Watt Community Rowing Center High-Performance Athletes Yield High-Performance Architecture

Allison Marie LaChance
Watt Community Rowing Center
*High-Performance Athletes Yield High-Performance Architecture*

by

Allison Marie LaChance

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Architecture

Department of Architecture
Golisano Institute for Sustainability

Rochester Institute of Technology
Rochester, NY
Spring 2014
Committee Approval

Dennis A. Andrejko, FAIA
Associate Professor, Chairman
Department of Architecture
Thesis Chair

Thomas A. Trabold
Associate Professor and Director
Center for Sustainable Mobility
Thesis Advisor

Enid Cardinal
LEED AP, Senior Sustainable Advisor
President’s Team
Thesis Advisor
 Acknowledgments 

Dennis Andrejko, Thomas Trabold and Enid Cardinal: A special thank you for your time, feedback, constructive criticism and knowledge shared with me during numerous thesis meetings, desk critiques, and periods of review.

Jules Chiavoroli: For challenging me to achieve above my best over a seven year educational design experience and encouraging me to pursue a master of architecture degree at RIT.

Stu Chait: For his mentorship, design knowledge, encouragement and artistic inspiration. A true foundation piece for my architectural success and confidence.

To my professors, who have provided me with a unique learning experience focused towards sustainability.

To Chaintreuil, Jensen, and Stark Architects: for their architectural knowledge and design experience and flexibility for an educational internship.

To my fellow student body, for accompanying me in this three year long marathon of sharing design suggestions, diverse talents and laughter.

To my fellow rowing community, for teaching me a new sport that has allowed me to experience a passion for teamwork.

To my friends and family, for their unconditional love and continuous support.

For my Mom, who taught me that I can do all things through Christ who strengthens me.

For my Dad, who prepared me for a world full of challenges and his encouragement to pursue my dreams.

For my younger brother, who expects me set the bar.

Thank you.
Preface

The following thesis project was completed in partial fulfillment of a Master of Architecture degree at the Rochester Institute of Technology. The document illustrates a passion for both architecture and athletics. The driving factor to choose the sport of rowing was influenced by my participation in National Collegiate Athletic Association (NCAA) rowing as an undergraduate athlete at the Rochester Institute of Technology (RIT). My current position in the Rochester area rowing community, as an assistant rowing coach for McQuaid Jesuit High School, further explains my interest in sharing my passion for rowing with others.
Abstract

The Watt Community Rowing Center (WCRC) is a conceptual project that will demonstrate and quantify how an architectural design response can be both spatially evocative and technologically grounded. The WCRC is an architectural design evolving the typical rectangular boathouse into an energy-efficient boathouse that stimulates ‘out of the box’ forward thought, focused both on architectural form and sustainable design. The WCRC is a synthesis of architecture, environment, and athletics and is a conceptual design and theoretical research exploration. The proposed architectural solution motivates a new form in sustainable architecture that encourages the participation of building occupants. The interaction between individuals and architecture will promote energy efficiency. Athletes will be viewed as a viable source of energy as the watts generated during ergometer workouts will be recycled back into the grid.

In the advancement of our technological age, new and innovative means of discovery can improve current trends and practices for future generations, a true sustainable thought. The proposed thesis is a catalyst to show how athletes and active individuals can contribute to energy production via athletic gait. **Rowing for Power** is the idea that energy produced by rowers during common indoor training ergometer workouts can serve as a potential for energy harvesting. The concept serves a site specific design in Philadelphia, Pennsylvania, but can be applied globally. Sports serve as a great segway to promote sustainability due to high fan populations and the natural draw of attention from the surrounding local community. High-performance athletes are role models who have the capability to yield high-performance architecture, which was explored in this design. Watts generated during ergometer workouts will be recycled back to the grid to offset energy demands.

The Watt Community Rowing Center (WCRC) is an accommodating design for the Temple University Crew in Philadelphia, Pennsylvania and the surrounding area rowing community. The rowing center provides indoor exercise facilities that support rowing-related conditioning year-round as well as adequate boat storage and waterway access. The architecture is an engaging experience for rowers, coaches, and visitors as it displays the energy produced and achievements earned by the rowers during training sessions and conditioning.
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1.0 Background
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1.1 HISTORY OF ROWING

Rowing is a historical sport that first originated as a form of punishment when the Vikings forced patrons to row as a form of transportation over seas. The racing aspect of the sport did not begin until the early 1500s when ferrymen of England competed in duals against other local taxi waterways. The sport has evolved from service of warfare and transportsations into an athletic hobby and passion.

Rowing, also referred to as crew, is both a club and competitive sport that continuously stretches the physical and mental limits of athletes both on and off the water. Each team is unique in their coaching, rowing technique, and goals that encourages success and teamwork. However, each crew has a boathouse. A boathouse plays a crucial role in the sport of rowing since it provides shelter to the team’s expensive rowing equipment and serves as a focal point to showcase awards and accomplishments.

1.2 ROWING ON THE SCHUYLKILL RIVER

The Schuylkill River is widely known for its passion and love of rowing. The proof of adoration for rowing on the Schuylkill River can be seen in Thomas Eakins’ nineteenth century paintings such as Max Schmitt in a Single Scull (1871), Biglin Brothers Racing (1872), and The Oarsman (1874). Philadelphia-born, Thomas Eakins completed twenty-four painting relating to rowing and even participated in the sport himself. Eakins lived an avid amateur rowing career and obtained his rowing knowledge of the physical efforts required for the sport through his own participation in crew. The paintings express his affection towards the sport. Eakins involvement in the sport inspired his artistic career focused on precision, form, and human figure.1

Aside from local artists, the Philadelphia’s infamous Boathouse Row is an architectural feature that supports rowing along the Schuylkill River. Boathouse Row is a compilation of fifteen Victorian-style boathouses for local area rowing clubs and surrounding universities, most of which are associated with the Schuylkill River Navy. Each boathouse has its own history, but all occupy addresses 1-15 of East River Street on the east side river shore of the Schuylkill River.

1.3 HISTORY OF KELLY DRIVE

Kelly Drive is a historic road located on the East side of the Schuylkill River. The roadway was named after a famous Philadelphia oarsman: John Brendan Kelly, Jr., also known as Jack Kelly. Jack Kelly was a four-time Olympian, eight-time United States National Champion, and was awarded the top amateur athlete in the United States, James E. Sullivan Award, in 19472. Jack Kelly competed in the single scull (1x) event in the following Summer Olympics: London (1948), Helsinki (1952), Melbourne (1956). Kelly also represented in the United States at the Summer Olympics in Rome (1960) in the double scull (2x). Kelly is well known

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1.0 Background

rowing and was inducted into the Olympic Hall of Fame.

Having the east side transportation route named after Jack Kelly illustrates the passion and appreciation Philadelphia has for rowing, no matter the level of athlete.

1.4 DAD VAIL REGATTA

Philadelphia’s passion for crew can also be seen at the Aberdeen Dad Vail Regatta, an annual spring, sprint race of two thousand meters. The Aberdeen Dad Vail Regatta is the largest intercollegiate rowing competition in the United States. The regatta was originally founded in 1934 by the University of Pennsylvania’s rowing coach, Rusty Callow, “Rusty” to serve as a race for amateur crews. Rusty named the regatta after Harry Emerson “Dad” Vail, an early twentieth century coach from the University of Wisconsin-Madison, an individual who encouraged rowing to all.

The original Dad Vail Regatta was held between four crews: Marietta, University of Pennsylvania, Rollins College and Rutgers. Manhattan and Wisconsin joined racing five years later. However, it was not until architect, Lev Brett, helped to establish the Dad Vail Rowing Association, that the regatta crew was able to host hundreds of crews.

Today, the regatta hosts 150 different crew teams of 3,000 competitors along with thousands of fans and spectators. The six lane, two thousand meter annual race is held on the Schuylkill River in Philadelphia’s Fairmount Park. The race experience is a memorable part of each participants career.
2.0 Introduction
2.0 Introduction

2.1 PROJECT BACKGROUND

The Watt Community Rowing Center (WCRC) is a community-oriented boathouse design whose mission is to achieve positive change on the Schuylkill River focused towards energy efficiency and sustainable design. WCRC will accommodate Temple University, supporting the growth and achievements of its collegiate men and women’s rowing team.

The design of the WCRC is modeled after the eight-man heavy weight race (8+). Just as the 8+ is the blue ribbon event, as it draws the most attention and is prioritized by most teams, the WCRC will mimic the blue ribbon idea, but in an architectural fashion. As there are eight rowers in the 8+ event, there are eight main project goals:

1. Promote sustainability within and surrounding the proposed boathouse design.

2. Determine efficacy and feasible use for energy produced by rowers.

3. Maintain views and access to the river for both rowers and spectators.

4. Promote mobility through site and building design.

5. Draw the attention of the local community to sustainability and rowing through architectural features.

6. Visual attractiveness that mimics both the sport and the encompassing biological environment.

7. Facilitate rowing needs year round.

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2.0 Introduction

8. Create a unique boathouse design to serve the Dad Vail Regatta.

2.2 ARCHITECTURAL PROBLEM & CURRENT EVENTS

In December of 2013, the Temple University crew teams were informed rowing would be cut from university sports from the lack of funding to build a new boathouse. Before this time, the Temple University crew teams were rowing out of the East Park Canoe House, which was condemned in 2008. From 2008-present, the teams rowing shells are housed in two temporary fabric structures. This situation is not appropriate for the sport of rowing, but the Temple University crew teams felt they would rather be supported by temporary architecture than have their sport cut altogether.

Temple University current team members and alumni brought public attention to what they felt was an unjust situation. The student-athletic body began a petition to prove to the university their support and willingness to endure the challenges they sought before them. The athletes believed that their commitment to Temple could not be overlooked. The rowing team’s relentless pursuit to better themselves and their teammates was recognized by Temple University board of trustees, when they voted to keep the men’s and women’s rowing teams in February 2014. The team will be supported through funds from Gerry Lenfest: Lenfest Foundation and the City of Philadelphia. These financial efforts will be used to construct a new home for Temple crew.

2.3 PROJECT VISION

WCRC provides a foundation for the creation of sustainable strategy and energy reuse. The kinetic energy generated by rowers during indoor rowing conditioning on Concept 2 rowing machines will be converted into electrical energy. This energy will be recycled back into the grid to help offset costs and energy consumption used to support the boathouse and Dad Vail Regatta. Energy will be produced in a collaborative environment with a task force of stakeholders provided by the Philadelphia rowing community and Temple University rowing athletes. The WCRC sets a blueprint for a bright future on its historical and scenic river site. It is intended for this architectural piece to benefit the city, Temple rowing, as well as set a new trend in athletic architecture and sustainability.

2.4 PROJECT MISSION

This thesis focuses on the dimensional requirements for rowing and coaching, while maintaining energy efficiency to support a sustainable design solution. WCRC will develop a distinct design character that draws attention to its form and function. The functional design approach will encourage physical determinism and energy efficiency. The built environment influences social behavior, promotes activity in and around the proposed architecture, and set a new standard for future generations, and athletic design. Rowing is a unique sport with many participants globally, who serve as a potential viable energy source. The WCRC aims to set new standards in architecture by:
2.0 Introduction

• Re-examining human needs and set appropriate goals which prioritizes a synthesis between the built environment, biological environment and athletics.
• Rethinking the basic nature, methods, and goals of the design process itself.
• Integrating knowledge from other fields concerned with human and ecosystem health.
• Introducing new technologies, systems of production and construction methods that do not rely on natural capital, fossil fuels, and harmful chemicals.
• Promoting human activity, occupant participation, and environmental health.
• Recycling or repurposing local material resources to evoke forms seen in the sport of rowing.

The WCRC project mission standards will compliment and achieve the eight projects goals.
3.0 Feasibility Study
3.0 Feasibility Study

3.1 PURPOSE

The purpose of a feasibility study is to evaluate the practicality of the proposal of a new training center and boathouse along the Schuylkill River in Philadelphia, Pennsylvania. The structure will occupy a vacant lot within Philadelphia’s established recreational zone and work within the existing boundaries of the site. This study focuses on how power generated from athletes can be converted and used to help offset costs related to electricity via recycling energy to the grid.

