



Caribbean Community Climate Change Centre

MODULES' REFERENCE BOOK

BIOENERGY COURSE

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Caribbean Community Climate Change Centre

Content

Module Number M01 – Introduction to Energy and Bioenergy	3
Module Number M02 – Introduction to Bioenergy and Sustainability	4
Module Number M03 – Bioenergy Feedstock	5
Module Number M04 – Biogas	6
Module Number M05 – Biogas Technology and Design	7
Module Number M06 – Biogas Project Development	8
Module Number M07 – Solid Biofuels	9
Module Number M08 – Liquid Biofuels	10
Module Number M09 – Greenhouse Gas Basics (GHG Basic)	11
Module Number M10 – Economic Indicators	12
Literature List	13



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Module Number M01 – Introduction to Energy and Bioenergy

Module Title	Introduction to Energy and Bioenergy
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the understanding of energy and bioenergy technologies, system design and applications and gives an overview of concepts. It enables students to appreciate the performance of technologies and sharpens ability to communicate effectively and knowledgably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Overview Bioenergy• Basics of energy• Solid biomass• Liquid biofuels• Biogas
Study Material, Literature	Please check literature list at the end of this manual.
Comments	3/5 Bioenergy, 2/5 energy



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Module Number M02 – Introduction to Bioenergy and Sustainability

Module Title	Introduction to Bioenergy and Sustainability
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the understanding of bioenergy and sustainability and gives an overview of related social and environmental aspects. It enables students to appreciate the performance of these and sharpens ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Environmental sustainability of bioenergy• Social pros and cons of biofuel production (Food vs. Fuel)
Study Material, Literature	Please check literature list at the end of this manual.
Comments	3/5 Bioenergy, 2/5 Sustainability



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Module Number M03 – Bioenergy Feedstock

Module Title	Bioenergy Feedstock
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the understanding of bioenergy feedstocks and gives an overview of related wood crops and biomass residues. It enables students to know about the energetic performance of these crops and sharpens ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Forestal and agricultural produced wood and residues• Ligno-cellulosic crop species and their residues• Sugar and starch crops and their residues• Sustainability and various environmental aspects of the energy crop production
Study Material, Literature	Please check literature list at the end of this manual.
Comments	4/5 Bioenergy feedstock 1/5 Practical



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Module Number M04 – Biogas

Module Title	Biogas
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module enables the deeper understanding of Biogas Systems and gives an overview of related processes. It enables students to know about the Biogas processes and different systems, the performance of these systems and sharpens ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• The anaerobic digestion process & Characteristics of biogas• Biogas process & Biogas production• Digestors & Digestate• Agricultural plants, Industrial plants, Household plants• Utilization of biogas• Cogeneration• Cooling
Study Material, Literature	Please check literature list at the end of this manual.
Comments	5/5 Biogas



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Module Number M05 – Biogas Technology and Design

Module Title	Biogas Technology and Design
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the deeper understanding of Biogas Systems and gives an overview of related processes and how to design a specific system. It enables students to know about the different design of systems, the performance of these systems and sharpens ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Biogas plant components• Conditioning and pretreatment of substrates• Substrate input technology• Mixing devices• Pumps• Measurement and control systems
Study Material, Literature	Please check literature list at the end of this manual.
Comments	5/5 Biogas Technology and Design



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Module Number M06 – Biogas Project Development

Module Title	Biogas Project Development
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the deeper understanding of how to develop Biogas Systems and gives an overview of related economic processes. It enables students to know about feasibilities and key financial terms of these systems and sharpens ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Economics• Costs and revenues• Economic analysis• Financing and sensitivities• Financial parameters• Analysis of project risks
Study Material, Literature	Please check literature list at the end of this manual.
Comments	4/5 Bioenergy feedstock 1/5 Practical



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Module Number M07 – Solid Biofuels

Module Title	Solid Biofuels
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the deeper understanding of Solid Biofuels and gives an overview of related processes. It enables students to know about the processes and different systems, the performance of these fuels and sharpens the ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Energy relevant characteristics of solid biofuels• Heating values & Advanced fuel products• Thermochemical basics• Furnaces & Gasifiers• Heat-to-power conversion• Economy & Ecology of solid biofuels
Study Material, Literature	Please check literature list at the end of this manual.
Comments	4/5 Solid Biofuels 1/5 Practical



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Module Number M08 – Liquid Biofuels

