MEDRC

# Guidelines for Preparation of Final Project Reports

## Middle East Desalination Research Center

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# INTRODUCTION

The Middle East Desalination Research Center (MEDRC) is a non-profit institution, which grants partial financial support for research & development projects in desalination and related fields. As practiced by other funding organizations, the Center requests for progress reports from the principal investigator during the course of the project execution for monitoring the project progress and the final report after completion of the project for all its funded projects. The Center prepared Guidelines for preparation of progress reports as separate document.

The Final Project Report is an important document to MEDRC and material presented should be original and not copied from any sources. Since MEDRC is a non-profit making organization and committed to disseminate desalination knowledge in the Middle East and North Africa (MENA) region in particular, and worldwide in general, it intends to publish the contents of the final reports in different publications and formats, for example:

1. The full report as a separate publication, maybe comparable with the old OSW reports
2. The full report on a CD
3. On the Center's website
4. In the Center's annual report
5. In an Info-Booklet with an overview of Center-funded projects

In order to cater for the above requirements, MEDRC requests the following two additional reports along with the final report from the principal investigator.

1. Executive Summary
2. Project Profile (see Appendix A for format)

The Executive Summary forms part of the final report, whereas the Project Profile should be submitted as separate document.

MEDRC also ask the principal investigator for photographs related to the project experimental setup or other suitable material to use them on our website, in the annual report or in other PR publications.

# REVIEW AND PUBLICATION PROCESS

1. The Principal investigator (PI) should submit a draft final report, with executive summary, in the same format and contents as the final report. The draft final report should cover the complete work carried out in the project and should include the material presented in all the progress reports.

2. The Center and the Project Advisory Committee (PAC) will review the draft final report and send the comments, queries and alterations to the Principal investigator.

3. After any discussion or clarification, the PI should produce a Project Final Report to the Center for review and comment in accordance. This step may be repeated till the PAC and the Center are satisfied with the final report contents and format.

4. The Center should forward to the PI the Final Project Report as prepared for publication. The PI should review the report in a timely manner as requested by the Center.

5. The PI warrants that prior to the submission of the initial draft final project report.
   - that, the work to be included in the Final Project Report is the original, previously unpublished work of the PI;
   - that no part of the Final Project Report infringes upon the legal rights of any other Person; and
   - that all necessary approvals, consents, permissions and waivers for copyright have been obtained and complied with.

# THE STYLE AND FORMAT REQUIREMENTS FOR FINAL PROJECT REPORTS

The intended purpose of the final report will be the dissemination and making it available to the international desalination community and any other interested individuals or organization. The Report must follow the format and style as described below.

## Submission

Draft final reports should be submitted as e-mail attachment in MS Word files for review by the Center. It is imperative that all material, in the report is provided in electronic format. This includes pictures, charts, graphics and any other appendices/attachments. More details concerning the format of different types of figure are given below.

# Format

The body of the text should be typed single spaced in 12-point font, Times New Roman on A4 size paper. Margins for the page shall be one inch for top, bottom and right, 1.5 inch for left, zero for gutter, 0.5 inch for header and 0.5 inch for footer.

# Final Report components

## 1. Cover

The front and inside covers should be prepared in a format like that in the sample cover.

## 2. Title page

The title page should contain the same information as the front cover.

## 3. Partner information

The names and contact details (postal address, telephone and fax numbers, and e-mail address) should be given for the PI and all other partners on a separate page.

## 4. Table of contents

The table of contents should be prepared in a format like that in the sample Table of Contents. Lists of tables and Figures should also be included in the format used in the sample lists.

## 5. Abstract

An abstract of no more than 150 words should be included in the Report.

## 6. Acknowledgments

The Center should be acknowledged as the sponsor of the research. Other acknowledgments are optional. However, when they are included, only those persons who made meaningful contributions to the research or to the report should be included.

## 7. Executive summary

An executive summary should be submitted in every report. In the final report, the executive summary should contain an introduction, a project approach, and a list of principal findings and practical benefits to the desalination community. It should not exceed three pages.

Pages up to and including the Executive Summary should be numbered with Roman numerals (i, ii, iii etc.). The body of the report should be numbered with Arabic numerals, 1, 2, 3 etc.

