IF1405: Biobased Economy

Study manual

Biobased economy versus crude oil economy (WageningenWorld, 2011)

University of Applied Sciences HAS Den Bosch
International Food and Agribusiness
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1. Introduction

Present day, crude oil dominates world economy (and even world politics…). More and more the tendency is to change into a *biobased economy (BBE)*. Both types are basically not so different. They run on an identical chemical origin; biological materials such as plants and animals.

The big difference is that oil (as well as natural gas and coal) are fossilized over de last millions of years. In this process of fossilization lies the big difference with the BBE. Because of the fact that it takes such a long time to be produced we consider fossil fuels as *non renewable*. In other words, someday in the near future we run out of fossil fuels. Another suggested problem is that over all these years the fossil fuels have served as a big carbon sink. All this carbon is released (after combustion) as carbondioxide (CO_2) in a relatively short period of time. This results in an increase of CO_2 levels from 270 ppm at the beginning of the industrial revolution to over 370 ppm nowadays. This increase of CO_2 level is suspected to be one of the main driving forces causing climate change.

Contrary to fossil fuels, biobased materials are renewable simply due to the mechanism called *photosynthesis*. Because plants incorporate CO_2 during photosynthesis it also releases (more or less) the same amount during usage. It appears to be that this relatively short cycle of CO_2 does not contribute to an increase of CO_2 levels in the atmosphere.

In short: the fact that biobased materials are renewable and do not contribute to increasing atmospheric CO_2 levels are important driving forces behind the development of a BBE. This is also referred to as a *circular economy*. Companies that genuinely focus on being sustainable will be committed to 'closing cycles' and minimize waste.
The first developments towards a BBE were driven by the demand for renewable energy. For example algae production was considered to have a huge energy potential. Nowadays the focus is shifting more and more towards the development of high value products. Bioplastics and fibres are dominating these developments but in the (near) future also chemicals will be produced from biobased materials.
Figure 1 presents a scheme which shows the main topics on which developments in the BBE will be addressed to.

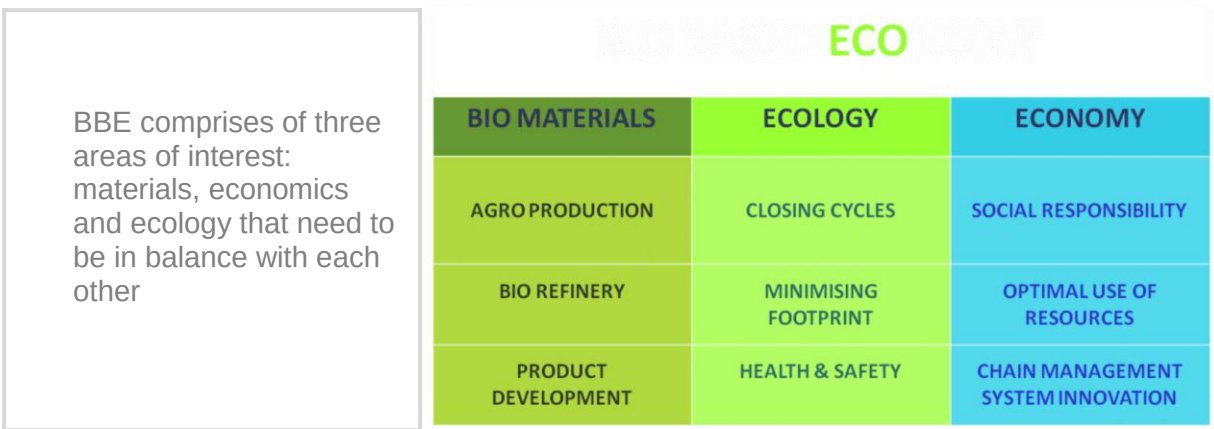


Figure 1: steppingstones developments in BBE

This transition provides many opportunities for new business. For this reason the department of International Food and Agribusiness (IFA) thinks it is of the utmost importance to provide students with knowledge on this subject. In this way these students can contribute in developing business in the new economy.

