



# 现代农业与 生物质能源研究

Research on Agriculture and Bioenergy





#1. 课程背景及简介



农业和能源在很大程度上息息相关，一般来说，3-10卡路里的能量可以生产1卡路里的食物，这是因为矿物肥料和农用化学品的生产、作物种植和收割机械的使用、食品的运输和储存都需要能源来提供能量（主要是化石燃料）。根据联合国粮农组织的说法，到2050年前，全球粮食生产应在目前的基础上增加70%才能满足人口增长的需求，由于粮食与能源安全的密切关系，人们需要大量的能源为农业生产提供动力。为解决这一问题，可再生能源则提供了一个很好的选择，其中大多数提供电力的清洁能源（例如太阳能、风能、潮汐能等），均是可再生能源，这为解决能源安全问题提供了思路。

随着我们迈向以生物为基础的经济，来自能源作物的生物燃料似乎是另一个不错的选择。然而，第一代生物燃料作物，如油棕、甘蔗、玉米和大豆，给用于粮食生产的耕地带来了额外的压力，对生物多样性景观构成了直接威胁。目前，种植油棕、甘蔗和大豆可用于生产生物柴油和生物乙醇，但大面积的热带雨林却也因此遭到破坏，所以我们迫切需要开发更加可持续的生物质能源。

通过厌氧消化利用农业废弃物生产沼气是一个不错的选择，但是其资源有限，难以发展规模。来自非粮食作物的第二代生物燃料，例如微藻，以及来自木材和农业废料（木质纤维素）的第三代生物燃料，提供了一个最佳的选择。然而，第二代和第三代生物燃料的生产成本仍需进一步降低，但该领域的最新研究看起来非常有希望，且研究表明这可以在几年内实现。因此，农业和生物质能源的关系是一个新兴领域，可能在不久的将来提供许多就业机会，因为我们必须向可持续的粮食和燃料生产过渡。我们有责任使这一过渡尽可能顺利，以实现今世后代的粮食和能源安全。

在本课题的学习中，教授将概述农业和生物质能源的最新发展，回顾当前在新兴生物经济中生产食品、饲料、纤维、生物材料和生物燃料的农业实践，并介绍有关可持续农业发展解决方案的最新研究，以解决粮食和能源安全问题。本课程将有助于获得对最先进的食品和生物质能源生产概念、模型和技术的折衷理解的机会，并将概述这些领域的最新研究。本课程将让同学们熟悉作物和生物质能源生产技术的广泛领域以及新兴趋势，这些趋势为农业和能源部门提供了向更可持续的食品和生物质能源生产迈进的机会。通过理论和实际应用来提升学生在农业和生物质能源概念方面的知识和技能，包括解决现实世界的问题、形成和检验新假设，以及制定可持续食品和生物质能源生产的新战略。

#2. 学习目标



本课程将解决许多挑战，如：

- ★ 学习如何评估当前粮食和生物质能源作物农业实践的环境足迹和可持续性
- ★ 了解新兴的生物燃料作物及可持续的农业实践技术

- ★ 探索如何解决粮食和能源安全问题，促进可持续农业和生物质能源产业的发展
- ★ 学习如何与企业、非政府组织和研究机构合作，实现食品和生物质能源的可持续发展

#3.任课教师信息



Prof. P S

教授就职于昆士兰大学农业与食品科学学院，担任藻类生物技术实验室主任，CRC 糖类生物技术创新组织主任，同时也是农业和食品创新联盟成员及作物科学中心成员。在抗病植物、商业油菜品种、大规模、低成本的藻类培养和收获技术，以及可去除危险的微生物和油污的过滤系统等研究领域颇有建树，其研究共获得了 7 项专利技术、协助成立了两家初创公司。

