Course

Biobased Logistics

Course code	ORL-51306
Period	6
Contact person	Dr. A. (Argyris) Kanellopoulos (ORL)
Lecturers/ Examiners	Prof. Dr. J.M. (Jacqueline) Bloemhof (ORL) Dr. ir. G.D.H. (Frits) Claassen (ORL) Dr. A. (Argyris) Kanellopoulos (ORL)
Language of instruction	English
Assumed prerequisite knowledge	Biobased economy (BCH-51306)
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Profile of the course

Biobased Logistics (BBL) is a disciplinary course in the field of Operations Research and Management. The course aims to provide a good understanding of the biobased supply chain focusing on decision problems related to the logistical structure of the chain as a whole. The students are trained to recognise problems, conceptualise solutions and develop quantitative models to support decision making in the biobased supply chain.

The main managerial topics which are discussed are:

- Network design and geographical allocation of processing steps: we discuss decisions related to where to produce, how to transport and where to process main biobased products and byproducts to maintain a sustainable production.
- Assessment of sustainability: techniques and indicators that have been used to quantify the sustainability performance of the chain as a whole taking into account all three dimensions of sustainability (i.e. planet, people, profit) are discussed.
- Closing loops in the biobased supply chain: possibilities and ways to close nutrient cycles and minimize inflows to the chain are explored.

The largest part of the course focuses on training students on Mixed Integer Linear Programming techniques that are used to solve problems in the biobased supply chain. We start by providing an overview of existing methods used in Operations Research to optimize decision-making in supply chains. MILP techniques that are useful to address questions of the biobased supply chain are introduced with lectures and small scale exercises adapted to the biobased supply chain context. We use computer practicals throughout the course to apply acquired knowledge and solve real life problems in the bio-refining sugar supply chain. The students have the opportunity to work intensively with cutting edge optimization software that is commonly used in the field of Operations Research.

Learning outcomes:

After successful completion of this course, students are expected to be able to:

1. recognise situations where typical decision problems occur in biobased supply chains;
2. understand important concepts of biobased logistics and mathematical programming;
3. Translate presented decision problems of the biobased supply chain into mathematical models;
4. develop implementations of mathematical models with state of theart, design-oriented optimization software;
5. solve implementations of mathematical models
6. interprete outcomes of mathematical models to support managerial decision-making in the biobased supply chain;
7. Design blueprints of alternative logistical structures of the biobased supply chain.

Learning materials and resources:

Studying material and course notes will be provided digitally through Blackboard.

Educational activities: The programme consists of a combination of five different work forms: (i) lectures, (ii) tutorials, (iii) computer practicals, (iv) article review and (v) self-study, in which a variety of relevant concepts and models are addressed.

- *Lectures*
  The lecture sessions focus on teaching supply chain concepts and introduce theory of mathematical programming. Guest speakers are invited to share their experiences on problems and examples related to the biobased supply chain.

- *Supervised tutorial*
  The tutorials give ample opportunity to practice modelling skills using examples on the biobased supply chain.

- *Computer practicals.*
  In practicals, students work with optimization software to model and solve relevant problems for the biobased supply chain. The practicals are built around a central case-study on the supply chain of sugar beet biorefining.

- *Reviewing an article*
  Students get experience with reading and commenting an article published in highly ranked scientific journals in the field of biobased logistics. Students are asked to read, comment and present (shortly) one relevant article.

- *Self study*
  The total number of contact hours comprises only a part of the 6 credits. Experience has taught that keeping up with the subjects and studying during the lecture period is much more effective and efficient than a great study effort shortly before the exam.

Assessment strategy (Examination):

The final grade is based on:

1) a written exam (70%), which tests the knowledge on supply chain concepts and optimization techniques (mathematics). It is a closed book exam – you are recommended to bring your calculator (no mobile phone allowed).
2) assignments (20%) which test the ability to translate decision problems in biobased supply chains into comprehensive optimisation models and software and interpret the main outcomes of the model to support decision making. The mark is decided based on 2 main related assignments.
3) Reviewing and presenting an article (10%). The students are asked to read an interesting article from the literature related to the biobased logistics. They are asked to reflect on the goal, methods, and main findings in a report and prepare a short (10') pptx file that will be presented infront of the class.

To pass the course a minimum average grade of 5.5 and a minimum of 5 for each of the three elements (i.e. written exam, assignments, article review) is required.

Assessment strategy

	Learning outocmes \ where assessed?	**Written exam**	**Assignments (practicals)**	**Article review**
1	Recognise situations where typical decision problems occur in biobased supply chains;	**x**		**x**
2	Understand important concepts of biobased logistics and mathematical programming	**x**		**x**
3	Translate presented decision problems of the biobased supply chain into mathematical models;	**x**	**x**	
4	Develop implementations of mathematical models with state of the art, design-oriented		**x**	
5	Solve implementations of mathematical models		**x**	
6	Interpret outcomes of mathematical models to support managerial decision making in the biobased supply chain		**x**	**x**
7	Design blueprints of alternative logistical structures of the biobased supply chain.		**x**	
	Contribution to final mark (%)	70	20	10

Principal themes of the content:

Operations Management (OM):
Week 1: Introduction to the biobased supply chain.
Week 2: Location allocation and network designing
Week 4: Measuring sustainability in the biobased supply chain
Week 5: Closing loops and nutrient cycles

Mathematics and Operations Research:
Week 1: Basic theory of Linear programming
Week 2: Generic formulation of Mixed Integer Linear Programming models
Week 3: Conditional statements if-then, either-or, and balancing equations
Week 4: Multi-Criteria Decision Making and Multi-Objective optimization
Week 5 & 6: Discrete valued variables and linear approximations of non-linear functions

Outline and schedule of the course programme:

WEEK 1.

