Determining Maximum Demand in an Off Grid System

INTRODUCTION

- Designing a system is not just choosing the individual components
- It is designing the system to meet the clients requirements
- System failures do result from equipment failures

  BUT
- When the owner's expectations are not met, the system has failed in that owner's view

ENERGY EFFICIENCY

- Discuss energy efficient initiatives that could be implemented by the site owner. These could include:

i. Replacing inefficient electrical appliances with new energy efficient electrical appliances;

ii. Replacing incandescent light bulbs with efficient LED lights;

iii. Using laptop computers instead of desktop units;

iv. Using energy efficient flat-screen TVs instead of older units with picture tubes.

LOAD (ENERGY ASSESSMENT)

- Electrical power is supplied from the batteries (dc) or via an inverter to produce either 230 volts ac (South Pacific) or 110/120 volts ac (North Pacific). Electrical energy usage is normally expressed in watt hours (Wh) or kilowatt hours (kWh).
- To determine the daily energy usage for an appliance, multiply the power required by the appliance in Watts times the number of hours per day it will operate. The result is the energy (Wh) consumed by that appliance per day.

LOAD (ENERGY ASSESSMENT)

- Appliances can either be dc or ac. An energy assessment should be undertaken for each type. Examples of these will be shown in tables 1 and 2.
- You need to discuss the electrical energy usage in detail with the end-user. Many systems have failed over the years not because the equipment has failed or the system was installed incorrectly, BUT BECAUSE THE END-USER BELIEVED THEY COULD GET MORE ENERGY FROM THEIR SYSTEM THAN THE SYSTEM COULD DELIVER.

WHY CONDUCT AN ENERGY ASSESSMENT?

- Failure to conduct an accurate energy assessment means that the system is not designed to meet the load it will actually be power.

WHY CONDUCT AN ENERGY ASSESSMENT?

- Batteries could be undersized and will not have the same life as initially predicted, increasing replacement costs for the customer (Customer not happy ☹)
- If the load is less than predicted and the batteries are larger than required then the customer has invested capital in equipment that was not required (Customer not happy ☹)

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WHY CONDUCT AN ENERGY ASSESSMENT?

- An unhappy customer will not recommend you to their friends!

- Doing an energy assessment allows you to explain the limitations of the system to the owner BEFORE they buy!!!

WHY CONDUCT AN ENERGY ASSESSMENT?

- MANY SYSTEMS HAVE FAILED BECAUSE THE CUSTOMER BELIEVED THEY COULD GET MORE ENERGY FROM THEIR SYSTEM THEN THE SYSTEM COULD DELIVER.

WHAT'S A WATT?

In general the customer will get very confused with Watts and Watt-hrs and will not always understand why a system requiring 10kWh per day is so much more expensive then a system requiring 5kWh per day.

They will not necessarily understand the difference between 1kW and 2kW for an appliance.

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EXPLAIN IN TERMS THEY UNDERSTAND

