access by trucks and good foot access from the center of campus. Keeping truck traffic out of the middle of campus is a priority. Two possible locations were discussed:

- Near the northeast corner of the Field House, towards the end of the Field House access road. Not blocking the view through the Field House windows is important.
- On the site of Old Boys, more or less in the location of the current Post Office/Store. This would be a small one-story building.

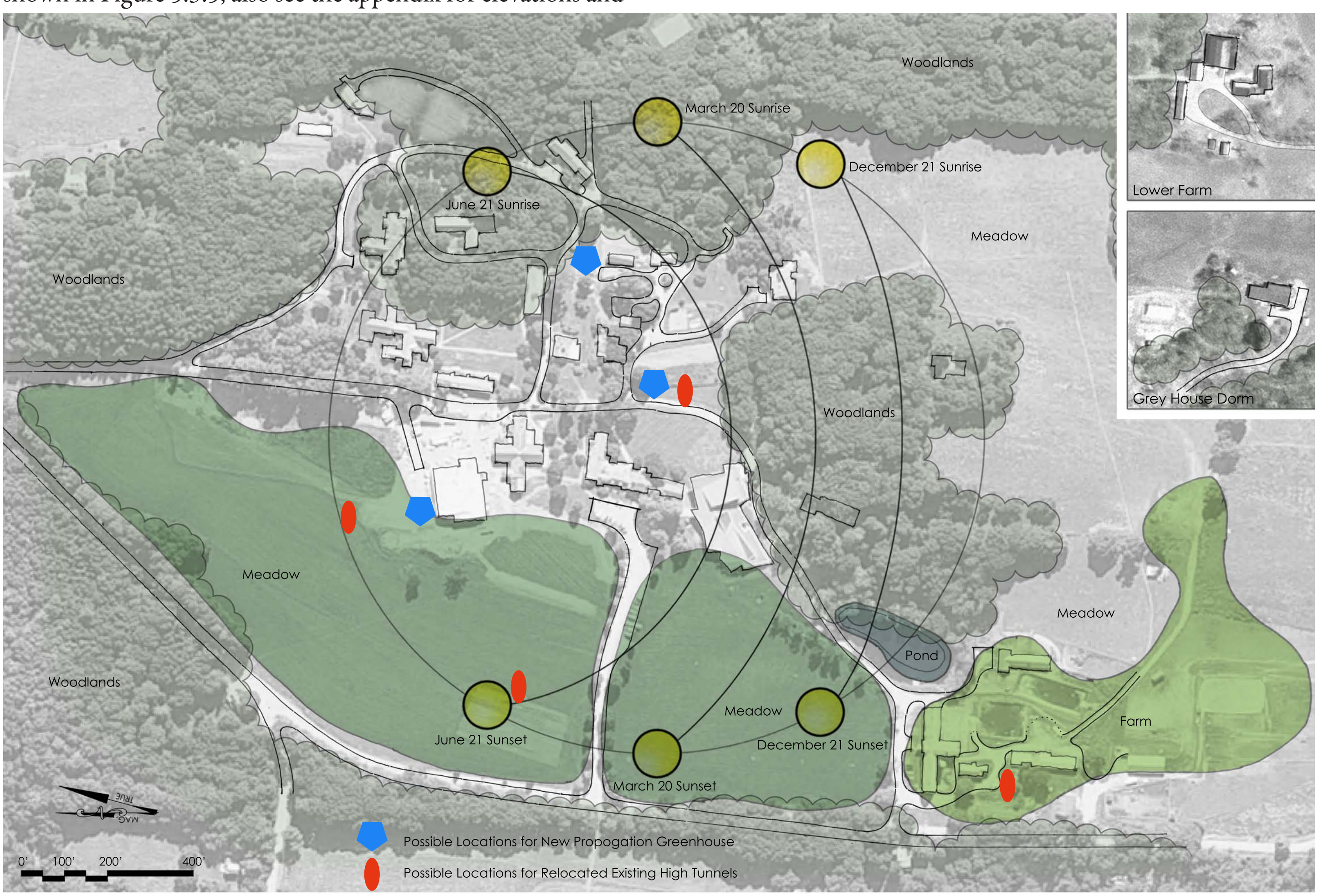


Figure 5.5.1 - Possible Greenhouse locations

5.5 Farm/Support - Greenhouses

The majority of the farm and support structures have not been investigated for this Master Plan beyond the inclusion of the annual energy use. The proposed new dorm location by Huseby and New Boys where the greenhouses are currently located has required the new greenhouse location to be examined. The following are recommendations to consider relocating the greenhouse and high tunnels on campus. Additional information on each proposed location can be found in the Appendix.

Orientation to Sun

The greenhouse should be located away from trees or buildings that would shade the structure. A north-south orientation would be ideal for the propagation greenhouse (but east-west would work), and a north-south or east-west orientation would work equally well for the high tunnels. Ideally the greenhouse will be located in a central, visible location. Siting the greenhouse in a visible location will help highlight the farm and garden program and encourage the community to visit the structure.

Space

For the propagation greenhouse: 50 ft x 85 ft minimum. It is recommended that a greenhouse be located at a distance equal to at least twice the height of any potential shade source. For the high tunnels if side by side, this area would be 80 ft x 90 ft, or end to end would be 35 ft x 160 ft.

Wind

Shelter/windbreak to the north can buffer winds and save energy. Orient a greenhouse north-south to get the best ventilation. However, single-bay greenhouses can be oriented perpendicular to prevailing winds if they have roll up sides.

Vehicle Access

Truck and tractors need to be able to pull up to greenhouse (even in snowy weather) to load and unload seedlings and other supplies.

Soil

For the high tunnels, soil quality is an important consideration. A well-drained loam with high organic matter content is ideal.

Access to Utilities

The new propagation greenhouse and high tunnels must be connected to electricity and water.

Impact on Existing Land Use

An important consideration is how the location will impact the current use of the land, including current farm use of land as well as other campus uses.

Topography and Drainage

A level, dry site that drains well is ideal. Excavation can be done to level a site as long as slope isn't too steep (avoid greater than 1:5 slope)

Possible Sites

Figure 5.5.1 illustrates possible sites. These sites should be considered as well as reviewing additional campus locations for additional potential sites not noted below.

Possible location for new propogation greenhouse:

- Same location
- Just above White Cottage garden (where blackberries are)
- Just below White Cottage garden (where skatepark is)
- Near Field House

Possible locations to move existing high tunnels:

- Near field house/alpacas (other side of ditch)
- Just above White Cottage garden
- Behind tractor shed/farm shop
- Front field

5.6 Vehicular Infrastructure

One of the largest challenges of The Putney Campus is the movement of vehicles through the central green space. The main vehicular circulation path travels straight through the East Lawn and the Central Park spaces. This Master Plan saw it as a goal to remove vehicular circulation from the center of campus as much as possible, and to better define separate locations for vehicular and pedestrian circulation. In order to do this, recommendations are made to install gates to the center of campus cirulation to be used for infrequent or emergency access.

The Putney School also sees some challenges with parking. Though the amount of parking on campus is close to ideal, the location of this parking is not necessarily well thought-out. The majority of parking on the campus exists in front of the main building which provides some challenges including the prevalence of bus parking so that visitors see busses in the parking lot before the rest of the campus. Parking recommendations include the following.

- The main campus parking to the west of the Main Building should be better delineated and broken up by landscaping in order to minimize the visual impact of this parking lot. Currently this parking lot is wider than need be and does not have a very organized flow, meaning it is used inefficiently. Better delineation of parking could lead to a smaller square footage of space being denoted as parking but serving the same number of vehicles.
- Establishing a lot for cross country ski parking. Cross country ski parking currently occurs haphazardly at the entrance to the main parking lot, during the winter when patrons can park on the snowy field, which causes wear and tear on the field. If established as a visitor parking lot, with signage about the trails, it would mean less wear and tear at the entrance to the School.
- Expand parking to the north of the Field House. A small amount of parking currently exists to the north of the Field House. This parking should be expanded so that buses can be parked here, hidden behind the Field House, but still easily accessible by faculty and staff for field trips and athletic events. This parking can also be used by faculty and staff, which would leave the front parking lot more open for visitors to the campus.

Future infrastructure needs for electric vehicles should be discussed and planned for as opportunities arise to convert to electric vehicles and buses.

5.7 Water and Wastewater Infrastructure

The campus water and wastewater system underwent significant upgrades in 2012, but since that time the School has investigated the existing system and how it pertains to the two new dorms and the theater relocating to campus. An investigative report from Stevens Associates serves as an update to the 2015 water and wastewater infrastructure feasibility report titled The Putney School: Infrastructure Feasibility Report 2018 Update, both available in the appendix. This report update recommends:

- Installing additional flow meters to the water and sewer systems so that accurate data can be used with a high level of confidence to allow for permitting based on the metered use.
- Removing the agricultural and irrigation uses from the drinking water supply by dedicating the disconnected Noyes well and the Puddle pond for the agricultural water supply and storage.
- Updating the campus leach field to the current permitting rules so that flows may be increased depending on metered use.
- Constructing a new leach field and pre-treatment station for the disposal of wastewater disposal to increase the capacity of campus systems. The report discusses two sites for this improvement: 1) Behind the Greenhouse dorm; 2) At the Spencer/Paige field property.
- Drilling a new potable well for inclusion in the campus water supply to increase the long-term reliability of the system.

Recommendations from Stevens Associates include the following steps to be immediately taken to prepare the water and sewer infrastructure for the upcoming projects. These items will affect the project approach and permitting timeline since the new leach field design/permitting and new water source design/permitting both have long lead times:

Immediate Recommendations

- Install water meters to agricultural uses to begin collecting the data needed to justify the elimination of these flows by the Puddle irrigation/ag-use project. Additionally, it's recommended that a meter be installed to the KDU water supply.
- Field measurements should be done to determine the flow rates of each pump in the water supply system. Once determined, those flow rates should be added to the Mission system so that remote monitoring of pump operation provides real-time gallonage of the well pumps, which is already required under the current operating permit.
- Begin the process of updating the Indirect Discharge Permit to the current Indirect Discharge Rule as this may prove to "green-light" the first dorm project without leach field construction. This will involve the hiring of a hydrogeologist. At this time, we do not anticipate this being a construction project, but to be permitting and long-term operational costs.

Near Term Recommendations

We recommend the Puddle storage pond supplied by the existing Noyes well be converted to the water supply for all non-potable purposes used by the farm and irrigation: estimated at an order of magnitude construction budget of $40,000-60,000. The schematic design of this upgrade is as follows:

- Extend the extra dry hydrant line from the Puddle berm. This line and gate valve was installed during the dredging project in anticipation of this project.
- Install a pitless-booster-station (e.g. Baker Water Systems).
- Install a new submersible high-capacity pump and controls in the booster station to supply water to irrigation zones and the barn.
- Re-plumb the barn so there is a clear distinction and isolation between the potable and nonpotable water systems. Non-potable system in barn is to include in-line pressure tanks to maintain working pressure and prevent submersible pump from operating during short duration flows.

Completion of this work will reduce the demands on the existing water system, which is currently overburdened and in need of immediate improvement for system reliability, regardless of permitting needs.

Alternatively, instead of removing water demand from the community system, the supply may be increased substantially. This would be done by a new well added to the water system as had been discussed in the original feasibility report. For planning purposes, a lead time of 12 months for water system permitting approvals and a budget of $125,000-175,000 should be assumed.

Short-Term and Long-Term Recommendations

The short-term and long-term recommendations are subject to change depending on the choices taken and their outcomes. At this time, Stevens is optimistic that the first dorm project will be feasible by updating the indirect discharge permit to current rule and by reducing water demand by supplying agricultural uses with a new non-potable supply. We anticipate that the long-term needs of the School

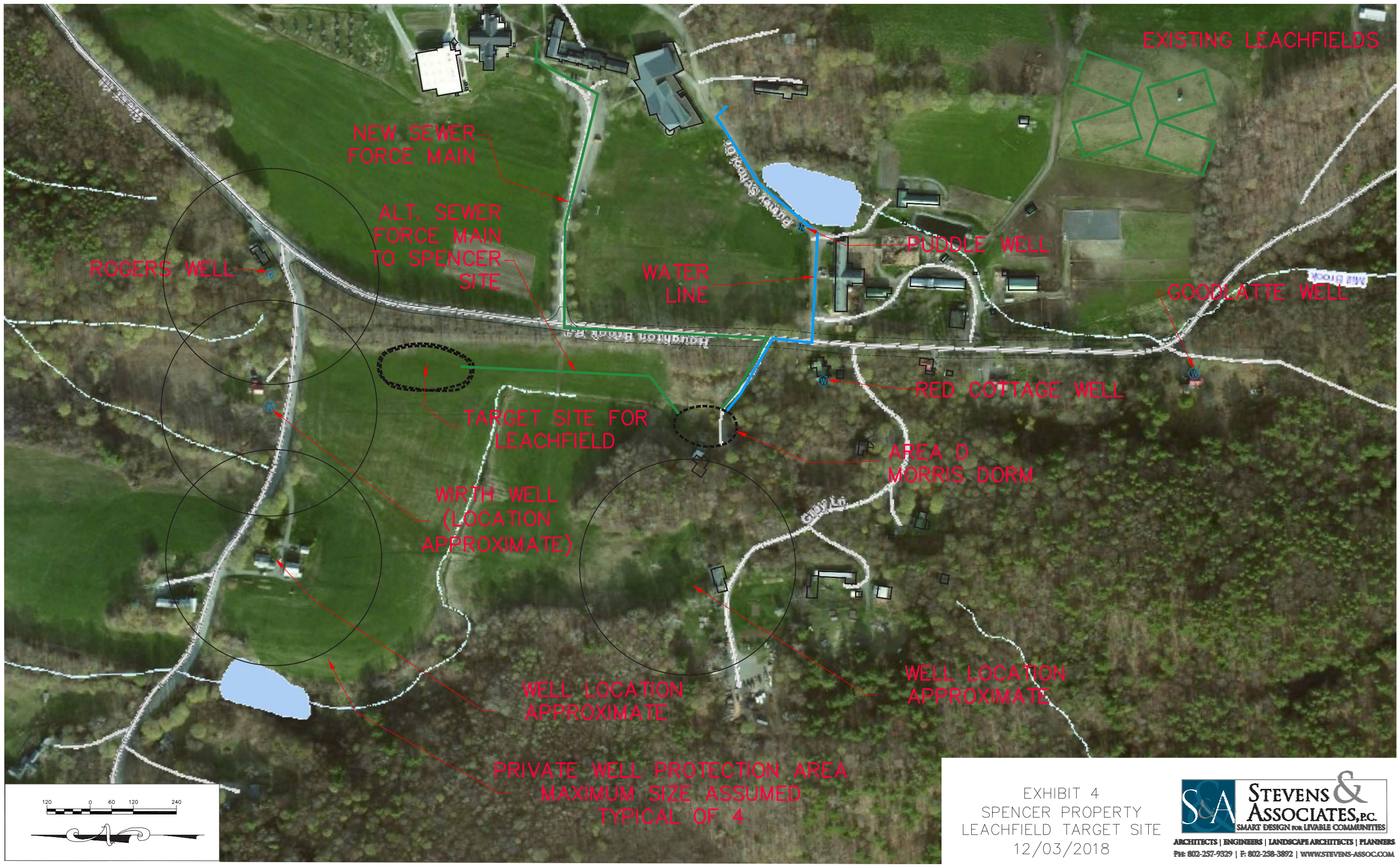


Figure 5.7.1 Campus Infrastructure Upgrades

and the second dorm project will require a new wastewater disposal site and will ultimately require an additional well and further investigation of the performance and capacity of the existing Red Cottage and Huseby wells.

Depending on the results of further investigation into the indirect discharge permit update, we may recommend the drilling of a monitoring well in the Greenhouse leach field site soon, if the School proceeds with that approach.

5.8 Landscaping

Improving landscaping on The Putney School campus follows two general goals, one of enhancing the pedestrian experience on campus and the other of establishing a better gateway and transitional feeling to the campus. The landscaping should enhance the organization of the built environment and serve as contextual navigation throughout the campus. The following recommendations are identified here as opportunities for The Putney Campus to embrace.

- Enhance the entrance experience between the Main Building and the KDU
- Enhance outdoor spaces for teaching, learning and informal gathering
- Allow the growing of food to become a primary experience in the center of campus
- Cull the smaller trees and brush from the woods spanning the central campus to improve security and aesthetics
- Extend the central green to the northeast in order to create a strong connection between all the main campus buildings
- Create better defined parking through landscaping improvements
- Develop wayfinding for intersections between campus and recreation paths
- Develop a stronger entrance experience into the campus from the main entrance point that of the parking lot to the west of the Main Building. Master Plan recommendations identify specific landscape changes to this area to better identify a gateway and transition the visitor from parking to the central campus. The following specific recommendations address this issue:
    - Pull the parking further from the Main

Building providing a larger swath of natural growth across the front of the building

- Develop an arbor or more identifiable structure between parking and the Main Building
- Develop actual gateways to the campus at both the south and north ends of the Main Building

Maintaining the intersection between the two separate ecosystems on The Putney School campus, that of the field and the forest, is important in enhancing the intrigue and privacy that is created when these spaces come together. Dormitories nestled into the surrounding woodlands create a much more intimate feeling than dormitories set in the middle of the field. Enhancement of the existing ecosystem could occur in the culling of smaller trees and brush from the somewhat overgrown woods that span the central campus, surrounding the Wender Arts Building. Both from an aspect of safety, in providing sight lines through the space, as well as an aesthetic quality, in providing a more park-like space, this intersection of the ecosystems could be enhanced.

Landscaping efforts will also function to enhance the pedestrian experience on The Putney School campus. The centerpiece of these improvements is the conversion of the former central driveway to a pedestrian corridor with very limited vehicle access. This will not only improve the quality and safety of the corridor, but also introduce a central pedestrian artery along what is now a road. As pedestrian transportation is the most common day to day transportation for campus users, this experience should be recognized in all future changes to The Putney School campus.

5.9 Campus Plan Summary

The overall campus plan as shown in Figure 5.9.1 and 5.9.2 graphically shows the campus plan and location for the elements described in the proceeding sections. Key elements include:

- 2 new dorms
- Theater addition on the south side of Currier
- Classroom addition on Reynolds
- Removal of Old Boys, and new Post Office
- Expanded north lawn/central campus green
- Central pedestrian focused circulation
- Landscaped gateways to campus from the Main Building

The central gateway between the main building and the KDU provides a focused arrival to campus. The East Lawn, Central Park area, and enlarged North Lawn (with the removal of Old Boys) focuses the academic spaces around these enhanced and enlarged greens that become the heart of the campus. The majority of student housing is relocated to the periphery of the main academic campus. Restricting traffic through the center of campus with gates will strengthen the pedestrians' connections and enhance safety.

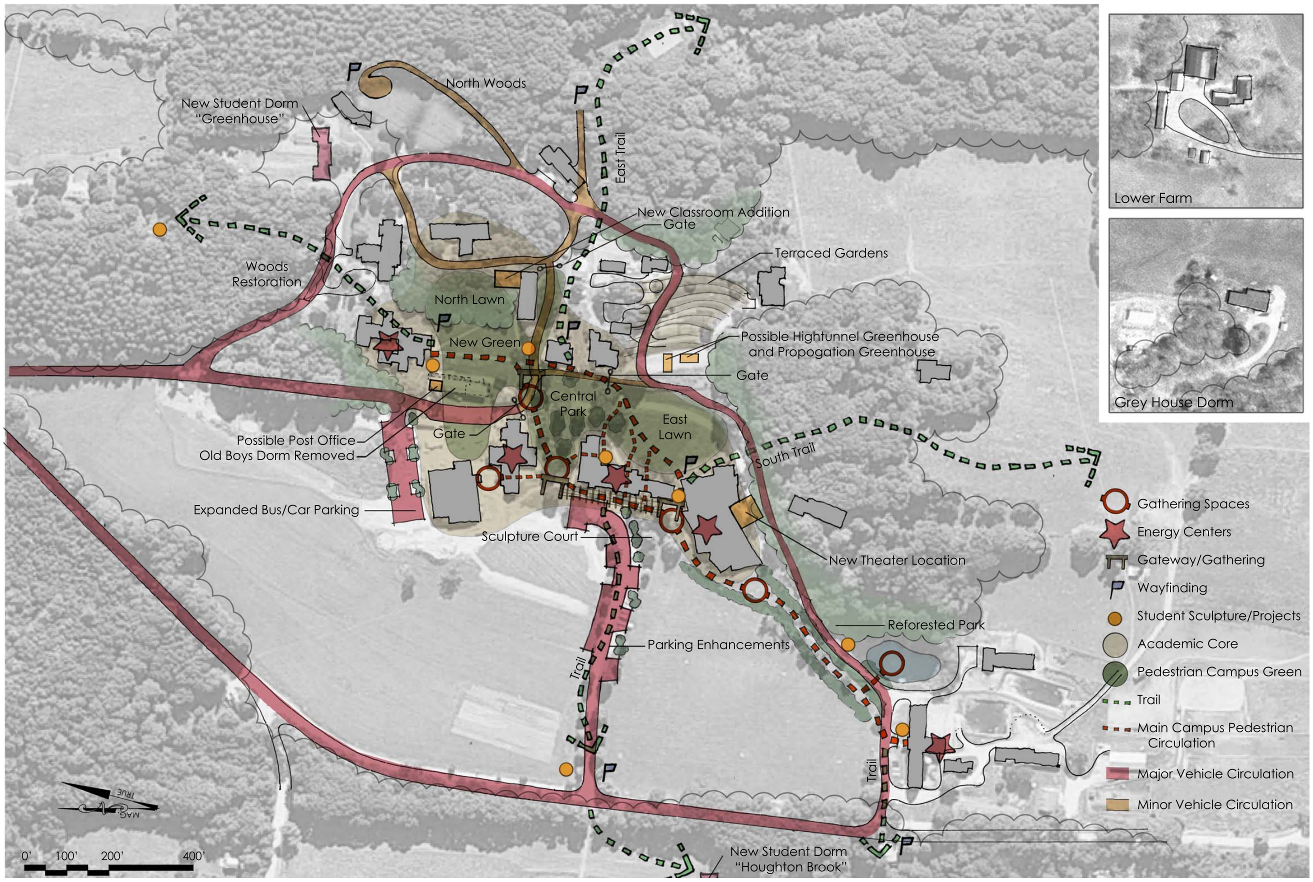


Figure 5.9.1 - The Putney School Master Plan Concept

Figure 5.9.2 - The Putney School Master Plan Concept Enlarged

6. The Net-Zero Campus

With fuel oil price volatility and prices tripling in recent years, through the success of the net-zero Field House and the recent Gray House dorm retrofit, both the desirability and feasibility of major energy reductions have become apparent to the School. This realization led The Putney School to ask for an energy Master Plan as part of the overall campus Master Plan in 2011, and for it to be updated in 2018. This energy plan is intended to guide the School toward a secure, affordable, environmentally responsible energy future for the campus. As part of the plan, we have developed energy standards for all future renovations and new construction and recommended renewable energy sources to meet the reduced building energy loads. The Plan also outlines the necessary action steps to move toward the goal of a net-zero campus.

