



# ESS Peer Review 2002

## Alaska [Battery Diesel System] Modeling and Analysis Project

November 19, 2002

**Dennis Meiners**  
**Alaska Energy Authority**  
**Alaska Industrial Development and Export**  
**Authority/Alaska Energy Authority**

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.





# Alaska Modeling and Analysis Project

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- **Project Partners**
  - Sandia National Labs
  - Alaska Energy Authority
  - Lime Village Traditional Council
  - McGrath Light and Power
  - University of Alaska, Fairbanks



# **Alaska Modeling and Analysis Project Partnership Objectives**

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- **Provide a reliable/cost-effective power system for Lime Village.**
- **Develop inexpensive capability to remotely monitor, collect, and analyze performance data.**
- **Create diesel battery PV modeling tool (HYBSIM)**
- **Validation test-bed for HYBSIM Model.**



# Alaska Modeling and Analysis Project

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- **HybSim (Hybrid Simulation) Model**

- A flexible easy to use hybrid power system simulator developed for Sandia National Laboratories by Sentech Inc.
- Allows the user to quantify the benefits of installing a hybrid generating system versus straight diesel gensets
- Diagnostic tool for troubleshooting existing systems and optimizing dispatch strategies and component configurations
- Version 3.0 to be completed this year
  - Simulates systems with any combination of diesel gensets, PV arrays, and battery energy storage systems



# Alaska Modeling and Analysis Project

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- **Analysis results using HybSim**

- Analysis utilizing an earlier version of HybSim indicated:

- battery/diesel hybrid systems can reduce fuel consumption in rural Alaskan Villages by 20%
    - these systems can offer other advantages:
      - defer genset replacement, due to load growth
      - power conditioning,
      - make intermittent energy sources more economical
      - offset fuel storage



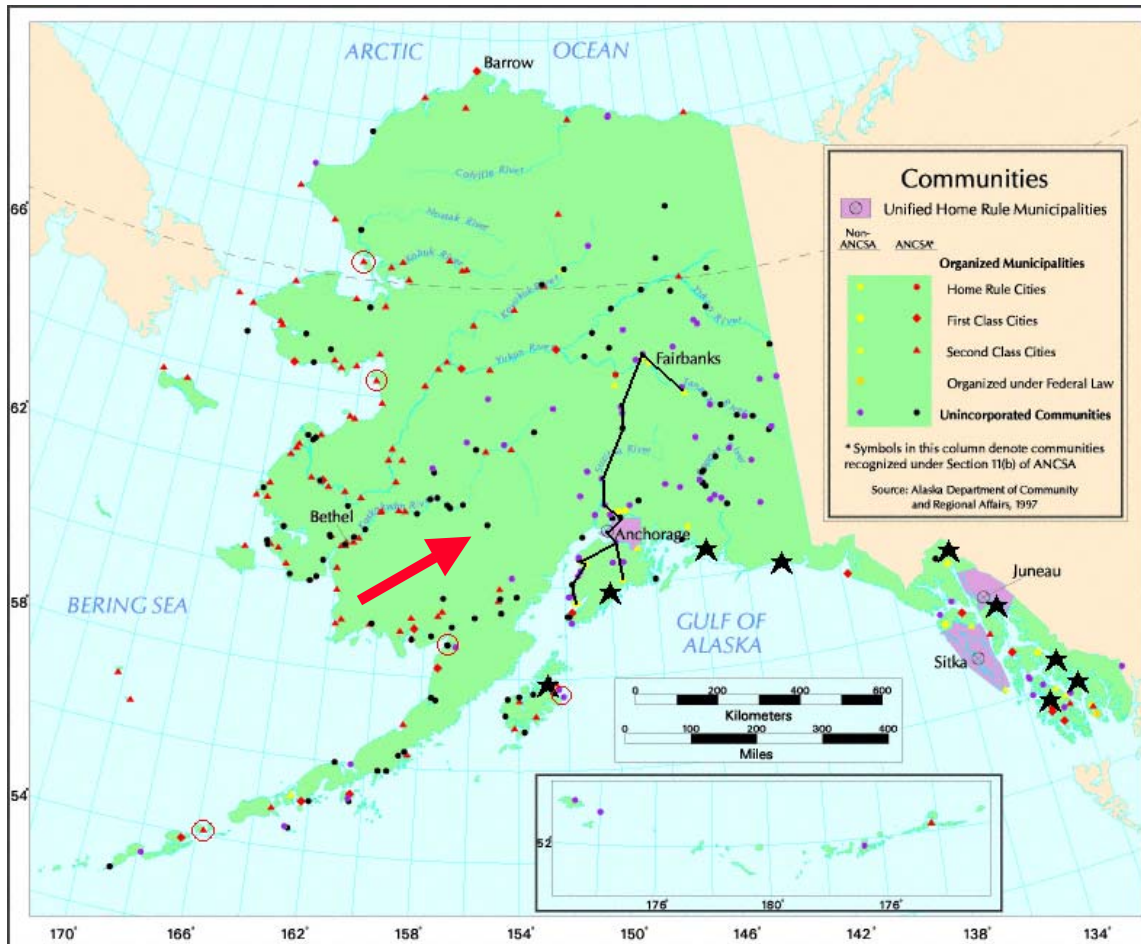
# Just a little about AEA

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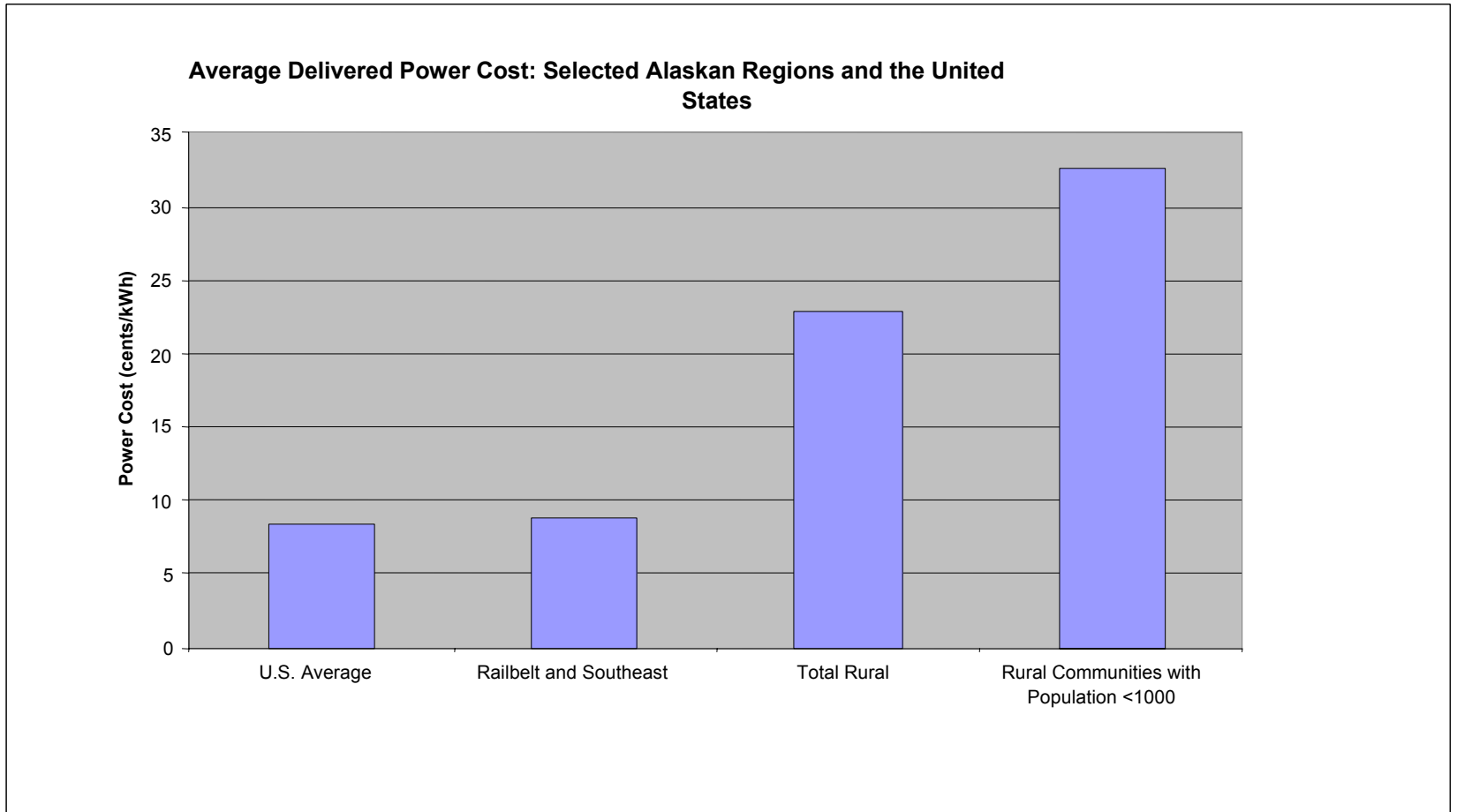


