**Closing Seminar**
**14-15 May, 2012**
**Malmö**

NordFoU

# Introduction of new ETSI tools – Life Cycle Assessment (LCA)

Prof. Helge Brattebø
Industrial Ecology Programme
Dept. of Hydraulic and Environmental Engineering
Norwegian University of Science and Technology

*E64 - Atlantic Ocean Road*
*(near Kristiansund, Western Norway)*

# Why LCA tool in ETSI?

**Bridge Life Cycle Optimisation**

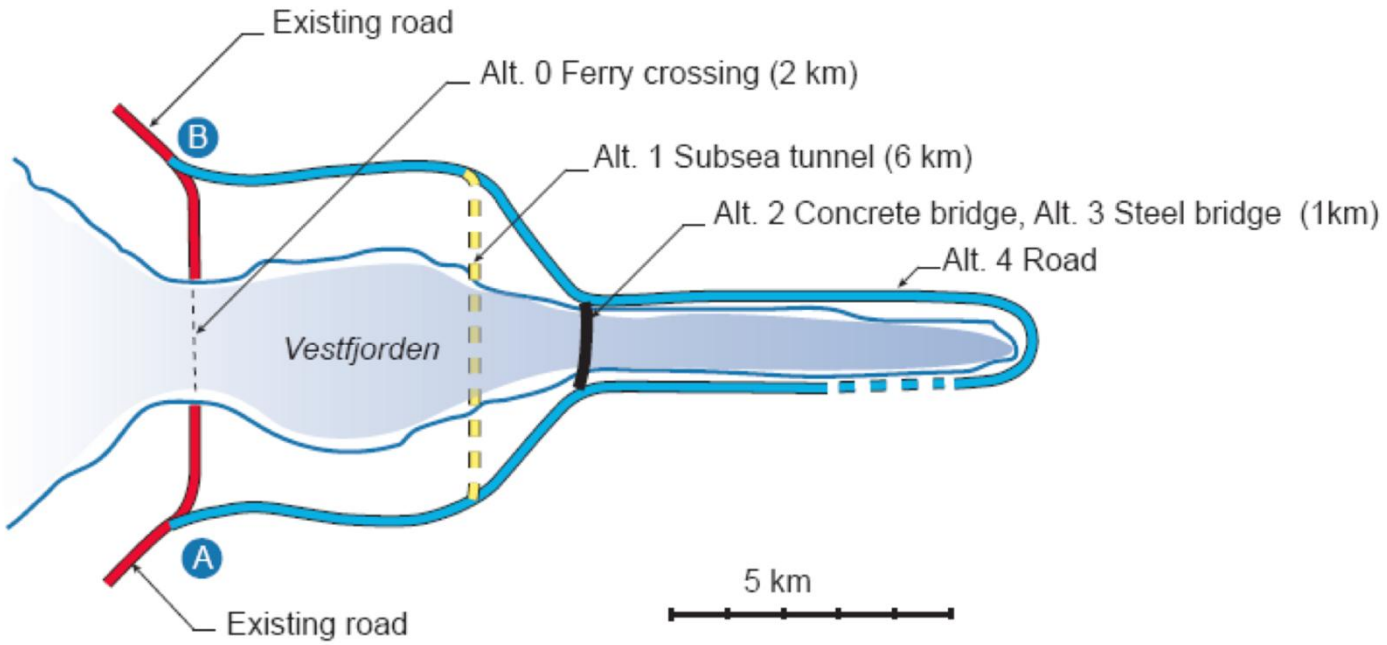
- Growing demand for sustainable infrastructure solutions
  - particularly regarding resource efficiency, and energy and carbon efficiency
- Life cycle thinking a required premises today, to be added to the local environmental issues
  - as normally covered in SEA and EIA of road projects
- Material and product suppliers offer LCA information
  - EPDs as basis for market competition

**=> LCA likely to be mandatory during a few years**

**=> From early phase planning to bridge contract**

# Early phase planning – Route location?

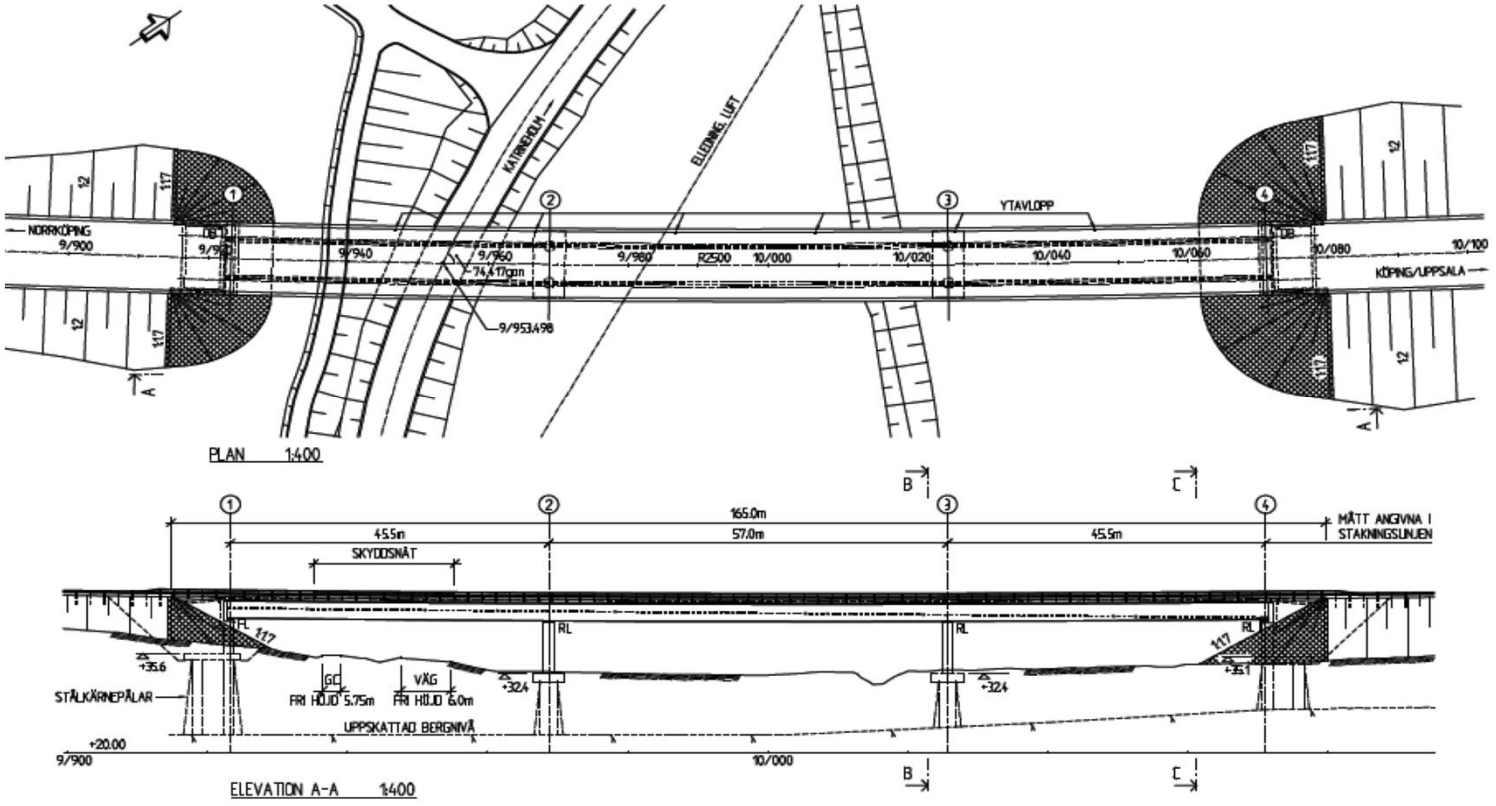
**Bridge Life Cycle Optimisation**




- **Comparing route alternatives (with a set of road elements)**
- **LCA (energy and GHG emissions) method developed in EFFEKT (Norway) and in the LICCER project (Road ERA-net) – based on archetype geometry elements**

# Feasibility study to contract – Design?

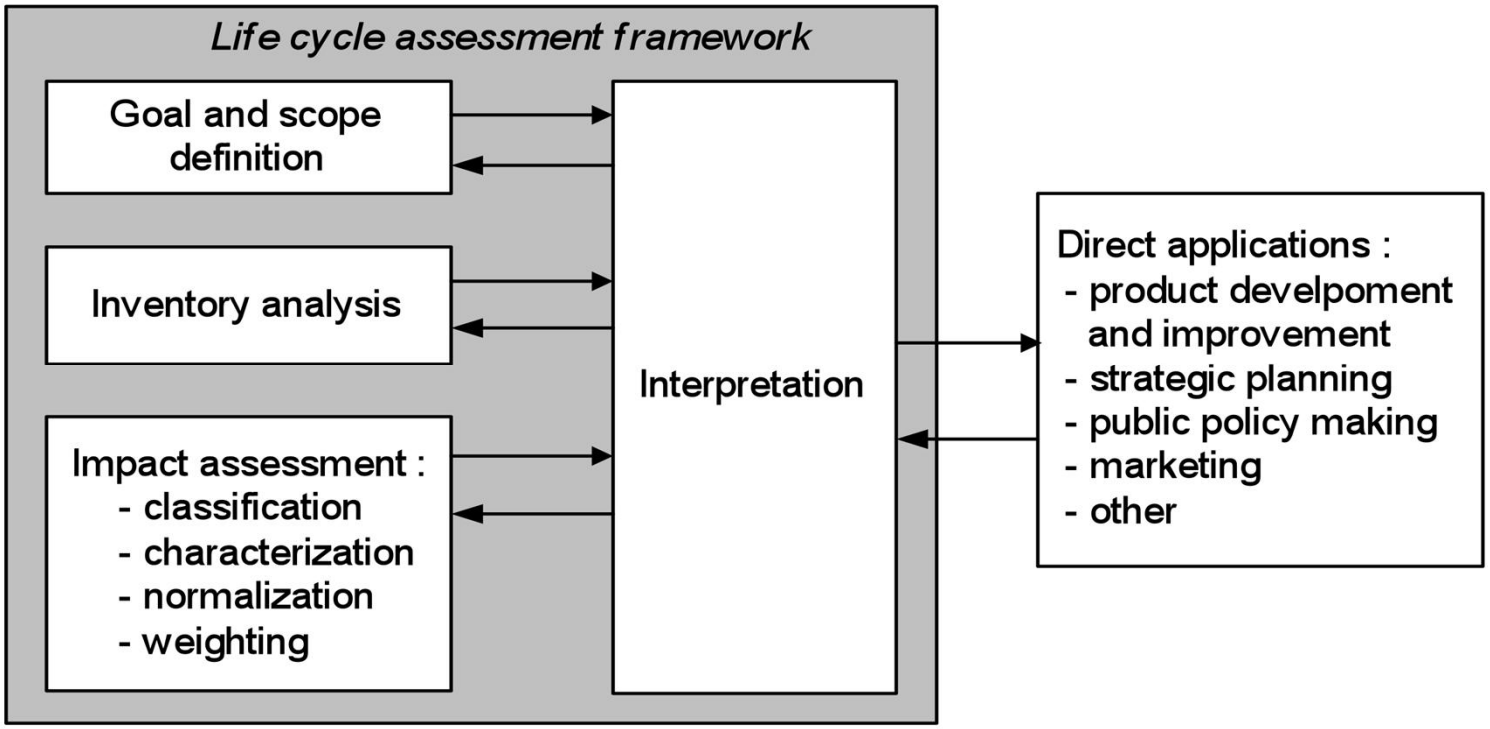
**Bridge Life Cycle Optimisation**




- **Assessing LCA consequences of a given bridge design, with/without a corresponding Life Cycle Plan (LCP)**
- **LCA method developed in ETSI – based on masses**

# The LCA framework (ISO 14041)

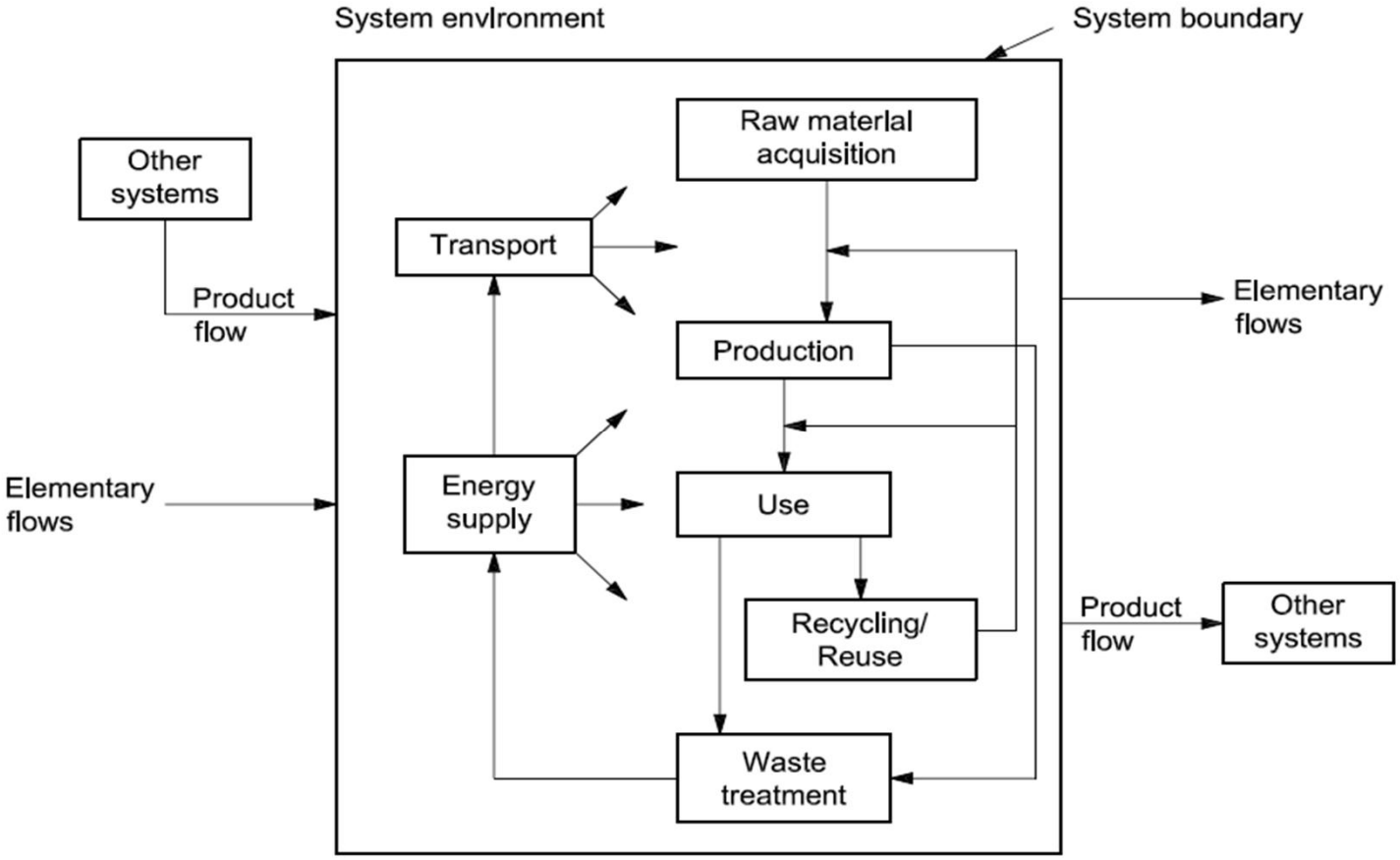
**Bridge Life Cycle Optimisation**




- ISO 14041:2006 specifies how to carry out LCA
- Further detailed by ILCD Handbook of LCA (2010-11)
- And Product Category Rules (PCR) on how to develop Environmental Product Declarations (EPD) in Construction

