Making Energy Affordable
SURVIVE THIS DRIVE
1. Summary of SIDS-related projects by VIA

2. Detailed project summary for Vanuatu

3. Design philosophies

4. Design tools and innovations

5. Results to date

6. Near term future plans
Village Infrastructure Angels is a not-for-profit company focused on investing in micro-infrastructure projects for villages in developing countries, primarily focused on energy and electricity access.

The staff have been working in village energy for over 15 years and have helped over 2 million people in 30 developing countries gain access to modest amounts of electricity.

The wider VIA network includes investors, research institutions, supply chain and manufacturing experts, agro-processing specialists, technology entrepreneurs, capital-raising consultants, fund managers, and others with useful skills.
Summary of SIDS-related Projects

**Ghana, 2012 - now**  
**Client:** Barefoot Power + G20  
200 households of solar charging stations + solar DC minigrids for lighting & phone charging services, 3 year loans

**Vanuatu, 2012 - now**  
**Client:** internal project supported by IRENA, Rotary, angels  
200 households of solar charging stations + solar mills

**Indonesia, 2012 - now**  
**Client:** Hivos  
600 households of solar charging stations + solar mills

**Honduras, 2012 - now**  
**Client:** internal project supported by Rotary, angels  
200 households of solar charging stations

**Liberia, upcoming project**  
**Client:** Mercy Corp and European Union  
3000 households of solar minigrids and solar mills

**Other projects:**
Pacific SE4All Infrastructure Investment Fund Feasibility Study (ADB), household location mapping (various), mass design of minigrids for Master Planning rural electrification (various), Working Group Chair for Mapping for UN Foundation, Policy Advice for Water Pumping and Kerosene subsidies in India (World Bank), SE4All White papers on financing and development finance (Sierra Club), solar agro-processing mill technology development (IRENA)
Household Georeferencing Tool

Click on map and create marker

Mouse Position: x=647, y=556

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Vanuatu Lighting Project Location

Tanna Is. Vanuatu

Nth Tanna villages (Middlebush)

West Tanna villages
Technology Used

1-lamp kit
Sun King Pro

3-lamp kit
from Betta Lights
Agro-processing Project Location

Lae, PNG

Tanna Is. + Port Vila in Vanuatu
threshing maize

grinding flour

pounding = grinding corn/cassava or hulling rice

winnowing

grating cassava / yams

grating coconut
Mechanized offgrid agro-processing

**Diesel**
2-20 kW engines directly driving mills via belts

Consume 1-7 L/hour of fuel, costing $1-7/hour, serves 200-2000 households at 200 kg/hr

1-4 hours/day operation means $300-3000/year on fuel

**Solar**
0.2-2 kW solar systems drive mills directly or via batteries.

Panels $1-2/watt = $300-2000
Batteries 0-300Ah = $0-2000
Controllers, other = $100-500

Solutions can be delivered for $500-5000 for 25-250 kg/hour, but may be slower than diesel

2-5 year paybacks on diesel
Mills installed (target of 2 mills)

- 3 mills installed in Vanuatu
  - 2 in ACTIV main office at the end of Port Villa
    - coconut grater + flour grinder
    - offgrid villages next door can use to value-add and sell in urban markets
    - real-time energy metering installed on coconut grater, can see performance online
  - 1 in Tanna Island (West Tanna), a cassava grater

- 4 mills installed in Papua New Guinea
  - All at Malahang Industrial Compound, head office of PSS PNG
  - coconut grater + flour and feed grinder + rice mill + herb chopper
  - offgrid staff and industry area workers and nearby offgrid villages can use

Controlled conditions, not remote, for best feedback and visibility by stakeholders
UN Target: "Access to Energy" for all by 2030

- Lighting + phone charging ≠ "access"
  Need more than 2-10W solar lamps/kits

Possible "Access to Energy" package:

- Residential, mostly night-time needs:
  Lighting, phone charging, radio, fan and/or TV
- Community/business, mostly day-time needs:
  Refrigeration (especially for clinics), communications for market access, productive power for processing crops, carpentry, others?
  = "Tier 2+" service package
  = 75-150 kWh/year/house, or 25-50W/house