- **Repair Fuel Storage System**
- **Upgrade Diesel Power Systems**
- **Small hydro**
- **Short interties**
- **Conservation**
- **Training**
- **Planning**
- **Financial Assistance**

# Alaska Modeling and Analysis Project

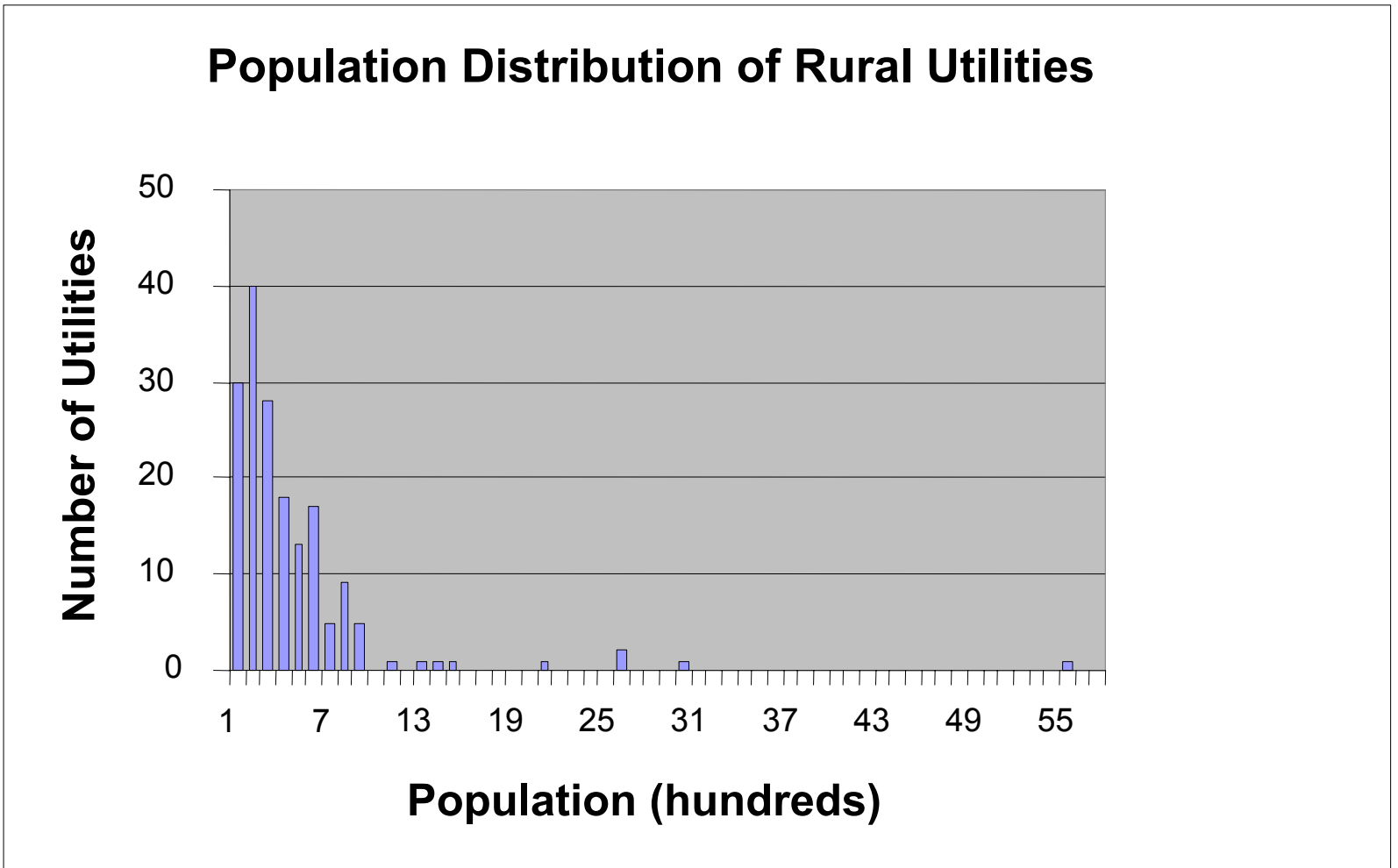


# Market





# Market



# Lime Village

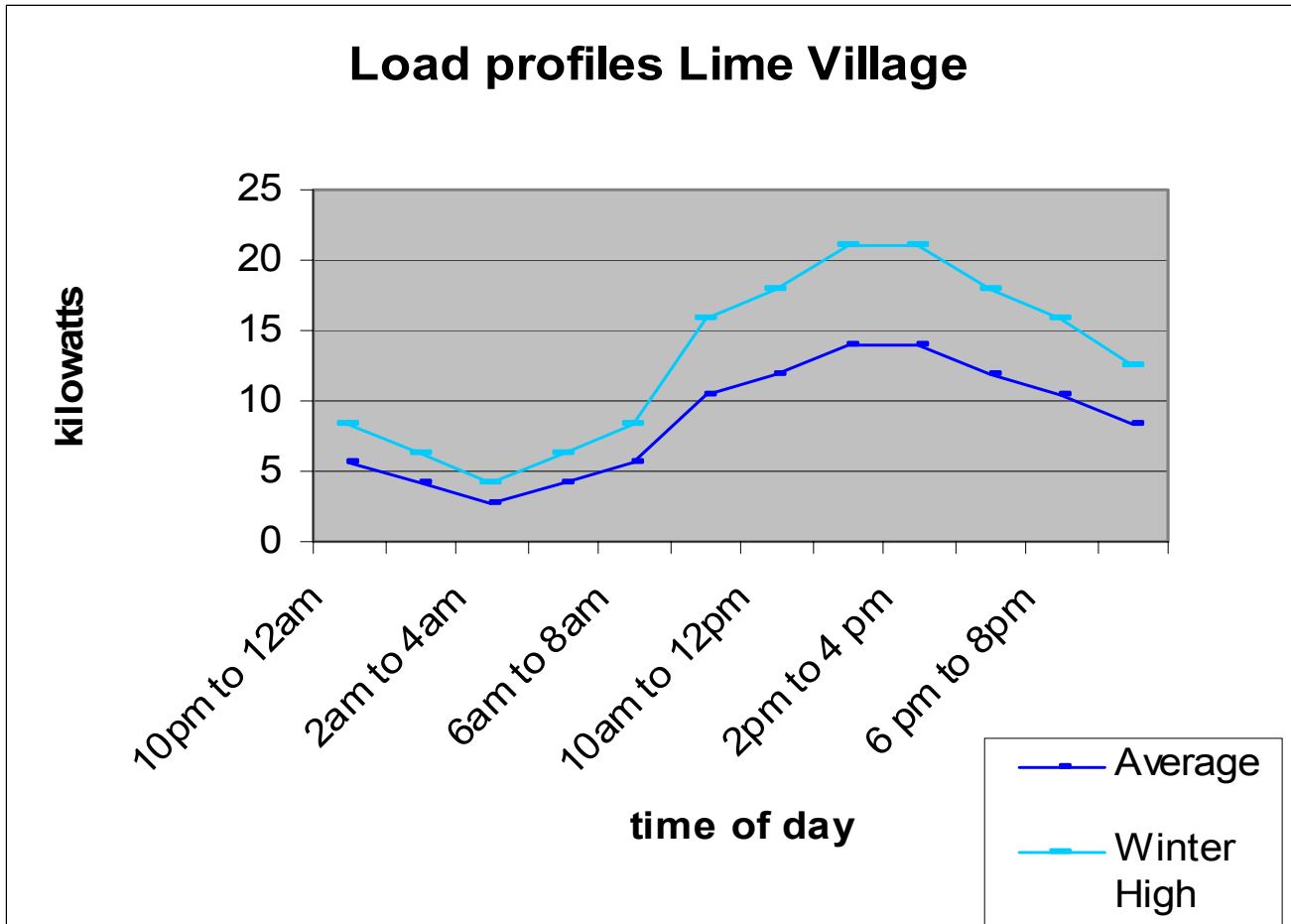


# Lime Village Data Collection

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# Alaska Modeling and Analysis Project



