Innovate UK

Results of Competition: Solar Powered Irrigation Pump SBRI Phase 1
Competition Code: 1509_DFID_SBRI_SPIP

Total available funding for this competition was £300K from DFID

Note: These proposals have succeeded in the assessment stage of this competition. All are subject to grant offer and conditions being met.

Participant organisation names	Project title	Proposed project costs	Proposed project grant
Prodrive Engineering Ltd	Prodrive Steam Condensing Irrigation Pump	£49,999	£49,999
Project description - provided by applicants			
Title: Prodrive Steam Condensing Irrigation Pump Abstract: A surface mounted diaphragm pump operated directly through low pressure generated by condensing steam. Steam is generated in an atmospheric pressure solar concentrating trough boiler. The novel design is a simple arrangement of diaphragms and valves that requires no sealing of moving parts. The boiler and pump form a closed system so only a small volume of clean water is necessary and owing to the low operational pressure of the boiler, condensate can be returned to the boiler under gravity. A low pressure and temperature steam system means that it could be produced almost entirely from low cost plastics to form a light weight, low cost and robust solution that meets the pumping performance requirements of the brief.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
University of Liverpool	Small scale, one-size-fits-all, solar water pumps	£42,369	£42,369

Project description - provided by applicants
This project proposes the development of a novel solar powered, water-pumping system for irrigation ' either direct to irrigation or to an intermediate water storage facility. Building on recent work at the University of Liverpool, the system will be 'one-size fits all' ' i.e the same pump system will be used irresepctive of well depth (up to e.g. 10m), but still giving optimum performance. The system will also be designed to be modular, allowing quick and simple maintenance. Two key problems exist in solar water-pumping technology: 1. the ability of a pump to start under low solar irradiance; and 2. the matching of pumps to specific locations. Without complicated electronics, positive displacement pumps are rarely able to achieve either of these. The first of these becomes more realistic with centrifugal pumps, which begin to spin with low input power and then pump once 'critical' rotational speed is reached. However, centrifugal pumps have defined operating characteristics ' away from their intended output head they operate at low efficiencies and with low water output. Research at the University of Liverpool, using novel 'induced flow' technology, has demonstrated proof of concept in a system that significantly broadens the operating conditions of centrifugal pumps. For example, a small 12V input pump, with only 6V input (equivalent to low sunlight), was still able to operate at 5 times its design output head and twice its normal maximum head, but with efficiency similar to its peak. In the laboratory, the system is manually tuned to the operating conditions, but with electronic control systems could be made to auto-tune itself to the conditions in which it is situated. However, this project will investigate the feasibility of providing a 'passive' system with minimal electronics. We will explore how broad the operating conditions can be without changing the pump system/electronics, aiming to optimise system performance whilst minimising system complexity. The design will be fully modular, to allow easy and cheap manufacture/maintenance/replacement. The "one-size fits all" nature of the entire system is expected to significantly reduce costs, through providing economies of scale. In doing so, a single, non-site-specific, low-cost pumping unit would be able to pump water from a multitude of sources, to any given height-demand, be it for human consumption, animal consumption or irrigation.

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Longcroft Engineering Ltd	Development of a Solar Powered	£47,000	£47,000
Project description - provided by applicants			
The design of a solar powered pump is detailed in a patent currently held by Longcroft Engineering Ltd (LCE), the inventor Dennis Carey being the founder of the company. A novel feature of this pump is that it does not have any moving parts. Several prototype pumps have been built and successfully demonstrated under UK climatic conditions with promising results. The company is planning to embark on a development programme aimed at improving the efficiency and capability of the pump. In order to do this LCE have asked The University of Huddersfield to help in the development of thermodynamic models of the pump so that the fundamental operation of the pump can be better understood. These models will then be used as a design simulation tool to scale up the performance of the pump to meet the flow and lift targets of this competition. With simplicity of design and operation, the pump offers a cost effective solution to small farms in Africa wishing to improve irrigation of their land.			

