

# **APPENDIX**

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## APPENDIX A

### Material benchmark

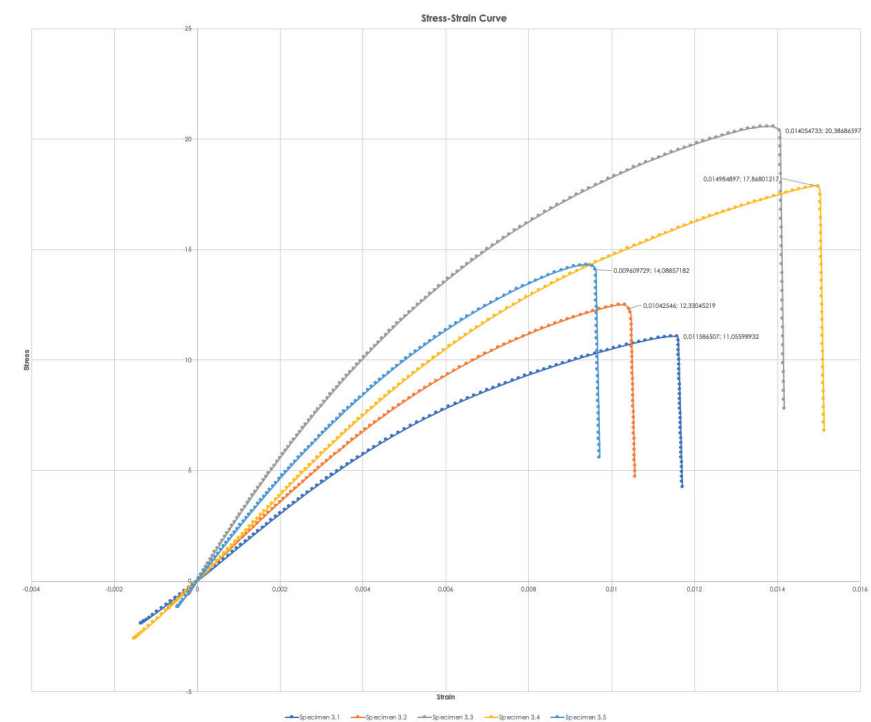
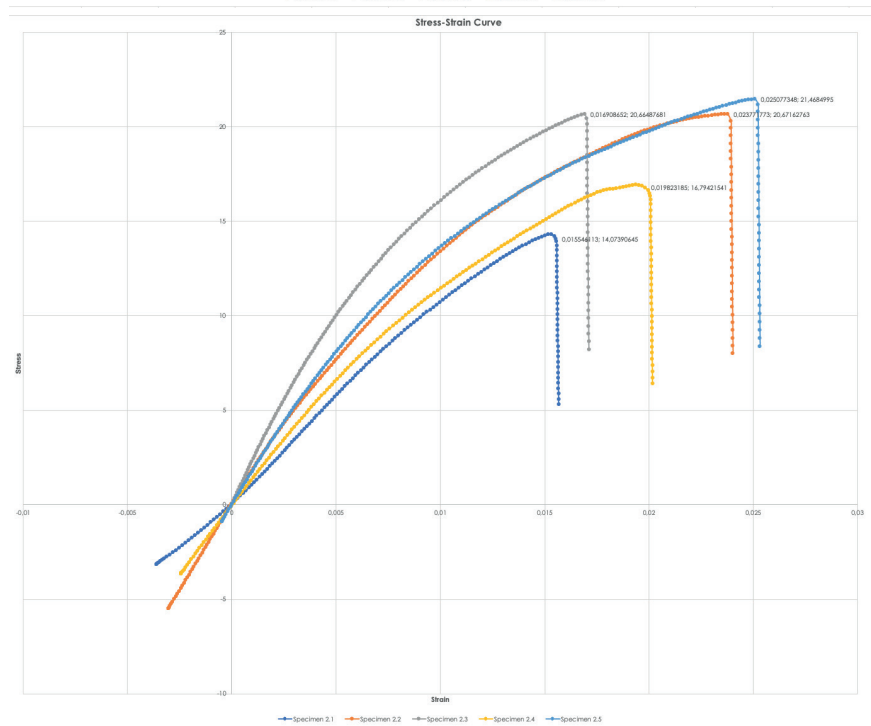
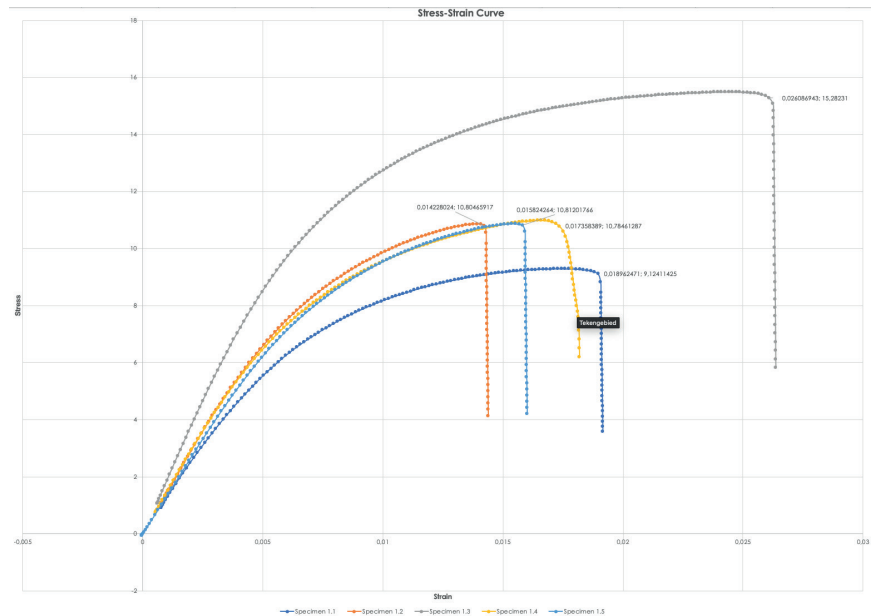
## Material Benchmark of Natural Fibre & Plastic Composite used in extrusion processing

