Optimizing clean power everywhere

Hybrid Renewable Mini-grids

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HOMER

- Developed for NREL's Village Power Program
- 20 year track record
- HOMER Energy: NREL spin-off 2009
- 86,000+ users in 193 countries
- Most are trying to promote mini-grids

Mini-grids are not new

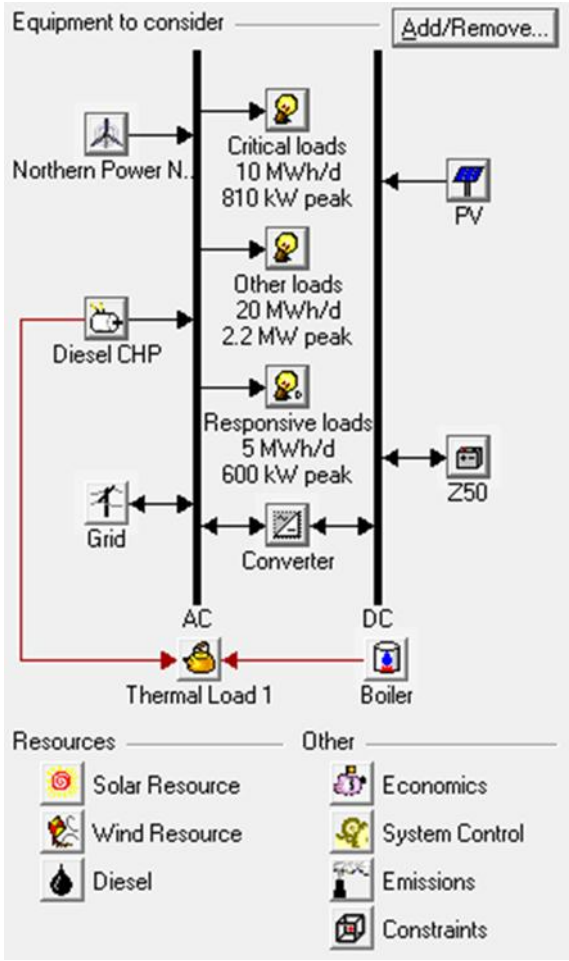
- Mostly dumb, dirty diesel microgrids
  - Unsustainable operating costs
- Thousands of island grids
  - Multiple units, real utility company
- Millions of individual diesels
  - Part-time service
- Billions of people with no service

Clean, smart, hybrid renewable mini-grids are new

- Solar and wind don't stand on their own
- Get peak performance from the diesels

- Renewable generation
- Conventional generation
- Multiple load types
- Storage

- Modular technologies
- Design flexibility



Design Challenges

- Many possible hybrid configurations
- How much fuel consumption?
- How long can the storage last?
- Understanding trade-offs
  - Storage size
  - Renewable capacity
  - Load management
  - Fuel usage

A Confused Mind Says "No"

Solar

Wind

Hydro

Geothermal

Biomass

New Storage Techs.

Electric Vehicles

Smart grids

Fuel Cells

Micro-turbines

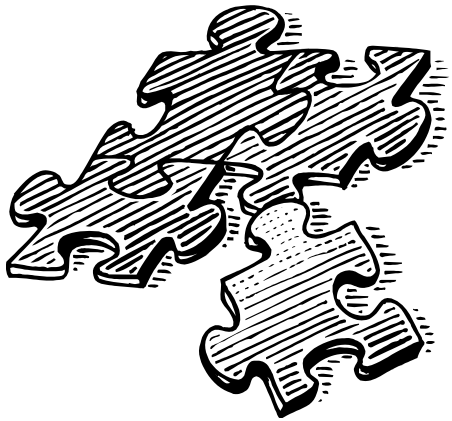
Combined heat and power

Demand Response

Load Management

What is best?

