Exam BYG404 Life cycle Assessment of Constructions

1) Functional units

a) Production of potatoes and carrots

Tons produced or kg produced

b) Production of paints

↳ Assume production, not use!

Litre or m^3 of paint produced

c) A mobile telephone

MHZ (CPU)
Storage capacity

d) Roof on a building

Roof for 60 years
or per m^2 of roof installed

(Two possible, depending on goal I would say)

e) Comparative analysis between coal power production and wind power production

Annual production (GWh/year or TWh/year)

⇒ Hard to compare other ways! (Or whole lifetime possible)

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2) a) Construction project in Norway

→ Lots of steel

- China?
- Poland?
- Norway?

} Equal steel

⇒ Least environmental impact per ton!

→ Since the quality of the steel is the same, I assume same production and thus same waste of the productions

Important things to include:

- Energy used (Coal, oil, hydro wind?)
  ↳ Especially the electricity production
- Waste treatment
- Emission cleaning and all emissions
- Energy reusage

↳ Basically all the things that has evolved Norway into a cleaner industry, thus expensive one.

⇒ Functional unit would be per ton steel preferably

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2a) I think waste treatment and Energy usage will impact their decision, Especially the electrility production, since this is different in these countries.

2b) Main Components of LCA:

1. Goal and Scope

Here the total goal for the study is set by the comissioner. The functional unit is set and system boundaries. Basically how the study is going to be performed and what limits

2. Inventory analysis
→ Data collection

· Flow chart
→ process diagram for the complete process

· Data collection
→ collect data in various ways

· Calculation of environmental loads
→ Calculate emissions based on the data

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2b) 3. Life Cycle impact assessment

- Impact categories
- Classification
- Characterization

In this section the environmental loads is assigned to the correct impact category and thus assigned an impact ↳ calculated for how much factor they have in each category.

4. Interpretation

This section is almost included in all the others, this is where you analyze and interpret the results you have gotten

It is also possible to do different analyses based on what you want see what had greatest impact and so on
(sensitivity, break even analysis and so on)

→ Continously used to improve the study.

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3) a) Allocation

Norwegian Shipping Company

Norway → South Africa

1 000 000 ton Capacity MS Brunost Express

Kristiansand →(1) Rotterdam →(2) Porto →(3) Lagos →(4) Capetown

In order to allocate I will divide the route into all the different trips and allocate to each goods per "route". There will be 4 routes in total.

→ 6000 tons of SO_2 - eq emissions for the total 8600 km journey. I assume I can use this as average, and thus be able to divide it into each route.

$$\frac{6000 \text{ ton } SO_2}{8600 \text{ km}} = \frac{30}{43} \text{ ton } SO_2/\text{km}$$

→ Assume that it is wanted answer per destination

⇒ So each goods will be responsible for a part of this emission during the trip to each destination

⇒ Since different amount is at each time, there percentage will be different.

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3a)

1. Kristiansand → Rotterdam

$\frac{30}{43} SO_2 \text{ ton/km} \cdot 800 = 558,14 \text{ ton } SO_2$

Total load 900 000 ton

Brown Cheese:

$\frac{600\,000}{900\,000} = \frac{2}{3}$

Gravel : $\frac{300\,000}{900\,000} = \frac{1}{3}$

Emission on goods: Brown cheese : 372,1 ton SO_2
Gravel : 186,05 ton SO_2

2. Rotterdam → Porto

$\frac{30}{43} \cdot 1600 = 1116,28 \text{ ton } SO_2$

Tot = 800 000

Brown Cheese : $\frac{500\,000}{800\,000} = \frac{5}{8}$

Tulips : $\frac{300\,000}{800\,000} = \frac{3}{8}$

Emission on goods: Brown Cheese : 697,7 ton SO_2
Tulips : 418,6 ton SO_2

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3a) 3. Porto → Lagos

$\frac{30}{43} \cdot 3500 = 2441,86$ SO_2 ton

Tot load : 1000000

Brown cheese : $\frac{400000}{1000000} = 0,4$

Tulips : $\frac{200000}{1000000} = 0,2$

Wine : $\frac{400000}{1000000} = 0,4$

Emission on goods : Brown cheese : 976,74 SO_2 ton
Tulips : 488,37 SO_2 ton
Wine : 976,74 SO_2 ton

4. Lagos → Cape town

$\frac{30}{43} \cdot 2700 = 1883,72$ ton SO_2

Tot load : 1000000 ton

Brown cheese : $\frac{200000}{1000000} = 0,2$

Tulips : All gone in Lagos

Wine : $\frac{300000}{1000000} = 0,3$

Furniture : $\frac{500000}{1000000} = 0,5$

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3a) 4. Lagos → Cape town

→ All remaining Cargo drop off in Cape Town.