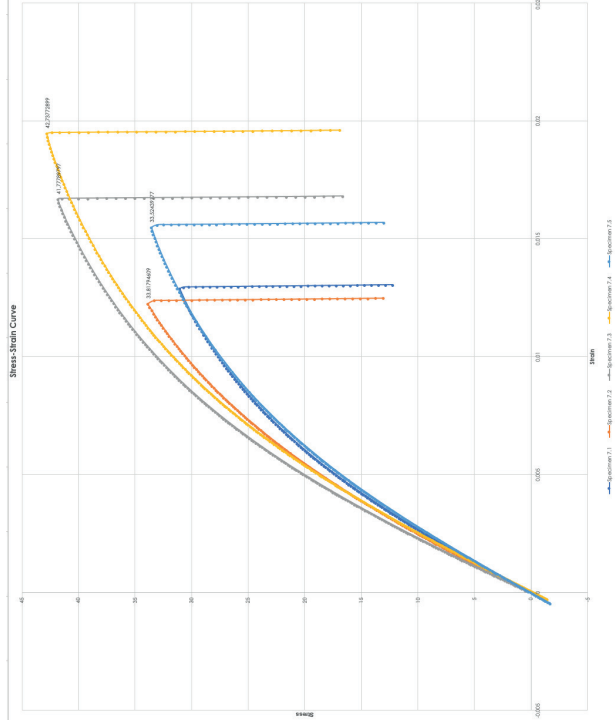
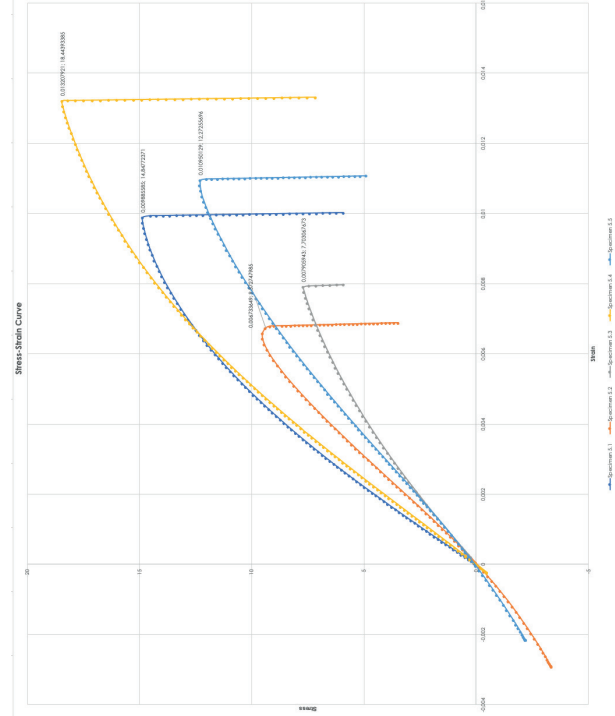
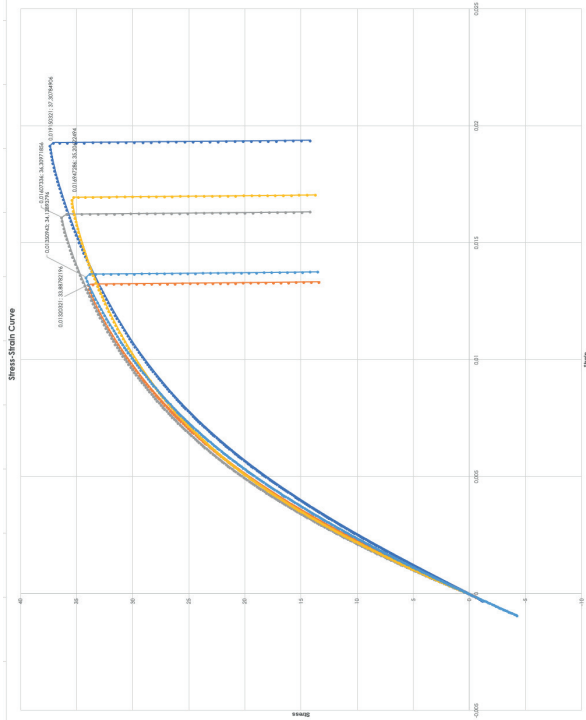
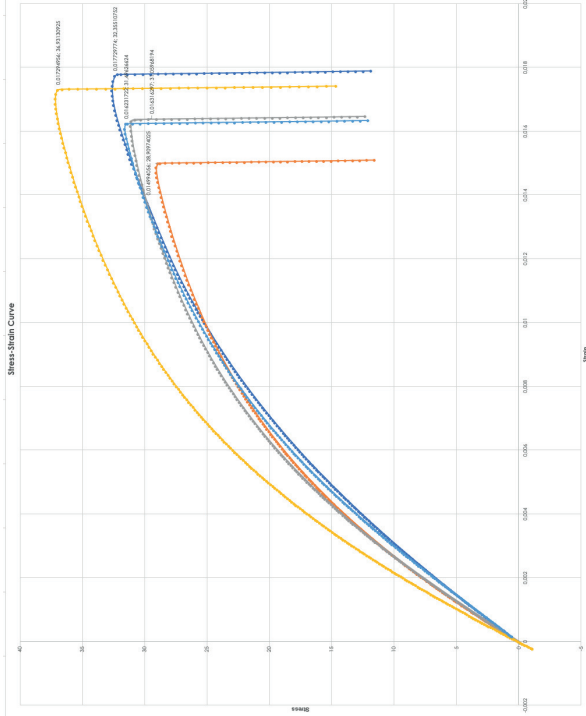
| MATERIALS                                             |               |                          |                 |                |               |                  |                            |                 |                     |                      |                              |                    |                       |
|-------------------------------------------------------|---------------|--------------------------|-----------------|----------------|---------------|------------------|----------------------------|-----------------|---------------------|----------------------|------------------------------|--------------------|-----------------------|
| Company                                               | Fibre         | Mixture                  | The wood Region | My Soda        | Akvila        | ORN/TES          | Fibrolon                   | Linagard        | OEMs                | BLB Industries       | Hiend/ NFC                   | Aesop Technologies | Form us with love/kea |
| Product                                               | Wag II        | Wag I + Wag III-V        | Chair           | Soda Stream    | Cutlery       | Bar              | Pellets                    | Outdoor Decking | Automotive Interior | Stool                | Profile system               | Pellets            | Chair                 |
| Material                                              | PP/Wood fibre | PP/WF+ Lignin +cellulose | UPM Formi 3D    | UPM EcoAce SPB | UPM EcoAce WB | PLA/Bamboo fibre | WPC for Injection moulding | WPC             | Sappi Symbio PP40   | Stora Enso DuraSense | Xy/omer PP/70% Natural Fibre | Liquidwood rPP     | 30% wood/70% rPP      |
| APPLICATIONS                                          |               |                          |                 |                |               |                  |                            |                 |                     |                      |                              |                    |                       |
| Outdoor Furniture                                     | yes           | yes                      | yes             | yes            | yes           | yes              | yes                        | yes             | yes                 | yes                  | yes                          | no                 | yes                   |
| Construction                                          | yes           | no                       | yes             | no             | no            | yes              | no                         | yes             | no                  |                      | yes                          | no                 | no                    |
| Decorative                                            | yes           | yes                      | yes             | yes            | yes           | yes              | yes                        | yes             | yes                 | yes                  | yes                          | yes                | yes                   |
| LSAM Related                                          | yes           | yes                      | yes             | no             | no            | yes              | no                         | no              | no                  | yes                  | no                           | no                 | no                    |
| EXPERIENTIAL QUALITIES & EMERGING EXPERIENTIAL ISSUES |               |                          |                 |                |               |                  |                            |                 |                     |                      |                              |                    |                       |
| Natural colour                                        | revealed      | revealed                 | recovered       | recovered      | revealed      | recovered        | revealed                   | recovered       | recovered           | revealed             | revealed                     | recovered          | revealed              |
| Imperfections                                         | high          | medium                   | low             | low            | high          | low              | medium                     | none            | none                | high                 | medium                       | low                | low                   |
| Roughness                                             | high          | high                     | low             | none           | low           | low              | low                        | none            | none                | high                 | low                          | low                | medium                |
| Scent Intesity                                        | high          | high                     | low             | n/a            | high          | n/a              | none                       | n/a             | low                 | high                 | n/a                          | n/a                | n/a                   |
| Visible Fibres                                        | high          | medium/low               | none            | low            | high          | none             | high                       | low             | none                | high                 | medium                       | none-medium        | medium                |
| Authenticity                                          | high          | high                     | medium          | medium         | high          | medium           | high                       | low             | high                | high                 | high                         | medium             | medium                |
| Naturalness                                           | high          | high-medium              | medium          | low            | high          | medium           | medium                     | medium          | low                 | high                 | medium                       | high-low           | medium                |