## 8. Body of the Report

The body of the Report will be dependent on the type of research project. In general, it should consist of the following chapters: introduction, literature review, materials and methods, theory/modeling, and results and discussion. Section numbering is recommended, but not essential (see below).

## 9. Conclusions and Recommendations

The Report should include a section entitled "Conclusions and Recommendations". This section should present logical conclusions and recommendations drawn from the study and findings. This section should be placed after the body of the report. Both conclusions and recommendations are best presented as brief statements proceeded by bullets or numbers. Authors should refrain from citing text data as conclusions in this section.

## 10. References

References should be listed at the end of the text on a separate sheet numbered. The Harvard method (author's name and date) is preferred, although the numbered system, in which the references should be cited in the text (in the order of first citation), either by numbers in square brackets or as numbers typed as unparenthesized superscripts.
The preferred style of presenting the references is as follows:

Amjad Z., Zibrida J.F., Zuhl R.W. (1997). A New Antifoulant for Controlling Silica Fouling in Reverse Osmosis Systems. *Proceedings of IDA World Congress on Desalination and Water Reuse,* Madrid, October 1997: 459–480.

Porteous A. (1975). *Saline Water Distillation Processes*, 1st edn. Longman Group, London.

Taylor J.S., Mulford L.A., Duranceau S.J., Barret W.M. (1989). Costs and Performance of a Membrane Pilot Plant. *Journal of the American Water Works Association* **81**(11): 52–60.

In the Harvard system the references should be sorted alphabetically by author, with references by the same author(s) sorted by date. For the numbered system, the references should be listed in numerical order.

It is important that all reference information is provided. All references that are cited in the text must be included in the reference list with enough information for the reader to be able to access them. For publications that have not been included in books or journals, it is a good idea to include the address of the issuing institution or at least its geographical location. For published books, ensure that the place of publication is given.

Any references that are not cited in the text should be listed as "Further reading". In all cases, give the full (not abbreviated) titles of journals and organizations and ensure that volume and page numbers are given. It is only necessary to give the part or issue number (in addition to the volume number) if the page numbering of each part restarts from 1.

# Other related information

## Data Record

A Data Record included, as an Appendix, should contain all of the pertinent data taken during the investigation and used in drawing conclusions and making evaluations. These data should be keyed to the appropriate sections of the main body of the report in such a way as to allow the reader to review the treatment of data.

## Figures

In general, figures and tables should be interspersed in the text near where they are mentioned; otherwise they should be placed together at the end of the text. Too many figures or tables interspersed in the text may make it difficult to read and comprehend. Only necessary photographs should be scanned; all tables should be supplied as text and figures (see below) provided in vector format wherever possible.

Although figures should be included in the text, it is helpful, particularly for photographs, if they can also be supplied separately as electronic files. Whenever possible, line drawings and graphs should be supplied in vector format (e.g. eps or wmf – Windows Metaformat), while ideally photographs should be supplied in TIFF format, although JPEG is acceptable. Please check that the file sizes of scanned figures are as small as possible, consistent with the quality required.

If possible, line drawings should all be on a similar scale, with the lettering in proportion. Ensure that all lettering is readable and, as far as possible, matches the notation used in the text. Graphs and other lines should be drawn at a thickness that allows reduction to page width.

Ensure that every figure has a caption/legend, but give these separately. Do not include the caption/legend as part of the figure. It is also a good idea to include supplementary text information as part of the caption, rather than include it in the figure. A large amount of text within a figure, particularly if the size is small, is often difficult to reproduce satisfactorily.

As a standard practice, photographs, charts and figures will be printed in black and white using half tones for photographs. Color should be used only if it contributes “demonstrable value” to the report. It is important that graphs should be distinguishable in a black-and-white version, i.e. they should not simply be distinguishable by colour. In bar graphs and plots, therefore, use shading and cross hatching or open and closed symbols so that the graphs can be readily interpreted when reproduced in black and white.

Refer to figures as ‘Figure 1’ etc. and do not abbreviate to ‘Fig. 1’. Section numbers can be included in the figure numbering if preferred, although this is not generally necessary. Figures in Appendices should be numbered as Figure A1 etc.

## Tables

Tables should be supplied as text and not as graphics or scanned copies. Avoid unnecessary abbreviations (and, if abbreviations are used, make sure that they are explained). Use table cells, rather than carriage returns, to handle the layout of tables. Unless there is no other alternative, format tables in a portrait orientation.