Emissions on goods: Brown Cheese : 376,74 ton SO_2
Wine : 565,12 ton SO_2
Furniture : 941,86 ton SO_2

This is the way I interpreted the question, If the total for transporting the different goods it can be summed up. But that is not good. Best to have it like this, per trip.

3b) In this example is the average of the emissions used. But allocation method is partitioning, with the physical relationship of mass as the partition method. at each trip

↳ Many other relations can be used, but mass often the best

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4) Inventory analysis

Stjernehus housing Block

OLD → TEK10

Kruse-smith

↳ Test LCA study
CO_2 - Emissions and energy demand

Upgrade:
- exterior wall, with insulation and material barrier
- New doors and windows
- Fixing roof
- New ventilation system
↳ Heat requirements from Rt. Sand incineration plant

Stjernehus data:
. 3717 m² heating area

. 63 m² average appartement size

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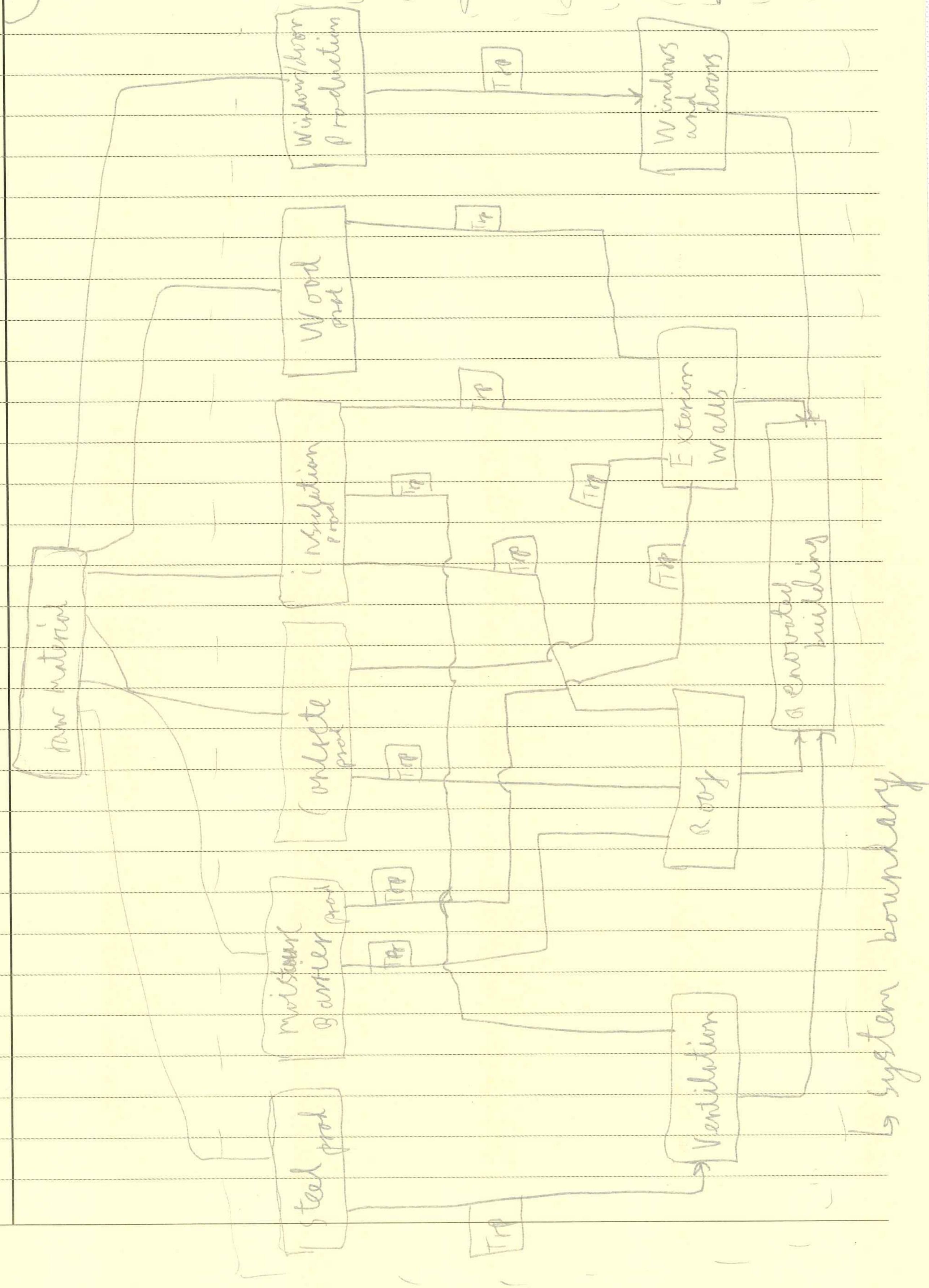
a) Basic Flow Chart. (page 11 for Assumptions)



