

**SOLAR ENERGY TECHNOLOGY**



**Introduction Solar Photovoltaic Systems**


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14-18 June 2010  
Jakarta  
Indonesia

Training Course on Renewable Energy Part II - MEMR  
CASINDO



**Introduction**




What will be discussed:

- Introductions
- PV system arrangements
- Units of measurement and basic formula
- The client
- Meeting the needs of the client
- PV system components
- PV process and construction of modules
- Batteries
- Charge regulators
- Loads and inverters

2

**Introduction**




**Duties of a solar entrepreneur**

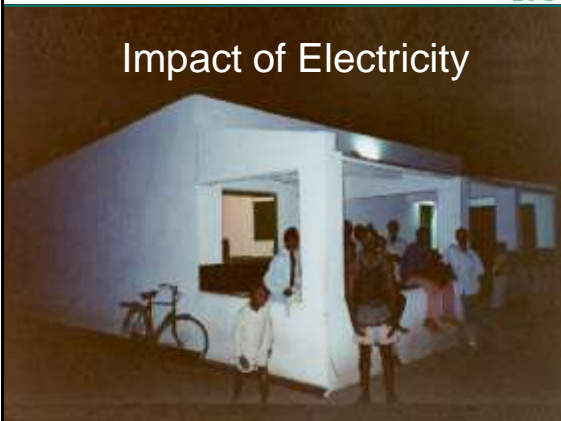
1. Evaluate the energy needs of the client
2. Determine the appropriate size of the solar system
3. Estimate the prices of such systems
4. Select and purchase quality components
5. Ensure the marketing of solar systems as well as other services for the clients
6. Install maintain and repair the solar system
7. Inform and advice current and future solar system users

3


**Introduction**



**Impact of Electricity**



**Introduction**



**Electricity plays an important role**

After                      Before





Photo: Jon Exel



5

**Introduction**




**WARNING!**

- Photovoltaic modules can be short-circuited without damage. However, a short circuit in other system components or sparks may cause component damage and dangerous, even lethal, conditions. This is particularly true for storage batteries.
- **Never short-circuit batteries!**