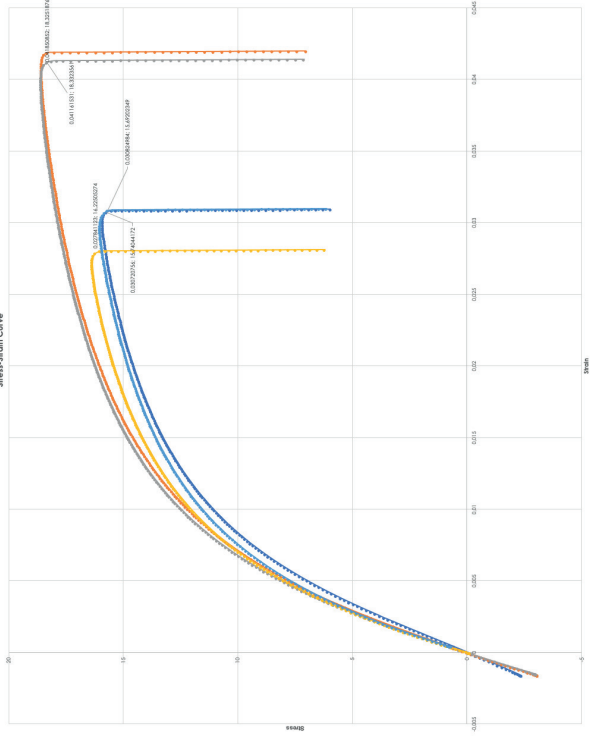
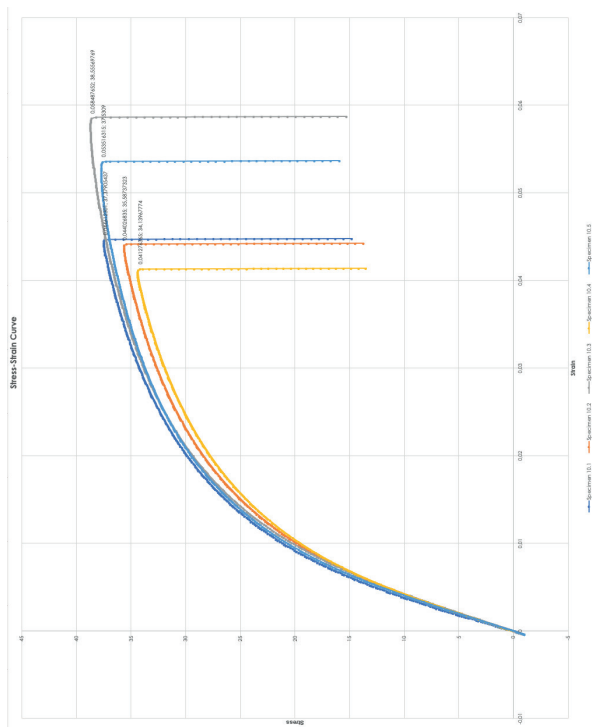
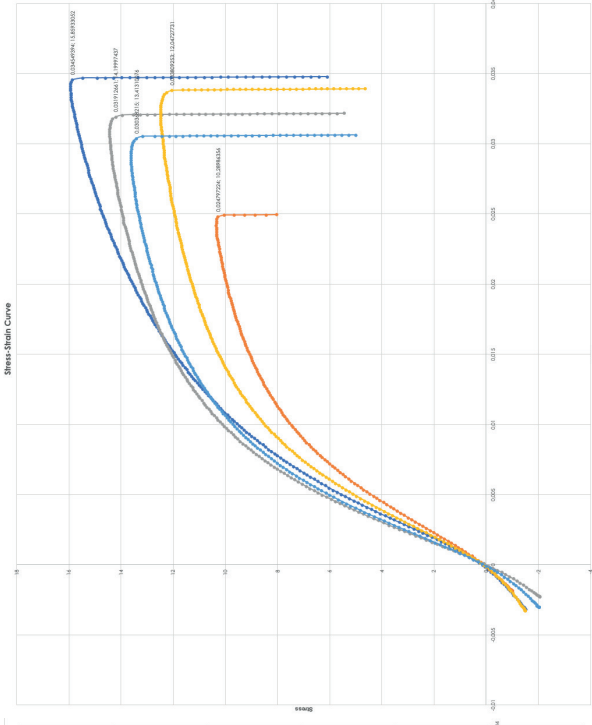
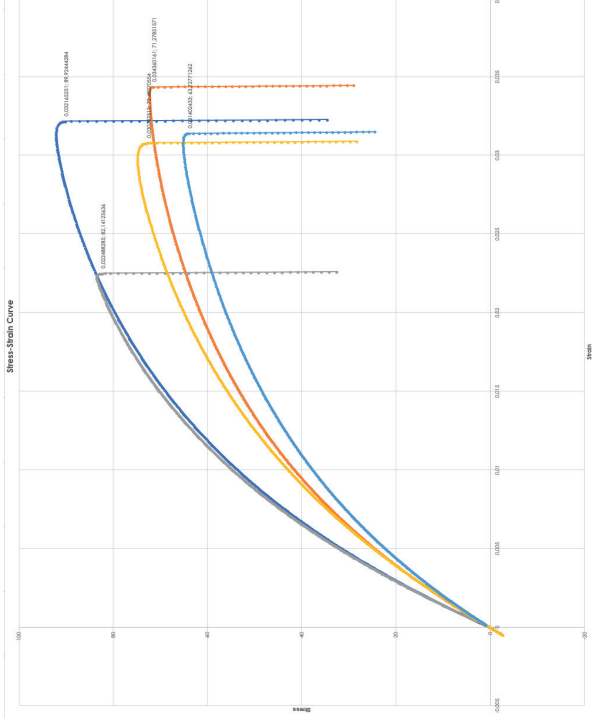
## APPENDIX B

### Tensile test results

1. UPM Formi 3d
2. UPM Formi WB60
3. 10XL/WUR I
4. 10XL/WUR II
5. 10XL/WUR III
6. 10XL/WUR IV
7. 10XL/WUR V
8. PPGF
9. Durasence
10. Sappi Symbio PP40
11. Durasence (Dried)