3.2 EXECUTIVE SUMMARY

Temple University joins many surrounding area universities in bringing recognition to the sport of rowing in Philadelphia, PA. Philadelphia is one of few cities in the United States that can support the physical and geographical setting suitable for rowing. The city of Philadelphia has illustrated its attraction to the Schuylkill River and continues to support rowing. This can be seen in the fifteen Victorian style boathouses that support public and private rowing uses off of Kelly Drive on the eastbound side of the Schuylkill River. The establishment of this rowing community is commonly recognized by Boathouse Row.

The addition of a new boathouse, supporting Temple University men’s and women’s rowing team, will add character to the physical presence and rowing tradition on the Schuylkill River. The site for the proposed boathouse will be located just north of Boathouse Row. The structure will add to the genesis of the Philadelphia rowing community. The proposed architecture will be sustainable, functional and logical for support of Temple University rowing and the surrounding area rowing community.

3.3 PROGRAM

The proposed boathouse will serve the University of Temple Men’s and Women’s crew team. The team’s current population, including novice and varsity rowers, is 93 athletes. The team varies in numbers on an annual basis, but averages this size.

The ideal building program will include: a secure entrance, reception area, flexible conference space, lounges, boat storage, indoor rowing tanks, a training facility, locker rooms, athletic trainers, spectator viewing platforms, and offices. Support spaces include bathrooms on each floor, mechanical space, and general storage. All spaces will included sufficient circulation.

To facilitate this program within the constraints of the site, 220 Kelly Drive, approximately 20,000 total square feet are estimated to be required. This footprint was estimated based on research completed and case studies described later in this document.

3.4 COMMUNITY

Every piece of architecture plays a vital role within its community. The WCRC will serve the Philadelphia community through sustainable design and practice. The structure will occupy part of Fairmount Park. The City of Philadelphia requires that the boathouse either contribute to the city in a positive way or add additional greenscape with a 1:1 ratio of the area occupied. The
3.0 Feasibility Study

WCRC will allow community access with learn-to-row programs for inner city school districts, physically disabled and amateurs, providing service to the community. The design of the WCRC will also provide a suitable and functional design for its occupants. As a former rower and current rowing coach, I am very familiar with the rowing architectural needs as well as necessities that output successful crews. Rowing, like most sports, demands a specific architectural program for storage of equipment, adequate training areas, conference space, and riverfront access. Since the sport uses equipment that is very long and obtuse, the architectural solution needs to accommodate this equipment and provide appropriate methods for circulation.

3.5 DESIGN FOR SUSTAINABILITY

The current conditions in which we live have expressed change in our environment from previous decades due to expansion and an unmonitored consumption of goods. To name a few, these negative changes include: ozone depletion, acid rain and global warming. It is unfortunate that development and construction of built environments have negatively contributed to these harmful environmental factors. Today, as an inspiring architect, it is necessary to pay attention to environmental degradation and encourage the notion of ecological sustainability and responsible design.

“In designers are potential change agents, whose decisions can constrain, alter, guide or enhance the future decisions of others.”

In agreement with Birkeland, architects can aid in promoting sustainability through green incentives and design decisions.

3.6 THE SIX S’S

Sustainability needs to be incorporated within the built environment in the early phases of the design process. This thesis will explore Duffy and Grand’s Six S’s (below) to help generate a design solution that reduces energy demands while enhancing the quality of life.

“The adaptive building has to allow slippage between the differently-paced systems of Site, Structure, Skin, Services, Space Plan, and Stuff. Otherwise the slow systems block the flow of the quick ones, and the quick ones tear up the slow ones with their constant change. Embedding the systems together may look efficient at first, but over time it is the opposite, and destructive as well.”

Capitalizing on Frank Duffy’s “four S’s for commercial buildings”, Brand himself revises the four S’s into six S’s that can be designated to buildings in general: Site, Setting, Structure, Skin, Services, Space Plan, and Stuff. Each piece of the equation is interdependent to one another. Since change is inevitable, design must learn to adapt.

3.7 SITE

WCRC will be located on the east side of the Schuylkill River near Peter’s Island. The site is currently a vacant lot, part of Fairmount Park. The Schuylkill River trail winds through the untamed grassland. Having been to the site myself, it is not uncommon to see litter floating through the site on any given day. The construction of a new boathouse will add an attraction to this site and develop the surrounding area with a more scenic running route and

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3.0 Feasibility Study

FIRM FLOOD PLAIN MAP, FEMA

Figure 2  FIRM of Kelly Drive
http://fema.gov
active exhibits that will engage Philadelphia’s community in physical activity and sustainable awareness. The site will serve as a gateway for communicating sustainable design by illustrating energy conservation and efficiency. Essentially creating an iconic piece of architecture.

Since the site is located adjacent to the river, potential flooding is a risk. An initial assessment was completed to determine floodplain elevations of the site. The current site is located with the 100-year floodplain, and is part of the flood risk Zone AE: High-Risk Flooding (FEMA). Through conversation with the City of Philadelphia zoning officials and using the Flood Insurance Rate Maps (FIRM) produced by the Federal Emergency Management Agency (FEMA) it was determined that the site is high enough above sea level where flood proofing is not a concern. Fig. 2 (above) illustrates the flood risk for the site, with section L (Fig. 3). According to the documents, the base floodplain elevation for the site is 25.29 feet. However, the current conditions of the river and man-made retaining walls are built to support a flood of thirty feet above sea level, exceeding the 100-year floodplain by nearly five feet.

3.8 STRUCTURE

Watt Community Rowing Center (CRC) will be designed using a combination of engineered lumber with steel structure. This structure promotes maneuverability and functionality to the interior floor plan as it eliminates the need for interior columns and allows for a greater span. Steel is a wise choice as it is made out of 70% recycled content. All materials will be obtained from within in 500 miles of the site to promote sustainability and obtain...
### 3.0 Feasibility Study

Concrete will also be used in the design to help support and distribute mass. Adding to its bearing strength, concrete is desirable for its environmental and performance qualities and contributions towards sustainable construction. Concrete is 100% recyclable and can be made from local, inert material, reducing greenhouse gas emissions from transport. Concrete also has a high thermal mass, allowing for passive solar and heating strategies to be explored.

#### 3.9 SKIN

The skin of the WCRC will provide a graceful building facade that uses reclaimed lumber to represent oar handles and mimic the surrounding treescape.

**Roof System:** The roof will provide an elegant geometric form that breaks outside of the box of the flat roof. The shape will serve as an aesthetic function that peaks interest in the surrounding area community interest, supporting the idea of an inviting public space. The roof form will be composed of aluminum paneling, glue laminated timber, plywood, and insulation (R-38 TO R-60 [energystar.gov]).

**Window Systems:** Windows are triple pane insulated glass units and will be thermally broken to protect against seasonal heat loss or gain. Curtain walls, with similar properties, are located at the east and west elevations of the training facility to promote views to the river. Upper level clerestory located in the indoor rowing tanks and boat bay allow for natural light to illuminate interior spaces, a passive solar strategy.

### 3.10 SERVICES

Various services will be provided to the boathouse including utilities (gas and electric) and access to public transportation and the waterway. All of these services are necessary for operable function and mobility to please architectural and community needs. Specific services will include: doors, bathrooms, elevators, heating, ventilating, and air conditioning (HVAC), plumbing, fire protection, electrical, telephone, and a security system.

### 3.11 SPACE PLAN

Rowing equipment requires strict spatial planning. When planning interior spaces, the following dimensional requirements need to be kept in mind, at a minimum, for rowing specific equipment:

- **Shell:** Racing shells come in a variety of lengths supporting anywhere from one up to eight rowers. Boat lengths range from 27 feet up to 62 feet. Boats are stored horizontally, but are stacked up to six boats high with 3 feet of clearance between each rack height and eight foot bays in between each rack.
- **Oars:** Oars are stored vertically to avoid damage and promote organization. Although there are two variations of blades, port and starboard, the length of each sweep oar is roughly the same, 12 feet.
- **Erg:** An erg is an indoor rowing machine. Each machine requires a clear floor space of 2 feet by 8 feet.
- **Tanks:** Tanks are current pools that allow rowers to train indoors when outdoor rowing is not feasible. Tanks need to accommodate a minimum of
3.0 Feasibility Study

- eight rowers, creating a floor area of 8 feet by 60 feet with adequate room between each tank that promotes mobility of coaches and rowers.

3.12 STUFF

Rowing has a lot of extra “stuff.” Whether it is a nut and bolt holding a rigor onto port side, coxswain speed coaches, bow numbers, or the first aid station, it is crucial that added thought be paid attention to all of these “extras” to maintain organization and mobility. As Coach Jim, the head rowing coach at the Rochester Institute of Technology says:

“A clean boathouse is a fast boathouse!”

3.13 THE BIG GREEN IDEA

Rowing for power, can it be done? The answer is yes. Preliminary studies have been conducted to determine the realistic amount of energy a team of rowers can be expected to pull annually. The results were determined based on the current population of the Temple crew team and existing methods of harvesting human energy from indoor rowing machines. Current systems for harvesting energy roughly generate half of the watts a rower is producing during a workout. The energy lost from input to output happens during energy transfer from system to system, this can be seen in the illustration below:

3.14 SUMMARY

The Six S’s provide a informative guideline that promotes sustainable design decision making. By applying the Six S’s to the architecture design process, passive and active strategies can be explored through both design and human efforts. The application of the Six S’s in the early design phases helps achieve efficiency within and surrounding the new structure.
4.0 Rowing for Power
4.0 Rowing for Power

4.1 CONCEPT

If you are an athlete you have probably found yourself thinking “Wow! How great it would be if the energy I am producing during this workout could power this gym!” or similar thought. Well, the inspiration behind this thesis is exactly that. Watt Community Rowing Center uses athletes as a sustainable tool for success of an energy efficient boathouse. Rowing for Power represents a synthesis between architecture and athletics through fluid and mechanical rhythm. Creating a design that leaves a sustainable footprint where high-performance athletes yield high-performance architecture incorporating energy efficiency, transparency and mobility.

4.2 SUBJECT

The experimental investigation was completed using the current population of the Temple Crew team, 93 athletes. This population is composed of both men and women, all of which are competitive, collegiate rowers. The following analysis assumes that all athletes row six out of seven days of the week on an annual basis with workouts consisting of or similar to wattage output listed below:

**TYPICAL ROWING WORKOUTS BY SEASON:**

- **Fall:** (12 weeks) daily 10 minute warm-up, weekly 6k testing
- **Winter:** (16 weeks) daily 10 minute warm-up, weekly 2k testing, daily long-distance piece
- **Spring:** (10 weeks) daily 10 minute warm-up, weekly 2k testing
- **Summer:** (14 weeks) daily 10 minute warm-up, weekly long distance training

Four categories were developed to illustrate the different rowing seasons, directed towards the distance the team is training for at any given time throughout the year. Erg workouts may be flexible and have the opportunity to change, but the experimental calculations were based on maximum potential based on the watt average during certain erg workouts.

Average wattage during these workouts were documented through my own personal training, RIT 6k testing results and through various workouts completed by McQuaid crew, where I am a current coach. All results were documented in spreadsheet form to determine average wattage achieved during a specific workout. Figure 7, below, is a graphic representation of average watts achieved during various workouts.

4.3 SYSTEM EFFICIENCY

In order to convert athletic gait, which in this scenario is a rower erging, into usable electrical energy, an alternator must be applied to the erg to convert mechanical energy to alternating current (AC). There is an assumption of sixty percent efficiency, from the initial chemical energy produced by the rower on the erg who generates kinetic energy released by the flywheel and transferred to the alternator (Jai Juneja). This system of energy transfer can be seen in Figure 5, below. The sketch illustrates how the energy transfer will occur from its origin, rower, to end product or reuse. Current systems that convert the kinetic energy applied to the flywheel, by the rower, require and alternator since the energy
4.0 Rowing for Power

applied is not constant, such as running on a treadmill or biking on a spinner. Rather, the energy applied to the flywheel is a surge of energy that generates a peak in wattage (fig. 6), there for an alternator is needed to help generate a constant flow of energy or alternating current (AC). (Alternators may also be referred to as AC generators.) Since house hold items powered by electricity use AC power, the energy may be recycled back to the grid for reuse after it is applied to an alternator.

