BORANG LRGS–A1(R)-PROGRAM

Kod Rujukan:	

(Diisi oleh RMC)

JABATAN PENGAJIAN TINGGI
KEMENTERIAN PENGAJIAN TINGGI

LONG TERM RESEARCH GRANT SCHEME (LRGS)
APPLICATION FORM-PROGRAM

One (1) copy of this form must be submitted to the Institution of Higher Education Excellence Planning Division, Department of Higher Education, Level 6, Block E14, Complex E, Federal Government Administrative Centre,62505 Putrajaya.
[Incomplete Form will be rejected]

A. **LRGS MODE:**
Mod LRGS

☐ **Top down**
Atas ke bawah

☑ **Bottom up**
Bawah ke atas

B. **NICHE**
Bidang Nic

☐ Global Warming
Pemanasan Global

☐ Infectious diseases
Penyakit berjangkit

☐ Tropical Medicine
Perubatan tropika

☐ Energy and Water Safety
KeselamatanTenaga & air

☐ Food Security
Kecukupan makanan

☑ Advanced and value-added manufacturing
Pembuatan termaju dan tambah nilai

☐ Information and communication technology
Teknologi komunikasi dan informasi

☐ Others, please specify
*Lain-lain, sila nyatakan*_____

C. **NAME OF PROGRAM:**

ENHANCING PRODUCTIVITY AND SUSTAINABILITY OF PALM OIL MILLING INDUSTRY

NAME OF PROGRAM LEADER: **PROFESSOR DR. ROBIAH YUNUS**
Nama Ketua Program

IC NUMBER/PASSPORT:
No. Kad Pengenalan/ Pasport:

	POSITION (PLEASE TICK(√)): *Jawatan (Sila tanda (√))* ☑ Professor / *Profesor* ☐ Assoc. Prof. / *Prof. Madya* **FACULTY/SCHOOL/CENTRE/UNIT/UNIVERSITY (Please provide full address):** *Fakulti /Jabatan /Pusat/Unit/Universiti (Sila nyatakan alamat penuh)* **INSTITUTE OF ADVANCED TECHNOLOGY, UNIVERSITI PUTRA MALAYSIA, 43400 UPM SERDANG, SELANGOR** **OFFICE TELEPHONE NO.: 03-89467531** *No. Telefon Pejabat:* **HANDPHONE NO.:012-2306009** *No. Telefon Bimbit* **EMAIL ADDRESS: robiah@eng.upm.edu.my** **A***lamat e-mel*
D.	**DURATION OF RESEARCH:** *Tempoh masa penyelidikan* **Duration**: 5 years *Tempoh* **From: 1 July 2012** Dari tahun **To: 30 June 2017** Sehingga tahun
E.	**LEADING IPT:** *IPT Peneraju* **UNIVERSITI PUTRA MALAYSIA**
F.	**OBJECTIVE PROGRAM:** To enhance the productivity and sustainability of palm oil milling industry

G.

EXECUTIVE SUMMARY OF PROPOSAL (MAXIMUM 1000 WORDS)
(Please include the background of research, literature reviews, objectives, research methodology and expected outcomes from the research project)
Ringkasan Cadangan Eksekutif Penyelidikan (maksima 1000 patah perkataan)
(Meliputi latar belakang penyelidikan, kajian literatur, kaedah penyelidikan, objektif dan jangkaan hasil penyelidikan)

Background :

Palm oil industry is among the 12 National Key Economic Areas (NKEAs) areas which are at the core of the Economics Transformation Program (ETP). Malaysia's palm oil industry is currently the fourth gross national income contributor to our economy. By year 2020, the Performance Management and Delivery Unit (PEMANDU) has targeted that the industry will further contribute RM178 billions in Gross National Income (GNI) and 42,000 creation of new jobs to the country (PEMANDU, 2012). Through the Economic Transformation Program (ETP) launched recently by the Prime Minister, the government has outlined 4 segments to be focused on as far as palm oil industry is concerned; plantation, palm oil milling and trading, non-food downstream and food and health based downstream. In order to achieve this vision, the government has identified two strategic thrusts of sustainability in both upstream and downstream activities and amongst the entry point projects listed is improving the oil extraction rate. It is estimated that, on every 1% increase of OER, the country will benefit extra RM1 billion each year from this industry. The impact of improving the current OER is therefore big and one of the promising focus areas to increase OER is through improvement in palm oil milling processes and recovery of oil from the palm oil waste materials. It is the "low hanging fruits" to the country. GNI from the saving in reducing palm oil losses alone is estimated at RM13.7 billion which contributes to 10,000 jobs involving more than RM3.0 billion investments.