# Phase 1: Goal and scope definition

**Bridge Life Cycle Optimisation**




- **What would this look like for a road bridge? (purpose, function, system boundary)**

# Phase 2: Life Cycle Inventory Analysis

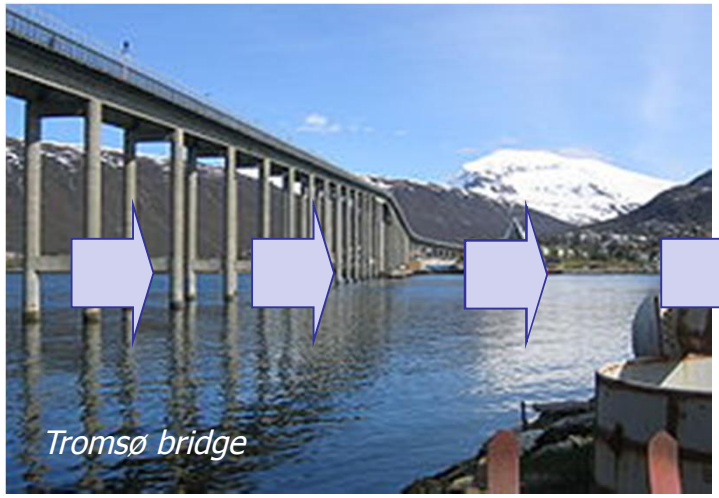
**Bridge Life Cycle Optimisation**

**Example – A bridge system:**

**Service to society (Functional Unit)**

**Production of elements** → **Transportation to bridge site** → **Construction on site** → **Operation, repair & maintenance** → **End-of-life management**

- **Foundation**
- **Slope & embankment**
- **Abutments & piers**
- **Main load-bearing structure**
- **Secondary load-bearing structure**
- **Bridge equipment**




**Extra traffic generation**

**LCI = Quantifying the environmental stressors from the system**

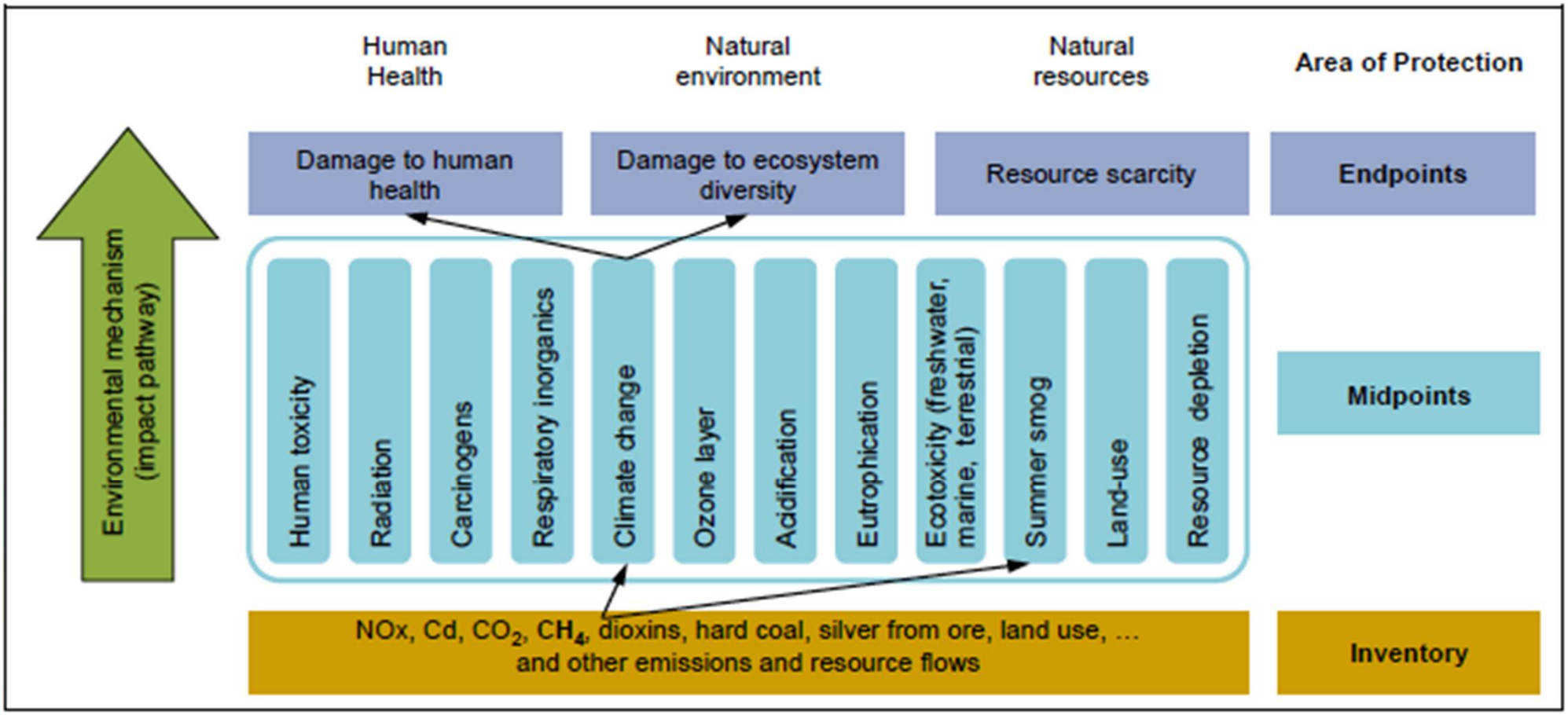
**Resource consumption**
**(Renewable resources, non-renewable resources)**

**Emissions to water, air and soil**
**($NH_3$, $NO_x$, $SO_2$, P, $CO_2$, $CH_4$, $NO_2$, CFC-11, CO, etc.)**

# Phase 3: Life cycle impact assessment

**Bridge Life Cycle Optimisation**

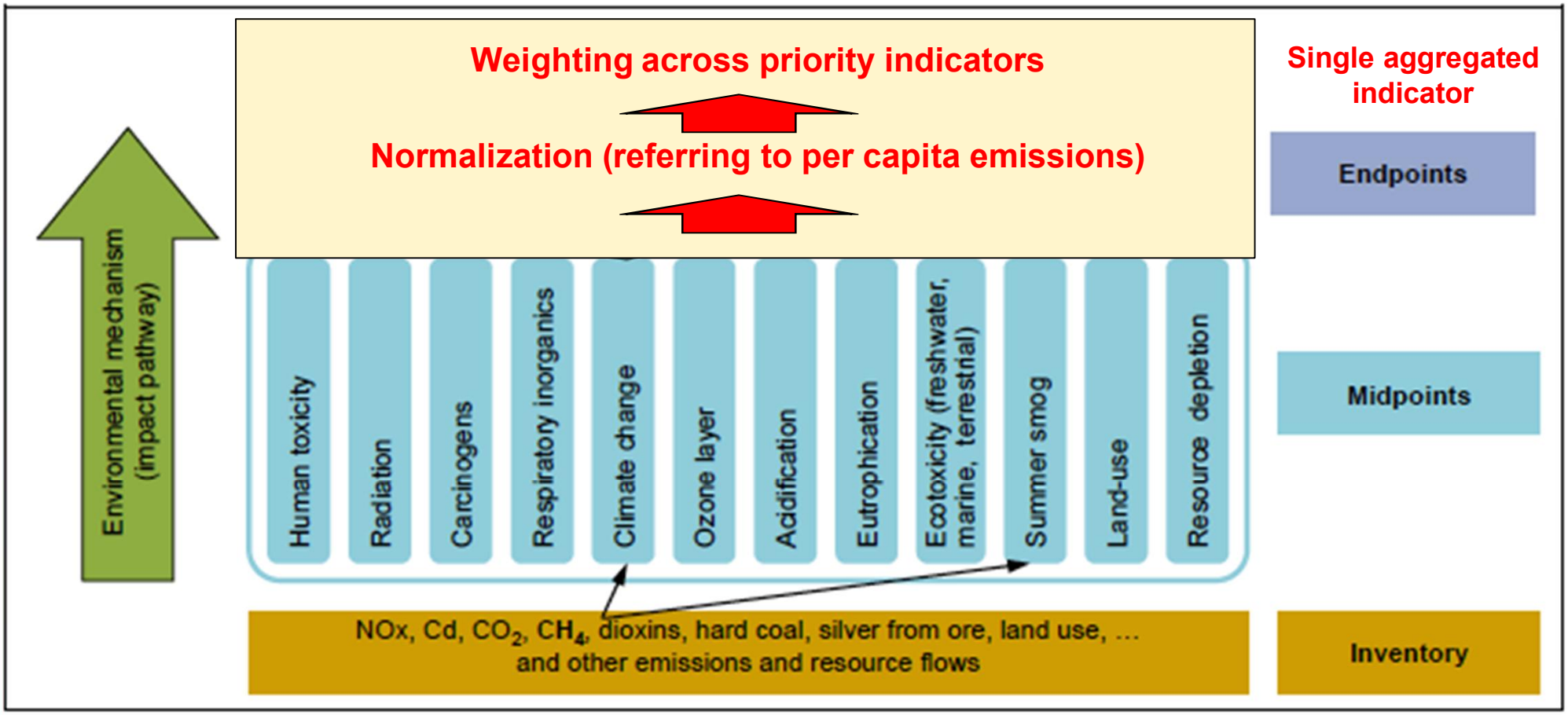
- **Grouping and aggregating different environmental impacts is needed for decision support!**