4.4 GRID VERSUS BATTERY

Battery System: Rower - Flywheel - Alternator - AC/DC Converter - Battery - Inverter - Use
Grid System: Rower - Flywheel - Alternator - Use (Fig. 5)

Converting energy from a rower to battery storage requires additional equipment and technologies that decrease system efficiencies. In a battery storage system, transferring chemical energy from a rower to AC power for reuse is a seven-step process rather than a four-step process before reuse. In a battery system, the power needs to be converter from AC to DC power and then inverted an additional time back to AC power for reuse. Although battery efficiency is quite high, some energy is still lost between power transfer between systems. In a erg-to-outlet system approach where energy is stored in batteries, the system efficiency is 45% whereas the efficiency of recycling energy to the grid is 60%. The efficiency was calculated using the following assumptions:

- Alternator: 60%
- Battery (storage): 90%
- Inverter: 85%
- Losses due to friction: negligible

(Based on research found in a magazine, Bang!, printed by the University of Oxford.1)

In addition to decreased efficiency, a battery system requires on-site local storage. For the amount of energy being generated on a team-effort level and the current footprint of the proposed boathouse, it was deemed a disadvantage to increase building square footage for a decreased amount of energy. A battery storage system would increase total building costs and would require the team to put added costs into a battery storage unit for on-site storage. Recycling energy back to the grid allows for improved efficiencies, but also has trade offs since one has to buy the energy back at a discounted price. However, system efficiency was prioritized in this solution over economic costs.

4.5 RESULTS

Rowing for power, can it be done? The answer is yes. The following results were determined based on the current population of the Temple crew team, 93 athletes, and existing methods of harvesting human energy from indoor rowing machines. Current systems for harvesting energy roughly generate half of the watts a rower is producing during a workout. The energy lost from input to output happens during energy transfer from system to system, this can be seen in the illustration pictured to the

4.0 Rowing for Power

The width of each column represents the time and wattage achieved during each rowing workout previously specified. The total watts produced is graphical represented with the total bar length. However, the amount of usable energy that is effectively transferred to the grid is highlighted with cyan.

1. Rower (Chemical)
2. Flywheel (Kinetic)
3. Alternator (Electrical)
4. Grid Transfer
5. Reuse

Conceptual sketch of Erg-to-Outlet.
WATTS GENERATED DURING TIME
SPECIFIC ROWING WORKOUTS

Figure 7  Erg Energy Transfer Graph
4.0 Rowing for Power

EFFICIENCY RATE OF WATTS OBTAINED

<table>
<thead>
<tr>
<th>Distance (meters)</th>
<th>Power (watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 watts</td>
<td>10 min warm-up</td>
</tr>
<tr>
<td>60 watts</td>
<td></td>
</tr>
<tr>
<td>160 watts</td>
<td>90 min steady state</td>
</tr>
<tr>
<td>96 watts</td>
<td></td>
</tr>
<tr>
<td>180 watts</td>
<td>30 min steady state</td>
</tr>
<tr>
<td>108 watts</td>
<td></td>
</tr>
<tr>
<td>205 watts</td>
<td>6k test</td>
</tr>
<tr>
<td>123 watts</td>
<td></td>
</tr>
<tr>
<td>225 watts</td>
<td>10 min ladder</td>
</tr>
<tr>
<td>135 watts</td>
<td></td>
</tr>
<tr>
<td>250 watts</td>
<td>2k test</td>
</tr>
<tr>
<td>150 watts</td>
<td></td>
</tr>
<tr>
<td>400 watts</td>
<td>500 m test</td>
</tr>
<tr>
<td>240 watts</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8  Erg Energy Transfer Graph

WATTS PRODUCED BY ROWER:

AVERAGE ENERGY OUTPUT PER ROWER

22.85 kWh/year

Figure 9  Output of Energy by Rower and Team

AVERAGE ENERGY OUTPUT PER TEAM

2124.6 kWh/year
4.0 Rowing for Power

NET ENERGY CONSUMPTION OFFSET DIAGRAM

The average US home uses 10,837 kWh annually.*
*United States Energy Information Administration (EIA)

Figure 10a  1:1 Ratio Using Average Size Home in the United States

Figure 11a  Erg Energy Transfer Pie Chart

NET ENERGY PIE CHART WITH ELECTRICITY BREAK DOWN
4.0 Rowing for Power

NET ENERGY CONSUMPTION OFFSET DIAGRAM

The training center will use approximately 22,125 kWh annually.*
*Based on DOE High Performance Commercial Buildings.

Figure 10b 1:1 Ratio Using Average Size Home in the United States

Figure 11b Erg Energy Transfer Pie Chart

Watt Community Rowing Center
Allison Marie LaChance
4.0 Rowing for Power

4.6 CONVERSION

\[ \text{kWh} = \frac{\text{W} \times \text{hr}}{1000} \]

4.7 DETERMINING AN IDEAL USE

The energy produced by rowers will be recycled back into the grid to help offset energy costs of the boathouse and Dad Vail Regatta. Info-graphics will be used in and around the facility to illustrate the amount of energy the rowers, as a team, have generated. Wayfinding and outdoor exhibit parks will create public interest and encourage community engagement both at the mini-park locations as well as the Watt Community Rowing Center. This method was determined to be the most effective design solution compared to on-site local battery storage due to the oversized cost and architectural requirements associated with this method for energy storage. Energy produced during workouts will be visually transparent to patrons through imagery to promote sustainable awareness.
5.0 Code Analysis
5.0 Code Analysis

5.1 ZONING ANALYSIS

During the design process, it was important to complete a zoning code analysis to determine the appropriate building location, size and function. The following data was obtained through the City of Philadelphia interactive web resources for zoning code and through direct communication with current zoning code officials.

ZONING DISTRICT
SP-PO-A: Active Parks and Open Space (Special Purpose)

PERMITTED USES
Natural Resource Preservation, Passive Recreation, Active Recreation, Libraries, and Cultural Exhibits, Accessory parking, childhood daycare, underground basic utilities and services.

Current zoning conditions pose a unique situation. The City of Philadelphia mandates, that although the site has a determined zoning district, it must follow the most stringent neighboring zoning district. In the case of 220 Kelly Drive, the most stringent adjacent zoning district is I-3 or Heavy Industrial.

ZONING DISTRICT
I-3: Heavy Industrial

PERMITTED USES
Caretaker Quarters, Passive Recreation, Active Recreation, Safety Services, Storage Facilities, Vehicle Repair and Sales, Animal Services, Building Supplies and Equipment, Medical Office Suites, Commercial Sales, Artist Studios, Community Gardens and Green-houses.

SITE LIMITATIONS
Max. Occupied Area: 100%
Min. Front Yard Depth: 0 Ft.
Min. Side Yard Width: 6 Ft
Min. Rear Yard Depth: 8 Ft
Max. Height: 60 Ft.
Max. FAR: 500%
New construction of a two-story boathouse to be used for institutional and public purposes on the east-side of the Schuylkill River in Philadelphia, Pennsylvania. This structure will be shared amongst Temple University and the surrounding area rowing community. The International Building Code (IBC 2009) was used, and determined the use of the building to be assembly, (A-3).

**5.0 Code Analysis**

**5.2 BUILDING CODE ANALYSIS**

New construction of a two-story boathouse to be used for institutional and public purposes on the east-side of the Schuylkill River in Philadelphia, Pennsylvania. This structure will be shared amongst Temple University and the surrounding area rowing community. The International Building Code (IBC 2009) was used, and determined the use of the building to be assembly, (A-3).
6.0 Case Studies
6.1 Fontana Boathouse

Year Built: 2008
Location: Buffalo, NY
Architect: Frank Lloyd Wright

Fontana Boathouse was originally designed for the University of Wisconsin by Frank Lloyd Wright but is now located in Buffalo, New York. The Fontana Boathouse was the only boathouse designed by Frank Lloyd Wright and is one of his most prized designs (Holzhueter, 273). Fontana Boathouse has large vertical piers that are used to support horizontal planes seen in the facade design (fig. 13). Wright's design found its home in 2007 on shore side of the Niagara River where it meets Lake Erie. The site neighbors the Westside Rowing Club, a popular rowing club in Buffalo.

Wright's design focuses on a modular and functional approach to what a boathouse should be. However, the door widths are not practical for boat maneuverability, as rowers have to tilt the boat sideways when entering and exiting the boathouse. Wright was aware of this problem, but was too stubborn to change his design. Otherwise, the floor plan focuses directly towards practicality and successfully organizes interiors, developing spacial hierarchy within interior spaces. The first floor is an open boat bay, housing community rowing shells. Mean while, the second floor houses all gathering spaces: locker rooms, conference rooms and second-story observation deck for uninterrupted views to the river.

Today the structure is actively used by the rowing community and surround area of Buffalo for public events and regattas. The structure serves as an architectural attraction
6.1 Fontana Boathouse

and joins Wright’s other pieces of art in Buffalo, such as the Martin House and Larkin Building.

Architectural features in Wright’s design of the Fontana Boathouse that inspired similar design executions at the Watt Community Rowing Center include:

• Exterior observation deck (fig. 15)
• Second Story Locker Rooms (fig. 16)
• Clean modern design
• Functionality
• Accommodation for community use and building reservation for events
6.2 Devon Boathouse

Year Built: 2010  
Location: Oklahoma City, OK  
Architect: Rand Elliot, Elliot & Associates Architects

Devon Boathouse is part of the Oklahoma City University and serves as the headquarter for the OKC National High Performance Center. This training center provides water access to all community members and provides an area for Olympic hopefuls for rowing, kayaking and canoing. The structure occupies a continually growing riverfront project and new series of boathouses erecting from the Oklahoma River.

The 33,000 square foot facility offers training tools for both elite rowers and amateurs (Elliott + Associates). The facility is open year-round with indoor, sport specific equipment including rowing tanks, laps pools, high altitude training, a variety of cardio machines, and weights. Aside from the training room and conditioning access, teams are granted locker rooms, boat storage and a boat repair area. Public spaces include rooms for reservation, group meetings, and catering facilities.

The first floor of the Devon Boathouse is organized to incorporate boat storage, training, rowing tanks, event rooms, kitchen, storage, toilets and mechanical space. The second floor includes an observation room, balcony, aerobic and weight training, lockers, offices, and galleria space.

The minimal use of finishes and materials, in combination with modern form create a unique architectural character for the Devon Boathouse. Polycarbonate walls and expansive windows allow natural light to flood the two-story boat bay and Ann Lacy Event Center as well as increase transparent views to the river.
6.2 Devon Boathouse

Dramatic, blue LED lights (fig. 21, 22) accent the exterior form of the facade during non daylight hours. Rowers find this a fascinating add-on and form of identification from the river, since that is where most rowers are able to identify their home. The light reflects into the river waters making a clearly identifiable structure for the teams during early morning training sessions. The light encompasses the river corner of the structure as it breaks the edge of the river bed and penetrates river front with a dominant architectural feature (Elliott + Associates).

The transparent design elements seen in the Devon Boathouse serve as a great inspiration for the Watt Community Rowing Center.
6.3 Harry Parker Boathouse

Year Built: 2008
Location: Brighton, MA
Architect: Anmahian Winton Architects

Harry Parker Boathouse supports Community Rowing, Inc. (CRI) on the famous Charles River, which feeds most crews in Boston, Massachusetts. The rowing facility consists of two structures, a boathouse and glass pavilion.

The Harry Parker Boathouse supports all levels of rowers including inner-city programs, Row Boston, and Adaptive Rowing for the physically disabled.

The main building’s skin is constructed using phenolic resin wood composite panels (right). The material is lightweight and gives the exterior facade a natural feel to help off-set the technicality of fully functional, operating building skin. The resin panels operate as louvers and open up to naturally.

http://aw-arch.com
6.3 Harry Parker Boathouse

Ventilate interior spaces. The louver system serves as an energy efficient design solution that accents the similar design elements found in the body mechanics of rowers. The skin in divided into four bay to allow for overhead balconies (fig. 25).

