



**Faculty of Electrical and Electronic Engineering Technology**



**DEVELOPMENT OF SOLAR PHOTOVOLTAIC WATER PUMPING  
SYSTEM**

**MUHAMMAD SYAHMI BIN TAQIYUDDIN**

**Bachelor of Electrical Engineering Technology (Industrial Power) with  
Honours**

2023

# **DEVELOPMENT OF SOLAR PHOTOVOLTAIC WATER PUMPING SYSTEM**

**MUHAMMAD SYAHMI BIN TAQIYUDDIN**

A project report submitted  
in partial fulfillment of the requirements for the degree of  
**Bachelor of Electrical Engineering Technology (Industrial  
Power) with Honours**



**Faculty of Electrical and Electronic Engineering Technology**

**UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

2022

**BORANG PENGESAHAN STATUS LAPORAN  
PROJEK SARJANA MUDA II**

Tajuk Projek :

Sesi Pengajian :

Saya Muhammad Syahmi bin Taqiyuddin mengaku membenarkan laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (✓):

**SULIT\***

(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

**TERHAD\***

(Mengandungi maklumat terhadap yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

**TIDAK TERHAD**

Disahkan oleh:



(TANDATANGAN PENULIS)

Alamat Tetap: NO. JALAN PINGGIRAN PUTRA  
5/34, DESA PINGGIRAN PUTRA,  
43000, KAJANG, SELANGOR.



(COP DAN TANDATANGAN PENYELIA)

**Ts. Dr. MOHD HATTA BIN JOPRI**

Pensyarah  
Jabatan Teknologi Kejuruteraan Elektrik  
Fakulti Teknologi Kejuruteraan Elektrik dan Elektronik  
Universiti Teknikal Malaysia Melaka (UTeM)

Tarikh: 23.12.2022

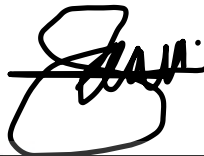
Tarikh: 23.12.2022

\*CATATAN: Jika laporan ini SULIT atau TERHAD, sila lampirkan surat daripada pihak berkuasa/organisasi berkenaan dengan menyatakan sekali tempoh laporan ini perlu dikelaskan sebagai SULIT atau TERHAD.

## DECLARATION

I declare that this project report entitled Development Of Solar Photovoltaic Water Pumping System is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

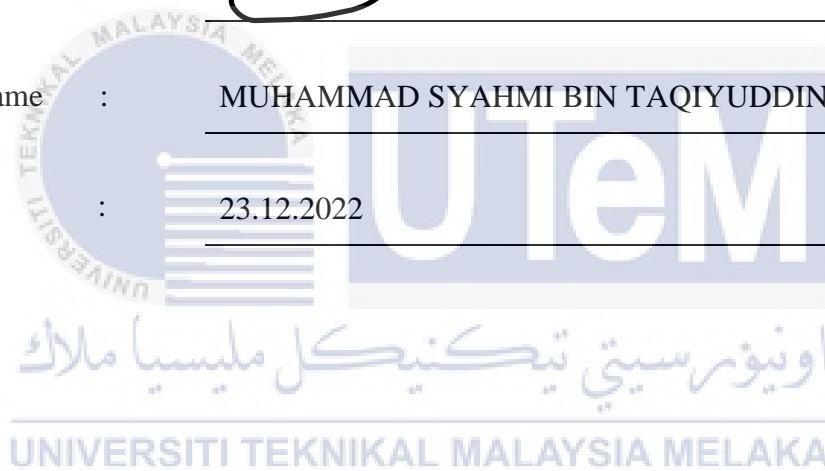


Student Name :

MUHAMMAD SYAHMI BIN TAQIYUDDIN

Date :

23.12.2022



## APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

Signature : 

Supervisor Name : DR. MOHD HATTA BIN JOPRI

Date : 23.12.2022

Signature : 

Co-Supervisor  
Name :

Date :



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

## DEDICATION

To my beloved supervisor, Ts. Dr. Mohd Hatta bin Jopri, who helped me throughout this final year project 2. To my beloved parents, family, and friends that helped me to complete this report



## ACKNOWLEDGEMENT

In the name of Allah S.W.T, thankfulness to the Almighty who gave me the ability to carry out and completes this Final Year Project 2. First of all, I would like to thanks my family for all their support and prayer for me for 14 weeks for me to complete my report for this Final Year Project 2.