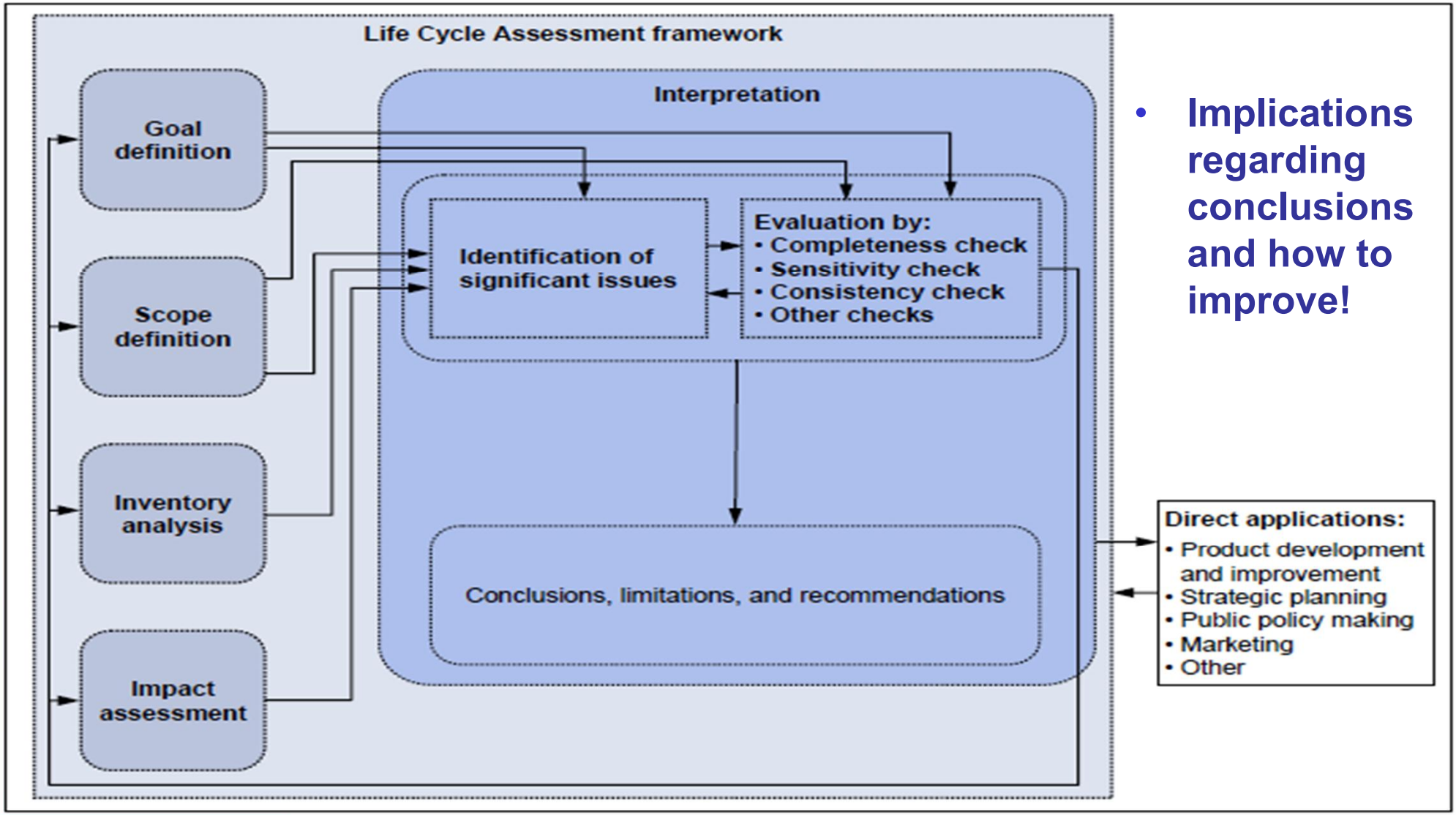
# Phase 3: Life cycle impact assessment

**Bridge Life Cycle Optimisation**

- **Alternative aggregation method as decided upon in ETSI-II**



# Phase 4: Interpretation



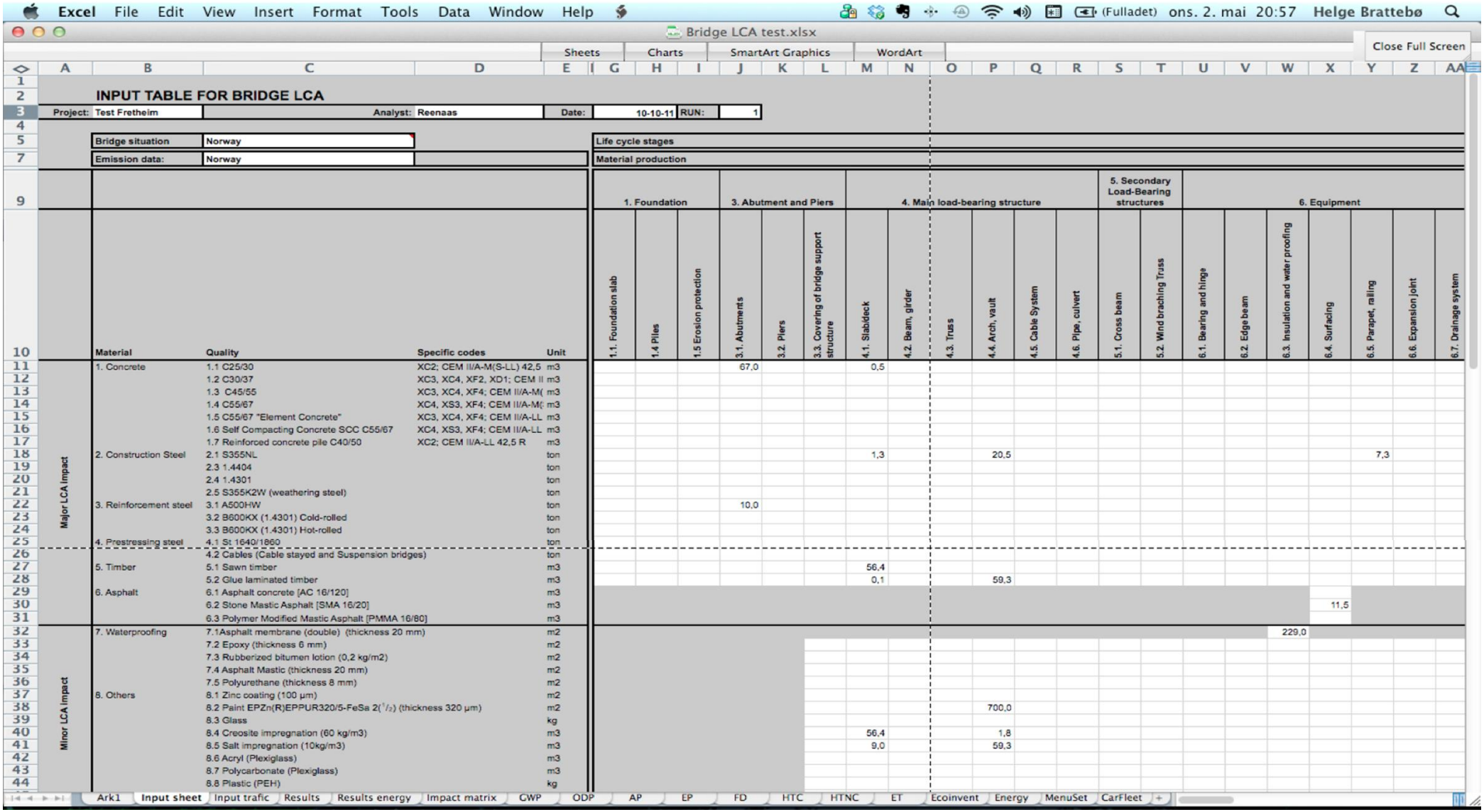

- **Implications regarding conclusions and how to improve!**

# The ETSI *BridgeLCA* tool

**Bridge Life Cycle Optimisation**

- ETSI definitions are used
  - Bridge system and elements
  - Bridge life cycle plan
- State-of-the-art LCA methodology is used
  - ILCD Handbook of LCA
  - PCR for Constructions
  - Ecoinvent v2 LCA database (default emission values)
- Excel model
  - Prepared for using national specific or project specific emission data
  - Calculating selected midpoint-level environmental impact categories, and normalized and weighted results
  - Calculating energy consumption
  - User friendliness and flexibility (ETSI-II recommendations)

# *BridgeLCA*
# Input: Major and minor impact materials



Bridge LCA test.xlsx

**INPUT TABLE FOR BRIDGE LCA**

| Project: | Test Fretheim | Analyst: | Reenaas | Date: | 10-10-11 | RUN: | 1 |
|---|---|---|---|---|---|---|---|