6

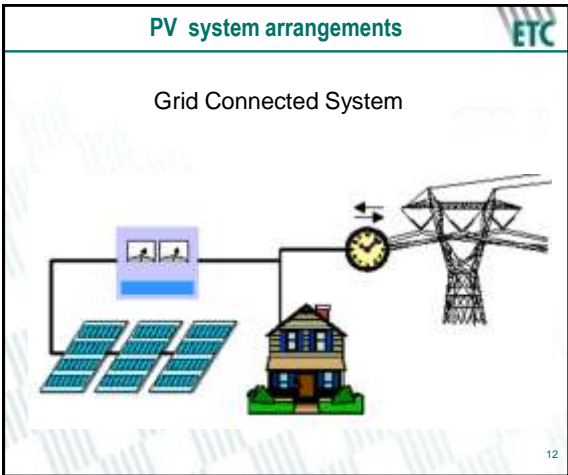
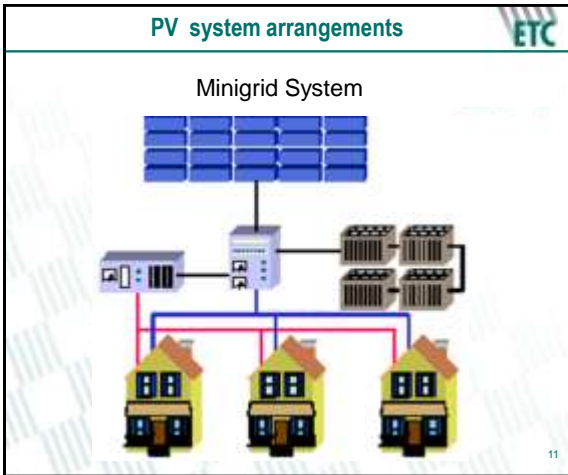
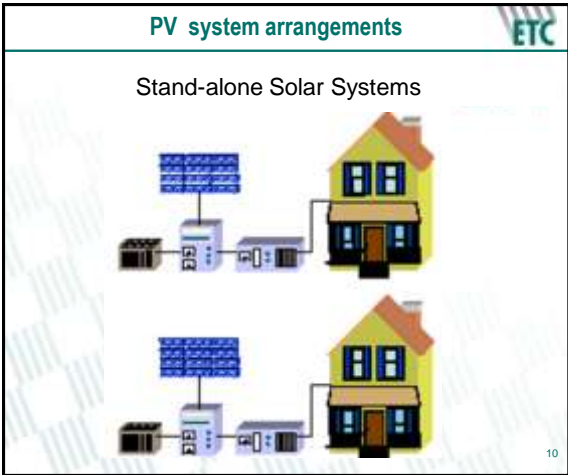
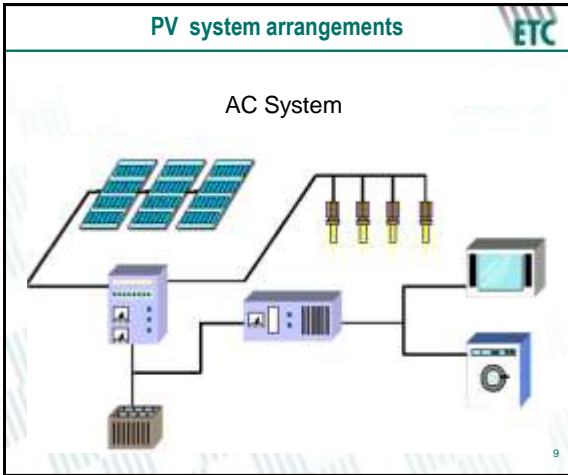
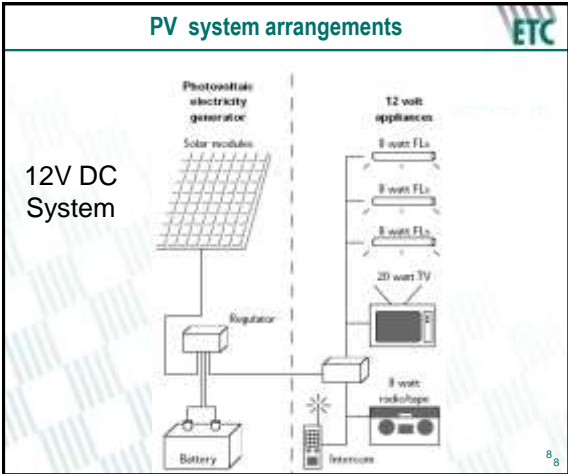
**PV system arrangements** 

PV Technologies for Rural Electrification

- Solar Lantern
- Solar Home System
- PV Battery Charging Station
- PV Mini-grid

DC  
AC  
Hybrid Systems  
PV - Diesel engine  
PV - Windmill

7



### PV system arrangements

Types of Stand-Alone PV Systems

13

### PV system arrangements

System for Communication

14

### Units of measure and basic formulas

## Back to the Basics

- **Energy:** ability to do work (J or Wh)
- **Electric power:** rate at which energy is consumed or supplied
- **Irradiation:** Solar radiation per square metre ( $W/m^2$ )

15

### Units of measure and basic formulas

## Units and Formulas

Unit	Symbol	Measure	Symbol	Expressed in other units
Time	t	Second	S	---
Voltage	V	Volt	V	$P/I$
Current	I	Ampere	A	$P/V$
Power	P	Watt	W	$V \times I$
Energy	E	Watt-hour	Wh or J	$W \times t$
Battery capacity	Q	Ampere-hours	Ah	$I \times t, E/V$
Irradiation	Ir	Watt per square metre	$W/m^2$	---
Lumen	lm	Flow of light	---	---
Lux	lx	Illumination	$lm/m^2$	---

