Hybrid renewable microgrids: Clean power everywhere.

The Economics of Village Power

January 28, 2012

Dr. Peter Lilienthal

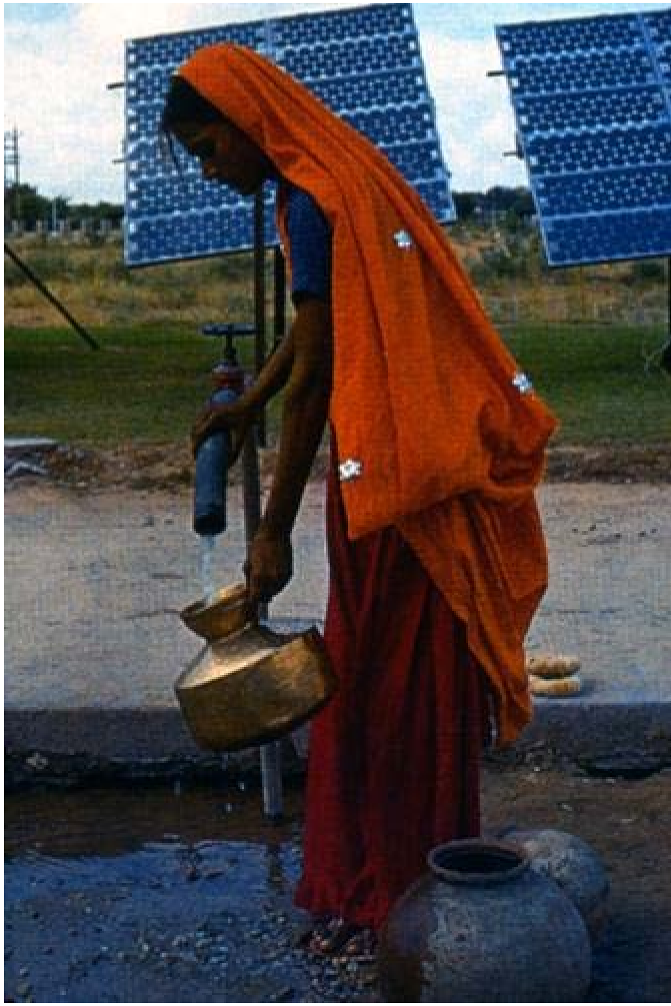
ETHOS,

Seattle, Washington

2334 Broadway, Suite B, Boulder, Co. 80304 www.homerenergy.com 1-720-565-4046

Background on HOMER & Village Power

- 1992: NREL created the Village Power Program
  - The Hybrid Optimization Model created for internal use.
- 1998: Distribution over internet
- 2008: Original developers created HOMER Energy, LLC. with exclusive license
- 2012: 70,000 users in 193 countries



Lessons Learned

- Holistic approach
  - Local involvement
  - Support infrastructure
- Technical
  - Simplicity and robustness
  - Remote monitoring
  - Hybrid systems
- Economic
  - Tariffs and subsidies