| | |
|---|---|
| Bridge situation | Norway |
| Emission data: | Norway |

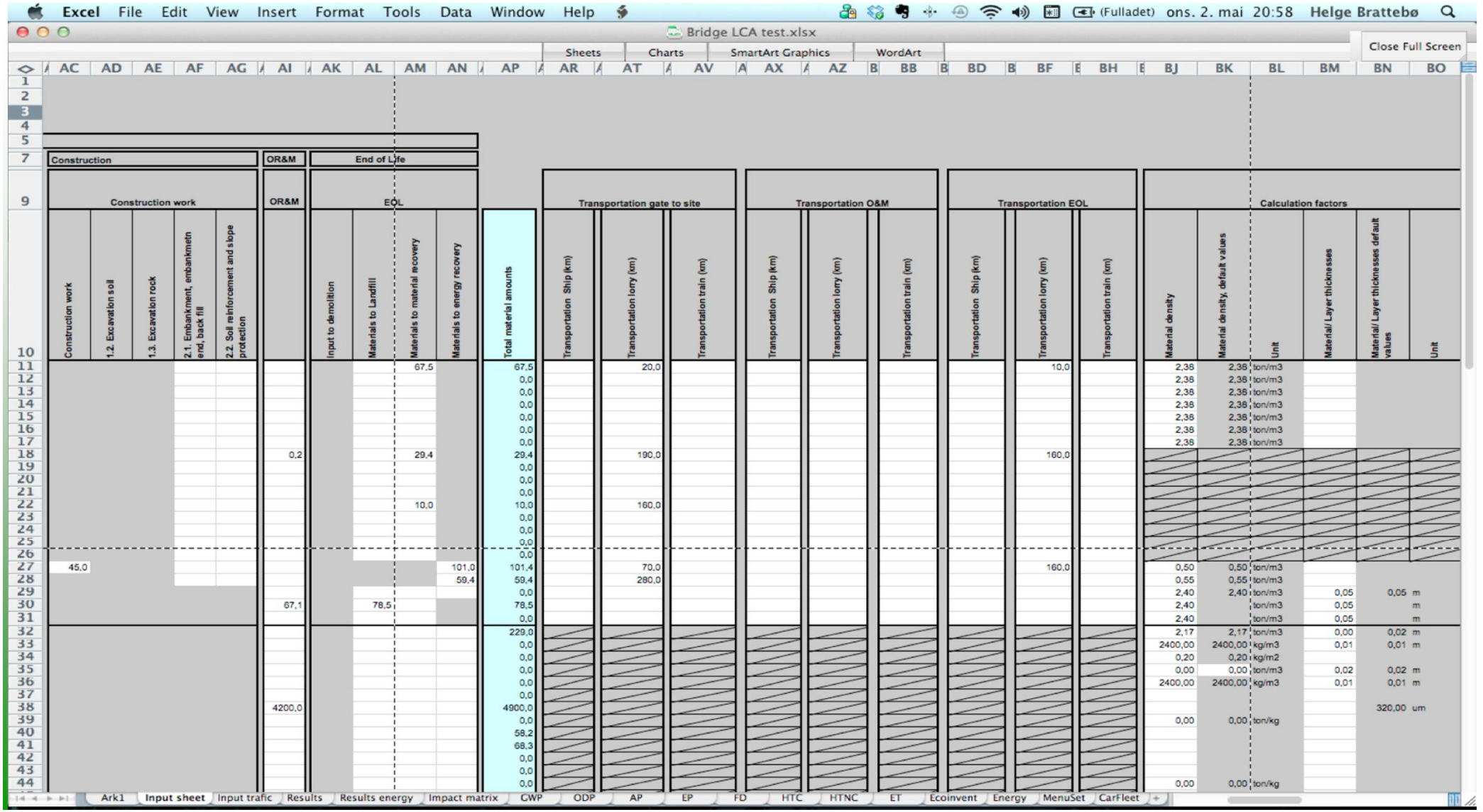
Life cycle stages

Material production

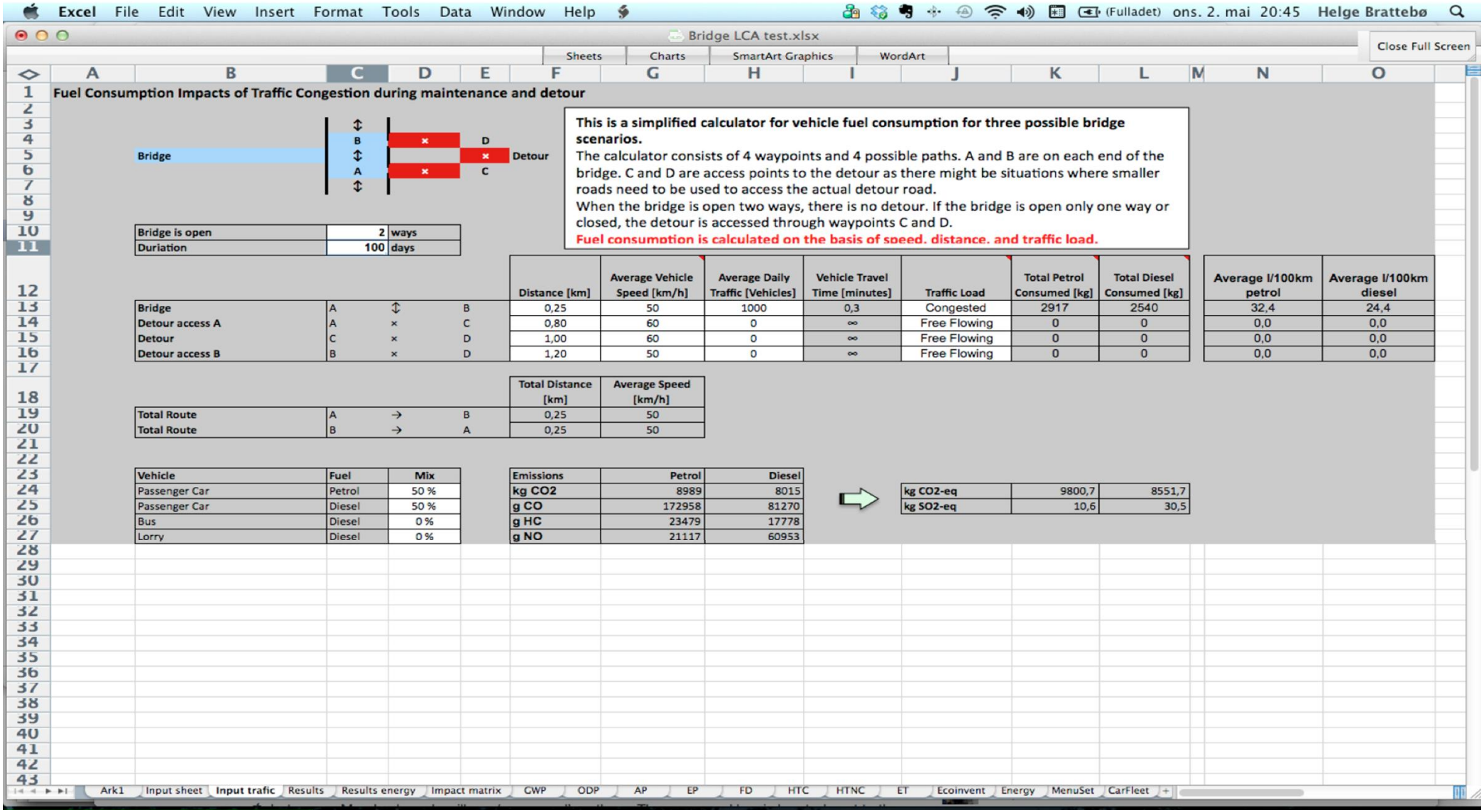
| | Material | Quality | Specific codes | Unit | 1.1. Foundation slab | 1.4 Piles | 1.5 Erosion protection | 3.1. Abutments | 3.2. Piers | 3.3. Covering of bridge support structure | 4.1. Slabdeck | 4.2. Beam, girder | 4.3. Truss | 4.4. Arch, vault | 4.5. Cable System | 4.6. Pipe, culvert | 5.1. Cross beam | 5.2. Wind braching Truss | 6.1. Bearing and hinge | 6.2. Edge beam | 6.3. Insulation and water proofing | 6.4. Surfacing | 6.5. Parapet, railing | 6.6. Expansion joint | 6.7. Drainage system |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 1. Foundation | | | 3. Abutment and Piers | | | 4. Main load-bearing structure | | | | | | 5. Secondary Load-Bearing structures | | 6. Equipment | | | | | | | |
| Major LCA Impact | 1. Concrete | 1.1 C25/30 | XC2; CEM II/A-M(S-LL) 42,5 | m3 | | | | 67,0 | | | 0,5 | | | | | | | | | | | | | | |
| | | 1.2 C30/37 | XC3, XC4, XF2, XD1; CEM II | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 1.3 C45/55 | XC3, XC4, XF4; CEM II/A-M( | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 1.4 C55/67 | XC4, XS3, XF4; CEM II/A-M( | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 1.5 C55/67 "Element Concrete" | XC3, XC4, XF4; CEM II/A-LL | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 1.6 Self Compacting Concrete SCC C55/67 | XC4, XS3, XF4; CEM II/A-LL | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 1.7 Reinforced concrete pile C40/50 | XC2; CEM II/A-LL 42,5 R | m3 | | | | | | | | | | | | | | | | | | | | | |
| | 2. Construction Steel | 2.1 S355NL | | ton | | | | | | | 1,3 | | | 20,5 | | | | | | | | | 7,3 | | |
| | | 2.3 1.4404 | | ton | | | | | | | | | | | | | | | | | | | | | |
| | | 2.4 1.4301 | | ton | | | | | | | | | | | | | | | | | | | | | |
| | | 2.5 S355K2W (weathering steel) | | ton | | | | | | | | | | | | | | | | | | | | | |
| | 3. Reinforcement steel | 3.1 A500HW | | ton | | | | 10,0 | | | | | | | | | | | | | | | | | |
| | | 3.2 B600KX (1.4301) Cold-rolled | | ton | | | | | | | | | | | | | | | | | | | | | |
| | | 3.3 B600KX (1.4301) Hot-rolled | | ton | | | | | | | | | | | | | | | | | | | | | |
| | 4. Prestressing steel | 4.1 St 1640/1860 | | ton | | | | | | | | | | | | | | | | | | | | | |
| | | 4.2 Cables (Cable stayed and Suspension bridges) | | ton | | | | | | | | | | | | | | | | | | | | | |
| | 5. Timber | 5.1 Sawn timber | | m3 | | | | | | | 56,4 | | | | | | | | | | | | | | |
| | | 5.2 Glue laminated timber | | m3 | | | | | | | 0,1 | | | 59,3 | | | | | | | | | | | |
| | 6. Asphalt | 6.1 Asphalt concrete [AC 16/120] | | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 6.2 Stone Mastic Asphalt [SMA 16/20] | | m3 | | | | | | | | | | | | | | | | | | 11,5 | | | |
| | | 6.3 Polymer Modified Mastic Asphalt [PMMA 16/80] | | m3 | | | | | | | | | | | | | | | | | | | | | |
| Minor LCA Impact | 7. Waterproofing | 7.1Asphalt membrane (double) (thickness 20 mm) | | m2 | | | | | | | | | | | | | | | | | 229,0 | | | | |
| | | 7.2 Epoxy (thickness 6 mm) | | m2 | | | | | | | | | | | | | | | | | | | | | |
| | | 7.3 Rubberized bitumen lotion (0,2 kg/m2) | | m2 | | | | | | | | | | | | | | | | | | | | | |
| | | 7.4 Asphalt Mastic (thickness 20 mm) | | m2 | | | | | | | | | | | | | | | | | | | | | |
| | | 7.5 Polyurethane (thickness 8 mm) | | m2 | | | | | | | | | | | | | | | | | | | | | |
| | 8. Others | 8.1 Zinc coating (100 µm) | | m2 | | | | | | | | | | | | | | | | | | | | | |
| | | 8.2 Paint EPZn(R)EPPUR320/5-FeSa 2(1/2) (thickness 320 µm) | | m2 | | | | | | | | | | 700,0 | | | | | | | | | | | |
| | | 8.3 Glass | | kg | | | | | | | | | | | | | | | | | | | | | |
| | | 8.4 Creosite impregnation (60 kg/m3) | | m3 | | | | | | | 56,4 | | | 1,8 | | | | | | | | | | | |
| | | 8.5 Salt impregnation (10kg/m3) | | m3 | | | | | | | 9,0 | | | 59,3 | | | | | | | | | | | |
| | | 8.6 Acryl (Plexiglass) | | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 8.7 Polycarbonate (Plexiglass) | | m3 | | | | | | | | | | | | | | | | | | | | | |
| | | 8.8 Plastic (PEH) | | kg | | | | | | | | | | | | | | | | | | | | | |

Ark1 | Input sheet | Input trafic | Results | Results energy | Impact matrix | GWP | ODP | AP | EP | FD | HTC | HTNC | ET | Ecoinvent | Energy | MenuSet | CarFleet

# *BridgeLCA*
# Input: Transportation of materials



# *BridgeLCA*
# Input Traffic Sheet (due to bridge closure)



Excel File Edit View Insert Format Tools Data Window Help (Fulladet) ons. 2. mai 20:45 Helge Brattebø

Bridge LCA test.xlsx

Sheets | Charts | SmartArt Graphics | WordArt | Close Full Screen

**Fuel Consumption Impacts of Traffic Congestion during maintenance and detour**



**This is a simplified calculator for vehicle fuel consumption for three possible bridge scenarios.**
The calculator consists of 4 waypoints and 4 possible paths. A and B are on each end of the bridge. C and D are access points to the detour as there might be situations where smaller roads need to be used to access the actual detour road.
When the bridge is open two ways, there is no detour. If the bridge is open only one way or closed, the detour is accessed through waypoints C and D.
Fuel consumption is calculated on the basis of speed, distance, and traffic load.

| | | |
|---|---|---|
| Bridge is open | 2 | ways |
| Duriation | 100 | days |

| | | | | Distance [km] | Average Vehicle Speed [km/h] | Average Daily Traffic [Vehicles] | Vehicle Travel Time [minutes] | Traffic Load | Total Petrol Consumed [kg] | Total Diesel Consumed [kg] | Average l/100km petrol | Average l/100km diesel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bridge | A | ↕ | B | 0,25 | 50 | 1000 | 0,3 | Congested | 2917 | 2540 | 32,4 | 24,4 |
| Detour access A | A | × | C | 0,80 | 60 | 0 | ∞ | Free Flowing | 0 | 0 | 0,0 | 0,0 |
| Detour | C | × | D | 1,00 | 60 | 0 | ∞ | Free Flowing | 0 | 0 | 0,0 | 0,0 |
| Detour access B | B | × | D | 1,20 | 50 | 0 | ∞ | Free Flowing | 0 | 0 | 0,0 | 0,0 |

| | | | | Total Distance [km] | Average Speed [km/h] |
|---|---|---|---|---|---|
| Total Route | A | → | B | 0,25 | 50 |
| Total Route | B | → | A | 0,25 | 50 |

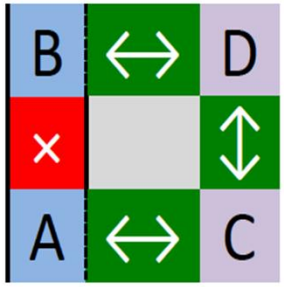
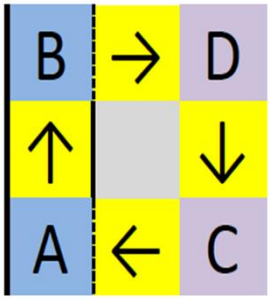
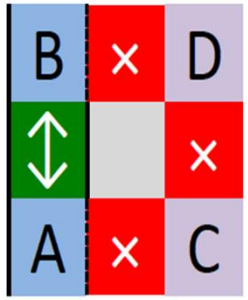
| Vehicle | Fuel | Mix |
|---|---|---|
| Passenger Car | Petrol | 50 % |
| Passenger Car | Diesel | 50 % |
| Bus | Diesel | 0 % |
| Lorry | Diesel | 0 % |

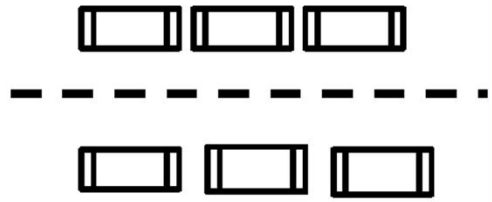
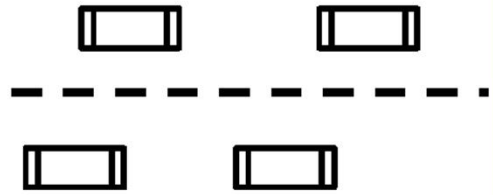
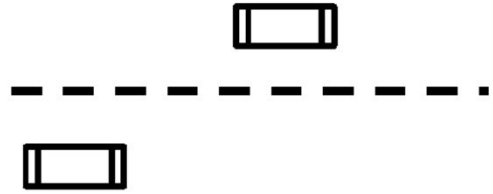
| Emissions | Petrol | Diesel |
|---|---|---|
| kg CO2 | 8989 | 8015 |
| g CO | 172958 | 81270 |
| g HC | 23479 | 17778 |
| g NO | 21117 | 60953 |

| | | |
|---|---|---|
| kg CO2-eq | 9800,7 | 8551,7 |
| kg SO2-eq | 10,6 | 30,5 |

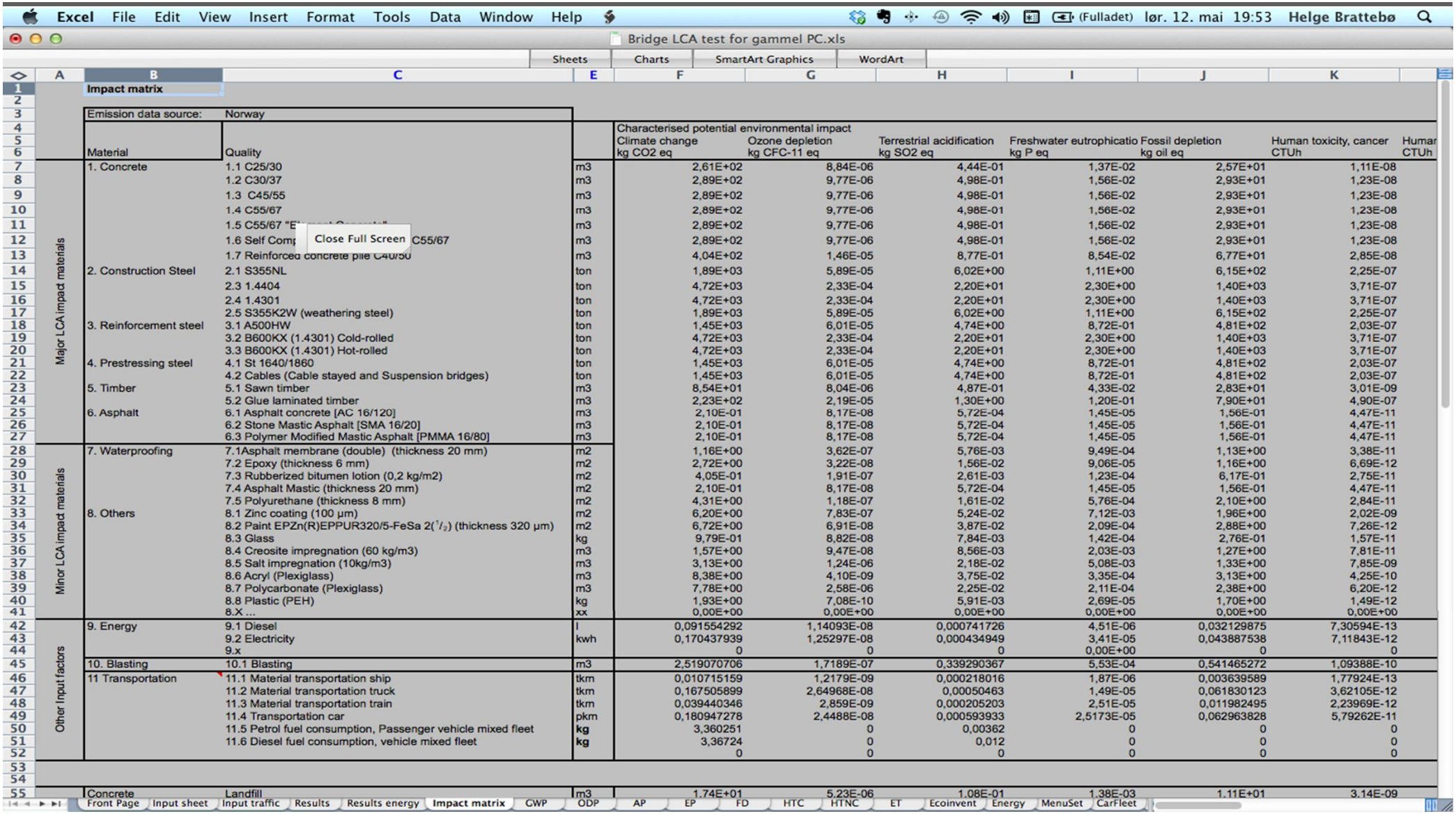
Ark1 | Input sheet | Input trafic | Results | Results energy | Impact matrix | CWP | ODP | AP | EP | FD | HTC | HTNC | ET | Ecoinvent | Energy | MenuSet | CarFleet