The project area is roughly 30,000 square feet that now occupies a once neglected narrow strip of river front property. The boathouse was built in efforts to positively impact the urban neighborhood in which it is located and the surrounding rowing community. Since the boathouse has opened, the rowing population of CRI has nearly doubled.

The Harry Parker Boathouse applies geometries of rowers directly to architectural form. The poetic and programmatic nature of the Harry Parker Boathouse inspires the same concept in the Watt Community Rowing Center. Both architectural pieces are expressive forms relating to their purpose.

The Ruth W. Somerville Sculling Pavilion is a marvelous structure that houses sculling shells. The pavilion houses community rowing shells in a unique, yet elegantly simple structure. The transparent boathouse draws attention from many patrons since it is a drastically different approach to the surrounding historic architecture found on the Charles River.

"The architecture of the exuberant new Community Rowing Boathouse in Brighton is such a joy. This is a building that is happy to look, fresh, new, democratic and up-to-date… This is one of the best new pieces of architecture in Boston."

Robert Campbell, FAIA

Boston Globe
6.4 WMS Boathouse at Clark Park

Year Built: 2013
Location: Chicago, IL.
Architect: Jeanne Gang, Studio Gang Architects

WMS Boathouse at Clark Park supports a diverse group of high school rowing in Chicago, Illinois as part of the Chicago Rowing Foundation mission. The WMS Boathouse is located on the Chicago River and is part of the city’s plan to make the river a usable resource as the mayor believes it is “the city’s next recreational frontier” (Kamin).

The WMS Boathouse is a pair of buildings. The one-story shed building houses the rowing shells and rental canoes. Another two-story building serves as a field house with an ergometer room and indoor rowing tanks. The field house also provides offices for coaching staff and a community room for various functions and social gatherings. Gange, project architect, separates the buildings into two separate structures since the boat bays did not require heating or cooling. The opening between the two structures creates a piazza and maintains views to the river from the road.

The WMS Boathouse uses V and M shaped roof trusses that create a jagged roof profile and unique interior and exteriors perspectives. The roof forms generate a
6.4 WMS Boathouse at Clark Park

poetic momentum that express the rowing nature (Kamin). The inverse roof trusses allow southern light to warm floor slabs during winter months. During summer months, these same windows serve as points for ventilations to help minimize energy use. The 22,620 square foot rowing complex also incorporates other uses sustainable design practices such as rain gardens and permeable concrete, which direct water back to the river to avoid flooding.

The WMS Boathouse was an influential case study for the Watt Community Rowing Center. Gang’s design was executed effectively at a sustainable scale with minimal design accessories. The synthesis amongst design and functionality is evident and an important observation for a young architect to witness the effectiveness of and appreciate.
6.5 University of Kansas Boathouse

Year Built: 2009
Location: Lawrence, KS
Architect: Treanor Architects, Peterson Architects

University of Kansas Boathouse was designed with collaborative efforts from Treanor Architects and Peterson Architects. The boathouse is located on the Kansas River in Burcham Park in North Lawrence. Lawrence is known as the River City and a developing recreational area in Kansas.

The boathouse was designed to mitigate waters during periods of flooding, common for its location. Strategic design solutions were followed in accordance to the Federal Emergency Management Agency (FEMA) regulations. These design strategies included pier foundations to the bedrock below and porous concrete. Other materials and finishes were chosen based on their cleaning friendliness.

The building was strategically located on site to allow for increased open park space and reduce the number of trees that would need to be removed for construction.

The floor plan was designed to provide scenic views to the river. This significant architectural feature can be seen in the second story of the building as it appears as a glass box floating on top of the boat bays. The second story is protected and shaded by a large roof overhang.
6.6 Beckwith Boathouse

Year Built: 2009  
Location: Iowa City, IA  
Architect: Neumann Monson Architects

Beckwith Boathouse is home to the largest women’s sport at the University of Iowa, and is located on the Iowa River. The 20,000 square foot boathouse was the first Leadership in Energy and Environmental Design (LEED) certified building on the campus of University of Iowa. The boathouse achieved LEED Gold in 2009.

Beckwith boathouse incorporates numerous sustainable building construction strategies to promote green design. Local building material were used during construction with high recycled content. Geothermal heat pump system and daylight harvesting

The Beckwith Boathouse was designed to withstand flooding. The design incorporated flood mitigation strategies, moving mechanical and electrical systems to the second floor. The design also uses flood friendly materials and finishes in case of a flood.

The floor plan includes four boat bays, locker rooms, training rooms for erging, indoor tanks, collaboration space, and offices for collegiate and club rowing. The architecture firm worked independently with the university to design a tank that allowed a stronger current to pass the current pools. Having a stronger current flow through the tanks creates a feasible and appropriate condition for indoor training, therefore training is not limited to technique only.
Robert B. Tallman Rowing Center

Robert B. Tallman Rowing Center is located in Ithaca, New York and serves both men’s and women’s Ithaca College D3 rowing teams. The rowing center of 8,500 square feet, reuses the same lot the Haskell Davidson Boathouse once occupied. Uniquely, the coaching staff worked closely with the architects to communicate team needs and promote functionality. The boathouse is equipped with three boat bays and a heated workshop area to store the necessary epoxy and paint needed for boat repair. (This is a crucial design element for competitive crews. Boats that can be fixed in-house save time, since the boat does not have to be transported to and from the manufacturer for repair.) The roof line allowed for a 1,200 square foot, multi-purpose mezzanine. The space is used for presentations, small conference meetings, training space, added storage and balcony (fig.42). Interior spaces are also occupied with locker rooms, coaching offices and a senior lounge. Awards, donor appreciation, and training equipment are placed sparatically throughout.

The slab on grade boathouse is equipped with radiant heating and increased insulation to illustrate just a few sustainable design practices seen in a walk through. The cedar shingles and stonework of the exterior create an architectural form that essentuate rowing fashion and style. Holt Architects broke the linearity of the boathouse with an eyebrow window, that creates a wave on the roof line on the riverside elevation.
6.7 Robert B. Tallman Rowing Center

The Robert B. Tallman was an influential design on the Watt Community Rowing Center from its attention and appreciation to sustainable design efforts. Although the client and architect did not pursue LEED certification, due to high costs, the building was still built in a sustainable manner. Holt used local materials and finishes that were high in recycled content, passive solar gain, increased insulation, and active radiant heating to promote a clean environment for the athletes.
7.0 Literature Review
### 7.0 Literature Review

#### 7.1 INTRODUCTION

The scholarly articles researched, in combination with design trends written in commonly viewed architectural magazines, provide a general understanding of what current methods for harvesting human energy currently exist and current trends in architectural, sustainable design solutions. The texts explored deliver an above average understanding of energy systems and sustainable design strategies. The authors are able to digest scientific and artistic language into comprehensive terminology effectively. Various methods of scavenging energy were researched including piezoelectric, electrostatic, electromagnetic, and kinetic energy systems to determine the best sources for harvesting human energy from rowers. Some systems are more recent, such as piezoelectricity (Shenck & Paradiso, 2001) and pose as battery/generator free, durable harvesting system. While other systems such as electromagnetic and kinetic energy systems (while obvious) need not be forgotten and should still be considered for design integration.

#### 7.2 EXISTING SUSTAINABLE ENERGY SYSTEMS

**“Human Powered MEMS-based Energy Harvest Devices” (Chung-Yang Sue & Nan-Chyyuan Tsai, 2012)**

Chung-Yang Sue and Nan-Chyyuan Tsai’s article focuses on how to harvest human energy to power implant biomedical devices (IMDs) used for diabetes, heart disease, colon cancer and other chronic diseases. These devices include technologies such as pace-makers, glucose monitors, insulin pumps and other IMDs. The article provides a lot of useful information that can be applied to other mechanical systems. According to their citations from Starner and his article “Human Generated Power for Mobile Electronics” a person weighing 68 kg (150 lbs.) with 15% body fat stores chemical energy up to 384 MJ (384000000 Watts), which is consumed by physical daily activities such as exercise. Although it seems nearly impossible to capture chemical energy in present day for means of energy output, what if it was not that difficult? Could this be something that may be considered for future implantable devices or other energy systems? The body serves as a great machine for energy and scientists would be silly to overlook the potential of harvesting chemical energy from the human body and only kinetics. The article continues to thoroughly break down how energy can be harvested from both chemical and physical human energy sources. Motion induced kinetic energy, thermal gradient, or airflow of respiration can potentially be captured through systems involving either micro-biofuel, magnetic induction, electrostatic or piezoelectric energy. Sue and Tsai provide designs for IMDs using human scavenged energy to eliminate the use of battery systems used in the present day IMD technologies. If the systems can successfully be created for the human body from within, why not apply the same systems to other technologies?

**“Vibrational Energy Harvesting From Human Gait” (Neill G. Elvin and Alex A. Elvin, 2011)**

Elvin & Elvin investigate converting mechanical energy from human motion into electricity through by means of vibrational energy. The two engineers successfully break down the advantages and disadvantages of energy systems from various wearable
devices. Vibrational devices have minimal effect on walking patterns and are discreet. However, there is a low microwatt range compared to shoe-heel devices (Shenck & Paradiso, 2001), harvesting backpacks and knee-brace systems. Though, the systems found to have a better power output posed difficult integration and had negative gait impacts.

Piezoelectric and electromagnetic based devices are the two most commonly studied systems for vibrational energy harvesting. Both walking and running gaits are used as gateways to scavenge human energy. Applying the device to the lower leg provided maximal power output for athletes walking at 4km/h (2.48 mph).

“The associated power spectral density shows that peak acceleration power density occurs at the harmonics of the foot strike cadence...peak acceleration power density occurs at twice the running cadence.”

This evidence serves as an interesting fact in that the difference between energy captured between runner and walkers was not a great amount. What matters the most with this system is the amount of strides taken within a time frame or distance. The change in horizontal displacement and the increased amount of heel strikes generate the maximum energy output.

To support their evidence, Elvin and Elvin used a controlled experiment with two support groups: elite athletes (4) and recreational athletes (13) to provide a wide range of runners. The test investigates the optimal power that can be extracted from human gait over a wide range of athletic abilities using electromechanical vibration conversion for a generator mounted on the lower leg. The fitness assessment allowed the runners to warm up for one-minute before the workout began. The test began at a slower pace (based on the runner type) and the runner was forced to increase their speed by 1 km/h every minute until they voluntarily decided to stop. The study found that there was only a 4% difference in energy output between the two running groups. I found these results to be practically interesting since I would not expect the average runner to log the same amount of energy output as the South Africa national champion. However, the energy was not determined by the energy exerted, the energy consumed was based on the displacement and stride count across a horizontal plane.

“Harvest Human Kinetic Energy to Power Portable Electronics” (Longhan Xie and Ruxu Du, 2012)

Longhan Xie and Ruxu Du researched harvesting human energy through a similar pendulum system as Elvin and Elvin (the authors above). However, Xie and Du’s system was based on electromagnetic induction instead of a heel-strike vibration capture. The two developed a larger device that consists of a “stator and rotor pair” to create a changing magnetic field, where energy is caught and transformed into electricity. Xie and Du’s method allowed them to store energy horizontal and vertical exerted energy whereas Elvin and Elvin’s method only harvests energy on a horizontal plane. To do this, Xie and Du’s device added a rotational spring to harvest

7.0 Literature Review

human energy exerted on a horizontal plane. The “torsion spring” is a helix with two ends in “special shape” and was proven successful based on an early energy law of Isaac Newton. Again, the system harvests the greatest amount of energy with the greater torque applied. With this said, it is safe to draw a conclusions that based on the last three devices, the greater the displacement within a system, the greater the amount of energy consumed by the system.