#4.课程设置



| 周期                     | 时间             | 课程设置内容   | 课时 |
|------------------------|----------------|--|----|
| 第一周<br>学习指南<br>教授及助教辅导 | 1 月 28 日<br>周六 | 什么是 PBL 教学方法   | 1  |
|                        |                | PBL 教学的常见形式  | 1  |
|                        | 1 月 29 日<br>周日 | 教授课-1<br>交叉学科PBL 课程设计及知识点学习<br>学习目标：了解当前的农业和生物质能源生产系统<br>描述：介绍基本的农业、粮食生产和生物质能源发电术语。    | 3  |
|                        | 1 月 30 日<br>周一 | 助教课-1<br>知识点查漏补缺   | 2  |
|                        | 1 月 31 日<br>周二 | 教授课-2<br>制定个人项目方向<br>学习目标：农业和生物质能源中的新兴技术<br>描述：介绍现代和传统粮食和生物质能源作物生产系统中使用的技术的战略知识和价值。深入了 | 3  |





|                        |            |  |     |
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|                        |            | 解当前的食品、饲料、生物材料和生物燃料生产系统如何解决粮食和能源安全问题。  |     |
| 第二周<br>教授及助教辅导         | 2月1日<br>周三 | 助教课-2<br>知识点查漏补缺   | 2   |
|                        | 2月2日<br>周四 | 教授课-3<br>交叉学科课程知识点学习<br>学习目标：农业和生物质能源的最新研究和案例研究<br>描述：介绍食品、饲料、生物材料和生物燃料生产系统的最新研究和趋势。以真实案例解锁农业和生物质能源行业的发展情况。  | 3   |
|                        | 2月3日<br>周五 | 助教课-3<br>知识点查漏补缺&<br>跟进个人项目调研进度  | 2   |
|                        | 2月4日<br>周六 | 教授课-4<br>互动与项目设计跟进答疑   | 1.5 |
|                        | 2月6日<br>周一 | 助教课-4<br>跟进个人项目调研进度  | 2   |
|                        | 2月7日<br>周二 | 教授课-5<br>交叉学科课程知识点学习<br>学习目标：应用研究方法、生命周期和社会技术经济分析<br>学习评估当前和新兴食品和生物燃料生产系统可持续性的方法。<br>了解用于开发新作物和生物质能源生产系统并评估其经济、环境和社会可持续性的研究方法。                       | 2   |
|                        |            |  |     |
| 第三周<br>教授及助教辅导<br>未来展望 | 2月8日<br>周三 | 助教课-5<br>跟进个人项目调研进度  | 2   |
|                        | 2月9日<br>周四 | 教授课-6<br>交叉学科课程知识点学习<br>学习目标：农业和生物质能源的转化研究和商业模式<br>描述：从当前的农业和生物质能源研究中获得新想法和创新技术，学习数据驱动决策的管理策略。认识和分析农业和生物质能源的未来趋势及其对组织、环境和社会的影响。培养在农业或生物质能源领域成立创新型初创公 | 2   |

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|-----|-------------|---------------------------------|--------|
|     |             | 司的基本技能，包括提出创新想法和筹集资金的能力。        |        |
|     | 2月10日<br>周五 | 助教课-6<br>知识点查漏补缺&<br>指导个人项目成果展示 | 2      |
|     | 2月11日<br>周六 | 教授课-7<br>教授点评个人项目成果             | 1.5    |
|     | 2月12日<br>周日 | 升学与就业方向展望<br>个人规划及发展建议          | 1<br>1 |
| 总课时 | 32          |                                 |        |

#5. 阅读材料



- ★ Sustainable Development Goal
- ★ The State of Food Security and Nutrition in the World 2021 | FAO.
- ★ Garcia, S.N., Osburn, B.I. and Jay-Russell, M.T., 2020. One health for food safety, food security, and sustainable food production. Frontiers in Sustainable Food Systems, 4, p.1.
- ★ Prospects of bioenergy cropping systems for a more social-ecologically sound bioeconomy. Agronomy, 9(10), 605.
- ★ Hanssen, S. V., Daioglou, V., Steinmann, Z. J. N., Doelman, J. C., Van Vuuren, D. P., & Huijbregts, M. A. J. 2020. The climate change mitigation potential of bioenergy with carbon capture and storage. Nature Climate Change, 10(11), 1023-1029.