6.1 Strategic Energy Planning

The impending climate change tipping points are drastically changing how we assess building and energy performance. Detailed financial modeling indicates that significantly higher investments in efficiency and renewables than have been common are not only a responsible response to climate change but have an excellent return on investment, and a drastically reduced risk and exposure to future energy cost changes. Not only is this likely a secure investment, but it is obviously also good for the planet and the community. Thus, this large initial investment might in fact be the most prudent investment and best solution.

6.2 The Path to Net-Zero

The path to net-zero[1] energy consists of two separate but related pieces. The first aspect of the net-zero strategy is building energy-efficiency improvements. These include building enclosure improvements above current code, as well as remediating moisture (and in some cases, mold) problems that need to be addressed for occupant health and safety as well as building durability. Additionally, moisture problems could get worse if they are not addressed as the buildings are tightened up. This requires controlling unwanted moisture entry and controlling indoor moisture generation and indoor air quality with, in most cases, new ventilation systems that do not presently exist. Mechanical systems will need updating, to allow proper temperature control of spaces and ventilation, to be more efficient, and to allow the systems to be powered by renewable electrical energy. Proper enclosure upgrades and mechanical systems result in better, more even temperature control that improve comfort and productivity.

The second aspect of the net-zero strategy is the addition of renewable energy sources to meet campus energy needs with solar electric (photovoltaic (PV) systems) to produce electricity. Solar hot water systems may be appropriate in limited areas. With the continued increase in air source heat pump technology and the decrease in cost for photovoltaics, The Putney School has determined to pursue the

1 A "net-zero" campus is defined here as all building energy requirements being met by solar energy, on an annual basis. That is, photovoltaic systems would generate as much energy over the course of the year as all campus building energy requirements. The solar photovoltaic systems could be located on site, or could be offsite and grid connected to The Putney School.

net-zero energy campus plan with PV as the sole power source, not the biomass options as originally outlined in the 2011 Master Plan. Additionally, the specter of near-term climate change tipping points makes us consider that CO2 emissions from wood burning result in near term atmospheric CO2 increase, even though these emissions may be offset in the long run by forest re-growth in properly managed forests.

Efficiency and renewables are proposed to be pursued in tandem to make progress toward the goal. In the past, the perceived wisdom has been "conservation first, renewables second." There are three reasons this is no longer the case.

- In order to address climate change, both conservation and renewables are needed simultaneously to move towards a net-zero future as quickly as possible.
- It is wise to take advantage of opportunities as they arise: If a building is being worked on for programmatic, deferred maintenance, or another reason, then improvements should meet the proposed energy standards so that there is incremental building improvement.
- Funding should be used as opportunities arise, whether for renewables or conservation, through grants, gifts, Federal or State incentives, or through efficiency programs offered by Efficiency Vermont.
- Regulation and incentives for renewable equipment installation are in a state of flux, with incentives decreasing and restrictions increasing. It may be prudent to install renewables while incentives are higher than may be expected in the future.

We recognize that the path to net-zero for The Putney School is not an easy one. The campus' many older buildings require repair (often urgent) and many require repurposing or remodeling, in addition to energy upgrades. Meeting all these needs will require integrating energy improvements with all program improvements and deferred maintenance upgrades. We generally advocate allocating resources toward a complete net-zero "fix" of fewer buildings at a time, rather than minor fixes to a larger number of buildings. There are two main reasons for this approach. First, it costs more to partially retrofit a building and then to come back and do the rest at another time. The added costs come from having to un-do some of the things done in the first round to complete the second, in addition to mobilizing the builders twice. The second reason is to accomplish tangible, visible progress by achieving the net-zero goal as each building is worked on. It is expected that it will be easier to raise funds for three net-zero buildings than for 6 partial building improvements. This approach also allows the School and its contractors to become more proficient at accomplishing these "deep energy retrofits," which require a level of attention to detail that is not typical, while providing research opportunities for students to see the tangible impact on health, energy, comfort, etc.

Notwithstanding the above discussion, we feel it is worth considering some incremental approaches. The level of effort and fundraising is so large for complete net-zero ready retrofits, and deferred maintenance is so daunting, we have tried to identify incremental projects that could begin immediately to lower costs while addressing deferred maintenance and avoiding installing anything that would have to be redone in a complete deep energy retrofit. These are being identified as projects with significant impact with manageable costs.

Annual review of projects completed and projects to move forward will keep The Putney School moving toward their ultimate Master Plan goals of a net-zero energy campus.

6.3 Energy Usage

To review campus energy use, the buildings were broken into subcategories: Administration/Classroom, Dorm/Apartments, Staff Housing, KDU, Support Buildings, and Farm. The 2011 Master Plan broke out the total energy use for the campus excluding support and farm buildings. It had been determined that farm and support, although contributing to the overall campus energy use, were not large energy users because they did not have heating systems and therefore envelope upgrades and mechanical systems to upgrade to the net-zero ready levels. For the 2018 analysis, the team decided to include the farm and support buildings in the total energy use for the campus in

FY 2018 Fuel Use Totals and Cost

	Oil gallons	Propane gallons	Electricity kWh	Pellets tons	Fire Wood cords	Solar Array kWh sold	Total
Use, units	67,400	22,476	885,851	63	16	528,500	
Cost	$ 140,157	$30,589	$ 132,989	$ 16,181	$ -	$ (22,726)	$ 297,000
$/unit	$2.08	$1.36	$0.15	$257	$0	-$0.043	

Solar array return is net to the school, after PPA costs, total includes payment to school for PV

$/unit are average: total usage divided by total cost

Table 6.3.1 FY 2018 Fuel Use Totals and Costs order to offset all of the energy use on campus. The following analysis includes all buildings' energy use, including farm and support buildings, and adds estimated usage for those buildings to the SchoolDude 2012 data as shown in Table 6.3.2.

Current energy use and cost (for all buildings, including farm and support buildings, excluding farm diesel and transportation) for The Putney Campus is shown in Table 6.3.1.

The oldest data set for energy use that is comparable in scope to the present tally – using SchoolDude software – is 2012. Electricity usage has increased in 2018 compared to 2012 by approximately 75,000 kWh.

This aggregated data is from SchoolDude, where the School has tracked all energy use since 2012. Jeffrey Campbell Theater, Pump House, and Pratt House were not in the 2012 tally. But even taking those buildings out of the 2018 data, electricity usage is still higher by about 14%. Some electrical increase was from the Gray House heat pumps and ventilation installed in 2016-2017. If Gray House-added electricity is removed from the 2018 data, resulting in a better comparison to 2012, it makes the 2018 data about 10% larger than 2012 (75,000 kWh).

Electricity	kWh/yr		
2018	2012	2018, less new buildings	2018, less new buildings less HP in Gray
885,851	734,907	840,271	810,271

Table 6.3.2 Comparison of Electricity Tracked in 2012 and 2018

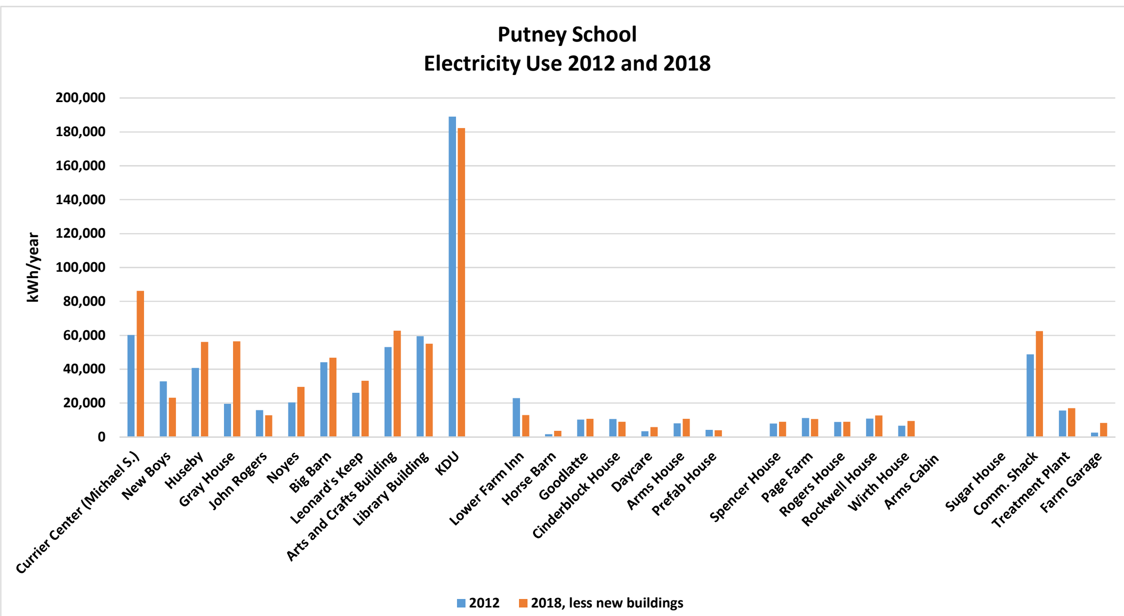


Figure 6.3.1 2012 and 2018 Building Electrical Use Comparison

Electricity usage by building for both 2012 and 2018 is shown in Figure 6.3.1, showing significant increased usage in Currier, Huseby, Gray House dorm and the Communications Shack. These individual building increases account for most of the difference from 2012 to 2018. Increased electronics usage is assumed to be contributing to some degree, but due to minimal submetering on campus it is difficult to determine what else is contributing to the slight increase of energy use. Once EGauges are installed in these buildings, the causes of these types of spikes can be more readily identified.

Table 6.3.3 and Figure 6.3.2 compare total energy use in 2012 to 2018, adjusting the 2012 data to include energy for buildings that were added to the campus since 2012 (Pratt, Spencer, and Aiken). This was done in order to enable comparison of the increase or decrease in campus energy use. The farm and

Putney School Energy Usage						
	Electricity - MWh	Oil - gallons	Propane - gallons	Wood pellets - tons	Firewood cords	Total MMBtu
FY 2012 [1]	773	64,000	19,000	67	15	14,475
FY 2018	940	67,000	22,000	63	16	15,699
[1] adjusted to include values for buildings added since 2012 for comparision purposes						

Table 6.3.3 Putney School Energy Usage 2012 vs. 2018

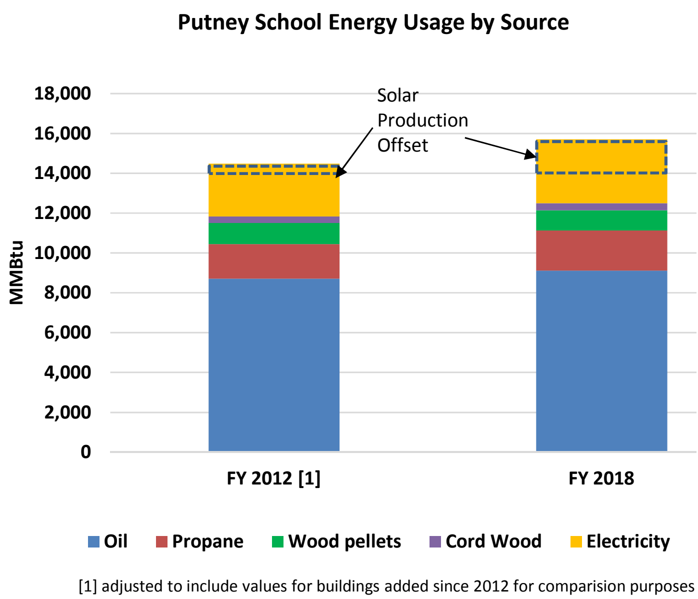


Figure 6.3.2 Putney School Energy Usage by Source

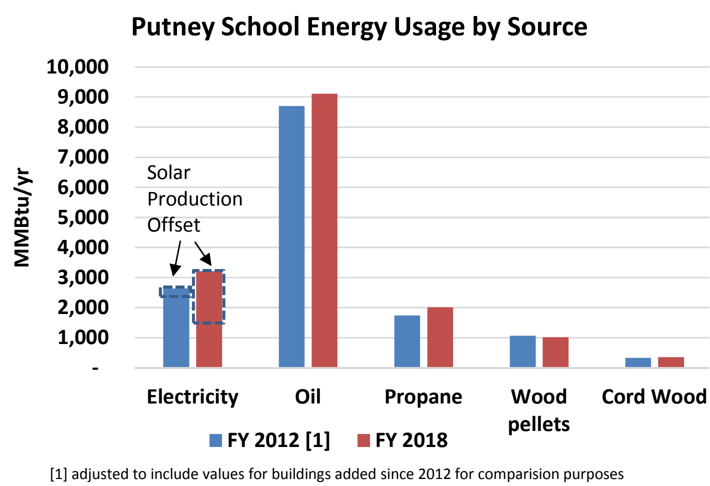


Figure 6.3.3 Putney School Energy Usage by Source

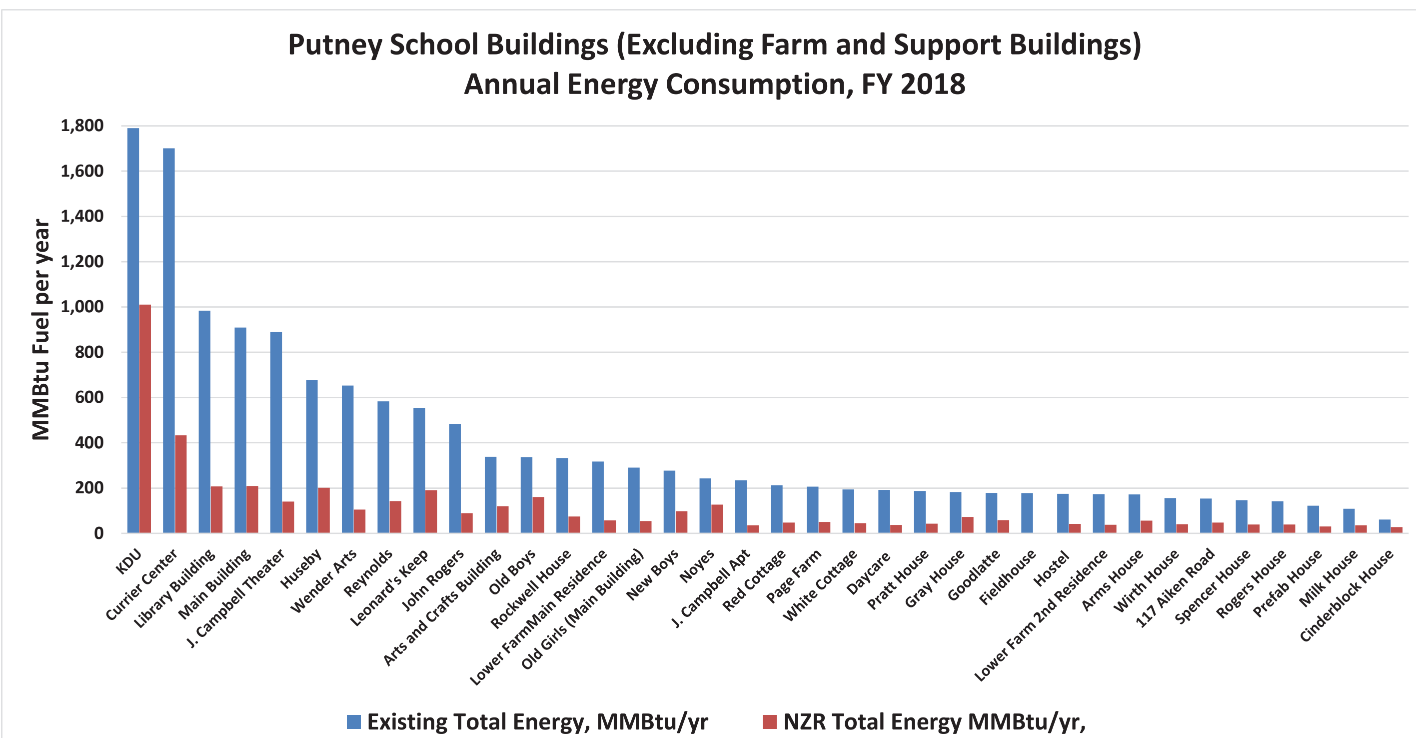


Figure 6.3.4 Putney School Energy Usage by Building Comparison

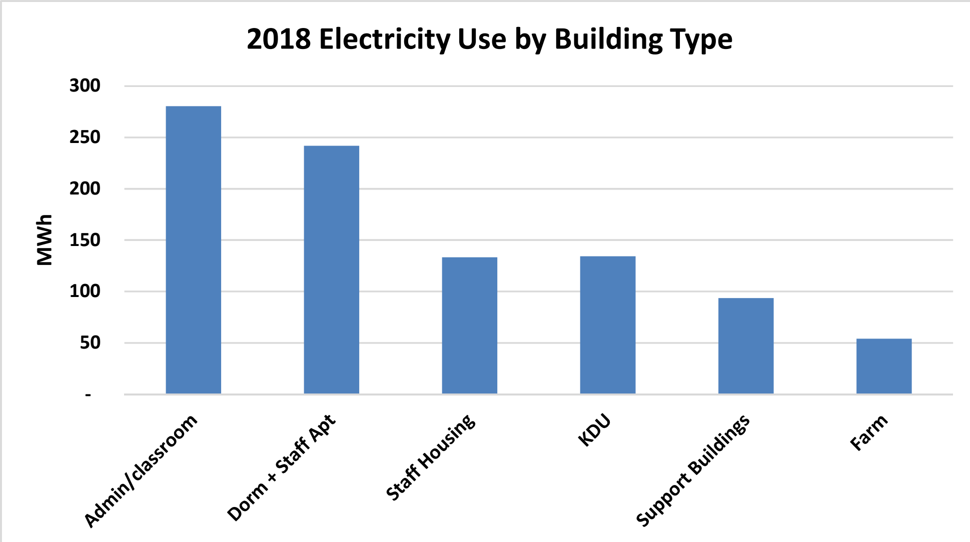


Figure 6.3.5 Putney School Electricity Usage by Building Type

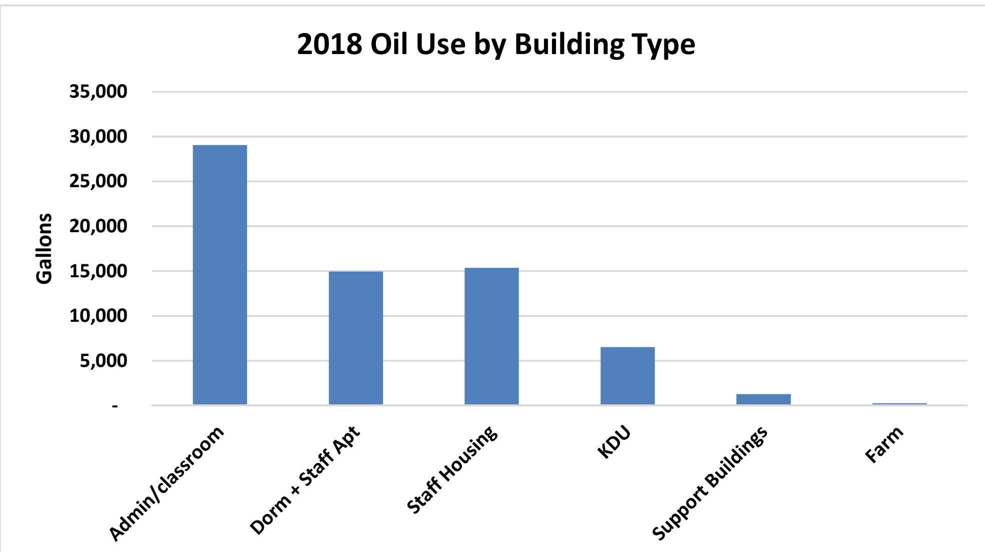


Figure 6.3.6 Putney School Oil Usage by Building Type

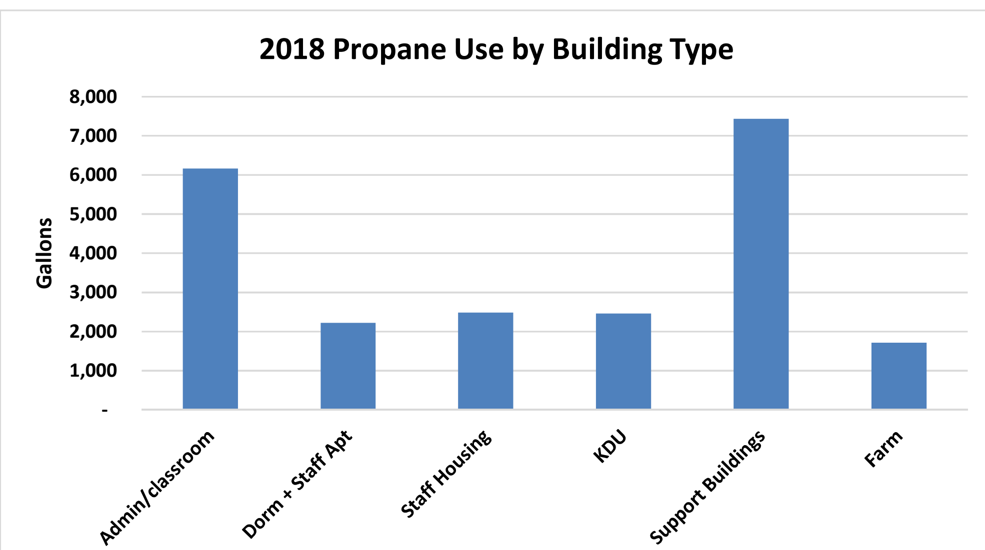


Figure 6.3.7 Putney School Propane Usage by Building Type

support buildings account for approximately 150 MWh in both the 2012 and 2018 data.