# *BridgeLCA*
# Extra traffic generation model

| Bridge scenario | Graphic | Description |
|---|---|---|
| 0 |   | Bridge is closed, all traffic goes through detour path |
| 1 |   | Bridge is open one way, other traffic takes detour path |
| 2 |   | Bridge is open both ways, no traffic uses detour path |

| Traffic Load | Decription | Graphic image |
|---|---|---|
| **Congested** | At low speeds, traffic will have high RPM/rapid gear change due to start-stop motion. This causes high fuel consumption. |  |
| **Average** | Average traffic (40-70 km/h) will have smooth motion/little gear change. Low RPM/high gears lead to low fuel consumption for most vehicles |  |
| **Free Flowing** | High speed traffic (>70 km/h) will have slightly higher RPM than average traffic, and therefore higher fuel consumption. |  |

# *BridgeLCA*
# Impact matrix (Ecoinvent or other data)



Excel File Edit View Insert Format Tools Data Window Help (Fulladet) lør. 12. mai 19:53 Helge Brattebø

Bridge LCA test for gammel PC.xls

Sheets | Charts | SmartArt Graphics | WordArt

Close Full Screen

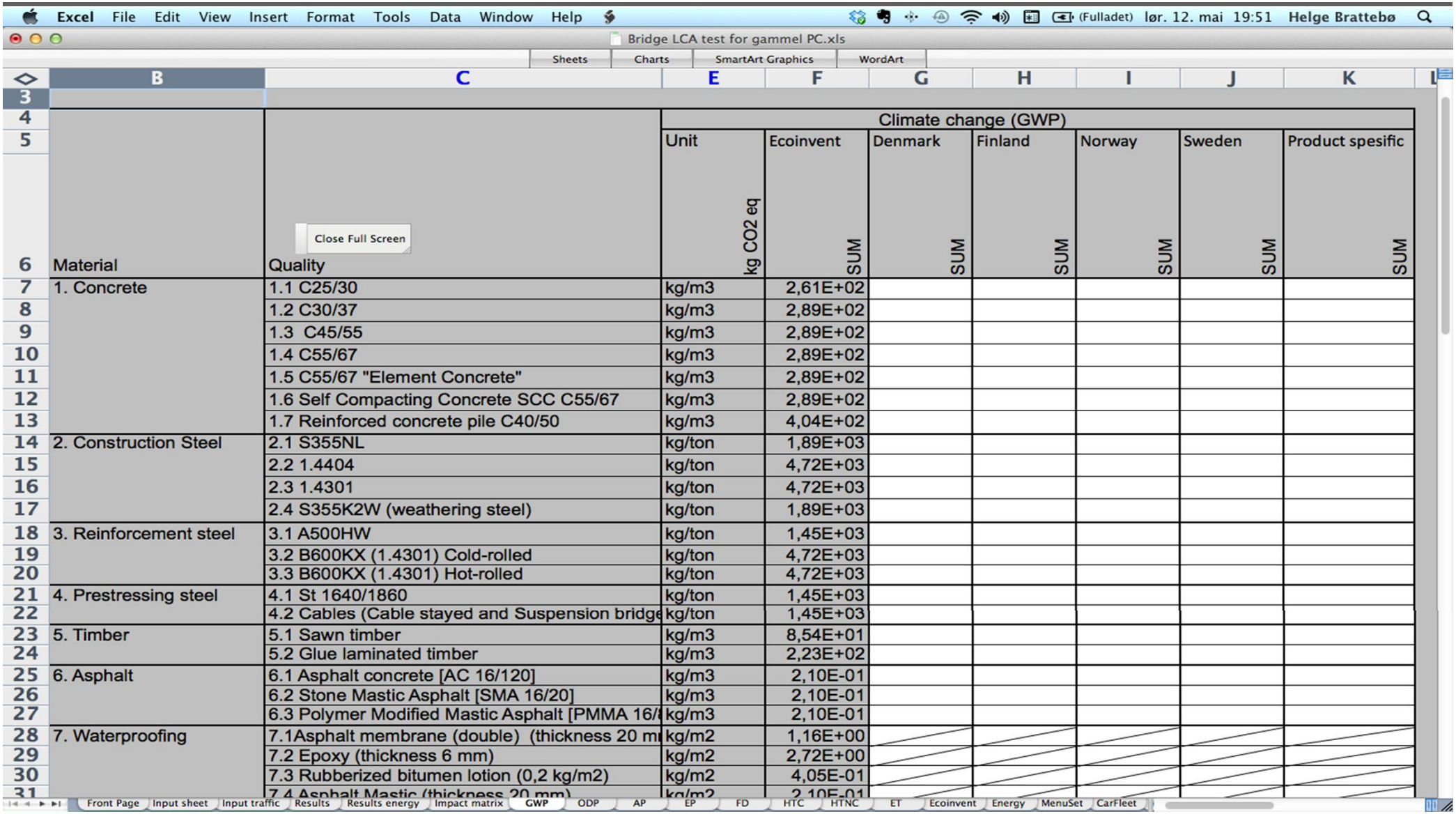
**Impact matrix**

Emission data source: Norway

| | Material | Quality | | Characterised potential environmental impact: Climate change kg CO2 eq | Ozone depletion kg CFC-11 eq | Terrestrial acidification kg SO2 eq | Freshwater eutrophicatio kg P eq | Fossil depletion kg oil eq | Human toxicity, cancer CTUh | Humar CTUh |
|---|---|---|---|---|---|---|---|---|---|---|
| Major LCA impact materials | 1. Concrete | 1.1 C25/30 | m3 | 2,61E+02 | 8,84E-06 | 4,44E-01 | 1,37E-02 | 2,57E+01 | 1,11E-08 | |
| | | 1.2 C30/37 | m3 | 2,89E+02 | 9,77E-06 | 4,98E-01 | 1,56E-02 | 2,93E+01 | 1,23E-08 | |
| | | 1.3 C45/55 | m3 | 2,89E+02 | 9,77E-06 | 4,98E-01 | 1,56E-02 | 2,93E+01 | 1,23E-08 | |
| | | 1.4 C55/67 | m3 | 2,89E+02 | 9,77E-06 | 4,98E-01 | 1,56E-02 | 2,93E+01 | 1,23E-08 | |
| | | 1.5 C55/67 "E | m3 | 2,89E+02 | 9,77E-06 | 4,98E-01 | 1,56E-02 | 2,93E+01 | 1,23E-08 | |
| | | 1.6 Self Comp C55/67 | m3 | 2,89E+02 | 9,77E-06 | 4,98E-01 | 1,56E-02 | 2,93E+01 | 1,23E-08 | |
| | | 1.7 Reinforced concrete pile C40/50 | m3 | 4,04E+02 | 1,46E-05 | 8,77E-01 | 8,54E-02 | 6,77E+01 | 2,85E-08 | |
| | 2. Construction Steel | 2.1 S355NL | ton | 1,89E+03 | 5,89E-05 | 6,02E+00 | 1,11E+00 | 6,15E+02 | 2,25E-07 | |
| | | 2.3 1.4404 | ton | 4,72E+03 | 2,33E-04 | 2,20E+01 | 2,30E+00 | 1,40E+03 | 3,71E-07 | |
| | | 2.4 1.4301 | ton | 4,72E+03 | 2,33E-04 | 2,20E+01 | 2,30E+00 | 1,40E+03 | 3,71E-07 | |
| | | 2.5 S355K2W (weathering steel) | ton | 1,89E+03 | 5,89E-05 | 6,02E+00 | 1,11E+00 | 6,15E+02 | 2,25E-07 | |
| | 3. Reinforcement steel | 3.1 A500HW | ton | 1,45E+03 | 6,01E-05 | 4,74E+00 | 8,72E-01 | 4,81E+02 | 2,03E-07 | |
| | | 3.2 B600KX (1.4301) Cold-rolled | ton | 4,72E+03 | 2,33E-04 | 2,20E+01 | 2,30E+00 | 1,40E+03 | 3,71E-07 | |
| | | 3.3 B600KX (1.4301) Hot-rolled | ton | 4,72E+03 | 2,33E-04 | 2,20E+01 | 2,30E+00 | 1,40E+03 | 3,71E-07 | |
| | 4. Prestressing steel | 4.1 St 1640/1860 | ton | 1,45E+03 | 6,01E-05 | 4,74E+00 | 8,72E-01 | 4,81E+02 | 2,03E-07 | |
| | | 4.2 Cables (Cable stayed and Suspension bridges) | ton | 1,45E+03 | 6,01E-05 | 4,74E+00 | 8,72E-01 | 4,81E+02 | 2,03E-07 | |
| | 5. Timber | 5.1 Sawn timber | m3 | 8,54E+01 | 8,04E-06 | 4,87E-01 | 4,33E-02 | 2,83E+01 | 3,01E-09 | |
| | | 5.2 Glue laminated timber | m3 | 2,23E+02 | 2,19E-05 | 1,30E+00 | 1,20E-01 | 7,90E+01 | 4,90E-07 | |
| | 6. Asphalt | 6.1 Asphalt concrete [AC 16/120] | m3 | 2,10E-01 | 8,17E-08 | 5,72E-04 | 1,45E-05 | 1,56E-01 | 4,47E-11 | |
| | | 6.2 Stone Mastic Asphalt [SMA 16/20] | m3 | 2,10E-01 | 8,17E-08 | 5,72E-04 | 1,45E-05 | 1,56E-01 | 4,47E-11 | |
| | | 6.3 Polymer Modified Mastic Asphalt [PMMA 16/80] | m3 | 2,10E-01 | 8,17E-08 | 5,72E-04 | 1,45E-05 | 1,56E-01 | 4,47E-11 | |
| Minor LCA impact materials | 7. Waterproofing | 7.1Asphalt membrane (double) (thickness 20 mm) | m2 | 1,16E+00 | 3,62E-07 | 5,76E-03 | 9,49E-04 | 1,13E+00 | 3,38E-11 | |
| | | 7.2 Epoxy (thickness 6 mm) | m2 | 2,72E+00 | 3,22E-08 | 1,56E-02 | 9,06E-05 | 1,16E+00 | 6,69E-12 | |
| | | 7.3 Rubberized bitumen lotion (0,2 kg/m2) | m2 | 4,05E-01 | 1,91E-07 | 2,61E-03 | 1,23E-04 | 6,17E-01 | 2,75E-11 | |
| | | 7.4 Asphalt Mastic (thickness 20 mm) | m2 | 2,10E-01 | 8,17E-08 | 5,72E-04 | 1,45E-05 | 1,56E-01 | 4,47E-11 | |
| | | 7.5 Polyurethane (thickness 8 mm) | m2 | 4,31E+00 | 1,18E-07 | 1,61E-02 | 5,76E-04 | 2,10E+00 | 2,84E-11 | |
| | 8. Others | 8.1 Zinc coating (100 µm) | m2 | 6,20E+00 | 7,83E-07 | 5,24E-02 | 7,12E-03 | 1,96E+00 | 2,02E-09 | |
| | | 8.2 Paint EPZn(R)EPPUR320/5-FeSa 2(1/2) (thickness 320 µm) | m2 | 6,72E+00 | 6,91E-08 | 3,87E-02 | 2,09E-04 | 2,88E+00 | 7,26E-12 | |
| | | 8.3 Glass | kg | 9,79E-01 | 8,82E-08 | 7,84E-03 | 1,42E-04 | 2,76E-01 | 1,57E-11 | |
| | | 8.4 Creosite impregnation (60 kg/m3) | m3 | 1,57E+00 | 9,47E-08 | 8,56E-03 | 2,03E-03 | 1,27E+00 | 7,81E-11 | |
| | | 8.5 Salt impregnation (10kg/m3) | m3 | 3,13E+00 | 1,24E-06 | 2,18E-02 | 5,08E-03 | 1,33E+00 | 7,85E-09 | |
| | | 8.6 Acryl (Plexiglass) | m3 | 8,38E+00 | 4,10E-09 | 3,75E-02 | 3,35E-04 | 3,13E+00 | 4,25E-10 | |
| | | 8.7 Polycarbonate (Plexiglass) | m3 | 7,78E+00 | 2,58E-06 | 2,25E-02 | 2,11E-04 | 2,38E+00 | 6,20E-12 | |
| | | 8.8 Plastic (PEH) | kg | 1,93E+00 | 7,08E-10 | 5,91E-03 | 2,69E-05 | 1,70E+00 | 1,49E-12 | |
| | | 8.X ... | xx | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | |
| Other Input factors | 9. Energy | 9.1 Diesel | l | 0,091554292 | 1,14093E-08 | 0,000741726 | 4,51E-06 | 0,032129875 | 7,30594E-13 | |
| | | 9.2 Electricity | kwh | 0,170437939 | 1,25297E-08 | 0,000434949 | 3,41E-05 | 0,043887538 | 7,11843E-12 | |
| | | 9.x | | 0 | 0 | 0 | 0,00E+00 | 0 | 0 | |
| | 10. Blasting | 10.1 Blasting | m3 | 2,519070706 | 1,7189E-07 | 0,339290367 | 5,53E-04 | 0,541465272 | 1,09388E-10 | |
| | 11 Transportation | 11.1 Material transportation ship | tkm | 0,010715159 | 1,2179E-09 | 0,000218016 | 1,87E-06 | 0,003639589 | 1,77924E-13 | |
| | | 11.2 Material transportation truck | tkm | 0,167505899 | 2,64968E-08 | 0,00050463 | 1,49E-05 | 0,061830123 | 3,62105E-12 | |
| | | 11.3 Material transportation train | tkm | 0,039440346 | 2,859E-09 | 0,000205203 | 2,51E-05 | 0,011982495 | 2,23969E-12 | |
| | | 11.4 Transportation car | pkm | 0,180947278 | 2,4488E-08 | 0,000593933 | 2,5173E-05 | 0,062963828 | 5,79262E-11 | |
| | | 11.5 Petrol fuel consumption, Passenger vehicle mixed fleet | **kg** | 3,360251 | 0 | 0,00362 | 0 | 0 | 0 | |
| | | 11.6 Diesel fuel consumption, vehicle mixed fleet | **kg** | 3,36724 | 0 | 0,012 | 0 | 0 | 0 | |
| | | | | 0 | 0 | 0 | 0 | 0 | 0 | |
| | Concrete | Landfill | m3 | 1.74E+01 | 5.23E-06 | 1.08E-01 | 1.38E-03 | 1.11E+01 | 3.14E-09 | |