Holistic approach

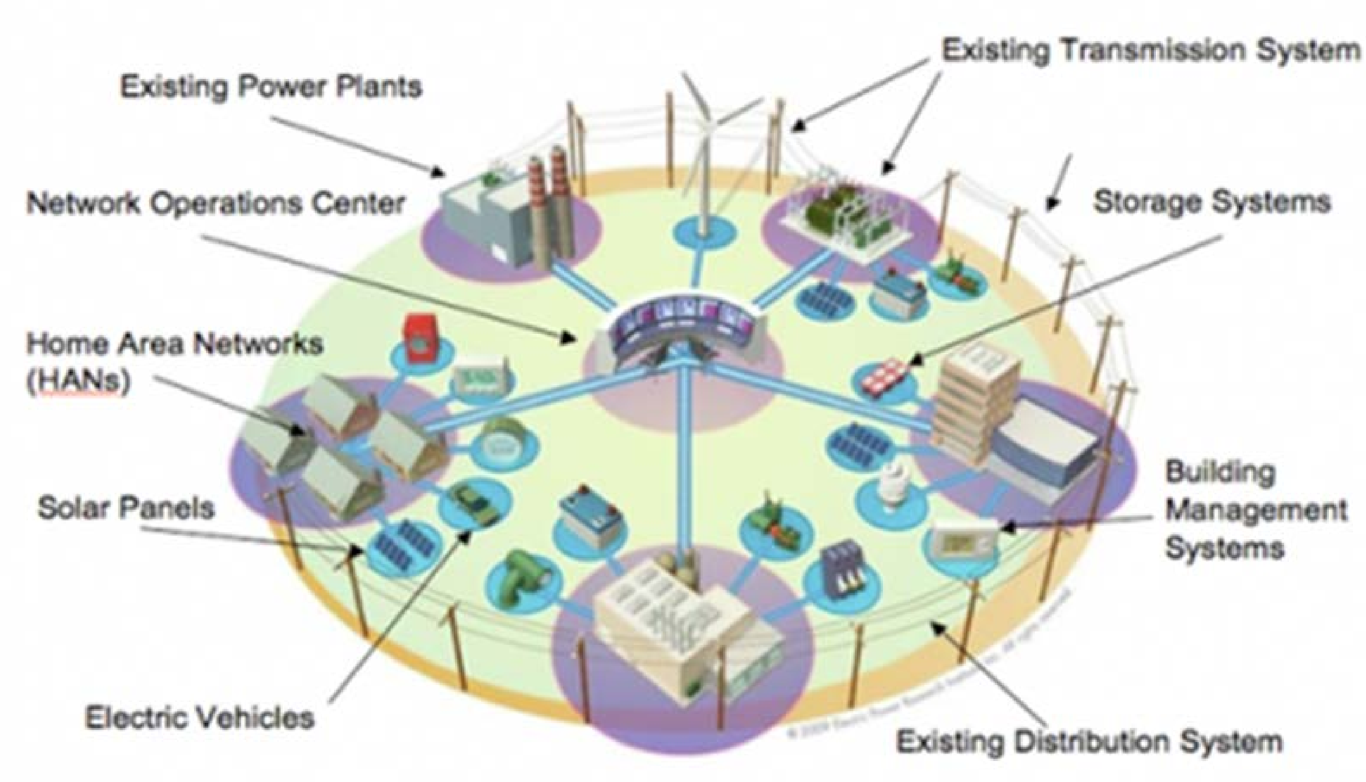
- Health
  - Cooking
  - Water
  - Clinics
- Public safety
- Regional support infrastructure
- Development
  - Communication
  - Education
  - Productive uses
- Lighting
- Local involvement

Telecomm as the killer app

- Anchor tenant
- Provides support infrastructure
- Requires reliable power
- Millions of small diesels

What is a microgrid?

- Local power systems that stand on their own



- Remote microgrids – Villages & Islands
- Connected microgrids - Military bases & Campuses

Too Many Choices

Solar

Wind

Hydro

Geothermal

Biomass

New Storage Techs.