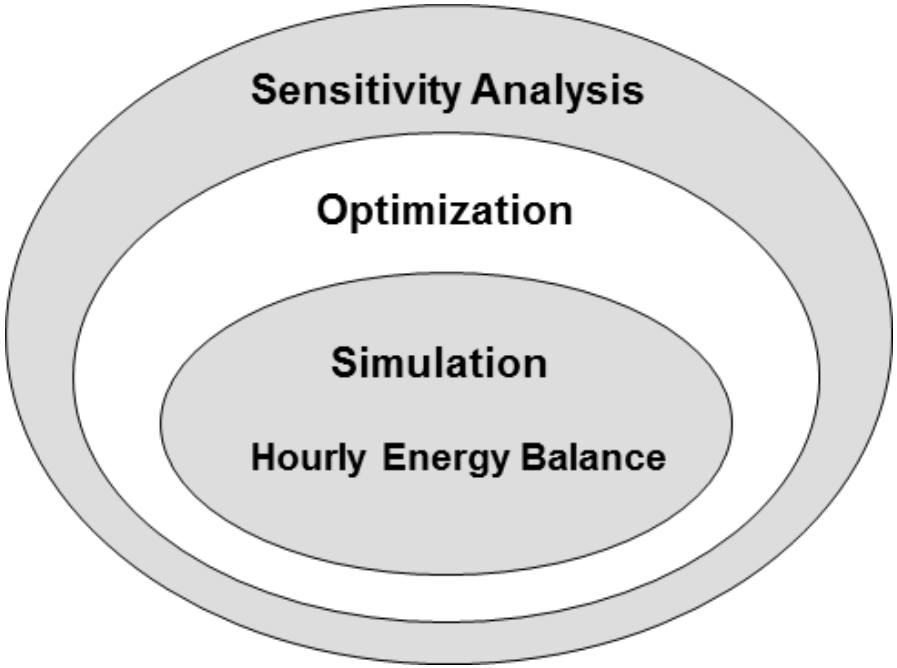
- Depends on the application
  - Resources
  - Loads
  - Equipment prices
  - Equipment performance



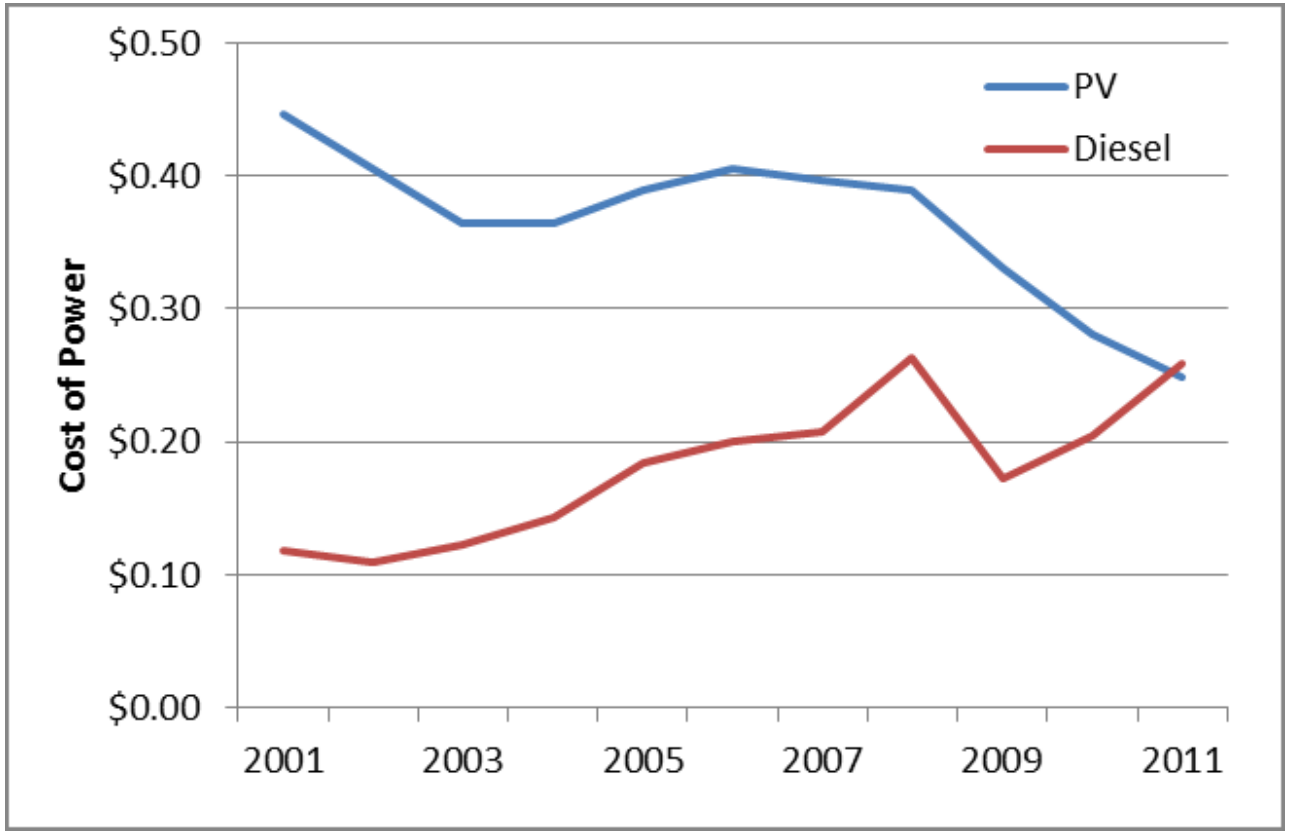
- **HOMER fits the pieces together**
  - Bridge technical & economic analyses