Oil extraction rate (OER) is a universal indicator to measure the actual amount of oil obtained from the fresh fruit bunch (FFB). The maximum OER from a ripe FFB is estimated to be 30% (Azis and Tan, 1989). OER is the most important parameter that is directly related to the productivity of oil palm mills. Changes in OER has a bearing on the economy as such changes can result in higher or lower output of CPO from a given land area. Low OER will result in low profit to the palm oil mill, thus reduce the contribution to national income. Other impacts would be less potential for investment in developing new technology and environmental management as well as welfare of the workers. If OER continues to be produced at the current level, the present value of annual loss to company's profit and national income will be very significant and may result in slower economic development of the country. Among other factors that would affect OER, inefficient milling technology and poor oil/water separation contribute highly to oil losses in the press cakes and waste water. Oil losses on FFB at the mills are generally very high at 1.8% (w/w). This translates into about 40 tons of oil losses/day per mill or about RM120000/day/mills or RM36million/year/mill. Physico-chemical properties of fruits and oil will undoubtedly play key roles in the existing milling technologies for improving OER. However, the level of understanding of the fundamental issues related to these technologies is limited. The program covers all major aspects of palm oil mill technology from FFB grading, sterilization, stripping, digestion, pressing, clarification, purification, and drying. Besides, oil recovery from wastewater, EFB, sludges, decanter cake, press fibers will also be studied for opportunity to develop new technology towards zero wastes. The target is to improve the OER to at least 25%.

Over the past few decades the OER has not made significant improvement and the reasons always being associated with soil, climate, oil palm species, poor milling operation and machine efficiency. Not much effort has been given to determine the oil loss in the palm oil wastes and wastewater and recover it. The proof is over the years, the palm industry has not changed much in terms of its processing methodology and improved designed. Most of the design components in the mill are still like 50 years ago. Therefore there is an urgent need to re-engineering the some of the processing components so that oil extraction rate is improved and oil loss is reduced. Typical oil recovery potentials from palm oil biomass are as follows;

No	Description	Strategy	Potential Income
1	Determination of oil loss in EFB USB and its contribution the overall oil extraction rate (OER).	1. Design a new press-shredder machine. 2. Modelling study of appropriate design strategy. 3. Characterisation of high value derivatives in press-shredder liquid.	RM1.98 million per mill per year. Assumptions: 1.Processing capacity 1000 tonned per day. 2.Operation 300 days. 3.Oil content 2% in EFB. 4.EFB is 22% of FFB. 5.CPO price is RM3000 per tonne. 6.Recovery rate is 50% only.
2	Oil recovery from Decanter cake	1. Improvement analysis on the performance of decanter system and characterisation of high value chemical components. 2. Design a new system to recover oil from decanter cake.	RM850,000 per mill per year. Assumptions: 1.Processing capacity 1000 tonned per day. 2.Operation 300 days. 3.Oil content 4.5% in DC. 4.DC is 42 kg/tonne FFB. 5.CPO price is RM3000 per tonne. 6.Recovery rate is 50% only.
3	Improvement in the existing design to increase the oil recovery rate.	1. Monitoring study on the oil loss, design efficiency of the current sludge pit design and provide recommendations for improvement. 2. Propose a new and improved design system to recover oil. 3. Thermodynamic modeling of oil recovery from the improved sludge pit design.	RM2.1 milllion per mill per year. Assumptions: 1.Processing capacity 1000 tonned per day. 2.Operation 300 days. 3.Oil content 0.75% in POME. 4.POME is 0.62 tonne per tonne of FFB. 5.CPO price is RM3000 per tonne. 6.Recovery rate is 50% only.