Electric Vehicles

Smart grids

Fuel Cells

Micro-turbines

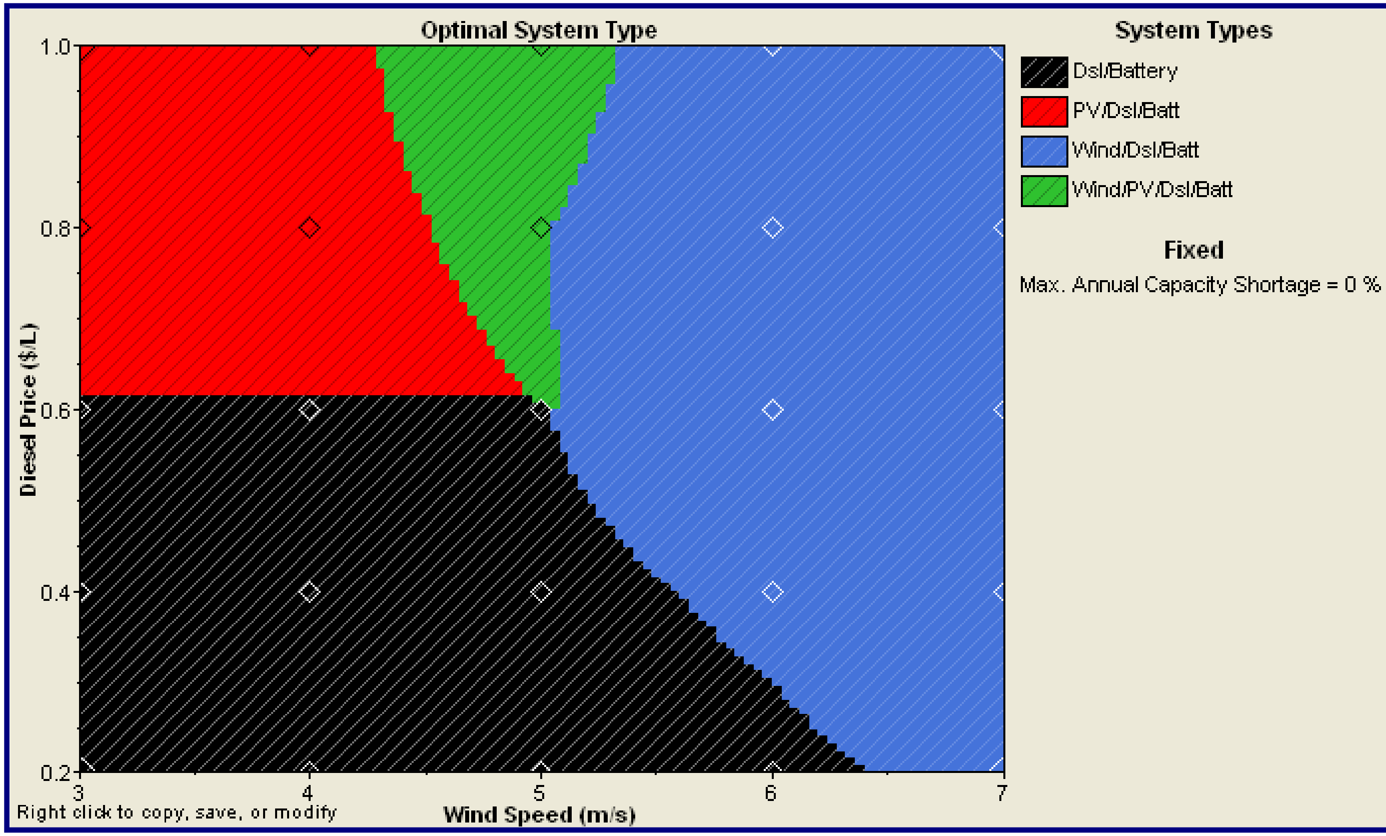
Micro-grids

Demand Response

Load Management

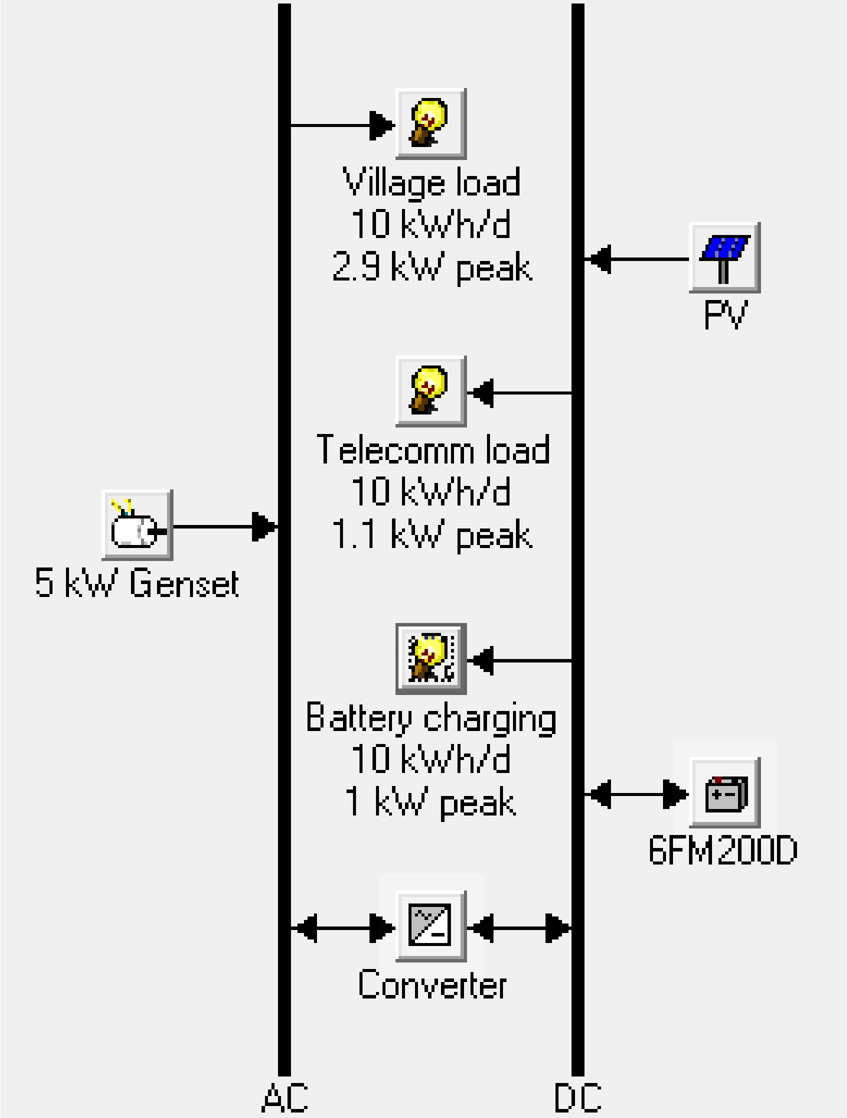
Optimal System Design