#6. 项目主题



本课程使用 PBL 教学法，PBL 即项目式学习，是一种以学生为中心的教学方法，教师提供关键素材构建学习环境，学生通过在此环境里解决一个开放式项目的经历来学习。以下为本课程可选的项目主题：

- 制定可持续蛋白质供应战略
- 确定研究差距并提出粮食安全解决方案
- 确定研究差距并提出生物燃料生产的解决方案
- 评估生物燃料作物的经济、环境和社会方面
- 为可持续食品或生物质能源生产设计一家初创公司

英文版教学大纲



|                    |   |
|--------------------|---|
| Course Title       | Research on Agriculture and Bioenergy   |
| Credit Hours       | 32 (one credit hour is 45 minutes)  |
| Course Objectives  | <p>This class will address many challenges such as:</p> <ol style="list-style-type: none"><li>1. How to assess the environmental footprint and sustainability of current agricultural practices for food and bioenergy crops?</li><li>2. What are emerging biofuel crops and what are Sustainable Agricultural Practices?</li><li>3. How to address Food and Energy Security? How to mediate the growth of the Sustainable Agriculture and Bioenergy industry?</li><li>4. How to work with companies, NGOs and research organization to achieve sustainable development for food and bioenergy?</li></ol>   |
| Course Description | <p>This research-oriented science course will discuss some of the most important topics in agriculture and bioenergy, covering both theoretical aspects and hands-on projects. This class will facilitate the opportunity for gaining an eclectic understanding of the state-of-the-art food and bioenergy production concepts, models, and techniques and will provide an overview of the latest research in these areas. This class will familiarize you with a broad cross-section of crop and bioenergy production technologies and emerging trends that offer opportunities for the agricultural and energy sectors to move towards more sustainable food and bioenergy production. The course will prepare you not just with knowledge in</p> |

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|  | <p>agriculture and bioenergy, but also with skills for real world problem scenarios and the latest research technologies.</p> <p>In this program that lasts for 10-hour online sessions (5 Modules) with 2-hour Q&amp;A session, you will be able to upgrade your knowledge and skills in agriculture and bioenergy concepts by learning the theory and practical application of supervised and unsupervised learning, including solving real-world problems, forming and testing new hypotheses, and developing new strategies towards sustainable food and bioenergy production.</p> |
|--|--|

Course Background

Agriculture and Energy are closely linked. We currently require 3-10 calories of energy to produce just 1 calorie of food. This is because energy (mostly derived from fossil fuels) is required for the production of mineral fertilizers and agrochemicals, use of machinery for crop cultivation and harvesting, transportation and storage of food. Hence Food Security and Energy Security are of equal concern as we are required to produce 60% more food until 2050 according to FAO. Renewable energy sources provide a good option. However, most of these provide electricity (e.g. solar, wind, tidal, etc), rather than fuel, but liquid and gaseous fuels (diesel, petrol, jetfuel, methane gas) will still be needed in the distant future for transportation, in particular for the aviation industry. This is because the energy density of fuel is about 20 times denser (lighter weight) than current battery energy storage technology.

As we move towards a bio-based economy, biofuels from energy crops appear like a good option. However, First Generation Biofuel crops, such as oil palms, sugarcane, maize and soybean, put additional pressures on arable land used for food production and/or provide a direct threat towards biodiverse landscapes. At present, large areas of rainforest are destroyed to grow oil palm, sugarcane and soybean for biodiesel and bioethanol. Hence, there is a strong need towards the development of more sustainable bioenergy sources. The production of biogas from agricultural wastes via anaerobic digestion provides a good option, but resources are limited. Second Generation Biofuels from non-food crops, such as microalgae or Pongamia and Third Generation

Biofuels from timber and agricultural wastes (ligno-cellulosics), provide a good option. However, production costs for second and third generation biofuels still need to be further reduced, but the latest research in this area looks extremely promising and shows that this can be achieved within a few years. Hence, the nexus of Agriculture and Bioenergy is an emerging area that is likely to provide many jobs in the near future as we must transition towards sustainable food and fuel production. It is up to us to make this transition as smooth as possible to achieve Food and Energy Security for now and future generations.

Introduction of the course

In this 12-hour class, Professor Peer Schenk will provide an overview of the latest developments in Agriculture and Bioenergy. The course will review current agricultural practices to produce food, feed, fiber, biomaterial and biofuels in the emerging bioeconomy and introduce the latest research on Sustainable Agricultural development solutions to address Food and Energy Security.