In this manual the course IF1405 Biobased Economy is outlined. It discusses the module itself in general in chapter 2. In chapter 3 is explained how the course is organized regarding activities, planning, grading and which lecturers are involved. In order to cover most of the important backgrounds for proper understanding of the BBE, several Problem Based Learning (PBL) cases are developed. The outline of these cases are presented in chapter 4. Chapter 5 gives a reflection of the competences which play a role in IFA in general and in which IF1405 plays a specific role. In appendix 1 there an example of a written exam is incorporated.

2. Module IF1405 Biobased Economy

2.1 General description

This paragraph provides a detailed description of the module IF1405 Biobased Economy. Table 2 Table 2provides a short overview of the general aspects of this module.

Subject	Description
Code of module	IF1405
Name of module	Biobased Economy
Credit points (ECTS)	6
Coordination	Dimitri Lamers (LaD) LaD@hasdb.nl
Prior required knowledge	none

Table 2: general information module IF1405

Contents:
Nowadays, the topic *'Biobased Economy'* pops up in various TV programs, magazines and newspapers. This course serves as a general introduction in the recently evolved field of BBE.

The aim of this course is to give you a proper insight in what *biobased* actually means. Which backgrounds and motivations are there for wanting to realize a BBE? What impact can the BBE have on the global environment? And what kind of knowledge is required in order to make a proper contribution to this evolving field of expertise?

By the end of this course you will have a basic understanding of materials, ecological and economical aspects that belong to the BBE. Eventually you are able to put developments into a global and environmental context.

In order to achieve this the course IF1405 is set up by means of Problem Based Learning (PBL) cases. These cases, five in total, will provide the general introduction into the BBE. The PBL cases are described more into detail in paragraph 2.2.

Biobased thinking requires some basic knowledge on chemistry. This course contains three guided self-study moments and one practical. During these three moments you are going to get an introduction into basic chemistry.

At the end of the course the IF1405 Biobased Economy course will be concluded with a guest lecture about business economics in the BBE.

Learning materials:

- Asveld, L., Van Est, R. & Stemerding, D. *Getting to the core of the bio-economy: A perspective on the sustainable promise of biomass.* Rathenau Instituut 2011. http://www.rathenau.nl/en/publications/getting-to-the-core-of-the-bio-economy-1.html
- Essent. *Natural Power; Essent and the bio-based economy.* 2011. http://igitur-archive.library.uu.nl/chem/2012-0320-200530/89679_whitepaper_natural_power.pdf
- Additional materials which will be provided when required.

2.2 Additional information

Not applicable for IF1405.

3. Module organisation

3.1 Activities

Table 3 gives a general overview of the coming ten week period. This overview gives insight into the topics which are going to be dealt with as well as the prognosed studyloads.

Week	Topic description	Guided studyload	Selfstudy	Total
1	-	-	-	
2	General introduction Case 1: System Earth Lecture	2 3 2	 16 	
3	Case 2: Biomass Lecture Intro Chemistry I	3 2 2	16 6	
4	Case 3: Value versus Volume Lecture	3 2	16 	
5	Case 4: Food versus Fuel Lecture Intro Chemistry II Practical Chemistry	3 2 2 2	16 6 4	
6	Case 5: Cycle of Elements Lecture Intro Chemistry III	3 2 2	16 6	
7	Completion of PBL Guest Lecture by Toine Hattink	3 2	4 2	
8	Guest Lecture by Toine Hattink	2	2	
9	Written exam (see appendix 1 for an example)		12	
10	Guest Lectures	4		
	Total Studyload	46	122	168

Table 3: overview of contents and prognosed studyloads

3.2 General learning goals

1. Introduction to BBE (reasons and background): case 1

- Definition and background of the biobased economy (BBE)
- BBE is related to global environmental issues and could be part of the solution
- Transition towards a biobased economy has started and may last decades.
- Various socio-economic factors will influence the transition process
- BBE comprises of three joint areas of interest: bio-materials, economics and ecology that need to be in balance with each other