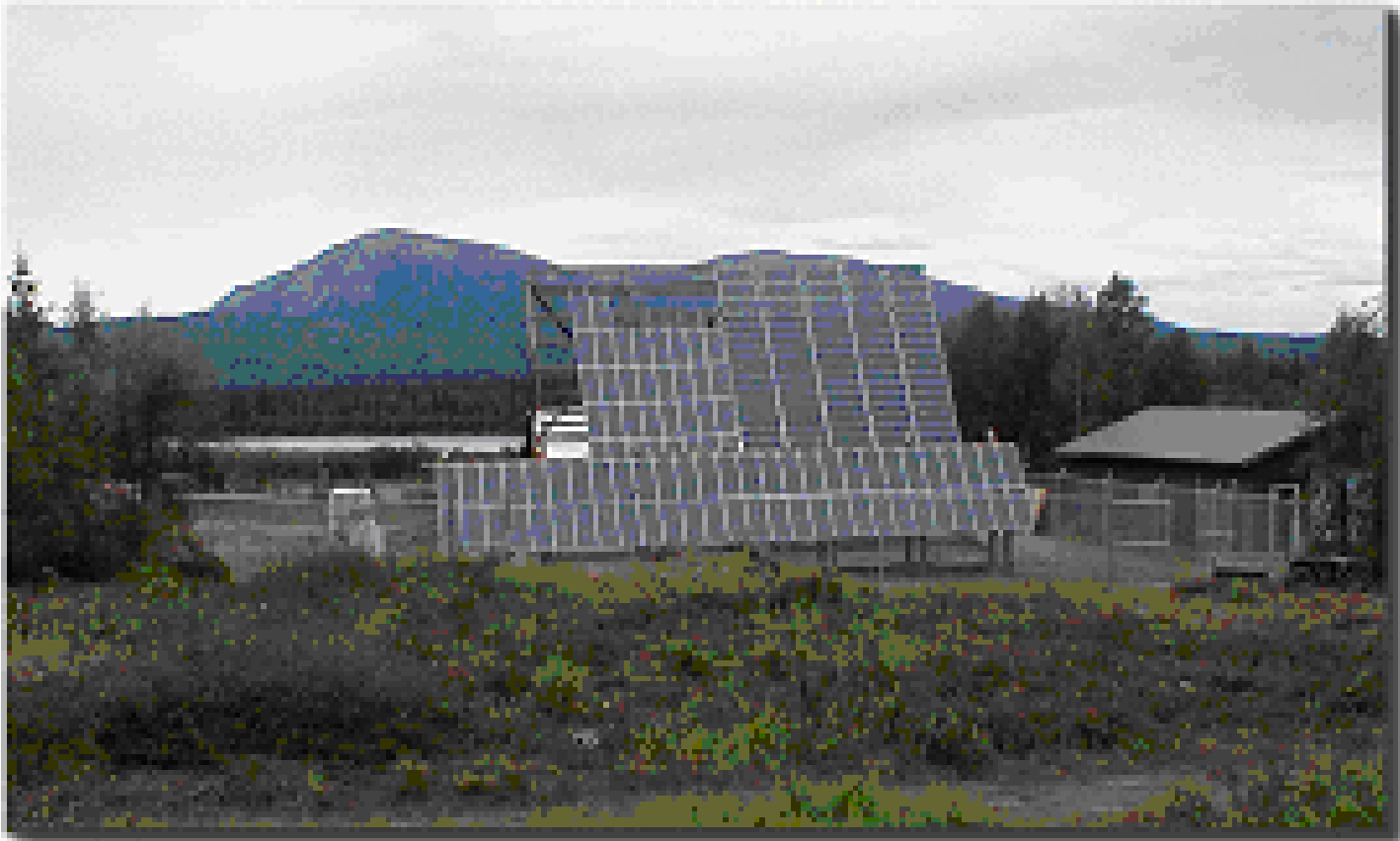


# New small generator



# Expanded Solar Array

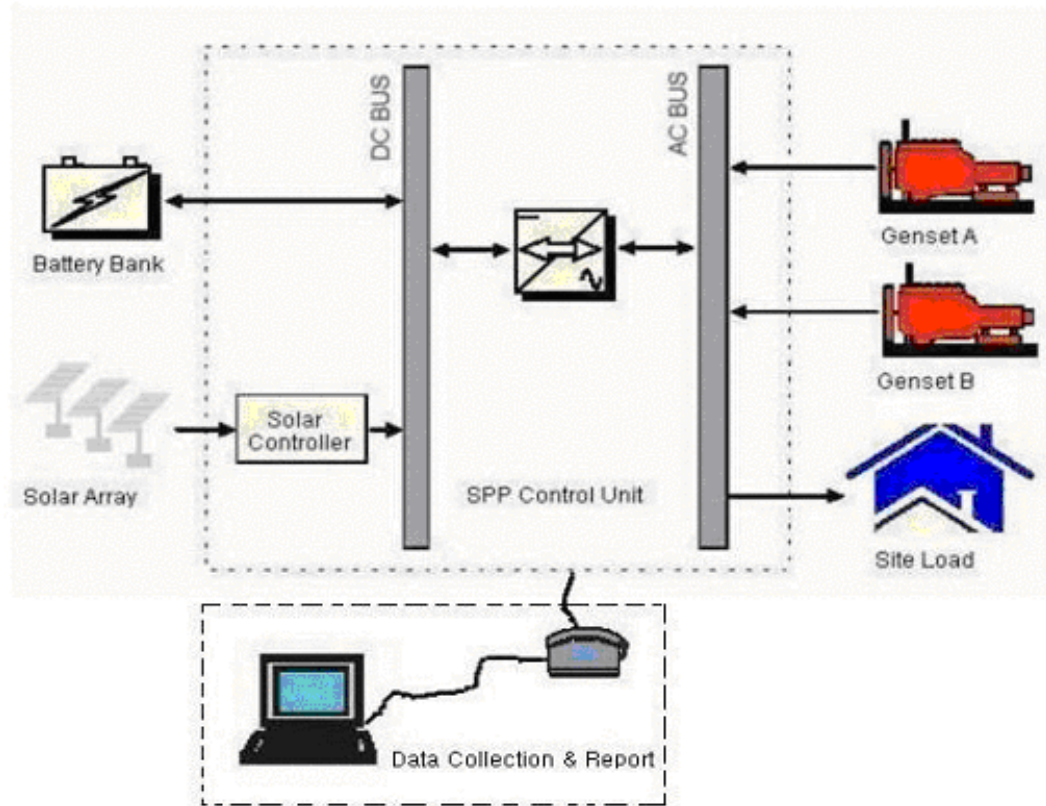
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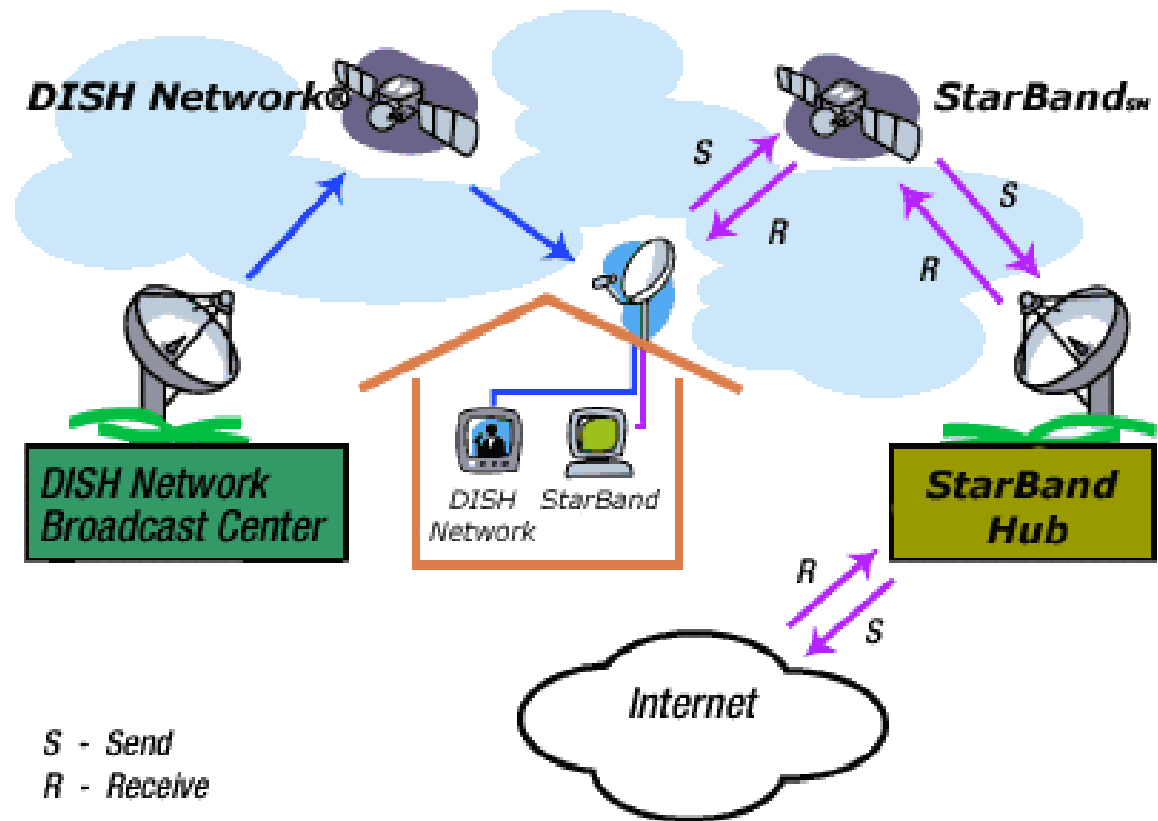
# Solar-Diesel-Battery Diagram





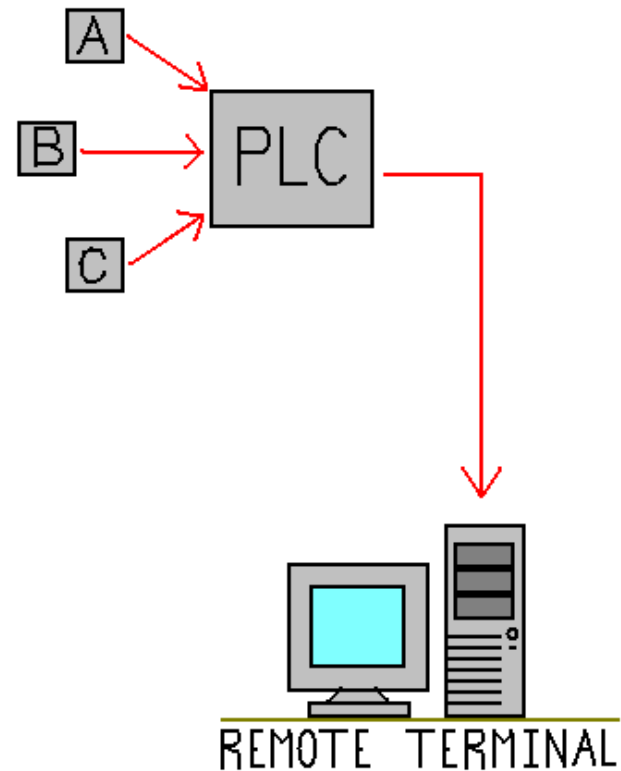
# Data Transmission

- Low cost
- Accessible
- Reliable



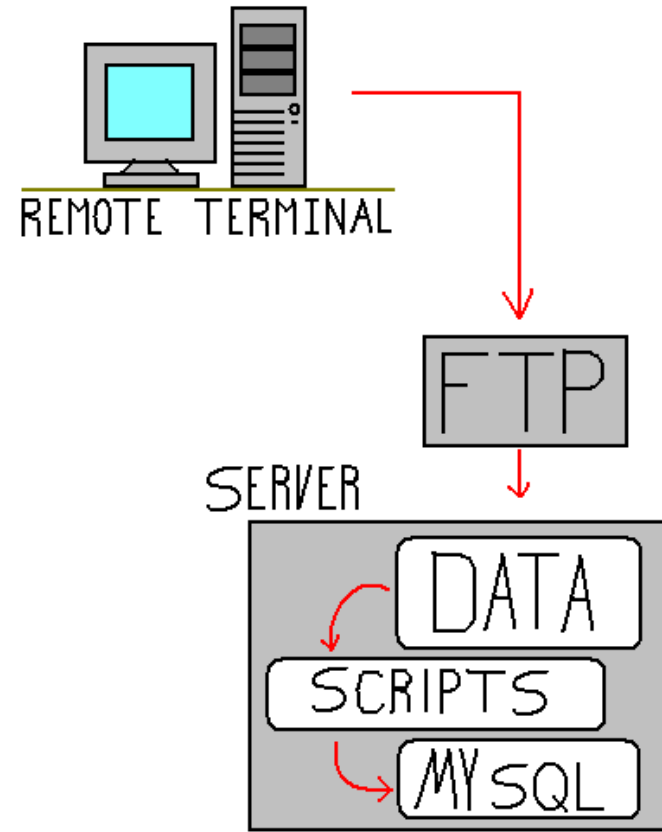
