A novel solution for universal electricity access
1.3 billion people still lack access to electricity
Electricity is not affordable
Electricity is not reliable
Electricity is not scalable
For 1 in 5 people worldwide, electricity is not

Affordable

Reliable

Scalable
Electricity access is a significant OPPORTUNITY
Electricity access is a significant **OPPORTUNITY**

<table>
<thead>
<tr>
<th>Solar Lanterns</th>
<th>Solar Home Systems</th>
<th>Grid Extension</th>
</tr>
</thead>
<tbody>
<tr>
<td># Eligible Consumers</td>
<td>561M</td>
<td>478M</td>
</tr>
<tr>
<td>Est. Market Size</td>
<td>$4B</td>
<td>$8B</td>
</tr>
</tbody>
</table>
What is a microgrid?

Microgrids have the potential to electrify 145M to 410M people.
Existing solutions do not meet all three needs

1. Affordable
2. Reliable
3. Scalable

DC Microgrids
Scalable: Microgrids enable higher tiers of electricity use

- Solar lantern
- Solar home system
- Microgrid
- Macrogrid (developing world)
- Macrogrid (U.S.)

Per capita electricity use (kWh/day/person)
AC microgrids can be improved

**Not** affordable
- Larger solar arrays

**Not** reliable
- Central storage

**Not** scalable
- Inverters
How is our system different?

Power Generation: Solar PV

Inverter

Battery Bank
CHARGEBOX™ enables benefits of the DC system

- Steps Down Voltage
- Payment System Compatible
- Charge Meter
- Wireless Communication
- Lithium-based Storage
DC microgrids succeed where others fail

<table>
<thead>
<tr>
<th></th>
<th>Device / Solar Kit</th>
<th>Solar Home System</th>
<th>AC Microgrid</th>
<th>DC Microgrid + CHARGEBOX</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFFORDABLE</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>RELIABLE</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>SCALABLE</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
Higher distribution efficiency in DC microgrids

AC Microgrid  | DC Microgrid
---|---
73% | 79%
81% | 98%

*AC microgrid efficiency excludes AC/DC rectifier losses*
A more efficient system is more affordable
Microgrids are the most affordable option for the desired level of service

LCOE ($ / kWh)

Level of Service

Phone charging, lighting

Entertainment

Comfort and productivity

Solar Home Systems

Solar Devices

Microgrids
**DC microgrids will be cost competitive**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Levelized Cost of Electricity ($/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Lantern</td>
<td>~ $10.00</td>
</tr>
<tr>
<td>Solar Home System</td>
<td>~ $1.00</td>
</tr>
<tr>
<td>AC Microgrid</td>
<td>~ $0.50 - $1.00</td>
</tr>
<tr>
<td>Grid Extension</td>
<td>~ $0.10</td>
</tr>
<tr>
<td><strong>DC Microgrid</strong></td>
<td><strong>~ $0.50</strong></td>
</tr>
</tbody>
</table>
How can we make microgrids more affordable?

- Solar Lamps and Kits: $30-80/year
- Solar Home Systems: $80-120/year
- Microgrids: $100-150/year
A reliable system prevents brownouts
A scalable system supports projected growth in energy demand

Real GDP Growth

Annual Percentage Change

Emerging market and developing economies
Advanced economies
World
A scalable system can be tailored
Why is the market ready now?

- Decreasing PV costs
- Decreasing storage costs
- Rise of pay-as-you-go
Initial markets were evaluated using 3 criteria

- High WTP
- Value Energy Efficiency
- Strong Partners
Islands are an attractive premium market

- 70% Pacific Islands lack electricity access
- 10-30% of GDP spent on imported fuel (diesel)
- World Bank Islands Sustainable Energy Finance Project
Path to market

- Islands: $1B, 1 year
- Peri-urban: $1.6B, 3 years
- Rural electrification: $4B+, 5 years
For 1 in 5 people worldwide, electricity **CAN BE**

Affordable

Reliable

Scalable
One step closer to universal electricity access
THANK YOU

Sherry MBA 2015

John GSPP / ERG 2016

Sara MBA 2015

Tia MBA 2015

Nick MBA 2015

Molly MDP 2015

Achintya Madduri
Questions?
Microgrids let customers move up the energy ladder

- Batteries
- Kerosene lamp
- Solar lamp
- Solar home system
- Micro-grid
- Central grid