2. Material side of the biobased economy: case 1 and 2

- Solar light is the major principle source of energy for life
- Carbon fixation by photosynthesis produces chemical energy and building blocks
- Soil and water based, natural and agricultural flows of biomass
- Nature's incredible conversions – leading to innumerable types of biomaterials
- Possible conversions by nature and men (conventional and 'green' chemistry)
- Availability of biomass – past – present – future in the Netherlands
- Agro meets chemistry – new challenges

3. Biobased economics: case 3 and 4

- Value versus volume – a common economic principle
- Classic, present and future uses of biobased resources
- Cascading principle: same crop, multiple benefits
- Integrated approaches in industry –waste for one as resource for another
- Processing and upgrading brings added value
- BBE: natural based innovations
- Wood sector as an example
- Competing claims: Food versus Fuel

4. Ecological thinking = cyclic thinking: case 5

- Everlasting resources need everlasting cycles
- Food, feed and biobased raw materials for industry
- Global mineral constraints
- Human factors disturbing ecological balances
- A closer look at N, P and C cycles
- Corporate Social Responsibility and BBE
- Distinguishing genuine efforts by Industry from plain greenwashing

3.3 Grading

Grading of this course will be based on a written exam. Next to this grade the student has to pass the PBL course. Attending of the scheduled PBL meetings is obliged. Presence is one of the (minimum) criteria of passing this part of the course. The rest of criteria will be discussed during the PBL meetings.
Grading of IF1405 is summarized in Table 4.

Element	Way of grading	Weighing factor
Problem Based Learning	Pass/fail	0
Written Exam	Mark: 1 -10	100

Table 4: Grading

3.4 Module team

The team in charge of IF1405 consists out of three persons; René Schoorl, Gert-Jan van Delft and Dimitri Lamers. In Table 5 the contact information is presented. One of the directors of HAS Hogeschool, Toine Hattink, will contribute to this course as well as a guest lecturer.

Name	Role	Office	E-mail
René Schoorl 	- Lecturer - PBL tutor	2D-32	Sre@hasdb.nl
Gert-Jan van Delft 	- Lecturer - PBL tutor	2C-04	DeG@hasdb.nl
Dimitri Lamers 	- Lecturer - PBL tutor - Coordinator of IF1405	3D-30	LaD@hasdb.nl
Toine Hattink 	- Guest lecturer	-	-

Table 5: Module team IF1405

4 PBL cases

4.1 Case 1: System Earth; Alien helicopter views

System earth
The earth we live on is a very unique and complex system, which contains many elements and subsystems. Earth is not a completely closed system because radiation (sunlight) enters the atmosphere (an earth subsystem) and an almost similar amount of it leaves the atmosphere per unit of time. No other material exchanges take place. Fortunately for us, more than that happens within the system. From outside not much may seem to happen but within the system very interesting activities take place. For instance, the earlier substance called water, flows in regular patterns and different forms (vapor, ice, liquid) over the surface of planet earth. On average (looking at the total from the outside) nothing seems to happen, but actually a lot is happening and it happens in a continuous apparently harmonious cycle. A river is a continuous flow of water, but it is part of the water system and is in a state of dynamic equilibrium.

From outer space…
Before the Roswell incident in 1947 extraterrestrial spacecraft unnoticeably passed the earth several times. The first time (a long time ago) planet earth looked like a barren place, without much going on there. A millennium ago they came by another time and were very much surprised to observe (from space) the presence of an incredibly rich variety of well-organized chemical entities and processes. No other known planet has a hydrosphere and living systems which are comparable to the earth's biosphere. Using 'black box' theory, they figured out that system earth must be a solar powered system. Furthermore they hypothesized that the astonishing biodiversity found in various ecosystems on this special planet is possible due to a number of fortunate circumstances and involves continuous cycling of elements and nutrients in so-called bio-geochemical cycles.

The next time their investigation team arrives is planned in 2050…

4.2 Case 2: Biomass

Biobased Economy has everything to do with the change from the current oil based economy into a new type of economy. Expectations are rising towards the sky regarding this phenomenon but if you ask people directly you will notice that many different scenario's will be sketched…. Some will say that the biobased economy is just a hype which will pass. Others will state that this transition has already been started. Those people are convinced that all the energy and materials we use will eventually be based on renewable sources. Different scenario's or not, some kind of transition will eventually have to take place.
A proper functioning government wants to be well prepared for the future. In the case of biobased economy it is therefore wise to learn from the past. How did the Dutch deal with all the challenges, which affected the complete society, regarding energy and materials in the past?
A group of policymakers from *'the Hague'* is doubting in which area of the biobased economy the estimated billions of euros are going to be spent. They´ve hired a firm of consultants to shed some light on the topic Biomass.