Formula	Symbols
Power = Voltage x Current	$P = V \times I$
Power = Current x Current x Resistance	$P = I^2 \times R$
Energy = Power x Time	$E = P \times t$
Energy = Battery capacity x Voltage	$E = Q \times V$
Resistance = Voltage / Current	$R = V/I$

16

### The client

## Adding up to succes

17

### The client

## It is important to:

- Take time to listen to the client in order to identify and quantify his or her needs.
- Clearly present the range of systems on offer in terms of services provided, warranties and after-sales service.
- Inform the user of the advantages and limitations of solar systems in order to avoid any disappointment.
- Sell quality systems and spare parts at affordable prices.
- Install reliable and long-lasting systems with the correct care.
- Train and inform the user about the system during installation and at other major stages in the life of the system such as during servicing and repair visits.
- Remain available and accessible to the user - a locally based technician is an advantage.
- Finally, create and maintain good relations with the user.

**The client or system user is a key person.**

*There is nothing worse than to hear a client complaining "my solar system is not capable of doing what it would".*

Remember: a serious entrepreneur means being clear and honest with the client: your clients will be satisfied and grow in number.

### Meeting the needs of the client

## Appliances

	Appliance	Typical power consumption (Watts)	Typical daily use (hours/day)	Typical daily consumption (Wh/day)
Common appliance in SHS	Light bulb	5-15	1-4	5-60
	Radio	5	1-10	5-50
	Radio cassette player	10	1-5	10-50
	B/W television	35	1-5	35-175
	Small fan	5	3-6	15-30
Possible appliances in SHSs	Battery charger	2	2-10	4-20
	Mobile phone charger	5	0-1	0-5
	Stereo installation	20	1-4	20-80
	Radio transmitters	stand-by: 5 transmit: 300	0-2 0-0.5	0- 10 0-150
	Video recorder	70	1-3	70-210
Appliances only for larger PV systems or alternatives	Lap-top	40	1-6	40-240
	Blender	300	0.1-1	20-300
	Sewing machine	150	1-3	150-450
	Small refrigerator	70	24	1,680
	Water pump	200	4-10	800-2,000
	Electrical drill	600	1-3	600-1,800
	Electrical iron	600	1-3	600-1,800
	Electrical cooking plate	1,000	0.5-3	500-3,000
14' colour TV	80	1.4	80-320	

19

### Meeting the needs of the client

## Sizing of a DC Solar System (1)

### Meeting the needs of the client

## Sizing of a DC Solar System (2)

### Meeting the needs of the client

## Different Cable Sizes

22

### PV system components

## Solar Home System

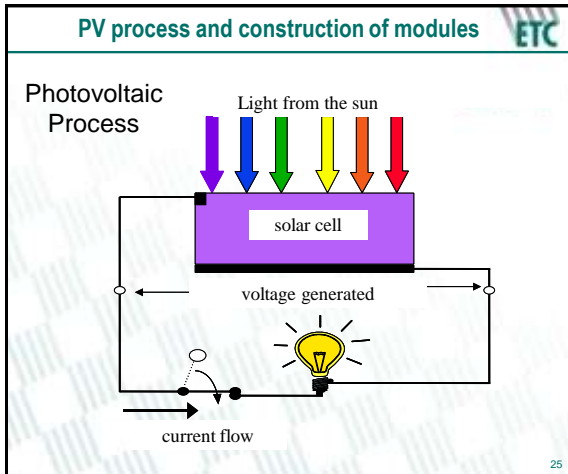
23

### PV system components

## Components of a small SHS

24





### PV process and construction of modules ETC

**PV Cell Types**

mono-crystalline

multi-crystalline

Solar cell efficiency:

$$\eta \% = \frac{\text{generated energy}}{\text{incident energy}} \times 100$$

26

### PV process and construction of modules ETC

**PV Cell Types**

**Silicon Monocrystalline**

- 14% to 16% efficiency

**CIS thin film**

- 12% efficiency
- uniform colour

27

### PV process and construction of modules ETC

**Characteristics of a PV Module**

- One solar cell produces approximately 0.5V DC
- Normally 36 cells are connected in series
- Nominal voltage of the module is 12V DC
- The area of the solar cells determines the current