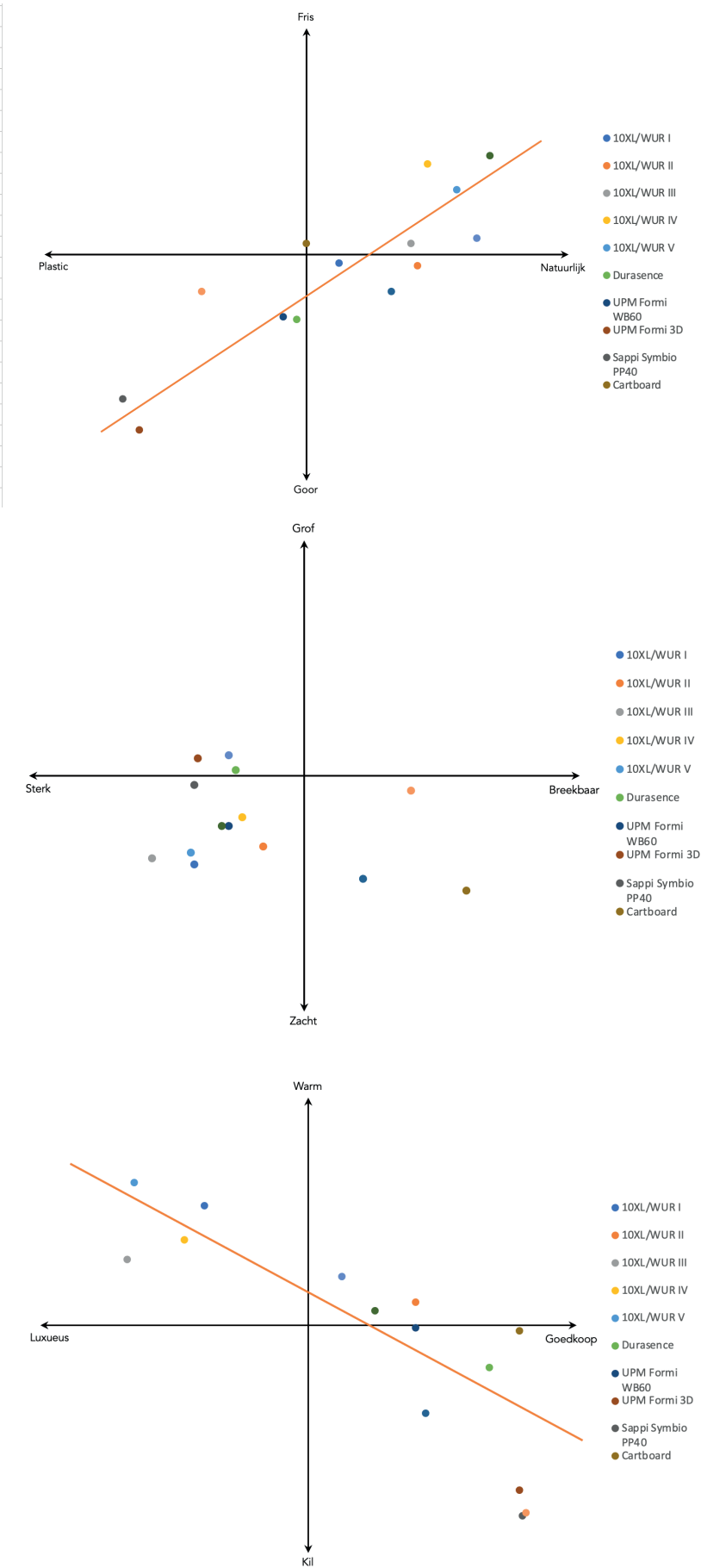




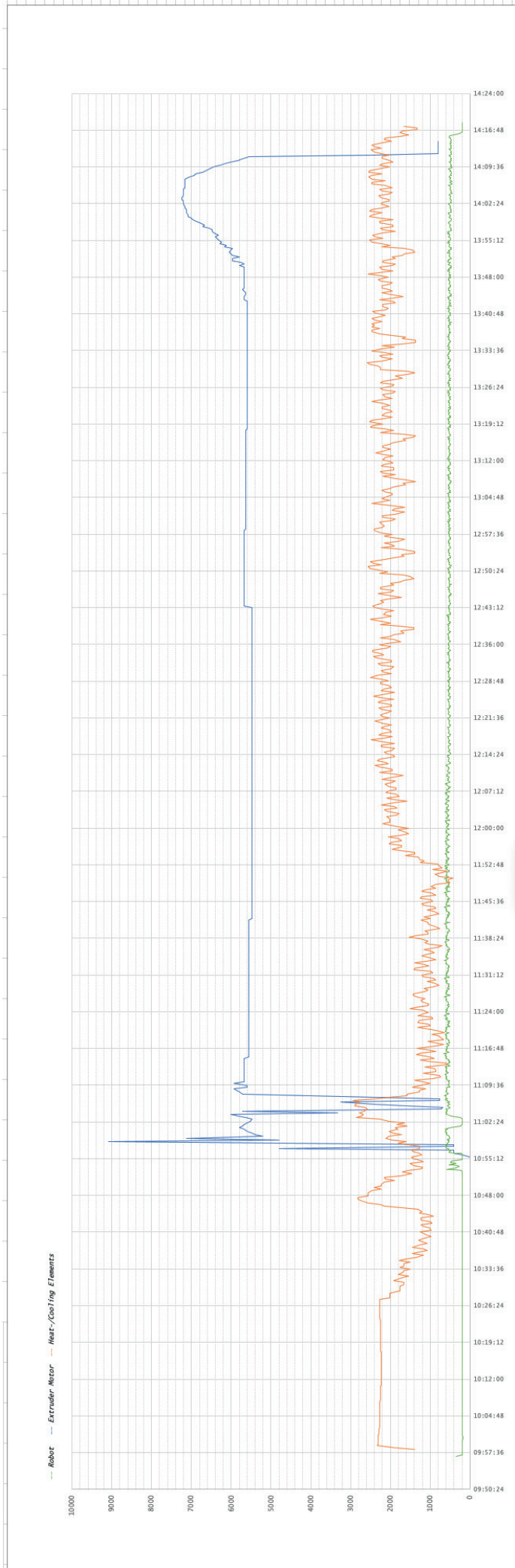


APPENDIX C

User research Matrix

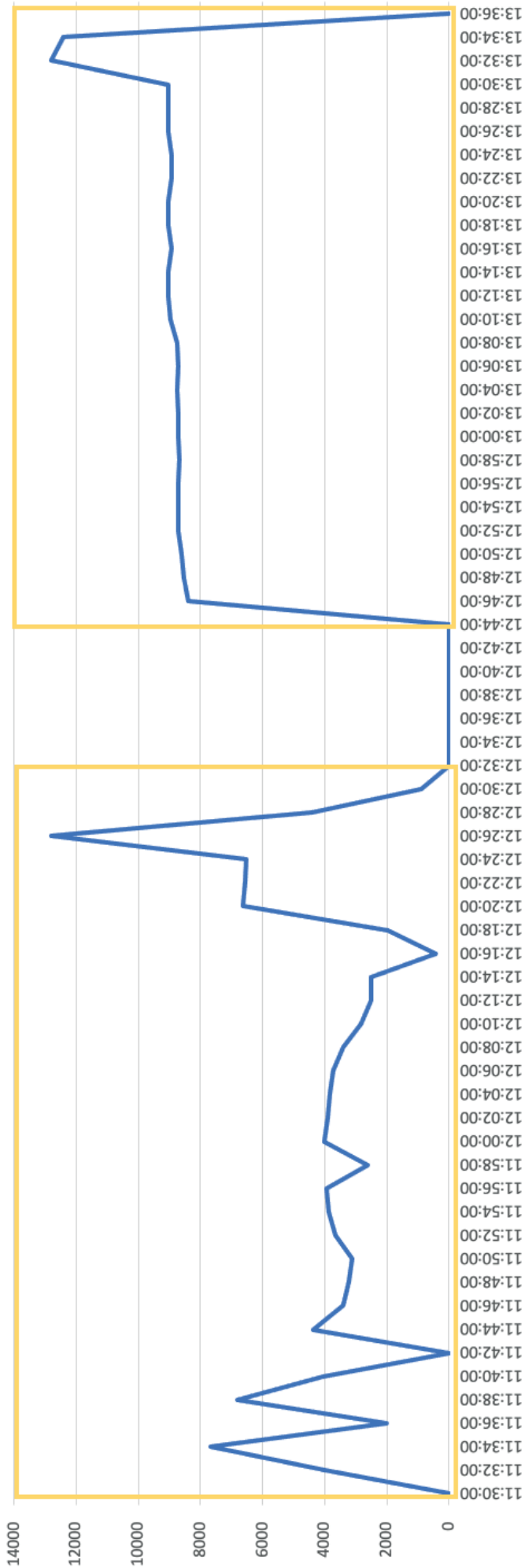


**APPENDIX D**  
Energy Measurements  
in Watt For printing  
GFPP

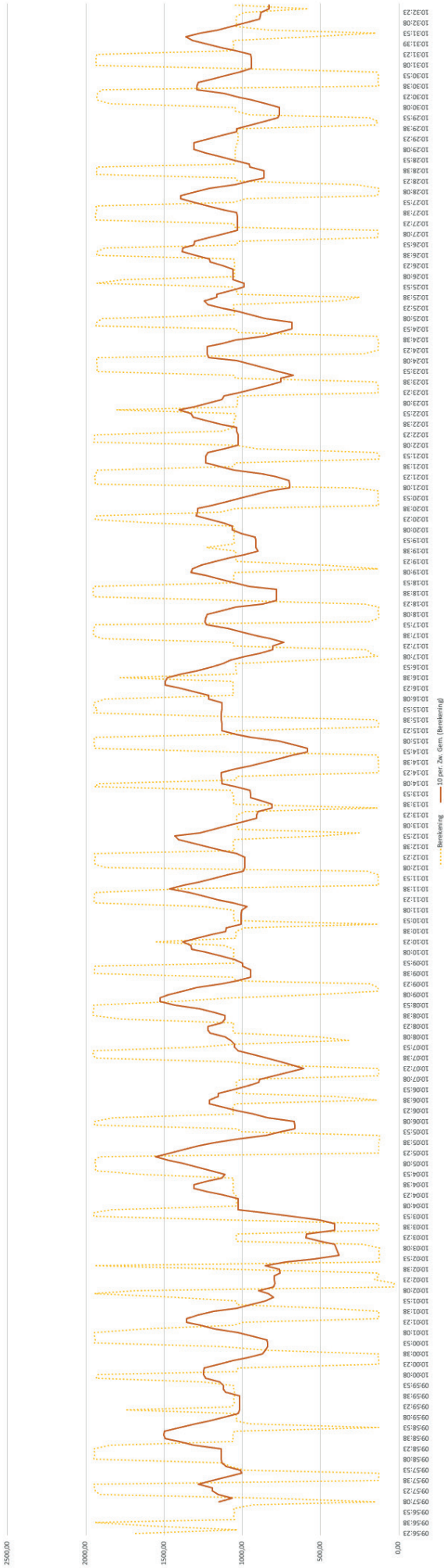


**APPENDIX E**  
Energy Measurements  
in Watt For printing  
WPC

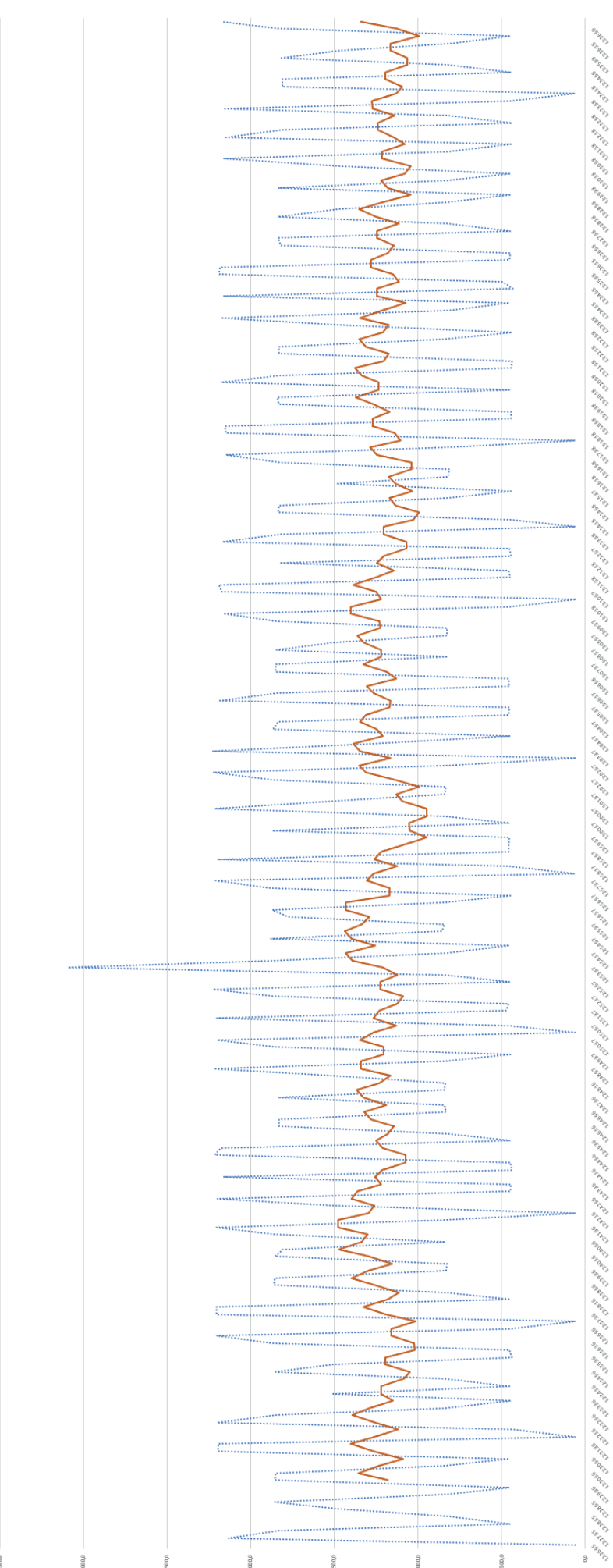
Energy use Extruder



Energy use Drying



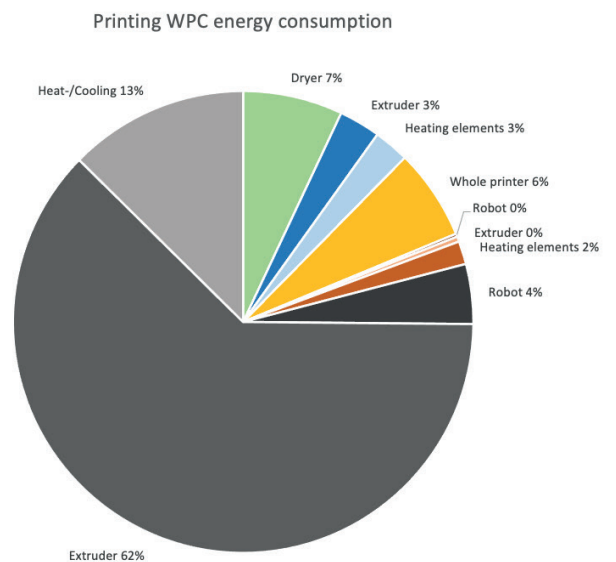
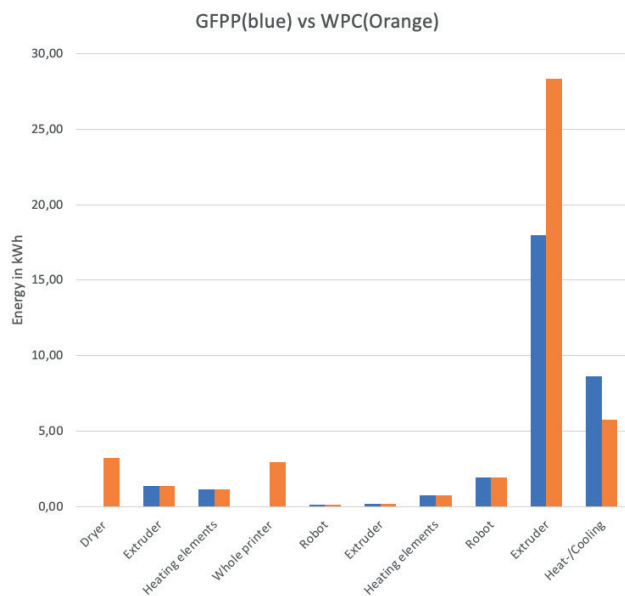
Energy use Heating



## APPENDIX F

### Energy model overview and comparison

| Printed object:         | CityGard Den Bosch |               |               |                 |                 |                 |  |                |                |
|-------------------------|--------------------|---------------|---------------|-----------------|-----------------|-----------------|--|----------------|----------------|
| Printing time:          | 03:12              |               |               |                 |                 |                 |  |                |                |
| Average Printing Speed: | 8000               |               |               |                 |                 |                 |  |                |                |
| # of Fans needed:       | 3                  |               |               |                 |                 |                 |  |                |                |
|                         | Material:          | PPGF          | WPC           |                 | PPGF            | WPC             |  | PPGF           | WPC            |
| Process                 | Section            | Power<br>[kW] | Power<br>[kW] | Time<br>[hours] | Energy<br>[kWh] | Energy<br>[kWh] |  | Energy<br>[MJ] | Energy<br>[MJ] |
| Drying                  | Dryer              | 0             | 1,06          | 3               | 0,00            | 3,18            |  | 0,00           | 11,45          |
| Heating-Up              | Extruder           | 2,64          | 2,64          | 0,5             | 1,32            | 1,32            |  | 4,75           | 4,75           |
|                         | Heating elements   | 2,26          | 2,26          | 0,5             | 1,13            | 1,13            |  | 4,06           | 4,06           |
| Rinsing                 | Whole printer      | 0             | 5,78          | 0,5             | 0,00            | 2,89            |  | 0,00           | 10,40          |
| Standby                 | Robot              | 0,19          | 0,19          | 0,5             | 0,10            | 0,10            |  | 0,35           | 0,35           |