# Data Collection Process

- Data originates from sensors on the equipment. (Diesel Engines, Solar Array, Inverter, etc.)
- Sensors pass data to the PLC logger.
- Logs are saved to the on-site remote terminal.



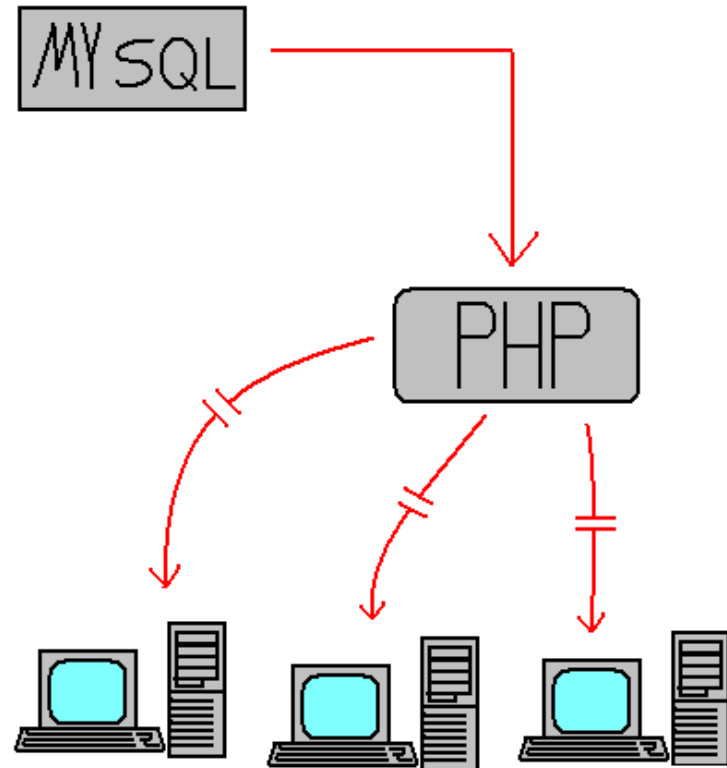
# Data Collection Process

- Daily, all logs are uploaded to a remote FTP server.
- Web/database server checks for logs on the FTP server, and downloads.
- Logs are saved on the server, processed by formatting scripts and imported into MySQL.