- What kind of system is best under which conditions?



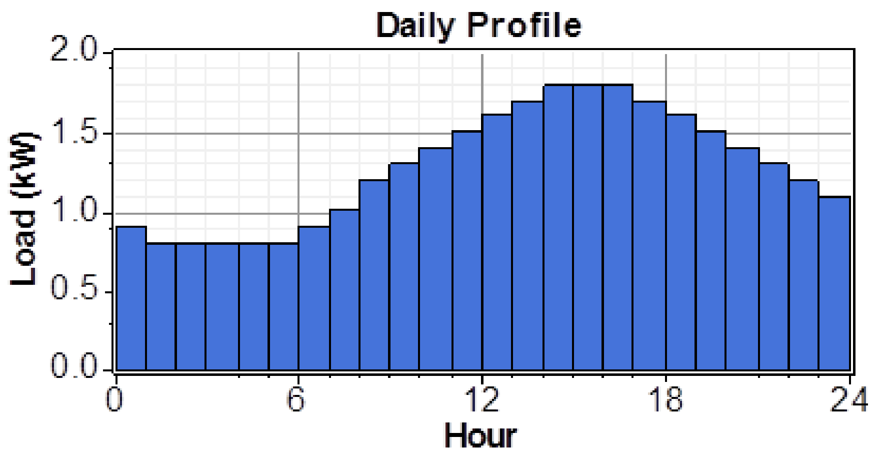
Example analysis

- Primary telecomm load
- Small AC distribution system
- Deferrable battery charging