In terms of units of energy (not units of fuel) used, a significant portion of the electricity usage is offset by the large 446 kW solar array at Lower Farm and the 36.8 kW tracker system at the Field House as shown in Figures 6.3.2 and 6.3.3.

Figure 6.3.4 shows the existing MMBtu per building compared to the future net-zero ready energy use. Not too much stock should be taken in each individual building because this is a broad brush look at what is generally achievable by eliminating fossil fuels, reducing lighting and plug loads, while adding ventilation and heating every building with air source heat pumps. This broad look is not the result of an audit of each building, but is instead based on assumptions for energy reduction targets based on building type. For example, Pratt and Old Boys are still listed but are going away completely.

Energy use by source and building type is tallied in Figures 6.3.5, 6.3.6 and 6.3.7. In addition to electricity and fossil fuels, firewood was burned in FY 2018, mostly at the KDU for the oven (10 cords) and in three staff houses (6 cords total). Wood pellets (63 tons) were burned serving the Main Building and Old Girls.

CO2 emissions vary by fuel type and are tallied in Table 6.3.4 for 2018 and are compared to a net-zero campus. The small PV emissions (0.064 CO2e lbs/kWh) reflects an estimate of the energy required to produce and install the system per kWh produced over a 25-year lifetime of the system. This is a very small amount compared to the 1.2 CO2e lbs/kWh for grid electricity based on the fuel mix supplying the grid.

In order to understand where the greatest need for improvement exists it is helpful to understand energy usage on the campus at a building-by-building level. Figures 6.3.9 and 6.3.10 look at the total energy usage by each building on the campus. All fuel types are included – oil, propane, wood and electricity -- normalized by the energy in the fuels in kBtus (thousands of Btus). Figure 6.3.9 illustrates the total energy use by building, while figure 6.3.10 looks at energy use per square foot, in order to illustrate how efficient the building is for its size. The graphs depict FY 2018 energy data, and usage data is estimated for buildings that share meters with other buildings, based on the best available information. See the Appendix 2018 Meter Information that describes what is known about which meters serve which buildings and Section 8.4 that describes in detail the submetering that would enable accurate building by building energy comparison.

Pratt House, Jeffrey Campbell apartment, the Hostel and several other small buildings all have unusually high energy intensity that should be investigated with a thorough energy audit, and perhaps circuit monitoring. The Hostel usage is estimated, as it shares fuel with the Lower Farm Inn building, resulting in uncertainty in the values (see the discussion

CO2e Emissions, All Buildings, pounds per year

	Grid Electricity - kWh	PV Electricity kWh	Oil - gallons	Propane - gallons	Wood pellets - tons	Fire Wood - Cords	Total
2018	500,000	37,000	2,000,000	400,000	200,000	69,000	3,206,000
Net Zero	-	90,000				69,000	159,000
CO2e lbs/unit	1.2	0.064	29	18	3,123	4,294	

Table 6.3.4 Putney School CO2e Emissions, All Buildings, Pounds Per Year

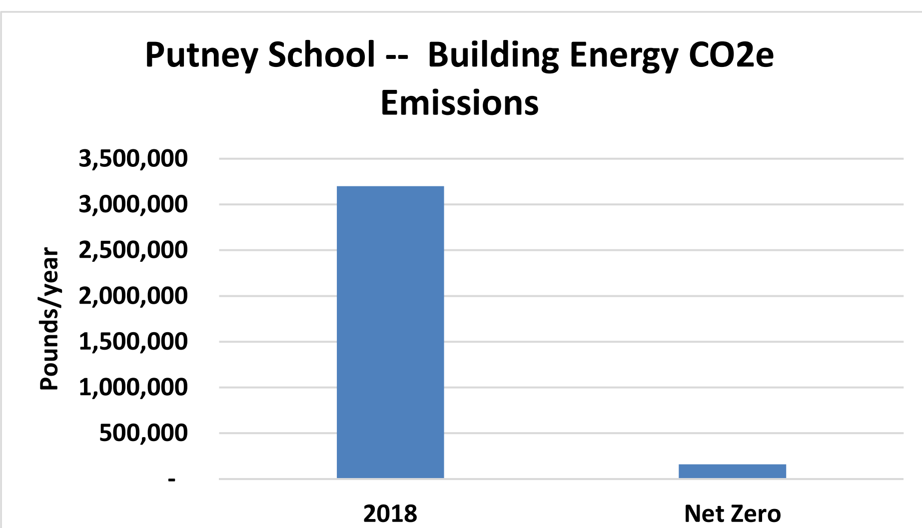


Figure 6.3.8 Putney School Building Energy CO2e Emissions Compared to Net-zero

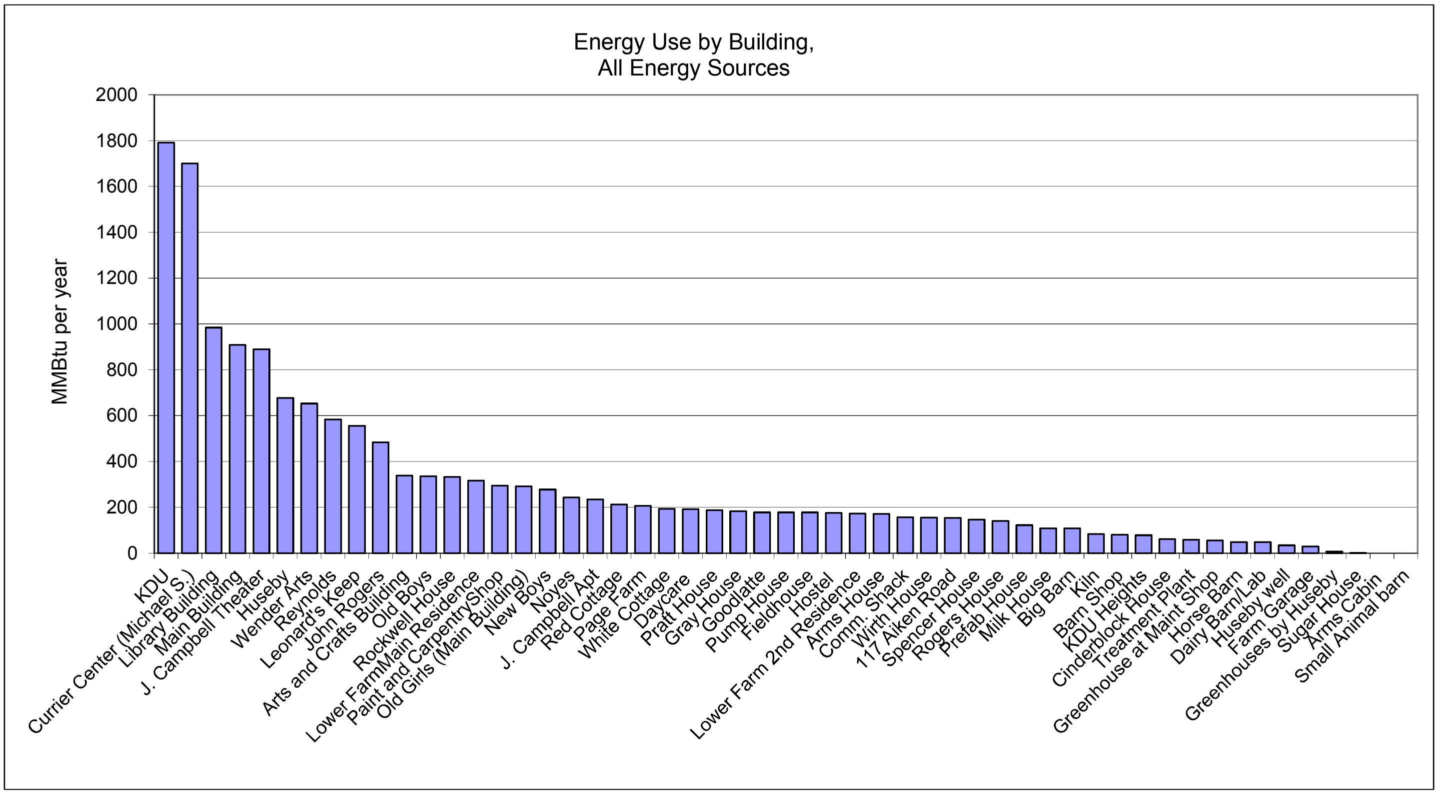


Figure 6.3.9 Putney School Building Energy Use by Building

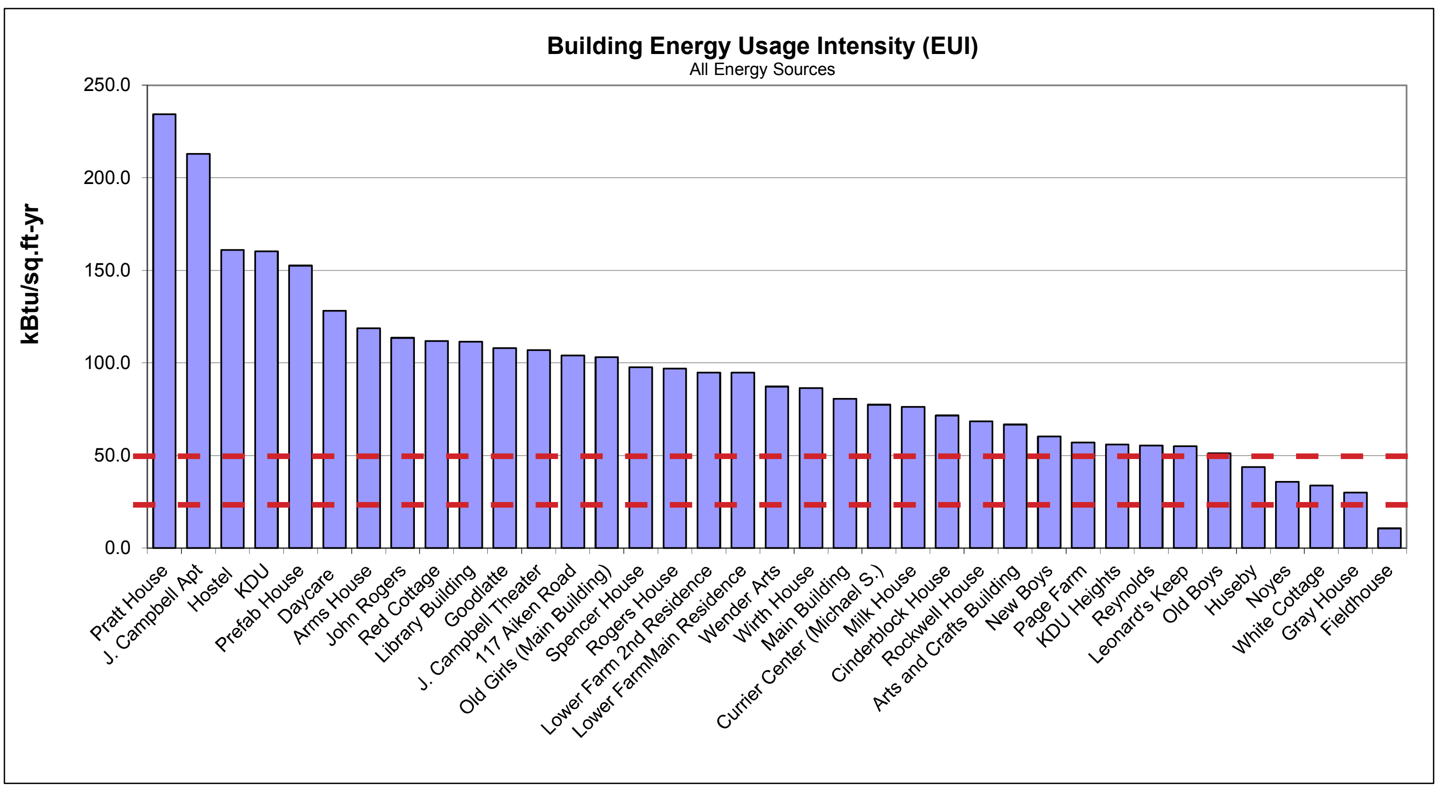


Figure 6.3.10 Putney School Building Energy Usage Intensity (EUI) by Building

on metering in Section 8.4). Cordwood consumption in staff housing also raises the EUI due to low efficiency (approximately 60%) of burning cordwood. Audits should be prioritized for all buildings over 100 kBtu/sf-yr. Some of the cost of audits as well as some retrofits can receive incentives from Efficiency Vermont. The red dotted lines between 25-50 kBtu/sf-yr represents the target range for Energy Use Intensity (EUI) that is desirable for net-zero buildings. As costs for solar photovoltaics (PV) decline, an economic optimum – balancing efficiency vs. the cost of PVs to support the remaining energy use – may raise this line higher. However, this needs to be balanced with building resiliency.

The KDU is, as expected, the highest energy user due to the inclusion of the commercial kitchen (see Section 8.2 for recommendations for reduction). Electricity usage is estimated since the power comes from the Main Building meter, which is a priority to submeter. Of the larger buildings, The Currier Center, the Main Building/Old Girls and Library are high users on an energy intensity basis.

Figure 6.3.9 and 6.3.10 give a partial roadmap of where to begin energy reduction on the School campus. Of course there will be other reasons to choose which buildings to work on first, such as program or deferred maintenance upgrades, but from an energy perspective, reducing the largest users first will produce more immediate energy and cost savings.

A third metric of energy use is how much heating energy each building uses per square foot per degree day, or Heating Energy Intensity. Figure 6.3.11 indicates which buildings would benefit most from building enclosure upgrades and from heating system efficiency improvements. One item to note is the wood-heated homes show up again with high heating energy use intensity because of the inefficiency of cord wood. The comparative metric used in figure 6.3.11 (Btu/sf-dday) refers to the number of BTUs of energy in the heating fuel that were consumed per square foot of floor space per heating degree day. Heating degree day is a measure of how cold the climate is, approximately 7,700 degree days at Putney. In general, a value lower than 5 Btu/sf-dday indicates an efficient building, 5-10 Btu/sf-dday a building where cost-effective improvements can be made, and greater than 10 indicates significant opportunities and very large savings potential. For net-zero ready buildings, the heating energy intensity is between 2 and 3 Btu/sf-dday for the Gray House dorm retrofit (pending submetering) and about 3 Btu/sf-dday for the Field House. It should be noted that many of the existing buildings share fuel tanks, so fuel use was approximated and should continue to be refined with submetering.

To more easily compare similar building types on campus, Figures 6.3.12, 6.3.13, and 6.3.14, break down total energy intensity by the 3 building use categories on campus: administration and academic buildings, faculty housing, and student dorms.

Figures 6.3.15, 6.3.16, and 6.3.17 indicate energy use by end use, including heat, hot water and "other" which, in the case of the KDU, includes cooking. There are 3 graphs for the various