Solar agroprocessing rationale
**Tiers of Energy Service**

**Supply side:** Tiers based on attributes of electricity supply

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<tr>
<td>Formality (Legality)</td>
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<td>-</td>
<td>-</td>
<td>√</td>
<td>√</td>
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<td>Quality (Voltage)</td>
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<td>-</td>
<td>-</td>
<td>√</td>
<td>√</td>
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</table>

**Global Tracking for SE4All**

- No
- Basic
- Advanced

**Service side:** Tiers based on regular use of appliances

<table>
<thead>
<tr>
<th>Tier-0</th>
<th>Tier-1</th>
<th>Tier-2</th>
<th>Tier-3</th>
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<td>-</td>
<td>Task Lighting AND Phone Charging</td>
<td>General Lighting AND Television AND Fan</td>
<td>Tier-2 AND low-power appliances</td>
<td>Tier-3 AND medium-power appliances</td>
<td>Tier-4 AND high-power appliances</td>
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</table>

Current view of “access to energy” is still uncertain, and current thinking is based on tiers of services.

However, very focused on consumers / households

Does not account for
- clinic needs for health
- community mills
- school equipment, comms
- solar water pumping

and similar.....mostly community-scale needs.

Hence, "Tier 2+" suggested which includes these needs.

Source: [https://www.climateinvestmentfunds.org/](https://www.climateinvestmentfunds.org/)
Opportunity of Productivity

Saving 1 hour/day for 250 million women globally that lack electricity

= 100 billion hours/year of productivity

= 50 million peoples' worth of 8-hour days

= entire workforce of the UK or France

by reducing energy-related time spent by women processing crops, fetching water and collecting firewood.....needs patient loan finance

Solar agro-processing recently recognized by AFD's Challenge-Climat (http://challenge-climat.com/home/) as one of top 12 global leading innovations for agriculture
Lighting Project History

Project History

- **Dec 12:** 1st Lighting Loan starts ($11k guarantee + $10k work. cap.)
- **Mar 13:** Reconnaissance field visit to find field partners
- **Jul 13:** $24k IRENA contract secured for capacity building
- **Sep 13:** Field visit to show product samples, collect orders
- **Oct 13:** Products ordered, all household locations mapped on Tanna Island
- **Nov 13:** Balance of investment secured ($40k total work. cap.)
- **Dec 13 - May 14:** Installation of 180-200 lighting kits (45 small + 135-155 large)
- **Apr 14:** 2nd IRENA contract secured ($45k) for solar agro-processing
- **Jun 14:** Technical check and default management field visit
- **Aug 14:** 2nd Rotary loan secured ($10k) for solar agro-processing
- **Aug 14:** Project audit and default management training
- **Sep 14 - now:** preparation for scale-up from 200 to 2000 households

*Next field visit likely in May 2015*

*Investors include Rotary Melbourne and one angel investor*
### Lighting Project Financial Model

- $200 installed cost per house - financed by Construction Investors (10-15%)
- $3/week/house gross revenue for loan - financed by Lending Investors (0-10%)
- 3 year lending period = $450/house gross revenue
- Gross profit = $250 after capital repayment

- Operating costs per house
  - 10% profit to Construction Investors at refinancing $20
  - 10% cost of making Kiva profiles $20
  - 10% revenue share for loan collection partners $45
  - Net project profit over 3 years $165

- For 1000-2000 houses of loans in Vanuatu, $165k-330k operating profit over 3 years is sufficient to run a small team costing $50k-10k/year = breakeven scale
Access 2 Energy Power Stations

LIGHTING + PHONES

- $150-200 cost per house for 3-lamp solar kit
  - $2-8/month current expenditure = $25-50/year
  - 2-8 year payback

MILLING

- 3kW diesel
- 120 kg/hour, 200 kg/day
- 1 L/hr for fuel
- 500 hrs/year
- $500 + 5x$500 (@ $1/L)
  = $3000 every 5 years

- 1kW solar
- 50 kg/hour, 200 kg/day (slower)
- no fuel, use long-life (LiFePO<sub>4</sub>) batteries
- 1500 hrs/year (= sun-hours)
- $1500 panels+$300 mill+$700 other
  = $2500 for 5-10 year life? longer?