Next, I would like to thanks and appreciate to my respect supervisor Ts. Dr. Mohd Hatta bin Jopri for giving me the chance to do this project under him. A big respect and thanks to Ts. Dr. Mohd Hatta bin Jopri for his guidance, encouragement, advice and a lot of ideas that have been devoted to me during the time that had been given to me to complete this Final Year Project 2. A very helpful supervisor that always help me and my other members to complete this report. All the knowledge and lot of experience in engineer technologist field that has been given to me and all my members even though he also busy with his work really help me to overcome my problem and create something very useful for my project. Thank you for willing to take me as his candidate under his wings. Without his help and guidance, I will not get this lot of knowledge and experience about this project that I had done.

I also would like to express my thankful to Pn Kamilah binti Jaffar and Che Wan Mohd Faizal bin Che Wan Mohd Zalani for be the panel for my Final Year Project 1 and also be the panel for my presentation day for my Final Year Project 2. Their comments and guide really help me to improve my idea and received a very good comment and reaction from them for my presentation. Even though they also busy with work they also teach and give me some ideas about my project that useful as addition knowledge for me to complete my task. Last but not least, thank you to all individual that take part in helping me since the first day me start this project until finished the project and report directly and indirectly especially to my beloved members. Thank you.

## ABSTRACT

Agriculture has taken the role of being the backbone and driving force behind Malaysia's economic strength and prosperity. The agriculture sector has experienced a new trend in the development on off-grid solar powered construction concepts throughout the world over the last decade, with significant endorsement from influential organisations and the implementation of PV powered solar panels. Nowadays, the conventional ways has switched over to renewable sources such as solar system. A benefit of using solar energy to power agricultural water pump systems is that increased water requirements for livestock and irrigation tend to coincide with the seasonal increase of incoming solar energy. When properly designed, these PV systems can also result in significant long-term cost savings and a smaller environmental footprint compared to conventional power systems. A prototype of this PV water pumping system will be demonstrated throughout this project as the load to the system. In this research, a monocrystalline solar panel will be used to measure their efficiency and determine the best installation of solar panel semiconductor type. A solar energy storage plays an important role as an dependency for the supply during the unavailability of sunlight. Hence, the installation of solar energy storage leads to identify the best solar controller in order to get a maximum electrical generation output from the solar panel to charge the battery.



## ***ABSTRAK***

Pertanian telah mengambil peranan sebagai tulang belakang dan penggerak di sebalik kekuatan ekonomi dan kemakmuran Malaysia. Sektor pertanian telah mengalami norma baharu dalam pembangunan konsep pembinaan kuasa solar luar grid di seluruh dunia sepanjang dekad yang lalu, dengan sokongan daripada organisasi berpengaruh dan pelaksanaan panel solar berkuasa PV. Pada masa kini, cara konvensional telah beralih kepada sumber boleh diperbaharui seperti sistem solar. Faedah menggunakan tenaga suria untuk menggerakkan sistem pam air pertanian ialah peningkatan keperluan air untuk ternakan dan pengairan cenderung bertepatan dengan peningkatan bermusim tenaga suria yang masuk. Apabila sistem direka dengan betul, sistem PV ini juga boleh menghasilkan penjimatan kos jangka panjang yang ketara dan jejak alam sekitar yang lebih kecil berbanding sistem kuasa konvensional. Prototaip sistem pam air PV akan ditunjukkan di dalam projek ini sebagai bebanan sistem. Dalam penyelidikan ini, sebuah monohablur akan digunakan untuk mengukur kecekapannya dan menentukan pemasangan terbaik jenis semikonduktor panel solar. Storan tenaga suria memainkan peranan penting sebagai pergantungan untuk bekalan semasa ketiadaan cahaya matahari. Oleh itu, pemasangan storan tenaga suria membawa kepada mengenalpasti pengawal cas suria yang terbaik untuk mendapatkan pengeluaran tenaga yang maksimum daripada panel suria untuk mengecas bateri.