Analytical Requirements

- Simple graphical user interface
- Chronological simulation
  - Storage
  - Variable generation
  - Demand response
- Economic optimization
  - Expensive components
  - Expensive fuel
  - Many hybrid design choices
- Sensitivity analysis
  - Data uncertainty
  - Changing technologies
  - Disparate applications



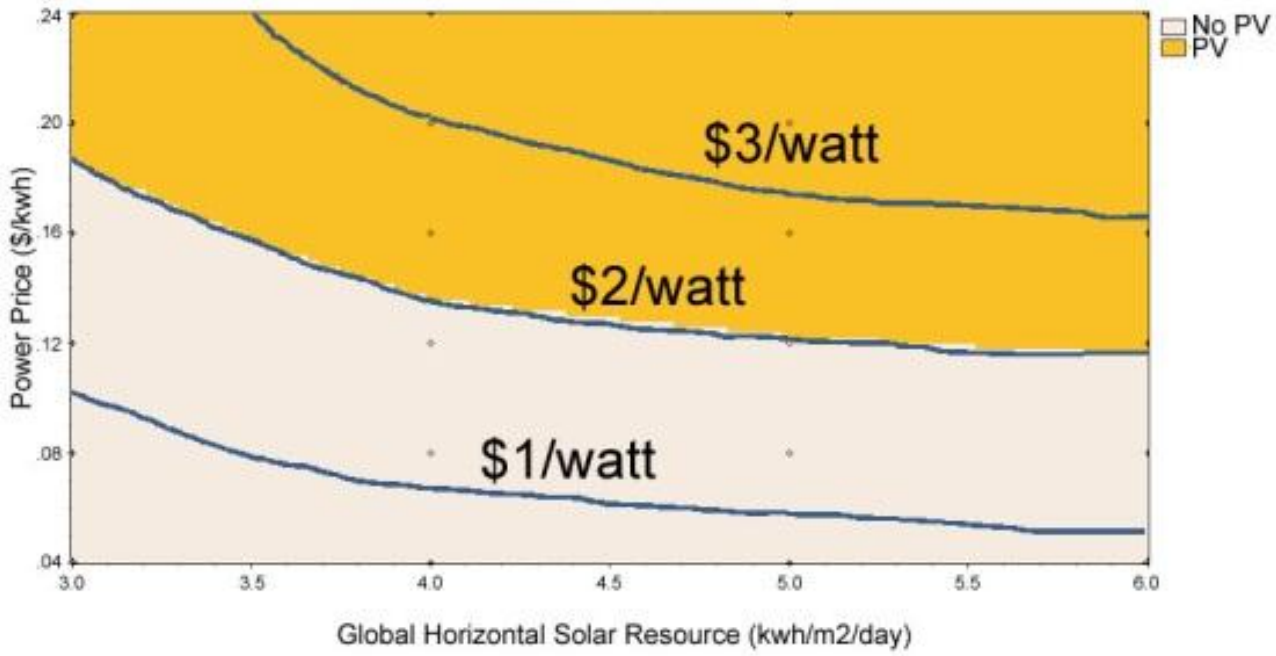
Cost Parity for PV on Diesel Grids



- Assumptions:
  - Low PV penetration system; no subsidies or incentives
  - Fuel savings only: no capital or O&M cost savings

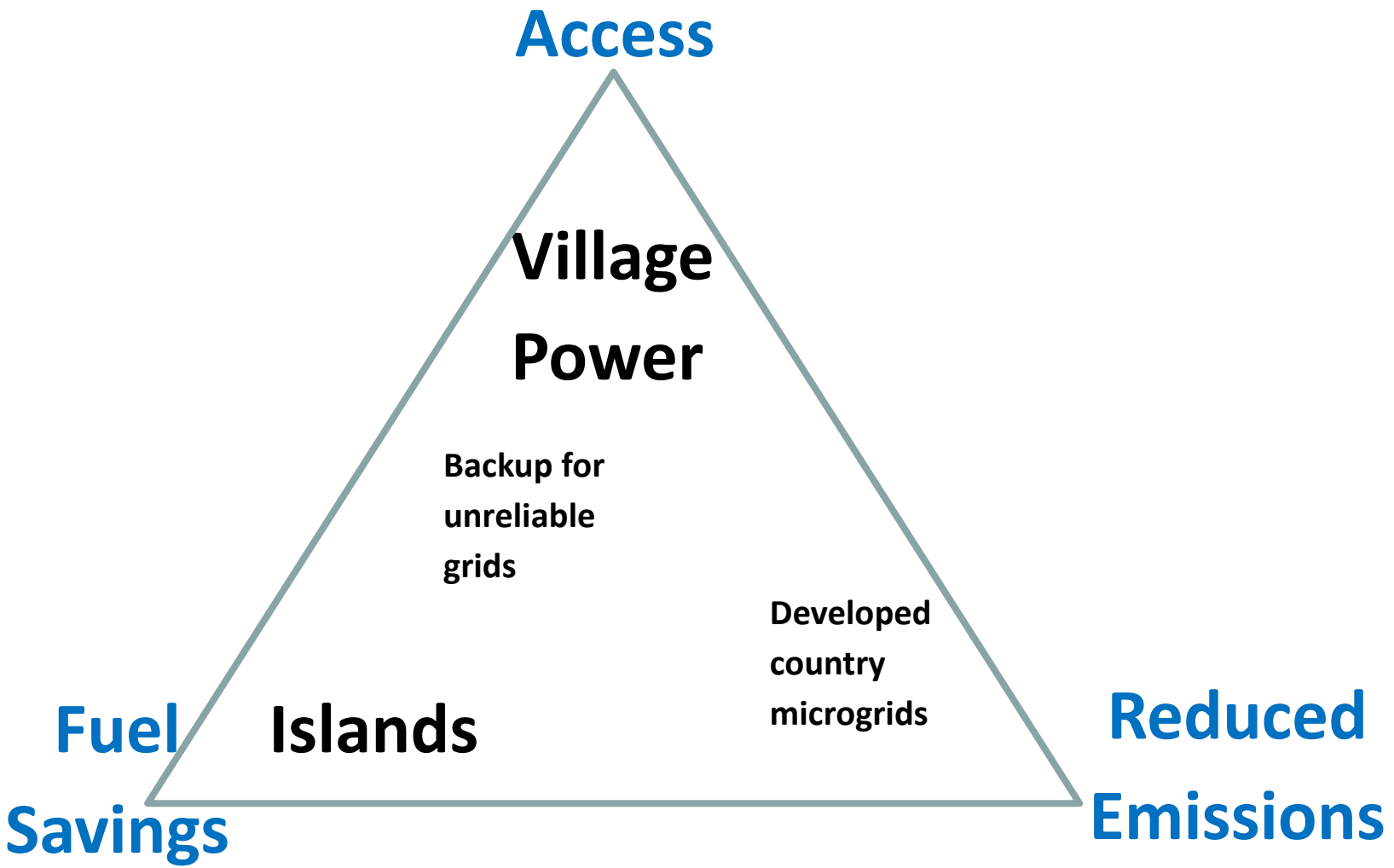
http://blog.homerenergy.com/2011/10/the-island-energy-challenge/

