Quadracci SUSTAINABLE ENGINEERING LAB.

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The Fu Foundation School of Engineering and Applied Science

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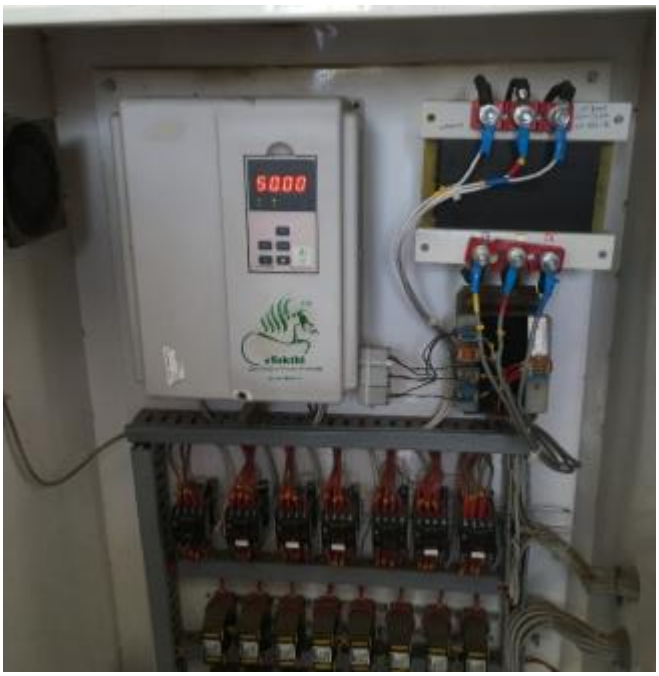
Acacia Irrigation - a qSEL project
Pay-as-you-go (or lease to own) system for smallholder irrigation

Smallholder irrigation has alluded much of Sub-Saharan Africa, even though it played a key role in lifting Asia out of poverty and hunger. The Acacia Irrigation system developed by the qSEL addresses this challenge. Recognizing the need to provide a low operating cost solution, yet not burden the farmer with high capital costs of solar equipment, we developed a pay-as-you-go model for irrigation water provision. The system can power one or more pumps located in close proximity (200 meters) to each other with a single solar PV power source. Successful current usage has been in the Niayes zone in Senegal, stretching from Dakar to St. Louis. Here 5 to 7 kWp PV installation power one or more one kW three phase AC motors to drive pumps. The farmers receive water as a service. We are also developing a low-cost single farmer (but share-able) system.

The core system is flexible enough to operate up to 15 kW of load so one can upgrade from a smaller installation to larger installation without modifying core controllers.

The use of a variable frequency drive as an inverter keeps costs low and also allows pumps to start easily.

The use of an embedded controller allows for an inexpensive stable control system that integrates a data and payment monitoring platform. The use of robust low-cost AC pumps driven by induction motors keeps farmer-side investments and maintenance low. Our prototype systems have increased the productivity of farmers working with us dramatically. Those utilizing the system are able to generate annual revenues per hectare of about $10,000. Each system is being utilized by seven farmers owning anywhere from a 1/3 to 1 hectare of land, growing onions, shallots and carrots, with water drawn from their own private shallow wells. Farmers pay for pumping power on a daily basis thus removing the capital cost burden of energy provision. The cost of energy works out to less than 5 cents/m3, several fold saving over manual means.



The system can be adapted for a variety of financing mechanisms to allow weekly/monthly or seasonal payments eventually leading to full ownership by the

farmer if preferred. Or, the system can be operated as on a pay per use model by an energy service provider.

No fuel means significant savings from fuel, labor, and engine maintenance. Near daily availability of water implies efficient water management through use of drip lines. One beneficiary said, "I'm very lucky to be part of this pilot program. Before the solar system I had 50 sacks of onions and for this last campaign with solar irrigation, I have 97 sacks." That increase in production means a huge increase in income for the farmer as well as the added benefit of more food availability in the region. Soon after installation the 3 installed systems in Gabar, Senegal approached full utilization with farmers paying daily for the energy they use.

Through these installations a few important lessons have been learned. High utilization is key to reduce the operating costs. Ability to share system across farmers provides added flexibility. Pay-as-you-go is critical to bring small farmers into the fold of irrigation or to implement financing. The primary system costs are those for solar panels, mounting and the pumps. Wiring costs are dependent upon the distances from the solar system to the pump. At scale the pump controller can be inexpensively assembled and containerized with solar panels, mounting hardware, pumps, and cable. Economies of scale can make this system a profitable product. The system does not use batteries which dramatically reduces the initial and recurring costs but requires the farmers to irrigate when the sun is available. This was initially a concern but farmers have since taken to irrigating during the day given the trade-offs. The other benefits of the system outweigh this small issue.

With our learning over the last year, we anticipate that the market in Senegal alone is in thousands of systems, and perhaps much larger in the Sahel. We are ready to provide the solution to farmer groups or entrepreneurs wishing to sell/operate such systems. With an appropriate financial analysis and market study, an entity that can start selling as few as 100 systems annually, can profitable operate a business with system costs of $3,000 per hectare of irrigated land including the cost of pumps, wire, electronics, mounting hardware, solar PV modules, and hardware. It is also possible for a single operator to manage operation at multiple systems through a payment and scheduling app. If provided through a program with low-interest finance costs scaling up would be at even lower costs.

Please contact John Peacock (at jhp30@columbia.edu) to request an appointment and to be placed on our mailing list. Updates are also posted at qsel.columbia.edu, of the Quadracci Sustainable Engineering Laboratory (formerly sel.columbia.edu) established through a generous gift from the Windhover Foundation. The laboratory is directed by Prof. Vijay Modi (modi@columbia.edu) of the Department of Mechanical Engineering in SEAS.