Front Page | Input sheet | Input traffic | Results | Results energy | Impact matrix | GWP | ODP | AP | EP | FD | HTC | HTNC | ET | Ecoinvent | Energy | MenuSet | CarFleet

# *BridgeLCA*
# Ecoinvent, national or project specific data



Excel File Edit View Insert Format Tools Data Window Help (Fulladet) lør. 12. mai 19:51 Helge Brattebø

Bridge LCA test for gammel PC.xls

Sheets Charts SmartArt Graphics WordArt

Close Full Screen

| | Material | Quality | Unit (kg CO2 eq) | Climate change (GWP) Ecoinvent SUM | Denmark SUM | Finland SUM | Norway SUM | Sweden SUM | Product spesific SUM |
|---|---|---|---|---|---|---|---|---|---|
| 7 | 1. Concrete | 1.1 C25/30 | kg/m3 | 2,61E+02 | | | | | |
| 8 | | 1.2 C30/37 | kg/m3 | 2,89E+02 | | | | | |
| 9 | | 1.3 C45/55 | kg/m3 | 2,89E+02 | | | | | |
| 10 | | 1.4 C55/67 | kg/m3 | 2,89E+02 | | | | | |
| 11 | | 1.5 C55/67 "Element Concrete" | kg/m3 | 2,89E+02 | | | | | |
| 12 | | 1.6 Self Compacting Concrete SCC C55/67 | kg/m3 | 2,89E+02 | | | | | |
| 13 | | 1.7 Reinforced concrete pile C40/50 | kg/m3 | 4,04E+02 | | | | | |
| 14 | 2. Construction Steel | 2.1 S355NL | kg/ton | 1,89E+03 | | | | | |
| 15 | | 2.2 1.4404 | kg/ton | 4,72E+03 | | | | | |
| 16 | | 2.3 1.4301 | kg/ton | 4,72E+03 | | | | | |
| 17 | | 2.4 S355K2W (weathering steel) | kg/ton | 1,89E+03 | | | | | |
| 18 | 3. Reinforcement steel | 3.1 A500HW | kg/ton | 1,45E+03 | | | | | |
| 19 | | 3.2 B600KX (1.4301) Cold-rolled | kg/ton | 4,72E+03 | | | | | |
| 20 | | 3.3 B600KX (1.4301) Hot-rolled | kg/ton | 4,72E+03 | | | | | |
| 21 | 4. Prestressing steel | 4.1 St 1640/1860 | kg/ton | 1,45E+03 | | | | | |
| 22 | | 4.2 Cables (Cable stayed and Suspension bridge | kg/ton | 1,45E+03 | | | | | |
| 23 | 5. Timber | 5.1 Sawn timber | kg/m3 | 8,54E+01 | | | | | |
| 24 | | 5.2 Glue laminated timber | kg/m3 | 2,23E+02 | | | | | |
| 25 | 6. Asphalt | 6.1 Asphalt concrete [AC 16/120] | kg/m3 | 2,10E-01 | | | | | |
| 26 | | 6.2 Stone Mastic Asphalt [SMA 16/20] | kg/m3 | 2,10E-01 | | | | | |
| 27 | | 6.3 Polymer Modified Mastic Asphalt [PMMA 16/ | kg/m3 | 2,10E-01 | | | | | |
| 28 | 7. Waterproofing | 7.1Asphalt membrane (double) (thickness 20 m | kg/m2 | 1,16E+00 | | | | | |
| 29 | | 7.2 Epoxy (thickness 6 mm) | kg/m2 | 2,72E+00 | | | | | |
| 30 | | 7.3 Rubberized bitumen lotion (0,2 kg/m2) | kg/m2 | 4,05E-01 | | | | | |
| 31 | | 7.4 Asphalt Mastic (thickness 20 mm) | kg/m2 | 2,10E-01 | | | | | |

Front Page | Input sheet | Input traffic | Results | Results energy | Impact matrix | GWP | ODP | AP | EP | FD | HTC | HTNC | ET | Ecoinvent | Energy | MenuSet | CarFleet

# *BridgeLCA*
# Results: Size of environmental impact

Bridge LCA test for gammel PC.xls

## AGGREGATED RESULTS

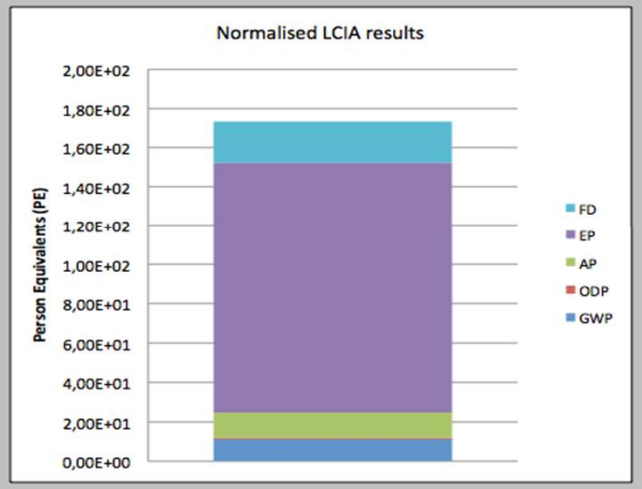
**Overall LCIA results - Midpoint results / Normalized results / Weighted results**

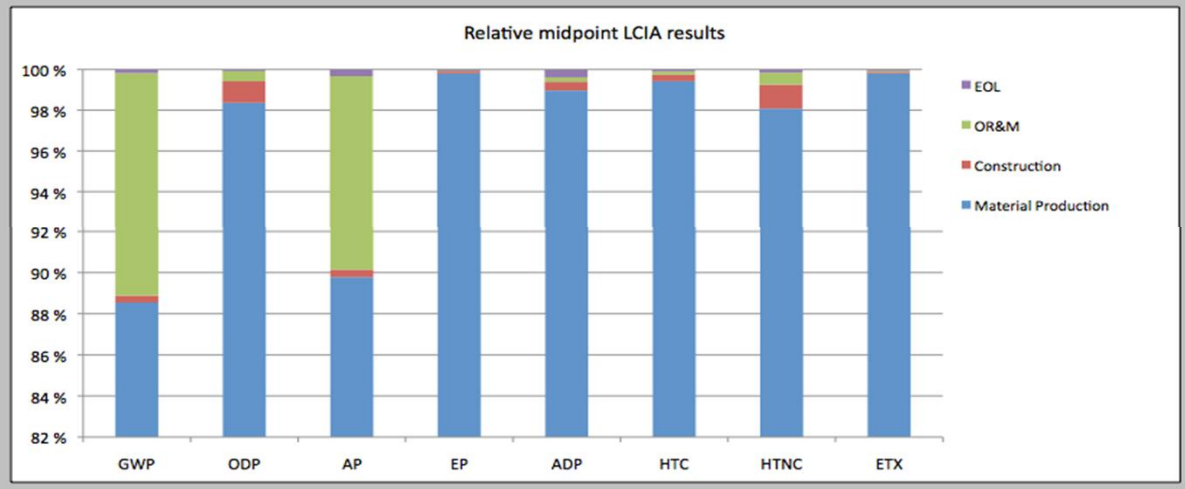
| Emission category | | Equivalent | Method | Midpoint results (kg eq.) | Normalised (PE) | Weighted (PE) |
|---|---|---|---|---|---|---|
| Climate change | GWP | kg CO2 eq | ReCiPe | 1,29E+05 | 1,15E+01 | 1,15E+01 |
| Ozone depletion | ODP | kg CFC-11 eq | ReCiPe | 5,56E-03 | 2,53E-01 | 2,53E-01 |
| Terrestrial acidification | AP | kg SO2 eq | ReCiPe | 4,45E+02 | 1,29E+01 | 1,29E+01 |
| Freshwater eutrophication | EP | kg P eq | ReCiPe | 5,30E+01 | 1,28E+02 | 1,28E+02 |
| Fossil depletion | | kg oil eq | ReCiPe | 3,49E+04 | 2,10E+01 | 2,10E+01 |
| Human toxicity, cancer | | CTUh | USEtox | 3,95E-05 | | |
| Human toxicity, non-cancer | HTNC | CTUh | USEtox | 5,56E-06 | | |
| Ecotoxicity | ETX | CTUe | USEtox | 1,06E+03 | | |

Close Full Screen

**Midpoint LCIA results - Distributed over bridge life cycle stages**

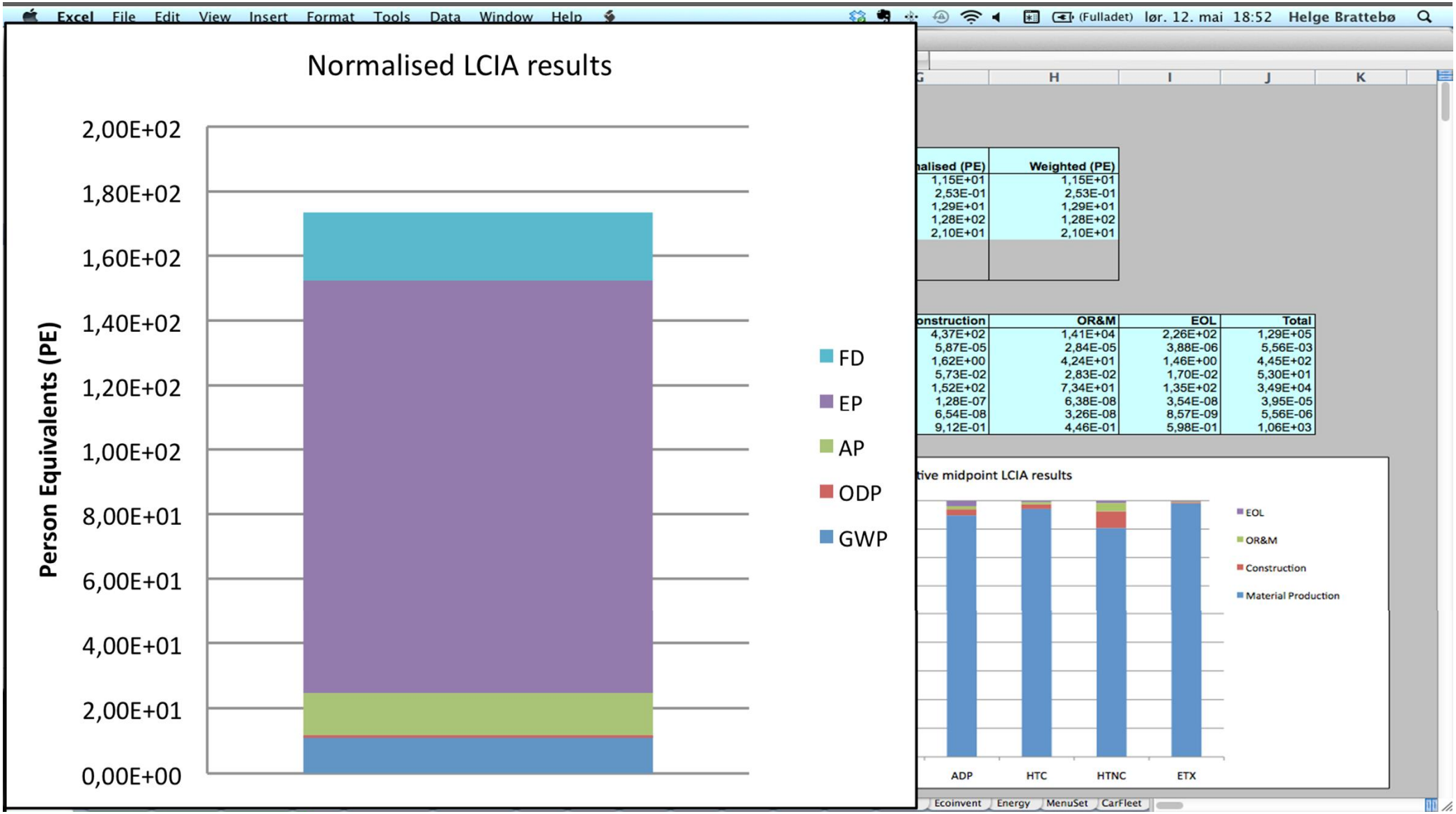
| Emission category | | Equivalents | Method | Material Production | Construction | OR&M | EOL | Total |
|---|---|---|---|---|---|---|---|---|
| Climate change | GWP | kg CO2 eq | ReCiPe | 1,14E+05 | 4,37E+02 | 1,41E+04 | 2,26E+02 | 1,29E+05 |
| Ozone depletion | ODP | kg CFC-11 eq | ReCiPe | 5,47E-03 | 5,87E-05 | 2,84E-05 | 3,88E-06 | 5,56E-03 |
| Terrestrial acidification | AP | kg SO2 eq | ReCiPe | 3,99E+02 | 1,62E+00 | 4,24E+01 | 1,46E+00 | 4,45E+02 |
| Freshwater eutrophication | EP | kg P eq | ReCiPe | 5,29E+01 | 5,73E-02 | 2,83E-02 | 1,70E-02 | 5,30E+01 |
| Fossil depletion | ADP | kg Sb eq | ReCiPe | 3,46E+04 | 1,52E+02 | 7,34E+01 | 1,35E+02 | 3,49E+04 |
| Human toxicity, cancer | HTC | CTUh | USEtox | 3,92E-05 | 1,28E-07 | 6,38E-08 | 3,54E-08 | 3,95E-05 |
| Human toxicity, non-cancer | HTNC | CTUh | USEtox | 5,45E-06 | 6,54E-08 | 3,26E-08 | 8,57E-09 | 5,56E-06 |
| Ecotoxicity | ETX | CTUe | USEtox | 1,05E+03 | 9,12E-01 | 4,46E-01 | 5,98E-01 | 1,06E+03 |