Dollars

LOAD ASSESSMENT: TWO METHODS

1. Use a *data logg*er to record the customer's actual energy use over a period of time
2. *Manual* method

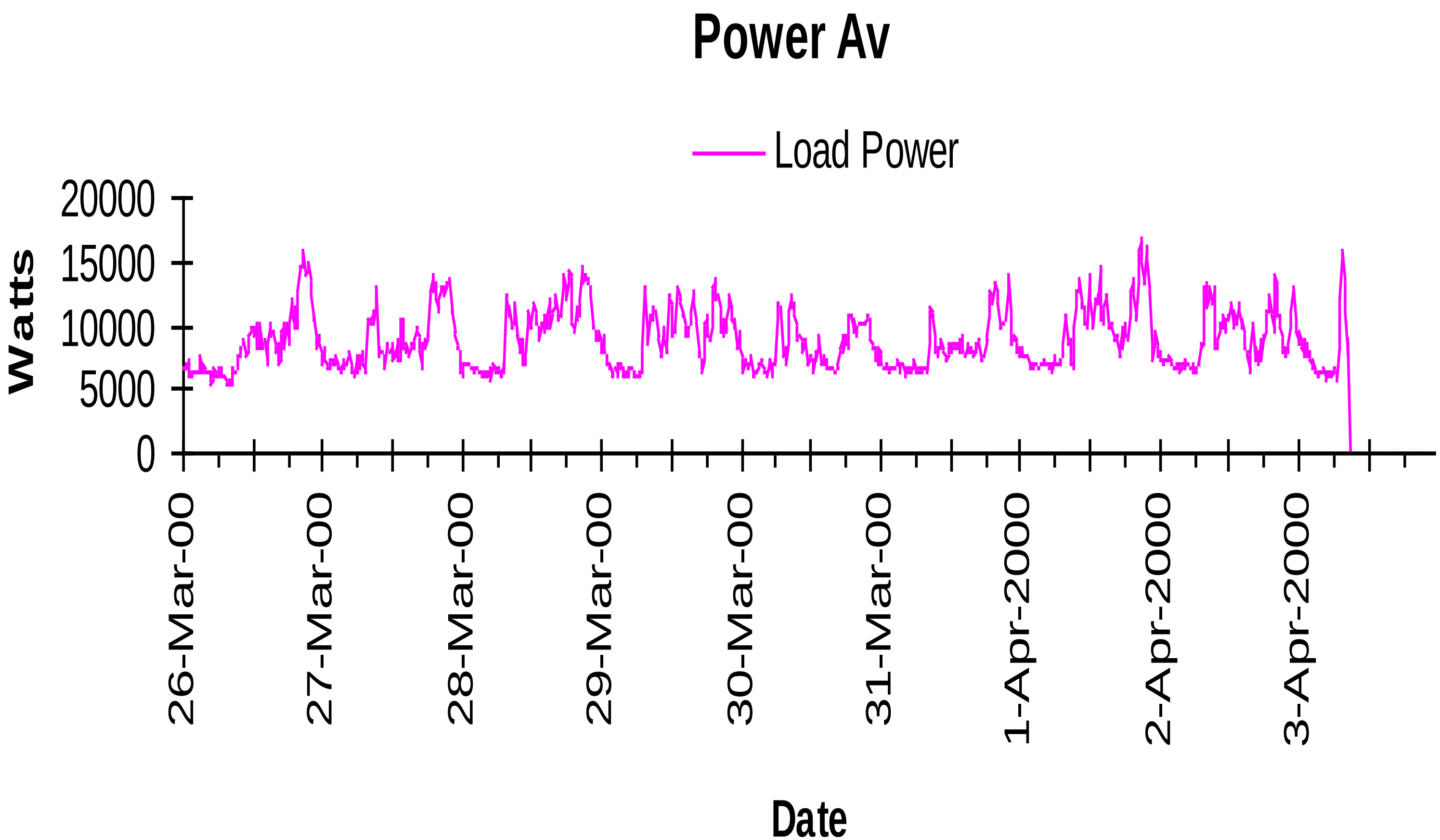
LOAD ASSESSMENT BY MONITORING

- Data logging can provide the following information:
  - Daily load profile over 24 hours
  - Total daily energy consumption
  - Maximum demand
- Implementing data logging involves installing a data logger recorder on the main switchboard
- It is preferable that the monitoring be performed over several weeks, with the minimum recommended time being a couple of days