28

### PV process and construction of modules ETC

**Construction of a PV Module**

- Tempered glass with low iron content
- Embedding medium
- Solar cell
- Back sheet
- Aluminium frame
- Connection box

Rubber profile

Front glass

Embedding medium

Solar cell

Back sheet

Frame

29

### PV process and construction of modules ETC

**Quality Labels**

TÜV Rheinland

TÜV Rheinland of North America, Inc. ISO 9001 Registered Company

CE

JOINT RESEARCH CENTRE ESTI - España

UL

FM APPROVED

30

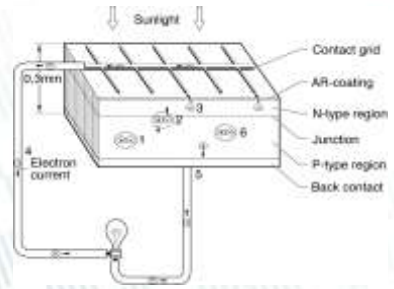
## PV process and construction of modules



## PV process and construction of modules



### Photovoltaic Process



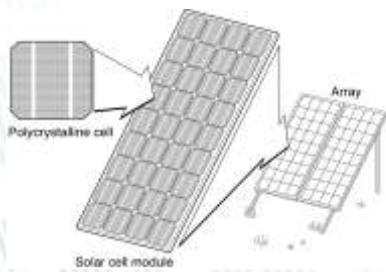
Mono-Crystalline, Poly-Crystalline and Amorphous silicon

32

## PV process and construction of modules



### Cells, Modules and Arrays

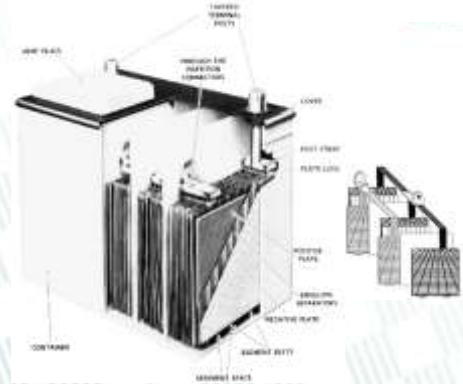


33

## Batteries



### Construction of a Lead-Acid Battery

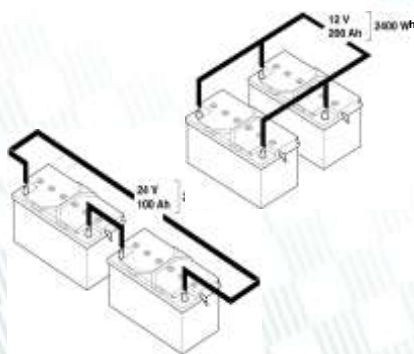


34

## Batteries



### Battery Capacity

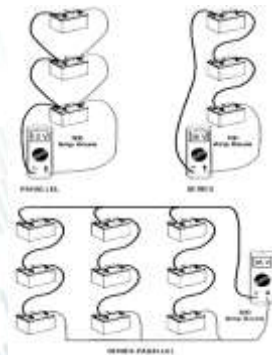


35

## Batteries



### Connecting Batteries



36

Batteries ETC

Battery Connections

37

Batteries ETC

Battery Connections

38

Batteries ETC

Battery Connections

39

Batteries ETC

Battery Connections

40

Batteries ETC

The Reality ...