This course comprises 10 lectures and 2 live lectures, as well as Project-Based-Learning (PBL) modules in which students learn by actively engaging in real-world and personally meaningful projects. It is primarily designed to develop business leaders, technology innovators and scientists who will be equipped with the skills and cutting-edge knowledge in Agriculture and Bioenergy. The important areas of Food Security and Energy Security are considered essential for the next decades with many expected employment opportunities. Project Based Learning (PBL) is a teaching method.

|                 |   |
|-----------------|---|
|                 | <b>Topics</b>   |
| <b>Module 1</b> | <u><b>Current Agriculture and Bioenergy Production Systems</b></u><br>Description:<br>Introduction of basic agriculture, food production and bioenergy generation terminology terminology   |
| <b>Module 2</b> | <u><b>Emerging Technologies in Agriculture and Bioenergy</b></u><br>Description:<br>Technology used in modern and traditional food and bioenergy crop production systems.<br>How current food, feed, biomaterial and biofuel production systems can address Food and Energy Security. |
| <b>Module 3</b> | <u><b>Latest Research and Case Studies in Agriculture and</b></u>   |



|          |  |
|----------|--|
|          | <p><b><u>Bioenergy</u></b></p> <p>Description:</p> <p>The latest research and trends in food, feed, biomaterial and biofuel production systems.</p> <p>Real-world cases across the agricultural and bioenergy industries.</p>  |
| Module 4 | <p><b><u>Applied Research Methodology, Life Cycle and Socio-Technoeconomic Analyses</u></b></p> <p>Description:</p> <p>Evaluating sustainability of current and emerging food and biofuel production systems.</p> <p>Learning research methodology used to develop new crop and bioenergy production systems and to evaluate their economic, environmental and social sustainability.</p>  |
| Module 5 | <p><b><u>Translational Research and Business Models in Agriculture and Bioenergy</u></b></p> <p>Description:</p> <p>Building an industry-ready portfolio of projects to demonstrate your ability to extract new insights</p> <p>How to develop new ideas and innovative technology from current research in agriculture and bioenergy with a managerial overview of data driven decision making.</p> <p>Analyzing future trends in agriculture and bioenergy and their impact on organizations, the environment and society.</p> <p>To develop basic skills for the formation of an innovative start-up company in agriculture or bioenergy, including the ability to present innovative ideas and to raise funding.</p> |

Required Readings

- ★ Sustainable Development Goal
- ★ The State of Food Security and Nutrition in the World 2021 | FAO.
- ★ Garcia, S.N., Osburn, B.I. and Jay-Russell, M.T., 2020. One health for food safety, food security, and sustainable food production. Frontiers in Sustainable Food Systems, 4, p.1.
- ★ Prospects of bioenergy cropping systems for a more social-ecologically sound bioeconomy. Agronomy, 9(10), 605.
- ★ Hanssen, S. V., Daioglou, V., Steinmann, Z. J. N., Doelman, J. C., Van Vuuren, D. P., & Huijbregts, M. A. J. 2020. The climate change mitigation potential of bioenergy with carbon capture and storage. Nature Climate Change, 10(11), 1023-1029.

**Suggested list of the topics for the final project**

1. Develop a strategy for sustainable protein supply
2. Identify research gaps and propose solutions for food security
3. Identify research gaps and propose solutions for biofuel production
4. Evaluate economical, environmental and social aspects of a biofuel crop
5. Design a start-up company for sustainable food or bioenergy production

**Class Expectation**

This class will apply a project-based learning (PBL) approach and encourages the practical and strategic application of various tools and methods to solve complex applied research problems. After completing this class, you will acquire the following skills:

- Ability to find and access latest research data in agriculture and bioenergy
- Research design to form and test hypotheses in agriculture and bioenergy
- Mining and interpretation of research data
- Conceptualization of research trends
- Formation of ideas and creative thinking
- Critical thinking and problem-solving
- Team building and communication
- Life cycle analyses and techno-economic analyses
- Business and Sustainability Intelligence
- Conceptual ability for start-up business formation in agriculture and bioenergy

You will complete a project that uses the core skills and concepts learned from this course. The project combines the technical, analytical, interpretive, economic, environmental and social concepts required to design and execute a full project in applied research in agriculture and bioenergy. You will learn essential skills that prepare you for long-term professional success in industry and academia in agriculture and bioenergy.