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Seawater Greenhouse Ltd	Flexible solar pump for irrigation in Africa	£50,000	£50,000

Project description - provided by applicants

We have assembled a team of designers and engineers, combining specific skills, experience, R&D facilities and a commercial presence in both the OEM pump industry and water management for agriculture. The team intentions are to develop a photovoltaic powered-pump using state of the art technology in the form of an innovative diaphragm pump. The operating principle is similar to that of a human heart. The pump will be flexible in coping with the varied and demanding conditions of use encountered in Africa. Operating conditions will include pumping from wells of varying salinities from fresh water to sea water and at different depths, delivering into various kinds of open channel, pipework and drip irrigation systems. The pump will lift against total heads up to 10 m (including friction losses) and suction heads up to 7 m. Head will be maintained while flow varies to accommodate changing sunlight conditions. Efficiency of the pump will be maximised to reduce its demand for power and hence cost of the solar PV. Taking advantage of our existing activities in the Horn of Africa, the pump will be rigorously tested and implemented there initially with commercialisation undertaken by Seawater Greenhouse Ltd. Low-cost will be achieved through supply chains known to the consortium and already set up for this type of pump, as used by BOXER pumps in OEM markets. With quantities of 100,000 per year, we project costs for the pump with electronic controller to be £20; including the PV panel and cable, total system cost be will be below £30 per unit. Use of a brushless DC motor will ensure longevity of the motor. The drive electronics, minituarised to allow integration with the motor housing , will include Maximum Power Point Tracking (MPPT) to optimise its performance under varying light intensities. To avoid corrosion, all parts of the pump in contact with water will be of polymer. The only parts subject to wear will be the valve seats and diaphragm, with estimated life >10,000 hours. The pump body will be designed such that this is an easily replace item with replacement instructions on the pump body. Seawater Greenhouse Ltd will set up replacement stockists for these parts alongside its greenhouse business in Somaliland.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
The Imagination Factory Ltd	Solar Steam Vacuum Pump	£48,500	£48,500

Project description - provided by applicants

The Imagination Factory is bringing together modern solar technology with a simple legacy pump from the steam era. Solar powered irrigation will be provided by a combination of a condensing steam pump and a solar steam generator. Steam vacuum pumps are robust, piston-less and have very few moving parts. These pumps date from the earliest days of steam and were widely used into the 20th century for pumping mines, ship bilges and for portable excavation work, they are well suited to pumping dirty water. Steam is used to apply direct pressure on the pumped water to provide positive displacement; condensing steam creates a vacuum to draw water into the pump. A vacuum is able to draw water to a height of ~30ft . Sub-Saharan Africa receives an abundance of solar energy. This will be used to create low pressure safe steam from a wet tube boiler. A compound parabolic solar thermal concentrator will concentrate heat onto a low cost solar vacuum tube. This will provide the heat to create the steam. Compound Parabolic solar thermal concentrators and solar vacuum tubes are well understood, reliable, solid state devices; both are light weight and portable. The ambition for this project is to combine these two well established pieces of mechanical technology in order to manufacture a modern solar steam vacuum pump design; appropriate to localised low cost production in the developing world. The Imagination Factory is able to draw on the talents of Motivation - Freedom through Mobility - charity who are skilled in setting up training, local manufacturing and production plant in the developing world. We will also receive advice from Oxfam's internationally recognised water program. The Imagination Factory has a number of creative approaches to meet the aggressive cost target for this pump. Recycled and repurposed fire extinguishers and other used pressure vessels are intended as the core pump components. The design intent will be cost sensitive from the outset, the pump will be available in kit form appropriate for simple production and servicing and maintenance in the developing world The Imagination Factory team includes members of the successful British Steam Car Challenge that broke and still holds the land speed record for a steam powered car. Steam and engineering experience are embedded.

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Participant organisation names	Project title	Proposed project costs	Proposed project grant
Azur Innovation Ltd	SEIS - Solar Engine Irrigation System	£50,000	£50,000
Project description - provided by applicants			
The Solar Engine Irrigation System (SEIS) is a solar powered irrigation system based around combining the mechanical output of a heat engine with a fluid pump. The heat engine is a free-piston variant of a Stirling/Ericsson cycle engine based on a thermomechanical generator developed at Harwell by Ted Cooke-Yarborough (see patent US 4,345,437) and further developed by others (see patent GB2298903). The thermomechanical generator has only one moving part and is designed so that it has no surfaces undergoing mechanical wear leading to an extremely reliable and long lasting mechanism. One version of the TMG recorded the the longest service-free design life for any engine and lasted 90,000 hours before service intervention was required. The SEIS uses the upper diaphragm on the TMG to act as the moving component and is coupled to the pump. Two pump type options (both positive displacement) are proposed to offer additional site-specific opportunities - such as differing well depths and levels of water contamination. Their designs have been chosen to provide good lift, dry running and self-priming characteristics, tolerance to grit and sludge and high efficiency. The heat source for the engine is provided by a very low cost solar reflector designed to capture ambient light over a range of solar elevations. Optionally other heat sources could be used. The work is to be undertaken by the combined capabilities of Azur Innovation, Bowman Process Technology and the water charity Practical Action with technical advice from Nottingham University.			

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