This will require detailed audit on the oil losses from all sources including pipe lines, processing tanks, other purification steps and storage tanks to provide baseline study of the oil losses from various processing equipment in the mill. Then engineering and management measures will be recommended to reduce the oil loss.

Finally, the financial and economic feasibility of new palm oil milling technology and its impacts to social, safety & health, environment, and national income will be evaluated. The environmental impacts of new milling technology in terms of willingness to pay for improved environmental quality and internalizing the cost by the industry with new milling technology are critical success factor. In addtition, the current existing technology in Malaysian oil palm mills had shown a clear indicator of severe risk of developing occupational disease from hazards such as physical, chemical and

ergonomics hazards. Previous study has shown that the noise level in oil palm mills exceed the permissible exposure limit of more than 90dB(A) with high prevalence of hearing loss and non auditory health effect such as significant increase of stress level. In addition, the study also indicates that the majority of the workers are in heat stress due to the high WBGT index reading. The outcome can be seen with a high prevalence of reported heat stress syndrome such as fatigue due to high heat and humidity in the workplace due to the use of current technology. All of the hazards that show from the stress level are an indicator on the psychosocial impact on the workers.

References:

i. Performance Management and Delivery Unit (PEMANDU), 2012. Available Online http://etp.pemandu.gov.my/ETPedia-@-NKEA_-;_National_Key_Economic_Area.aspx
ii. Basri Abdul Talib and Zaimah Darawi. 2002. An Economic Analysis of the Malaysian Palm Oil Market. Oil Palm Industry Economic Journal 2(1):19-27.
iii. Azis, A.A. and Tan Yew Ai, 1989. The effects of handling of FFB on the formation of FFA and the subsequent quality of crude palm oil. PORIM International Conference 1989.
iv. Tan, C.H., Hasanah, M.Ghazali, Ainie Kuntom, Chin-Ping Tan & Abdul A. Ariffin. (2009). Extraction and physicochemical properties of low free fatty acid crude palm oil. Food Chemistry 113: 645-650.
v. Owolarafe, O.K. & Faborode, M.O. (2008). Structural characterization of palm fruit at sterilization and digestion stages in relation to oil expression. Journal of Food Engineering 85, 598 – 605.
vi. Malaysia Palm Oil Board (MPOB), 2010. Available online (http://econ.mpob.gov.my/economy/industry2/profile2010/profile2010.html).
vii. Chang, L. C, Abdul Rahim Abdullah Sani and Zainon Basran. 2003. An Economic Perspective of Oil Extraction Rate in the Oil Palm Industry of Malaysia. Oil Palm Industry Economic Journal 3(1):25-31.
viii. Chen, M.L (2003). Heat stress evaluation and workers fatigue in a steel plant. AIHA, 64,352-359

Objectives:
The general objective is to enhance the productivity and sustainability of the oil palm milling industry.

Research methodology:
The overall methodology is shown in Figure 1. The detailed methodology for each project are described as follows:

In this program, an accurate determination of the oil content in fresh fruit bunches (FFB) entering the palm oil mill is crucial to set the bench mark for the potential OER that can be achieved. Thus, this program begins with Project 1 on the development of sensor technology for fruit grading and oil quality monitoring of which will be divided into two sections; development of sensors for fruit grading at the mill's gate and monitoring and removal technology of FFA. The fruit grading project addresses the issues of quality and quantity of the crude palm oil that can potentially be extracted from the fresh fruit bunches (FFB). It shall focus on the fundamental aspects of sensor characteristics that shall provide the highest sensitivity with respect to the quality of fruit. Theoretical electromagnetic analysis shall be done to predict the relationship between oil content and reflection coefficient of the microwave sensor. Measurements shall be carried out to establish the actual relationship between oil content, water content and microwave reflection coefficient. The amount of oil content shall be predicted directly from microwave reflection measurement. The microwave measurement shall consist of a microcontroller, microwave sensors, coupler and detectors. The accuracy of the technique shall be calculated by comparing the predicted oil content with the true oil content using standard method. For monitoring of FFA, study on synthesis and characterization of new materials to be incorporated in the FFA detection system will be carried out. New technique which is based on enzymatic reaction will

also be studied and optimized. As for the removal of FFA from the palm oil condensate, new chemical or biochemical polymers will be synthesized and characterized for effective, selective and rapid removal of FFA.