“Low Power Energy Harvesting and Storage Techniques from Ambient Human Powered Energy Sources” (Faruk Yildiz, 2008)

Yildiz’s long piece of work serves as a great informational tool and he uses numerous credible resources to provide existing tools already powered by human energy and great product knowledge. Yildiz makes particular note of the Zenith Televisions battery-free remote and Freplay’s wind up radios. Both technologies are effective energy systems for their low power use. Both the remote and radio serve as “active power systems”, which Yildiz defines as a system that requires additional human action that is not natural. Therefore, “passive power systems” are systems where a person is not required to put extra effort to generate power since the system naturally generates and stores energy within daily activities. Yildiz concluded that in order to develop an awarding design, the energy harvesting system must be reliable, efficient and user friendly. Consequently, the design requires an in depth understanding of the “harvesting transducers characteristics, capacity and chemistry of batteries and capacitors, power supply requirements, and application behaviors”1. A good design will generate off an individual who understands the project, the people using the product and what the product outcomes need to be in order to satisfy energy demands. Yildiz studies developed three system reviews on hydraulic door systems, fitness bicycles, and piezoelectric fiber composites used in sole inserts. All three systems were examined in depth and clearly annotated. For fitness machines, Yildiz did not find a current existing method that was feasible in providing needed energy output to power the machine.

Although “an average human body burns approximately 10.5 MJ of energy every day, which is equal to about 121 W of power dissipation” (pg. 40), the amount of captured energy on a fitness bicycle was only enough to power its own display. However, according to MIT and Starner research, the most reliable and exploitable energy source occurs at heel-strikes during running/walking.2

7.3 SUSTAINABLE SOLUTIONS FOR DESIGN RELATING TO SPORTS

“Leveraging the Cultural Influence of Sports to Advance Green Building”
(William Nutt, EDC Magazine)

“The sport's industry is an ideal catalyst for green building.”

Sports maintain a longstanding tradition

7.0 Literature Review

of cultural influence. We use them to connect with people and the surrounding community, even planning our schedules and routines around them. Extensive portions of salaries are spent on either attending ticketed sporting events, purchasing fan wear or sportswear, equipment, and participation related to specific sports. “We even choose where we live and learn based on the local sports environment” (Nutt, 12) Nutt also extends the argument to support that some individuals chose where they live and what schools their children attend, based on sport connectivity.

The world of sports is a multi-billion-dollar global industry, falling number fourteen in the list of America's top industries. Sports, no matter socioeconomic, political, or religious view attracts a wide variety of individuals. Sport participation “unites people from all walks of life, reaching individuals, businesses, institutions, and holistic communities.” (Nutt, 12). Some of the world’s most iconic figures have stemmed from sports, including the influence Muhammad Ali had on Martin Luther King Jr.

“Stadiums Compete for Sustainability: Every Building, Even Stadiums, Can be Made More Environmentally Friendly; Sometimes All it Takes is a Little Bit of Inspiration” (Derrick Teal, EDC Magazine)

USGBC has partnered up with Green Sports Alliance to help provide sporting arenas, gyms and stadiums sustainable initiatives. In the past decade, gyms and arenas have been recognized as sustainable gateway tools to raise awareness about the importance of sustainability. Athletic facilities are known for their overuse of water and energy, even when they are not facilitating events. Teal proves the importance and opportunity for sustainable facilities related to sports.


Reilman argues how sports stadiums are energy hogs, hording insanely amounts of utilities on a monthly basis. However, UCLA’s Pauley Pavilion is an exception. The sport facility uses buoyancy-driven natural ventilation with fan assistance to establish an efficient internal system. The system save the facility an astonishing $50,000 a year on electrical costs. The fan system saves 38% of its energy usage and is aiming to achieve LEED Gold, a significant accomplishment for a sporting arena.

The Pauley Pavilion works in conjunction with several internal computer monitored technologies that create two different building modes: active and inactive. The building is active during games events and increased traffic. When the building is operating daily for a smaller audience, the building goes into an inactive mode to decrease energy demands and increase efficiency using HVAC systems.

7.4 CONCLUDING THOUGHTS

“The body is an attractive ambient energy source” ¹

useful. However, present day systems and research projects based on capturing human energy seem to be focused towards micro-systems or low power energy systems. Future research should prove it is possible to harvest energy with better efficiency to serve a high power system.

A variety of credible average energy outputs were stated ranging from 10.5 MJ to 384 MJ. The average amount of energy consumed will need to further researched to determine a closer results. The new average will provide a maximum amount for harvestable energy. Of course no energy system will be 100% efficient. All authors make note that the body is a machine that can willingly work to generate more power. However, a system has yet to exist that serves as an awarding design. Physical and chemical energy can be harvested in a variety of ways including electrostatic, electromagnetic, piezoelectric, kinetics, hydraulic, and thermal energy systems to provide and alternative, self-sustaining energy source.
8.0 Context
8.0 Context

8.1 LOCATION

The Watt Community Rowing Center will be located at 220 Kelly Drive in Philadelphia, Pennsylvania. The proposed site is adjacent to the Schuylkill River and existing grand stand between the historic Strawberry Mansion Bridge and Peter’s Island. The WCRC will be located three miles west of the Temple University campus and three miles north of Boathouse Row, providing an ideal access point for launching boats during the Dad Vail Regatta. The WCRC will be located on the five-hundred meter mark of the regatta identifying the start of the sprint point during the race for athletes and officials on the course. The site is currently owned by the City of Philadelphia and is part of Farmount Park.
8.0 Context

The site location on along the Schuylkill River is an ideal location for a boathouse due to its adjacency to a feasible waterway. Few cities in the world offer waterways that promote an ideal situations for rowing, the Schuylkill River is one of these. The site shown in Figure 29 is located within Fairmount Park and is currently a vacant grass lot. The site is located 72 feet above sea level.
8.0 Context

8.2 SETTING

Boathouse Row: Boathouse Row is composed of fifteen Victorian-style boathouses 3 miles downstream from the proposed site for the Watt Community Rowing Center. The rowing village is an important adjacency for its historical ties to Philadelphia and the surrounding area local community. Each boathouse is unique, but non of which have indoor rowing tanks or community access. The addition of the Watt Community Rowing Center will provided year long rowing services to the Temple University as crews in relationship with the Schuylkill Navy. The WCRC is located distant to Boathouse Row since it introduces a different architectural form and directly serves the Dad Vail Regatta. For these reasons, the WCRC is located upstream, but still within a recreational setting.
8.0 Context

**Dad Vail Regatta:** The Dad Vail Regatta is a 2,000 meter rowing race on the Schuylkill River. The race is a sprint-style race where all of the boats are aligned across six lanes and all boats compete off the start line in heats at the command of a race official. Each boat is responsible for staying in their own buoyed lane. Currently, there is only one other community rowing center along the race course. The addition of the WCRC would add to the existing architecture to serve the Dad Vail Regatta across the four-day racing event, which began in 1934.
8.0 Context

Fairmount Park: Fairmount Park serves as a green space for community Philadelphians. The land is preserved by the City of Philadelphia Zoning Code for active and passive recreational use. Aside from historical landmarks, the park is currently equipped with a biking route, running route, baseball diamonds and multipurpose sport fields. This adjacency provides the perfect location for a boathouse. The Watt Community Rowing Center not only fits the mold of this recreational area, but will encourage participation from community members through learn to row programs, having the ability to house community events by reservation, and the openness for boathouse members to store their shells under its roof.
8.0 Context

Temple University Campus: Temple University is located three miles east of the proposed site for the Watt Community Rowing Center. The Campus is highlighted in red on the map pictured above. The WCRC is within commuter distance to campus with adequate access to running paths and biking lanes. Student athletes may also get to site by personal or public mobile transportation.
8.0 Context

8.3 CLIMATE ANALYSIS

A complete and thorough climate analysis was completed using the EnergyPlus Weather data (EPW) provided by the United States Department of Energy in combination with Climate Consultant.

GEOGRAPHIC DATA
LOCATION: Philadelphia, PA USA
COORDINATES: 40.2 North, 75.15 West
ELEVATION: 350 Feet
CLIMATE ZONE: TEMPERATE

WEATHER DATA
GROUND TEMPERATURE: 38-68 °F
DRY BULB TEMPERATURE: 31-76 °F
DEW POINT TEMPERATURE: 19-64 °F
RELATIVE HUMIDITY: 56-72 %
WIND DIRECTION: 230-250 °
(SUMMER MONTHS)

WIND SPEED
RANGE: 5.49-14.26 MILES PER HOUR
8.0 Context

CLIMATE ANALYSIS

Winter Winds

Daily Sun Exposure

Summer Breeze

Figure 54 Site Specific Climate Factors
8.0 Context

8.4 TOP 20 PASSIVE DESIGN STRATEGIES

One advantage to using Climate Consultant is that it suggests the top 20 passive design strategies that influence a more sustainable design. The suggestions help to decrease energy demands by taking advantage of passive design. Below are the top 20 design strategies for Philadelphia:

• Heat gain from equipment, lights and occupants.
• Lower the indoor comfort temperature at night.
• Incorporate ceiling fans or indoor air motion during summer months to decrease the need for air conditioning.
• Maintain a small building footprint.
• Sunny, wind-protected outdoor spaces.
• Minimize U-Factor.
• Added insulation promotes indoor comfort and maintains uniform temperature.
• Efficient, EnergyStar, Furnace.
• Increase natural ventilation methods during summer months.
• Maximize winter daytime solar gain and summer nighttime coolth by using thermal mass.
• Window overhangs that extend during summer months and retract during winter months.
• Well-insulated construction methods encouraged.
• Storage spaces encouraged on cold wind fronts to protect interior spaces.
• Plant trees in front of passive solar windows, 45° angle from building edge.
• Well shaded windows oriented towards prevailing winds.
• Organize floor plan to allow winter sun to penetrate into daytime use spaces.
• Incorporate a radiant heat barrier into roof design.
• Use high mass construction with small well shaded openings operable for night ventilation to cool the mass if needed.
• Maximize southern glazing to increase sun exposure during winter months but shade during summer month.
• Provide vertical distance between air inlet and outlet to produce stack ventilation when wind speeds are low.

Design strategies applicable to this site are highlighted and applied to the proposed design.
8.0 Context

8.5 SUSTAINABILITY AND PHILADELPHIA

WHY PHILADELPHIA?

Mayor Michael A. Nutter, elected in 2008 is making the leap to help Philadelphia become the greenest city in the country. The same year of election, 2008, Mayor Nutter appointed the city’s first Office of Sustainability. In 2009, he launched his first sustainable initiative Greenworks Philadelphia. The sustainable program focuses on energy conservation, environmental quality, social equity, economic vitality and community engagement. As mayor of Philadelphia, Nutter believes it is his responsibility to improve the quality of life for present and future Philadelphians, a true characteristic of sustainability.

Adjustments have been made to the Philadelphia zoning codes and comprehensive plan to encourage green building and sustainable transportation. One of the city’s first goals was to decrease miles traveled by vehicles by 10% by 2015. This goal has already been over achieved due to increased access to bicycle infrastructure and bicycle friendly travel routes. The city plans to establish a bike-share program with up to 200 stations across Philadelphia.

People are beginning to choose Philadelphia as a place of business practice or residence due to their increased sustainable initiatives and existing presence of sustainable architecture that is positively contributing to the quality of life. Philadelphia is transforming into a better city to both live and work, after all, Pennsylvania is known as the keystone state.

ARCHITECTURAL GLAMOUR

Philadelphia is glittered with sustainable architecture. From greenscapes to row houses to commercial architecture, sustainability is thriving in the growing city of Philadelphia that has been made an affordable environments for all economic classes.

Sustainable row houses are emerging to provide housing for the city’s increasing population. These new modern row houses add contextual character to the historic neighborhoods and create lively suburban havens and public plazas. The single and multi-family dwellings aim for energy efficiency and resource conservation, inspiring a higher level of sustainable living. Surrounding area architects seek opportunities for projects designing row houses since they see them as opportunities for design innovations and sustainability. But for Philadelphia, sustainable architecture does not end here.

“Sustainability is a methodology. It’s a perspective from which we make all of our decisions in terms of what we support when we go forward with a master plan.”

(Will Agate, Senior Vice President at Philadelphia Industrial Development Corporation)

The redevelopment of the Navy Yard has created job opportunities for Philadelphians directed towards the next generation of employees as it is heavily focused towards sustainability. The Navy Yard redevelopment provides serves as an architectural campus for Urban Outfitters, Energy Efficient Buildings (EEB) Hub, and Iroko. Various LEED achievements have
8.0 Context

been earned across the campus from LEED Silver to LEED Platinum, saving up to 30% in energy reduction.