# Data Collection Process

- Logs that have been stored in the MySQL database can be viewed on the web using PHP scripts.
- Clients with web access can view the Data
- Data can be viewed as raw values, or graphed for comparison.





# Web Integration

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- **RedHat**
  - Linux Operating System
- **Apache**
  - Web Server daemon
- **PHP**
  - Server side web scripts
- **MySQL**
  - Database daemon
- **Smoothwall**
  - Firewall security

# Web Integration

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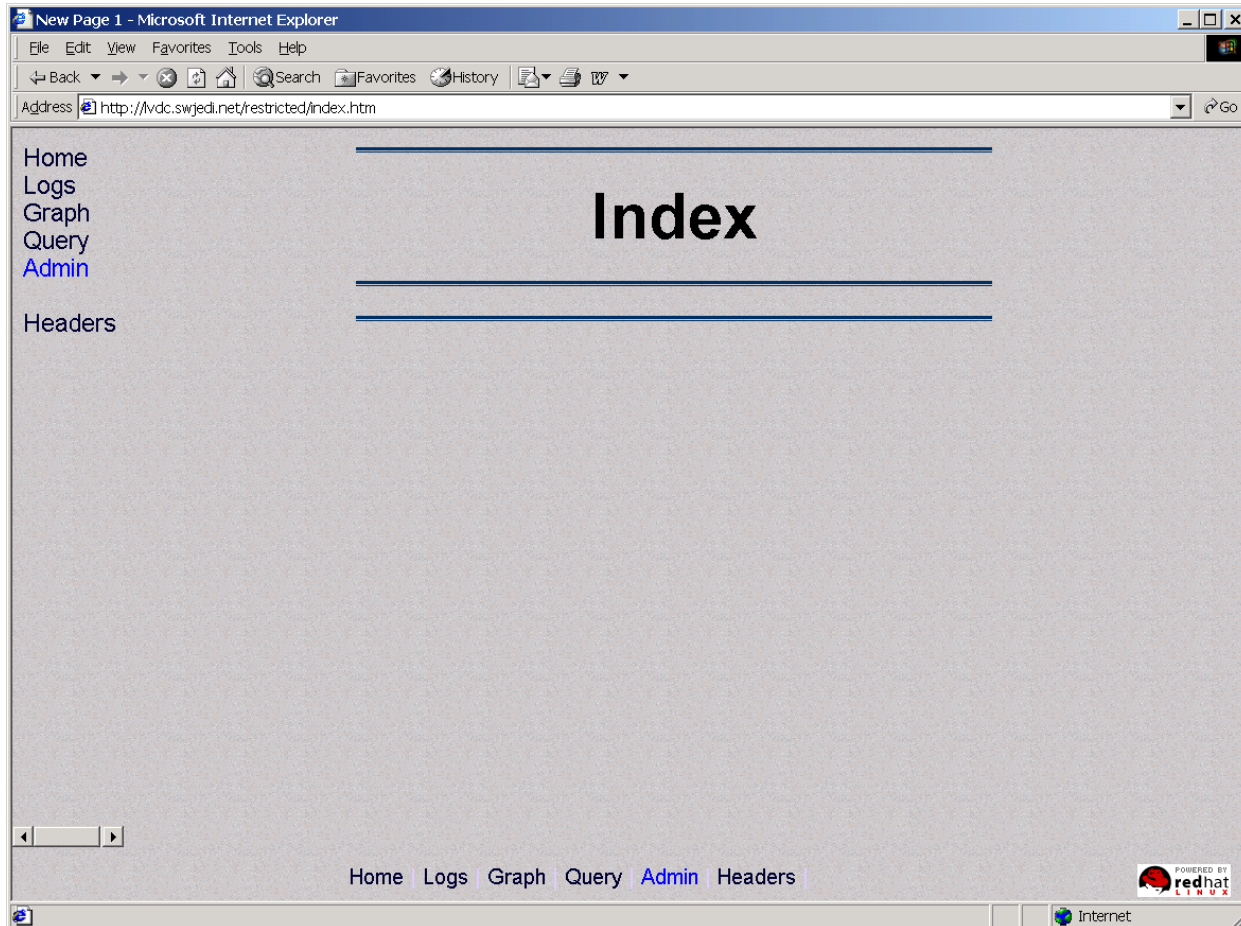
# Web Integration

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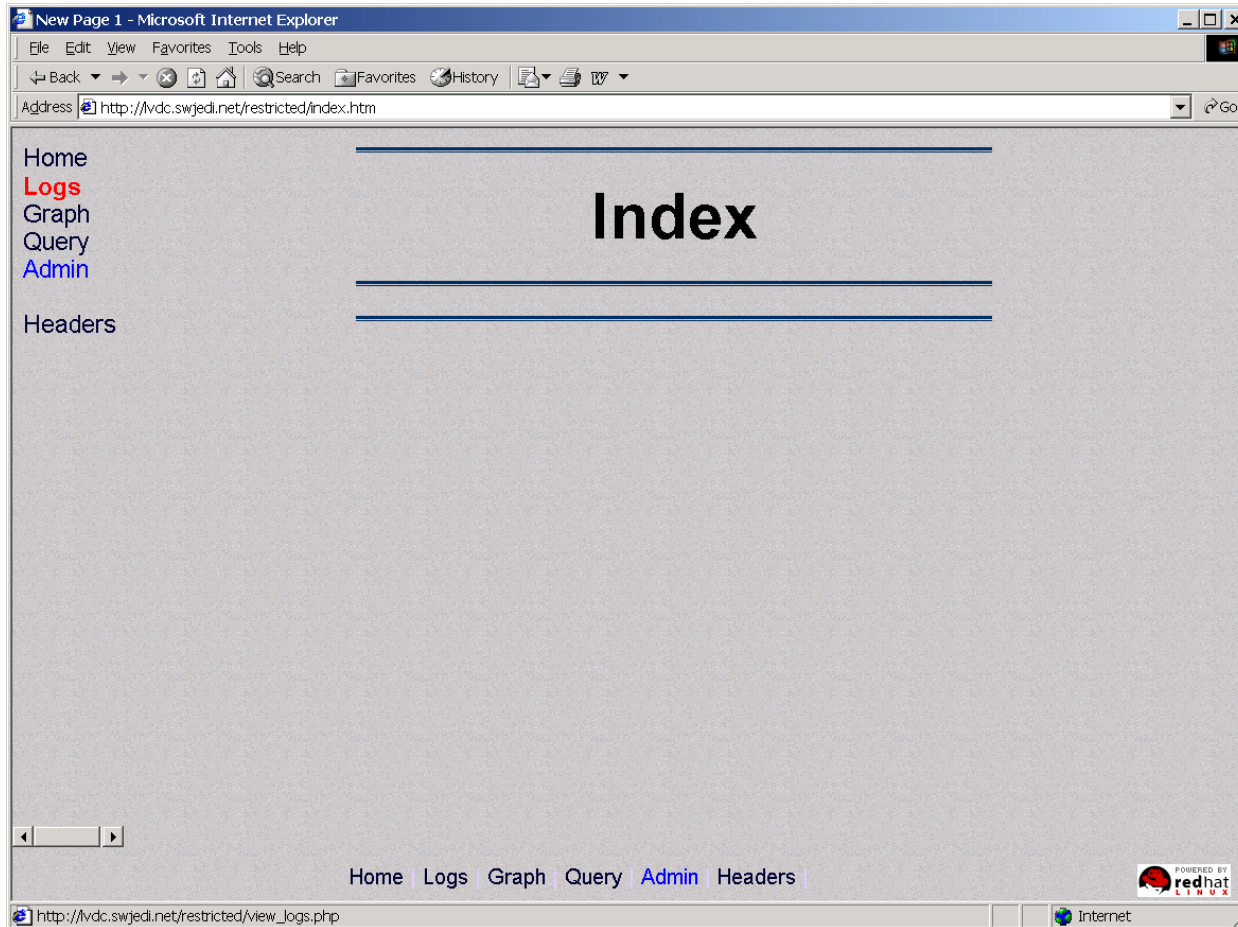