The second project focus on elucidation of fundamental principles and novel strategies for enhancing the sterilization and oil extraction processes to enhance the oil recovery (OER). The project will explore potential ways to improve the oil extraction and yield by using various operational strategies in the sterilizer and evaluating the potential of using ultrasound at digestion, pressing and also oil/water separation systems. Firstly, the analysis of the chemistry of fruit-stalk carbohydrate bond and factors that affect the hydrolysis of the binding carbohydrates during sterilization of FFB by incorporating the thermodynamic effects towards zero incidence of USB index will be carried out. Then the fundamentals principles that govern the performance of the existing digester will be elucidated to examine the opportunities to improve the oil recovery using ultrasonication. The interphase behaviour of oil/water layers in a clarifier will be studied for improvement the oil-water separation through engineering and scientific approaches. The performances of these new strategies will be assessed by developing prototypes of the improved sterilizer digester and clarifier at the pilot scale. This will involve process and plant design strategies which are the backbone of the chemical engineering approach. Finally, the alternative state of the art technology for oil extraction will be developed for opportunity to improve OER.

In the development of green technology to recover oil and kernel losses from palm press cakes, the press cake will be analyzed to determine the water, solid and oil content and the components of the oil. Project 4 focuses on four main strategies that will be used to recover the oil from pressed palm mesocarp streams and wastes: fractional solvent crystallization and extraction, solvent free subcritical water extraction, and supercritical CO2 separation. The project starts by determining the chemical engineering properties and compositions of these wastes. These include material & energy balances, energy management of the processes in the mill dependent of palm pressed fibres, identification of material processing to improve biomaterials quality for oil recovery, analysis of process systems, process design & process model databases, raw materials, gas, water & liquids testing, documentation & database. All of these chemical engineering mechanisms will be applied in the design of the process rigs. In addition, the baselines of mill production, material and energy ratios in palm mesocarp streams and wastes in the real mill condition will be used as the basis in the design. Benchmarking the current designs with new processes from this project will also be considered. Finally the fundamental characteristics of all the by-products of palm pressed fibres, fine debris and other solid biomass will be analyzed for the economics opportunity. Standard laboratory methods to determine quality, safety, biosafety and compositions of recovered palm mesocarp oils and biomass solids will be developed for benchmarking purposes.

Project 3 focuses on the improvement of palm oil extraction rate through oil recovery from wastes towards achieving zero waste strategy. This will require detailed audit on the oil losses from all sources including pipe lines, processing tanks, other purification steps and storage tanks to provide baseline study of the oil losses from various processing equipment in the mill. Then engineering and management measures will be recommended to reduce the oil loss. Over the past few decades, the average OER performance has not made significant improvements due to many factors and one of them is oil losses through palm oil mill waste materials such as empty fruit bunch (EFB), decanter cake (DC) and palm oil mill effluent (POME). Therefore the main objective of this study is to improve the current state of oil extraction rate by recovering the remaining oil available in the EFB, USB, DC and POME towards achieving zero waste strategy for the sustainability of the palm oil industry. Inefficient threshing process could also result in producing unstripped fruit bunch (USB) which can further reduce the overall OER. It is a normal practice by the mill operators not to recover the remaining oil from the waste materials because there is no proven technology available and the fundamental knowledge on the process is not fully understood. Statistics shown that nearly 70% of the FFB is identified as waste materials such as mesocarp fibers, palm kernel shell, decanter cake and empty fruit bunch. In addition huge amount (up to 50% of FFB processed) of wastewater (i.e POME) is also produced along with these wastes. Many scientific reports have been produced concerning the oil contents in these wastes, however no proper attempt has been made to recover it using green and environmental friendly methods and simultaneously achieving the zero waste strategy. The future of

palm oil industry in Malaysia depends very much on the sustainable issues on three main aspects in the manufacturing of palm oil i.e profitability, environmental protection and social well-being.