Another LEED Platinum campus is located in downtown Philadelphia, the Barnes Foundation. The Barnes Foundation houses quite the collection of Post-Impressionist and early Modern artwork. Tod Williams Billie Tsien Architects (TWBTA) designed the elegant 93,000, two-story masterpiece with a limestone rainscreen and light canopy. The Barnes Foundation is LEED Platinum certified.

Greenscapes within the city of Philadelphia have also been redeveloped to increase attraction and promote a sense of community. For example the Sister City Park, located in Logan Square, was transformed into a community attraction. The park, once overgrown with vegetation, became a manicured landscape and cafe. Play outdoor environments create an exciting terrain, attracting visitors and community engagement. The architects, DIGSAU, strategically directed the viewers eyes to nature by creating a modest structure, cloaked in rugged natural materials, blending in to its surrounding landscape.

The previous stated examples are only a surface level analysis of some of the excellent examples of sustainable architecture found in Philadelphia. What is important to note its the continuous support and drive for emerging sustainable designs.
9.0 Program
9.0 Program

9.1 INTRODUCTION

The design solution presented represents a conceptual design of a new building and the development of the surrounding area landscape. The site neighbors the Schuylkill River in Philadelphia, Pennsylvania. Exploration of the Six S’s and numerous case studies have been completed to serve as initial assessment methods and supporting research for design development. The building and site design will create an engaging solution for rowing athletes and community members. The two parties will be encouraged to turn watts into usable energy to power activities and events that take place on site.

9.2 PROJECT REQUIREMENTS

Watt Community Rowing Center will be designed to accommodate the needs of the Temple University rowing team and the diverse population of surrounding area athletes. The current team population is 93 athletes, but the design must accommodate a flexible range of athletes as there will be guests, members, and a varying team population count. Equal opportunity will be provided to each occupant through American Disability Act (ADA) compliance and wayfinding.

9.3 ARCHITECTURAL CHARACTER

Three key terms used to describe the architectural character of this facility are functionality, mobility, and transparency. It is a main goal to have the users and visitors well aware of the positive energy impact generated by the rowers. Architectural design solutions will be a critical part of the learning experience and awareness of active sustainable design strategies. The following features will be incorporated into the final design:

• Appropriate spatial hierarchy.
• Mobility and Transparency illustrated through all aspects of floor plans and surrounding context.
• Adequate and efficient circulation.
• Clear and concise visuals that illustrate generated power to both participants and visitors.
• Communication and display of rowing success and accomplishments achieved in a show-case entry.
• Unification and balance of interior/ exterior spaces. Additional space surround the architectural solution will be needed for boat maintenance, storage and exterior exhibits.
• Interactive exterior exhibits to engage patron involvement and curiosity.
• Sufficient river access for boat launch.

9.4 SPATIAL REQUIREMENTS

Watt Community Rowing Center will include the following spaces to be compliant with International Building Codes (IBC) 2012 and Americans with Disabilities Act (ADA) standards:

Grand Entry
Offices (3)
Team Locker Rooms (2)
ADA Public Restroom (2)
Training Center
Indoor Rowing Tanks
Boat Bay
Conference Room
Kitchenette
Community Room
Lounge/Flex Space
9.0 Program

Second Story Observation Deck
Check-In Desk
Mechanical Space
Display Space
Flammable Storage
Docks

SPATIAL DESCRIPTIONS

**Entrance:** An entrance will showcase awards, community events, and sustainable achievements of boathouse members. This area will be handicap accessible and provide views to the Schuylkill River and training room. The entrance will serve as a lobby that provides access to main office spaces, conference rooms, boat bays and indoor rowing tanks. The entrance will be accessible to all boathouse members and visitors.

**Training Room:** The training room will be organized to provide an efficient use of space for rowing specific workouts and indoor rowing machines (Concept 2 ergs). Ergs require a 2’ x 8’ floor spaces for each station. Additional area will need to be provided for weight lifting and stretching. The training room will overlook the Schuylkill river, providing athletes with a scenic view to the river. The training room will only be accessible to the University of Temple and approved boathouse members.

**Locker Rooms:** Gender specific locker rooms will be provided to serve both the Temple University rowing teams and boathouse members. These locker rooms may be separate identities for security purposes.

**Conference Room:** The conference room will provide a meeting area for teams and coaches combined. Flexible seating may be explored, but satisfy enough area for a meeting of 10-20 individuals.

**Community Room:** The Community Room is an event room that serves both boathouse members and the surrounding area community. This communal space will be ADA accessible and overlook the Schuylkill River. The room shall accommodate 50-100 individuals. This space will be provided by reserve only.

**Offices:** 120 square feet should be provided for each office with adequate room for storage and seating for up to two visitors. These offices will be used by coaches and racing officials. There should be three offices included in the floor plan to accommodate the needs of the boathouse employees.

**Boat bay:** The boat bay will need to accommodate a variety of boat and oar sizes for both the University of Temple crew teams and community rowing. Oar sizes range from 8-12 feet. These boat sizes are illustrated in FIG. 55 below:

![Figure 55 Various Shell Lengths](http://www.row2k.com)
9.0 Program

Indoor Rowing Tanks: Indoor rowing tanks will be provided to serve a seasonal source of rowing or a sheltered center when river/weather conditions are not feasible for outdoor rowing. Each tank should accommodate a minimum of 8 rowers. Minimum tank sizes will included a tank size of 8’x50’ and a clear width of 5’ between each tank. An observation deck will also need to be incorporated for coaching purposes. The tanks will be used by the Temple and surrounding area crew teams by reservation.

Kitchenette: A small kitchenette shall be incorporated into the design to serve the conference room and great room. The kitchen should provide common kitchen utilities and storage accessible to all users.

Second Story Observation Deck: Integrate an observation deck into the second story floor plan so that visitors and athletes may watch and cheer on teammates during regatta events. This deck will be compliant with egress requirements and International Building Code (IBC).

Public Restrooms: In additional to the ADA restrooms located in the lockers rooms, one additional public restroom shall be provided to accommodate boathouse visitors.

Parking: Provide adequate parking for vehicles and bicycles.

Elevator: Provide an elevator to serve the first and second floors.

Handicap Accessibility: ADA compliant access will be provided to allow for handicap accessibility provided to the entrance, first and second floors.

Site Plan: A strategic site plan will be designed to accommodate the various users and visitors at the proposed rowing center. The site plan will show opportunities for everyday use as well as regatta use for visiting teams, spectators and vendors.

Outdoor Exhibits: Exterior exhibits will surround the rowing center and serve as active display centers to illustrated positive, sustainable initiatives. These displays will act as a mini-park that promote activity and community engagement.

Mechanical Space: Adequate mechanical space will be provided on the second story to avoid damage caused by potential flooding.

Electrical Systems: Interior and exterior lighting systems will be provided to serve as active lighting and energy providers. Electrical systems will need to be carefully designed to assure appropriate connection to existing electrical lines.

HVAC System: Provide adequate heating, ventilating, and air condition systems to appropriate interior areas that promote energy efficiency.
9.0 Program

SPATIAL PLANNING CHART

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<th>SF (proposed)</th>
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Figure 56 Program Spatial Requirements

9.5 SPATIAL PLANNING

The following spatial planning chart provides the suggested square footage by Time Saver Standards. All calculations were executed using the current population of the rowing team at Temple University, 93 athletes.
10.0 Design Development
10.0 Design Development

10.1 PARTI

The parti of the Watt Community Rowing Center (WCRC) echoes the sport of rowing and the importance and notion of set. Set is a term commonly used in rowing to identify when the boat is in perfect balance on top of the water. There are many internal contributors within a boat that contribute to set, such as weight distribution, handle heights, water conditions and boat mechanics. In the sport of rowing, it is crucial for a boat to maintain set, or balance within their boat to efficiently complete a race. Just as set is essential to have in a boat, it is substantive to have it interwoven into the architecture and surrounding site of the WCRC. WCRC will achieve set by transferring the same desired balance between the athletes and their boat on the water to athletes and their fixed architecture on land. The parti of the WCRC will focus strongly on functionality, mobility and transparency. These key terms provide inspiration to all architectural forms and organization of interior spaces, with sustainability in mind.

10.2 PROJECT VISION

Athletes as a sustainable tool, a blue ribbon idea. Each rower generates a rippling effect, promoting sustainability. Teamwork has a significant impact on both the sport of rowing and energy efficiency.
10.0 Design Development

10.3 SCHEMATIC DESIGN

**BUBBLE DIAGRAMS**

The earliest phase of the design process for the Watt Community Rowing center began with bubble diagramming. Since the design revolves around the concept of energy, it was necessary that the concept is clearly visible to occupants. Figure 56 illustrates how the circulation, or common path of travel, orbits around the training center in plan. This allows for the training center, where the energy by athletes is generated and displayed, to act as the heart or core of the structure.

![Figure 58: Initial Bubble Diagram Sketch](image)

![Figure 59: Finalized Bubble Diagram](image)

10.4 SCHEMATIC DESIGN

**BLOCK DIAGRAMS**

Following the bubble diagramming phase, block diagramming began to help create an efficient floor plan. Figure 59 shows how the shape and form of the building from an early sketch, fig. 57, are starting to synthesize into a concrete design that is unique, but still functional.

![Figure 60: Block Diagram Concept Sketch](image)

![Figure 61: HVAC Zoning Concept Sketch](image)

![Figure 62: Block Diagram Progression](image)
10.0 Design Development

10.5 SCHEMATIC DESIGN

**SKETCHING**

During this thesis process, sketching evolved and inspired the final concept for the Watt Community Rowing Center. Various mediums were used to generate sketches including marker, pen, pencil, and trace. A conceptual model was also completed using scrap balsa wood. The sketches shown below illustrate the initial evolution in the design process.

*Figure 63 Sketch Collage*
10.0 Design Development

10.6 SCHEMATIC DESIGN
INSPIRATION

Inspiration for the Watt Community Rowing Center originated from my own participation in rowing and exposure to the unique sport. However, the inspiration for this project extends far beyond personal experience and exposure. Aside from personal interaction and being a rower myself, I was able to find inspiration outside of rowing for architectural forms and sustainable design strategies. Below is a collage of images that represents what truly inspired this thesis.

![Inspirational Image Collage](image)
10.6 SCHEMATIC DESIGN

As a designer, I find it challenging to incorporate all of my ideas simultaneously under one core or key concept. One way I help organize my thoughts is through word mappings, or generating a visual that uses words to convey or determine the ‘big idea’. In the sketch below, all of the initial vocabulary relating to the WCRC falls underneath a conceptual umbrella, or the idea of erg-powered architecture. The final word map includes the following words that were both informative and inspirational:

- Flexible
- Power
- Energy
- Rowing
- Teamwork
- Efficient
- Self-Sufficient
- Net-Zero
- Sustainability
- Practical
- Contiguous

Figure 65  Word Mapping
11.0 Sustainability and Design
11.0 Sustainability and Design

11.1 PERFORMANCE GOALS

Watt Community Rowing Center will strive to achieve the highest level of sustainability according to USGBC and LEED Credentials. According to the conceptual LEED 2009 checklist, as followed, the structure has the potential to achieve a minimum of LEED Gold and a maximum of LEED Platinum. The checklist is a tentative figure that represents the best possible solution given the current conditions of the site.

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## 11.0 Sustainability and Design

### Materials and Resources, Continued

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### Total Possible Points: 110

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## 11.2 LEED

LEED credentials can be achieved in numerous ways for the WCRC using both active and passive design strategies. The LEED scorecard helps to establish a recipe for a sustainable building in addition to the Six Ss previously discussed in this document. From site development to innovation in design, the proceeding diagrams and explanations discuss sustainable design strategies used at the WCRC, which were encouraged by LEED.
11.3 SITE DESIGN STRATEGY

REFLECTION POOLS

The reflection pools, shallow pools of water, are located along the entrance facade of the WCRC. The pools serve for two purposes:

1. Sustainable Site Design: According to Best Practices in Sustainable Design, reflective surfaces on the south side of a structure provides an excellent design strategy for cool and temperate climates. This architecture feature allows for the sun angles to reflect from the pool and into the interiors, providing a method of passive heating and lighting.