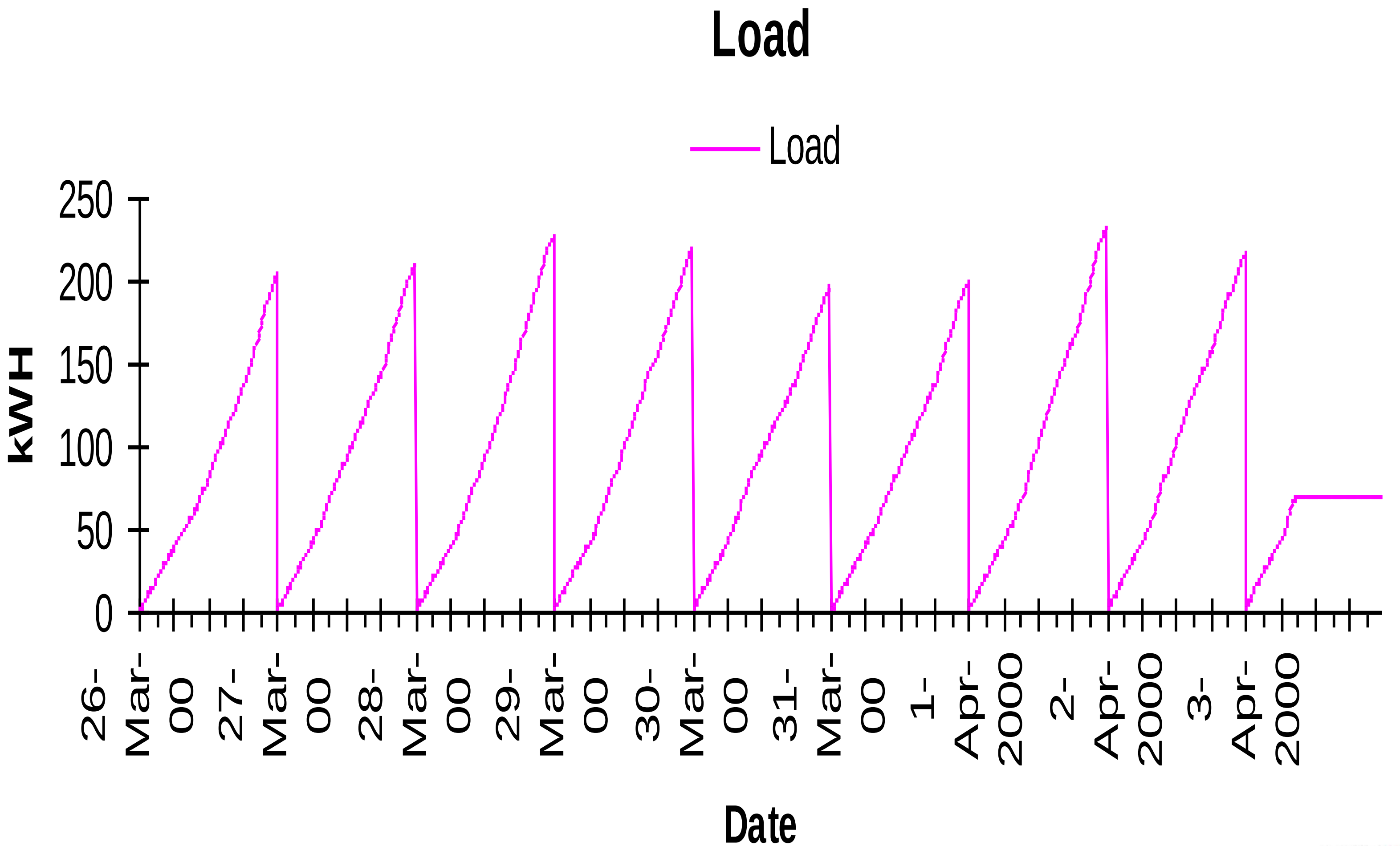
RECORDS THE FOLLOWING INFORMATION:

- Voltage per phase (V)
- Load current per phase (A)
- Power factor per phase
- Real Power (kW)
- Apparent Power (kVA)
- Energy over a period of time (kWh)
- Maximum Demand
- Time
- Date