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a) Assumptions
- Not included ~~raw~~ material extraction and Transport
- Assume materials is in the fabrics (factories)
- The roof sections not included information

⇒ The system got a little messy, but should be correct.

b) Material requirements for one apartement

$\frac{63}{3717} = \frac{1}{59}$ ⇒ so I assume each apartement is responsible for $\frac{1}{59}$ of all the emissions, and constructions

Material requirements for one apartement, will do per thing first than ~~sum~~ sum up for each part at end.

Exterior walls:

Insulation: $15\text{ ton} \cdot \frac{1}{59} \Rightarrow \frac{15}{59}$ ton/app

Concrete: $47 \cdot \frac{1}{59} = \frac{47}{59}$ ton/app

Wood: $102\ m^3 \cdot \frac{1}{59} = \frac{102}{59}\ m^3/ap$

Moisture barrier: $1{,}5 \cdot \frac{1}{59} = \frac{3}{118}$ ton/ap

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b) Windows and doors:

Windows: $760 m^2 \cdot \frac{1}{59} = \frac{760}{59} m^2/ap$

Wooden doors: $139 m^2 \cdot \frac{1}{59} = \frac{139}{59} m^2/ap$

~~Windows [illegible]~~

→ Not calculated for frame here, because is in window.

Roof:

moisture seal: $2,3 \text{ ton} \frac{1}{59} = \frac{23}{590} \text{ ton}/ap$

Insulation: $3,0 \cdot \frac{1}{59} = \frac{3}{59} \text{ ton}/ap$

Concrete: $2,0 \cdot \frac{1}{59} = \frac{2}{59} \text{ ton}/ap$

Ventilation:

steel ducts: $2,1 \cdot \frac{1}{59} = \frac{21}{590} \text{ ton}/ap$

Insulation: $1,7 \cdot \frac{1}{59} = \frac{17}{590} \text{ ton}/ap$

These calculations above is the material requirements for all the different things per part, to be able to view it properly it viewed like this. No time to sum up. (See c for summation)

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c) Total transport for average appartement:

Material:

Wood: $\frac{102}{59} m^3/ap \cdot 480 kg/m^3$

$= \frac{1224}{1475} ton/ap \cdot 25 km = \frac{1224}{59} ton \cdot km/ap$

Concrete: $\frac{47}{59} + \frac{2}{59} = \frac{49}{59} ton/ap \cdot 25 km$

$= \frac{1225}{59} ton \cdot km/ap$

Insulation: $\frac{15}{59} ton/ap + \frac{3}{59} + \frac{17}{590} = \frac{197}{590} ton/ap$

$\frac{197}{590} ton/ap \cdot 25 km = \frac{985}{118} ton \cdot km/ap$

Moisture barrier: $\frac{3}{118} + \frac{23}{590} = \frac{19}{295} ton/ap$

$\frac{19}{295} \cdot 200 km = \frac{760}{59} ton \cdot km/ap$

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1) Steel ducts:

$\frac{21}{590}$ ton/ap $\cdot$ ~~1000 km~~ $= \frac{2100}{59}$ ton·km/ap

Wooden doors: $\frac{139}{59}$ m^2/ap $\cdot$ 0,03 m $\cdot$ 0,48 T/m^3

$\cdot$ 75 km $= \frac{3753}{1475}$ ton km/ap

Windows: $\frac{760}{59}$ m^2/ap $\cdot$ ~~0,03 m $\cdot$~~ 2,6 T/m^3 = $\frac{1482}{1475}$ T/ap