Include units in column headings or a stub column, rather than including them in every cell. Put the units in parentheses after the column or row title. See below for further notes on units.

Try to ensure that a consistent number of significant figures is used for the same type of data and always include a zero before the decimal point for numbers less than one.

The scheme used for numbering of tables should be consistent with that used for figures.

## Equations and variables

Equations, unless very simple, should be set on a separate line (displayed). If required, they can be numbered. Please ensure that the notation in the equations is consistent with that in the main text. Variables should generally be in italic type (unless a combination of letters is used for a single variable, e.g. BP for boiling point). All other characters should be Roman. Ensure that all quantities are defined and that any unusual notation is explained.

## Glossary

A glossary should be included if the Report contains numerous acronyms, abbreviations, symbols, or uncommon terms. A short glossary (one or two pages) should be placed between the Table of Contents and the first page of text. A longer glossary should be placed at the end of the Report, possibly as an appendix.

## Use of SI units

SI units must be used. If Imperial or US units are used, they should be followed by the SI metric equivalents in parentheses. When a dimension is repeated on a page, its metric equivalent in parentheses need not be repeated; that is, the equivalent needs to be cited only the first time it appears on a page. Unusual units should be explained when they are first used. In general, use negative powers rather than the slash or solidus, e.g. $\mathrm{g\ m^{-3}}$ rather than $\mathrm{g/m^3}$. Use (capital) L for litre.

## Spelling and punctuation

Either North American or British spelling can be used, but should be consistent. Ensure that either -ise or -ize endings are used consistently (although note that there are words that always take an -ise ending; common ones are: advertise, advise (as a verb), arise, comprise, despise, devise (as a verb), disguise, exercise, improvise, incise, practise (British verb; North Americans use practice), revise, supervise, surmise, surprise, televise.

Similarly, US or UK punctuation styles are acceptable, but should be consistent.

## Abbreviations and acronyms

Unless they are very common, e.g. USA, UK, always give the full version of an abbreviation or acronym at the first mention. Do not include full stops.

## Section headings

Sections can be numbered or not, as the author prefers. However, if numbering is not used, then it is important that the hierarchy of the sections and headings should be clear from the type face, style and size used. Headings should use only initial capitals, except where they include proper nouns (names) and acronyms. Unless it is absolutely necessary, do not use more than four levels of heading, as shown in the box below.

# 1. LEVEL 1

All capitals; 18 pt Tahoma bold. This heading should normally go on a new page.

# 1.1. Level 2

Initial capital only; 18 pt Tahoma bold.

### 1.1.1. Level 3

Initial capital only; 14 pt Tahoma.

#### 1.1.1.1.Level 4

Initial capital only; 14 pt Tahoma bold italic.

Although these are the sizes and styles used in the formatted version of the reports, when reports are submitted, it is only necessary to ensure that the levels of heading are distinguishable; the actual size and typeface are not important. If the headings are numbered, it is preferable to add the numbering manually as part of the text, rather than using the automatic numbering provided by Microsoft Word and other word-processing programs.

## Dates

Use either the US or the British system, but be consistent, so that, for example, it is clear whether a date is 3 May or 5 March. For date ranges use an en-dash, e.g. 1999–2000. Do not include ‘th’ etc., e.g. 7th.

## Sample pages

Sample cover page, sample table of contents and other pages are given as Appendix B.

# APPENDIX A

# PROJECT PROFILE FORM

The Principal Investigator shall provide a **Project Profile** as a separate document along with the final project report.

The purpose of a profile for each MEDRC research report is to give the busy desalination professional an overview of the full report. Profiles of all MEDRC projects’ final reports are made available on the Center’s web site and are provided to all individuals and organizations engaged in various desalination activities.

A completed Project Profile Form shall be submitted with the revised draft final project report. Please note that the final report itself will still contain an **Executive Summary**. In writing the Project Profile, the Principal Investigator may use few abbreviations, symbols, or equations. However, if such terms are used, their definitions should be clearly stated the first time they are mentioned.

The Profile is about two (2) pages of text in the format shown below.

### Project Profile Form

(Please provide the profile in Microsoft Word format as an attached file to an e-mail message.)