|                         | Extruder           | 0,33          | 0,33          | 0,5             | 0,16            | 0,16            |  | 0,59           | 0,59           |
|                         | Heating elements   | 1,47          | 1,47          | 0,5             | 0,73            | 0,73            |  | 2,64           | 2,64           |
| Printing                | Robot              | 0,59          | 0,59          | 3,2             | 1,90            | 1,90            |  | 6,85           | 6,85           |
|                         | Extruder           | 5,61          | 8,83          | 3,2             | 17,95           | 28,25           |  | 64,62          | 101,70         |
|                         | Heat-/Cooling      | 2,68          | 1,79          | 3,2             | 8,59            | 5,73            |  | 30,91          | 20,62          |
| <b>Total</b>            |                    |               |               |                 | <b>31,88</b>    | <b>45,39</b>    |  | <b>114,77</b>  | <b>163,41</b>  |



## APPENDIX G

LCA Model GWP for WPC I and II  
CFPP and WFPP (alternatives)  
and GFPP PCW and PIW

### Do-It-Yourself LCA Estimation From Lookup Tables

**Purpose:** \_\_\_\_\_

**Boundaries:** \_\_\_\_\_

**Functional unit:** 1 CityGuard that will last for 10 years

**Impact unit:** kg CO2 eq.

Uncertainty rubric: 10% for precise data & perfect database match, 30% for plausible substitution, 100%+ for wild guess

### Design option:

**NPC with solely wood fibre**

### Materials & Compounding

|                                        | Eco-intensity<br>(impacts/kg) | Mass per item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes              | Calculated<br>Impact |
|----------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|--------------------|----------------------|
| Polypropylene - Virgin                 | 1,63                          | 23,840                | 1,00                          | 10%              | Use of virgin PP f | 38,961155            |
| Wood Waste - VolkerWessel saw dust     | 0,05                          | 44,700                | 1,00                          | 50%              |                    | 2,0399093            |
| Maleated Polypropylene (MAPP) [Binder] | 1,65                          | 3,725                 | 1,00                          | 100%             | Reaction process   | 6,1327695            |
| Aerafin 35 [Flow Improvement]          | 2,43                          | 2,235                 | 1,00                          | 100%             |                    | 5,4416663            |
| Compounding                            | 0,19                          | 74,500                | 1,00                          | 30%              | Assuming this va   | 14,212533            |