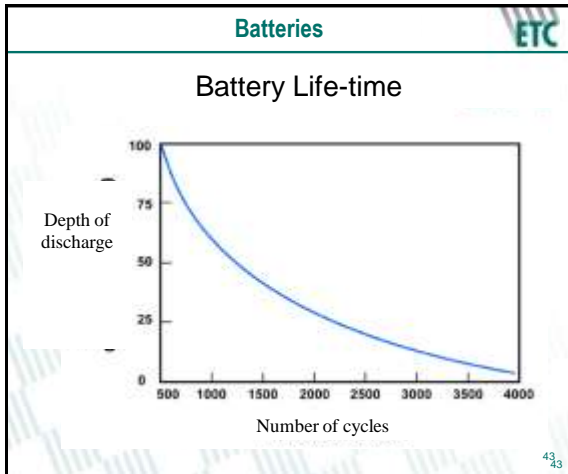
41

Batteries ETC

Automotive versus Deep Cycle Battery  
(discharge rate = 25 A)

Number of cycles	Deep cycle battery (min)	Automotive starting battery (min)
0	150	150
10	160	140
20	170	120
30	175	100
40	178	80
50	180	60
60	180	60
70	180	60
80	180	60
90	180	60
100	180	60
110	180	60
120	180	60
130	180	60
140	180	60
150	180	60
160	180	60
170	180	60
180	160	60

42



### Batteries

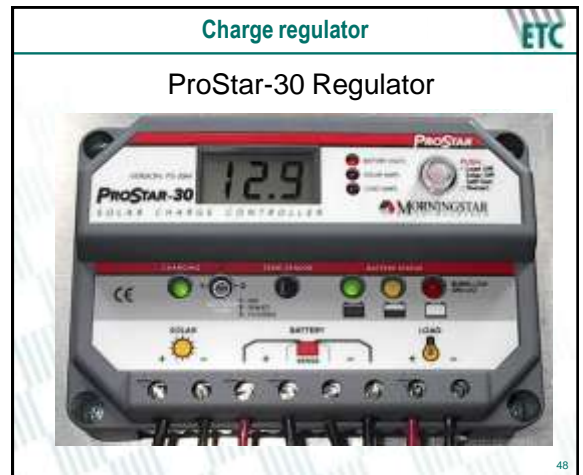
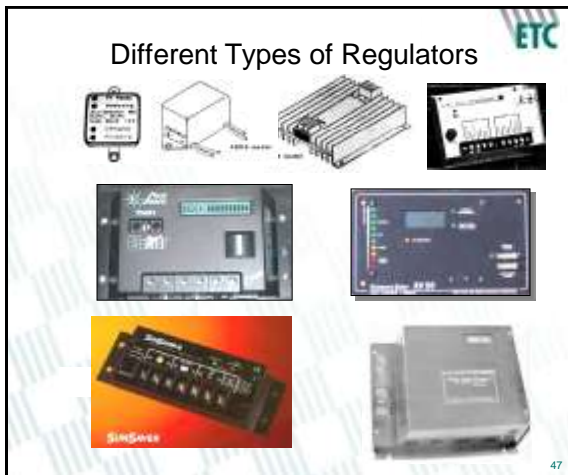
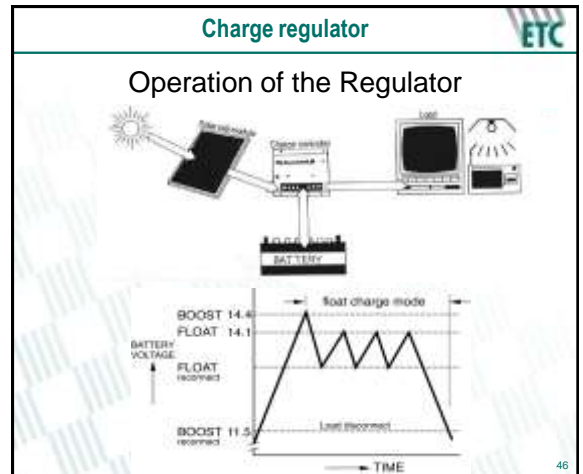
#### Battery Life-time