**Project Title:**
**Project Number:**
**Principal Investigator:** (give name, institution and address including e-mail)
**Research Partners:** (give name, institution and address including e-mail)
**Objectives:** (State the relevant objectives of the project; *75 words or less.*)
**Background:** (Provide background information; *75 words or less.*)

**Highlights:** (Provide "at a glance" the main findings of the research [minimum of three]; *100 words or less.*)
**Approach:** (Describe the research approach for this project. May use subject subheadings; 125 *words or less*.)
**Results/Findings:** (Describe the results/findings of the research. May use subject subheadings; *200 words or less*.)
**Impact:** (Describe the relevant impacts that the research results may have on the cost of desalination, the development of sustainable technologies, the environment, and the strengthening of regional research capabilities. Use general subheadings such as recommendations or benefits. Subheadings more specific to the project may also be included *100 words or less*.)

# APPENDIX B

# SAMPLE PAGES

MEDRC

MEDRC Series of R&D Reports
MEDRC Project: 00-AS-014

# Development of a Logistic Model for the Design of Autonomous Desalination Systems with Renewable Energy Sources

Principal Investigator

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**February 2002**

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# ABSTRACT

A desalination system driven by a hybrid power supply system consisting of renewable-energy power generation systems coupled to conventional power generation systems is considered as an attractive solution to providing water and electricity to remote areas where water scarcity is severe and no grid electricity is available. A Reverse Osmosis desalination unit powered autonomously by a wind generator and/or photovoltaics is considered today as one of the most promising configurations in view of the power matching of desalination and renewable-energy technologies.

In this study the HybridRO simulation software has been developed on the basis of a logistic approach. It can be used for the design of an autonomous hybrid power supply system to drive a Reverse Osmosis unit for the desalination of brackish water and seawater. It is used to assist a designer in developing an optimal configuration for a hybrid power supply system and in sizing the components of such a hybrid power system . It can also be used to help in selection of appropriate operating options based on overall system performance and the economics for specific conditions and load profiles. It has been developed on the basis of accurate theoretical information collected in a detailed literature review.

The main components of the model are the power production systems, the power consumption source, storage units and the economic analysis module. The model is principally used to calculate the power produced by all the power systems, the fuel consumption of the diesel generator, the energy required to drive the desalination unit as a function of water demand, the type of available feed water etc., and the performance of batteries on scale with an adjustable time step. Furthermore, it allows a wide choice of system components and of configurations and operating strategies in order to achieve the highest usage of renewable energy in order to reduce the use of the diesel unit and provide the least cost-option for unit water production.

HybridRO is user-friendly software run in the Microsoft Windows environment and can be used to assist engineers to design hybrid power supply systems to drive an Reverse Osmosis desalination unit. It is an important tool for the coupling of the two technologies.

# ACKNOWLEDGMENT

CRES and the other project partners would like to thank the Middle East Desalination Research Center for its financial support and technical guidance which have contributed to the successful completion of this project.

CRES also thanks its other partners from National Energy Research Center (NERC) in Jordan for their useful contributions.

# EXECUTIVE SUMMARY

Coupling renewable-energy technologies with desalination processes is the most appropriate option for

supplying water and electricity to locations where no grid electricity is available and where the water scarcity is severe. It has been accepted that the combination of hybrid power supply systems (wind/PV/diesel) with the reverse osmosis (RO) desalination process, for desalination of both seawater and brackish water, is a very economica way of providing fresh water to such areas. A user-friendly software package that can be used to assist engineers in designing these hybrid power supply systems to drive the RO unit is an important tool. A useful guide for the designers as well as for the end-users is the inclusion in the software of a module that uses several alternative strategies to develop the 'best design' and least-cost options for the water supply at a specific location.

In this project, the HybridRO simulation softwarehas been developed, based on logistic approach, for the designof an autonomous hybrid power supply system to drive an RO unit for the desalination of brackish and seawater. It has been developed on the basis of accurate theoretical information collected by conducting a detailed literature survey. It simulates the performance of energy supply systems and provides results in terms of power production, capacity ratios, energy and fuel savings and component wear, which can be used as inputs to an economic analysis model for predicting unit water cost. It can assist a designer in sizing hybrid power supply hardware and in selecting appropriate operating options on the basis of overall system performance and cost for specific weather conditions and load profiles. It uses a time-series approach for long-term predictions.