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# Web Demo



# Web Demo





# Web Demo

New Page 1 - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites History Print

Address <http://vdc.swjedi.net/restricted/index.htm> Go

Home  
Logs  
Graph  
Query  
Admin  
Headers

---

## Logs

---

[View raw Data](#)

<b>View All records</b>	Submit
<b>Create a Graph</b>	Submit
<b>Execute Query</b>	Submit

Home | Logs | Graph | Query | **Admin** | Headers

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Internet

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Internet

# Web Demo

Home  
Logs  
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Admin

Headers

## Create Graph

Pre-Designed Graphs

Original Preset

Range	Starting at	HELP
<input type="radio"/> 1 Hour(s)	<input type="checkbox"/> 00:00:00	HELP
<input type="radio"/> 1 Day	<input type="checkbox"/> 14	HELP
<input type="radio"/> 1 Week		HELP
<input type="radio"/> 1 Month	<input type="checkbox"/> 11	HELP
<input type="radio"/> 1 Year	<input type="checkbox"/> 2002	HELP

Submit

Create a Graph

Submit Create a custom designed graph.

Home | Logs | Graph | Query | Admin | Headers

Done Internet



# Web Demo

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Headers

## Create Graph

Pre-Designed Graphs

Original Preset		
<input type="radio"/>	Original Preset	HELP
<input type="radio"/>	Absolute Power Comparison	
<input type="radio"/>	Percent Total Capacities	HELP
<input type="radio"/>	Ho VPC, BA, TVPC, BT, AMBT	
<input type="radio"/>	1 Day	<input type="text" value="14"/> HELP
<input type="radio"/>	1 Week	HELP
<input type="radio"/>	1 Month	<input type="text" value="11"/> HELP
<input type="radio"/>	1 Year	<input type="text" value="2002"/> HELP

Submit

Create a Graph

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Home Logs Graph Query Admin Headers

Done Internet

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## Create Graph

Pre-Designed Graphs

Percent Total Capacities

Range	Starting at	HELP
<input type="checkbox"/> 1 Hour(s)	<input type="text" value="00:00:00"/>	HELP
<input checked="" type="checkbox"/> 1 Day	<input type="text" value="14"/>	HELP
<input type="checkbox"/> 1 Week		HELP
<input type="checkbox"/> 1 Month	<input type="text" value="11"/>	HELP
<input type="checkbox"/> 1 Year	<input type="text" value="2002"/>	HELP

Submit

Create a Graph

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Home | Logs | Graph | Query | [Admin](#) | Headers

Done Internet

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Logs  
Graph  
Query  
Admin

Headers

## Create Graph

Pre-Designed Graphs

Percent Total Capacities

Range	Starting at	HELP
1 Hour(s)	00:00:00	HELP
<input checked="" type="radio"/> 1 Day	22	HELP
<input type="radio"/> 1 Week		HELP
<input type="radio"/> 1 Month	11	HELP
<input type="radio"/> 1 Year	2002	HELP

Submit

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Done Internet



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Graph  
Query  
Admin

Headers

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Pre-Designed Graphs

Percent Total Capacities

Range	Starting at	HELP
<input type="radio"/> 1 Hour(s)	<input type="checkbox"/> 00:00:00	HELP
<input type="radio"/> 1 Day	<input checked="" type="checkbox"/> 22	HELP
<input type="radio"/> 1 Week		HELP
<input type="radio"/> 1 Month	<input checked="" type="checkbox"/> 11	HELP
<input type="radio"/> 1 Year	<input type="checkbox"/> 2002	HELP

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Graph  
Query  
Admin

Headers

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Pre-Designed Graphs

Percent Total Capacities

Range	Starting at	HELP
<input type="checkbox"/> 1 Hour(s)	<input type="checkbox"/> 00:00:00	HELP
<input type="radio"/> 1 Day	<input checked="" type="checkbox"/> 22	HELP
<input type="radio"/> 1 Week		HELP
<input type="radio"/> 1 Month	<input checked="" type="checkbox"/> 08	HELP
<input type="radio"/> 1 Year	<input type="checkbox"/> 2002	HELP

Submit

Create a Graph

Submit Create a custom designed graph.

Home | Logs | Graph | Query | [Admin](#) | Headers

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Internet

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Pre-Designed Graphs

Percent Total Capacities

Range	Starting at	HELP
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<input checked="" type="radio"/> 1 Day	<input checked="" type="checkbox"/> 22	HELP
<input type="radio"/> 1 Week	<input type="checkbox"/>	HELP
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Submit

Create a Graph

Submit Create a custom designed graph.