What makes PV cost-effective?



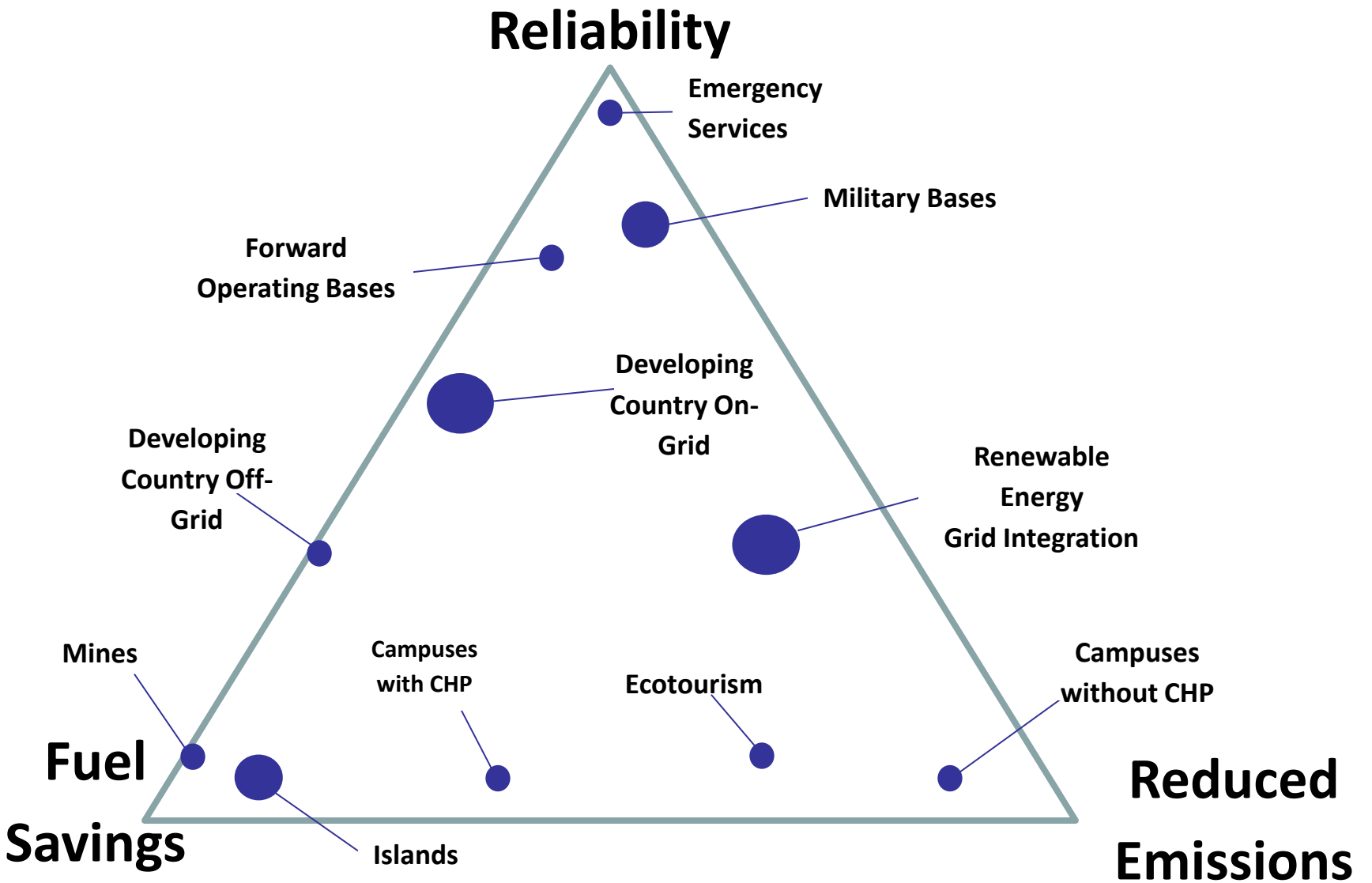
- Solar resource less critical than the wind resource
- PV capital cost is critical
- PV cost-effective vs. diesel almost everywhere

