In-current Kinetic and Head-based Hydropower Systems for Off-grid Distributed Power
About 1/5 of the world’s population lives without power
By Any Measure, Energy is Key

... and in many areas of the world, the quickest and least expensive way to get energy to those that don’t have it is to use distributed power systems.
Distributed Power Systems

- what they are: generation and/or storage located near the point of use
- they can include
  - renewables
  - fossil fuels,
  - storage, and
  - controls
- typ. 1 - 50 MW nameplate
- can be grid-connected or non-connected
A common approach is a hybrid system. This incorporates a mix of energy sources, often including fossil fuels.

KIREIP (nameplate 3.3MW) is entirely self-contained and allows King Island to be self-reliant for its electricity needs.

Up to four subsystems may be called at any given time: one fossil fuel, two renewable, and one storage.

The logic control provides updates about twice a second. Basic algorithm:
1. looks at system demand
2. strip off what can be had from the renewables
3. top up the battery bank if surplus, and
4. run diesel gens if all else fails
• Tidal power is the only renewable that is 100 percent predictable.

• As such, it can stabilize power generation.

• It is every bit as predictable as diesel power, and indeed costs in theory can pinned down even tighter.

• As such, if there is velocity and flow sufficient to produce power in a coastal DP system, it can supplant diesel backups altogether.
Case Study: Indonesia

- ~1,000 inhabited islands
- only 300 have power
- tidal resource is complex but looks good
A Quick Look Into LPS: In-Current MHK

Tidal Array Early Cost Breakdown

- Structure: 28%
- PTO and control
- Foundations/moorings
- Connection
- Installation: 28%
- Other capex
- Decommissioning
- Opex: 21%

Source: SI Ocean 2013
• O&M regime – attack the #1 cost driver
• logistics – use common marine equipment
• respect UKC
• placement in optimal part of water column
• hot-swappability – no downtime; cf. solar
• minimize structure – exploit tension
• allow for hyper-local variations in flow
LPS Buoyant Modular Tethered Rack System

Per rack:
- swept area 360m²
- 950kW output in 2.5m/s flow
• use common marine equipment and cargo logistics to greatly reduce ICC
• exploit power of the standardized module
• pursue “server farm” topology
• respect UKC at all times but locate at acceptable height in water column

• Minimize maintenance downtime with hot-swappable cassettes

• Monitoring controls optimize maintenance cycles for lowest possible O&M costs

LPS Recycled Container Temporary/Disaster Relief MHK Unit

- Inexpensive, quickly deployed
- Current energy for:
  - Forward areas
  - Disaster relief
  - International patents pending
ROR HEAD-BASED HYDROPOWER
Domestic new stream-reach potential in the USA is a $600 million/yr industry. 12 million MWh/yr can be harvested annually. (source: U.S. Department of Energy)
• 2013 FERC regs: streamlined permitting for small hydro sites
  • non-Federal canal <5MW in capacity: 60 day
  • anything under 10MW in capacity: fast-tracked, est. <1 yr
  • in conduits, up to 40MW in capacity: <1 yr
  • minimal pondage; minimal environmental impact

• ROR takes advantage of natural flows and drops

• natural habitats and productive farmlands are not wiped out

• eligible for Class I RECs

• its Achilles heel is extreme variations in flow – so not suitable as a baseload technique as is tidal
Net head from 10 to 60 feet

Cost reduction factors:
- shop (offsite) fabrication & assembly
- transport to site by ship/ rail/ truck
- removable power cassettes
- de minimus decommissioning costs @ end of service life
Penstock, powerhouse, spillway and impoundment modules are all ISO containers

fast installation, no cofferdam needed
Modular Pumped Storage Hydro Using Water Towers

- Closed-loop modular PSH
- High frequency reversal
- Civil works built and permitted
- Pumps built and permitted

- $1.8 million
- subcontractors:
  - UMass Dartmouth
  - ALDEN Research Laboratory
  - NREL
  - GZA GeoEnvironmental
- 20% cost-share obligation covered by MA Dep’t of Energy Resources
- Principal Investigator: David Duquette


- partners:
  - UMASS-Dartmouth School for Marine Science & Technology
  - ALDEN Research Laboratory
  - GZA GeoEnvironmental
  - Lockheed-Martin Sippican
  - TPI Composites Inc.
  - Fairhaven Shipyard
Meet the Team

David Duquette, CEO  Over 20 years of leadership and technology experience, founder of Sceata Technology Group LLC, a technology commercialization firm, co-founded Flexible Medical Systems LLC, a specialty medical device and diagnostic company.
- University of Virginia School of Law, J.D.
- Princeton University, A.B.

- Massachusetts Institute of Technology, B.S.

John Ashburne, VP Business Development  Over 30 years of corporate and project finance experience in renewable energy and power. Founded Black Horse Advisors, previously JP Morgan, Barclays, UBS, Bankers Trust, Deutsche Bank, Senior Advisor to U.S. Department of Energy Renewable Energy Loan Guarantee Program
- Tuck School of Business at Dartmouth College, MBA in Finance
- Northeastern University, B.S. in Business with Management, Accounting and Finance concentrations

- B.S. in Physical Metallurgy from Washington State University

Jeff Glick, CFO, CPA  Previous CFO, Sagard Capital (AUM $250MM); CFO, ALMAZ USA, INC., Phibro Energy, Inc.; Merrill Lynch & Co. Registered investment advisor representative - Series 65 FINRA license; Series 3 NFA license
- State University of New York at Binghamton, B.S. Accounting

© 2016 Littoral Power Systems Inc. – PROPRIETARY & CONFIDENTIAL
Board of Advisors

David Torrey, Ph.D is Manager of the Electrical Machines Laboratory at General Electric in Schenectady, NY. He has decades of experience in the design of energy conversion systems that involve power electronics, electric machines, and embedded controls. He was previously a professor in the Electrical Engineering department at Rensselaer Polytechnic Institute in Troy, NY.

Joe Burke is the founder and CEO of SPEC LLC, an internationally prominent engineering firm in both high- and low-carbon power initiatives. SPEC provides multidisciplinary engineering services, project consulting, permitting; and construction management services to large industrial clients.

Peter Wayner, Ph.D is a nationally known writer and technologist known for his books on complex evolving sociotechnical systems, such as a series on the emerging digital economy. He has written for publications including The New York Times, InfoWorld, Wired and The Atlantic. He is a mathematics graduate of Princeton University.

Erik deBrun Erik is a principal engineer and co-founder of Ripple Design in Philadelphia and San Francisco. He has experience in the design, development, and manufacturing of products for commercial, medical, and defense applications. He previously worked at Boeing Rotorcraft as a control system designer/analyst and flight test lead for the V-22 Tiltrotor aircraft. Erik holds an M.S. in Mechanical Engineering from the University of Pennsylvania and a B.S. in Mechanical and Aerospace Engineering from Princeton University.

Dan MacDonald, Ph.D is an Associate Professor of Civil Engineering at UMass Dartmouth. He holds a Ph.D from MIT in Oceanographic Engineering, an M.S. from Cornell University in Civil Engineering, and a BS in Civil Engineering from the University of New Hampshire. He specializes in watershed studies, dam safety, and marine renewable energy.

Martin Wosnik, Ph.D is an Associate Professor of Marine Engineering at the University of New Hampshire, and is the Director of the UNH Center for Ocean Renewable Energy. He specializes on fluidics, with an emphasis on renewable energy applications.