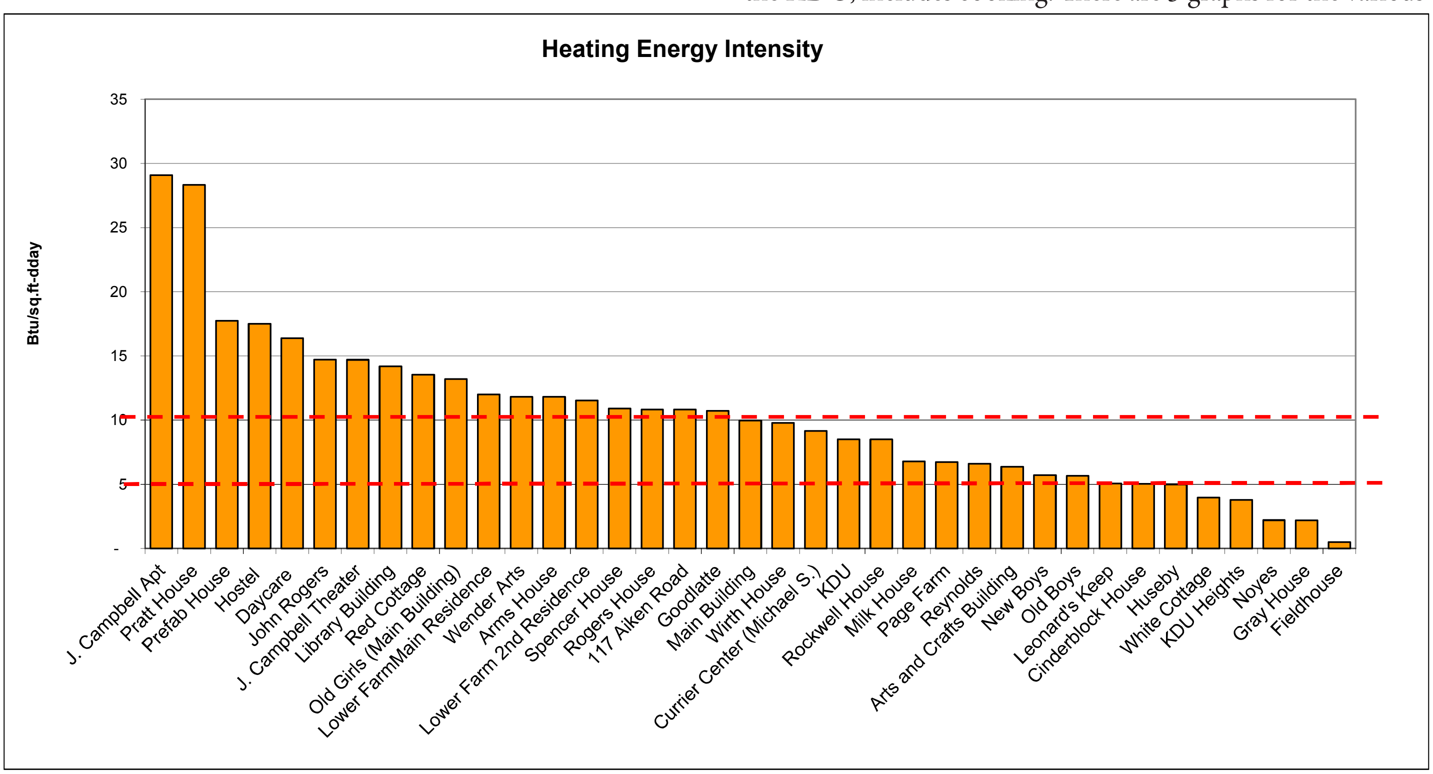


Figure 6.3.11 Putney School Building Heating Energy Intensity by Building

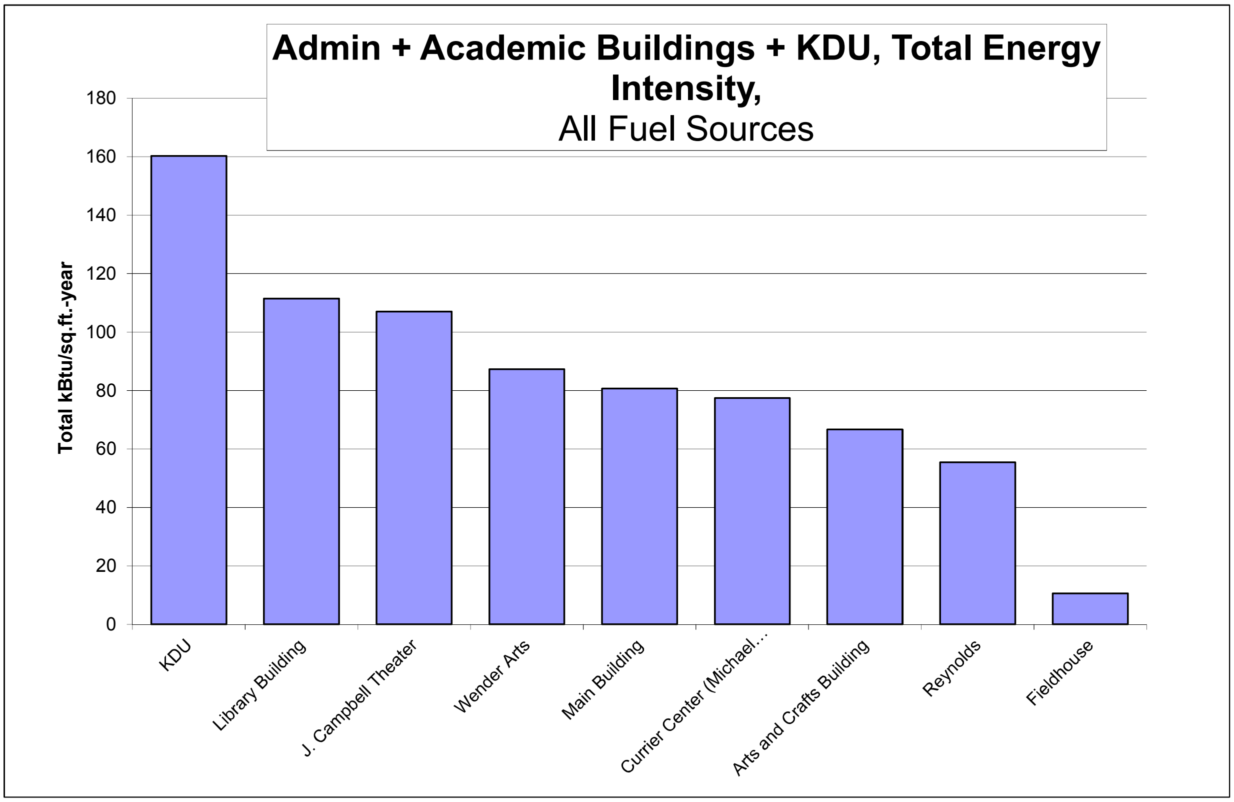


Figure 6.3.12 Administration, Academic, and KDU Energy Usage Intensity

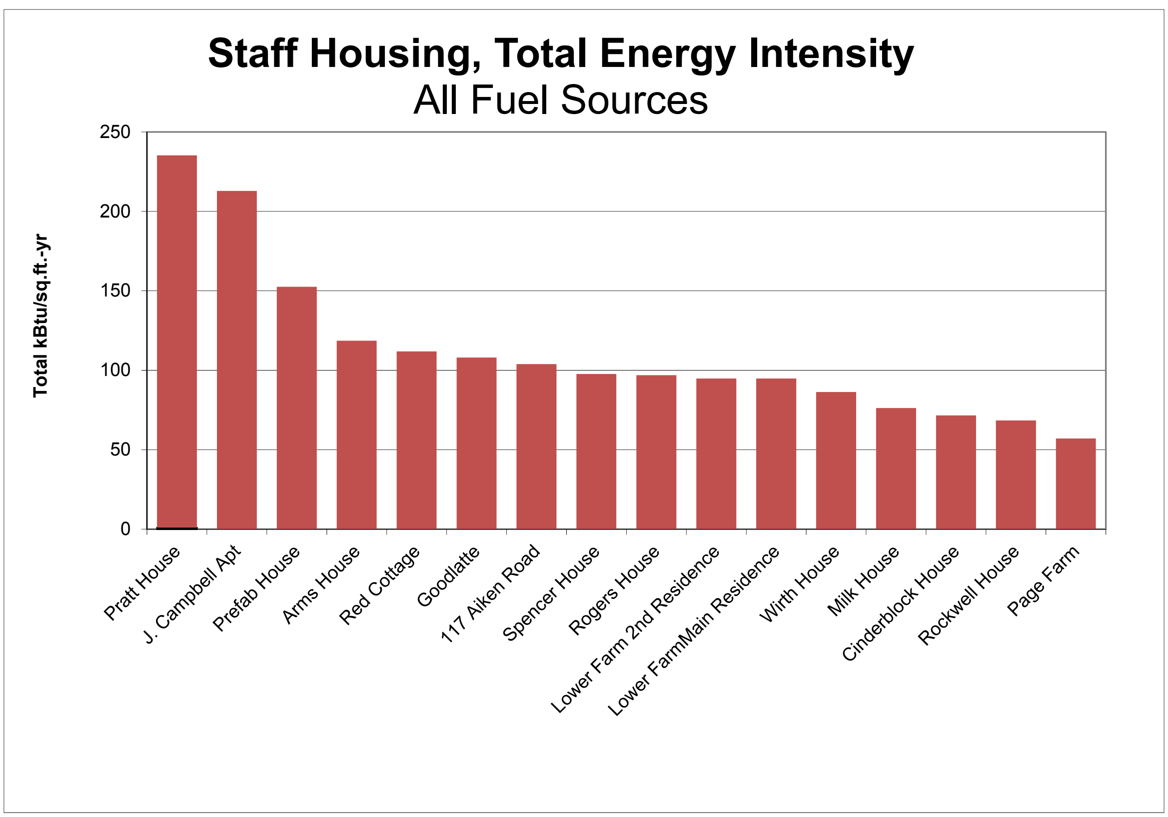


Figure 6.3.13 Staff Housing Energy Usage Intensity

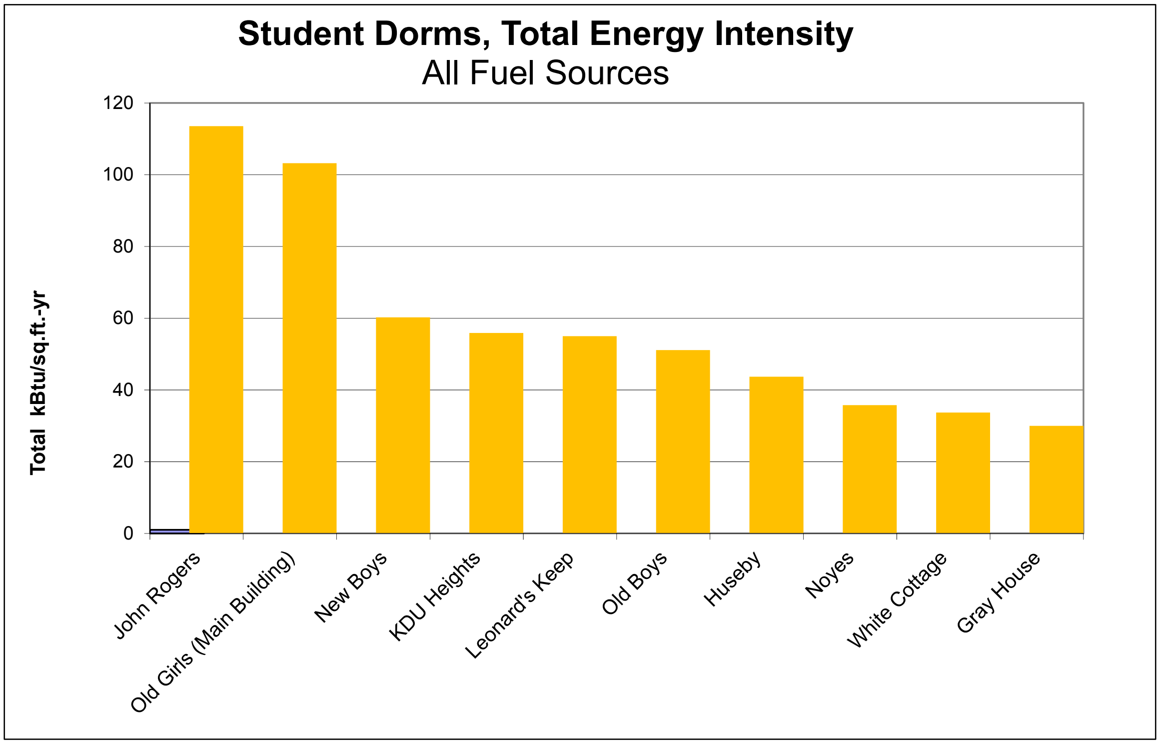


Figure 6.3.14 Student Housing Energy Usage Intensity

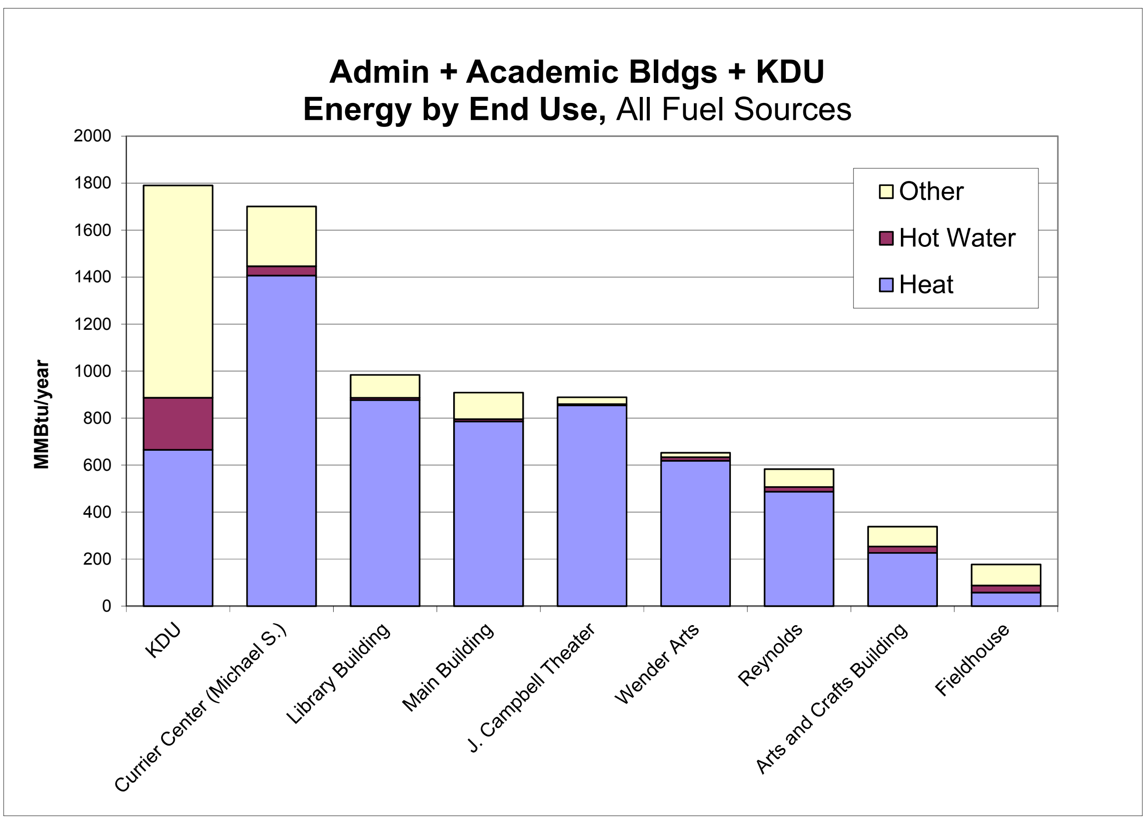


Figure 6.3.15 Administration, Academic, and KDU Energy by End Use

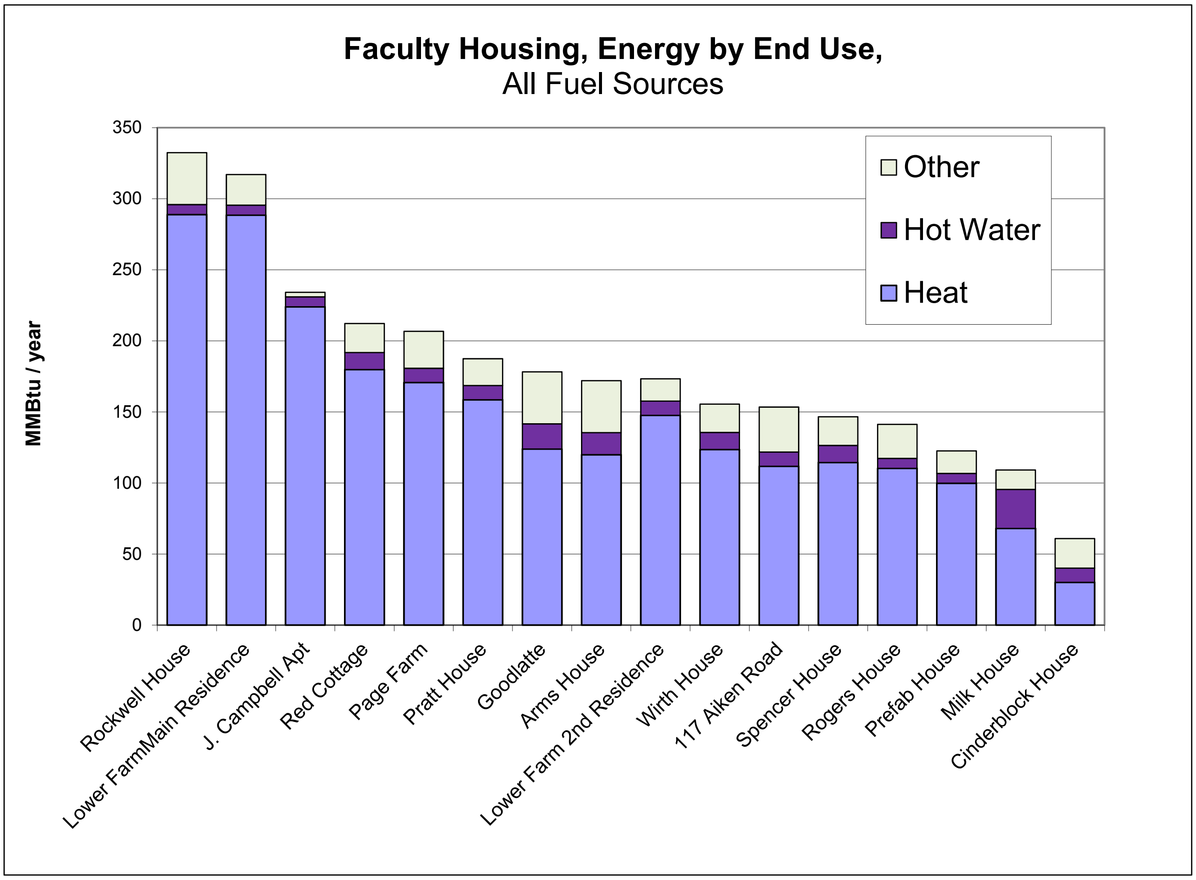


Figure 6.3.16 Faculty Housing Energy by End Use

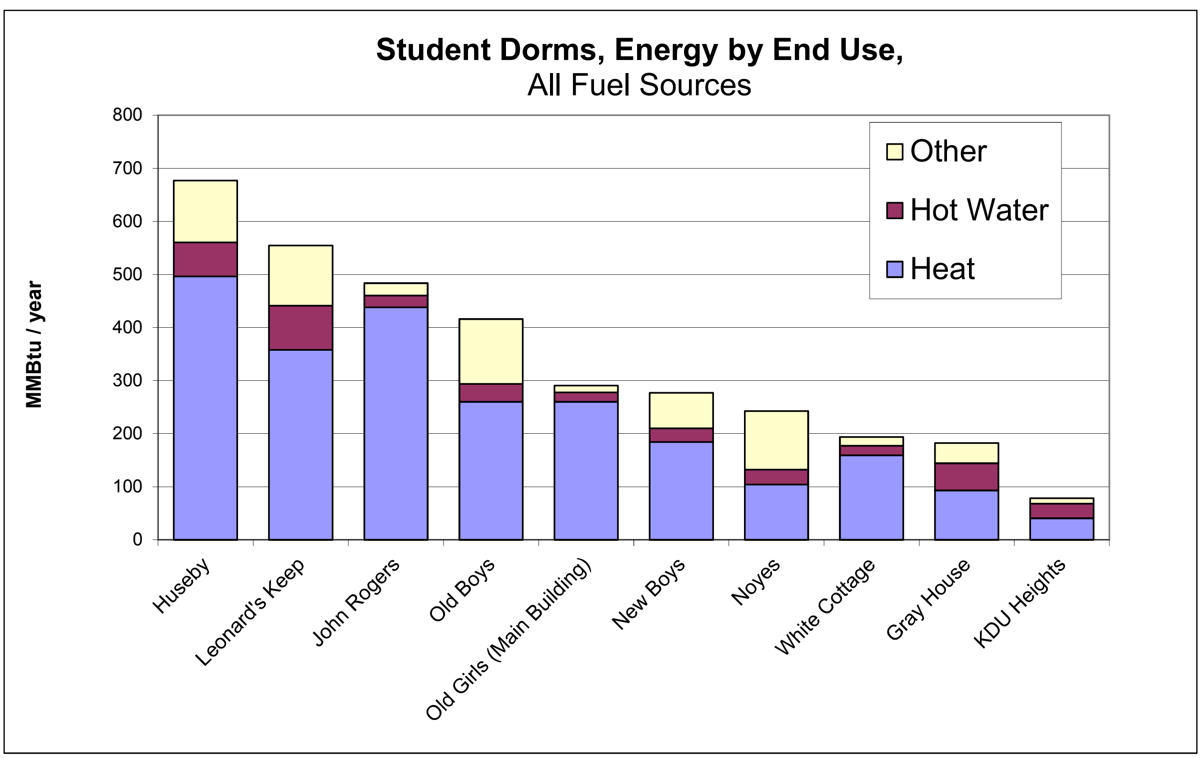


Figure 6.3.17 Student Dorms Energy by End Use

building types: administration and academic buildings, faculty housing, and student dorms. In all cases, heating is the single largest energy use. These estimated breakdowns are based on fuel usage records, equipment inventory and usage patterns. While not exact, they are sufficient to indicate how energy is being used to support the effort of prioritizing energy reduction recommendations for each building. By estimating the future heating loads reduction for each building, similar to that achieved at the Gray House dorm, the total heating loads were used to estimate how much PV would be needed to make The Putney School campus net-zero. Hot water heating loads were reduced by a factor of 2, in order to reflect an in-place efficiency of heat pump water heaters.

6.4 Energy Improvements

When moving toward a net-zero campus, what is the optimal level of energy efficiency that should be implemented in the buildings? For a "net-zero" campus (all electric with on-site or off-site renewable energy installations) all energy must be supplied from renewable sources which, as we will discuss later, means photovoltaics for The Putney School campus. Since 2011, Maclay Architects have been implementing the following net-zero envelope metrics below that create cost effective, durable, healthy and resilient buildings. This standard enables buildings in cold climates to withstand power outages and only lose a few degrees, maintain consistent interior temperature, and to create a healthy indoor environment that reduces condensation risk and mold growth.

From a strictly financial point of view, it makes sense to do all energy improvements that cost less than the cost of purchasing photovoltaics to provide the amount of energy that the improvements will save. For example, if it costs $500 to insulate a roof to R-60, and that saves enough energy to avoid installing $800 of PVs, we would put in that insulation, as the insulation is the lower cost option. However, if adding additional insulation to go from R-60 to R-80 will cost $300 more, and only avoids installing $200 of PVs, we would not add that extra insulation, because it would cost less to install the PVs. However, as the cost of PVs has declined rapidly, this approach results in buildings that are less resilient, durable, and healthy than is desirable. A "prescriptive path" to a both net-zero and resilient building will result in the following levels of efficiency:

- R-5 windows (minimum)
- R-20 below-grade walls and slabs
- R-40 above-grade walls
- R-60 roofs
- Air leakage rates of less than 0.05 cfm 50/sf of building gross surface area. Air leakage rates are often expressed in terms of allowable cubic feet per minute of air leakage per square foot of above-ground building surface, at a given test pressure (usually 50 Pascals or 50 Pa.) A tested leakage rate of less than 0.05 cfm50/sf is required for deep energy retrofits. A rate of 0.05 is desirable but can be difficult to achieve on existing building envelopes. We would expect the first projects accomplished to reach 0.1 and subsequent projects to approach the 0.05 level (the Field House achieved 0.048 cfm50/sf of surface area). The air leakage and insulation goals may be adjusted for particular buildings, such as the Main Building, where it may be more costly to achieve a given level of insulation than in other simpler, less historic buildings.

Mechanical ventilation is required in all buildings that will be rehabilitated, both from an air quality point of view and to meet current building codes. Heat recovery ventilation (HRV) systems, that are now very common, allow the recapturing of up to 80% or even 90% of the heat in outgoing winter exhaust and transfer of that heat into the incoming fresh air, without mixing of outgoing and incoming air streams. High efficiency HRV's are assumed in the renovation of every building on The Putney School campus.

In the 2011 Master Plan, biomass[2] was looked at as a viable option for heating buildings. We no longer believe that burning wood is an appropriate net-zero technology. The increasing urgency of climate disruption pushes us toward emitting as little CO2 as possible, and burning wood pellets or cordwood emits at least as much CO2 as burning fossil fuels. Wood burning advocates rely on re-sequestration of the carbon dioxide combustion emissions by growing trees to offset those emissions, but that re-sequestration can take decades to occur, while critical climate change tipping points could be as little as a decade or less away. If firewood can be harvested in a way that actually increases the net rate of carbon sequestration of the managed forest (sequestration rate minus combustion emissions greater than zero in the first year or two or three), this would seem to be a very responsible, if small scale, approach. If this is possible, perhaps The Putney School

2 There are many different biomass scenarios, some of which may be considered carbon neutral and some may not. Because sustainable forestry actually increases forest carbon sequestration, biomass (chips or pellets or cordwood) from sustainably harvested wood can be considered carbon-neutral (or even carbon-positive.) Biomass from waste wood products that would otherwise rot can be considered carbon neutral because the carbon released by rotting is similar to that released by burning. However, biomass from wood cut in an unsustainable manner should not be considered carbon neutral, because this process would cause a net increase of carbon in the atmosphere. The issue of fossil fuels used for cutting, preparing and delivering biomass fuels further complicates the matter.

can manage its firewood harvesting accordingly for the needs of the KDU wood-fired oven and 4 faculty houses using cord wood.

There are many questions as to what the best balance of forest resource utilization and forest ecosystem conservation will be in the future. If forests in the northeast become stressed, as some have suggested they will, based on large scale biomass utilization, it may be advantageous to develop a plan which allows for the conservation of more forest. Additionally, we believe that the forest resource can be used responsibly, and that the best way to ensure that is to use the minimum amount of biomass, which eases the problem of harvesting sustainably. Biomass should be envisioned more as a bridge to an all-solar future than an end in itself, in which case there is a benefit to preparing buildings for solar as the only source of energy when renovated.

With an increase in the availability of cold climate heat pumps, and the reduction in price for photovoltaic panels, there is a decreasing need to bridge to all solar buildings. Due to an uncertain energy future, we now strongly recommend retrofitting all buildings to the same standard, the "net-zero" standard noted above. Though this decision will cost more today, it will save The Putney School a large amount of money into the future.

Air-to-water heat pumps that produce 150F hot water are available in other parts of the world and are likely to come here; they may be ready for general use in as soon as 5 years. These will be a direct swap-out for an existing boiler, but may require, depending on the building and distribution system, some level of load reduction or distribution modification to use water that is not quite as hot as that produced by a fossil boiler. Hydronic distribution will allow much finer grained and better controlled zoning, compared to existing ASHP systems that can lose efficiency as zone loads get as small as they are in net-zero ready buildings with many small rooms. These newer heat pumps will also use CO_2 as the refrigerant, which has a global warming potential (GWP) of one, as compared to hundreds or thousands for conventional refrigerants.

In general, the recommended net-zero level of building enclosure improvements will result in building energy usage intensity between 25-50 kBtu/sf–yr. Some of the older and more articulated buildings and those with historic constraints, such as the Main Building, will cost more per unit area for energy improvements, so the higher end of this range of energy use (or even higher) may be appropriate for those buildings. Simpler and less precious facades can be changed at a lower cost, so deeper energy retrofits are more cost effective and would target the lower end of the EUI range. As a reference point, the Field House uses only 9.6 kBtu/sf-yr (32 kWh/sm-yr) and the Gray House dorm now uses 34 kBtu/sf-yr. Note however that occupancy of the Field House is relatively low, temperatures are kept relatively low inside since it is primarily an exercise area, and the square footage is quite large, so energy use per square foot in this building is lower than if this building were occupied as a dorm or classroom. The higher EUI for the Gray House dorm illustrates the energy intensity of the increased occupancy, ventilation and hot water requirements for a dorm. This may also be able to be modified once submetering of systems in the building has been examined and specific system use information is available. An EGauge was installed in December 2018 by students, so data as soon as spring 2019 could provide insight into the building energy end uses.

6.5 Renewable Energy Production

The second part of the net-zero strategy is the implementation of renewable energy. The choices for net-zero using all electricity from renewable energy are photovoltaics (PV), wind, or small-scale hydro. Since hydro resources are not available on The Putney School campus and the wind resources on this site make it less cost-effective than solar PV, all energy would have to be supplied from PV for this campus.