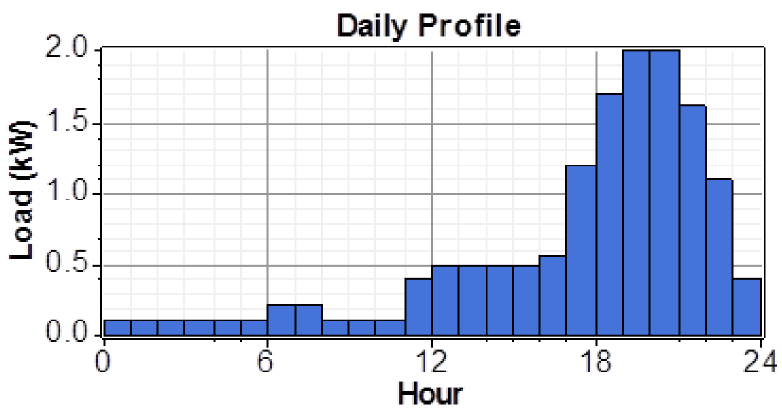


Load diversity

Telecomm load



Village load



Battery charging can be done whenever there is excess energy

Each load = 10 kWh/day

Telecomm only
3 kW PV, 12 batteries
$27,800

Telecomm and battery charging
5 kW PV, 12 batteries
$37,800

Telecomm and village AC loads
6 kW PV, 36 batteries
$52,400

All 3 loads
7 kW PV, 28 batteries
$54,200

HOMER Summary Results

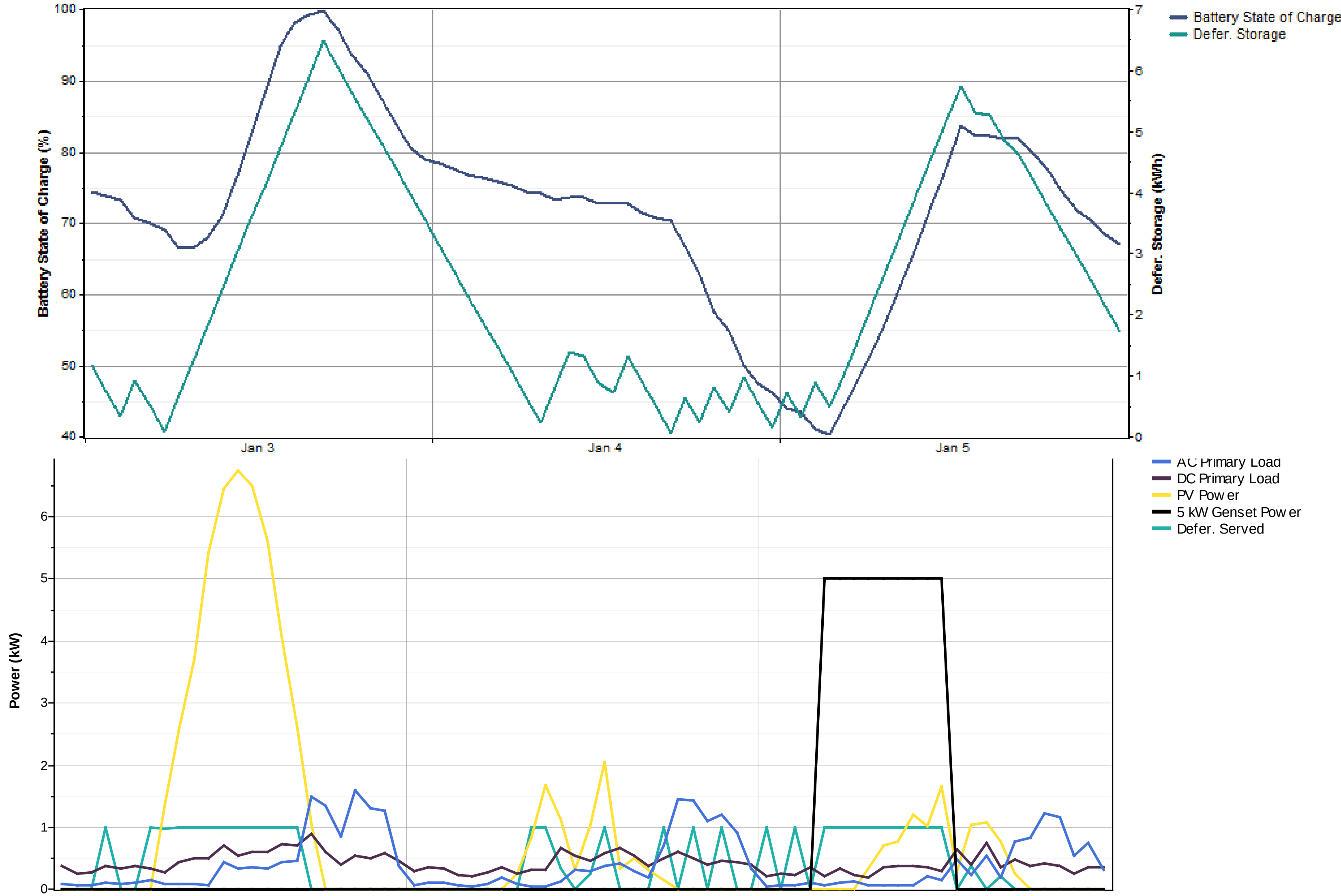
Village load (kWh/d)	Battery char (kWh/d)						PV (kW)	Gen5 (kW)	6FM200D	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Gen5 (hrs)
10.000	10.000						7	5	28	5	$ 54,200	3,491	$ 98,821	0.706	0.87	475	291
10.000	0.000						6	5	36	5	$ 52,400	2,330	$ 82,183	0.881	0.99	19	12
0.000	10.000						5	5	12	5	$ 37,800	1,665	$ 59,086	0.634	0.92	202	127
0.000	0.000						3	5	12	5	$ 27,800	1,046	$ 41,167	0.882	0.98	25	15