4.3 Case 3: Value versus volume

Background information
Your (wealthy) family is owning a SME in Germany that manufactures kitchen furniture based on polymers from fossil fuels. The business has not performed well in recent years, because prices of fossil commodities have risen, while markets for kitchen chairs and tables were also affected by the EU financial crisis. A meeting was held last weekend in which all family-shareholders including yourself were present, to discuss possible plans for the future. The 2 options are: closing the factory or making a 'new start'…

The founder of the company was your great grandfather who made furniture from wood and run a sawmill as well. The sawmill disappeared but the small factory remained and is located on his former property of 250 acres of forest, which is still privately owned by your family. The family has not really exploited the forest during last decades. This forest used to be the primary source of all wood based products that your great grandfather made. Now the area is covered by three types of trees: oak (25%), beech (20 %) and birch (55 %).

The family has become increasingly aware of the positive impact that 'using wood' may have on the climate. In order to achieve this positive impact, sustainable management of wood-based production chains is essential. The other issue that triggered the interest of the family is the fact that lignocellulosic feedstock can lead to wide range of novel products, varying from wooden bridges to lipstick.

In the meeting it was decided to close the plastic furniture production site a.s.a.p.

Instead of this SME, is was proposed that a new company will be set up, that:

- uses the 250 acres in a sustainable manner as source for raw materials
- works as much as possible in accordance to C2C principles
- aims to focus on producing furniture or any other wooden products from the 250 acre forest, thereby maximizing the economic benefits, and minimizing waste

Of course, this decision is not taken without proper consideration. First some potential business cases should be carefully looked at, (in a broad sense) considering potential market prices of possible end products and the type of investments that would be needed to set up and run a wood-based SME. Money for the investments is in this case not a limiting factor, but the family wants primarily to develop business cases that has a good long term potential. They are not afraid to consider innovative products as well.
For the next meeting you are asked to work out at least a number of possible business cases.

4.4 Case 4: Food versus fuel

After a long school day, you go to a pub, waiting for "the others".
Gazing at your first beer you wonder: "Beer is made from barley. I could also have eaten barley as food. What a waste. I might have given food to a fellow world-citizen if I wouldn't have been drinking this beer. It seems that we already don't have enough arable land to feed all the people in the world properly. Or is it because we do not cultivate our arable land properly and are not able to divide our foodproduction to everyone." "We better go to Africa to buy some arable land and improve production/ha of food, feed or biomass. We all will benefit. Or is the social impact of this land-grabbing negative?"

Gazing at your second beer you wonder: "Crops for human consumption like soybean is sometimes also used as cattle feed. And even converted into bio-fuel." While watching the movie https://www.youtube.com/watch?v=HmlUSMaM2rc on your iPhone you are told that bio-fuel is actually a waste product of soybean as cattle feed.
"What if all our fossil fuel consumption would be replaced by bio-fuel, would there be enough arable land available to produce this amount of bio-fuel?"

Your friends have arrived and you all start looking at youtube films on your iPhones about the subject food versus fuel. All these movies show their opinion: Some say that bio-fuel will save the world (http://www.youtube.com/watch?NR=1&v=rQgccUlJiv0&feature=endscreen); others say it will cause starvation in developing countries (http://www.youtube.com/watch?v=igUtLwruUjA), but none of them founded their opinion properly.

On several websites you see successful stories about palm-oil, soy-oil and rapeseed for production of bio-fuel, but which of these three crops produces most? Or should we culture maize or corn to produce bio-ethanol? Does that give a higher production? Does 1 liter of ethanol have the same energy-level as 1 liter of biodiesel? Or does a forest produces more energy if we would burn the wood?

So you all decide to look for hard proof.