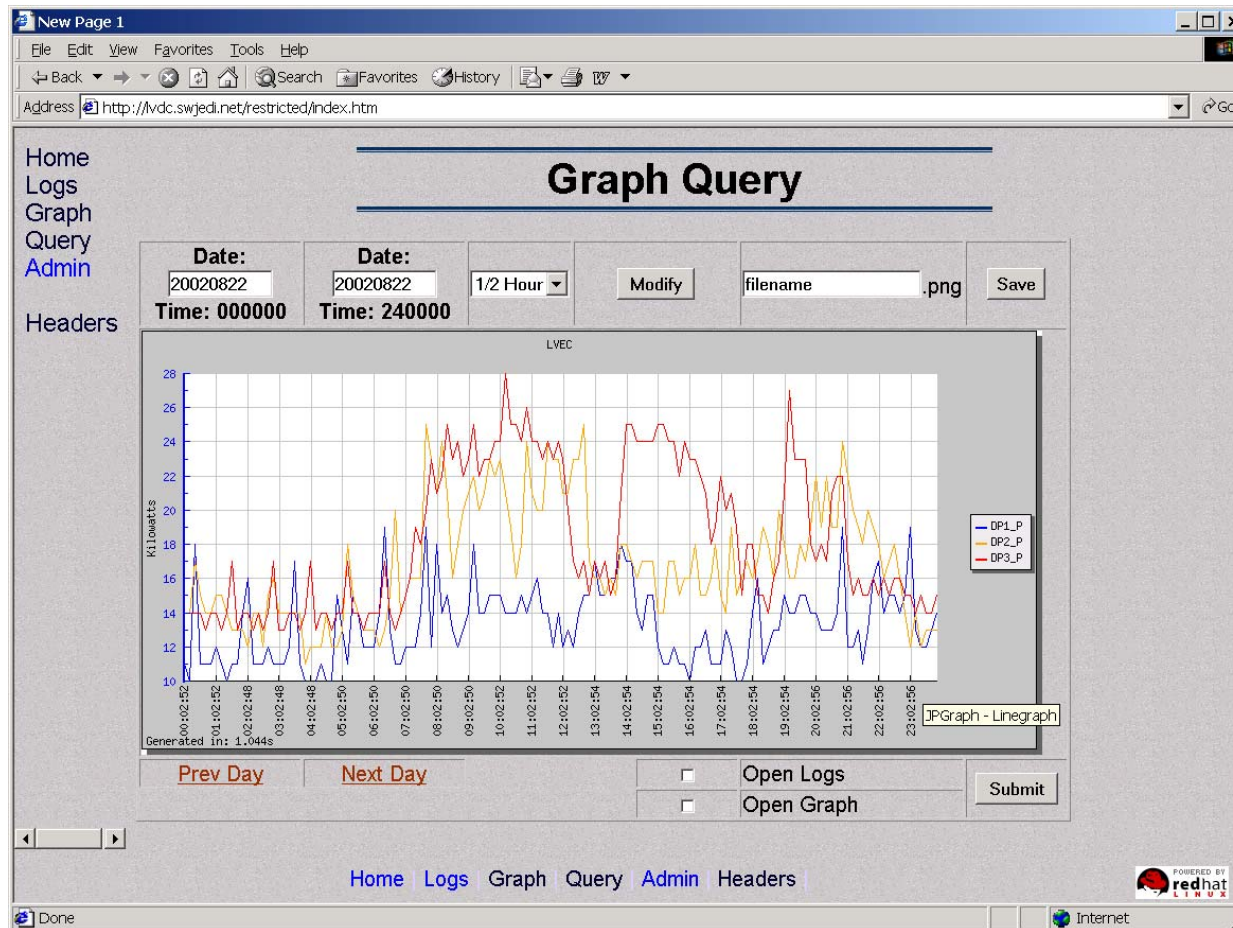
Home Logs Graph Query Admin Headers

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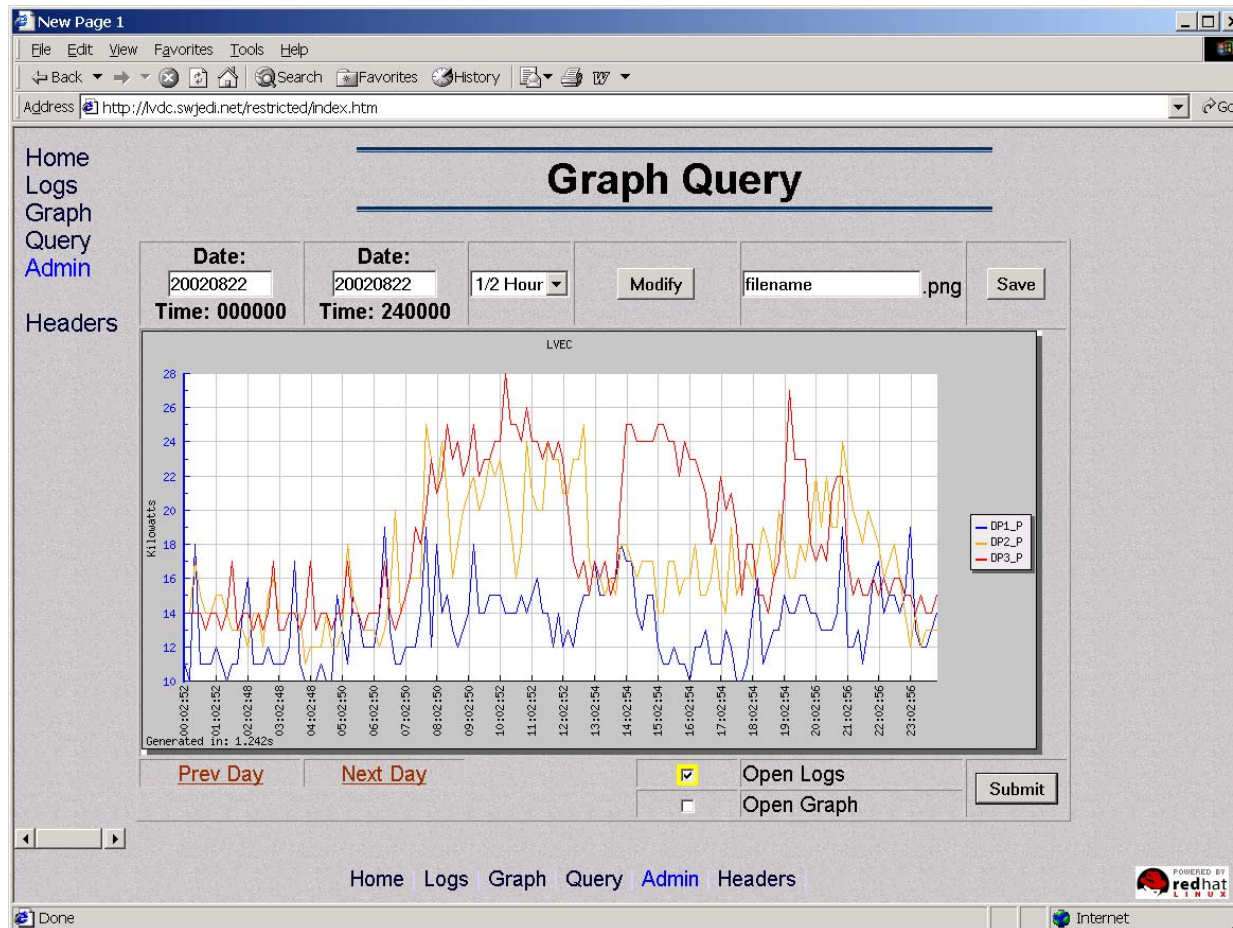
Opening page <http://ivdc.swjedi.net/restricted/graphs/preset2.php...> Internet