Multiple Market Segments with Different Value Propositions

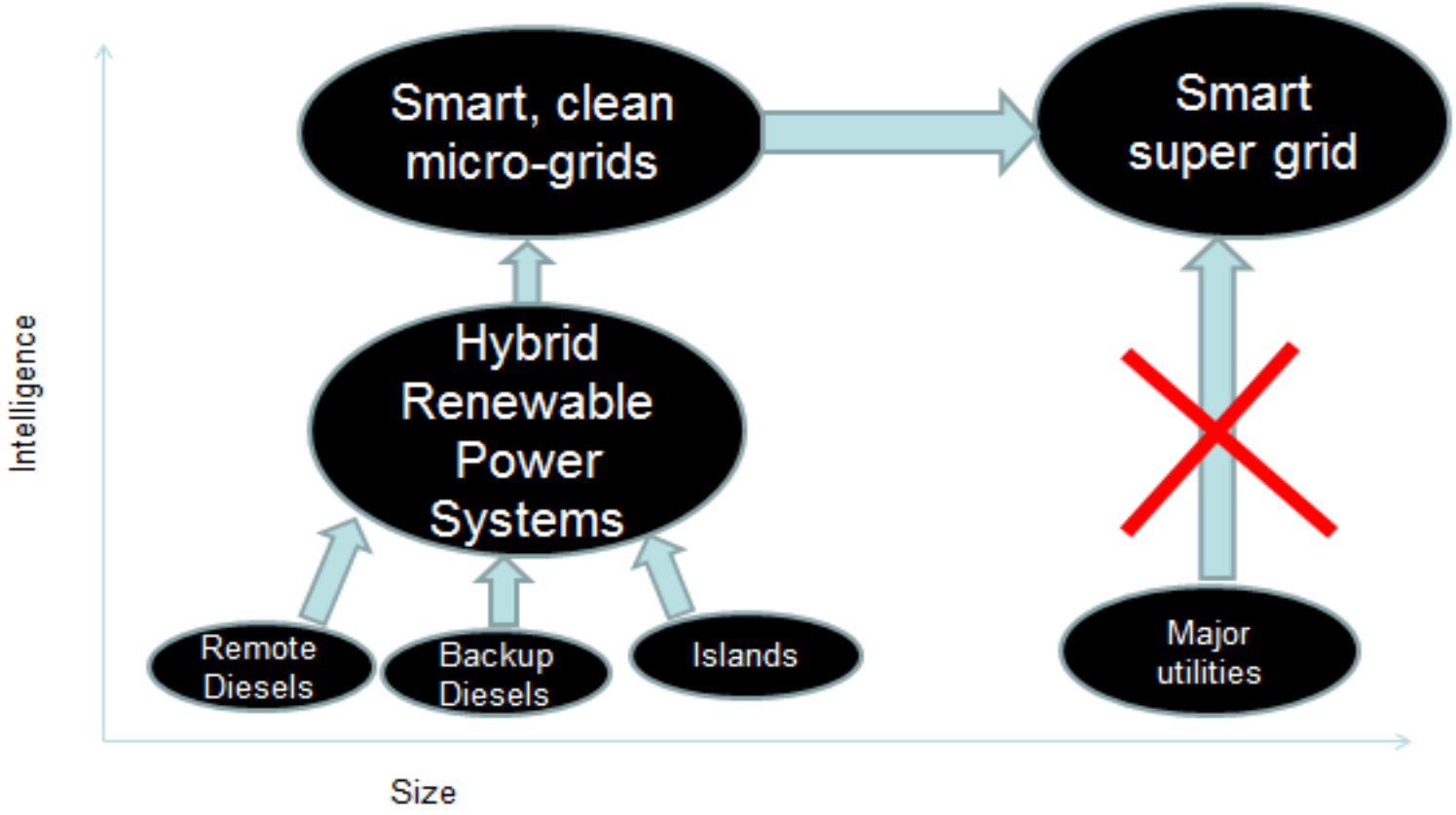


http://blog.homerenergy.com/2012/01/microgrid-value-propositions/

Microgrid Value Propositions



Clean Power Evolution



- Smaller systems
  - Liquid fuels from oil
  - High renewable penetrations
- Large utilities
  - Security obstacles
  - Regulatory obstacles

The Minigrid Gap

Solar lanterns

Solar home systems

Village power

Island power

Wind farms & Solar Parks

Products

Single user

No grid or meter

Financeable Projects

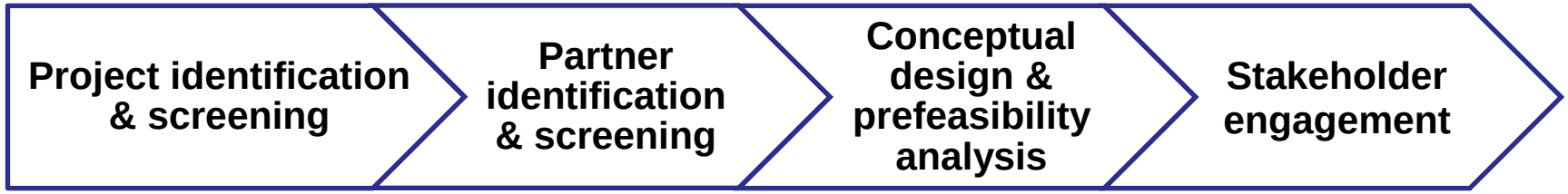
Programs

Taxonomy

	Size	Customer	Tariff	Finance	Subsidy	Distribution model
Lanterns	<10 watts	End-user	No	No	No	Product
SHS	10-300 watts	End-user	No	Micro	Loan terms	Almost a product
Village Power	300 watt – 300 kW	Govt.??	Yes	???	???	Program
Island Grids	300 kW – 3 MWs	Utility	Yes	???	Reduce development risk	Almost a project
Wind farms Solar Parks	>3 MWs	Utility	Yes	Project Finance	FITs & RPS	Project

Early project development steps are the risky ones

HOMER's role



Later stages

- Governments' role
  - Capacity building
  - Resource assessment
  - Standardizing permits & contracts

Conclusion

- Enormous potential for mini-grids
- Small, isolated diesel grids will demonstrate high penetration renewables first
- Larger mini-grids need more efficient project development process
- Smaller mini-grids need more packaged products
- Governments' role
  - Capacity building:
    - Analytical tools
    - Legal & financial requirements
  - Resource assessment
  - Standardizing permits & contracts