### Transport

|                          | Eco-Intensity<br>(impacts/<br>ton-km) | Mass per<br>item<br>(ton) | Distance<br>per item<br>(km) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes             | Calculated<br>Impact |
|--------------------------|---------------------------------------|---------------------------|------------------------------|-------------------------------|------------------|-------------------|----------------------|
| Collecting Polypropylene | 0,086                                 | 0,024                     | 38,6                         | 1,00                          | 30%              | Collected at Tran | 0,0787094            |
| Collecting Wood Waste    | 0,086                                 | 0,045                     | 192,0                        | 1,00                          | 30%              | Collected at Tran | 0,7340774            |
| Collecting MAPP          | 0,086                                 | 0,004                     | 97,7                         | 1,00                          | 30%              | Collected at Tran | 0,0311282            |
| Collecting Aerafin 35    | 0,086                                 | 0,002                     | 97,7                         | 1,00                          | 30%              | Collected at Tran | 0,0186769            |
| Transporting Compound    | 0,086                                 | 0,075                     | 152,0                        | 1,00                          | 30%              | Compound to 100   | 0,9685743            |

### 3D Printing

|            | Eco-Intensity<br>(impacts/MJ<br>or other) | Amount per item<br>(MJ or other) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes            | Calculated<br>Impact |
|------------|-------------------------------------------|----------------------------------|-------------------------------|------------------|------------------|----------------------|
| Drying     | 0,15                                      | 11,45                            | 1,00                          | 10%              | Collected from m | 1,7388591            |
| Heating Up | 0,15                                      | 8,82                             | 1,00                          | 10%              | Collected from m | 1,339453             |
| Rinsing    | 0,15                                      | 10,4                             | 1,00                          | 10%              | Collected from m | 1,5794004            |
| Standby    | 0,15                                      | 3,56                             | 1,00                          | 10%              | Collected from m | 0,5406409            |
| Printing   | 0,15                                      | 129,17                           | 1,00                          | 10%              | Collected from m | 19,616457            |

### Machinery

|                                                        | Eco-Intensity<br>(impacts/kg) | Mass per item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes                                           | Calculated<br>Impact |
|--------------------------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-------------------------------------------------|----------------------|
| Motors                                                 | 19,15                         | 60,000                | 0,00                          | 50%              | According to mar                                | 0,225757             |
| Robot material - Cast iron                             | 1,77                          | 987,730               | 0,00                          | 50%              | Mass calculated f                               | 0,343895             |
| Robot part manufacturing (energy)                      | 0,15                          | 3,555828              | 0,00                          | 50%              | <a href="https://www.diva">https://www.diva</a> | 0,000106             |
| Extruder motor (with manufacturing)                    | 15,66                         | 247                   | 0,00                          | 50%              | From sensitivity a                              | 0,759867             |
| Electronics                                            | 1055,42                       | 3                     | 0,00                          | 100%             | From sensitivity a                              | 0,621959             |
| Extruder (screw and barrel, discs, gear box, extruder) | 4,65                          | 521,56                | 0,00                          | 30%              | From sensitivity a                              | 0,476604             |
| Wiring (robot and extruder)                            | 0,15                          | 50                    | 0,00                          | 50%              |                                                 | 0,001519             |
| Printing plate                                         | 1,63                          | 64,08                 | 0,00                          | 30%              |                                                 | 0,020571             |

### End of Life

|                                              | Eco-Intensity<br>(impacts/kg) | Mass per item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes               | Calculated<br>Impact |
|----------------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|---------------------|----------------------|
| Insineration for Electricity - PP            | 1,22                          | 29,800                | 1,00                          | 50%              | Including all the i | 36,475105            |
| Insineration for Electricity - Wood material | -0,83                         | 44,700                | 1,00                          | 50%              |                     | -37,20539            |

### WPC with added Cellulose & Lignin

|                                        | Eco-intensity<br>(impacts/kg) | Mass per item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes               | Calculated<br>Impact |
|----------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|---------------------|----------------------|
| Polypropylene - Virgin                 | 1,63                          | 23,840                | 1,00                          | 10%              |                     | 38,961155            |
| Wood Waste - VolkerWessel saw dust     | 0,05                          | 29,800                | 1,00                          | 50%              |                     | 1,3599395            |
| Cellulose Fibre                        | 0,64                          | 11,175                | 1,00                          | 50%              | Eco-intensity from  | 7,1647126            |
| Kraft Lignin                           | 0,72                          | 3,725                 | 1,00                          | 50%              | Eco-intensity from  | 2,683413             |
| Maleated Polypropylene (MAPP) [Binder] | 1,65                          | 3,725                 | 1,00                          | 100%             | Reaction process    | 6,1327695            |
| Aerefin 35 [Flow Improvement]          | 2,43                          | 2,235                 | 1,00                          | 100%             |                     | 5,4416663            |
| Compounding                            | 0.19                          | 74,500                | 1.00                          | 30%              | Assuming this value | 14,212533            |

## Transport

| Transport                  | Eco-Intensity<br>(impacts/<br>ton-km) | Mass per<br>item<br>(ton) | Distance<br>per item<br>(km) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes             | Calculated<br>Impact |
|----------------------------|---------------------------------------|---------------------------|------------------------------|-------------------------------|------------------|-------------------|----------------------|
|                            |                                       |                           |                              |                               |                  |                   |                      |
| Collecting Polypropylene   | 0,086                                 | 0,024                     | 38,6                         | 1,00                          | 30%              | Collected at Tran | 0,0787094            |
| Collecting Wood Waste      | 0,086                                 | 0,030                     | 192,0                        | 1,00                          | 30%              | Collected at Tran | 0,4893849            |
| Collecting Cellulose Fibre | 0,086                                 | 0,011                     | 1286,0                       | 1,00                          | 30%              | Collected at Tran | 1,2291973            |
| Collecting Kraft Lignin    | 0,086                                 | 0,004                     | 1286,0                       | 1,00                          | 30%              | Collected at Tran | 0,4097324            |
| Collecting MAPP            | 0,086                                 | 0,004                     | 97,7                         | 1,00                          | 30%              | Collected at Tran | 0,0311282            |
| Collecting Aerafin 35      | 0,086                                 | 0,002                     | 97,7                         | 1,00                          | 30%              | Collected at Tran | 0,0186769            |
| Transporting Compound      | 0,086                                 | 0,075                     | 152,0                        | 1,00                          | 30%              | Compound to 10    | 0,9685743            |

## 3D Printing

| 3D Printing | Eco-Intensity<br>(impacts/MJ<br>or other) | Amount per item<br>(MJ or other) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact |
|-------------|-------------------------------------------|----------------------------------|-------------------------------|------------------|-------|----------------------|
|             | Drying                                    | 0,15                             | 11,45                         | 1,00             | 10%   | 1,7388591            |
|             | 3D Printing - Heating Extruder            | 0,15                             | 4,752                         | 1,00             | 10%   | 0,7216645            |
|             | 3D Printing - Extruder                    | 0,15                             | 101,7                         | 1,00             | 10%   | 15,444713            |
|             | 3D Printing - Robotic Arm                 | 0,15                             | 6,84                          | 1,00             | 10%   | 1,0387595            |
|             | 3D Printing - other Heating/Cooling       | 0,15                             | 24,7                          | 1,00             | 10%   | 3,7510759            |
|             |                                           |                                  |                               |                  |       |                      |

## Machinery

| Machinery | Eco-Intensity<br>(impacts/kg)                          | Mass per item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact                            |          |
|-----------|--------------------------------------------------------|-----------------------|-------------------------------|------------------|-------|-------------------------------------------------|----------|
|           | Motors                                                 | 19,15                 | 60,000                        | 0,00             | 50%   | According to mar                                | 0,225757 |
|           | Robot material - Cast iron                             | 1,77                  | 987,730                       | 0,00             | 50%   | Mass calculated f                               | 0,343895 |
|           | Robot part manufacturing (energy)                      | 0,15                  | 3,555828                      | 0,00             | 50%   | <a href="https://www.diva">https://www.diva</a> | 0,000106 |
|           | Extruder motor (with manufacturing)                    | 15,66                 | 247                           | 0,00             | 50%   | From sensitivity a                              | 0,759867 |
|           | Electronics                                            | 1055,42               | 3                             | 0,00             | 100%  | From sensitivity a                              | 0,621959 |
|           | Extruder (screw and barrel, discs, gear box, extruder) | 4,65                  | 521,56                        | 0,00             | 30%   | From sensitivity a                              | 0,476604 |
|           | Wiring (robot and extruder)                            | 0,15                  | 50                            | 0,00             | 50%   |                                                 | 0,001519 |
|           | Printing plate                                         | 1,63                  | 64,08                         | 0,00             | 30%   |                                                 | 0,020571 |

## End of Life

| End of Life | Eco-Intensity<br>(impacts/kg)                | Mass per item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact |           |
|-------------|----------------------------------------------|-----------------------|-------------------------------|------------------|-------|----------------------|-----------|
|             | Insineration for Electricity - PP            | 1,22                  | 29,800                        | 1,00             | 50%   | Including all the    | 36,475105 |
|             | Insineration for Electricity - Wood material | -0,83                 | 44,700                        | 1,00             | 50%   |                      | -37,20539 |
|             |                                              |                       |                               |                  |       |                      |           |
|             |                                              |                       |                               |                  |       |                      |           |
|             |                                              |                       |                               |                  |       |                      |           |



**Do-It-Yourself LCA Estimation From Lookup Tables****Purpose:** To compare different 3DP filament recipes**Boundaries:** Cradle to grave**Functional unit:** 1 CityGuard that will last for 10 years**Impact unit:** kg CO2 eq.