PVC: $\frac{760}{59}$ m^2/ap $\cdot$ 0,065 T/m^2 $= \frac{247}{295}$ ton/ap

Steel: $\frac{760}{59}$ m^2/ap $\cdot$ 0,02 T/m^2 $= \frac{76}{295}$

$= \frac{3097}{1475}$ ton/ap

$\frac{3097}{1475}$ ton/ap $\cdot$ 75 km $= \frac{9291}{59}$ ton km/ap

Sum it up: → 258,3 ton·km/ap

$\frac{1224}{59} + \frac{1225}{59} + \frac{985}{118} + \frac{760}{59} + \frac{2100}{59} + \frac{3753}{1475} + \frac{9291}{59}$

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d) Assuming previous calculation was correct this is used here:

MJ → Direct energy

Energy usage:

Transport: (Assume the trucks

$258,3 \text{ ton-}\cancel{km}/ap \cdot 0,02 l/\cancel{ton\,km} \cdot 44 MJ/l$

$= 227,3 MJ/ap$

Diesel machine on sight

$120 d \cdot 0,923 l/d \cdot \frac{1}{59} \cdot 44 MJ/l = 826 MJ/ap$

Electricity used:

$45277 kWh \cdot 3,6 MJ/kWh \cdot \frac{1}{59} = 2762,7 MJ/ap$

⇒ Total energy per apartement (average

3816 MJ/ap By my calculations!

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e) Type of study.

This is an attributional/accounting study.

→ Due to the fact that it looks into what has happened on a specific building site. All the values is given and it accounts for what has happened. There no change it, not looking at what ~~to~~ to choose between.

→ Looking ~~at~~ past, what has happened

5) Life cycle impact assessment

Norwegian energy Company

1 GJ of ethanol fuel wood products.

· Terrestrial acidification

· Photochemical oxidant formation

Calculate the total for these two for producing 50 GJ of ethanol.

Terrestrial acidification: SO_2, NOX, Ammonia

SO_2 – Sulfur dioxide:

$0,23620 \, kg/GJ \cdot 50 \, GJ = 11,81 \, kg/50 \, GJ$ (1)

NOx

$0,17377 \cdot 50 \, GJ = 8,67 \, kg/50 \, GJ$

$eq \Rightarrow 8,67 \cdot 0,560 = 4,86 \, kg \, SO_2 \, eq/50 \, GJ$

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5) Ammonia:

$0,03382 \, kg/GJ \cdot 50 \, GJ = \frac{1691}{1000} = 1,69 \, kg/50GJ$

$1,69 \, kg/50GJ \cdot 2,450 \, kg \, SO_2\text{-eq}/kg = 4,14 \, kg \, SO_2/50GJ$

$\Rightarrow$ Total SO_2-eq $= 4,14 + 4,86 + 11,81$

$= 20,81 \, SO_2\text{-eq}/50GJ$ fuel

Photo Chemical oxidant formation:

SO_2: $11,81 \, kg/50GJ \cdot 0,655 = 7,74 \, kg$ NMVOC-eq

Nox: $8,67 \, kg/50GJ \cdot 1,375 = 11,92 \, kg$ NMVOC-eq

Non-methane...

$0,05699 \, kg/GJ \cdot 50 = 2,85 \, kg/50GJ$

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5) Carbon monoxide:

$0,20242 \cdot 50 = 10,12 \text{ kg } CO/_{50GJ}$

$10,12 \cdot 0,095 = 0,96 \text{ kg NMVOC-eq}/_{50GJ}$

⇒ Total Photochemical oxidant formation:

$7,74 + 11,92 + 2,85 + 0,96 = 23,47 \text{ NMVOC-eq}/_{50GJ}$

6) The only difference in the description is

1. electricity prod, hydro, pumped, storage
2. market for

⇒ In number one it is specified that the electricity comes from hydropower with a pumped storage. But on the other one it is average market in Norway

↳ Not all electricity in Norway come hydro, so these will be different.

↳ Pumped storage is not that common

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7a) Stjernehus building:

Original 337 kWh/m² per year

renovated: 102 kWh/m² per year

Total renovation energy:

$$9\,430\,000\ MJ \cdot \frac{1\ kWh}{3,6\ MJ} = 2\,619\,444,4\ kwh$$

Improved energy consumption

337 - 102 = 235 kWh/m² improvement

235 · 3717 m² = 873 495 kWh/building
↳ Annual improvement

$$\frac{2\,619\,444,4}{873\,495} \approx 3\ år$$ Approximately

7b) Trump won, but Hillary most votes
I think to remember.