2. Aesthetics: The pools serve as reflective surfaces that accent the unique facade and roof line of the WCRC.

The proposed reflection pools are undisturbed, since there are no water jets. The pool act as rain gardens as they are filled with runoff water. Similar design strategies can be compared to at a grandeur scale are the Lincoln Memorial and Taj Mahal.

The reflection pools help to control stormwater management and maximize open space on site, earning up to three potential LEED credits.
11.0 Sustainability and Design

11.5 SITE DESIGN STRATEGY
DEAD AIR SPACE AND EVERGREEN SHRUBS

The incorporation of the dead air space in combination with the evergreen shrubs on the north west, or riverside of the WCRC serve a protective barrier from the cool winter winds. The vegetation acts as a wind-break to reduce energy consumption during winter months, acting as an energy-conserving landscape. These barriers helps to decrease the potential of heat loss with the built up vegetation of native evergreen shrubs. The use of evergreen shrubs in collaborative efforts with other site design elements promotes site and architectural efficiencies. This design strategies can reduce heating and cooling demands by up to 40% (landscapeforlife.org). Native plants were selected to be low maintenance, flood resistant, and promote site diversity for year long foliage.

The dead air space and evergreen shrubs maximize open space on site and uses native vegetative species, earning up to two potential LEED credits.
11.0 Sustainability and Design

11.6 SITE DESIGN STRATEGY

DECIDUOUS TREES AND SHRUBS:

The proposed planting plan for deciduous trees and shrubs also play a role in energy efficiency. The deciduous vegetation is strategically located on the southwest side of the building to allow for appropriate seasonal foliage. In winter month, when the trees and shrubs are bare, the sun is allowed to penetrate through the vegetation and act as a source of passive heating for the tanks. Since the tanks have a majority use during winter months, the serves as a great benefit. During the warm summer months, the same vegetation, now full in foliage, acts as a shading agent or passive cooling strategy. The trees are located close enough to provide shade to the structure, but far enough away where damage to the foundation caused by growing routes is not a concern.

The deciduous planting help to control internal heating loads, assist in stormwater management, maximize open space on site, and use native vegetative species, earning up to five potential LEED credits.
11.0 Sustainability and Design

11.7 SITE DESIGN STRATEGY
PERMEABLE PAVERS

Permeable pavers were incorporated in the design of the site for numerous reasons. Not only are the pavers a sustainable design that eliminate the need for an asphalt drive and decrease the possible heat-island effect, they promote greenscape and help maintain run off. Permeable pavers act as pervious material that allow for stormwater penetration and filtering. This design solution improves current site conditions.

Porous turf can be used since the highlighted area would be used for event parking or occasional parking only. The solution serves as a durable surface for trailer parking needed for visiting teams during the Dad Vail Regatta. When the lot is not used for parking, it will appear as a grass field, where athletes may complete outdoor workouts.

Permeable pavers help to control stormwater runoff and maximize open space on site, earning up to two potential LEED credits.
11.8 LOCAL SUSTAINABLE RESOURCE AVAILABILITY
GEOTHERMAL

Since the boathouse neighbors the Schuylkill, why not take advantage of a local sustainable resource, geothermal. The WCRC will incorporate a closed loop system that will act as a heat pump to serve heating demands to the central core of the building. The closed loop pond system will help offset heating demands.

Currently, the State of Pennsylvania, in collaborative efforts with the City of Philadelphia are providing grants for design integration using geothermal on the Schuylkill River. According to city zoning officials, the river is a feasible waterway for geothermal and they are encouraging new structures to actively become involved so that they may obtain results for the surrounding area.

Geothermal systems have six outstanding benefits (geothermalgenius.org). These benefits include:

Lower operating costs: Geothermal delivers a 400% efficiency rating compared to the most efficient gas furnace of 94% efficiency, lowering the costs by up to 70%.

Quiet Operation: Geothermal units are very tolerable in operational noise, offering a quieter solution compared to typical HVAC. In addition to their friendliness in noise, the durability of geothermal units provides another advantage since they internally located and not exposed to wear and tear caused by snow, rain, ice, or vandalism.
11.0 Sustainability and Design

Environmental Impact: Geothermal systems are the most environmentally friendly way to heat and cool a home (EPA & U.S. DOE). Geothermal provides a sustainable design solution that satisfies heating and cooling demands that serve human comfort. Geothermal, unlike other comfort systems, does not emit carbon dioxide, carbon monoxide, or other greenhouse gases which are off-gassed from burning fossil fuels, contributing to air quality pollution. Geothermal uses less electricity, reducing energy needed during peak grid demands.

Clean and Safe: A higher level of indoor air quality can be met using geothermal systems since there is no combustion or burning of fossil fuels.

Life Cycle Cost: Geothermal has a lifespan of up to 15 years (EPA), lasting longer than a typical furnace. The ground loop is made up of polypropylene pipe, the same pipe which is used in city gas lines and has an average warranty of fifty years. Although the initial costs of the system may be more expensive, the lifespan of the system pays for itself in the long run.

Positive Cash Flow: For new construction, the integration of geothermal helps generate energy savings. The payback period depends on the site and project scale, but has been decrease by 3-8 years, due to the recent tax break of 30% (US DOE).

Geothermal helps optimize building energy performance, improves indoor environmental air quality and thermal comfort, decrease energy costs, and uses local available resources. Geothermal creates a potential to earn up to fourteen LEED credits.
11.0 Sustainability and Design

11.9 WAYFINDING

Wayfinding is an important tool that will draw attention from the surrounding locals and visitors. Wayfinding will be expressed on site through graphic visuals, playful parks and signage. This will clearly identify what the building is, why it is there and the positive impact it has on the surrounding area related to energy efficiency and encouraging amateur and professional level rowing. It is important to express this to the community through exterior exhibits as the boathouse is not open to the public outside of standard hours of operation.
11.0 Sustainability and Design

11.10 HVAC

The Heating Ventilation and Air Conditioning (HVAC) provided to WCRC will be groups of zoned interior spaces, which are described below. The zones will act as a network on a computerized system to assure energy efficiency. The network will allow for custom setting of each zone and use monitoring.

Zone 1: Indoor Rowing Tanks

Zone one will require increased attention to humidity due to the current pools, tanks. When the tanks are not in use they will be covered, decreasing the exposed water surface area and potential for water evaporation. Dehumidifiers will also be installed to the heating system for condensation control. Zone one will be occupied most often during winter months, or when the weather/water conditions on the Schuylkill River are not feasible for rowing outdoors. For these reasons, zone one will need to be supplied with heating. Heating will be achieved through radiant floors, which are powered by the geothermal heat pump.

Air flow requirement for the tanks will be minimized to decrease evaporation for the current pools. Ventilation will be applied to zone one through a forced air system with supply ducts located near exterior windows and returns located at the ceiling.

Zone 2: Rowing Center

Zone two will be occupied daily and require HVAC on both floor plan levels. Thermostat temperatures may be decreased since athletes give off a substantial amount
11.0 Sustainability and Design

of waste heat. Heating will be achieved through a radiant floor heating, which is the best alternative for the increased ceiling heights and openness of the floor plan. When the zone two is not occupied, active systems can be put into effect to help decrease the building load, increasing energy efficiency.

Zone 3: Boat Bay and Storage

Zone three does not require HVAC. However, subtle heating is a commodity. Since boat repairs are completed in house, interior temperatures will need to meet a minimum of 55-65 degrees to assure settling of resin and glue for repair surface. This can be achieved simply through radiant floor heating.

11.3 SUSTAINABLE PROGRESS

Innovative design ideas are integrated into the design solution of the Watt Community Rowing Center to highlight and promote energy efficiency. Interdependence and shared responsibility among athletes and the surrounding community optimize the building’s performance, created from a holistic design approach. The design of the WCRC will have visual communicators within and surrounding the architecture that express energy efficiency and fluid transparency. This concept will encourage and mobilize an energy-aware culture. The innovative design solution of harvesting human energy from indoor rowing machines establishes a bridge to new possibilities in the athletic realm for both local and global sustainable initiatives. The WCRC will act as a catalyst for change, and will encourage a rippling effect.
12.0 Design
12.0 Design

12.1 Adjacencies
1. Existing Grand Stand
2. Peter's Island
3. Schuylkill River
4. Kelly Drive
5. Existing Boat Houses
6. Fairmount Park

Legend
- Vegetation
- Existing Roadways
- Existing Waterways
- Existing Structures
- Proposed Site

12.01 Site Map
Watt Community Rowing Center

Allison Marie LaChance
PASSIVE STRATEGIES
WATT COMMUNITY ROWING CENTER

12.11

Passive Solar
Breeze
12.12 INTERIOR PERSPECTIVE, ENTRY

Watt Community Rowing Center
Allison Marie LaChance
12.16 SITE PLAN MODEL, PHOTOGRAPHS

Watt Community Rowing Center
Allison Marie LaChance
13.0 Structure
13.0 Structure

13.1 WALL SECTION

Wall construction is composed from structural materials including steel and concrete. Insulated Concrete Forms (ICFs) will help to alleviate heat loss, serving as an insulator. In a similar fashion, all windows and curtain walls will be thermally broken, insulated glass. Reclaimed lumber will provide a decorative the skin to the exterior of the building, adding architectural character that resembled both the surrounding treescape and oar handles.

Steel Beam Calculation:

Live Load: 40 psf  
Dead Load: 10 psf  
Span: 57'  
Spacing: 10’ O.C.

Load = 57’ x 10’ x 50 psf  
= 28500 psf = 28.5 K

Steel Member Size: W24x55
Wall Section: Roof Detail
14.0 Outline Specifications
14.0 Outline Specifications

01 GENERAL REQUIREMENTS
The Watt Community Rowing Center is a conceptual design that involves using human energy as a helpful tool in an athletic setting. The proposed design for the new athletic training center has specific design requirements and architectural detail. The following specifications will discuss material selection, plumbing, HVAC, lighting, electric and finishes in greater detail.

02 EXISTING CONDITIONS
Section not used.

03 CONCRETE

033000 CAST - IN - PLACE CONCRETE
A. Section includes cast-in-place concrete, including formwork, reinforcement, concrete materials, vapor barriers, mixture design, placement procedures, and finishes, for the following:
   1. Footings.
   2. Foundation walls.
   3. Slabs-on-grade.
   4. Building walls.

B. Quality Standard: ACI 301.

C. Reinforcement:
   1. Reinforcing Bars: ASTM A615 Gr. 60
   2. Welded Wire Reinforcement: ASTM A185

D. Concrete Materials:
   1. Portland Cement: ASTM C 150, Type I
   2. Aggregate: Normal weight
   3. Water: Potable

E. Waterstops: Flexible PVC.

F. Curing Materials: Clear, waterborne, membrane-forming curing

G. Vapor Barrier: ASTM E1745

H. Compressive Strength (28 Days):
   1. Footings: 3000 psi
   2. Foundation Walls: 4000 psi
   3. Slabs-on-Grade: 4000 psi
   4. Building Walls: 4000 psi

033100 CONCRETE
Use 4,000 psi concrete with a maximum slump of 4”. Use Grade 60 reinforcing steel (epoxy coated when required). Slab on grade floors.

04 MASONRY
Section not used.

05 METALS

051200 STRUCTURAL STEEL FRAMING
A. Section includes structural steel and grout.

B. Quality Assurance:
   1. Fabricator Qualifications: An AISC qualified fabricator to be used.
   2. Comply with applicable provisions of AISC’s “Code of Standard Practice for Steel Buildings and Bridges.”

C. Structural Steel Components:
   1. W-Shapes: ASTM A 992/A 992M.
   2. Channels, Angles: ASTM A 36/A 36M.

D. Welding Electrodes:
   Comply with AWS requirements.
14.0 Outline Specifications

E. Bolts and Fasteners:
1. High-Strength Bolts, Nuts, and Washers:
   ASTM A 325, Type 1
2. Shear Connectors: ASTM A 108,
   Grades 1015-1020, headed-stud type,
   cold-finished carbon steel; AWS D1.1,
   Type B.

F. High-Strength Bolts:
Install high-strength bolts according to
RCSC’s “Specification for Structural Joints
Using ASTM A 325 or A 490 Bolts”.