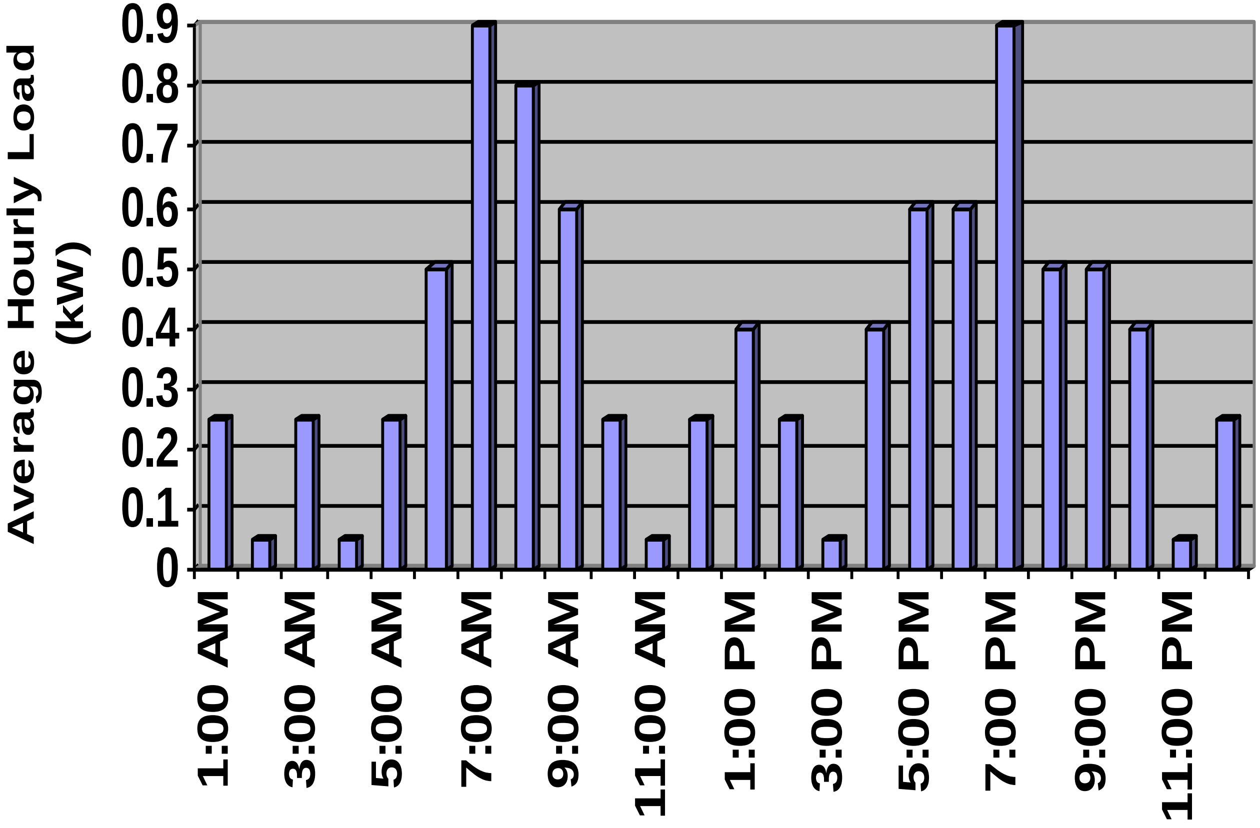
AVERAGE INSTANTANEOUS POWER FOR A SCHOOL SITE



ENERGY (LOAD) IN CUMULATIVE kWh



HOURLY LOAD PROFILE AS BAR CHART



PROBLEMS WITH MONITORING

- Sites are remote
- Someone must go, install and retrieve the equipment
- Hire of the equipment
- Time spent analysing data

- **WHO PAYS?**

Monitoring

- It is practical fro large sites like hotels and villages etc.

- Not necessarily practical for a single household.

WHY MANUAL LOAD ASSESSMENT?

- The system is for a new site;
- The site is very remote and it would be too expensive to install and retrieve the monitoring equipment
- Nobody will pay for monitoring.

INFORMATION TO BE OBTAINED BY DESIGNER

- List all the electrical appliances that the system owner currently uses and discuss potential future requirements
- Investigate all the current and future energy requirements of the owner e.g. water heating, cooking and space heating and cooling

IDENTIFY ENERGY SERVICES

Energy Load	Proposed Energy Source	Additional information
Water heating		
Space cooling		
Refrigeration		
Lighting		
Cooking		
Kitchen appliances, office equipment		
Power tools		
Water pumping		
Water & waste treatment		
???		

ENERGY SOURCE MATCHING

- Though the price of solar modules has reduced dramatically in recent years it is still best to match some of the energy needs of the end-user with other sources if possible.
- For example, though microwave ovens are suitable for cooking using electric power from off-grid PV power systems, it is more appropriate to use biomass (or kerosene or LPG if available) for cooking and not electric stoves

ENERGY SOURCE MATCHING

- If hot water for showers and washing is required, then a solar hot water system could be used.