4.5 Case 5: Cycle of Elements

'Unbelievable how much materials can be made from a single forest!' two IFA students, Hielke en Jos, claim while working on their *PBL case Value versus Volume*. It also gives a very detailed example of how the Carbon Cycle and Biomass from the first sessions are related Jos adds to the discussion. Hielke does not see that and asks if Jos can elaborate on that. 'Not now, I am very busy with *Food and Health*' Jos says. 'I will explain it next week'.
'Is it actually only about carbon?' Hielke asks. Jos doesn't think so. He has heard that nitrogen and phosphorus also play a very important role. He only hasn't got a clue in what way. Jos also realizes that when he adds *Pokon* to his plants at home that the bottle says that there are a lot of macro- and micronutrients in it.
´Come to think of it', Hielke says, 'if you only take the wood out of a forest, in the end it will be exhausted, or won't it?'. 'I think you are right', says Jos, 'actually, I can also remember something about phosphorus during one of the other lectures…'. 'About how fast we are running out of P and that the cycle is much more complicated than the cycle of N for example'.
´And biobased and sustainability are of course also about closing cycles and making sure that future generations have equal possibilities, that we know by now…´ 'This seems important one way or the other' Hielke thinks, 'they should make a PBL case about this!'

5 Competences

IFA is a competence based course. IF1405 contributes to that by addressing the following competences:

Competence 2: Designing and monitoring sustainability in existing supply chains

The student demonstrates that he is capable of designing, developing and auditing for sustainable supply chains. He can relate his actions to a conceptual framework of sustainability. He is aware of the specific elements of agro-commodity chains, and can translate his knowledge to practical agro-engineering solutions and/or business opportunities.

The student:

- is able to define supply chains, its multi-dimensionality: primary actors, politics, civil society
- is aware of specific developments and innovations in international supply chains and networks in agro-food commodities (ex1)
- is able to qualify and quantify the environmental impact of production, processing and transportation methods

Competence 4 Global Citizenship

The student has the values, attitude, knowledge, understanding and skills to be a well informed, confident, responsible world citizen and to act as such in both his personal and professional life

The student:

- knows how to to communicate professionally in at least two foreign languages (one of which is english)
- knows how to develop strong emotional intelligence which makes him able to identify, assess and manage his own emotions, and those of the people and groups he works with.
- knows how to gain insight in international developments and can relate these to his daily life and work. he can see the social/cultural/political context of his work and acts accordingly.
- can apply language and communication skills while interacting with people from different countries/cultures/languages (presentation, negotiation, cooperation, persuasion, networking, interfering, advising)
- kan adviseren over het adequaat inspelen op verschillen in bedrijfsculturen binnen landen of regio's waar deze vreemde taal wordt gebruikt;

Competence 8: valorization of water and bio mass for nonfood purposes

The student, being aware of the urgency of a sufficient water and food supply, is able to contribute to the improvement of both water quality and supply and to the development of energy and nonfood products from biomass.

On a compulsary level the student:

- has knowledge of biomass, fibre, multipurpose and speciality crops and crop-production
- has technical knowledge of processing methods like water treatment, fermentation/anaerobic digestion, extraction, and thermo chemical conversion methods and their conversion efficiencies (energy, money)
- understands the need that technical options are to be evaluated from the viewpoints of food security, food safety, energy production/requirements, environmental pressure, waste and water management, business economics (return on investment, payback period)

Appendix 1 Example written exam

Question 1

a) 3 points

Agriculture and forestry can provide Renewable Raw Materials (RRM). Give examples of major types of RRM that are commonly used worldwide.

b) 5 points

It is often said that building a Biobased economy requires a 'multidisciplinary' approach. What is a multidisciplinary approach, what types of knowledge do we need to combine, and why?

Question 2

a) 2 points

The sun provides energy for driving the process of photosynthesis. Explain what the ***solar constant*** is (short definition, value and SI-units)

b) 4 points

The amount of radiation reaching the earth's surface varies considerably. Explain why.

c) 3 points

Three types of photosynthesis are present in the global plant kingdom. According to this, three groups of plants can be defined. Which ones? Which of these three groups are adapted to hot climates? To which one of the three belongs a common crop like maize?

