Warren J. Baker Endowment
for Excellence in Project-Based Learning
Robert D. Koob Endowment *for Student Success*

CAL POLY

I. Project Title

Multipurpose Pedal-Driven Power System

II. Abstract

This proposal seeks funding for a senior design project in the college of Mechanical Engineering. Cal Poly alumni and professional engineer Geoffrey Wheeler is sponsoring the project. He requires us to design a drive system that will provide reliable mechanical power to a variety of other machines in the absence of electrical power. The intention behind this project is that the resulting system would be implemented in developing countries where electricity from the grid is unreliable. Our system will be capable of producing a broad range of output torques and speeds in order to run a diverse array of implements. We plan to design, build, and test a prototype, provide Mr. Wheeler with detailed parts drawings, manufacturing instructions and an "Operation and Repair" manual. We anticipate our most significant design challenge to be manufacturability because we are constrained to relatively low-tech low-precision fabrication methods by the nature of the problem.

It is important to note that the Cal Poly Chapter of Engineers Without Borders (EWB) has previously undertaken similar projects on multiple occasions focusing on implementation in a community in southern Malawi. Our project will take a somewhat broader approach and focus primarily on the mechanical design. We plan to provide EWB with our documentation, and they will have the option to implement our design at their discretion. Mr. Wheeler will also have the opportunity to implement the design as he chooses.

III. Introduction

The format of our senior project class requires us to define the clients and users our project will include. Our sponsor, Mr. Wheeler is our primary client. We also must define the user of our project. In order to design the drive system with specific users in mind, we will consider the people of a certain rural community to be the primary users. The community we chose has an ongoing history of working with EWB, thus we will have access to highly specific information concerning their needs and resources.

Users

The Kumponda group-village residents are intended users of the system we will design. They are a rural agricultural community dispersed over approximately a 40 square kilometers area in Southern Malawi. Malawi is a relatively small, under-developed country located in southeast Africa. The federal government of Malawi is not fiscally solvent and relies heavily on foreign aid to function. Kumponda is on the north western outskirts of Malawi's major commercial and financial city, Blantyre [4]. We anticipate that our design will require manufacturing tools and processes not available within Kumponda. Therefore, we will consider the cost and logistics of transporting some parts, if not the entire system to the operation site.

Problem Background

Action for Environmental Sustainability (AFES), a NGO was started in 2007 to determine the most critical factors contributing to poverty and environmental degradation in communities in Malawi. Beginning in 2013 EWB began traveling to Malawi to determine how they might address the needs determined by AFES. Kumponda self-identified their greatest need as food security. Through meeting with residents and discussing their daily routines, EWB learned that villagers walk up to 3 hours with upwards of 15 kg of maize to an electric mill to have it ground into a fine flour. The entire country of Malawi is run from one power plant that is prone to outages. This poses a large problem for the villagers who have travelled to grind their maize because they do not have certainty that the mill will be operational when they need. Furthermore, the cost to use the electric mill is roughly one day's wages. In the case that electric mill remains non-operational, the villagers may need to carry their maize back and return a different day. The only other known alternative for the villagers to grind maize is by hand which is arduous and time consuming. We need to develop a power source for a custom-built maize mill and other machines that will be used in Kumponda.

IV. Objectives

Problem Statement

Villagers in rural Malawi need a reliable source of rotary mechanical power to drive machinery, chiefly a maize flourmill, because current methods are inaccessible and reliant on inconsistent electrification.

Goals:

- Design a robust, efficient drive system that can be sourced and fabricated in Blantyre which includes:
  - Human pedaling as primary energy source
  - Rigid mountings for the machines that will receive power (vertical and horizontal)
  - Frame and drive train (with necessary reductions)
  - Emphasis in design will focus on the use of the system to power a maize mill. Other uses for the drive system will be considered secondarily.
- Build and test a prototype of the system here in San Luis Obispo.
- Compile technical drawings necessary for manufacturing.
- Create a document with sufficient instructions for construction in Malawi.
- Create an 'Operation and Repair' manual.

Engineering Specification

In the tables below, risk is assessed in terms of high, medium, and low (H, M, L) and the compliance column letters refer to testing, analysis, or inspection (T, A, I) as means by which to measure how well we met each criteria.

Table 1 Quantitative Specifications

Spec	Parameter	Requirement	Tolerance	Risk	Compliance
1	Efficiency	90%	Maximize	M	T, A
2	Set-up Time	<5 (min)	Minimize	M	T
3	Compatible Wheel Sizes	60-68 (cm)	±1	L	I
4	Cost	$100	Minimize	M/H	A
5	Driven Machine Mounting Height	1 (m)	±0.25	M	I
6	Stability	90 (kg) unbalanced pedal load*	±5	L	T
7	Maximum Tolerable Power	500 (Watts)	±10	M	T, A
8	Speed Range	20-600 (rpm)	±200	H	T
9	Maximum Torque	250 (N m)	±5	M	T, A

V. Methodology

Basically we will follow the iterative design approach laid out for us by the Mechanical Engineering department.

The steps are:

- Problem Definition
- Conceptualization
- Evaluation and Analysis ----- (we are here)
- Detail Design
- Manufacturing
- Validation (testing)
- Documentation

This process is non-linear and repeating but the above are the major areas in roughly the order they will occur.

VI. Timeline

- 11/14 to 12/2 window -- Preliminary Design Review with Mr. Wheeler
- 1/31 to 2/16 window -- Critical Design Review with Mr. Wheeler
- 3/20 -- Project Update Report
- 5/1-- Prototype Completion
- 5/30 -- Final Report
- 6/2 -- Design Expo

VII. Final Products and Dissemination

The final products of this project will be:

1. Preliminary Design Report
2. Critical Design Report
3. A functional, testable prototype (built in San Luis Obispo)
4. A compilation of technical drawings required for part manufacture
5. A document with sufficient instructions for entire system assembly
6. An Operation and Repair manual
7. User safety manual

VIII. Budget Justification

In our senior design course we methodically avoid limiting our ideation process by, not assuming the form of our solution but, focusing on the problem. Our design is still in the conceptual analysis and evaluation phase. We plan to select a preliminary design during the week of November 14. Hence, specific costs are difficult to predicted with much precision. Therefore, we plan to request the minimum grant amount of $1000.

We require funding for strictly modeling and prototyping materials. We anticipate our primary materials needs to be steel angle iron, concrete, fasteners, and salvaged bicycle components (cranks, chain, chainrings, rear cassette, derailleurs, seat, shifter lever).

Through our research and our contacts in Malawi, we determined an appropriate production cost to be $150. We figure in a factor of three on production cost considering our prototype is a one-off build 3 x $150 = $450. We anticipate running into design and fabrication issues that we are currently unaware of prompting the potential need to rebuild our system from the ground up. Hopefully this will not be the case, but if so, we should be able to redo our system for less than the first iteration. $450 + $300 = $750. Furthermore, we plan to build some sub-system prototypes to validate our ideas along the way $750 + $250 = $1k.

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PROPOSAL BUDGET

Student Applicant(s):	
Faculty Advisor:	
Project Title:	**Requested Endowment Funding**
Travel *subtotal*	**$0**
Travel: In-state	**$na**
Travel: Out-of-state	**$na**
Travel: International	**$na**
Operating Expenses *subtotal*	**$1k**
Non-computer Supplies & Materials	**$1k**
Computer Supplies & Materials	**$na**
Software/Software Licenses	**$na**
Printing/Duplication	**$na**
Postage/Shipping	**$na**
Registration	**$na**
Membership Dues & Subscriptions	**$na**
Multimedia Services	**$na**
Advertising	**$na**
Journal Publication Costs	**$na**
Contractual Services *subtotal*	**$0**
Contracted Services	**$na**
Equipment Rental/Lease Agreements	**$na**
Service/Maintenance Agreements	**$na**
TOTAL	**$1k**