## TABLE OF CONTENTS

	<b>PAGE</b>
<b>DECLARATION</b>	<b>i</b>
<b>APPROVAL</b>	<b>ii</b>
<b>DEDICATION</b>	<b>iii</b>
<b>ACKNOWLEDGEMENT</b>	<b>iv</b>
<b>ABSTRACT</b>	<b>i</b>
<b>ABSTRAK</b>	<b>ii</b>
<b>TABLE OF CONTENTS</b>	<b>i</b>
<b>LIST OF TABLES</b>	<b>iii</b>
<b>LIST OF FIGURES</b>	<b>iv</b>
<b>LIST OF SYMBOLS</b>	<b>vii</b>
<b>LIST OF ABBREVIATIONS</b>	<b>viii</b>
<b>LIST OF APPENDICES</b>	<b>ix</b>
<b>CHAPTER 1 INTRODUCTION</b>	<b>1</b>
1.1 Background	1
1.2 Problem Statement	2
1.3 Project Objective	3
<b>CHAPTER 2 LITERATURE REVIEW</b>	<b>4</b>
2.1 Scope of Project	4
2.2 Overview	4
2.3 Type of Solar Panel	5
2.3.1 Monocrystalline Solar Panel	5
2.3.2 Polycrystalline Solar Panel	7
2.4 Type of Motor Pump	9
2.4.1 Centrifugal Motor Pump	9
2.4.2 Diaphragm Motor Pump	11
2.4.3 Submersible Motor Pump	12
2.5 Type of Microcontroller	15
2.5.1 Arduino UNO R3	15
2.5.2 Raspberry Pi	16
2.6 Type of Charge Controller	17
2.6.1 PWM Solar Charge Controller	17
2.6.2 MPPT Solar Charge Controller	19

2.7	Type of Sensor	21
2.7.1	Water Level Sensor (HW-038)	21
2.8	Type of Battery	22
2.8.1	Lithium-Ion Battery	22
2.8.2	Lead-Acid Battery	24
2.9	Type of Switch	26
2.9.1	1 Channel 5V Relay	26
<b>CHAPTER 3 METHODOLOGY</b>		<b>28</b>
3.1	Introduction	28
3.2	Circuit Design	29
3.3	Calculation in sizing the equipment specifications	32
3.3.1	Estimate Load Wattage	32
3.3.2	Determining Approximate Solar Panel Dimension	32
3.3.3	Calculation Battery (Ah)	32
3.3.4	Evaluate Charger Controller Amperage	33
3.4	Equipment and Component	33
3.4.1	50Wp Monocrystalline Solar Panel	33
3.4.2	30A MPPT Solar Charge Controller	34
3.4.3	12V Battery 30Ah (Lead-Acid)	35
3.4.4	1 Signal Relay (5V)	36
3.4.5	Water Level Sensor (HW-038)	37
3.4.6	Arduino UNO R3	37
3.4.7	12V DC Diaphragm Electric Motor Water Pump	39
3.5	Summary	40
<b>CHAPTER 4 RESULT AND DISCUSSION</b>		<b>41</b>
4.1	Introduction	41
4.2	Water Level Monitoring	41
4.3	Circuit Design as A Stand-Alone Solar System	45
4.4	Variables and Location of Data Collection throughout the Experiment	49
4.5	Experimental Setup	52
4.6	Battery Voltage monitoring	53
4.7	Statistical Analysis in Charging Phase	56
4.8	Statistical Analysis in Discharging Phase	58
4.9	Statistical Analysis in Power Consumed	61
4.10	Return on Investment (ROI)	62
<b>CHAPTER 5 CONCLUSION</b>		<b>68</b>
5.1	Conclusion	68
5.2	Future Works	69
<b>REFERENCES</b>		<b>70</b>
<b>APPENDICES</b>		<b>73</b>

## LIST OF TABLES

<b>TABLE</b>	<b>TITLE</b>	<b>PAGE</b>
Table 1:	Type of submersible pumps and its application	14
Table 2:	Connection of water level sensor	22
Table 3:	Working principle of Li-Ion battery	23
Table 4:	Working principle of Lead-Acid battery	25
Table 5:	Specification of Monocrystalline solar panel	33
Table 6:	Specification of MPPT	35
Table 7:	Specification of 1 Signal 5V Relay	36
Table 8:	Specification of Arduino UNO R3	38
Table 9:	Specification of Diaphragm motor pump	39
Table 10:	Variables in Solar Experiment	51
Table 11:	Battery Voltage Capacity	54
Table 12:	List of Materials	63
Table 13:	Situation Concept for Future Work Dimension	64
Table 14:	TNB Tariff A - Domestic Tariff	65

## LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 2.1:	Monocrystalline Solar Panel	5
Figure 2.2:	Cross-section of Monocrystalline Solar Panel	6
Figure 2.3:	Czochralski method	6
Figure 2.4:	Polycrystalline Solar Panel	7
Figure 2.5:	Comparison method in producing solar panel	9
Figure 2.6:	Centrifugal Motor Pump	9
Figure 2.7:	Centrifugal Pump working principle	10
Figure 2.8:	Diaphragm Motor Pump	11
Figure 2.9:	Working principle of diaphragm motor pump	12
Figure 2.10:	Submersible DC Motor Pump	12
Figure 2.11:	Arduino UNO R3	15
Figure 2.12:	Raspberry Pi	16
Figure 2.13:	PWM Solar Charge Controller	17
Figure 2.14:	Connection PWM Controller to the system	18
Figure 2.15:	MPPT Solar Charge Controller	19
Figure 2.16:	MPPT Working Principle	20
Figure 2.17:	Water Level Sensor HW-038	21
Figure 2.18:	Li-Ion Battery	22
Figure 2.19:	Sealed Lead-Acid Battery	24
Figure 2.20:	1 Channel 5V Relay	26
Figure 3.1:	Circuit design of the system	30
Figure 3.2:	Circuit design of the external water level sensor	30

Figure 3.3: Overall Project Flowchart	31
Figure 3.4: 50Wp Monocrystalline solar panel	33
Figure 3.5: MPPT Solar Charge Controller	34
Figure 3.6: 12V Battery 30Ah (Lead-Acid)	35
Figure 3.7: 1 Signal Relay (5V)	36
Figure 3.8: Water Level Sensor (WH-038)	37
Figure 3.9: Arduino UNO R3	37
Figure 3.10: Diaphragm Electric Motor Water Pump	39
Figure 4.1: Arduino Connection With Relay	42
Figure 4.2: Arduino Connection of Water Level Monitoring	43
Figure 4.3: Immersion of Water Level Sensor HW 038	43
Figure 4.4: Water Level Monitoring Coding	44
Figure 4.5: Full Circuit Connection	45
Figure 4.6: Main Display of MPPT Solar Controller	47
Figure 4.7: Over Charging Protection Setting Display	47
Figure 4.8: Over Discharging Protection Setting Display	48
Figure 4.9: Overview of Solar Photovoltaic Powered Water Pumping System	49
Figure 4.10: View of experiment location via Google Maps	51
Figure 4.11: Collecting the Solar Data for Charging Phase	53
Figure 4.12: Collecting the data for Discharging Phase	53
Figure 4.13: Mean Charging Voltage Graph	56
Figure 4.14: Mean Charging Current Graph	56
Figure 4.15: Standard Deviation of Charging Voltage	57
Figure 4.16: Standard Deviation of Charging Current	58
Figure 4.17: Mean Discharge Voltage Graph	58

Figure 4.18: Mean Discharged Current Graph	59
Figure 4.19: Standard Deviation of Discharging Voltage	60
Figure 4.20: Standard Deviation of Discharging Current	61
Figure 4.21: Daily Power Consumed by the DC water pump	61
Figure 4.22: Total Power Consumed by the Load in November 2022	62



## LIST OF SYMBOLS

$\eta$	-	Efficiency
$\bar{X}$	-	Mean





## LIST OF ABBREVIATIONS

V	-	Voltage
A	-	Ampere
W	-	Watt
PV	-	Photovoltaic
$W_p$	-	Watt peak
Si	-	Silicon
DC	-	Direct Current
AC	-	Alternating Current
PWM	-	Pulse Width Modulation
MPPT	-	Maximum Power Point Tracking
COM	-	Common
NC	-	Normally Closed
NO	-	Normally Opened



## LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A:	GANTT CHART OF PROJECT	73
APPENDIX B:	CHARGING PHASE	74
APPENDIX C:	DISCHARGING PHASE	105
APPENDIX D:	CHARGING PHASE STATISTICAL ANALYSIS DATA	135
APPENDIX E:	DISCHARGING PHASE STATISTICAL ANALYSIS	136
APPENDIX F:	WATER LEVEL MONITORING CODING	137