This project will involve the economic, social and environmental impacts of new technology developed for the Malaysian palm oil milling industry using the "with" and "without project" approach based on incremental net benefit concept. The "with" project is the proposed new technology while the "without project" is the conventional technology which is being practiced at present. All the costs and benefits including environmental effects of new technology and conventional technology will be identified and estimated based on records or estimated data in this study. The financial costs and benefits as well as the environmental effects will be converted into economic costs and benefits using conversion factor developed by EPU. The non-market valuation technique will be employed to estimate the costs and benefits of environmental effects under the new and conventional technologies. The expected future costs and benefits will be determined based on baseline data obtained in this study and previous records. The economic and feasibility of new technology will be evaluated based incremental net benefit using three investment criteria: net present value (NPV), benefit cost ratio (B/C ratio) and internal rate of return (IRR). Sensitivity analysis will be conducted to determine the effects of changes of market parameters such as price, cost, and interest rate on NPV and IRR. The distribution impact analysis for different groups (consumer, government, and industry) resulting from an introduction of new technology for the Malaysian palm oil industry will be computed to determine the distribution of costs and benefits to these groups. The impacts of new technology on social, safety and health of the workers and society will also be evaluated especially on occupational safety and health aspects. Finally, the economic impact to national income will also be analyzed.

Expected outcomes:

The study will provide solutions/technologies/strategies to improve the existing milling technologies and biomass utilization in order to enhance the oil extraction rate (OER) to 25%.

H. LIST OF PROJECTS
Senarai Projek

No.	Project Title *Tajuk Projek*	Membership *Keahlian*	Field *Bidang*	Institution *Institusi*
1	**STUDIES ON NOVEL AND PRACTICAL AUTOMATED FRUIT GRADING AND OIL QUALITY MONITORING TECHNOLOGY IN PALM OIL MILLS**	**Assoc. Prof. Dr. Nor Azah Yusof (Leader)**	**Chemical and Biosensor**	**UPM**
		Assoc.Prof. Dr. Zulkifly Abbas	Microwave Sensor and Instrumentation	UPM
		Dr. You Kok Yeow	Microwave Sensor and Instrumentation	UTM
		Assoc. Prof. Dr. Mohd. Nizar Hamidon	Microelectronic(sensor technology)	UPM
		Prof. Dr. Md. Jelas Haron	Analytical Polymer	UPM
		Prof. Dr. Musa Ahmad	Chemical and Biosensor	USIM
		Assoc. Prof. Dr.Abdul Rashid Mohamed Shariff	Precision farming, GIS/Remote Sensing	UPM
		Ezrin Mohd Husin	Smart Farming Technologies	