- $1 per 25-50 kg per family lasts 2-4 weeks, so $12-25/year
- families need 2-3 kg processed per day, so can serve 70-100 houses
- $12-25 / year x 70-100 houses = $1000-2500/year gross revenue
- 4-5 yr payback if solar loan = $500/year (fuel cos)t = 20-50% of revenue

3-5 YEAR LOANS MINIMUM REQUIRED

100 houses x $175 + $2500 per mill
= $20,000 / village
Delivering "access to energy"

"Access" ≠ only lights and phone charging

2-4 1W LED lamps + phone + TV/fan (20-30W per house)
+ agro-processing (10-20W per house)
+ clinic refrigeration + comms/internet (2W + 1W per house)

**Power** = 30-50W / house  **Energy** = 45-75 kWh/year vs IEA = 250-500 kWh/year

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**Retail values of systems installed**

- Offgrid market ~$200m now
- $1 billion by 2020
- $5 billion by 2025
- 30-50% CAGR

$150 billion ok, not >$650 billion
$200-500 / house x 300 mill households (via 5-10 year loans)  
= $60-150 billion of lending capital to 2030  
.....$500 million required in the next 3-4 years  
.....$1 billion per year by 2020  
....mostly debt, not equity....**start lending!!!**
Lighting Project Results

Technical
• No tech problems, products work well. Demand shifts 90% to larger 5-10W kits.

Social
• Charging station design re-arranged to solar home system by villagers due to inconvenience of having to charge every 2 days (ie. panels moved from operator back to households)
• OK for households who are paying promptly, but solar panels being removed from households who are not paying on time, and later, full kit will be removed

Financial
• 85% repayments by Households to Operators to date
  – West Tanna: 72%
  – North Tanna: 94%
• 99% repayment by Operators to West/North Regional Managers
  – West Tanna: 96%
  – North Tanna: 100%
• 58% repayment by Regional Manager to VIA (Target is 70%, 30% covers costs)
  – West Tanna: 77% OK, within target
  – North Tanna: 49% Outside target

Solution: PAYG technology
Kiva refinancing

- VIA launched on Kiva May 2014
  http://www.kiva.org/partners

- 0% 3-year loans from >100 investors = "crowdfunding" at $20-100 per investor

- Credit level raised from $20k to $50k in Sep 2014

- First $10k of projects put on Kiva in mid 2014
  Only took 3-4 hours per project to get financed

- Next $40k of projects to be put on Kiva Apr-Jun 2015

- Aim is to increase to $200k-400k in mid-late 2015
0% default during 2015 thanks to Rotary guarantee

Average time to raise funds only 3-4 hours!!!!

Credit raised from $20k to $50k in Sep '14
Energy Poverty affects 1.2 billion of the world’s population living in the dark, lighting their homes with dirty, dangerous and expensive fuels like kerosene.

In the small Pacific island state of Vanuatu, our organization along with our partners, have spent years helping households buy small solar lights. Distributed through cooperatives and women’s groups and sold for the same cost as a few months of kerosene, the lights have allowed women to continue beyond sunset. Families can keep businesses running and children can study with the health risks of breathing in kerosene fumes or getting burnt are no longer creating worry. Our field partners have sold more than 10,000 of these solar lights and have been a part of eradicating kerosene from close to 50% of the entire country.
• $200,000-400,000 budget for 1000-2000 households

• $10,000 pre-installation investment to fund low cost project managers (PM) to live on Tanna for 3-4 mths during Jan-Jun 2015
  – prepare the next $40k of Kiva profiles (photos, profile)
  – completing the "flip" of all pilot-scale investments to the crowd
  – reduce default issues, strengthen local capabilities

• $100,000-200,000 cost of products from China

• +90-100% additional cost to install into villages
  – 5-15% international shipping (China to Port Vila)
  – 5-10% local clearance taxes, duties
  – 40-50% importer margin at Port Vila (capital of Vanuatu)
  – 10-15% local shipping (Port Vila to Tanna Island)
  – 20-30% local installation costs
Breakeven Analysis

- VIA makes 10% on the build, and 10% per year managing the assets (better than usual fund manager rates of 2-4%)

- Hence, needs $1.5 million of assets built or managed per year to "breakeven" against $150k/year of costs per asset manager, to stop needing to do consulting