# Web Demo

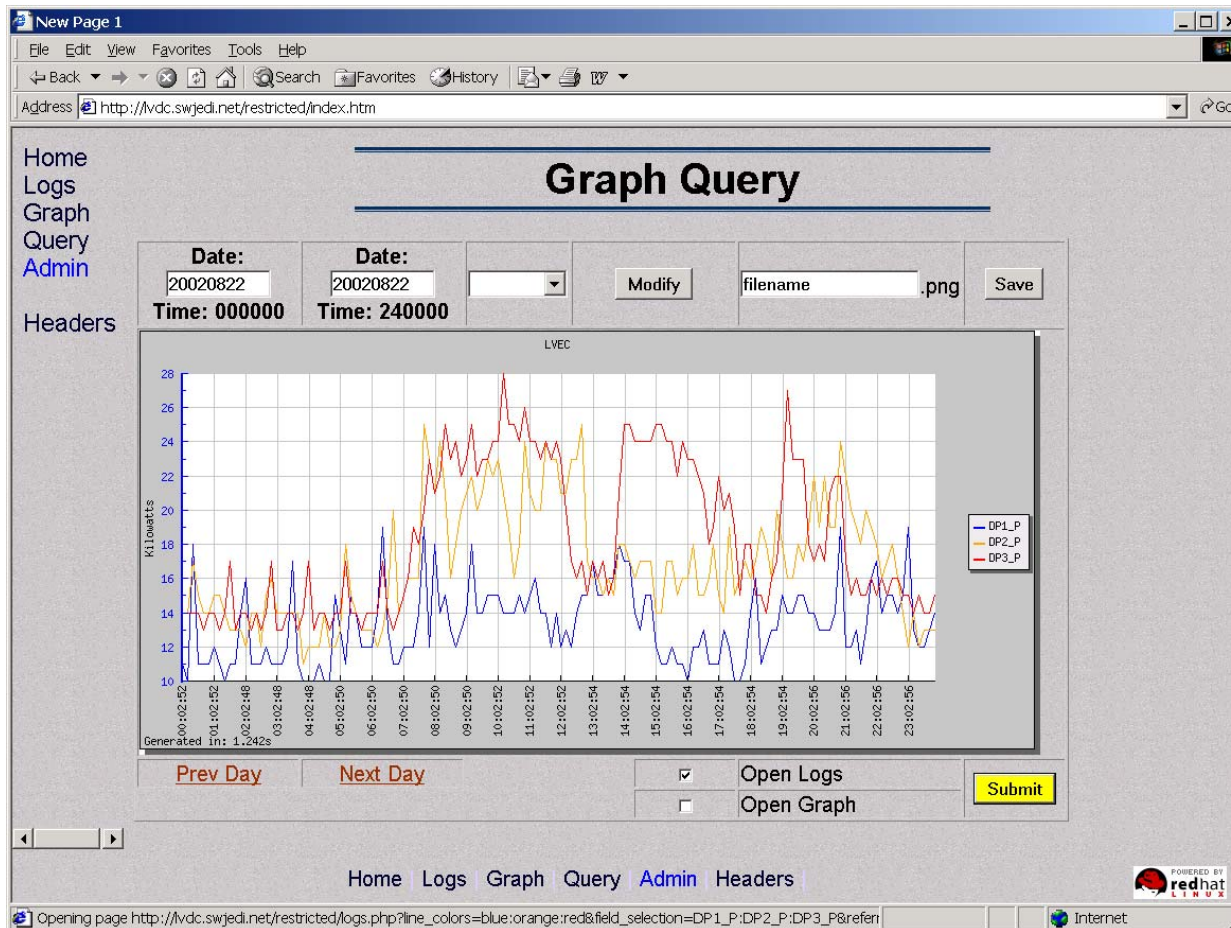


# Web Demo





# Web Demo



# Web Demo

Home  
Logs  
Graph  
Query  
Admin  
Admin  
Headers

## Log Results

Default Order    Current    Default    Type    Color by    Limit

Submit            Ascending     Column  
        Descending     Row

Open Graph    Graph    filename    Save

LOG	TIME	DATE	DP1_P	DP2_P	DP3_P
72	00:02:52	2002-08-22	11	14	14
73	00:12:52	2002-08-22	10	14	14
74	00:22:52	2002-08-22	18	17	14
75	00:32:52	2002-08-22	11	15	14
76	00:42:52	2002-08-22	11	14	13
77	00:52:52	2002-08-22	11	14	14
78	01:02:52	2002-08-22	12	15	14
79	01:12:52	2002-08-22	11	15	13
80	01:22:52	2002-08-22	10	14	14
81	01:32:52	2002-08-22	11	13	17
82	01:42:52	2002-08-22	11	13	13
83	01:52:52	2002-08-22	14	13	14

Home    Logs    Graph    Query    Admin    Headers

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# Alaska Modeling and Analysis Project

## • HybSim Sample Output Report

Diesel/battery hybrid model output - Summary

**Warning: the model detected unmet load during the simulation.**

General Parameters	
Dispatch Algorithm	Peak Shave
Fuel Cost (\$/gal)	1.6
Performance Simulation Length (days)	10.9
Economic Simulation Time Period (yr)	20

	Baseline	Hybridized
<b>Parameters - Diesels</b>		
Manufacturer	Generic	Generic
Model #	N/A	N/A
Rated Capacity (kW)	100	80
Generator Cost (\$)	80000	48000
Nominal Lifetime (yr)	15	15
Existing?	TRUE	TRUE
Age at start of simulation (yr)	5	5

Parameters - Battery	
Manufacturer	Generic
Model #	N/A
System Voltage (V)	240
System Capacity (kWh)	19.2
System Cost (\$)	5760
BOS Cost (\$)	1000
Lifetime (Ah)	19200
Shelf Life (yr)	7

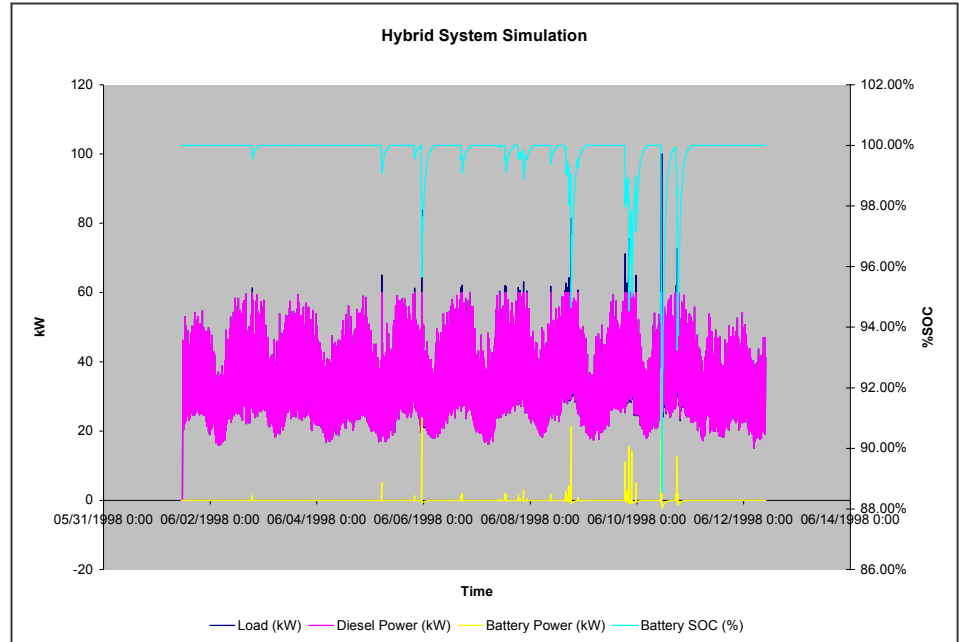
Parameters - PCS	
Manufacturer	Generic
Model #	N/A
Capacity (kW)	46.08
Cost (\$)	4608
Lifetime (yr)	10

Summary of Output		
Unmet Load During Simulation (kWh)	0.000	0.112
Instances of Unmet Load During Simulation	0	2
Diesel Assists During Simulation	---	0
Annual Energy Produced (kWh)	252,079	252,079
Annual O&M Costs (\$/yr)	\$2,001.90	\$2,001.90
Annual Fuel Expenses (\$/yr)	\$44,857.73	\$38,046.76
Present Value of Total Capital Investments (\$)	\$47,351.88	\$50,790.88
Annualized Total Expenses (\$/yr)	\$53,799.56	\$46,879.75
Levelized Cost of Energy (\$/kWh)	\$0.21	\$0.19
Annual Fuel Used (gal)	28,036	23,779
Average System Efficiency (gal/kWh)	0.111	0.094
Diesel Annual Hours of Operation (hr)	8,768	8,768
Projected Diesel Life (yr)	15.0	15.0
Battery Annual Charge Throughput (Ah)	---	1,348
Projected Battery Life (yr)	---	7.000

System Comparison	
Annual Fuel Savings (gal)	4,257
Annual Fuel Savings (%)	15.18%
Annual Fuel Savings (\$)	\$6,810.96
Initial Capital Cost of Hybrid System	\$11,368.00
Simplified Payback Time (yr)	1.67
Net Annual Savings	\$6,919.81
Payback Time (yr)	1.64

Annual Avoided Emissions	
NOx (kg)	1,166
SOx (kg)	77
CO (kg)	251
PM-10 (kg)	82
CO2 (kg)	43,377

Summary sheet



Graph of system performance



# Alaska Modeling and Analysis Project

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## • HybSim Current Development Activities

- Utilization of the new Lime Village Test Bed data for model validation
- Integration of PV generation module utilizing:
  - SNL's PV Electrical Performance Model Equations
  - SNL's module characteristics database data
- Development of specification libraries for commercially available battery and diesel systems
- Other Upgrades
  - Improved battery performance model
  - Operation with multiple fossil fuel generators
  - Incorporation of fuel storage tank costs for economical analysis



# Alaska Modeling and Analysis Project

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## • HybSim Upcoming Plans

– Version 3 to be completed this year

- Specification libraries
- Lime Village Test Bed data for further validation
- HybSim Test Plan implementation for:
  - component and system level validation
  - user functionality and interface



# Summary

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- **Working Partnership**
- **Optimizing Lime Village**
- **Data Collection System**
- **HYBSIM tool**
- **Expand project**