# CHAPTER 1

## INTRODUCTION

### 1.1 Background

All around the world, farmers have struggled to water their crops during the dry season since they must utilize well-water. Farmers' work in creating agricultural items is ineffective when it comes to irrigating farmland by using his power to lift water to agricultural grounds. Many people are unable to utilize water pumps on their farmland because they are without access to electricity. Alternative energy sources such as solar water pumps can help solve these problems. This article is going to calculate the solar data in comparison of two main solar panels which commonly used nowadays. In this comparison, some analysis will be conducted to observe their efficiency during the availability of sunlight. A types of mainstream PV modules were selected in this study which is Monocrystalline to measure their efficiency. Mainly, this project purposes to draw water from underground source to fill up the tank storage without using utility grid. This project also pre-built with the connection to battery so that during the night, user still has an option to run the system normally.[1]

## 1.2 Problem Statement

There are some problems faced during the study of solar energy. The distribution of water resources is a critical challenge in improving such agriculture or crop result. Small-scale farmers desire to start with a low-cost, dependable technology for irrigating crops and increasing production. For many farmers around the world, a solar-powered water pump could be the answer for this solution.[2]

But, there is a problem would be faced when implementing this system which is the location factor. Nowadays, many peoples are desire to start their business in agriculture sector. But when it comes into a location factor, usually the farm or land is located far from the electrical grid supply. Besides that, at inner state people used water from well and pump it manually using their own energy. But, this method is not efficiently, waste time and it is not user friendly. That's why solar water pumping is important to replace this work to draw the water from the resource.[3]

The unpredictability of how much of the sun's rays will receive in solar panel, as weather might change at any time, poses a barrier for solar PV and during the night, while there is still a demand for electricity, sunlight is clearly unavailable. This would make a solar energy storage is so much dependable. The sizing of storage is needed to determine how much energy to store for future usage. Hence, a proper sizing of storage is also an important thing to provide a sufficient energy storage for a continuous usage to the users.[4] There's so much water pumping system available out there, where its operation doesn't have a self-monitoring system. When the motor pump either requires a manually switching on or off by the users, this creates an inconsistent situation where users cannot fully deal with the time to monitor the level of the water inside the storage. Hence, an automatic level monitoring system is so important to install towards this system.

A solar data without a statistical analysis would deteriorate the future estimation on the system. This is because, solar panel performance mostly effected from the weather changes. Hence, knowing the pattern weather based on the statistical data is very crucial as a preparation of system sizing in term of solar storage and solar controller needed.[5]

### 1.3 Project Objective

The main aim of this project is to propose a comparative analysis of solar cell efficiency between Mono-crystalline and Poly-crystalline toward the water pump system. Specifically, the objectives are as follows:

1. To design a dependable of solar energy storage based on its supply longevity.  
This project will calculate the sizing of minimum battery needed for load depend on the daily usage.
2. To install a self-monitoring water pumping system using solar photovoltaic powered. This project mainly to setup a standalone water pumping system without any supply from the electrical grid supply.
3. To analyze the solar data collection using the statistical method.

## CHAPTER 2

### LITERATURE REVIEW

#### 2.1 Scope of Project

To avoid any uncertainty of this project due to some limitations and constraints, the scopes of the project are defined as follows:

- a) Calculate the solar efficiency which can be generated by 50W<sub>p</sub> Monocrystalline solar cell panel.
- b) Generate the power supply from the solar panel into the load in direct current.
- c) Coding the operation of relay as a switch using Arduino UNO R3.

#### 2.2 Overview

This research uses a direct measurement method to compare the performance of a mono-crystalline with a peak power of 50 W<sub>p</sub>. Mono-crystalline materials were compared in terms of efficiency to achieve this goal. To observe the characteristics of different Si-based solar PV systems under various conditions, environmental parameters such as solar radiation and temperature are varies from time to time.[6]

Solar panels with a power capacity and a peak power capacity of 50 W<sub>p</sub> is using a direct measurement approach in this study. These areas are arranged in order to show the information about the process of decision making about the project. It is important to obtain clear data and must use the precise and strong database. This chapter was divided as below into Section 2.2 Type of Solar Panel, Section 2.3 Type of Water Motor Pump, Section 2.4

Type of Microcontroller, Section 2.5 Type of Charge Controller, Section 2.6 Type of Sensor, Section 2.7 Type of Battery, Section 2.8 Type of Switch.