- $1.5 million at $250/house installed
  = 6000 households  = 60 x 100-house village projects

- Targeting $5-10 mill assets under management to support a 3-5 person team --> 20,000-40,000 households
Key Weblinks

• House mapping service  (first 1000 households mapped can be free)
  http://www.developmentmaps.org

• Global SE4All Developers Atlas (500 layers, 2 million data points)
  http://unmapper.developmentmaps.org
  username: UNMAPS     password: maps2012

• Minigrid mapping example, Tanna Island
  http://editor.giscloud.com/map/309747/tanna-minigrids-plan

• Solar agroprocessing video (rough 1st cut draft only)
  https://www.youtube.com/watch?v=dS60hV7QV0s&feature=youtu.be

• VIA / Sierra Club / LBNL paper on financing SE4All by 2030
  http://content.sierraclub.org/press-releases/2014/06/new-report-reveals-
  clean-energy-solution-energy-poverty

• VIA project reports for IRENA on Vanuatu solar lighting + milling
  https://www.dropbox.com/sh/4z5b4hhc623c45j/AADAZLwOSzo5LbsHd_o0j
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Further Information

Questions?

Please email stewart@villageinfrastructure.org
Case Study - Cassava grating

Base Case
Manual cassava and yam graters are used 15-30 mins/day are used across the Pacific, at a rate of around 5 kg/hour. During large festivals, up to 30 women process 200-500 kg over many hours.

Solar solution
A 2/3 hp (500W) electric drill has a grating attachment added, or more sophisticated graters can be purchased, that can process up to 150 kg / hour serving 75-150 households with 1 hour of use per day.

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<td>1 x electric grating machine</td>
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<td>1 x 40Ah battery for 1 hour/day use</td>
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<td>1 x 2000W Whistler Pro inverter</td>
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<td>Controller, wires, other</td>
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<td><strong>TOTAL COST</strong></td>
<td><strong>$600-1000</strong></td>
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If paid in cash, $0.05/kg generates $7-8/hour revenue
If paid in kind, one $10/house/month local handicraft can be exchanged for supply of the service, and sold

Revenue = $1000/year, 1-2 year payback possible
Case Study - Coconut Grating

Base Case
In South-East Asia, freshly grated coconut is available in local markets as well as whole coconuts, whereas in the Pacific, only whole coconuts are available. Peri-urban households can grate coconut for time-poor urban housewives or restaurants.

Solar solution
A 1/4 hp (175W) electric coconut grater can process up to 50 nuts per hour (typically 10-20 nut), producing 250g of grated meat per nut or 2.5-10 kg per hour.

1 x 80W solar panel for 1 hour/day use = $100-150
1 x 175W coconut grater with DC motor = $100-200
1 x 24Ah battery for 1 hour/day use = $ 50-100
Controller, wires, other = $ 0-50
**TOTAL COST** = **$250-500**

Whole coconuts sell for $0.10 each while one 500g of coconut milk (1 nut worth) sells for $1, so the selling price of grated coconut is set at $0.25 per nut (250g).

Profit = $0.15 x 20 nuts/day = $3/day = $1000/year
Of this, $0.05/nut is charged for mill use = $1/day
Hence, 1-2 year payback possible
Case Study - Coconut Oil

Base Case
Coconut oil can be used to displace fuel in remote islands, or as a cooking oil, or for other uses. It is usually made in centralized mills, and villagers supply dried coconut meat (copra). Small scale oil expelling may also be possible to add local value to this crop.

Solar solution
A 1/4 hp (175W) electric coconut grater can process up to 50 nuts per hour (typically 10-20 nut), and a 150-500W oil expeller can produce 3-5 L/hour.

1 x 150W solar panel for 1 hour/day use = $150-250
1 x 175W coconut grater = $100-200
1 x 150W electric cold oil press = $400-600
1 x 40Ah battery for 1 hour/day use = $ 80-150
1 x 2000W Whistler Pro inverter = $150-250
Controller, wires, other = $ 20-50
TOTAL COST = $900-1500

Coconut oil value $1-5/litre, depending on use.
Production = 4 L/day x 250 days/year = 1000 L/year
Gross revenue $1000-5000, payback period <2 years