Optimal system for each scenario

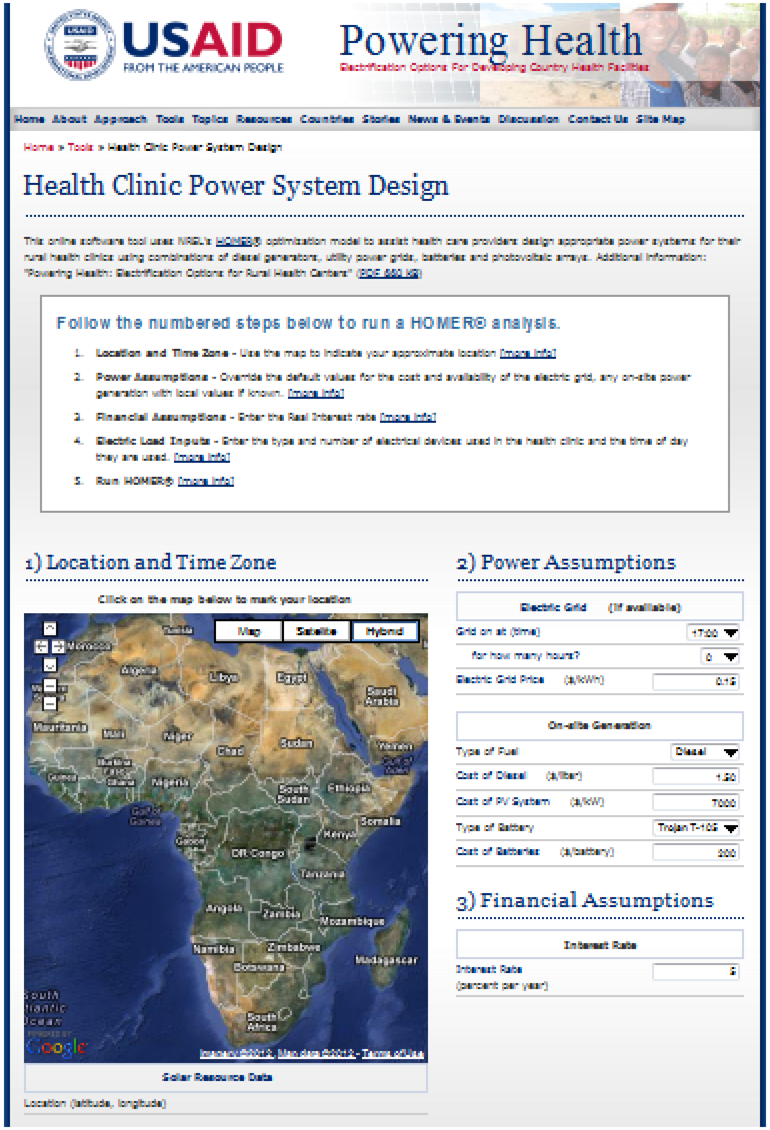
					PV (kW)	Gen5 (kW)	6FM200D	Conv. (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.	Diesel (L)	Gen5 (hrs)
					7	5	28	5	$ 54,200	3,491	$ 98,821	0.706	0.87	475	291
						5	4	5	$ 9,600	12,274	$ 166,509	1.190	0.00	4,795	3,644
						5		5	$ 8,000	17,586	$ 232,813	1.663	0.00	7,223	8,760

Scenario with all 3 loads

Detailed results



http://tools.poweringhealth.org/



Conclusion

- Essential community services require small amounts of electric power
- Every village is different
- Local involvement
- Regional support infrastructure