Uncertainty rubric: 10% for precise data &amp; perfect database match, 30% for plausible substitution, 100%+ for wild guess

**Design option:****Post-consumer waste PP****Manufacturing**

|                                                              | Eco-Intensity<br>(Impacts/kg) | Mass per Item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes                                         | Calculated<br>Impact |
|--------------------------------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-----------------------------------------------|----------------------|
| Mechanical recycled plastic pellets (downcycled) (53,5%)     | 0,32                          | 39,858                | 1,00                          | 30%              | But we do not m                               | 12,58045             |
| Glass fibre (23%)                                            | 2,05                          | 17,135                | 1,00                          | 30%              | Calculated from :                             | 35,11932             |
| Pigment (3%)                                                 | 3,40                          | 2,235                 | 1,00                          | 30%              |                                               | 7,597092             |
| Anti-microbial (1%)- better post treatment*                  | 5,22                          | 0,745                 | 1,00                          | 100%             | <a href="https://www.pol">https://www.pol</a> | 3,886393             |
| Flame retardant (5%) (V0,V2 - less toxic but less effective) | 5,73                          | 3,725                 | 1,00                          | 30%              | Calculated from :                             | 21,33222             |
| Coupling agent (5%) (MAPP)                                   | 1,65                          | 3,725                 | 1,00                          | 30%              |                                               | 6,13277              |
| UV .5% (anti-oxidants like Irganox 1010)                     | 2,26                          | 0,373                 | 1,00                          | 30%              | Bishenolic A from                             | 0,843215             |
| Mechanically recycled HDPE (9%)                              | 0,32                          | 6,705                 | 1,00                          | 30%              | Added for better                              | 2,116338             |
| Collectin and sorting plastic waste                          | 0,09                          | 74,500                | 1,00                          | 30%              |                                               | 6,554262             |
| Compounding                                                  | 0,19                          | 74,500                | 1,00                          | 30%              | Assuming this va                              | 14,21253             |
|                                                              |                               |                       |                               |                  |                                               | 0                    |
|                                                              |                               |                       |                               |                  |                                               | 0                    |

**Transport**

|                                                  | Eco-Intensity<br>(Impacts/<br>ton-km) | Mass per Item<br>(ton) | Distance<br>per Item<br>(m???) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes             | Calculated<br>Impact |
|--------------------------------------------------|---------------------------------------|------------------------|--------------------------------|-------------------------------|------------------|-------------------|----------------------|
| Collecting MAPP                                  | 0,09                                  | 0,004                  | 97,7                           | 1,00                          | 30%              | Collected at Tran | 0,031128             |
| Transporting waste Rotterdam-Amsterdam-Rotterdam | 0,09                                  | 0,040                  | 156,000                        | 1,00                          | 30%              | Post consumer w   | 0,531824             |
| Transporting compound                            | 0,09                                  | 0,075                  | 31,000                         | 1,00                          | 30%              | Transporting com  | 0,197538             |
| Transporting pigment from UniqueQolor            | 0,09                                  | 0,002                  | 69,700                         | 1,00                          | 30%              |                   | 0,013324             |
|                                                  |                                       |                        |                                |                               |                  |                   | 0                    |

**3D printing**

|                           | Eco-Intensity<br>(Impacts/MJ<br>or other) | Amount per Item<br>(MJ or other) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact |
|---------------------------|-------------------------------------------|----------------------------------|-------------------------------|------------------|-------|----------------------|
|                           |                                           |                                  |                               |                  |       |                      |
|                           |                                           |                                  |                               |                  |       |                      |
| 3D Printing - Extruding   | 0,15                                      | 26,14                            | 1                             | 10%              |       | 3,969762             |
| 3D Printing - Robotic Arm | 0,15                                      | 60,81                            | 1                             | 10%              |       | 9,234936             |
| 3D Printing - Heating     | 0,15                                      | 7,11                             | 1                             | 10%              |       | 1,079763             |
| 3D Printing - Computing   | 0,15                                      | 28,99                            | 1                             | 10%              |       | 4,402579             |
|                           |                                           |                                  |                               |                  |       |                      |
|                           |                                           |                                  |                               |                  |       |                      |
|                           |                                           |                                  |                               |                  |       | 0                    |

**Machinery**

|                                                            | Eco-Intensity<br>(Impacts/kg) | Mass per Item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes                                         | Calculated<br>Impact |
|------------------------------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-----------------------------------------------|----------------------|
| Motors                                                     | 19,15                         | 60,000                | 0,00                          | 50%              | According to mar                              | 0,225757             |
| Robot material - Cast iron                                 | 1,77                          | 987,730               | 0,00                          | 50%              | Mass calculated f                             | 0,343895             |
| Robot part manufacturing (energy)                          | 0,15                          | 3,555828              | 0,00                          | 50%              | <a href="https://www.dlv">https://www.dlv</a> | 0,000106             |
| Extruder motor (with manufacturing)                        | 15,66                         | 247                   | 0,00                          | 50%              | From sensitivity                              | 0,759867             |
| Electronics                                                | 1055,42                       | 3                     | 0,00                          | 100%             | From sensitivity                              | 0,621959             |
| Extruder (screw and barrel, discs, gear box, extruder box) | 4,65                          | 521,56                | 0,00                          | 30%              | From sensitivity                              | 0,476604             |
| Wiring (robot and extruder)                                | 0,15                          | 50                    | 0,00                          | 50%              |                                               | 0,001519             |
| Printing plate                                             | 1,63                          | 64,08                 | 0,00                          | 30%              |                                               | 0,020571             |
|                                                            |                               |                       |                               |                  |                                               |                      |
|                                                            |                               |                       |                               |                  |                                               |                      |
|                                                            |                               |                       |                               |                  |                                               | 0                    |

**End of life**

|                                 | Eco-Intensity<br>(Impacts/kg) | Mass per Item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes             | Calculated<br>Impact |
|---------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-------------------|----------------------|
| Incineration PP for electricity | 1,22                          | 71,800                | 1,00                          | 10%              | Including all the | 87,88297             |

**GFPP PIW**
**Manufacturing**

|                                                              | Eco-Intensity<br>(Impacts/kg) | Mass per Item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes                                               | Calculated<br>Impact |
|--------------------------------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-----------------------------------------------------|----------------------|
| Mechanical recycled plastic pellets (downcycled)             | 0,32                          | 67,795                | 1,00                          | 30%              | Also together with                                  | 21,39852             |
| Pigment (3%)                                                 | 3,40                          | 2,235                 | 1,00                          | 50%              |                                                     | 7,597092             |
| Anti-microbial (1%) post treatment                           | 5,22                          | 0,745                 | 1,00                          | 30%              | <a href="https://www.pol...">https://www.pol...</a> | 3,886393             |
| Flame retardant (5%) (V0,V2 - less toxic but less effective) | 5,73                          | 3,725                 | 1,00                          | 30%              | Calculated from :                                   | 21,33222             |
|                                                              |                               |                       |                               |                  |                                                     | 0                    |
|                                                              |                               |                       |                               |                  |                                                     |                      |
|                                                              |                               |                       |                               |                  |                                                     | #VERW!               |