## 2.3 Type of Solar Panel

### 2.3.1 Monocrystalline Solar Panel



Figure 2.1: Monocrystalline Solar Panel

Most photovoltaic cells are made of crystalline silicon because it is non-toxic, unlike cadmium or selenium. It also has high conversion efficiencies and makes up about 28% of the bark of terrestrial plants in the form of compounds (silicates and silica), making it a source that is almost impossible to run out of.

When exposed to light, the semiconductor solar cell is a device that sends an electric current to an outside load. The way it works is when a photovoltaic cell is exposed to sunlight, the energy of the photons that pass through the cell and into the junction is transferred to the atoms of the junction. If this energy is high enough, it can move the electrons from the valence band to the conduction band of the semiconductor material, making electron-hole pairs.

Then, an electric field, which is a potential barrier, keeps the electrons (which have N charges) and the holes (which have P charges) apart. If a charge is put across the cell, the

electrons in zone N connect to the holes in zone P through the external connection. This creates a potential difference, which makes an electric current flow.[7]

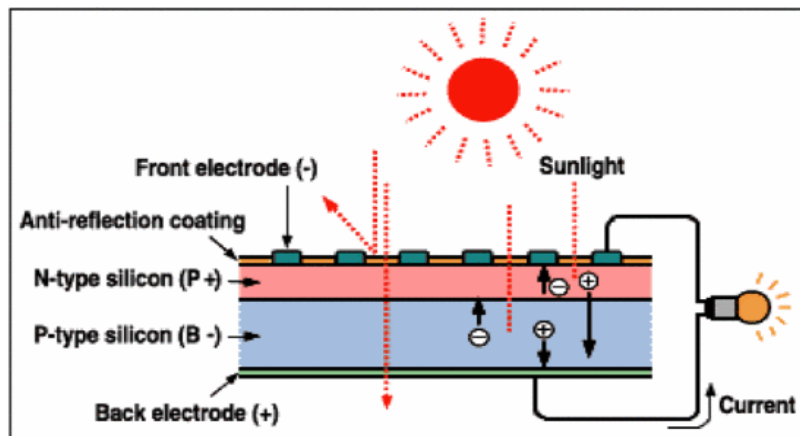


Figure 2.2: Cross-section of Monocrystalline Solar Panel

Monocrystalline solar panels contain monocrystalline solar cells. The term comes from a cylindrical silicon ingot made from high purity single-crystal silicon. As a single crystal cell, electrons have greater space to move, improving electrical flow. Ingots are broken into wafers and assembled into cells. Circular wafers are wire-cut into octagonal shapes to improve cell usefulness.

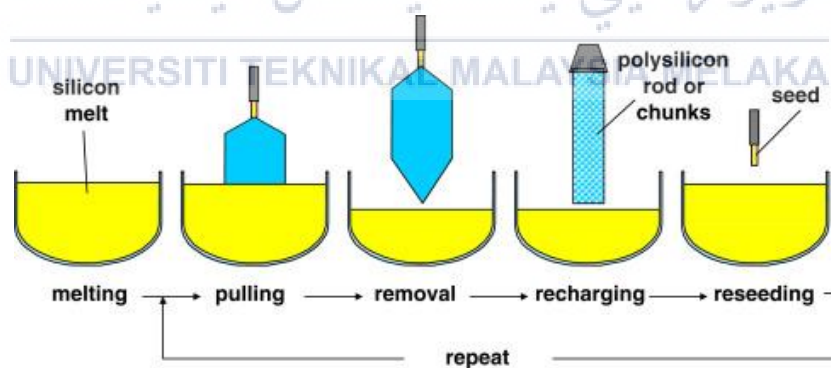


Figure 2.3: Czochralski method

Monocrystalline solar panels are built differently. Each solar cell has a single-crystal silicon wafer. The Czochralski procedure requires inserting a 'seed' crystal in liquid pure silicon at a high temperature. Molten silicon produces a single crystal around the seed. The ingot is