Question 3

a) 4 points

What is a dynamic equilibrium? Can you give an example? Show its dynamics and equilibrium.

b) 2 points

Explain the difference between a *short term* carbon cycle and a *long term* carbon cycle.

c) 5 points

Consider the given 2 figures: C-reservoirs (left) and C-pools important for short term C-cycles (right) in Gt

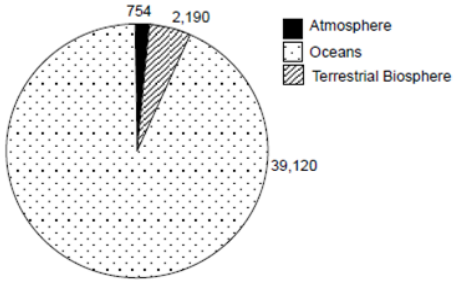
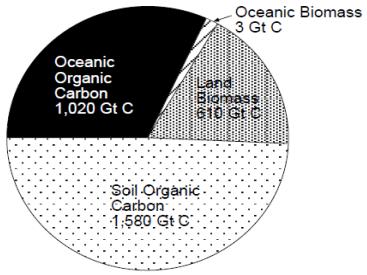


Figure 7. Comparison of the land and oceanic carbon pools that are important in the short-term carbon cycle.



According to this information, what percentage of the total Carbon present (expressed in Giga tons in both figures) is taking part in the short term C-cycle?

Question 4

a) 2 points

Carboyhdrates are divided into mono- and polysaccharides. A plant has two important purposes for carbohydrates. Give these two purposes.

b) 2 points

Give for each purpose the name of the molecules which are produced by a plant for that specific purpose.

Question 5

a) 3 points

Plants produce fats. Describe what a fatmolecule looks like.
Answer:Glycerol with three chains of fatty acids.

b) 4 points

What biobased products can be made from these plantfats? Give 4 examples.

Question 6

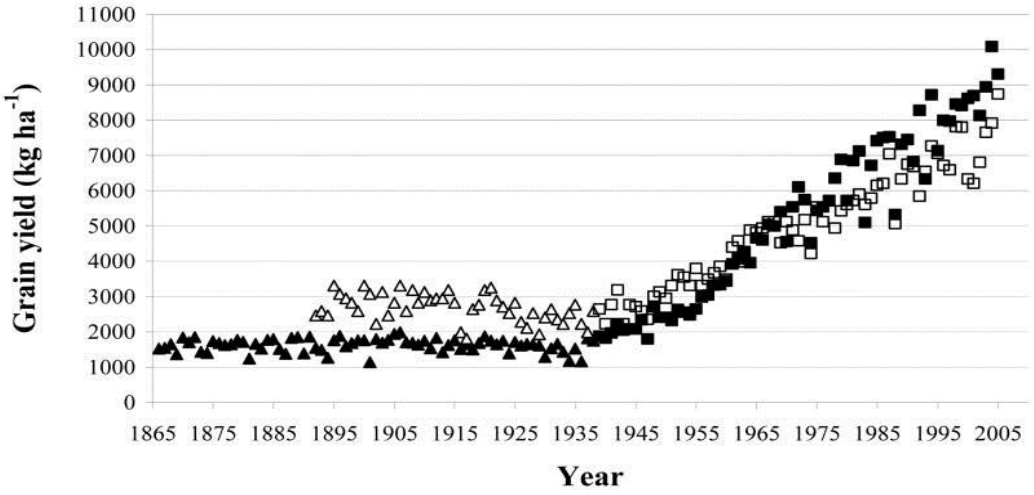
a) 5 points

Renewable resources come from arable land. Proteins are needed in our diets. Meat consumption in EU and USA is much higher than in other parts of the World. If the rest of the World would have a similar consumption pattern, we would need more land on earth than is available. Explain why.

b) 3 points

Draw a 'value pyramid' and explain the elements within it. Use the following elements: Food, Feed, Fibres, Fuels, Fine chemicals.