6.5.1 Solar/Photovoltaics (PV)

Photovoltaics are the "gold standard" of renewable electricity. The environmental and visual impact of these systems are as low as it gets for renewable electricity generation systems. The technology and delivery infrastructure are mature and the systems should require very little maintenance . PVs can be installed incrementally, as funding is available. PVs do take significant outdoor space, but they can be located at multiple locations, as well as elsewhere in Green Mountain Power territory with the output allocated to The Putney School accounts, to reduce the visual impact of any given array as well as meeting the capacity requirements for the closest electrical connection. The current 446 kW array at lower farm take up approximately 2.7 acres, and an additional 700 kW system would be needed to offset the future net-zero campus loads (approximately an additional 3.8 acres).

Pros of Photovoltaics:

- Only completely renewable solar energy is used
- Requires no non-renewable input for fuel transport
- Very little maintenance is required, and none on a regular basis
- May be located anywhere on campus that is reasonably close to power lines, preferably three-phase lines
- Cost has dropped significantly from 2011
- Power Purchase Agreements are possible that would not require upfront capital cost from The Putney School

Cons of Photovoltaics:

- Green Mountain Power infrastructure in Putney is currently a grid constrained area and will not allow additional solar installation (See Section 8.3 for recommended solutions)
- Large area of land required for PV installation: about 5.5 acres would be required for a one MW (megawatt, or 1000 kW) system. About 1.1 MW (6 acres) of installed would be required for electric loads for the all net-zero campus, which includes the current 446 kW array at lower farm
- Changes in net metering policy is ongoing, so the future payback to the School will likely fluctuate

6.5.2 What About Wind Power?

While wind energy is available at a lower cost per kWh generated for large turbines – 1-5-megawatt (MW) capacity – there is not enough wind at The Putney School for these very large systems, and siting them elsewhere is contentious. The Vermont Group Net Metering laws do allow large scale installations anywhere on the GMP utility grid that serves the School to be metered directly to the School. Therefore, developments of community-based wind, wind installations funded by the users of the energy, as opposed to by a third party or electric utility, should be monitored over the years to come, but at present this should not provide the basis for a future energy plan. In the future, community wind may become a strong alternative, and the magnitude of the electrical load at The Putney School may still be large enough at that time to make sense in relation to such a project.

6.5.3 Hot Water

Heating hot water renewably requires it to be electrically powered or solar thermal with electric backup. Where there are moderate to large hot water year-round loads, solar thermal hot water can be the best approach. For moderate year-round loads and for loads that are only during the school year, heat pump water heaters can be the best approach. For very low loads, electric resistance heating is the most cost-effective approach.

Low Hot Water Use Buildings

For those with very small hot water loads, such as the administration building, an electric hot water heater would make the most sense. If hot water usage points are distributed over a distance, instantaneous small electric water heaters located at the point of use can be the best approach. If the water is hard, these may be small tank-type water heaters, as instantaneous heaters would require softening or frequent flushing of the water heater with acid to remove scale. If hot water loads are centralized, or if water is somewhat hard, a very well insulated larger resistance tank-type electric water heater can be best. Well-insulated piping is critical to reducing loads on all hot water systems.

Moderate Hot Water Usage and Larger Hot Water Loads That Are Not Year-Round

Heat pump hot water heaters (HPWH) have become effective and common enough to use this approach for these buildings. PVs can offset electricity usage for these. HPWHs are particularly efficient where there is a source of unused heat, such as a basement with heat from a boiler or a solar oriented building where there is excess heat during sunny periods. Since these heat pumps draw heat from the surrounding air to heat the water, if that heat from the surroundings has to be supplied with an air-to-air heat pump, this reduction in efficiency needs to be considered in order to be sure there is enough gain over electric resistance water heating.

Additionally, heat pump water heaters have a limited upper range of operation – about 120F, although the technology is improving in this regard. For the present, however, for loads that require 140F water, such as a commercial kitchen, a second tank with electric resistance heating is recommended. That tank can be fed with water heated to 120F by the heat pump, and set to boost temperature to 140F. Additionally, the second tank, in a building that does not require 140F water, can have a timer to periodically increase temperature to 140F to reduce likelihood of legionella growing in the water. Upcoming technology for heat pump water heaters uses a CO2 refrigerant, which may be capable of achieving higher water temperatures; once that product has matured it should be considered. If the loads are distant from the tanks, a circulating system is required, which can feed back into the heat pump water heater first, so that piping loop losses are made up by the heat pump, rather than the electric resistance tank.

For faculty homes with moderate usage, heat pump water heaters are recommended, unless the load is quite low.

Year-Round Large Hot Water Loads

This is the one place that solar thermal hot water still can have a place. Drain-back systems that are closed loop are the only recommended system type, as the drain-back feature empties the collectors when they are not in use, thus saving the antifreeze in the system for over-temperature situations that degrade the antifreeze, causing lower pH and associated pipe corrosion or excess maintenance. These systems have low maintenance requirements. If the KDU were operated year-round, that would be a candidate, or a dorm that is in use all year, such as was done for Gray House dorm. Disadvantages of solar thermal hot water include:

- Must be located on the building where hot water is needed
- Requires periodic maintenance (mostly checking of pH in antifreeze)
- Location must have solar exposure directly on the building
- Systems require good design to be durable and functional

Heat Recovery Hot Water

For the KDU, recovering heat from the walk-in refrigeration compressors via a “de-superheater” can be a very cost-effective hot water preheat. These systems utilize the high temperature of the hot refrigerant gas leaving the compressor to pre-heat hot water. When the compressors are upgraded for the walk-ins, this should be explored.

The Future for Hot Water

As PV costs continue to go down, and outdoor-air-source heat pumps becomes more robust and more reliable, heat pump water heaters (HP WHs) will become more widely applicable. We look forward to outdoor-air-source heat pumps that use CO2 for refrigerant – present heat pump refrigerants have global warming potentials near 1,000 times that of carbon dioxide) and can make 140-150F water even in cold weather. Prototypes are operating here and in Europe, but they are not ready yet here for this application.

6.6 Predicted Future Energy Usage

Based on the assumptions that first, changes will be made to The Putney School buildings in accordance with the standards described in Section 6.4 and second, PV will be installed to offset the whole campus energy use, The Putney School will see a dramatic reduction in its non-renewable energy use. 2012 and 2018 energy usage are compared to a net-zero energy campus usage in table 6.6.1. About 150,000 kWh of the electricity is due to including farm and support buildings, in order to have a more complete view of building campus usage overall.

All Buildings, Energy Usage						
	Grid Electricity - kWh	PV Electricity kWh	Oil - gallons	Propane - gallons	Wood pellets - tons	Fire Wood - Cords
2012	780,000	-	66,000	16,000	-	15
2018	408,989	580,500	67,400	22,475	63	16
Net Zero		1,400,000				16

Table 6.6.1 All Buildings, Energy Usage

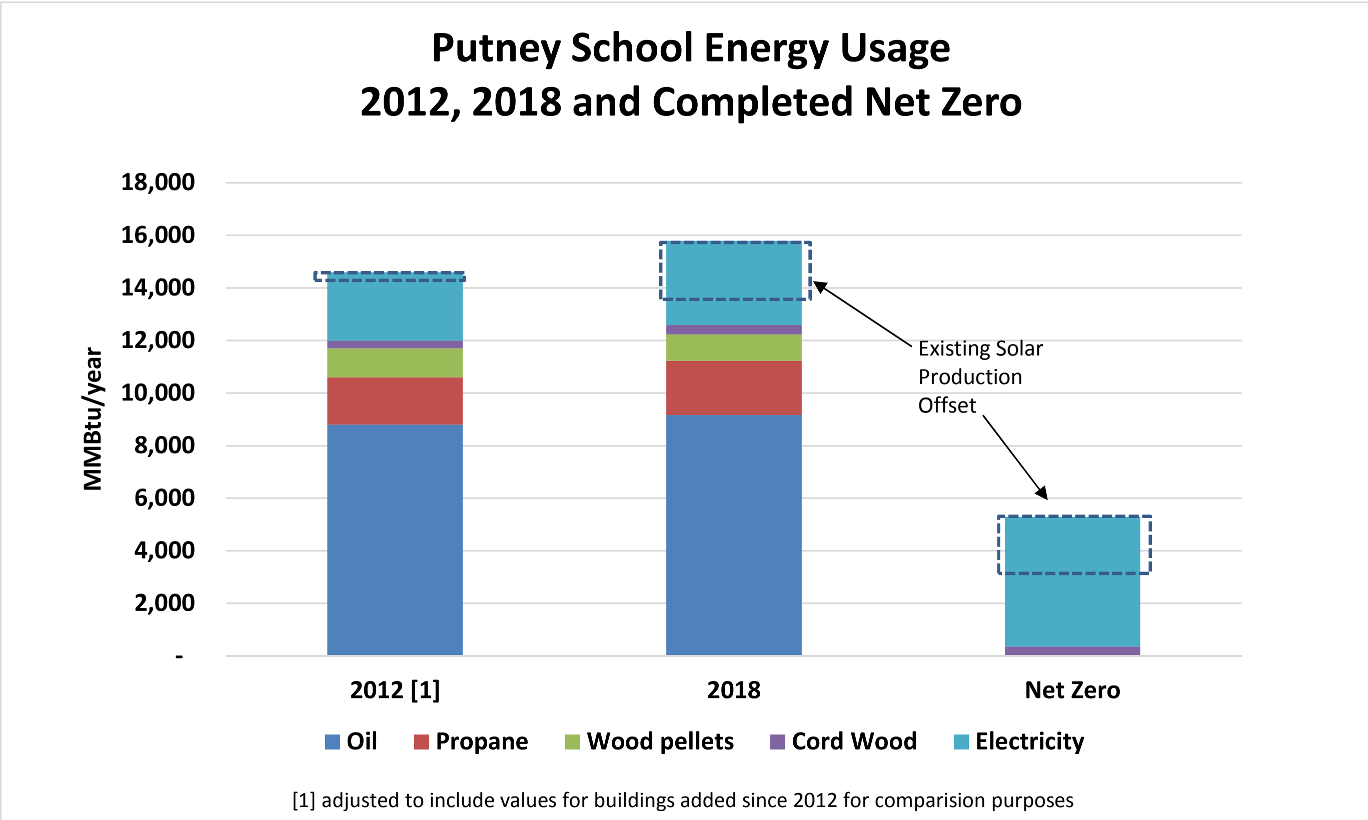


Figure 6.6.1 Total Campus Energy Use Comparison and Future Net-zero Campus

6.7 Carbon Dioxide Equivalent (CO2e) Emissions

2018 carbon dioxide equivalent[3] emissions are compared to a net-zero energy campus in Table 6.7.1 and Figure 6.7.1. This assumes the 16 cords of wood used in 2018 will continue to be burned.

Table 6.7.1 compares the energy usage and CO2e emissions for the campus as it exists today and for the future net-zero campus strategy. It can be seen that the energy use and CO2e are significantly reduced under the net-zero, all-PV strategy.

3 The "e" in CO2e refers in this case to the combustion emissions of CO2 plus the equivalent GWP of the methane leakage associated with natural gas that is used to generate almost half of the electricity used in New England. While there are other gases emitted with GWPs, this is the only one included here, as it raises the CO2e of grid electricity by about 50%.

Figure 6.7.2 compares the existing campus that has 62% of their electricity use from solar photovoltaics and the remaining from the grid with three other scenarios. Grid electricity has a higher CO2e, 1.2 lbs/kWh versus 0.064 kWh, due to the transmission losses and fuel composition of the grid from natural gas, coal, biomass, etc. If the campus were brought up to net-zero ready standards, but did not have solar to offset their use, the CO2e would be 522 tons/year, which is still a dramatic reduction from the existing campus CO2e of 1,500 tons/year. The ultimate goal of net-zero building renovations with the electricity use offset by solar would result in a CO2e of 27 tons/year for the entire campus.

CO2e Emissions, All Buildings, pounds per year							
	Grid Electricity - kWh	PV Electricity kWh	Oil - gallons	Propane - gallons	Wood pellets - tons	Fire Wood - Cords	Total
2018	500,000	37,000	2,000,000	400,000	200,000	69,000	3,206,000
Net Zero	-	90,000				69,000	159,000
CO2e lbs/unit	1.2	0.064	29	18	3,123	4,294	

Table 6.7.1 CO2e Emissions, All Buildings, Pounds Per Year

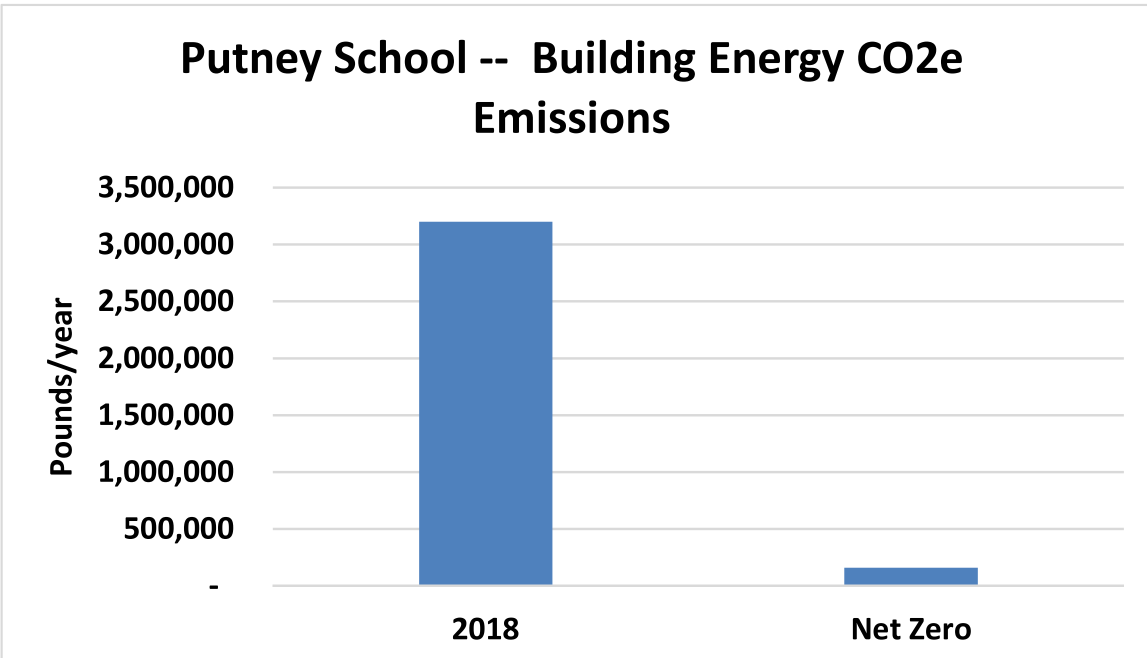


Figure 6.7.1 Total Pounds of CO2e Per Year Comparison

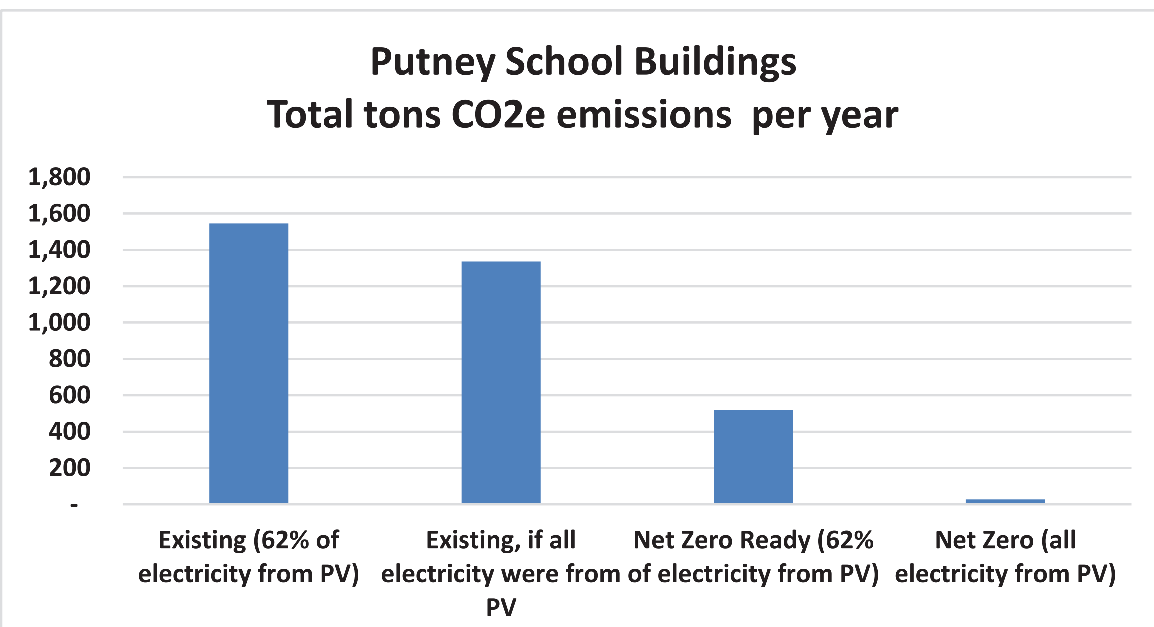


Figure 6.7.2 Various Emission Scenarios Depending on Grid Electricity Versus PV Electricity

7. Completed Projects

From 2011-2017, The Putney School has been proactive in acquiring land, buildings, and renovating structures. This section documents these accomplishments to date of projects over $100,000. Each of these projects has work that falls into the 4 categories within the cost estimate – *Energy Improvements, Deferred Maintenance, Building Health, and Additions/Acquisitions.*

Energy Improvements includes the work beyond maintenance to get each building to the net-zero energy standards of envelope, for example, using air source heat pumps and additional insulation.

Deferred Maintenance is any aspect of the building renovation that would be required regardless of the improvement to the net-zero standard, such as siding, roof repair, and interior painting.

Building Health is separated from energy improvements because this should occur with any building to improve the indoor air quality and provide a healthy space for all occupants. This category includes installing energy recovery ventilation systems for each heated building.

Additions/Acquisitions are added program elements beyond the existing campus examined in 2011. The School is constantly examining the benefits of purchasing properties for faculty housing, open space for farming, etc. which will continue to evolve and is not something that can be predicted today, so this category will document what has occurred retroactively versus predicting changes needed in the existing building stock.

Each of the costs for the projects listed in this section are broken out into the 4 categories outlined above in Table 7.0. See the Appendix Section 9.5.1 for documentation available for some of these completed projects.

Description	Date	Total	Net Zero Ready upgrades	Deferred Maintenance	Building Health	Remodel/ Add	Acquisition	New Buildings
KDU Dorm	11/30/2011	$ 110,118				$ 110,118		
Pellet Stove System - Main Building	11/30/2011	$ 195,142	$ 195,142					
Pratt House (Houghton Brook Site)	3/29/2012	$ 170,260					$ 170,260	
KDU Sprinkler System requiring electrical	4/14/2012	$ 112,238				$ 112,238		
Water System	12/31/2012	$ 927,049		$ 927,049				
Playing Fields	10/31/2013	$ 244,313		$ 244,313				
Goodlatte House - build from ground up, double sf	12/31/2013	$ 382,383	$ 76,477	$ 152,953		$ 152,953		
Library Building Remodel	1/31/2014	$ 413,826	$ 82,765	$ 206,913		$ 124,148		
KDU Remodel	6/30/2014	$ 165,676		$ 165,676				
KDU Basement and back sheds	4/5/2015	$ 317,829	$ 31,783	$ 63,566		$ 222,480		
Prework for New Dorms	6/30/2015	$ 208,346						$ 208,346
Aiken Road House	11/30/2015	$ 245,671					$ 245,671	
Reynolds Renovations	12/31/2015	$ 268,404		$ 187,883		$ 80,521		
Spencer House	6/9/2017	$ 587,966					$ 587,966	
Gray House Renovation	6/30/2017	$ 900,000	$ 235,400	$ 608,544	$ 56,056			
Totals		**$ 5,249,221**	**$ 621,567**	**$ 2,556,897**	**$ 56,056**	**$ 802,458**	**$ 1,003,897**	**$ 208,346**

Table 7.0 Completed Projects 2011-2017

7.1 KDU

Over the span of 2011-2015 the following improvements to the KDU were undertaken. These encompass minimal net-zero ready upgrades, with the main work within deferred maintenance and remodel categories:

- Refurbished the heating elements
- Removed underutilized storage areas
- Painted
- Upgraded serving line
- Upgraded insulation in the dining room
- Replaced rotting wood
- New floor
- New lighting
- New overhead fans
- Ungraded sprinkler system and electrical work
- New dorm rooms on the second floor

7.2 Pellet Stove System – Main Building

The boiler in the Main Building needed to be replaced in 2011, so a Froling pellet stove was installed to supply the majority of the heating need to the building. In 2018 only 3% of the heat load for the building came from oil; the rest was offset with wood pellets. This was installed with the understanding that a district biomass heating system could be a future heating potential for the campus, and when the Main Building was insulated to net-zero ready standards, excess heat from the boiler could be piped to an adjacent building. Since 2011, the campus strategy is to become an all-electric campus. Considering the rate of renovations on the campus, the pellet boiler will be used as a transition fuel until the Main Building is renovated, which is likely not a top priority given its complexity and historic nature; it may come toward the end of the pellet boiler lifespan.

7.3 Pratt House Acquisition

This house was purchased with the future insight of owning the land across Houghton Brook from the main campus. This strategic purchase proved prudent during the new dorm conceptual design when it was identified as the site for a future new dorm. The existing house will be used as faculty housing until the new dorm project is under construction, at which time it will be demolished. It is located on Houghton Brook Road across from the main campus drive and is approximately 800 sf.

7.4 Water System

The campus water system had significant upgrades performed in 2012.

7.5 Playing Fields

The playing fields were improved and re-sodded to support the School's mission for activity and connection between students.

7.6 Goodlatte House

This house underwent a complete rebuild and expansion from 800 sf to 1,800 sf. Exterior insulation was added to improve the envelope, while the upstairs was dormered for additional living space, a new mudroom/entrance and 2-car garage were built to provide much needed amenities to the property. The existing wood stove remains and will be replaced with heat pumps and adding monitoring as the final steps to make the house net-zero.