HybridRO is user-friendly simulation software, operating in the Microsoft Windows environment. The main components of this software are the power production unit, the power consumption source, the storage units and the economic analysis module. The software has around 20 projections/windows. The power supply unit comprises of wind generators, photovoltaics and diesel generators. The selection of the power supply system mainly depends on the potential of each renewable power source (wind, solar potential). The power required to drive the RO unit, as well as several auxiliary loads, is the power consumption source. The storage units are the battery storage system and the water reservoir for storing the water produced. An additional important component of HybridRO is the economic analysis module, which estimates the unit cost of the water produced based on the life-cycle cost method. The software also has features for viewing the simulation results in graphical form. Fourteen time-series data graphs are available as well as performance graphs.

The model developed is principally for calculation of the power produced by all the power generators, the fuel consumption of the diesel generator, the energy required to drive the desalination unit and batterie the performance of the batteries on a scale with an adjustable time step. Furthermore, it allows a wide choice of system components and of configurations and operating strategies in order to achieve the highest usage of renewable energy in order to reduce the use of the diesel unit and provide the least cost-option for unit water production.

The following approach has been adopted in executing the project:

. • literature review/selection of modeling equations;
. • elaboration of the theoretical basis for modeling;
. • development of the simulation software;
. • testing of the software developed;

. • production of the software User Manual;
. • training of the regional partner.

Further research should focus on the examination of other desalination methods and the use of solar collectors and geothermal energy in addition to the renewable-energy sources considered in this project.

# 1. INTRODUCTION

Many areas around the world are characterized by a lack of both water and energy. This is especially true for some areas in the arid region around the Mediterranean and in the Gulf, where water is inadequate or is not of suitable quality and where no grid electricity is available. Supplying water and electricity to such areas in order to improve quality of life and to enhance economic development is an important issue.

Hybrid power generation systems utilizing renewable energy and conventional diesel generators are important sources for the supply of electricity for remote areas away from the electricity grid. In some cases this is the most economical option, since long-distance grid extensions are very expensive. Moreover, hybrid autonomous systems are independent and they incorporate more than one type of power source, for example wind, solar and diesel generators. Diesel generators are modular and have a high power-to-weight ratio, which makes them an ideal power source for such hybrid power systems.

To maximize the use of the renewable energy source, the size and operation of the hybrid system components need to be matched to the load and the available renewable resource. This is best accomplished with the use of a modeling and simulation tools. The simulation models of hybrid systems should allow the user to consider easily a number of system-configuration and operating strategies so as to optimize the hybrid system design.

Building a desalination plant to cater for the water needs of remote locations that have a lack of adequate water resources may be a better option than laying long-distance water supply pipelines. Reverse osmosis (RO) is the most economical process available today as a result of recent developments in the technology. Because of its modular nature, this process is suitable for all plant capacities. Thus, hybrid power generation systems will be an obvious choice for supplying power to RO desalination plants if grid electricity is not available. In the literature, a number of combinations have been reported as the 'most promising' power supply system for RO units and several successful applications do exist. One of these is the coupling of wind energy and solar energy (photovoltaics) to drive RO. The problems of interfacing these technologies are significant and solving such problems seems to be the main issue in implementation. Renewable Energy Sources (RES), by their nature, tend to be intermittent and variable in intensity, while desalination processes are designed for continuous steady-state operation. The approach to solving this problem is the use of diesel generators as a backup system and/or the use of energy storage modules. Additionally, in cases where there is sufficient wind and solar energy potential, the use of a renewable-energy hybrid system is of significant importance. It clear that the design and operation of hybrid power-supply systems to power RO is a complicated process and requires simulation software for the achievement of optimum results. In the present project HybridRO simulation software has been developed to satisfy these needs.

HybridRO is user-friendly software suitable for the examination of several types of power-supply systems (using renewable and conventional energy sources) for an RO desalination unit. The propgram is an .exe file operating in Windows environment. The software allows the designer to examine, based on the availability of the renewable energy sources, the effect

Power curves for commercially available wind turbines are generally constructed on the basis of averaging intervals of 1 to 10 minutes. A typical curve for a wind turbine is shown in Figure 3.2. In the HybridRO software, a database containing data for several wind turbines and their characteristics, such as nominal power, hub height, rotor diameter and power generated for different wind velocities, is included to help the user and this data is presented in Table 3.1.