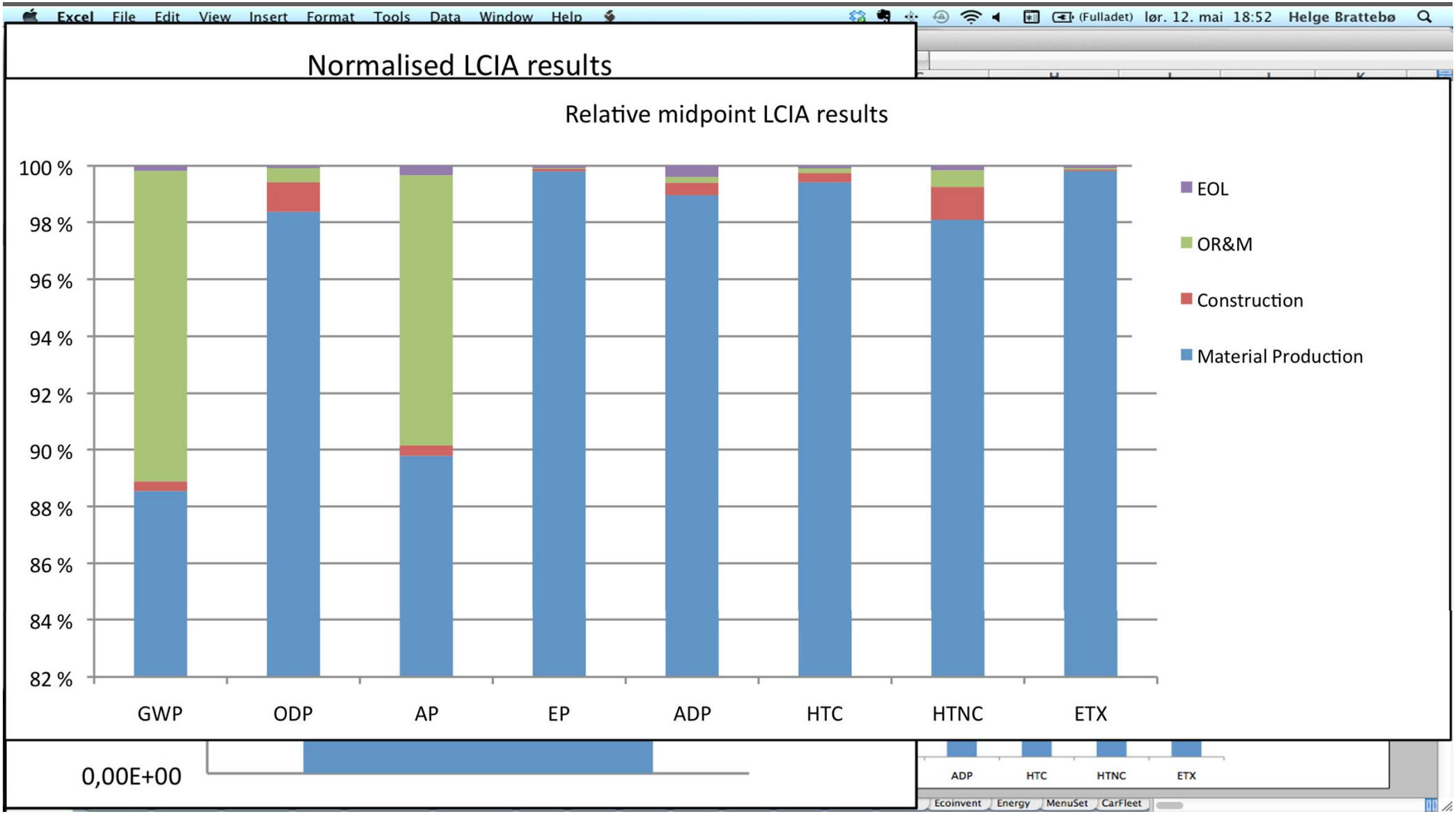




Front Page | Input sheet | Input traffic | Results | Results energy | Impact matrix | GWP | ODP | AP | EP | FD | HTC | HTNC | ET | Ecoinvent | Energy | MenuSet | CarFleet

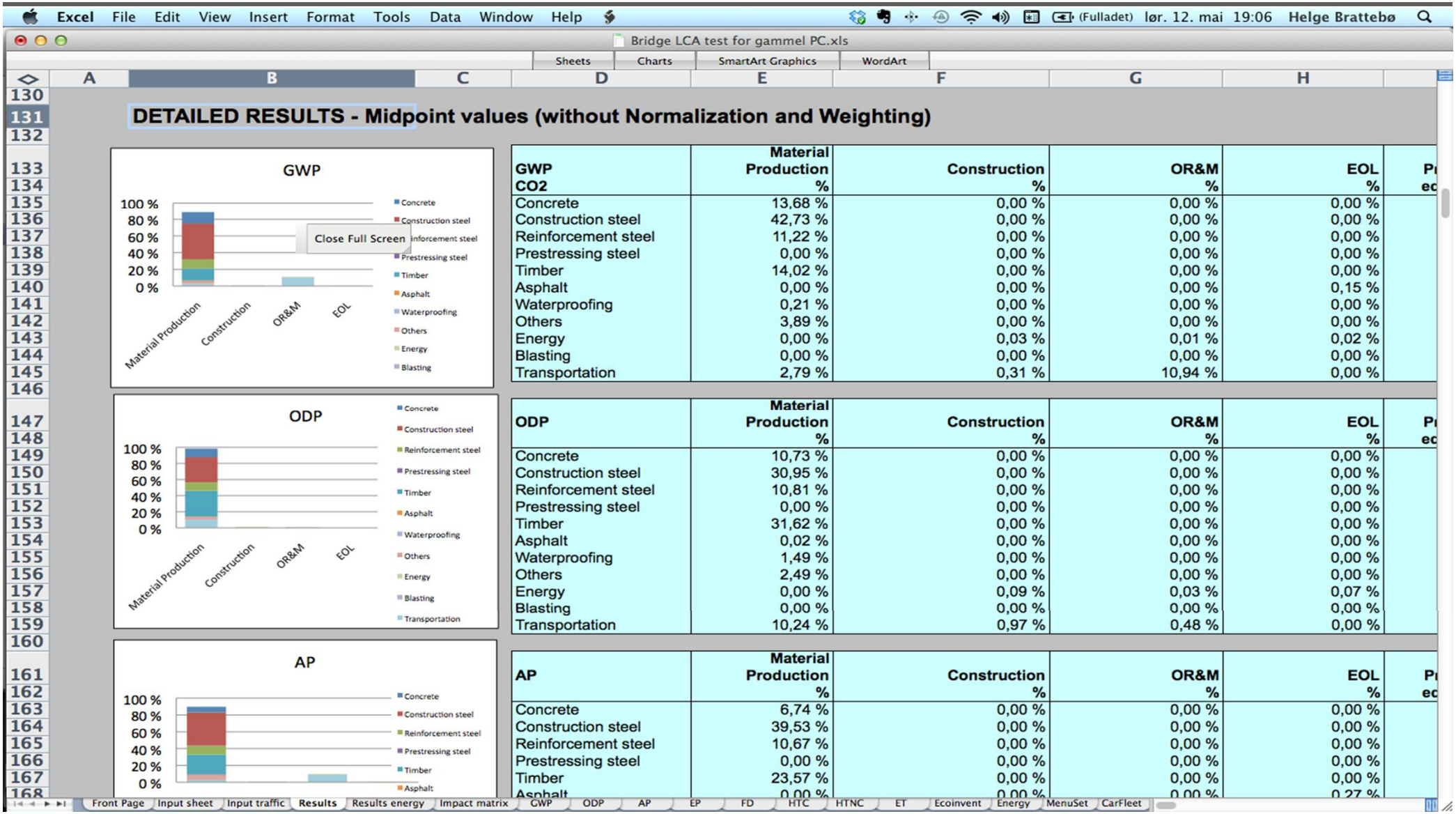
# *BridgeLCA*
# Results: Size of environmental impact



# *BridgeLCA*
# Results: Size of environmental impact



# *BridgeLCA*
# Results: Causes of impacts

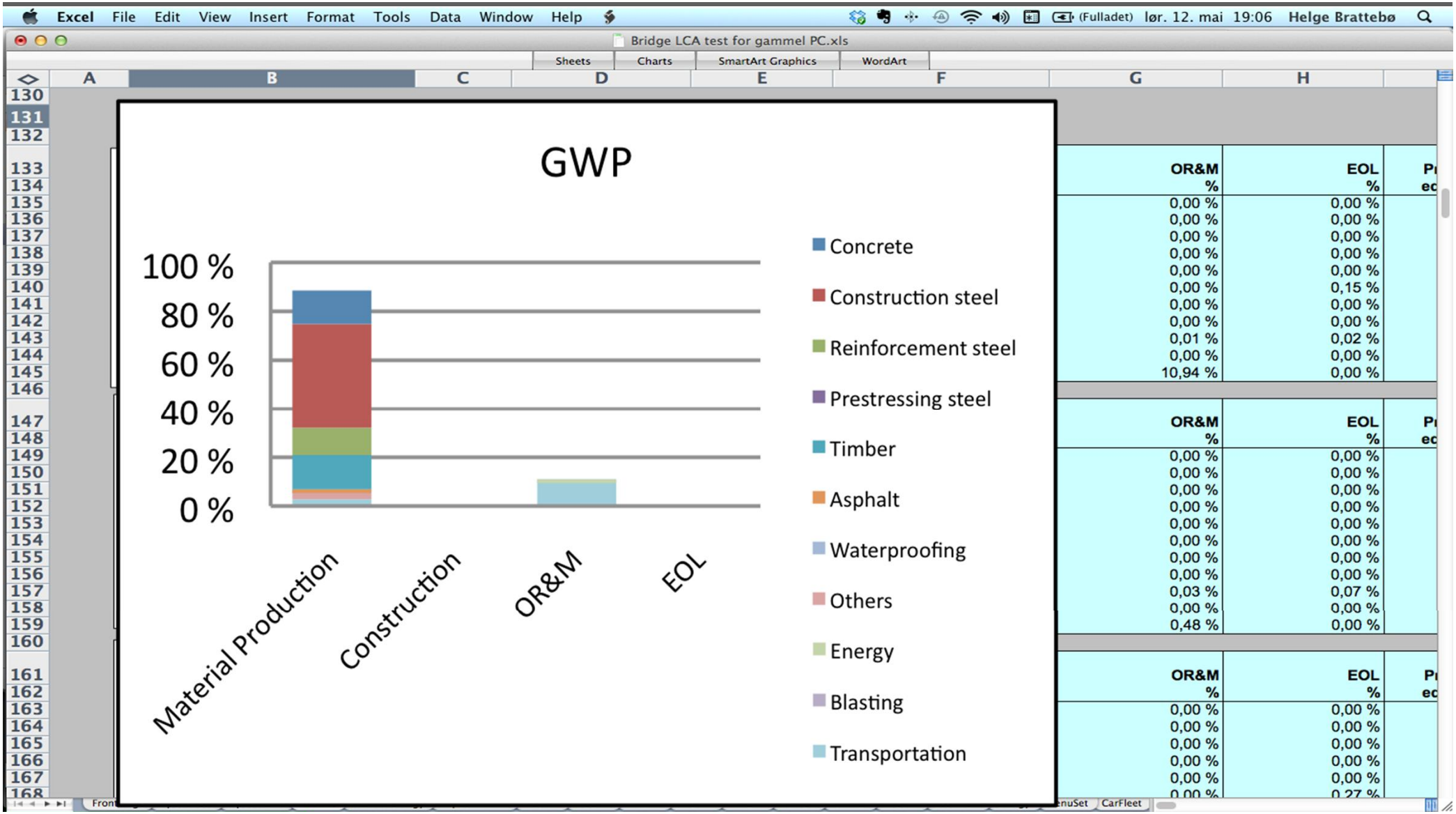



| GWP CO2 | Material Production % | Construction % | OR&M % | EOL % |
|---|---|---|---|---|
| Concrete | 13,68 % | 0,00 % | 0,00 % | 0,00 % |
| Construction steel | 42,73 % | 0,00 % | 0,00 % | 0,00 % |
| Reinforcement steel | 11,22 % | 0,00 % | 0,00 % | 0,00 % |
| Prestressing steel | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Timber | 14,02 % | 0,00 % | 0,00 % | 0,00 % |
| Asphalt | 0,00 % | 0,00 % | 0,00 % | 0,15 % |
| Waterproofing | 0,21 % | 0,00 % | 0,00 % | 0,00 % |
| Others | 3,89 % | 0,00 % | 0,00 % | 0,00 % |
| Energy | 0,00 % | 0,03 % | 0,01 % | 0,02 % |
| Blasting | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Transportation | 2,79 % | 0,31 % | 10,94 % | 0,00 % |

| ODP | Material Production % | Construction % | OR&M % | EOL % |
|---|---|---|---|---|
| Concrete | 10,73 % | 0,00 % | 0,00 % | 0,00 % |
| Construction steel | 30,95 % | 0,00 % | 0,00 % | 0,00 % |
| Reinforcement steel | 10,81 % | 0,00 % | 0,00 % | 0,00 % |
| Prestressing steel | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Timber | 31,62 % | 0,00 % | 0,00 % | 0,00 % |
| Asphalt | 0,02 % | 0,00 % | 0,00 % | 0,00 % |
| Waterproofing | 1,49 % | 0,00 % | 0,00 % | 0,00 % |
| Others | 2,49 % | 0,00 % | 0,00 % | 0,00 % |
| Energy | 0,00 % | 0,09 % | 0,03 % | 0,07 % |
| Blasting | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Transportation | 10,24 % | 0,97 % | 0,48 % | 0,00 % |

| AP | Material Production % | Construction % | OR&M % | EOL % |
|---|---|---|---|---|
| Concrete | 6,74 % | 0,00 % | 0,00 % | 0,00 % |
| Construction steel | 39,53 % | 0,00 % | 0,00 % | 0,00 % |
| Reinforcement steel | 10,67 % | 0,00 % | 0,00 % | 0,00 % |
| Prestressing steel | 0,00 % | 0,00 % | 0,00 % | 0,00 % |
| Timber | 23,57 % | 0,00 % | 0,00 % | 0,00 % |
| Asphalt | 0,00 % | 0,00 % | 0,00 % | 0,27 % |