7.7 Library Building Remodel

This project provided the following improvements to the library that fall within the net-zero ready upgrades, deferred maintenance and remodel categories:

- Moisture seals installed in the flooring
- Upgraded the heat distribution system
- Replaced the oil furnace with a propane unit
- Painted
- Redirected the storm water runoff
- Added curtain drains around the perimeter
- New furniture
- New lighting
- Signage
- New carpet
- Projector and two automated screens installed
- Reconfigured the quiet room to accommodate the computer lab, thus integrating technology and library

sciences more directly and freeing up space for an additional classroom

7.8 New Dorm Pre-work

The conceptual design and schematic design phases were completed for the new dorms project in 2015-2016. This also included significant investigation into the campus infrastructure in order to supply water and wastewater allocations to the new dorm beds and expanded faculty housing. Additional information on this project is in Section 5.2 and in the Appendix.

7.9 Aiken Road House

This house was purchased as a residence for a faculty family. It is located at 117 Aiken Road, is 1,500 sf, and has 3 bedrooms and 2 baths, on 3.01 acres.

7.10 Reynolds Renovations

The Reynolds building renovation project included deferred maintenance and needed program changes. The science labs underwent modernization, expansion, and some envelope work. The upgraded classrooms were refitted with modern equipment, furnishings, and received paint, new ceilings, lights, flooring, along with updated electrical and plumbing work.

7.11 Spencer House/Paige Field

This property consists of 86.87 acres of open fields, woodland (with extensive ski trails used by the School) and a farm house known as Spencer House that has been rented by The Putney School for some time prior to the purchase. This land is located directly across Houghton Brook from the main campus drive and provides prominent open space and recreational and farming opportunities for the School, as well as securing the longtime rented faculty house as a School asset.

7.12 Gray House Dorm Renovation

The Gray House dorm was chosen for a full energy upgrade in the spring of 2016. In partnership with DEW/MacMillin, Maclay Architects and Energy Balance, The Putney School forged a phased approach to upgrade the envelope and heating/cooling system and install a new full building ventilation system.

The building had extensive deferred maintenance and a heating system that needed replacement, so was a prime candidate for a deep energy retrofit. This project was phased over 2 summers to avoid construction work during the School year when it is occupied by students. By focusing on upgrading the envelope solely from the exterior, the interior had minor changes required. The faculty were able to occupy their apartments during summer construction for the majority of the renovation.

The retrofit to net-zero ready standards (R60 roof, R40 walls, R20 below grade, R5 windows, and air sealing of <0.10 cfm50/sf above grade shell) brought the EUI from an average of 74 kBtu/sf-yr to 34 kBtu/sf-yr, a 56% reduction overall. This includes the addition of energy recovery ventilation throughout and summer cooling capabilities. The estimated heating energy use is a 79% reduction, which will be confirmed with the EGauge data in 2020. This dorm has become one of the most loved on campus and is

Figure 7.12.1 Gray House Dorm, West Elevation Before the Renovation

Figure 7.12.2 Gray House Dorm, West Elevation After the Renovation

a model for showcasing the School's commitment to creating a net-zero campus.

The Gray House dorm renovation has received multiple awards including the 2019 Efficiency Vermont Honor Award for Best of the Best in Commercial Building Design & Construction and the 2018 Vermont's Going Greener Award from Vermont Green Building Network based on actual energy performance and other sustainable features.

7.13 Lower Farm 446 kW PV System

The large solar array near lower farm was installed in July 2015 by Namaste Solar, who holds the Power Purchase Agreement (PPA). The agreement with The Putney School is to provide fixed rates for 5 years, at which point the terms of

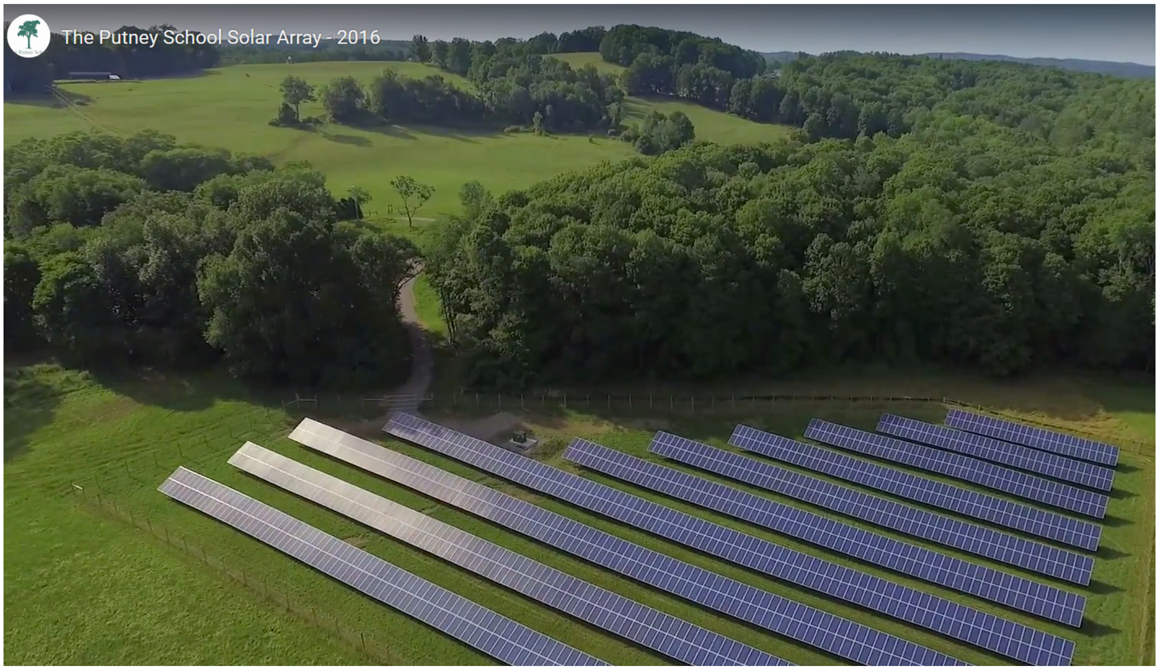


Figure 7.13.1 Photo of the Lower Farm Array

the agreement could be renegotiated. Using a PPA agreement enabled The Putney School to offset 62% of their electricity use with renewable sources without a capital investment. The array was sited close to existing 3-phase power, and on a relatively flat open field.

7.14 Student Project Accomplishments

Since 2011, students have developed a summary Master Plan for distribution to the student body highlighting how it impacts them the most. In 2018, 2 students undertook to install submetering in the Gray House dorm, the Heights dorm, and Reynolds, to inform building energy use. They will continue to monitor and, with the guidance from Dawn Zweig and Andy Shapiro, analyze the data to better inform the building energy uses. This more precise energy monitoring will become an important part of the energy awareness of the campus as the student GreenGuard program continues to educate and encourage more energy conservation and sustainable cultural norms in general.

UNDERSTANDING THE GRAPH

Izzy Snyder and Jules Fischer-White,
Fall Project Week 2018

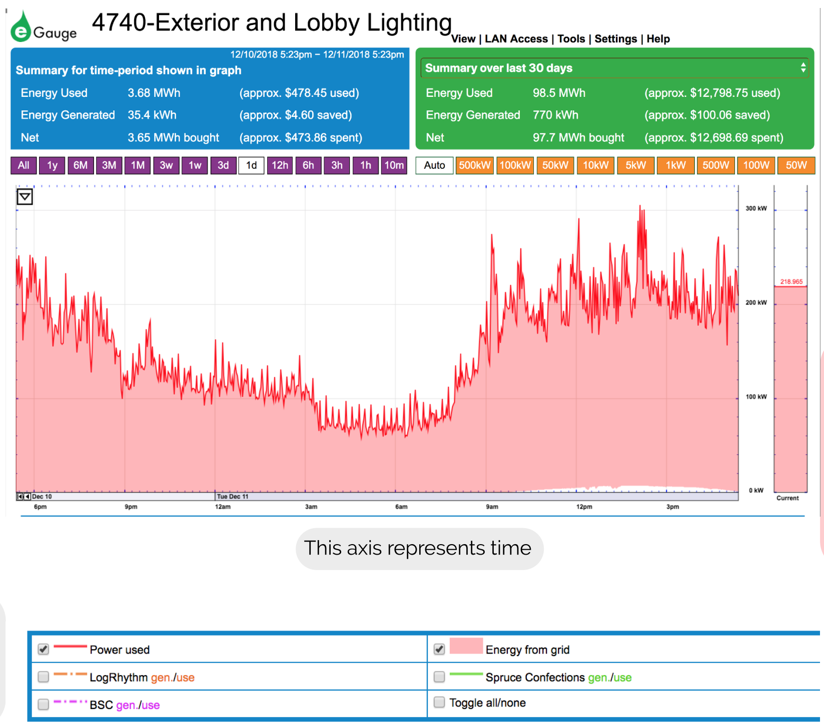
The Egauge system creates a graph of electricity use that updates in real time. You can view the total energy use of a building or of different sub-metered areas. You can also change the time scale to see data over the span of a full month or year, or for time intervals as short as 10 minutes.

The blue box shows energy use Information for the time frame displayed on the graph.

The purple buttons allow you to change the time scale so you can see shorter or longer term data.

The graph shows the rate of electricity use (power).

Use the check-boxes at the bottom to choose which parts of the building you want to display.



The green box shows Energy and power Information for last 30 days.

The orange buttons let you change the units of power. You should keep this on Auto.

This bar on the side shows the current. The current is proportional to the rate of energy use, so when the current goes up, it means we are using more energy.

Figure 7.14.1 Green Gaurd EGauge Student Information and Example of the Data Available

8. Prioritization and Implementation Plan

A priority for The Putney School in the 2018 updating of the Master Plan was to make the Plan accessible to students, faculty, and staff, and to make it a living document that provides guidelines and tools to facilitate the continual adaptation required to move the campus in the desired direction to meet the outlined goals in Section 1.0.

8.1 Recommended Energy Master Plan Implementation Process

The Putney School has taken many great steps toward implementing the contents of the 2011 Master Plan. Accomplishments range in size and scope, but each is moving the School toward its goal of a net-zero energy campus. These projects are outlined in Section 7.0 and should continue to be highlighted in the School's outreach to alumni and potential donors.

In recognition of the above factors, we recommend that The Putney School take the following actions laid out in Section 8.1.1 through 8.1.3.

8.1.1 Net-Zero Building Energy Conservation Action Plan

- Continue to track energy consumption annually by building
  - Install metering according to metering plan (Section 8.4)
  - Track data in SchoolDude
- Tabulate and review data annually to identify any outliers and investigate as necessary
  - Develop an expanded annual monitoring protocol of data collected. This will become incredibly important as changes are made on campus to track the effectiveness of each of the measures that are pursued and to tell the success stories to prospective students, alumni, and potential donors.
- Implement net-zero ready standards on all buildings
  - Perform micro-load retrofits whenever a building (or portion of building) is worked on in any capacity. The next buildings to target for a micro-load building enclosure retrofit should be based on needed upgrades for maintenance or program reasons, level of complexity, and funds available.
  - Use net-zero ready standards indicated in this Master Plan on all building improvements; review standards every 5 years and update as appropriate. Use Prioritization Matrix (Section 8.2) process for assessing/rating all buildings based on energy reduction potential, cost to carbon savings, maintenance, program needs, health, and occupant satisfaction for all buildings.
- Implement key priority projects annually as identified with Efficiency Vermont
  - KDU kitchen load reduction

- Decarbonizing staff housing
- Currier retrofit with new theater addition
- Air infiltration reduction (experiment with AeroBarrier)
    - Pick a test project and document savings/ROI
- Continue to raise funds for and implement micro-load retrofits, ASHPs, solar hot water and PVs

8.1.2 Renewable Energy Strategy and Plan

- Develop a PV plan: (See Section 8.3)
    - Concurrently, raise funds for PV arrays, and install in chunks as funds become available and as outside funding opportunities present themselves, being cognizant of changing grid restrictions and changing incentive structures
- Assess the financial feasibility and funding options:
    - Donors that have 3rd party ownership or leased land on non-constrained land within Green Mountain Power territory
    - Engage with a solar installation company to review options as they stand in 2019

8.1.3 Documentation/Highlight Successes

- Update the full net-zero plan every 5-7 years to address the changing world of energy prices and technologies and to continue to make the most advantageous decisions for The Putney School, support fundraising activities, and keep the Master Plan a living document for students and staff
- Use the Future Project Documentation tracking spreadsheet (Section 8.7) to record significant capital projects for the School (greater than $100,000). This will enable a deeper understanding of the pieces that are succeeding and provide documentation to tell the story of each project
- Annually review the net-zero plan to check in on progress in the previous year and prioritize projects for the upcoming year. As the world changes, some of the assumptions presented in this report will change and will require a reprioritization of the process

8.2 Future Project Prioritization

To help the School determine next projects to implement, the Committee discussed and established a weighted prioritization matrix for each building based on the following factors:

- Programming needs of the School (50%)
- Deferred maintenance priority (20%)
- Total energy reduction potential (10%)
- Carbon saving to cost ratio (10%)
- Occupant interior health (5%)
- Occupant satisfaction (5%)

To facilitate the ranking of next projects, some will be intuitive for the School, while others may be low lying fruit that certain analysis lenses reveal. During the update process, Maclay Architects and Energy Balance developed a spreadsheet located in the Appendix. Table 8.2.1 shows an example of this ranking and the indicators as column headings. The weights applied to each category can be easily adjusted within the spreadsheet.

Gray House dorm is included as an example of how the spreadsheet would have been used for that dorm before the full renovation occurred. Program did not need to change, but deferred maintenance was a 10 for the building, health and occupant dissatisfaction both scored 8 (again prior to renovation). The quantitative features - Total Energy Reduction Potential - is based on the amount of annual energy savings, and since this is a small dorm, it scored a 3 relative to all the buildings on campus, while dollars spent per carbon savings was quite high with a score of 8. Another example is if Huseby needs a new roof within the next two years, the deferred maintenance column could get an 8, while program changes would be 0, student discomfort was estimated at 6 due to zoning of the heating system that leaves some areas very cold. The two non-qualitative columns, Total Energy Reduction Potential and Carbon Saving to Cost Ratio are 4, and 7 respectively.

The School can immediately begin taking the following small steps to gather data about existing buildings and energy use:

- Submetering
- SchoolDude full implementation
- Retro-commissioning - possibly the KDU or Field House (Retro-commissioning will identify areas in complex building controls and complex HVAC systems where efficiencies may be obtained. Commissioning is a rigorous process that complex buildings undergo when first completed to assure that all components of the HVAC system are operating as designed. Retro-commissioning utilizes this same process later on in the building's life, as HVAC systems age, controls settings get changed, etc.)

% weighted by category	10%	10%	50%	20%	5%	5%	
Name	Total Energy Reduction potential	Carbon saving to cost ratio	Program needs of the School	Deferred maintenance priority	Health/ durability priority	Comfort/ Occupant dissatisfaction	**Total**
Reynolds	**4**	**5**	10			6	**6.20**
Library Building	**8**	**6**	6				**4.40**
Gray House, actual project	**3**	**7**	0	10	8	8	**3.80**
Huseby	**4**	**6**	0	8		6	**2.90**
John Rogers	**4**	**7**	0	5	7	7	**2.80**
Wender Arts	**5**	**7**			7	7	**1.90**
Currier Center (Michael S.)	**10**	**6**					**1.60**
KDU	**7**	**7**	0				**1.40**
Main Building	**5**	**6**					**1.10**
Goodlatte	**1**	**9**					**1.00**
Lower Farm 2nd Residence	**3**	**7**					**1.00**
Lower Farm Main Residence	**2**	**7**					**0.90**
Daycare	**2**	**7**					**0.90**
Rockwell House	**3**	**6**					**0.90**
Red Cottage	**2**	**6**					**0.80**
Leonard's Keep	**2**	**6**					**0.80**
Prefab House	**1**	**6**					**0.70**
Arms House	**1**	**6**					**0.70**
Page Farm	**2**	**4**					**0.60**
Arts and Crafts Building	**2**	**4**					**0.60**
New Boys	**2**	**4**					**0.60**
Wirth House	**1**	**5**					**0.60**
Spencer House	**1**	**5**					**0.60**
Milk House	**1**	**5**					**0.60**
117 Aiken Road	**1**	**5**					**0.60**
Rogers House	**1**	**4**					**0.50**
White Cottage	**1**	**2**					**0.30**
Noyes	**1**	**1**					**0.20**
Cinderblock House	**1**	**0**					**0.10**

Table 8.2.1 Example Project Ranking Using the Building Prioritization Matrix

The following are a list of possible key next projects for the School, which have been identified in meetings with the Master Plan Committee:

- 2 new dorms (remove Old Boys, and dorm rooms from Old Girls and Keep Basement)
- Theater addition to Currier
- Teaching Spaces – 2 Old Girls classroom conversions, 4 new classrooms plus shop and second level at Reynolds
- New Post Office
- Add solar and purchase existing system
- Keep dorm net-zero ready renovation
- New Boys dorm net-zero ready renovation and addition
- JR dorm net-zero ready renovation

8.2.1 Near Term Energy Project Possibilities

Following are projects the team identified as attractive in the near term. Some of these are comprehensive, and some are incremental. The incremental steps are identified to avoid any “backtracking” when a complete net-zero ready retrofit is accomplished at a future date.

21st Century Kitchen – Bring one of the biggest energy users on campus up to net-zero Campus standards.

- Step 1 -- update equipment and systems
  - New refrigeration equipment with heat recovery
  - Induction cooking
  - Solar/heat pump hot water
  - Fix make-up air for hood
- Step 2 – (may be deferred if whole project is not undertaken)
  - Simultaneous work with students on food advocacy for production, consumption, and composting to become zero waste
  - Improved enclosure
  - Heat pump space heating
- Outcome: lower major carbon footprint of campus

Decarbonizing Staff Housing: first steps of a major staff housing fix

- Step 1 -- Bundle basement repair, basement drainage fixes, basement insulation and heat pump hot water heaters in the 16 faculty houses into one project, taking advantage of some economies of scale
- Step 2 – Audit and upgrade
  - Home Performance with Energy Star/Efficiency Vermont program to audit and retrofit all staff 16 houses
  - Invest approximately $20-30k average invested per house for air sealing and insulation upgrades
  - Avoid items that would have to be redone in making the buildings net-zero ready. Even if the School had to redo some things, if 15 years of savings are recognized before the house gets a full net-zero ready renovation, the intermediary investment would have long paid for itself
- Outcomes: Air quality and comfort improves; energy and carbon emissions are lowered; operating costs for the School are lowered

Currier Makeover

- Steps:
  - Optimize mechanicals with recommissioned controls and set up system for future air-to-water heat pumps to replace boiler
  - Insulate roof well, eliminate green roof, cut-off thermal bridges, add glazing layers to existing windows and replace if needed, check possibilities of better wall and slab insulation
  - Extensive air sealing of the envelope
  - Commission and fix the enclosure with air leakage and IR testing
- Outcomes: Improve comfort, reduce energy use dramatically
- Timeline: possibly integrate with theater addition

8.3 Solar Build Out Strategy

The current grid constraints in Putney, Vermont have provided timely insights into the challenges renewable energy production is facing around the country on outdated infrastructure. The overall PV need to cover the existing electricity load of the campus is an additional 300 kW as shown in Table 8.3.1. To meet the future building load reduction, while adding heating and hot water system conversion to air source heat pumps and heat recovery ventilation, an additional 400 kW is needed for the campus to be net-zero energy. Table 8.3.1 shows the existing PV and the future PV needed for the net-zero campus compared to the existing campus, but excludes any load needed for electric vehicles.

The School should move ahead insulating buildings on campus, installing air source heat pumps, and installing incremental solar where possible and cost effective based on the current grid conditions. The long-term vision for the campus should remain the same as noted in this document toward a fully net-zero energy and renewably powered campus. The committee embraces the understanding that technology will catch up with the oversupply of renewable energy in the Putney Green Mountain Power area and enable the long term vision of net-zero to become accomplishable.

To address the grid constraints, a few solutions have been identified to be pursued in the near term:

- Install solar within Green Mountain Power (GMP) territory on alumni or other School supporter's owned land with a lease agreement. The solar production can be allocated to any GMP meter
- Engage with solar companies that can develop a strategy to install the current build out of campus electricity as well as a projection for when to install the additional capacity needed to run the ASHP and additional electric loads of the net-zero campus
- GMP is in the process of changing incentive structures

Existing Campus	
940,000	2018 kWh usage
446 kW + 36.8 kW	kWp Existing arrays
(580,500)	2018 kWh PV output
359,500	kWh remaining to zero out 2018 electric use
300	kWp needed to zero out 2018 electric use
Future Net Zero Campus	
1,420,000	kWh all bldgs Net Zero Ready (NZR)
446 kW + 36.8 kW	Existing arrays, kWp
(580,500)	2018 kWh PV output
839,500	kWh remaining to zero out NZR electric use
700	total additional kWp needed for Net Zero campus (above existing 2018 PV)

Table 8.3.1 PV Needed Comparison

from the original adder of $0.06/kWh in 2011; this is a tiered reduction, so the sooner Putney is able to install solar the better, financially. The current adder of $0.02/kWh will drop to $0.01/kWh on July 1, 2019

- Assess the financial feasibility of other ownership
    - The 30% federal tax credit can be taken, by donors, for the cost of the PV system. This incentive is planned to begin a tiered reduction on December 31, 2019, so immediate action should be taken to investigate this option. In 2020 the rate will be 26%, in 2021, 22%, and by 2022 the federal tax credit will drop to zero. Capturing this credit would involve a third party owning the PV systems and leasing them to the School, in essence functioning as a utility for the School. This arrangement is often set up by non-profits to be able to take advantage of the tax credits. For-profit businesses can also take an accelerated depreciation benefit in order to leave some financial benefit for the donor who would participate in such an arrangement. (This benefit also varies by tax bracket)

8.3.1 Grid Constraint Solar Strategy

There are emerging obstacles to new large PV arrays on campus. Some of these obstacles may also present opportunities.