OM LECTURE: Introduction BBL
This lecture starts with the set-up of the course. We present what should be expected during the next weeks including topics and assessment procedure. We introduce the biobased supply chain and we discuss major opportunities, and challenges for the agri-food and biobased supply chains.

LECTURE Guest speaker (Bert Annevelink)
To be announced

MATH SESSION 1: Operations Research and structure of MP models
In this math session, we explain what is Operations Research and we provide an overview of the methods and models used. The generic structure of Mathematical Programming (MP) models are presented and discussed.

MATH SESSION 2: Types of MP models and general formulation
This session focuses on typifying Mathematical programming models. Students learn how to formulate explicit mathematical programming models by practicing on exercises.
Read in advance: *Chapters 3 (look FPC material)*

WEEK 2.

OM LECTURE: Location allocation in a biobased supply chain
This lecture discusses a set of frameworks and tools used to design supply chain networks for a biobased application. This lecture will focus on the main strategic logistics decision that is to be taken: logistics network configuration (LNC).

MATH SESSIONS 3 & 4: General Formulation of MILP problems
These sessions combines lecture and exercises and focuses on teaching generic notation used in Mathematical Programming models.
Read in advance:

COMPUTER PRACTICAL: Introduction to XPRESS and general modelling

This computer practical is an introduction to XPRESS where students apply knowledge gained from the previous math sessions to develop their first mathematical programming models.

WEEK 3.

MATH SESSIONS 5 & 6: Conditional statements in MILP
These two sessions focuses on introducing some relevant MILP techniques that can be used to include conditional statements (if then, either or) in MILP models.

COMPUTER PRACTICAL: Conditional statements in MILP
In this computer practical, the students are asked to develop in XPRESS mathematical programming models with conditional statements that are needed often in problems of biobased logistics.

WEEK 4.

OM LECTURE: Measuring sustainable performance of a biobased supply chain
In this lecture we discuss the traditional key performance indicators for supply chains and their drivers. Further, we discuss new performance indicators to measure sustainability and various methods to benchmark the sustainable performances for various choices of biobased supply chains.

LECTURE Guest speaker (Lan Ge)
To be announced

MATH SESSIONS 7 & 8: Multi-Criteria Decision Making
The math sessions of this week focuses on Multi-Criteria Decision Making (MCDM) techniques. The students learn how to quantify trade-offs between conflicting indicators (e.g. economic and environmental). Minmax and maxmin type of problems are discussed and practiced in theoretical exercises.

COMPUTER PRACTICAL: Sugar beet bio-refining
The case study is introduced. Problems in the sugar refining industry are modelled by the students. The first part of the assignment focuses on optimizing production decisions and designing a network of bio-refining facilities.

WEEK 5.

OM LECTURE Biobased closed loop supply chains
This lecture discusses the framework of closing loops for biobased supply chains. This framework is applied in a biobased industrial park.

MATH SESSIONS 9 & 10: Discrete valued/semi-continuous variables and non-linear approximations
MILP techniques that are used often in lot-sizing problems in supply chains and basic principles of approximations of non-linear programming models are introduced in hearing sessions followed by exercises.

COMPUTER PRACTICAL: Sugar beet bio-refining continued
This is a continuation of the bio-refining assignment. After this practical the students are asked to hand in a report with the answers to the questions of the assignments and the description of models they developed during the previous computer practicals.

WEEK 6.

LECTURE Guest speaker (Grit Walther)
To be announced

MATH SESSION 11: non-linear approximations in MILP models
Approximations of non-convex problems are discussed and practiced with exercises.

COMPUTER PRACTICAL: Sugar beet bio-refining continued
The second part of the assignment begins. We extend the model of assignment 1 to optimize decision making in arable farming and sourcing of biomass.

WEEK 7.

Self-study and finalizing reports of the assignments.

Operations Research and Logistics

Time schedule: BBL (ORL 51306)

			Week 1	Week 2	Week 3	Week 4	Week 5	Week 6
			11-mei	18-mei	25-mei	1-jun	8-jun	15-jun
Monday	13:30	15:15			Whit Monday			
	15:30	17:15	Introduction: the bio-based supply chain and structure MP models	Location-Allocationa and Network designing		Measuring sustainability	Closing loops in the bio-based supply chain	Guest lecture Grit Walther
Tuesday	13:30	15:15	Guest Lecture: Bert Annevelink	General formulation of MP models 1	Balance equations, if-then formulations	MCDM, calculating trade-off curves	Discrete Valued/ semicont. variables	NLP : Linear approximations
	15:30	17:15						
Wednesday	13:30	15:15	Types of models, explicit/general			Guest lecture Lan Ge		
	15:30	17:15				PC room available for self study	PC room available for self study	PC room available for self study
Thursday	13:30	15:15	Ascension day	General formulation of MP models 2	Either-Or formulations	The maxmin and minmax problems	NLP : Linear approximations	article presentation
	15:30	17:15						
Friday	13:30	15:15		Computer Practical	Computer Practical	Computer Practical	Computer Practical	Computer Practical
	15:30	17:15						