2	**ELUCIDATION OF FUNDAMENTAL PRINCIPLES AND NOVEL STRATEGIES FOR ENHANCING THE STERILIZATION AND OIL EXTRACTION PROCESSES.**	**Prof. Dr. Robiah Yunus (Leader)**	**Palm oil process and product development**	**UPM**
		Assoc. Prof. Dr. Abdul Azis Ariffin	Oil & Fat Technology	UPM
		Dr Zurina Zainal Abidin	Ultrasonic assisted palm oil processes	UPM
		Dr. Dayang Radhiah Awang Biak	Palm oil crystalization	UPM
		Dr Chong Gun Hean	Supercritical Fluid Engineering; Equipment design	UPM
		Dr Anhar Suki	Palm Oil Mill Technology	Asuki Sdn Bhd
		Thang Yin Mee (May)	Chief Scientist	Sime Darby Technology Centre Sdn Bhd
		En Ahmad Jaril Asis	Palm Oil Mill Technology and biofuel	Sime Darby Research Sendirian Berhad
		Dr. Rosnah Shamsuddin	Equipment Design	UPM
		Dr Shanti Faridah Salleh	Process Engineering, Ultrasonication	UNIMAS
No.	**Project Title** *Tajuk Projek*	**Membership** *Keahlian*	**Field** *Bidang*	**Institution** *Institusi*
3	**RECOVERY OF CRUDE PALM OIL FROM EMPTY FRUIT BUNCHES (EFB), UNSTRIPPED BUNCHES (USB), PALM OIL MILL EFFLUENT (POME) AND DECANTER CAKE (DC)**	**Dr. Alawi Sulaiman (Leader)**	**Chemical & Bioprocess Engineering**	**UiTM**
		Dr. Karuppuchammy Subbian	Chemistry	UPM
		Prof. Ku Halim Ku Hamid	Chemical Engineering	UiTM
		Assoc. Prof. Dr. Ayob Md. Som	Chemical Engineering	UiTM
		Dr. Azhari Samsu Baharuddin	Chemical Engineering	UPM
		Dr. Mohd Noriznan Mokhtar	Chemical Engineering	UPM
		Dr Zulkifli Abdul Rahman	Milling and Operation	MPOB
		Zainuri Busu	Mechanical Engineering	FELDA Palm Industries Sdn Bhd.

4	**RECOVERY OF MESOCARP OIL FROM PALM PRESSED FIBRES AND REUSE OF EXTRACTED MESOCARP FIBRES: GREEN EXTRACTION PROCESSES AND FIBRES SIZE REDUCTION PROCESSES TO IMPROVE OER.**	**Assoc.Prof. Mustafa Kamal Abdul Aziz (Leader)**	**Palm oil milling technology**	**UTM**
		Prof Dr Foo Dominic C. Y.	Chemical Engineering environmental Science Energy	Nottingham University, Malaysia campus
		Assoc. Prof. Dr.Noor Azian Morad	Palm Oil Processes	UTM
		Dr. Mohd Azizi Che Yunus	Supercritical Fluid Engineering	UTM
		Mohd Halim Shah Ismail	Separation Processes	UPM
		Dr Mohamad Amran Salleh	Green Technology	UPM
5	**ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACTS OF NEW TECHNOLOGIES IN MALAYSIAN PALM OIL MILLING INDUSTRY**	**Prof. Dr. Awang Noor bin Abd. Ghani (Leader)**	**Forest Resource and Environmental Economics**	**UPM**
		Tan Sri Prof. Datuk Dr. Nik Mustapha R. Abdullah	Fishery Economics	UPM
		Prof. Dr. Ahmad Zubaidi Baharumshah	Econometrics	UPM
		Dr. Alias Radam	Agriculture Economics	UPM
		Assoc. Prof. Dr. Shamsul Bahri Mohd Tamrin	Occupational Safety & Health, Ergonomics	UPM
		Dr. Haslinda Abdullah	Occupation Health Psychology	UPM
		Prof. Dr. Noor Ghani Md. Noor	Economics and Management	UKM
		Assoc. Prof. Dr. Mohd Nazip Suratman	Applied Chemistry	UiTM

I. CONNECTION AMONG PROJECTS IN THE PROGRAM

Hubungkait Projek-Projek Dalam Program

The overall objective of this program is increase the productivity and sustainability of the palm oil milling industry. This can be achieved by improving the oil extraction rate to 25% through fundamental approaches. The program is developed to address the niche area of advanced and value-added manufacturing. Various studies on the use of advanced manufacturing technology in improving oil extraction rate (OER) and reducing oil losses in palm oil mill will be explored. Some of the value-added manufacturing will be applied to improve the added values of biomass and wastes from the mills. This will help to enhance the sustainability of palm oil milling industry. The Malaysian palm oil milling industry is not sustainable in the long term due to high oil losses and inefficient biomass utilization. The program covers all major aspects of palm oil mill technology from FFB grading, sterilization, stripping, digestion, pressing, clarification, purification, and oil recovery from wastes. The connection among projects in the program is shown in Figure 2.. This program begins with Project 1 which focuses on the development of sensor technology for fruit grading and oil monitoring. An accurate determination of the oil content in fresh fruit bunches (FFB) entering the palm oil mill is crucial to set the bench mark for the potential OER that can be achieved. Currently, the quality of FFB at mill gate is checked manually by competent graders of which exposes to human factors. Through this