G. Weld Connections:
Comply with AWS D1.1.

06 WOODS, PLASTICS, & COMPONENTS

061000 ROUGH CARPENTRY
Wood furring, sheathing, and blocking for
built-in casework and nailers for the top of
all roof-framing members; minimum
3/4-inch thick structural grade plywood for
roof sheathing.

07 THERMAL AND MOISTURE PROTECTION

072100 BUILDING INSULATION
ICF walls of EPS which provide two largely
continuous layers of insulation rated at
R-22 and higher. 2-1/2-inch thick (R-11+)
extruded polystyrene board perimeter
insulation at foundations. SuperTuff-R, with
R-value of R9.3/inch polyisocyanurate
insulation in roofs. A 6” board yields a R-55
insulated roof.

072600 VAPOR RETARDERS
4 mil thick polyethylene under slab on grade

074100 METAL ROOFING
2-inch high standing seam, Kynar 500 fin-
ished Galvalume metal roofing.

076000 FLASHING AND SHEET METAL
Galvanized sheet metal.

08 OPENINGS

081100 METAL DOORS AND FRAMES
Hollow metal doors and frames at toilets,
mechanical rooms, storage, and emergency
exits.

081400 WOOD DOORS
Provide paneled oak and glass doors with
oak frames at boat bay and tank entrances.

085213 METAL CLAD WOOD WINDOWS
Aluminum clad wood windows.

088000 GLAZING
Provide 1-inch sealed insulated glass, made
up of 1/4-inch thick clear float glass with
thermal breaks at openings.

09 FINISHES

092216 NON-STRUCTURAL METAL FRAMING
Metal stud wall and ceiling framing.

092900 GYPSUM BOARD
Use 1/2” gypsum board on interior walls
and ceilings. Use multiple layers of gypsum
board on partitions requiring fire rating.

096500 RESILIENT FLOORING
Provide resilient flooring in utility, storage,
and mechanical spaces.

Watt Community Rowing Center
Allison Marie LaChance
14.0 Outline Specifications

096813 TILE CARPETING
Recycled material carpet tile with a pile weight of not less than 36 oz. per square yard in Offices and Conference room.

099100 PAINTING
Epoxy coatings in toilet rooms, alkyd enamel semi-gloss paints on scheduled walls and ceilings. Use clear stain on interior and exterior wood trim. Ceilings painted white. Meet state volatile organic compound requirements.

10 SPECIALTIES

101400 SIGNAGE
Exterior signs will be composed of corten steel panels combined with aluminum and recycled wood content. Signs vary in size, shape and location. Please see attached drawings for sign locations.

102813 TOILET ACCESSORIES
Stainless steel (satin finish) recessed accessories including soap dispensers, towel dispensers, waste receptacles, toilet paper holders, grab bars, feminine napkin dispensers and disposals, and framed glass mirrors.

104313 DEFIBRILLATOR UNITS
Includes cabinet and automatic external defibrillator in each bay.

104400 FIRE PROTECTION SPECIALTIES
Manual extinguishing equipment located in accordance with NFPA 10.

105113 METAL LOCKERS
Aluminium lockers provided in second floor locker rooms at designated locations. Lockers include hinged doors, metal trim and filler panels, accessories and hardware.

B. Public Locker Room Lockers:
1. Type: All-welded, athletic metal lockers.
2. Size 12” x 24” x 18”; triple tier.
4. Locking System: Loop for owner provided locks
6. Finish: 3 mm powder coat.

107500 FLAGPOLE
Aluminum flagpole located near front entrance walk.

11 EQUIPMENT

115213 PROJECTION SCREENS
Recessed projection screens, power operation, glass beaded, heavy duty. Located in conference and great community room.

12 FURNISHINGS

122100 WINDOW BLINDS
Vertical blinds, operable by user, in Great Community Room and Conference Room.

125916 SYSTEMS FURNITURE
Freestanding component systems furniture in offices.

126200 PORTABLE AUDIENCE SEATING
Stackable/ganging chairs and folding tables in Great Community Room, color and fabric as selected by owner

129333 TRASH AND LITTER RECEPTORS
Steel receptacle with top to prevent rain from entering trash bin, including plastic
14.0 Outline Specifications

trash bin.

13 SPECIAL CONSTRUCTION
Custom architectural features throughout proposed community rowing center. Please refer to architectural drawings.

14 CONVEYING EQUIPMENT

142400 HYDRAULIC ELEVATORS
A. Section includes elevator cab, hoistway rails and supports, hydraulic cylinder and PVC sleeve, microprocessor controls and machine room equipment; ADA compliant.

1. Hydraulic Elevator System: One unit; hydraulic holeless type with cylinder in hoistway; with motor and pump adjacent to the hoistway.

B. Manufacturer: KONE Inc.

C. System Description:
   2. Number of Stops: 2
   3. Double sided – two door cab
   4. Maximum Rise:
   5. Clear Car Inside Dimensions: 6'-8” x 4'-9”.
   6. Car Height: 7'-11”
   7. Car Speed: 150 feet per minute.
   8. Door Width: 3'-6”
   9. Door Height: 7'-0”

E. Elevator Finishes:

2. Car Floor Finish: Tile.

15 MECHANICAL

150700 PLUMBING INSULATION
Pipe, equipment insulation

151100 FACILITY WATER DISTRIBUTION
Service weight cast iron waste, vent, and sanitary sewer systems; Type L copper domestic cold and hot water supply systems; and all related equipment accessories and appurtenances.

151123 DOMESTIC WATER PUMPS
Pumping equipment for domestic hot water.

154200 COMMERCIAL PLUMBING FIXTURES
Low-flow plumbing fixtures and related trim, fittings, and valves meeting ADA requirements. Use plumbing fixtures and fittings in accordance with International Plumbing Code (IPC, 2009) guidelines as follows:

Water Closets 1.6 gallons per flush (max)
Urinals Waterless
Showerheads 2.5 gpm (max) at 80 psi
Kitchen Faucet 2.2 gpm (max) at 60 psi
Lavatory Faucet 0.5 gpm (max) at 60 psi

Wall-hung water closets in the public restrooms. Electronic sensor operated flush valves and faucets in toilets. Freeze-proof drinking fountains located on the exterior of the building with operating mechanisms.
14.0 Outline Specifications

accessible from the interior of the building. Electric tank-type water heaters located near points-of-use.

155200 HEATING BOILERS
High efficiency, closed-combustion condensing type gas-fired boilers, flue gas vents, and vent terminations. AL29-4C stainless steel flue gas vents with sidewall vent terminations.

153100 HVAC DUCTS AND CASINGS
Ductwork and appurtenances in connection with HVAC. Spiral-wound round ductwork in exposed ceiling areas; rectangular ductwork in concealed locations such as the mechanical equipment room, chases, or above finished ceilings.

156000 CENTRAL COOLING
EQUIPMENT
Provide packaged air conditioning equipment with indoor condensing units with centrifugal fans, suitable for ducted connections to exterior wall louveres. Provide ventilation air during all occupied hours.

16 ELECTRICAL

160500 COMMON WORK RESULTS FOR ELECTRICAL
Conduit And Fittings: Rigid steel or intermediate metal conduits. Use compression type conduit fittings, but in trade sizes 3-inch and larger setscrew type connectors will be permitted. Where setscrew type connectors are installed, individual ground wires must be installed along with the circuit conductors.

Wiring: All copper 600-volt, type THW insulation except that all wiring running underground or in areas susceptible to moisture shall be rubber insulated type RHW.

162000 ELECTRICAL DISTRIBUTION
Run 120/208 volt, 3-phase 4-wire 60 hertz service to the high side of the transformer. Locate electrical equipment serving site utilities in the electrical equipment room. Locate transformer on concrete pad behind a safety barrier.

162400 SWITCHBOARDS AND PANELBOARDS
Bolt-on type panelboards with ratings exceeding the connected loads and available fault current in accordance with applicable sections of the International Electric Code (IEC, 2009).

165100 INTERIOR LIGHTING
In compliance with IES, dimmable luminaires on light track in athletic performance areas, indirect luminaires in Lobby, cove lighting in Conference Room and Great Room, task lighting in office areas, and flush fluorescent in mechanical rooms and toilets. Use energy efficient compact fluorescent where possible.

165600 EXTERIOR LIGHTING
Metal-halide and LED building security and parking lot lighting with high cutoff luminaires to minimize light pollution and glare.

End of Specifications.
15.0 Project Summary
15.0 Project Summary

15.1 Project Summary

The original design goals of the Watt Community Rowing Center were met in a variety of ways. Strategic spatial planning, sustainable initiatives, and extensive research all helped to achieve the final design. The initial eight design goals follow with the proposed solution to the initial architectural problem.

1. Promote sustainability within and surrounding the proposed boathouse design. Sustainability is achieved through passive and active sustainable design and human efforts.

2. Determine efficacy and feasible use for energy produced by rowers. Athlete gait offsets energy demands by up to 9.6%.

3. Maintain views and access to the river for both rowers and spectators. Increased views through first floor clerestory and second floor observation deck (outdoor).


5. Draw the attention of the local community to sustainability and rowing through architectural features. Way finding and graphics draw attention from patrons and promote activity.

6. Visual attractiveness that mimics both the sport and the encompassing biological environment. The architecture mimics both rowing geometries and the surround landscape and vegetation.

7. Facilitate rowing needs year round. Year long rowing is achieved through various equipment and boat storage.

8. Create a unique boathouse design to serve the Dad Vail Regatta. Watt Community Rowing sits on the 500m mark of the Dad Vail Regatta raceway.

15.2 Continuing Research

As any given research paper, there is always room for improvement, continuing research, and opportunities for future success. Continuing research efforts should focus on efficiency for athletic gait. Currently, alternator efficiency (from erg to alternator to alternating current (AC)) is roughly sixty percent. Various mechanics and engineering methods of system integration and application could be explored to improve efficiency rates. Should the efficiency improve, the amount of energy produced at the WCRC would be increased. Overall, improving efficiency would have a positive impact on the environment, structure, and economics.
16.0 Conclusion
16.0 Conclusion

16.1 CONCLUSION

The Watt Community Rowing Center (WCRC) is an innovative solution that synthesizes architecture, the environment, and athletics. The proposed architectural solution motivates a new form in sustainable architecture that encourages the participation of building occupants within a new interior environment that displays sustainable accomplishments. The interaction between individuals and architecture promotes energy efficiency and sustainability awareness. Rowers serve as a sustainable icon.

WCRC allows for high-performance athletes to yield high-performance architecture. Each rower is subject to product about 22 kilowatt hours annually. Although one individual may not be able to provide sufficient energy for the structure alone, teamwork is what makes for successful payback. The WCRC is a responsive, architectural solution that promotes energy efficiency through athletic activity and teamwork.

The Watt Community Rowing Center (WCRC) mimics the sport of rowing in both form and function. Design elements, such as the building facade, represent the stacking of oars, with vertical wooden members. Other geometries create efficient boat and athlete maneuverability with effective interior circulation patterns and room organization. The final plan serves as a year round training facility for surrounding area rowing community.
17.0 Resources
17.0 Resources

17.1 ROWING VOCABULARY

8+: An abbreviation for the eight man rowing race, sweep. (Sweep style rowing is pictured to the right.) This event is considered the blue ribbon even in races as they are the most competitive.

Puddle: A rower’s footprint left on the water after completing a stroke.

Set: Balance within the boat. Set is affected by the handle heights, weight distribution and catch timing.

Catch: The part of the stroke where the blade enters the water and the drive begins.

Erg: Indoor rowing machine. A training tool for rowers to showcase their strength in numbers to coaches. But, ‘ergs do not float’.

Drive: The portion of the stroke where the rower applies energy to ‘crank’ on the oar.

Shell: A racing boat made from either wood or carbon fiber material. The design of a shell is meant to allow for the crew to move quickly through the water, creating a long and narrow hull design.

Rigger: An additional component added to the shell to house the oarlock and dictate rowing geometries.

Oarlock: A device connected to the rigger to hold the oar in place.

Coxswain: The only forward facing member in the boat. A ‘cox’ is a team leader who encourages focus and power from their boat rowers while maintaining a quick line of direction on the water.

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