Type of plates	Car battery Thin plate	Vehicle "Solar" Thick plate	Sealed spill Thick plate	Stationary wetcell Tubular
Use capacity:	(25 to 200 Ah)	(30 to 200 Ah)	(25 to 150 Ah)	(100 to 2000 Ah)
100% DOD	1 to 4 years	5 to 7 years	6 to 8 years	> 10 years
80% DOD	2 to 3 years	4 to 5 years	5 to 6 years	10 years
50% DOD	3.5 to 2 years	5 to 4 years	6 to 5 years	6 years
25% DOD	6 months to 1 year	1 to 2 years	2 to 3 years	4 years
10% DOD	2 months	3 to 6 months	1 to 2 years	2 years

Type of Battery	Life span
Car Battery	3-12 months
Solar/Modified Car Battery	1-3 years
Sealed Battery	2-5 years
Deep Cycle Battery	4-8 years


- ### Charge regulator
- #### Regulator / Controller
- Indicates systems performance through LEDs and LCD screens
  - Controls the module and load
  - Minimises harm in case of short-circuit
- 
- 45





**Charge regulator**


**Old Design Regulator**



49

**Charge regulator**

**Old Controller Technology**



50

**Charge regulator**

**Controller - OutBack**

- OutBack MX60
- 60A at 48V
- MPPT
- Efficiency of 98%
- Large digital display
- Datalogger of 64 days
- Fully programmable



51

**Loads and inverters**

**Selecting Lights**

Type of bulb	Standard incandescent	Low voltage halogen	Fluorescent	LED
Lighting efficiency (lumens/W)	8 to 10	15 to 30	40 to 70	20 to 30
Lighting quality	Good	Excellent	Good	Medium to good
Lifetime (hours)	100 to 1,000	1,000 to 2,000	2,000	More than 1,000
Impact on the cost of the solar system (size of the battery and the panel)	Negative	Neutral	Excellent	Excellent
Examples of recommended use	5 to 10 W for short run-time; night lights, battery	5 to 30 W for short run-time; night lights, music	4 to 30 W for applications, reading systems, outdoor lighting	1.7 to 2 W for night lights, outdoor security lights

Important: Review of information indicated on some bulbs as table. Compact lamps equipped with 8 W fluorescent tubes can consume up to 1.1 W, whereas others with 1.8 W tubes may consume only 0.9 W.

**Loads and inverters**

**Power Rating of Appliances**

Appliance	Appliance Rating	Size of PV System		
		14W - 20W	50W	80W - 100W
Black & White TV (14")	20-30W	✓X	✓	✓
Color DC TV (14")	55-65W	X	✓X	✓
Color AC TV (14")	70-90W	X	X	✓
Color AC TV (21")	110W	X	X	✓X
VCR (Video)	20W	✓X	✓	✓
VCD/DVD player	20W	✓X	✓	✓
Radio (1 speaker)	5-10W	✓	✓	✓
Radio Cassette Player (1 speaker)	10-15W	✓	✓	✓

53

**Loads and inverters**

Appliance	Appliance Rating	Size of PV System		
		14W - 20W	50W	80W - 100W
Stereo system (2 speakers)	30-50W	X	✓	✓
Fridge	200-400W	X	X	X
Air Conditioner	1500W	X	X	X
Fan	60-100W	X	X	✓
Microwave	1000W	X	X	X
Desktop Computer	100W	X	X	✓X
Laptop Computer	40-60W	X	X	✓
Desk jet printer	60W	X	X	✓
Laser jet printer	1000W	X	X	X
Photocopier	1200W	X	X	X
Fax	20W	X	✓	✓
LCD Projector	200-300W	X	X	X
Iron	1000W	X	X	X
Room Light	3-6W	✓	✓	✓
Reading/Security Light	10-18W	✓	✓	✓
Mobile Phone charger	5W	✓	✓	✓
2-way radio charger	3-10W	✓	✓	✓
Sewing Machine	75W	X	X	✓
Electric Hair Cutter	15-25W	✓X	✓	✓
Diode	20-30W	X	✓	✓