Module Title	Liquid Biofuels
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the deeper understanding of Liquid Biofuels and gives an overview of related applications. It enables students to know about the processes and different systems, the performance of these fuels and sharpens the ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Vegetable oils• Biodiesel• Bioethanol• Advanced biofuels• Economy and ecology
Study Material, Literature	Please check literature list at the end of this manual.
Comments	5/5 Liquid Biofuels



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Module Number M09 – Greenhouse Gas Basics (GHG Basic)

Module Title	GHG Basic
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the understanding of GHG emissions and gives an overview on how GHG evolve. It enables students to know about climate change and the impacts of GHG to our ecology. They will strengthen their ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Evolution of temperature and CO₂ in air• Prediction and impacts of climate change• Relevant greenhouse gases (GHG)• Calculation and data of CO₂ emission
Study Material, Literature	Please check literature list at the end of this manual.
Comments	5/5 GHG Basic



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Module Number M10 – Economic Indicators

Module Title	Economic Indicators
Credits	To be determined by teaching institution
Module Aims, Trained Competencies	The module supports the understanding of economic indicators of energy projects and gives an overview on how to design projects feasible. It enables students to know about financial terms and also calculation software which will also strengthen their ability to communicate effectively and knowledgeably with relevant stakeholders.
Prerequisites	None
Level	First semester
Study Type	Campus and Online
Status	Compulsory / Non Compulsory (To be determined by teaching institution)
Frequency	(To be determined by teaching institution)
Assessment Type	Group Assignment / Exam / Online Exam (To be determined by teaching institution)
Assessment Criteria	Assessment criteria are communicated at the beginning of the module.
Content	<ul style="list-style-type: none">• Introduction to economic indicators• Introduction to financial indicators Required average electricity selling price for a given IRR and determining LCoE• Influences on the IRR with varying financial parameters• Introduction to RETScreen
Study Material, Literature	Please check literature list at the end of this manual.
Comments	3/5 Economic Indicators 2/5 Software



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Literature List

Author: Ayhan Demirbas

Title: **Biofuels**

ISBN: 978-1-84882-010-4

Page number: 336, Publisher: Springer-Publisher GmbH, 2009

Author: David M Mousdale

Title: **Introduction to Biofuels**

ISBN: 9781439812075

Publisher: Boca Raton, 2010

Author: Deublein, D.; Steinhauser, A.

Title: **Biogas from Waste and Renewable Resources: An Introduction**

ISBN: 978-3-527-32798-0

Page number: 578, Publisher: Wiley-VCH, 2010

Author: Peter, L.

Title: **Thermochemical conversion of biomass to liquid fuels and chemicals.**

ISBN: 978-1849730358

Page number: 437, Publisher: Royal Society of Chemistry, Cambridge; UK, 2010

Author: Nijaguna, B.T.

Title: **Biogas Technology**

ISBN: 978-81-224-1380-9

Page number: 300, Publisher: New Age, India, 2010

Author: Insam, h.; Franke-Whittle, I.; Goberna M.

Title: **Microbes at work**

ISBN: 978-3-642-04042-9

Page number: 329, Publisher: Springer Science, 2010

Author: **Kasthurirangan Gopalakrishnan**

Title: Sustainable Bioenergy and Bioproducts

ISBN: 9781447123231 (old: 1447123239)

Page number: 228, Publisher: Springer-Publisher GmbH, 2011



Caribbean Community Climate Change Centre

Author: Panagiotis Grammelis

Title: **Solid Biofuels for Energy**

ISBN: 9781849963923

Page number: 242, Publisher: Springer-Publisher GmbH, 2011

Author: Mudhoo, A.

Title: **Biogas Production – Pretreatment methods in anaerobic digestion**

ISBN: 978-1-118-06285-2

Page number: 320, Publisher: Scrivener Publishing LLC, 2012

Author: Abbasi, T.; Tauseef, S.M.; Abbasi, S.A.

Title: **Biogas Energy**

ISBN: 978-1-4614-1039-3

Page number: 169, Publisher: Springer Science, 2012

Authors: Komlajeva, L.; Adamovics, A.; Poisa, L.

Title: **Comparison of different energy crops for solid fuel production in Latvia.**

ISBN: 978-9984-48-070-1

Page number: 45-50

Published in: 2012

Author: Feng-Wu Bai

Title: **Biotechnology in China III: Biofuels and Bioenergy**

ISBN: 9783642284779 (früher: 3642284779)

Page number: 228, Publisher: Springer-Publisher GmbH, 2012

Authors: Kole, C.; Joshi, C. P.; Shonnard, D. R.