Energy Technologies Increasing in Price

Energy Service

- Cell-phone Charging
- Lighting
- Entertainment (Radio/TV/DVD)
- Comfort and Productivity (Fans; Refrigeration; Irons)
- Commercial Activity (Ag. Processing; Ice Production)

Consumer surplus from microgrid energy services (Area B + C + D + E)

Demand curve for energy services

Area A
Market size estimates (lower bound)

**# of People (M)**
- Solar lanterns: 561
- Solar home systems: 478
- Microgrids: 145
- Grid extension: 95

**Market Size ($M)**
- Solar home systems: $8
- Solar lanterns: $4
- Microgrids: $4
- Grid extension: $2
Addressable market, by technology

Households without modern lighting & electricity
Total = 274 million

- Solar & Rechargeable Lanterns: 18M
- Solar kits: 112M
- Rooftop SHS: 86M
- Grid Extension: 58M

% of Households
Less than $1.25
$1.25 to $5.50
$5.50 to $8.50
More than $8

Monthly household spending on traditional energy
Better service at the same LCOE

DC Microgrid
- Generation and Storage: $0.09
- Distribution: $0.08
- Labor and Transportation: $0.24
Total: $0.41

AC Microgrid
- Generation and Storage: $0.11
- Distribution: $0.06
- Labor and Transportation: $0.51
Total: $0.45
DC is more efficient, especially at night

AC Microgrid System Efficiency
- Solar PV Generation
- MPPT + Charge Controller
- AC Inverter
- AC Appliances
- Battery 48V
- Day/Night Efficiency: 73(62%)% & 81(69%)%

DC Microgrid System Efficiency
- Solar PV Generation
- MPPT
- DC/DC Converter
- DC Appliances
- Battery 12V
- AC Inverter
- AC Appliances
- Day/Night Efficiency: 79% & 100%
Battery costs expected to decrease

[Graph showing the decrease in battery pack costs from 1995 to 2030, with a note that EV battery prices have fallen 40% since 2010.]
## Business model choices

<table>
<thead>
<tr>
<th>Market Segment</th>
<th>Service Offering</th>
<th>Financing Method</th>
<th>Payment Collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>Tier 2: Basic Household Needs</td>
<td>Pay per use</td>
<td>Manual</td>
</tr>
<tr>
<td></td>
<td>Tier 3: Small Productive Power</td>
<td>Rental/Pure Lease</td>
<td>Scratch Card</td>
</tr>
<tr>
<td></td>
<td>Tier 4: Large Productive Power</td>
<td>Rent-to-own/Lease financing</td>
<td>Mobile Money</td>
</tr>
</tbody>
</table>
## Competitive Landscape

<table>
<thead>
<tr>
<th>Company</th>
<th>Country</th>
<th>Technology</th>
<th>Payment Collection</th>
<th>Business Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>DESI Power</td>
<td>India</td>
<td>Micro/mini-grid</td>
<td>Manual/cash</td>
<td>Lease time/energy</td>
</tr>
<tr>
<td>Devergy</td>
<td>Tanzania</td>
<td>Micro/mini-grid</td>
<td>Scratch card</td>
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</tr>
<tr>
<td>Energa</td>
<td>Senegal</td>
<td>Micro/mini-grid</td>
<td>Scratch card</td>
<td>Pay per use</td>
</tr>
<tr>
<td>Fenix International</td>
<td>Uganda</td>
<td>Device/solar kit</td>
<td>Mobile money</td>
<td>Pay per use</td>
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<td>Husk Power</td>
<td>India, Uganda</td>
<td>Micro/mini-grid</td>
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<tr>
<td>d.light design</td>
<td>SSA, Asia</td>
<td>Device/solar kit</td>
<td>Mobile money</td>
<td>Lease time/energy</td>
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<tr>
<td>Off:Grid Electric</td>
<td>Tanzania</td>
<td>Solar home system</td>
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Value Chain of a Microgrid

- Supply of cooking fuels, procurement of fuels/feedstock for mini-utilities or central utilities
- Development of product or service offerings for the market
- Creating awareness of new offerings
- Finding customers and delivering the product or service
- Collection of revenues from customers, product payment, or fee for service
- Providing a means to reduce the up-front cost of purchase

ECOSYSTEM CONDITIONS

- Legal & Regulatory
  - Tariffs, legal requirements, and other policy-related factors
- Corporate Finance
  - Manufacturing of products or generation of electricity
  - Accessing investment and working capital to fund growth and operations
  - Using public monies to break even or produce profits
  - Service, maintenance, and repairs
- Subsidies
- Carbon Finance
  - Securing income from carbon credits