project various types of sensors will be developed for quick and accurate determination of the quality oil palm fruits. The oil content of the FFB will be used to gauge the maximum potential of crude oil that can be extracted in the subsequent projects. The second part of project 1 will focus on developing sensors for oil quality monitoring based on FFA content in the crude oil. This information will be used by other projects to assess the extent to which new technologies/strategies affect the oil quality (FFA). The crude palm oil (CPO) with FFA less than 2% is called a premium crude and fetch higher price than the normal CPO.

Project 2 encompasses the fundamental principles and novel strategies for enhancing the sterilization and oil extraction processes. After the FFB are being properly graded in Project 1, the fruits is loaded and cooked in a steam sterilizer to stop the degradation of fruits by enzymatic activity as well as to assist in the loosening of fruits from the bunch. The best sterilization condition is one that allows every unripe, under-ripe, ripe and old bunches in the same consignment be equally cooked and all the fruits detached so there is unstripped fruit bunch (USB). Pressure/temperature and fluctuations of these energy inducing factors will have an effect on sterilization efficiency shown by the USB values. The amount of USB in the EFB will affect the outcome of Project 3 of which focus on the recovery of the remaining oil available in the EFB, USB, DC and POME towards achieving zero waste strategy for the sustainability of the palm oil industry. Project 3 includes the determination of oil loss in the empty fruit bunch (EFB) and unstripped bunch (USB) and proposes suitable devices to extract the available oil to improve the overall oil extraction rate (OER). Besides, working on the sterilizer, Project 2 also covers subsequent milling process namely digester and press. The purpose of the digestion is to release the palm oil in the fruit through the rupture or breaking down of the oil-bearing cells. Several studies have indicated that, for plant material, the diffusion of solute into and out of the solid matrix is the rate controlling factor. Hence, the raw material pretreatment prior to the extraction process determines the efficiency of extraction process and subsequently the EOR. Because of the non-oily solids the mixture from the press is very thick (viscous), thus hot water is added to the press output mixture to reduce the viscosity. The mixture is allowed to settle gravitationally in the decanter so that the palm oil, being lighter than water, will separate and rise to the top.

Detailed study on the performance of the existing decanter system and provides opportunities to improve the system and oil recovery from the decanter cake produced of which is also part of the objectives for Project 3. In addition, Project 3 will also study the effectiveness of the existing sludge-pit design and suggests improvement based on mass transfer effect to increase the oil recovery rate from the sludge-pit. This will require detailed audit on the oil losses from all sources including pipe lines, processing tanks, other purification steps and storage tanks to provide baseline study of the oil losses from various processing equipment in the mill. Then engineering and management measures will be recommended to reduce the oil loss. The audit findings will be useful for other projects to identify sources of losses from various processing equipment in the mill.

One of the outputs from Project 2 is the press cake which contains fiber (mesocarp), broken palm kernel and whole palm kernel. Because of the presence of kernel within the fruits, optimum pressing conditions are vital to prevent the kernel from being broken and at the same time maximizing the oil being pressed out from the mesocarp fiber. The challenge is for Project 2 to produce fruits of consistent shape by keeping the intrinsic water in the fruits intact, thus keeping the pressing condition at optimum. In general, there is about 5% of oil remained in the fiber. The press cake will be the raw material for Project 4. Thus. Project 4 focuses on the recovery of mesocarp oil from palm pressed fibres and potential reuse of extracted mesocarp fibres. The main focus will be on green extraction processes and fibres size reduction processes to improve OER The project will also assess the potential of developing new by-products of mesocarp oil & solids. Integration into mills to ascertain operating variations of palm mesocarp quality on extraction and separation processes will also be conducted. Standard laboratory methods to determine quality, safety, biosafety and compositions of recovered palm mesocarp oils and biomass solids will be developed for benchmarking purposes. Finally, the potential of process integration of the entire mill will also be assessed. This will require inputs from projects 1, 2, 3 and 4 to enable the integration to take place.