Title: **Handbook of bioenergy crop plants.**

ISBN: 978-1439816844

Page number: xxix + 824, Publisher: CRC Press Inc., London; UK, 2012

Author: FNR/GIZ

Title: **Guide to Biogas – From production to use**

Page number: 232, Publisher: FNR, 2012

Download at: <https://mediathek.fnr.de/broschuren/fremdsprachige-publikationen/english-books/guide-to-biogas-from-production-to-use.html>



Caribbean Community Climate Change Centre

Author: Maureen McCann

Title: **Plants and BioEnergy**

ISBN: 9781461493280

Page number: 289, Publisher: Springer-Publisher GmbH, 2013

Authors: Sunggyu Lee; Yatish T Shah

Title: **Biofuels and bioenergy : processes and technologies**

ISBN: 9781420089554

Publisher: Boca Raton, FL : Taylor & Francis, 2013

Author: Wellinger, A.; Murphy, J.P.; Baxter, D.

Title: **The Biogas Handbook – Science, Production and Application**

ISBN: 978-0-85709-498-8

Page number: 476, Publisher: Woodhead Publishing Limited, 2013

Authors: Prochnow, A.; Heiermann, M.; Plochl, M.

Title: **Permanent grasslands for bioenergy: factors affecting management and conversion efficiency.**

ISBN: 978-9979-881-20-9

Page number: 514-521

Published in: 2013

Author: Antonio Domingos Padula

Title: **Liquid Biofuels: Emergence, Development and Prospects**

ISBN: 9781447164814

Page number: 272, Publisher: Springer-Publisher GmbH, 2014

Authors: Silva, S. S. da; Chandel, A. K

Title: **Biofuels in Brazil: fundamental aspects, recent developments, and future perspectives.**

ISBN: 978-3-319-05019-5

Page number: 435, Publisher: Springer, Basel; Switzerland, 2014

Authors: Goldman, S. L.; Kole, C.

Title: **Compendium of bioenergy plants: corn.**

Page number: 398, Publisher: CRC Press Inc., Boca Raton; USA, 2014



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Authors: Langeveld, H.; Dixon, J.; Keulen, H. van
Title: **Biofuel cropping systems: carbon, land and food.**
ISBN: 978-0-415-53953-1
Publisher: Routledge, Abingdon; UK, 2014

Author: Nasib Qureshi
Title: **Biorefineries: Integrated Biochemical Processes for Liquid Biofuels**
ISBN : 9780444594983
Publisher: Elsevier Science Ltd, 2014

Editors: Eksioglu, Sandra D., Rebennack, Steffen, Pardalos, Panos (Eds.)
Title: **Handbook of Bioenergy : Bioenergy Supply Chain - Models and Applications**
ISBN: 978-3-319-20091-0
Publisher: New York Springer, 2015

Editor: Thrän, Daniela (Ed.)
Title: Smart Bioenergy : **Technologies and concepts for a more flexible bioenergy provision in future energy systems**
ISBN: 978-3-319-16192-1
Publisher: New York Springer, 2015

Authors: Shibu Jose; Thallada Bhaskar
Title: **Biomass and biofuels: advanced biorefineries for sustainable production and distribution.**
ISBN: 978-1-466-59531-6
Page number: 392, Publisher: CRC Press Inc., London; UK, 2015

Author: Robbie Larkin
Title: **Encyclopedia of alternative and renewable energy : liquid biofuels.**
ISBN: 9781632391889
Publisher: Callisto Reference, 2015

Author: Various
Title: **Solid biofuels: terminology, definitions and descriptions (ISO 16559:2014).**
Publisher: London : BSI Standards Limited, 2014

Authors: Ravindra Pogaku; Rosalam Hj Sarbatly
Title: **Advances in biofuels**
ISBN: 9781489986344
Publisher: New York Springer, 2015



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Author: Bhardwaj, Ajay Kumar

Title: **Sustainable biofuels : an ecological assessment of future energy**

ISBN: 9783110275841

Published in: 2015

Author: Anju Dahiya

Title: **Bioenergy - Biomass to Biofuels**

ISBN: 9780124079090 (früher: 0124079091)

Page number: 630, Publisher: Academic Press, 2015

Author: Carrie Eckert

Title: **Biotechnology for Biofuel Production and Optimization**

ISBN-13: 978-0444634757

Page number: 572, Publisher: Elsevier, 2016