# *BridgeLCA*
# Results: Causes of impacts



# *BridgeLCA*
# Results: Energy consumption

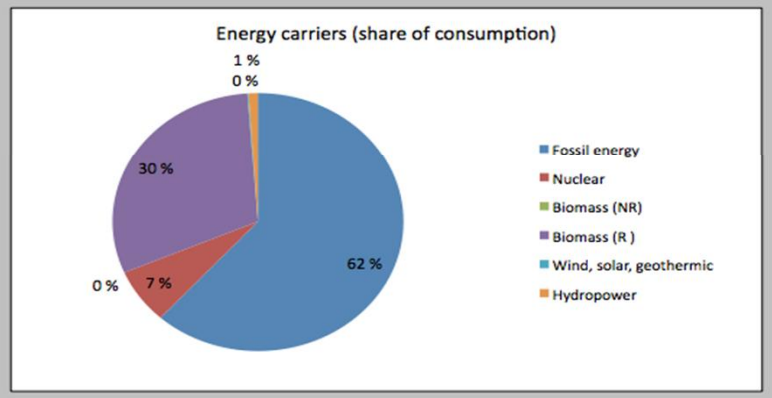
Bridge LCA test for gammel PC.xls

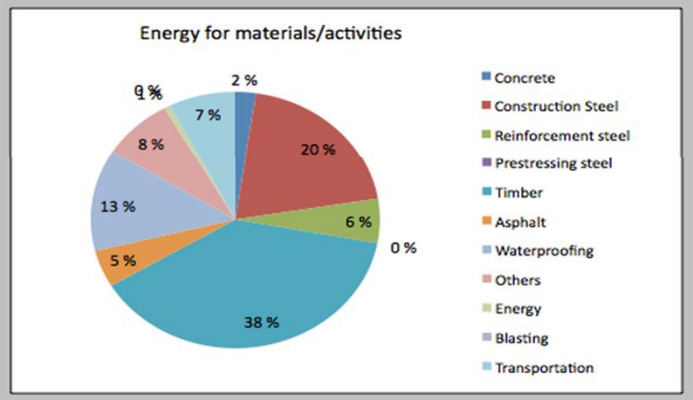
## RESULTS FROM ENERGY CALCULATIONS

| Energy | Unit | MJ | % |
|---|---|---|---|
| Non-renewable energy | Fossil energy | 2,56E+06 | 61,7 % |
| | Nuclear | 2,85E+05 | 6,9 % |
| | Biomass (NR) | 3,22E+00 | 0,0 % |
| Renewable energy | Biomass (R ) | 1,26E+06 | 30,3 % |
| | Wind, solar, geothermic | 5,28E+03 | 0,1 % |
| | Hydropower | 4,31E+04 | 1,0 % |
| **Total** | | **4,15E+06** | **100,0 %** |

Close Full Screen

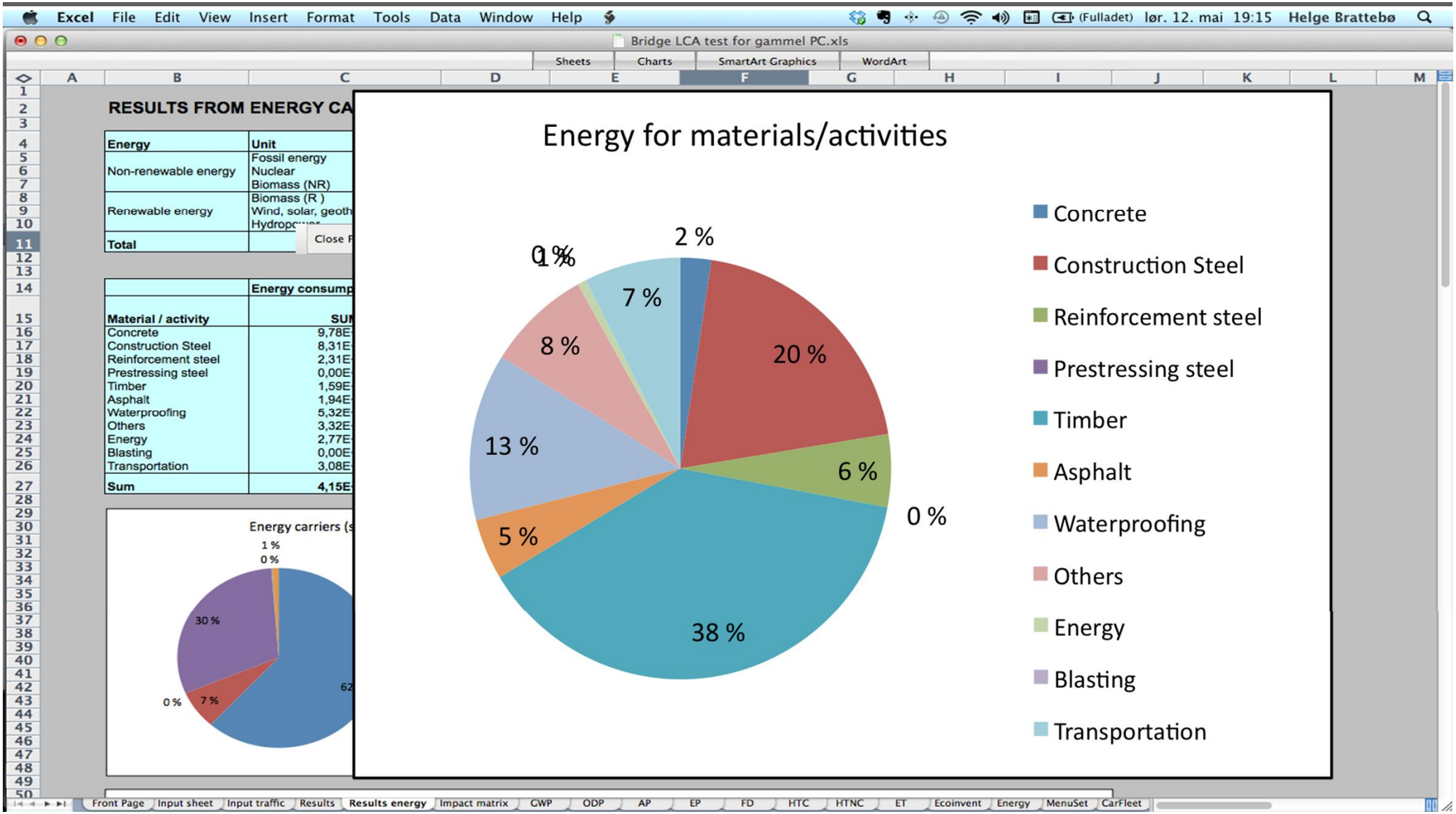
| | Energy consumption (MJ) | | | | | | |
|---|---|---|---|---|---|---|---|
| Material / activity | SUM | Fossil | Nuclear | Biomass (NR) | Biomass (R) | Wind, solar, geothermal | Hydropower |
| Concrete | 9,78E+04 | 7,28E+04 | 1,95E+04 | 2,37E-01 | 6,17E+02 | 6,64E+01 | 4,76E+03 |
| Construction Steel | 8,31E+05 | 7,54E+05 | 5,86E+04 | 3,59E-01 | 5,02E+03 | 1,06E+03 | 1,16E+04 |
| Reinforcement steel | 2,31E+05 | 2,02E+05 | 2,34E+04 | 1,21E-01 | 1,57E+03 | 4,28E+02 | 3,84E+03 |
| Prestressing steel | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Timber | 1,59E+06 | 2,64E+05 | 7,77E+04 | 7,40E-01 | 1,24E+06 | 1,32E+03 | 9,95E+03 |
| Asphalt | 1,94E+05 | 1,80E+05 | 9,31E+03 | 4,88E-01 | 1,89E+03 | 5,38E+01 | 2,11E+03 |
| Waterproofing | 5,32E+05 | 4,71E+05 | 5,13E+04 | 6,51E-01 | 3,20E+03 | 1,69E+03 | 5,08E+03 |
| Others | 3,32E+05 | 2,89E+05 | 3,61E+04 | 9,18E-02 | 2,11E+03 | 5,42E+02 | 4,41E+03 |
| Energy | 2,77E+04 | 2,70E+04 | 5,38E+02 | 3,57E-02 | 2,30E+01 | 9,97E+00 | 7,24E+01 |
| Blasting | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 | 0,00E+00 |
| Transportation | 3,08E+05 | 2,98E+05 | 8,33E+03 | 5,00E-01 | 2,85E+02 | 1,02E+02 | 1,27E+03 |
| **Sum** | **4,15E+06** | **2,56E+06** | **2,85E+05** | **3,22E+00** | **1,26E+06** | **5,28E+03** | **4,31E+04** |



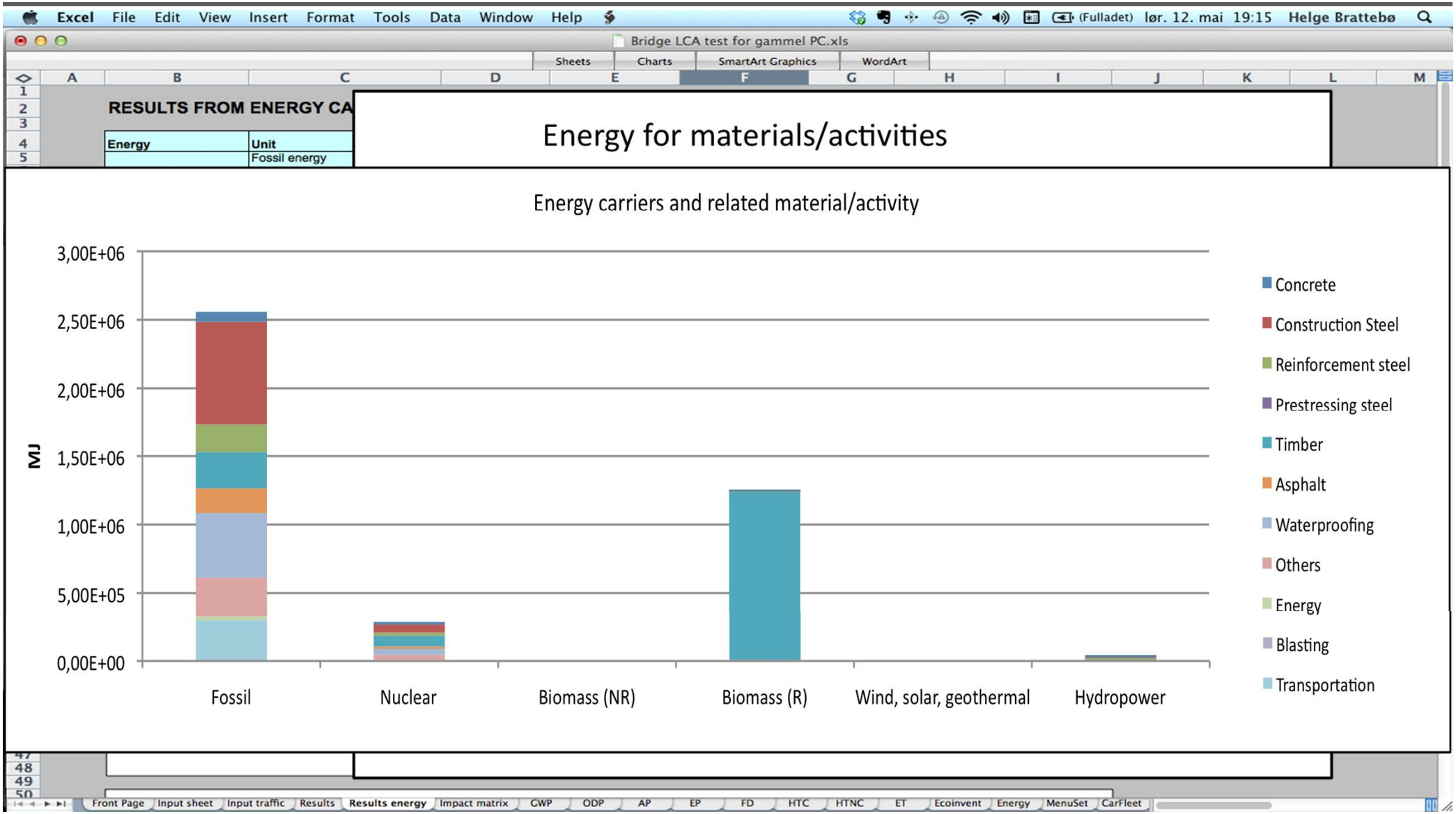




Front Page | Input sheet | Input traffic | Results | Results energy | Impact matrix | GWP | ODP | AP | EP | FD | HTC | HTNC | ET | Ecoinvent | Energy | MenuSet | CarFleet

# *BridgeLCA*
# Results: Energy consumption



# *BridgeLCA*
# Results: Energy consumption



# Conclusions and recommendations

**Bridge Life Cycle Optimisation**

- *BridgeLCA* covers all the most important LCA issues for road bridges
- The tool is flexible for use at various stages of the bridge planning and design process
- Relevance of the life cycle phases
  - Materials production is well covered
  - Construction phase needs good empirical data input!
  - OR&M phase needs inputs from a good bridge life cycle plan
  - EOL phase is probably not very important
- Recommendations
  - BridgeLCA to be tested on variety of bridges
  - Empirical data and experience to be collected
  - Database to be systematically improved