	The competitiveness of the industry depends on economics advantage, productivity and the supply chain of the overall milling industry. Project 5 will focus on evaluating the social, economic and financial feasibility of the new technologies in Malaysian palm oil milling industry. It begins with determining the physical impacts of new technology developed on the environment and human followed by iidentification of costs and benefits including the environmental effects of new technology as compared to the conventional technology. The improvement in oil recovery from all projects namely Project 2, Project 3 and Project 4 will be used by Project 5 to evaluate the overall economic viability of the project. Evaluating the impacts of new technology on social, safety and health of the workers and society will be paramount to the success of the program. The environmental impacts of new milling technology will be studied in terms of willingness to pay for improved environmental quality and internalizing the cost by the industry with new milling technology. All of the hazards that show from the stress level are an indicator on the psychosocial impact on the workers. The information from the SOP of all processing equipment in the mill will be used to assess the occupational and hazards to workers. To ensure the program is relevant and in line with the needs of the industry and stakeholders, the projects will involve field work at commercial palm oil mills. Hence, close collaboration with the major players of the palm oil milling industry namely Palm oil mills such as Sime Darby and FELDA as well as Malaysian Palm Oil Board (MPOB) and other research institutions will be fostered.
J.	**SUMMARY OF BUDGET BY PROJECT** *Ringkasan Belanjawan Program Mengikut Projek* ***(Sila lihat lampiran)***

K. **Declaration by applicant /** *Akuan Pemohon*
(Please tick ***(√)*****): /** *(Sila tanda (√)):*

I hereby declare that:
Saya dengan ini mengaku bahawa:

☑ **1. All information stated here are accurate, KPT and IPT has right to reject or to cancel the offer without prior notice if there is any inaccurate information given.**
Semua maklumat yang diisi adalah benar, KPT dan IPT berhak menolak permohonan atau membatalkan tawaran pada bila-bila masa sekiranya keterangan yang dikemukakan adalah tidak benar.

☑ ***2.*** **Application of this fundamental research is presented for the Long Term Research Grant Scheme (LRGS).**
Permohonan projek penyelidikan ini dikemukakan untuk memohon peruntukan di bawah Geran Penyelidikan Jangka Panjang IPT.

☐ ***3.*** **Application of this fundamental research is also presented for the other reasearch grant/s (grant's name and total amount)**
*Permohonan projek penyelidikan ini juga dikemukakan untuk memohon peruntukan geran penyelidikan dari (nama geran dan jumlah dana)*_____

Date :
Tarikh :

Applicant's Signature :
Tandatangan Pemohon :

L.	**Recommended by Vice Chancellor/Deputy Vice Chancellor (Research and Innovation)/Director of Research Management Center** *Perakuan Naib Canselor/Timbalan Naib Canselor(P & I)/Pengarah Pusat Pengurusan Penyelidikan*

Please tick (√)
Sila tandakan (√)

Recommended:
Diperakukan:

☐ ***A.*** **Highly Recommended**
Sangat Disokong

☐ **B.** **Recommended**
Disokong

☐ **C.** **Not Recommended (Please specify reason)**
Tidak Disokong (Sila Nyatakan Sebab)

Comments:
Ulasan:

Excellent program with the potential of contributing at least RM12 billion to GNI (gross national income) annually. The output of this research is essential in addressing one of the NKEA areas of the National Transformation Plan ----------

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Name: **Signature:**
Nama: *Tandatangan:*

Date:
Tarikh:

Note: APPLICATIONS SUBMITTED WILL BE TREATED IN FULL CONFIDENCE. THE DECISION OF THE LONG TERM RESEARCH GRANT SCHEME MAIN COMMITTEE MOHE IS FINAL.
Semua permohonan dianggap sulit. Keputusan Jawatankuasa Induk Skim Geran Penyelidikan Jangka Panjang KPT adalah **MUKTAMAD.**

Figure 1: Overall research methodology

Figure 2: Interconnection between projects