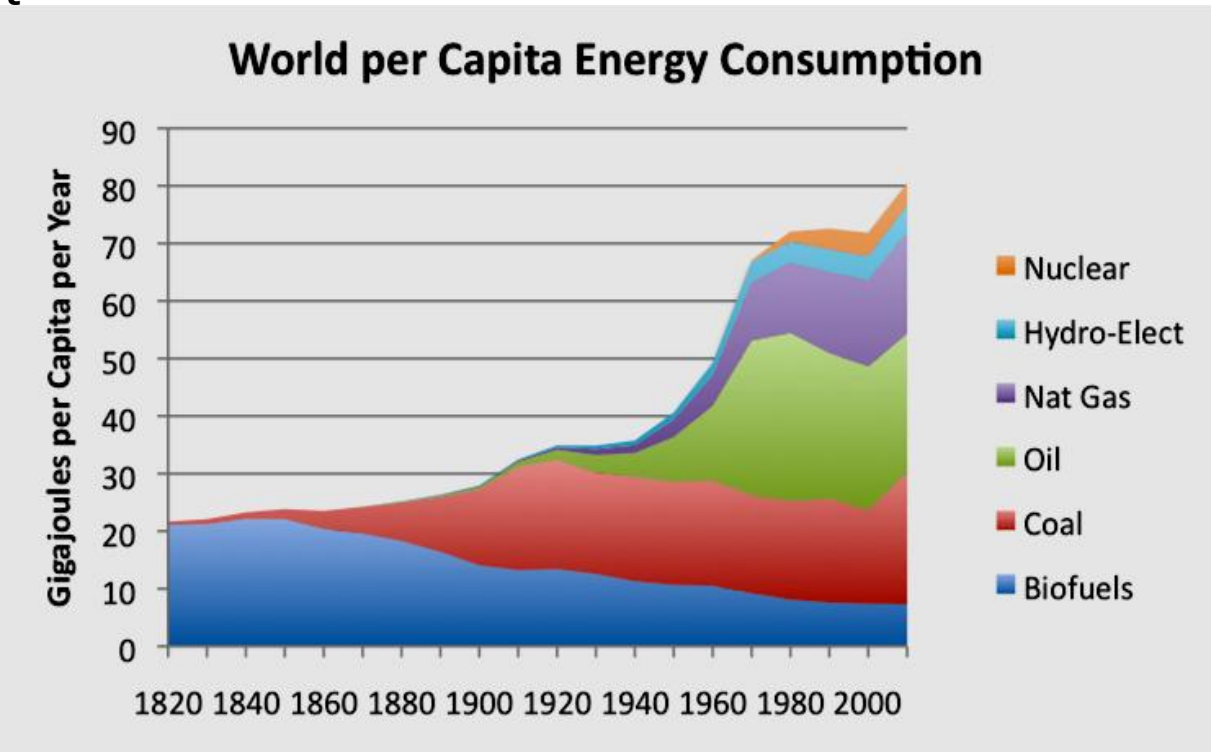
Question 7



4 points

Since approx. 1930, grain production/ha increases. Explain.

Question 8



a) 2 points

In 1820 almost all energy consumption came from biofuel. Which type of biofuel was mainly used in the Netherlands?

b) 3 points

Since 2000 it seems that coal-consumption is increasing in order to cope with the increasing total energy consumption.
Explain what causes the increasing energy consumption from 2000 till 2010.

c) 3 points

Explain why coal was used for this increasing energy consumption.

Question 9

Oil from palm, soy-bean rapeseed etc can be converted into biodiesel. The oil then will be hydrolyzed to form glycerol and fatty acids with 15-18 Carbon-atoms.

a) 3 points

What is meant by "hydrolyzed"?

b) 3 points

To change the fatty-acids into biofuel, methanol is added which reacts with the fatty-acid. 1 molecule of water is formed for each molecule biodiesel that is formed. Draw the structure formulae of a methanol-molecule.

c) 3 points

How much does 1 mole of methanol weigh?

Question 10

a) 5 points

Temperatures on earth are 'just good' to support life. The atmosphere enables this. Without our gaseous atmosphere temperatures would be different. What would be the consequence?

b) 5 points

Which major human influences have a direct or indirect large negative impact on the atmosphere because of GHG emissions?

-THE END-