GMP will not permit more PV in this area until the grid is upgraded, or demand is significantly reduced. GMP has a pilot program now to test demand reduction in buildings or campuses as a way to free up "space" on the grid. There are local folks in Putney area (such as Dynamic Organics -Morgan Casella) who are running at least one of the pilots. Piece of this could include:

- Aggregated metering to take advantage of opportunities for peak demand reduction for either cost savings or for making room on the locally constrained grid for more renewables/PV. Metering can be aggregated "virtually" by GMP. Their 15-minute data gathered by smart meters tracks demand, so existing metering configurations would not need to be changed to take advantage of demand reduction opportunities
- Aggregating heat-pump heated buildings onto a virtual meter and allow them to coast -- turn off the heat pumps -- through a peak demand period for cost savings or grid enhancement. This would require lowering the load for the building through net-zero ready renovations and/or leaving in place a fossil fuel fired heating system to provide heat during infrequent electric peak reduction times
- Lower cost controls should become available, similar to how lower cost monitoring has become

available with EGauge. These would be web-enabled, so that these controls could be used to aggregate demand reduction opportunities. This would require simple controls infrastructure to be developed with equipment providers using widely accepted operating systems and protocols, and designers and technicians capable of putting the equipment in place and operate it over time. This is likely a third party, not a skill the School would need to develop

- Performance contracting for demand reduction coupled with campus-wide controls
- On-site storage of energy to coast through high demand periods may become a viable option, with integration of car or bus batteries for peak load shaving

New optimizations will be coming. While this document recommends basing optimum levels of enclosure efficiency on resilience, comfort, and suitability for using heat pumps, new opportunities for assisting the electric grid by having buildings coast through peak electrical demand periods creates another factor to consider. Buildings with the level of enclosure efficiency recommended here would not notice the heat being off for one or more hours, even in cold weather.

8.4 Energy Submetering Plan

A primary purpose of energy metering is educational. Whole-building usage can be useful for tracking how one dorm or other building stacks up against another, or year to year. But if you want to know why, then the more detailed EGauge monitoring -- with subsystem data, with data online, nearly instantaneously, at any time interval from seconds to days or months -- can be very instructional. To submeter all existing buildings is estimated at $62,000, with additional costs of $7,000-10,000 to aggregate the data and provide an online dashboard (Section 8.4.1).

Energy use of many of the buildings at the School is uncertain, due to a lack of metering. (See appendices for a list of meters by building.) The lack of metering mostly applies to electricity, but propane and oil tanks are also shared between buildings. Without building-by-building accurate energy use, it is difficult to draw firm conclusions about usage and opportunities as would be desirable for planning. To this end, students, staff and Energy Balance investigated existing metering, and have the following recommendations for immediate follow up.

Additional energy metering – beyond the existing utility meters - at The Putney School has several purposes:

- Determine energy use of buildings that are not on their own meter, to better understand usage of all buildings individually; this will provide input into prioritizing energy saving activities
- Identify the magnitude of energy savings opportunities, to support cost/benefit analyses, within buildings with significant loads through submetering
- Study net-zero building usage, for learning and troubleshooting
- Provide educational/research opportunities for students and staff

A. Metering to separate electric use of buildings that are on one meter has been identified in the following locations:

- Library and Old Boys – There is a manually read meter in the Library boiler room that tracks Old Boys' energy use. Alternatively to the manually read meter, a stand-alone battery powered meter could be installed that would track data over time, to look at electricity use totals as well as electricity usage patterns in Old Boys. Alternatively, a more automatic, on-line system such as EGauge could be installed to provide detailed data that can be checked from any computer at any time
- Titus House/Red Cottage and Milk House get their electricity from the Barn – an EGauge system could be set up to separate these three, or two of the simpler data loggers could also be used, with advantages and disadvantages for each approach as noted above
- The meter serving Huseby is on a pole and appears to serve Huseby, a well for the campus water supply, and the two small greenhouses nearby. Separating metering at the pole would not be trivial, so we suggest a stand-alone logger located in Huseby on the mains coming in there and at the mains coming into the greenhouses
- Reynolds, CTL/Arts and Crafts, White Cottage, and Linen House all get power from White Cottage
- KDU, Old Girls and the Main Building. The meter is in the Main Building, with 7 circuits that could be metered at the main distribution panel. These could be metered with a 30-input EGauge with CT's (current sensors) to separate out the KDU from the Main Building and Old Girls. Depending on what circuits are controlled by what sub-panel breakers, the panels feeding the Main Building may be separated from the others to determine Main Building electrical use, and the existing Old Girls panels could be metered, or their usage determined by subtraction. The circuits in the sub-panels are not all marked as to what the

breakers control. We would recommend a couple people spending time with cell phones or radios and turning off circuit breakers to determine what circuits are fed by which circuit breakers and making a good chart for each sub-panel. The 7 sub-panels served by the main distribution panel are as follows:

- KDU
    - Panel 1 – Upstairs apartment, computer hub, bathrooms above, second floor kitchen, outlets and bath fans
    - Panel 2 – Old Girls dorm wing (?) -- not well marked
    - Panel 3 – Pellet boiler room
    - Panel 4 – Old Girls dorm wing (?) -- not well marked
    - Panel 5 – Infirmary and other parts of the Main Building (?) -- not well marked
    - Panel 6 – Main Building

B. Submetering of kitchen systems in the KDU, particularly refrigeration, would be helpful in identifying where electricity is going and estimating the magnitude of savings opportunities. This would give a baseline for better understanding potential improvements. This would require one 30-input EGauge with CT's[1]. It would be worth metering some circuits of the many in the basement, including:

- The three walk-in refrigeration compressors and evaporators
- Other refrigeration loads such as the two large double-door reach-in refrigerators
- Dishwasher booster heater
- Hood exhaust fan energy

C. Metering buildings to separate oil use in Old Boys and the Library – this could be done with a run-time meter on the oil burners in either building. Run-time multiplied by the gallon-per-hour usage rate of the burner nozzles will yield total gallons of oil used. This could be done with stand-alone data loggers. If you want to study a single system, such as boiler or water heater, for example, the stand-alone battery powered loggers can be quite useful

D. An additional purpose for submetering is to provide better understanding of systems within the net-zero or otherwise improved buildings. One would learn how well systems are working compared to projections, and could better allocate the amount of PV for the building. If a net-zero building does not meet its energy target, you don't know why unless you meter the basic systems. A building the size of the Gray House dorm might use a smaller 15 input EGauge, at about half the hardware cost of the larger EGauge, depending on how circuits are divided. Building Systems metered, based on student and Energy Balance investigation, would include:

- Building mains for total usage
- Heat pumps
- Ventilation system fans
- Pumps
- Hot water system
- Washers and dryers
- The observatory that is connected to Gray House's electrical panel
- Plug loads/lights can be calculated by subtraction

<u>Data from all the </u>EGauges can be aggregated, with a server and software to provide tallies on whatever

1 Hardware costs about $2,000 for one 30-input EGauge and 30 CTs and associated box; installation would require better part of a day for an electrician, and another day for programming and commissioning by an energy consultant. The 15 CT smaller EGauge hardware cost is in the $1,000 range each.

timescale is desirable – monthly for general use, or more fine-grained for troubleshooting or understanding trends in consumption. That aggregating system could also be programmed to identify outliers in the data for investigation and send an alert. Before this infrastructure is installed, someone will need to spend some time once a year to comb through at least the SchoolDude data to identify trends in consumption. The EGauge data should be able to be integrated with the SchoolDude data, so that all consumption can be looked at in one place – including buildings that don't have electric utility billing meters or individual oil tanks.

The data gathered on electricity with EGauges can be combined with fuel usage data from SchoolDude. It should be noted that the EGauge can tally fuel use where electricity is used to utilize the fuel. For example, monitoring an oil burner circuit will tell you, in combination with the burner capacity, how much oil is being used and when it was used. This will allow the oil usage that SchoolDude tallies by tank to be separated between two buildings that share an oil tank. EGauges allow finer grained analysis of the oil consumption over short periods of time to help troubleshoot issues that may arise.

The EGauge system will also monitor circuits within each building, so that when an outlier is identified from total usage, the cause of the over-usage can be more clearly identified. The combined SchoolDude and EGauge data will also allow an EUI (Energy Usage Index, in kBtu total for all fuels per sf per year) to be calculated for each building each year, as an overall indicator of consumption. Comparing these year by year will help identify overall trends.

8.4.1 Cost for Aggregating Data from all EGauge Systems

Additional educational value would be achieved if the EGauges are aggregated into a single dashboard for energy use investigation. This will require setting up a server on campus to query all the EGauges across campus and compile data into whatever totals, averages and other summary that is needed. The initial setup is most of the cost, while adding more buildings to the system would be relatively straightforward. Andy Shapiro spoke with Seth Seeger out of Leverett, Massachusetts, who specializes in this type of work, and he estimates a cost of around $5,000. This is a very rough estimate, not knowing about the infrastructure on campus, and should be investigated further as EGauges are installed on campus.

It would be an additional cost to have a dashboard of some type that makes the aggregated data readily accessible to the campus students, faculty, and staff. This could perhaps be accessed from the School's website, with graphics and photos as well as data display, which could be a student project or hired out. The cost for this will vary with how many features and graphics are involved, but an estimated cost is $2,000-5,000. For a total data aggregation cost of $7,000-10,000 on top of the EGauge implementation.

8.4.2 Cost for Integrating Water Metering into the Energy Metering at Each Building

Additional educational opportunity comes from the water flows on campus. Building water use could be tracked and assessed yearly similarly to the energy use of each building by students. Water must have a physical meter measuring a flow of liquid, and a plumber is needed for installation to shut off water to the building. Approximate costs per building are $700:

- Water meter cost $200
- Water meter installation $300
- Interface with EGauge system, including programming and commissioning $200

8.5 Cost for a Net-Zero Campus

What does this all cost and what is it worth? This is an easy question to ask, but tough to answer! This analysis must take into account the cost for the building energy efficiency upgrades, program changes for the School, the installation of PVs, and the costs for the installation of air source heat pumps. The total campus renovation costs are $24.2 million and are broken into two categories: deferred maintenance and health, and energy improvements. These improvements would occur simultaneously, but are broken out to show the added incremental cost to go beyond code compliance to net-zero ready. The incremental cost can vary greatly between projects, but the team's experience since 2011 has shown consistent project cost ranges from 10-30% of the project cost or $5-20/sf additional cost. The Gray House net-zero ready renovation was estimated to add 25% to the project cost, which included the full cost of adding heat pumps ($223,000). If solely the envelope costs are used it was an added 15% to the project costs ($138,000). For the purpose of the campus cost break out, we have conservatively used 30% to get to net-zero ready above code incremental cost, given the challenges of existing building renovations.

The additional factors to address some of the program needs on campus. Included in the New Construction category are the new black box theater addition on Currier, and the two new dorms for $15 million. That total excludes any endowment or interest during construction but does include construction escalation of 3.5% since the 2016 dorm estimate (see the Appendix for these drawing packets and detailed cost estimates for both projects). Other infrastructure needs to become a net-zero campus include the cost of solar photovoltaics to offset the net-zero ready loads of the buildings (at $2.50/watt, the total for the remaining PV needed is $1.8 million). The campus infrastructure improvements are estimated at $700,000 per the 2015 and 2018 revisions by Stevens Associates.

Subtotal for Deferred Maintenance and Health [1]	Subtotal for Energy Improvements [1]	New Construction [3]	Solar Photovoltaics [2]	Infrastructure [4]	Total Amount
$ 17,000,000	$ 7,200,000	$ 15,000,000	$ 1,800,000	$ 700,000	$ 41,700,000

[1] DEW developed a building by building cost estimate, additional cost for energy improvements above code come from Maclay's experiences of project costs for new construction ranging from 5-15% of the project cost, and renovations being potentially more. We have estimated a conservative 30% allocated to energy upgrades above code.

Costs for Air Source Heat Pumps include electrical service upgrades where appropriate.

[2] Based on 1.05 kWh/year per peak Watt installed; cost of $2.50 total per peak watt installed (before tax credits, if available)

[3] Cost for the theater and two new dorms to net zero ready standards, excluding endowment, or interest during construction

[4]Infrascture upgrades for expanding septic, and water sytems per 2018 Stevens Report

Table 8.5.1 Cost Estimates of Subcategories for a Net-Zero Campus

This brings the full upfront cost to bring the entire campus to net-zero with some program improvements to $41.7 million as shown in Table 8.5.1. The existing buildings cost estimate is broken out into two subcategories: energy improvements, deferred maintenance and building health. In general, the following items are contained within each subcategory:

Energy Improvements

- Air source heat pumps replacing the existing heating system and electrical upgrades as needed
- Blower door testing to guide air sealing
- Insulation, window improvements beyond code compliance
- Lighting changed to LEDs
- Convert hot water to electric (with solar supplement, air-to-water heat pump, or direct resistant electric depending on the load and availability)
- Engineering and design services

Deferred Maintenance/Building Health

- Bringing the building up to code levels of insulation, windows, air infiltration
- Addressing structural, drainage and material degradation, both interior and exterior
- Permitting
- New ventilation throughout with highly efficient heat recovery ventilation systems
- Drainage work to mitigate water moisture in basements

The full detailed costs of each of the buildings on the net-zero campus can be found in the Appendix from DEW document 2018 Updated Conceptual Estimate 1.5 for Putney Master Plan. The detailed cost estimate was initially completed in 2011. In order to update the number to 2018 dollars, taking into account construction escalation and difference in construction trades costs, the building detailed cost estimate was updated by DEW. An annual construction escalation of 3.5%/year should be added for each subsequent year beyond 2019.

Additional value to The Putney School stretches far beyond monetary savings on energy. While annual utility costs are approximately $350,000/year, the harder to quantify values include:

- Improved indoor air quality which improves health
- Reduced or zero-carbon emissions
- Nationwide visibility as a "green" school
- Improved ability to attract students
- Elimination of future fuel cost anxiety and buffered from energy fluctuations
- Improved durability of the buildings

It is difficult to place a dollar value on these attributes. There are studies attempting to evaluate the monetary values of these attributes, but these values are not included here. For the PV installation it's less clear what immediate steps to take; see Section 8.3 for additional direction. Other possible financing mechanisms would be to loan money from the endowment that is proven to be cash flow positive, therefore not diminishing the endowment but capitalizing on that existing resource. This and other financing strategies should be explored further as the School seeks financial support for the transformation of the campus.

8.6 Annual Energy Tracking Process

Since 2012 the School has tracked total energy consumption in SchoolDude. This software provides an easy way to track consumption by building, by fuel type, and by month. The system and data are easily queried to give annual building usage by fuel over several years in order to check if fuel consumption has changed more than might be due to differences in weather. This is very helpful in identifying things such as equipment not functioning properly, a sump pump or a well pump running constantly instead of just when needed, or excessive heating or hot water use.

For example, the Currier building's oil use is fairly consistent over the last 5 years as shown in Table 8.6.1 (the 2019 data is not for the full year). The 2016-2018 oil use exceeds the use since 2012 and 2013. Tables 8.6.1 and 8.6.2 come directly out of a SchoolDude "pivot table" excel report.

Electric use for Currier seems to have jumped up significantly in 2018 compared to previous years (the 2019 data is not for the full year). The cause could be investigated or maybe there has been additional use of the space, that can be easily accounted for.

This sort of systematic poking through each building's use of each fuel type can be very helpful in catching issues before they go on for too long.

As of 2019, there are several buildings that do not have their own electric meters or fuel tanks, so the School cannot track their performance or identify usage issues for those buildings. Once an EGauge submetering system is installed in each building (see Section 8.4), this data will be available. The EGauge system can also track water usage upon installation of water meters and interfaces. Once the EGauge and submetering plan is implemented, the annual tracking process will change from the noted steps above, and will provide a more accurate building-by-building data set. SchoolDude can generate reports on building EUI and comparisons over time that would enable the school to quickly identify outliers. Until that time, at least one day per year should be allocated for a person to review the program changes and project completion for the past year with the SchoolDude data and building-by-building energy use.

Total Use			
Year	Building	Utility Type	Total
2019	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	6,753.90
2018	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	10,342.40
2017	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	10,715.86
2016	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	9,180.90
2015	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	10,487.80
2014	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	9,713.30
2013	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	7,800.10
2012	Currier Center (Michael S.)	Fuel Oil No. 2 (Gal.)	8,075.50

Table 8.6.1 SchoolDude Export for Currier Oil Use

Total Use			
Year	Building	Utility Type	Total
2019	Currier Center (Michael S.)	Electric (KWH)	46,560
2018	Currier Center (Michael S.)	Electric (KWH)	86,280
2017	Currier Center (Michael S.)	Electric (KWH)	65,160
2016	Currier Center (Michael S.)	Electric (KWH)	54,960
2015	Currier Center (Michael S.)	Electric (KWH)	51,000
2014	Currier Center (Michael S.)	Electric (KWH)	58,560
2013	Currier Center (Michael S.)	Electric (KWH)	55,080
2012	Currier Center (Michael S.)	Electric (KWH)	60,240

Table 8.6.2 SchoolDude Export for Currier Electricity Use

8.7 Future Project Documentation

In order to document successes and project completions, The Putney School should continue to track their projects, and include some additional information. The Project Tracking Spreadsheet located in the Appendix has been developed in conjunction with the School. This sheet should be used for all projects as the information is relevant regardless of size. The School has tracked internal projects in two ways: 1. Small projects (less than $100,000): facilities uses a spreadsheet for cost projections versus actual, and 2. Large projects (greater than $100,000): the CFO tracks and breaks out into the 4 subcategories of the Master Plan cost estimate: energy improvements, deferred maintenance, building health, and solar photovoltaics. (see Section 8.5 for a description of each category).

In addition to cost information, the School should collect before and after pictures for marketing purposes (ideally from the same angle/location), envelope specifications pre- and post-upgrade, and program/use changes. For projects above $100,000, pre- and post-blower door numbers and infrared images would be ideal to show the full project impact and should be discussed on a project-by-project basis. This information will assist students in understanding the energy data by building, and will provide marketing information for the School to share their success stories as they move toward a net-zero campus.

8.8 Low Embodied Carbon Materials

Energy reduction is a visible, and financial, metric that the School can pursue to minimize their footprint. This includes the carbon dioxide *emissions* (or operational) equivalent data in Section 6.0. In broadening the perspective, the next level of sustainability is to look at materials and their *embodied* carbon impacts on the overall energy picture of buildings and renovations. The building industry and specifically The Putney School has made great strides in addressing operational energy consumption (the amount of energy used to run the building) and is the main focus of Section 6.0.

However, calculations around the carbon footprint often don't account for embodied carbon: the carbon emissions produced as a result of the harvest/extraction, refinement and production/manufacturing of a material. The embodied carbon value of a material reflects the amount of emissions released for that phase of a material's life cycle. Materials that grow from plant matter can store carbon and even be a net negative number, while extractive, petroleum-based products can have very high embodied carbon. The following information has been adapted from a white paper by New Frameworks in the NESEA Building Energy Magazine Fall 2018[2].

Why embodied carbon matters:

- The goal of reaching net-zero carbon emissions by 2050, set by the World Green Building Council in response to targets outlined in the 2015 Paris Agreement, can only be achieved by addressing embodied carbon, especially as operating emissions are dramatically reduced
- Embodied carbon has been released — and the climate damage done — before the building is even occupied; it cannot be recovered or offset. Given the "zero carbon by 2050" goal, the early-phase timing of these emissions is of critical importance
- There will be lower carbon emissions from operating energy consumption as the grid "decarbonizes" through increased renewable-sourced electricity production and as mechanical equipment becomes more efficient
- A building using high embodied carbon insulation to reduce operating carbon emissions may release more cumulative carbon emissions than a building with lower insulation levels

2 https://www.buildingenergymagazine-digital.com/eneb/0218_fall_2018/MobilePagedArticle.action?articleId=1422002#articleId1422002

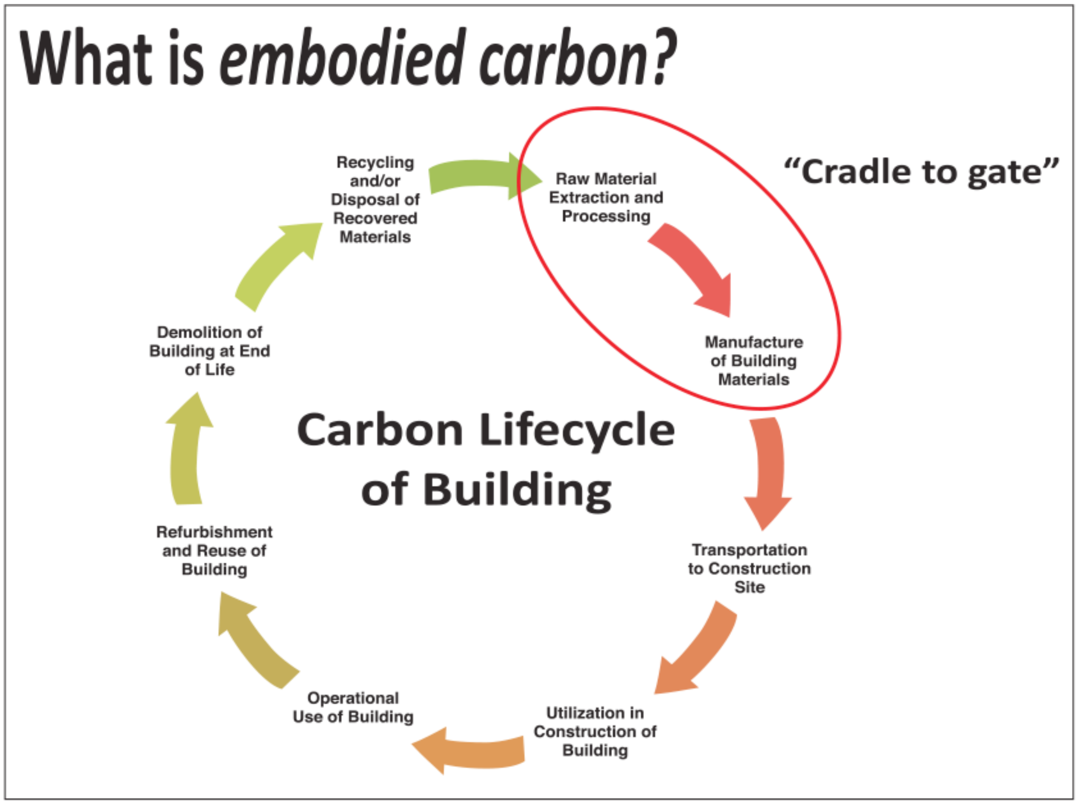


Figure 8.8.1: The Carbon Life Cycle of the Building. Credit: New Frameworks

and higher operating emissions within the 2050 timeframe. More insulation isn't always "better" from a climate perspective

- By using carbon-storing materials, buildings have the potential to actively reverse carbon emissions — as opposed to passively "doing less harm" — and to do so immediately, not after many years of renewable energy production
- Using carbon storing materials can have an amplifying effect on carbon reduction and storage by supporting sustainable silvicultural and agricultural systems
- Use of biologically-sourced materials such as wood, cellulose and agricultural fibers offers the greatest storage potential. This also supports working landscapes and localized, scale-appropriate economies in our region, providing myriad additional benefits beyond climate impact

Figure 8.8.2 compares embodied plus operational CO2e emissions for a single-family home built 5 different ways, all with PV-powered air source heat pump for heating. Results would be similar for renovation.