EXAMPLE- From Australian Standard

TYPICAL ENERGY SERVICES AND ENERGY SOURCE SELECTION

Energy service	Energy source	Comments
Water heating	Solar + gas boosting	Most appropriate energy source Minimum environmental impact Lowest cost at remote site
Space heating	Energy efficient house design, wood heating	Most appropriate energy source Lowest cost
Space cooling	Energy efficient house design	
Refrigeration	Electric (d.c.)	d.c. chosen for efficiency reasons
Lighting	Electric (d.c.)	Preference for fluorescent lamps. Some incandescent lamps for low use areas
Cooking	Gas stove, some electric appliances (e.g. microwave oven)	Only available option Efficiency produces lowest energy requirements Lowest system cost
Cleaning, entertainment, kitchen appliances, office equipment	Efficient electric	Only available option Efficiency produces lowest energy requirements Lowest system cost
Power tools	Electric	Only available option
Water pumping	Efficient electric	Lowest cost
Water and waste treatment	None	

Source: AS/NZS 4509.2: 2010

		Power	Energy Usage		Power	Contribution to Maximum Demand	Surge	Contribution to Surge Demand		
Appliance	No	W	Hrs/day	wh/days	Factor	VA	Factor	Potential	Design	Comment
Kitchen Lights	1	20	5	100	0.8					
Lounge Room Lights	1	15	1	15	0.8					
Bedroom 1 Lights	1	15	1	15	0.8					
Bedroom 2 Lights	1	15	1	15	0.8					
TV										
Stereo										
Computer	1	150	5	750	0.8					
Microwave	1	1000	0.25	250	0.8					
Fridge	1	150	10	1500	0.8					
Freezer	1	150	8	1200	0.8					
Pressure Pump	1	350	0.5	175	0.7					
Iron	1	1000	0.2	200	1					
Washing Machine	1	200	0.75	150	0.7					
TOTAL ENERGY				4370						
MAXIMUM DEMAND										
DESIGN SURGE DEMAND										
DESIGN SURGE DEMAND										

CALCULATING MAXIMUM DEMAND

- When calculating maximum demand there is not one "right" answer—there can be many combinations of what is on at any one time - that is why determining the maximum demand by load assessment is not easy and hence takes time to practice and learn
- A wrong answer is when the inverter is undersized and the customer has a blackout.

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Appliance	Power W	Power Factor	Contribution to Maximum Demand VA	Surge Factor	Contribution to Surge Demand Potential	Contribution to Surge Demand Design	
Kitchen Lights	20	0.8	25	1	25	25	on
Lounge Room Lights	15	0.8	18.75	1	18.75	18.75	on
Bedroom 1 Lights	15	0.8	18.75	1	18.75	18.75	on
Bedroom 2 Lights	15	0.8	18.75	1	18.75	18.75	on
TV							allowed to be on
Stereo							Allowed to be on --but could be left out
Computer	150	0.8	187.5	2	375	375	On a lot
Microwave	1000	0.8	1250	1	1250	1250	Only allowing for the Microwave- it and iron are largest—will not allow for Microwave and Iron and washing machine
Fridge	150	0.8	187.5	4	750	750	No control- turns on when required
Freezer	150	0.8	187.5	4	750	187.5	Though freezer could be on- have not assume it surges as same time as fridge or pump--that is only allowed for 2 motor surges at once
Pressure Pump	350	0.7	500	6	3000	3000	No control—this could come on any time tap is turned on
Iron	1000	1		1			Not to be operated when microwave or washing machine is on.
Washing Machine	200	0.7		4			
MAXIMUM DEMAND			2393.75				Allowing 10% Inverter approx 2.6kVA
DESIGN SURGE DEMAND					6206.25		
DESIGN SURGE DEMAND						5643.75	Surge 5.6kVA

UNDERTAKING MANAGEMENT INITIATIVES

- Daylight sensors on lighting circuits
- Timers on power and lighting circuits
- Circuits breakers sized to limit the maximum demand from a building
- Certain loads that only operate when the generator is operating
- Sites where load management could be used;
  - Tourist facilities
  - Communities with fluctuating populations

THREE PHASE LOAD MANAGEMENT

- In general, any system requiring an inverter or generator larger than 15 - 20kW will be a three-phase system
- In three phase systems, the system designer will need to ensure that as far as possible the loads are balanced across the 3 phases
- Although unbalanced loads do not cause any damage to a inverter or gen-set, there is the potential for supply capacity to be made unusable

THREE PHASE LOAD MANAGEMENT

- The designer will need to determine all the loads and then list which loads are in each of the three phases
- Care must therefore be taken to ensure that the three phase inverter can meet the peak demand and potential surge demand for each phase

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