**Transport**

|                                        | Eco-Intensity<br>(Impacts/<br>ton-km) | Mass per<br>Item<br>(ton) | Distance<br>per Item<br>(km) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact |
|----------------------------------------|---------------------------------------|---------------------------|------------------------------|-------------------------------|------------------|-------|----------------------|
| <b>Transporting PIW to Ovimo (???)</b> | 0,09                                  | 0,072                     | 900,000                      | 1,00                          | 30%              |       | 5,50558              |
| Transporting from Ovimo to 10 XL       | 0,09                                  | 0,072                     | 96,300                       | 1,00                          | 30%              |       | 0,589097             |
| Transporting pigment from UniqueQolor  | 0,09                                  | 0,002                     | 69,000                       | 1,00                          | 30%              |       | 0,01319              |
|                                        |                                       |                           |                              |                               |                  |       |                      |
|                                        |                                       |                           |                              |                               |                  |       |                      |
|                                        |                                       |                           |                              |                               |                  |       | 0                    |

**3D printing**

|                           | Eco-Intensity<br>(Impacts/MJ<br>or other) | Amount per Item<br>(MJ or other) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact |
|---------------------------|-------------------------------------------|----------------------------------|-------------------------------|------------------|-------|----------------------|
| 3D Printing - Extruding   | 0,15                                      | 26,14                            | 1                             | 10%              |       | 3,969762             |
| 3D Printing - Robotic Arm | 0,15                                      | 60,81                            | 1                             | 10%              |       | 9,234936             |
| 3D Printing - Heating     | 0,15                                      | 7,11                             | 1                             | 10%              |       | 1,079763             |
| 3D Printing - Computing   | 0,15                                      | 28,99                            | 1                             | 10%              |       | 4,402579             |
|                           |                                           |                                  |                               |                  |       | 0                    |
|                           |                                           |                                  |                               |                  |       | 0                    |

**Machinery**

|                                                            | Eco-Intensity<br>(Impacts/kg) | Mass per Item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes                                               | Calculated<br>Impact |
|------------------------------------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-----------------------------------------------------|----------------------|
| Motors                                                     | 19,15                         | 60,000                | 0,00                          | 50%              | According to mar                                    | 0,225757             |
| Robot material - Cast Iron                                 | 1,77                          | 987,730               | 0,00                          | 50%              | Mass calculated f                                   | 0,343895             |
| Robot part manufacturing (energy)                          | 0,15                          | 3,555828              | 0,00                          | 50%              | <a href="https://www.dlv...">https://www.dlv...</a> | 0,000106             |
| Extruder motor (with manufacturing)                        | 15,66                         | 247                   | 0,00                          | 50%              | From sensitivity                                    | 0,759867             |
| Electronics                                                | 1055,42                       | 3                     | 0,00                          | 100%             | From sensitivity                                    | 0,621959             |
| Extruder (screw and barrel, discs, gear box, extruder box) | 4,65                          | 521,56                | 0,00                          | 30%              | From sensitivity                                    | 0,476604             |
| Wiring (robot and extruder)                                | 0,15                          | 50                    | 0,00                          | 50%              |                                                     | 0,001519             |
| Printing plate                                             | 1,63                          | 64,08                 | 0,00                          | 30%              |                                                     | 0,020571             |

**Machinery**

|                                 | Eco-Intensity<br>(Impacts/kg) | Mass per Item<br>(kg) | Items per<br>func.unit<br>(#) | Uncertainty<br>% | Notes | Calculated<br>Impact |
|---------------------------------|-------------------------------|-----------------------|-------------------------------|------------------|-------|----------------------|
| Incineration PP for electricity | 1,22                          | 71,800                | 1                             | 10%              |       | 87,88297             |

# APPENDIX H Sensitivity analysis

|                            | Description       |      | Material name as stated in Idemat 2021 database                   | Carbon      | endpoint (Pt)   | human health    | ecotoxicity     | resources |              |
|----------------------------|-------------------|------|-------------------------------------------------------------------|-------------|-----------------|-----------------|-----------------|-----------|--------------|
| <b>MAPP</b>                | PP                |      | 89% Idemat2021 PP (Polypropylene)                                 | 1,63        | 4,52E-02        | 2,30E-06        | 5,53E-09        |           |              |
|                            | Hydrogen peroxide |      | 1% Idemat2021 H2O2, 70% in H2O                                    | 0,53        | 1,21E-02        | 6,30E-07        | 1,66E-09        |           | 0,458        |
|                            | Maleic anhydride  |      | 10% Idemat2021 Acetic Anhydride trade mix                         | 1,59        | 3,77E-02        | 1,90E-06        | 5,34E-09        |           | 0,073        |
|                            |                   |      | Idemat2021 Acetic Anhydride, Halcon process                       | 0,52        | 1,63E-02        | 8,01E-07        | 2,02E-09        |           | 0,391        |
|                            |                   |      | Idemat2021 Acetic anhydride, Ketene process                       | 3,49        | 7,58E-02        | 3,84E-06        | 1,12E-08        |           | 0,230        |
|                            |                   |      |                                                                   | <b>1,65</b> | <b>0,04</b>     | <b>0,00</b>     | <b>0,00</b>     |           | <b>0,45</b>  |
| <b>Aerafin™ 35 polymer</b> | EPDM              |      | Idemat2021 EPDM (ethylene propylene diene monomer rubber)         | 2,43        | 5,06E-02        | 2,56E-06        | 7,69E-09        |           | 0,455        |
|                            | Propylene         |      | Idemat2021 Propylene                                              | 1,35        | 3,88E-02        | 1,90E-06        | 4,85E-09        |           | 0,576        |
|                            | Ethylene          |      | n/a                                                               | n/a         | n/a             | n/a             | n/a             |           | n/a          |
|                            |                   |      |                                                                   | <b>2,43</b> | <b>0,05</b>     | <b>0,00</b>     | <b>0,00</b>     |           | <b>0,45</b>  |
|                            |                   |      |                                                                   |             |                 |                 |                 |           |              |
| <b>Cellulose</b>           |                   |      | Idemat2021 Board and recycled paper (test liner and fluting)      | 0,32        | 6,61E-03        | 3,55E-07        | 1,07E-09        |           | 0,006        |
|                            |                   |      | Idemat2021 Brown paper (kraft liner), FSC                         | 0,20        | 6,45E-03        | 3,47E-07        | 9,45E-10        |           | 0,011        |
|                            |                   |      | Idemat2021 Brown paper (kraft liner), FSC 70 gr/m2                | 0,01        | 4,56E-04        | 2,46E-08        | 6,62E-11        |           | 0,001        |
|                            |                   |      | Idemat2021 Brown paper (kraft liner), unsustainable               | 1,77        | 3,34E-02        | 1,80E-06        | 5,34E-09        |           | 0,011        |
|                            |                   |      | Idemat2021 Molded fiber products                                  | 0,36        | 7,04E-03        | 3,78E-07        | 1,15E-09        |           | 0,005        |
|                            |                   |      | Idemat2021 Paper, woodfree uncoated (virgin paper), FSC           | 1,33        | 2,79E-02        | 1,45E-06        | 4,24E-09        |           | 0,168        |
|                            |                   |      | Idemat2021 Paper, woodfree uncoated (virgin paper), FSC 80 gr/m2  | 0,11        | 2,24E-03        | 1,16E-07        | 3,39E-10        |           | 0,013        |
|                            |                   |      | Idemat2021 Paper, woodfree uncoated (virgin paper), unsustainable | 2,90        | 5,49E-02        | 2,91E-06        | 8,63E-09        |           | 0,168        |
|                            |                   |      | Idemat2021 Printing, flexography with coating                     | 0,18        | 5,78E-03        | 2,95E-07        | 1,17E-09        |           | 0,022        |
|                            |                   |      | Idemat2021 Semichemical fluting, virgin, FSC                      | 0,40        | 1,12E-02        | 6,06E-07        | 1,63E-09        |           | 0,011        |
|                            |                   |      | Idemat2021 Semichemical fluting, virgin, unsustainable            | 1,97        | 3,82E-02        | 2,06E-06        | 5,02E-09        |           | 0,011        |
|                            |                   | 0,00 |                                                                   | <b>0,72</b> | <b>1,51E-02</b> | <b>7,82E-07</b> | <b>2,29E-09</b> |           | <b>0,091</b> |
| <b>Wood Fibre</b>          |                   |      | Idemat2021 Bamboo (local China)                                   | 0,13        | 3,36E-03        | 1,77E-07        | 5,20E-10        |           | 0,013        |
|                            |                   |      | Idemat2021 Cork granulate 150 kg/m3                               | 0,17        | 5,22E-03        | 2,81E-07        | 7,26E-10        |           | 0,010        |
|                            |                   |      |                                                                   | <b>0,05</b> | <b>0,00</b>     | <b>0,00</b>     | <b>0,00</b>     |           | <b>0,00</b>  |