- *Code Min.:* Code minimum building using conventional building materials
- *Hp ccSF/XPS:* A high-performance building using carbon-intensive materials such as high-density closed cell polyurethane spray foam and XPS insulation
- *Hp HFO/EPS:* A similar building using HFO closed cell polyurethane spray foam and EPS insulation
- *Hp Carbon Smart:* A high-performance building using ultra-high carbon-storing materials such as straw, cellulose and earth
- *Code Min. Low Carbon:* A code-minimum building using conventional carbon-storing materials such as cellulose wood fiberboard and low-Portland concrete

The code-minimum building emits less cumulative CO2e than either of the foam-built structures, while the "carbon smart" building stores a net of 9 tonnes of CO2e (shown as a negative value). The code-minimum low-carbon building is effectively net-zero carbon.

Factoring in embodied CO2e, the foam-built, high-performance buildings — even lower-impact foams like HFO spray foam and EPS foam board — have the largest total CO2e footprint. Even with the lowest emission fuel source – PVs -- the lower-impact foam building is barely comparable to the code-minimum building, which is alarming given foam's prominence in our industry and reputation as a "green" product.

The "carbon smart" building using materials selected to optimize carbon storage, coupled with a low-carbon fuel/heating source, acts as a carbon sink — a direct reversal of the impact profile of the foam-based buildings built to the same standard using the same fuel/heating source.

The code-minimum building using conventional carbon-storing materials, coupled with a low-carbon fuel/heating source, is effectively net-zero carbon by 2050. This charts a compelling path towards achieving net-zero carbon buildings using available technologies and more moderate levels of enclosure performance, and it begs further exploration as a scalar approach.

Materials to Cool the Planet

There are a range of carbon-storing and low-embodied carbon

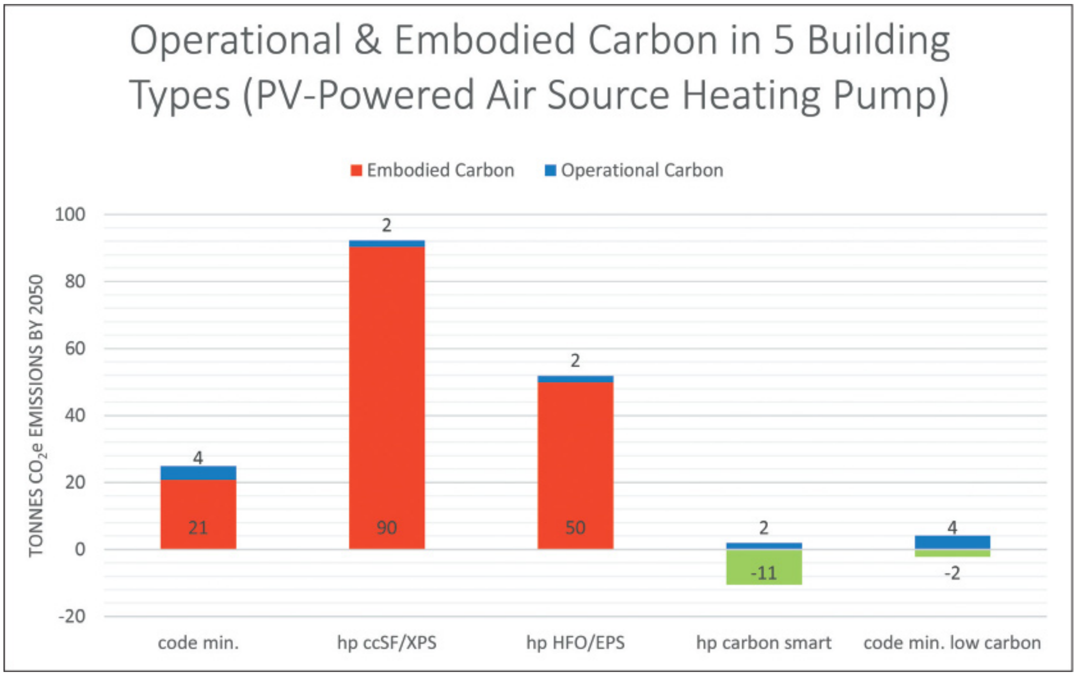


Figure 8.8.2: Operational and embodied carbon in five building types. Credit: New Frameworks

building materials available today, from the basic and commercially available to the new and innovative, across all scales of buildings. Some of these are listed below, but are not an exhaustive list. As project move from conceptual design toward construction, the School should examine materials available and the pros/cons of each.

Basic Commercially Available Solutions:

- Insulation
  - Cellulose fiber: dense-pack or damp-spray
  - Wood fiberboard sheathing (structural or non-structural): R-4/inch using high recycled content. Examples include Gutex, Steico, MSL Fiberboard
- Structure
  - Stud framing with lumber from regional, sustainably-managed forests
  - Timber: cross-laminated timber (CLT), whole tree timber, and sawn timber
  - Concrete options: add fly ash to your next concrete order from the plant; engineer structures to use less concrete; alternative foundations such as slabs, pier foundations and non-Portland cement ICFs such as Durisol
- Finishes
  - Wood: regionally-milled solid wood hardwood flooring, softwood siding, cedar roofing
  - Cork: flooring harvested from living trees that, in order to flourish, must be harvested
  - Paints and plasters: clay and lime finishes and paints without titanium dioxide Producers include LimeStrong, American Clay, Bioshield, Old Fashioned Milk Paint Company, Ecos Paint

New/Innovative Solutions

- Straw walls: Prefabricated panels or site-built walls. R-30 - R-50, vapor permeable, especially carbon-storing due to being a short-cycle crop. 1-2-hour fire rating
- Hempcrete: Lime mixed with hemp hurd, R-3/inch, stores carbon, vapor open, moisture resistant, fire resistant

- Mycelium insulation: “foam” insulation panels, mushrooms grown on an inert medium of hemp hurd and dried. Example: Ecovative Design
- Alternatives to concrete: rubble trench and helical pier foundations; cement-comparable masonry materials biomineralized CO2 to make lightweight aggregate. Examples include Blue Planet, CarbiCrete, CarbonCure, BioMASON
- Recycled structural panels: made of recycled plastic-coated cartons. Example: ReWall
- Earthen floors: clay and aggregate mixture, finished with natural oils. Example: Claylin

There is an immense opportunity to reduce the carbon footprint of our buildings immediately with low-embodied carbon materials, while energy savings occur over the lifespan of the building’s use. The plant-based, carbon-storing building materials noted above are a starting point to research materials that should be considered for every renovation and new project. Information on products’ embodied carbon can be found in Environmental Product Declarations as well as by industry experts such as Architecture 2030, and will continue to become more readily available.

As the School identifies projects, potential questions to ask are:

- What design strategies will promote carbon storing materials?
- Is product data and transparency available?
- Are there regional products available?
- What occurs at the end of use of each product?

8.9 Summary

There are a number of factors that impact the recommendations here for the future of The Putney School. These have been touched upon previously and are synthesized below.

- All buildings benefit from “net-zero ready” retrofits or “deep energy retrofits”
- Project prioritization should be viewed through multiple lenses
- Submeter buildings to better inform use patterns and changes
- CO2e emissions of materials should be considered for future projects
- Funds are likely to be raised incrementally
- Future regional energy demand and availability – electric, fossil and biomass – are unknown
- PV energy source has the lowest long-term environmental impact, lowest operating cost and lowest maintenance, and the lowest installation costs over biomass
- Grid constraints will play a part in planning of location and timing of PV

The strategy laid out here lowers fuel costs in the short term, moves toward a net-zero future, and preserves flexibility to accommodate future unknown conditions, which will affect the choices available and the factors favoring these choices.

Once again, begin where you can, at the scale you can. Gain experience with new techniques and new technologies incrementally, before embarking on large projects. Be persistent in moving toward the best possible future, retaining flexibility as you go.

9.0 Appendix and Living Documents

9.1 Campus Diagrams & Information

1. Master Plan Documents: The campus diagrams which appear as figures in the text, appear here at their original size for the purpose of a more detailed understanding of the forces affecting change on the

2. Building Plans: Floorplans have been developed for all of the academic/administrative buildings and the student dormitories. All of these plans exist here as well as individually in 7.8 Detailed Building Information. Individual building plans have been developed to different levels of detail and should be used accordingly.

3. Proposed Plan Changes 2011: Program changes have been suggested for multiple buildings around the Putney School Campus. Any proposed program changes are detailed in these floorplans, as well as existing individually in 7.8 Detailed Building Information. Note that some buildings do have multiple options that have been proposed.

4. Conceptual Projects 2018: This section provides drawing information developed by Maclay Architects for The Putney School on projects since 2011.
    1. Theater addition to Currier Center conceptual design packet and cost estimate
        1. Theater Plan and Elevation
        2. Theater Conceptual Costs
        3. Black Box Theater, Putney, VT Conceptual Estimate 1.0 18Feb19 ABF
        4. Theater Code Review Memo 190520
    2. New Dorms
        1. Schematic Design Package
        2. Dorm Locations
        3. Putney Dorm Presentation
    3. Reynolds Classroom Addition Conceptual Design
    4. Library Conceptual Classroom Additions
    5. New Boys Expansion/Renovation
        1. Plan
        2. Conceptual Cost
    6. KDU Efficiency Vermont Recommendations
    7. New Greenhouse Location Notes

5. Proposed Infrastructure Changes: Wastewater, water and stormwater changes have been suggested for the Putney School Campus. The proposed changes are identified in the 2015 report by Stevens Associates and the 2018 updates.
    1. 2015 Water & Sewer Infrastructure Feasibility Study
    2. 2018 Putney School Infrastructure Update
    3. 2018 Construction Cost Table Update
    4. 2018 Permit Schedule
    5. 2018 Putney School Stormwater Feasibility

6. Putney Building Program 2011: This excel spreadsheet details the individual programmed spaces within each of the buildings on the Putney School campus. All rooms are identified by number and correlate to the numbering which exists on the building plans and proposed building plans.

9.2 Cost Estimate

1. 2011 Complete Final Putney 1.3 Estimate Report 11-18-11: The final cost estimate as prepared by DEW includes detailed estimates for all individual building energy upgrades, program changes, infrastructure upgrades, and campus energy systems.

2. 2018 Updated Conceptual Estimate 1.5 for Putney Master Plan: The updated cost estimate as prepared by DEW includes detailed estimates for all individual existing building upgrades.

3. Cost Estimate by Building: This excel spreadsheet is the living document which allows the Putney School to continually update the cost estimate as changes continue to be made to the Putney School campus.

4. Metering Costs 181218: This document was generated by Energy Balance Inc to reflect an estimated cost to submeter buildings in order to generate accurate building use data.

9.3 Energy Assessment

1. Putney School Energy Usage FY 2018 190423: This excel spreadsheet provides all of the background information used by Andy Shapiro of Energy Balance to understand current energy usage on the Putney School campus as well as develop expectations for use in the future.

2. 2018 Building Meter Information: This chart details the current meters on campus and the connections to shared buildings and fuel tanks.

3. 2018 Energy Use By Building: This is a summary chart showing the energy use by building and fuel type.

4. Building Name by Building Type: A comprehensive list of the buildings on campus and the classification of each.

5. CO_2e Calculation and Documentation 190520: This excel spreadsheet shows the calculations of CO_2e reductions by making each building net zero energy.

6. 2005 Building Energy Audits

9.4 Prioritization and documentation of Projects

1. Building Prioritization Matrix v1.1_190522: This excel document provides the School an additional lenses to review project priorities based on the following factors; total energy reduction potential, carbon saving to cost ratio, program needs, deferred maintenance, health/durability, comfort/occupant satisfaction.

2. Project Tracking Spreadsheet 190516: This is an excel document that the Putney School can use to track and document each future project.

9.5 Implemented Projects

1. Implemented Campus Projects: This section includes construction documents for the following completed projects:
    1. Goodlatte House Renovation/Addition
    2. KDU Renovations
    3. Library Renovations
    4. Gray House Dorm Renovation
    5. Post Office in Old Boys
    6. 446 kW Solar Photovoltaic Array
    7. Paige Field Survey
    8. KDU Heights Entry

2. Student Projects: This section contains student developed reports and summaries since the 2011 Master Plan.
    1. A Student Guide to the 2011 Master Plan
    2. Green Guard Student Resources
    3. Energy Monitoring Project Info and Guidelines
    4. Putney Food Report
    5. ESG Glenmede Case Study
    6. Accessibility at Putney

9.6 Landscape Assessment

1. Putney School Landscape Review: This document, developed by Stevens & Associate, provides an overview of the landscaping that currently exists on the Putney campus as well as details landscaping recommendations for the entire campus.

2. Putney School Maps: This document includes all of the maps/imagery that have been completed by Stevens & Associates including land use, aerial photography, the recreational trail network, soil data and plant data.

3. Putney School Topography: This map outline the topographic data collected in the fly-over completed in the spring of 2011. Full topographic data has been transferred to the Putney School for future uses.

9.7 Forestry Assessment

1. Putney School Forest Management Plan: This document, developed by Andrew Sheere of Future Generations Forestry, outlines a foresty management plan for the extensive land that the Putney School owns, providing recommendations for use and protection of these lands into the future.

9.8 Detailed Building Information

This section includes detailed information for all of the academic/administrative, faculty housing and student dormitory buildings on the Putney School campus. Documents in this section are irregular, data has been collected in detail for some buildings and not for others, but will include a summary data sheet for each building which outlines program, energy and historic considerations. Also included for some of the buildings are pdfs of building plans, pdfs of proposed program changes, CAD models and sketch-up models.

9.9 Historical Assessment

1. Historical Assessment & Inventory: This document, developed by Lyssa Papazian details the overall history of the Putney School campus as well as the history of individual buildings on the Putney School campus. A small piece of this document appears in the master plan text, and the important notes for each individual building appear in 9.8 Detailed Building Information.

2. Timeline of the Physical Plant: This excel spreadsheet outlines the timeline for the construction of the Putney School campus by individual building, providing any information if known on the architect/builder, alterations, architectural style and features.

Acknowledgements

Consultants

Maclay Architects, *Lead Consultant*

Maclay Architects, led by founding principal Bill Maclay, is an architecture and planning firm specializing in the collaborative and integrated design of buildings that take care of human needs while incorporating energy and resource conservation, renewable energy use, optimal indoor air quality, healthy building design technologies and environmentally responsive land use planning. Bill Maclay and the firm are the authors of the comprehensive resource The New Net-Zero published by Chelsea Green in 2014. Maclay Architects, located in Waitsfield, VT, has received numerous awards for excellence in design and environmental innovation for commercial, institutional, planning, multi-family and single-family residential projects. The firm offers standard architectural services, feasibility and planning studies, space planning, historic preservation services, site assessments, environmental and permit consulting.

Bill has pioneered a replicable model for net zero and environmentally sustainable architecture. Through practice, advocacy, and outreach, Bill has influenced thousands in creating a renewable planet. By making sustainability inherent to his practice, Bill has been at the forefront of designing innovative projects that serve as replicable, concrete, and cost-effective models for over four decades. His firm has designed over 14 net-zero and net-zero ready buildings including office, educational, manufacturing, municipal, and commercial buildings in cold climates.

Laura Cavin Bailey was the project manager for the update of the 2018 document and is currently the Research Director at Maclay Architects. She has worked with systems thinking through diverse environmental design experience including permaculture, biodiesel production, solar installation, an off-grid design/build company in Colorado, and as a research fellow at the Energy Studies in Buildings Lab at the University of Oregon. Additionally she has worked on projects and masterplans combining site, program, and client needs for creative future oriented solutions.

Energy Balance, Inc. *Energy/Sustainability Consultant*

Andrew Shapiro, President of Energy Balance, Inc., has provided energy analysis and design and other high-performance building design consulting services for 30 years to a wide variety of clients, including owners, architects, engineers and builders, as well as housing developers, universities, businesses and demand-side management programs. Services range from sustainable building design to research and monitoring projects. He is also the Energy Engineer for the Vermont Energy Education Program, training teachers and students. Recent projects include NRG Systems manufacturing and office facilities (close to 100% renewably powered – LEED Gold) in Hinesburg, VT, Putney Field House (Putney School, Putney, VT, "net zero", LEED Platinum), several micro-load/"net zero" houses in Vermont, a "net zero" education LEED Platinum building at the Coastal Maine Botanical Gardens and White Pine CoHousing, a six-unit village where he now lives.

DEW CONSTRUCTION CORP., *Cost Estimator*

DEW Construction Corp. is headquartered in Williston, Vermont with an office in Hanover, New Hampshire. DEW is one of Northern New England's largest general contractors with annual sales in the $125 million range. DEW's committed to providing best in class preconstruction and construction services in the marketplace. As part of their preconstruction services, DEW provides Building Information Modeling (BIM) in-house. This includes 3D, 4D, 5D and post construction and facility management application. For every estimate DEW will prepare a comprehensive Cost Management Report with the following items:

- Narrative describing design intent and description outlining basis of cost
- List of documents used for basis of cost
- Schedules for pre-construction & construction phases
    - Recommendations sheet which will include:
    - Design or Program: issues that may impact cost will be addressed
    - Value Management: cost savings alternatives will be offered
    - Constructability: identify issues that may be a design impact during construction phase
    - Detailed estimate
    - Variance Report: this compares the previous estimate with the current estimate and itemizes why the changes occurred

STEVENS & ASSOCIATES, P.C., *Landscape and Civil Consultant*

Stevens & Associates, P.C. has a diversified, multi-disciplined staff consisting of engineers, planners and landscape architects. Based in Brattleboro, VT, the firm specializes in commercial and municipal projects with expertise in schools, affordable housing, senior housing, pedestrian and transportation network improvements, master planning and urban design.

Stevens & Associates, P.C. provides private and public sector clients with complete engineering services through comprehensive planning, feasibility studies, design, preparation of contract documents and construction management. The firm participates on civic boards and maintains a close professional relationship with regulatory agencies to understand the political and permitting context of each project.

The firm is committed to building sustainable projects through green design and Leadership in Energy and Environmental Design (LEED) certification. The staff is trained to be whole systems thinkers so that we can support our client's mission while creating a built environment that promotes economic, environmental and community vitality.

LYSSA PAPAZIAN, *Historical Consultant*

Lyssa Papazian, Historic Preservation Consulting is a woman-owned sole proprietorship specializing in historic preservation planning, funding, regulation, documentation, and architectural history and has been operating in Vermont since 1998. The firm has worked with a wide variety of clients including municipalities, state agencies, schools and other institutions, non-profits, affordable housing providers, businesses, property owners/developers, planning firms, engineers and architect. Services including National Register of Historic Places nominations, historic preservation plans and reports, the rehabilitation of historic buildings, historic tax credit applications, regulatory review of state and federally funded projects, grant writing, project management, history exhibits, and architectural history. Ms. Papazian believes in planning and partnership to achieve historic preservation goals. She particularly hopes to promote the rehabilitation of historic buildings for housing on all economic levels, the support of traditional neighborhoods and town centers, and the protection and enhancement of agricultural & commercial viability as a means to preserve both rural and urban historic resources. Ms. Papazian holds a Master of Science degree in Historic Preservation and has been working professionally in the field for the past 19 years, first as a Senior Architectural Historian in New Jersey State Historic Preservation Office and for the past 13 years as an historic preservation consultant in Vermont. She brings extensive experience and familiarity with historic structures, preservation law and standards, and the history of northern New England to each project. As a National Park Service (36 CFR Part 61) – qualified historic preservation consultant, she has completed many projects in consultation with or under the review of the state historic preservation office and is very comfortable working with historic preservation regulations at both the national and state levels.

Don Hirsch Design Studio LLC., *Theater Consultant*

Guided by a personal approach that celebrates performing arts centers, Don Hirsch Design Studio provides comprehensive theatre design and development for the performing arts community assisting clients in the intricate planning process for the creation of vibrant theatre spaces.

Don Hirsch Design Studio has created spaces in traditional and non-traditional settings for the presentation of an eclectic blend of performing arts, media, and special event programming. DHDS provides fully integrated design and technology services featuring New Design, Historic Restoration, & Adaptive Use, Master Planning & Needs Assessment, Program Space Study & Concept Development, Theatre Technology System Design, Audiovisual/Media System Design, Business and Operational Planning, Site Inspections & Safety Evaluations.

Don Hirsch, founding director of Don Hirsch Design Studio, LLC has been involved in the art of design for more than thirty years in a career centered on the arts and culture and on the importance of creating and preserving performance spaces. Don has led award winning new design and historic restoration projects with a balanced and pragmatic approach. He is a frequent speaker at conferences and seminars, and lectures extensively on performing arts center design, historic theatre restoration, and on the business of entertainment.

Future Generations Forestry, *Forestry Consultant*

As the sole proprietor of Future Generations Forestry, Andrew Sheere has been working closely with private landowners, municipalities, institutions, and businesses to help them manage their forestland in a sustainable and responsible fashion for over 15 years.

Future Generations Forestry manages ecosystems for many values such as timber, recreation, wildlife, and maintaining water quality depending on the client's needs; often a combination of all of the above. To that end, Future Generations Forestry offers an array of forest management services including but not limited to: forest inventory; forestland appraisal; invasive plant management; preparation of forest management plans; property boundary line maintenance; recreation & wildlife management; timber sale marking; planning, and administration; and timber trespass. FGF also offers third-party forest certification through the Forest Stewardship Council (FSC) or through the Tree Farm program under the Sustainable Forestry Initiative (SFI).