54

**Loads and inverters** ETC

**Connecting Inverters**

*Inverter connected to the regulator*

55

**Loads and inverters** ETC

**Different Types of Inverters (1)**

56

**Loads and inverters** ETC

**Different Types of Inverters (2)**

57

**Loads and inverters** ETC

**Installation using OutBack Inverters**

58

**Loads and inverters** ETC

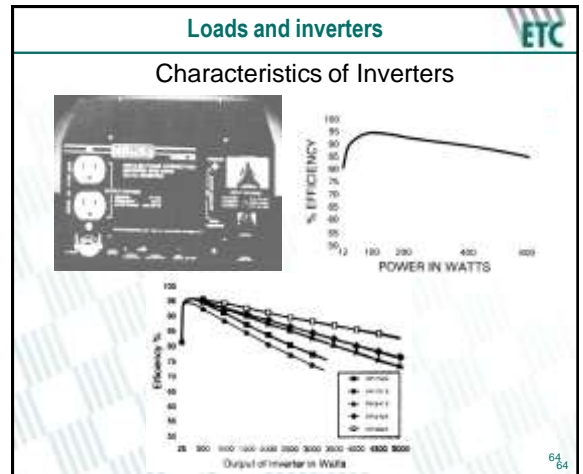
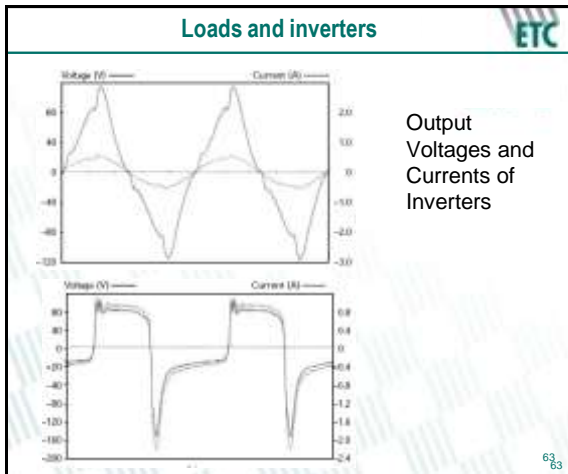
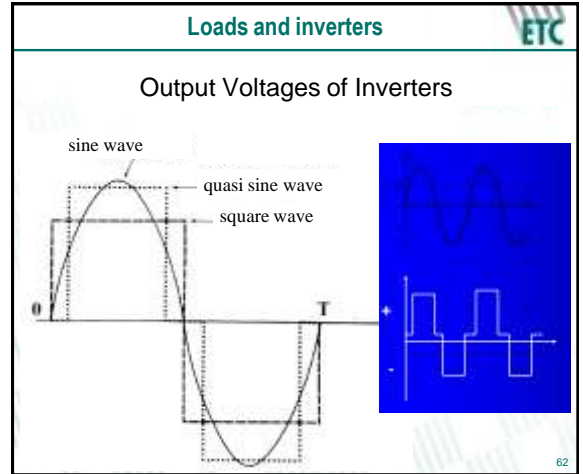
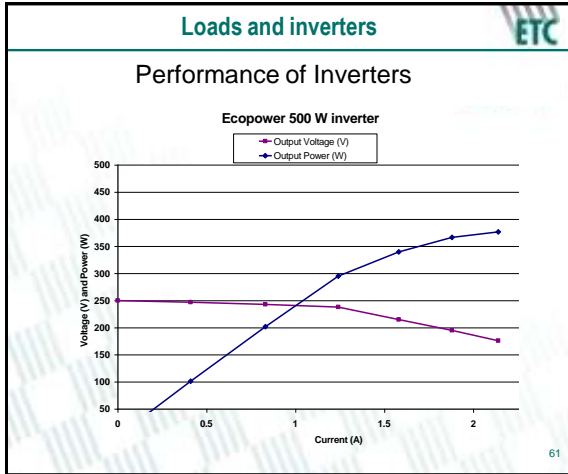
**Testing of Inverter**

59

**Loads and inverters** ETC

**Inverter Output Signal**

60



### QUESTIONS ?

ETC

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65