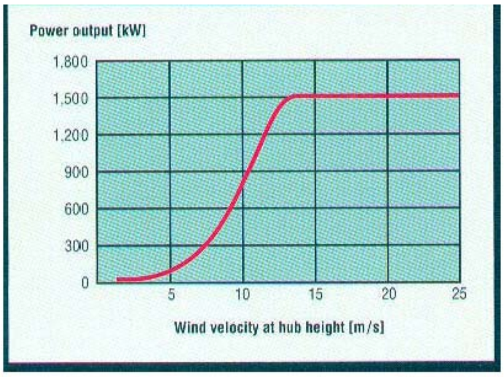


**Figure 3.2. A typical wind-turbine power curve**

A wind turbine has a cut-in wind speed at which it starts to generate power, a rated wind speed at which it starts to generate rated power, and a high-wind cut-out wind speed at which it is shut down for safety. A typical cut-in wind speed is 4 m $s^{-1}$ and a typical cut-out wind speed is between 25 and 30 m $s^{-1}$.

Number of corrections have to be applied to the power calculated from the power curve to account for the actual air density, the air velocity at the anemometer, wind speed variations and wind measurement intervals. In the wind-generator model all these corrections are applied and the average wind power and the standard deviation of the wind power over the simulation time interval are calculated. The following are the procedures for estimating these corrections.

## 3.1.1. The correction for differences in hub height and anemometer height

The power curve relates the power generated to the wind speed at hub height. The wind speed increases with height above ground. Thus, the wind speed that a wind turbine experiences at the hub height will be different from that measured by the anemometer.

The change in wind speed as a function of height is generally related to the ratio of the new height to the measured height raised to some power. Thus, the wind speed at hub height is

calculated by:

$$U_{hub} = U \frac{\ln(H_{hub}/z_0)}{\ln(H_{anem}/z_0)} \qquad (1)$$

where $H_{hub}$ is the wind speed at hub height (m $s^{-1}$), U is the wind speed at the anemometer height (m $s^{-1}$), $H_{hub}$ is the hub height (m), $H_{anem}$ is the anemometer height (m) and $z_0$ is the surface roughness length (m).

**Table 3.2. Input/output data for a wind generator**

| | |
|---|---|
| **Inputs** | |
| *Site data* | |
| Hub height, m | W/T hub-height |
| *Hanm*, m | Anemometer height |
| *z*0, m | Surface roughness length |
| ρair, kg m–3 | Air density at the site |
| ρstair = 1.255 kg/m–3 | Standard air density |
| *k* | Shape factor |
| *A*, m s–1 | Wind speed |
| *W/T Data* | |
| P–U curve | Wind power curve |
| *H*hub, m | Hub-height |
| | |
| **Outputs** | |
| *Uhub*, m | Wind speed at hub height |
| *Pwt* | Wind turbine output power |

## 3.2 Photovoltaic generators

Photovoltaics (PV) are specially designed semiconductor devices that convert the sunlight directly into electricity. The basic component of a photovoltaic system is the solar cell. When the surface of the solar cell is exposed to sunlight, direct current is generated and is carried through a thin electrode grid in the front surface and from an electrode in the back surface of the cell.

Groups of cells are mounted on a glass plate and wired in series to form a PV module, typically around 0.5 $m^2$ in size. These typical modules produce about 50 watts of electrical energy when exposed to the maximum intensity of solar irradiance. A wide range of module types (power, size, nominal voltage, etc.) is commercially available to suit the ever-growing variety of PV applications.

Groups of modules that are electrically connected together form a PV array. The nominal voltage and current of an array depend on the number of modules connected in series and in parallel. PV arrays can be mounted either on a fixed structure or on a sun-tracking structure to maximize the incident solar radiation on the solar cell surface.

The power production capacity of a PV array is expressed in watt peak ($W_p$) units. A solar cell is 'said' to be of 1 $W_p$ power if it produces 1 W of electrical power when exposed to 'peak' solar irradiance (1000 W $m^{-2}$) at a solar cell temperature of 25°C. The electrical power output of PV modules is proportional to the incident solar irradiance.

For example, a 54 $W_p$ module will produce 27 W at 500 W $m^{-2}$ of solar irradiance.

Typical PV modules exhibit a slight reduction of power output as their temperature increases.

The most common materials currently used for PV cell manufacturing are: