PROJECT DATA

Energy Unlimited, Inc. - 03GO13171

Variable Length Wind Turbine Blade

Recipient:	Energy Unlimited, Inc.	Instrument Number:	DE-FG36-03GO13171
Recipient Project Director:	Mark H. Dawson 208.853.6291 100 Four Fall Corporate Center, Suite 215 West Conshohocken, PA 19428	CPS Number:	17831
		HQ Program Manager:	Lisa Barnett 202.586.2212
		GO Project Officer:	Gibson Asuquo 303.275.4910
Recipient Type:	For Profit Organization	GO Contract Specialist:	Melissa Wise 303.275.4907
Subcontractor(s):		B&R Number(s):	ED1906020
		PES Number(s):	03-10157
EERE Program:	Wind & Hydropower Technologies	State Congressional District:	PA - 7

PROJECT SCOPE: The overall objective of this project is to produce a pre-production, working prototype of a wind turbine rotor with variable length blades to be mounted on an existing wind turbine for testing. The goal is to assess manufacturing costs and aerodynamic performance of the variable length wind turbine blade and improve upon an existing proof of concept design. Blade tips are to be designed to fit a 9 meter wind turbine blade. Structural design of blade slides and design of an actuator mechanism to move the blades will proceed in parallel with tip design. The variable length blades along with a controller to move the blades will be installed to test basic performance.

FINANCIAL ASSISTANCE

Approved DOE Budget:	$247,000	Approved DOE Share:	$247,000
Obligated DOE Funds:	$123,500	Cost Share:	$169,785
Remaining Obligation:	$123,500		
Unpaid Balance:	$0	**TOTAL PROJECT:**	**$416,785**

Project Period: 9/30/03-6/30/05

TECHNICAL PERFORMANCE

DE-FG36-03GO13171

Energy Unlimited, Inc.

Variable Length Wind Turbine Blade

PROJECT SYNOPSIS

The overall objective of this project is to produce a pre-production, working prototype of a wind turbine rotor with variable length blades to be mounted on an existing wind turbine for testing. The goal is to assess manufacturing costs and aerodynamic performance of the variable length wind turbine blade and improve upon an existing proof of concept design. Blade tips are to be designed to fit a 9 meter wind turbine blade. Structural design of blade slides and design of an actuator mechanism to move the blades will proceed in parallel with tip design. The variable length blades along with a controller to move the blades will be installed to test basic performance.

SUMMARY OF TECHNICAL PROGRESS

The project kickoff meeting was held on October 22, 2003. The results of the previous prototype testing have been analyzed and incorporated into the new design. A sacrificial blade was cut open, and it was determined that retrofitting existing blades was not feasible due to variation in weight and glue line thickness. As a result, the scope was modified to include producing new root blades with new root molds. Two blades have been fabricated with wet lay-up, and a third is being produced with infusion molding to compare manufacturing costs. Three tip sections have been fabricated with existing tip molds.

The actuator and controller design are complete. Drive parts have been received. Root winding and drilling jigs are in the process of being fine-tuned before being placed into production. A test root has been wound and testing is in progress to verify that the root stud anchoring technique works as planned. One blade has been fitted with spars, slides and a bulkhead; its operation will be tested before the two remaining blades are assembled.

SUMMARY OF PLANNED WORK

Planned work includes fabrication of the third blade using infusion molding. The slides and drive nuts will be installed in the tips. A polyurethane bushing will be installed in the spar to guide the drive screws. The driver mechanisms and controller will be assembled. The first variable length blade will be tested to verify the bolt inserts perform as expected. The test turbine will be ready once the blades reach that stage.

PROJECT ANALYSIS

The project scope changed slightly due to new root blades being fabricated rather than modifying existing blades. The project is on schedule with no major obstacles apparent at this time.

ACTION REQUIRED BY DOE HEADQUARTERS

No action is required from DOE Headquarters at this time.

STATEMENT OF WORK
DE-FG36-03GO13171
Energy Unlimited, Inc.
Variable Length Wind Turbine Blade

Detailed Task Description

Task 1. Kickoff Meeting

It is expected that a kickoff meeting will be held with DOE representatives and project participants to review project goals, schedule, budget, and resources.

Task 2. Review Proof of Concept Prototype Design and Data

All existing data, drawings, information, and field experience from the proof of concept will be reviewed. A report will be prepared outlining lessons learned to date and defining design goals, objectives, limitations, and expections.

Task 3. Procure a Test Wind Turbine

Energy Unlimited, Inc. will select and provide a suitable wind turbine within their operating wind farm that can be utilized as a test turbine. This turbine will be provided to the project at Energy Unlimited's cost and will count as a non-federal cost share.

Task 4. Blade Aerodynamic Design

Dynamic Design will perform aerodynamic design of the blade using the best available airfoil sections. The design will be tailored to provide an optimal balance of energy capture and mechanical loads. Dynamic Design will utilize their in-house design tools to create the blade design. It is expected that the design will be similar to the TPI ERS-100 blade in terms of airfoil, thickness, twist, and taper.

Task 5. Blade Structural Design

Dynamic Design and Chinook Wind will team up to prepare the structural design of the blade including material selection, ply lay-up, and internal geometry. This task will include an analysis to predict the blade's structural dynamic properties. Significant input from Energy Unlimited personnel and from TPI personnel is expected during this task.

Task 6. Blade Manufacturing

A manufacturer will be selected to manufacture a set of blades for the prototype turbine. It is expected that TPI Composites of Warren, Rhode Island will perform this task. They have a set of molds available for their ERS-100 blades. We will be able to utilize these molds, thereby saving the project significant cost for fabrication of a new set of molds.

Task 7. Actuation Mechanism Design

Energy Unlimited will design a mechanism to guide the outboard blade extension and to provide actuation as it extends and retracts relative to the inboard blade section. The mechanism must be compact, light weight, robust, and reliable. It is expected that the considerable experience with the proof of concept prototype will be drawn upon in designing this mechanism.

Task 8. Procure Actuation Mechanism

All motors, linkages, guidance system components, and other system components will be procured. It is expected that most of these components will be off the shelf parts selected from catalogs of various industrial equipment manufacturers. Some components, such as the guidance system, may require custom fabrication and machining. Energy Unlimited has access to the necessary equipment to perform custom fabrication.

Task 9. Assembly of Blades and Actuation Assemblies

The blade components and actuation assemblies will be delivered to Energy Unlimited's facility in Palm Springs when completed. There the components will be assembled into the final blade system and bench tested. A PLC controller will be implemented during assembly and bench testing.

Task 10. Installation on Test Turbine

The assembled blade system will be installed on the selected test turbine. Energy Unlimited has personnel who are trained and qualified to perform the installation. They also have access to the necessary cranes and other equipment to perform the installation. It is anticipated that use of some installation equipment will be provided to the project as a non-federal cost share item.

Task 11. Testing

Once installed, the prototype wind turbine will be instrumented with strain gages, accelerometers, electric power transducer, and potentiometer. A nearby meteorological tower will be instrumented with the appropriate sensors to provide an accurate indication of atmospheric conditions during the test. Data will be collected using an ADAS data acquisition system which was manufactured by Zond Systems of Tehachapi, California under support from the National Wind Technology Center. The ADAS system was designed specifically for use on wind turbines. It is expected that sixteen channels of data will be collected at 80 Hz. The data will be collected and processed in accordance with industry standard procedures. Power performance testing will follow the guidelines of IEC 61400-12, edition 1 to the extent possible.

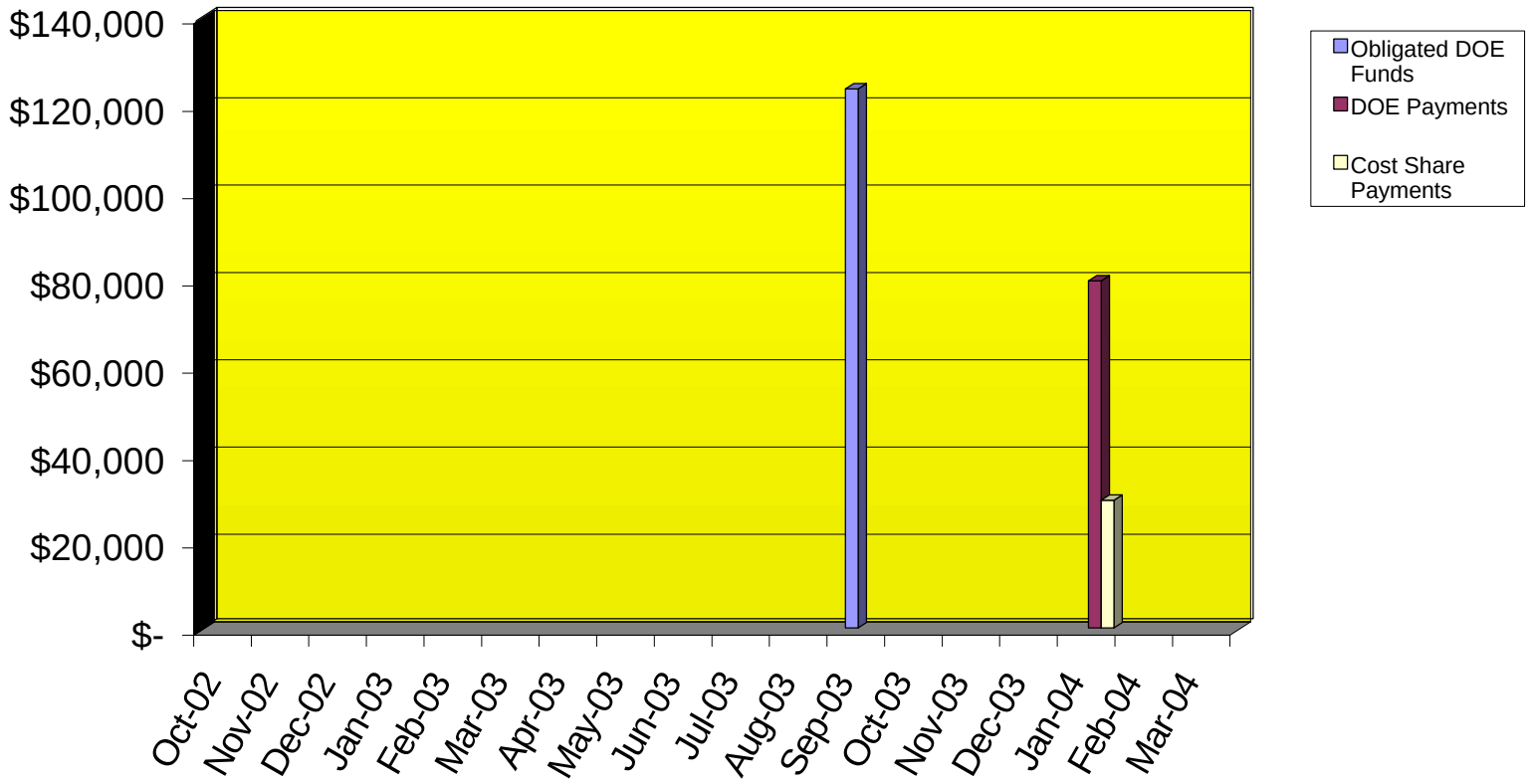
Task 12. Analysis, Assessment, and Commercialization Planning

After the test campaign has been completed, test data and anecdotal experience with the prototype will be analyzed and assessed. At this time, a commercialization plan can be developed outlining the steps required to take the product to market. Further steps may include design refinement, product certification, or further testing.

Project Cost Performance in DOE Dollars for Fiscal Year 2003

DE-FG36-03GO13171 **Energy Unlimited, Inc.**

Variable Length Wind Turbine Blade



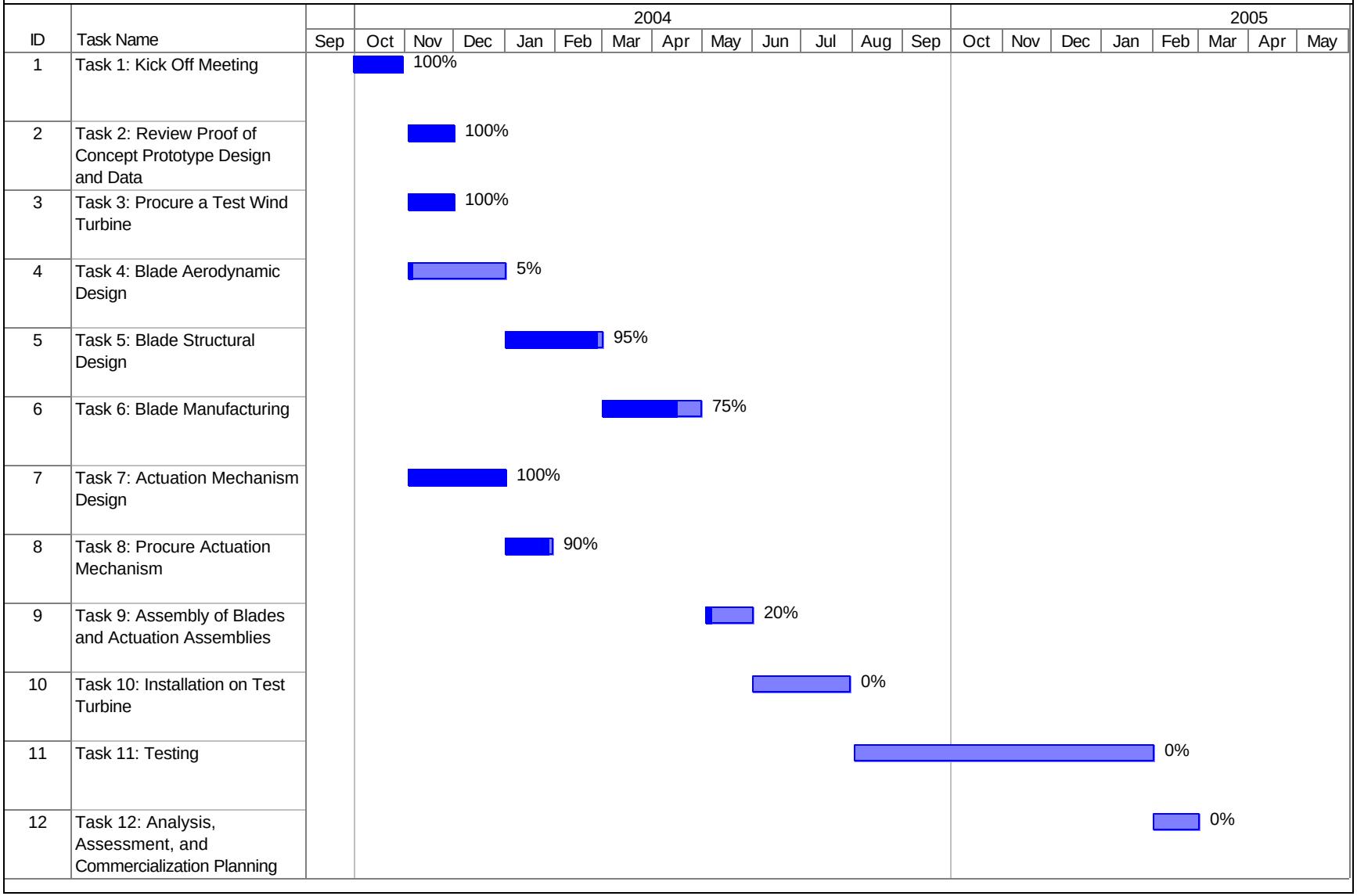
	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$123,500
DOE Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Cost Share Payment	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	PFY*	Cumulative
Obligated DOE Funds	$0	$0	$0	$0	$0	$0	$0	$123,500
DOE Payment	$0	$0	$0	$79,544	$0	$0	$0	$79,544
Cost Share Payment	$0	$0	$0	$29,284	$0	$0	$0	$29,284

Approved DOE Budget:	$123,500
Approved Cost Share Budget:	$169,785
Total Project Budget:	$293,285

* Prior Fiscal Years

Energy Unlimited, Inc. - 03GO13171



ID	Task Name	
1	Task 1: Kick Off Meeting	100%
2	Task 2: Review Proof of Concept Prototype Design and Data	100%
3	Task 3: Procure a Test Wind Turbine	100%
4	Task 4: Blade Aerodynamic Design	5%
5	Task 5: Blade Structural Design	95%
6	Task 6: Blade Manufacturing	75%
7	Task 7: Actuation Mechanism Design	100%
8	Task 8: Procure Actuation Mechanism	90%
9	Task 9: Assembly of Blades and Actuation Assemblies	20%
10	Task 10: Installation on Test Turbine	0%
11	Task 11: Testing	0%
12	Task 12: Analysis, Assessment, and Commercialization Planning	0%

Energy Unlimited, Inc. - 03GO13171

ID	Task Name	2004												2005							
		Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
13	Task 13: Submit Quarterly Reports																				0%	
14	Task 14: Submit Final Report																				0%	