# Locally produced PLA filament survey

March 2, 2018

## 1 Background

A survey was done to evaluate whether it was commercial interest in Norway for PLA 3d-printer filament that is locally produced. And whether people were interested in returning failed prints and other sources of PLA waste for recycling.

The motivation for the survey is a long-term goal of establishing a financially sustainable circular lifecycle for PLA bioplastic.

The survey was posted to two Norwegian Facebook groups focused on 3d-printing and 'making' on a Saturday in Feburary, 2018. Each group had approximately 1500 members. 120 reponses were collected over 2 weeks, approx 4% of the total 3000 group members (many which may not actually be active).

### 1.0.1 Authors

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```
In [2]: %matplotlib inline
        import pandas
        import numpy
```

## 2 Raw data

```
In [3]: raw = pandas.read_csv('./data/plafab-oslo-survey.anonymized.csv')
        print('Responses:', len(raw))
        raw[:2]
```

```
Responses: 121
```

```
Out[3]:            Timestamp  Hvor mange 3d-printere har du i aktiv bruk i dag?  \
        0  2/17/2018 15:34:51                                               NaN
        1  2/17/2018 16:20:34                                               2.0

           Hvor mange kilo PLA filament kjøper du per år?  \
        0                                               0
        1                                              10
```

```
     Hvilken diameter bruker du (mest)?  \
0                              1.75 mm
1                              1.75 mm

   Hva er det meste du er villig til å betale for norskprodusert PLA filament?  \
0                              mindre enn 300 kr/kg
1                                      350 kr / kg

   Hvilke farger bruker du mest? (maks 3 valg)  \
0                              Sort, Hvit, Klar
1                                     Sort, Hvit

    Hvor mye PLA filament kan du levere til gjenvinning per år?  \
0                                                         NaN
1                                                         2.0

    Vil du høre mer via epost når vi lanserer?  \
0                                          NaN
1                                          NaN

   Har du noen tilbakemeldinger eller tips til oss? Hvor i Norge bor du?
0                                               Nei             NaN
1                                               NaN             NaN
```

## 3  Data cleaning

```python
In [4]: field_name_map = {
            'Hvor mange 3d-printere har du i aktiv bruk i dag?': 'printers', # currently activ
            'Hvor mange kilo PLA filament kjøper du per år?': 'filament purchased', # per year
            'Hvilken diameter bruker du (mest)?': 'diameter used',
            'Hva er det meste du er villig til å betale for norskprodusert PLA filament?': 'pr
            'Hvilke farger bruker du mest? (maks 3 valg)': 'colors used',
            'Hvor mye PLA filament kan du levere til gjenvinning per år?': 'filament for recyc
            'Vil du høre mer via epost når vi lanserer?': 'contact_email',
            'Har du noen tilbakemeldinger eller tips til oss?': 'feedback',
            'Hvor i Norge bor du?': 'location',
            'Timestamp': 'timestamp',
        }
        cleaned = raw.rename(columns=field_name_map)
        cleaned.drop(0, inplace=True) # submission test
        cleaned[:2]

Out[4]:             timestamp  printers  filament purchased diameter used  \
        1  2/17/2018 16:20:34      2.0                  10       1.75 mm
        2  2/17/2018 16:21:15      1.0                   3       1.75 mm
```

```
        price preference        colors used  filament for recycling  contact_email  \
1       350 kr / kg          Sort, Hvit                       2.0            NaN
2       400 kr / kg  Hvit, Grå, Grønn                         2.0            NaN

        feedback location
1       NaN      NaN
2       NaN      NaN
```

```
In [5]: color_name_map = {
            'sort': 'black',
            'hvit': 'white',
            'grå': 'gray',
            'grønn': 'green',
            'rød': 'red',
            'blå': 'blue',
            'klar': 'transparent',
            'transparent': 'transparent',
            'oransje': 'orange',
            'oransj': 'orange',
            'orange': 'orange',
        }
        colors = {}
        for row in cleaned['colors used']:
            used = row.split(',')
            for c in used:
                original = c.strip().lower()
                mapped = color_name_map.get(original, "other")
                #if mapped == 'other': print('unknown color:', original)
                if colors.get(mapped) is None:
                    colors[mapped] = 0
                colors[mapped] += 1
        colors = pandas.DataFrame({'colors': colors})
        colors

Out[5]:            colors
        black         91
        blue          31
        gray          48
        green          8
        orange         4
        other          4
        red           28
        transparent    2
        white         82

In [6]: preference_map = {
            'mindre enn 300 kr/kg': '299 kr/kg or less',
            'mer enn 500 kr/kg': '501 kr/kg or more',
```

```
        }
        cleaned['price preference'].replace(preference_map, inplace=True)
        cleaned['price preference'].value_counts()
```

```
Out[6]: 299 kr/kg or less      39
        300 kr / kg            38
        350 kr / kg            26
        400 kr / kg            12
        500 kr / kg             3
        501 kr/kg or more       1
        450 kr / kg             1
        Name: price preference, dtype: int64
```

```
In [7]: cleaned['timestamp'] = pandas.to_datetime(cleaned['timestamp'])
        cleaned['timestamp'][:2]
```

```
Out[7]: 1   2018-02-17 16:20:34
        2   2018-02-17 16:21:15
        Name: timestamp, dtype: datetime64[ns]
```

## 4 Analysis

### 4.1 Responses

**50% left their email addresses** for further news/update about the project. This is a pretty strong indicator of interest in the project.

Note: Raw data unavailable about who left email is unavailable, email was nulled for anonymization reasons.

```
In [8]: timed = cleaned.copy()
        timed.index = timed['timestamp']
        timed['printers'].resample('3h').count().plot(figsize=(12,6));
```
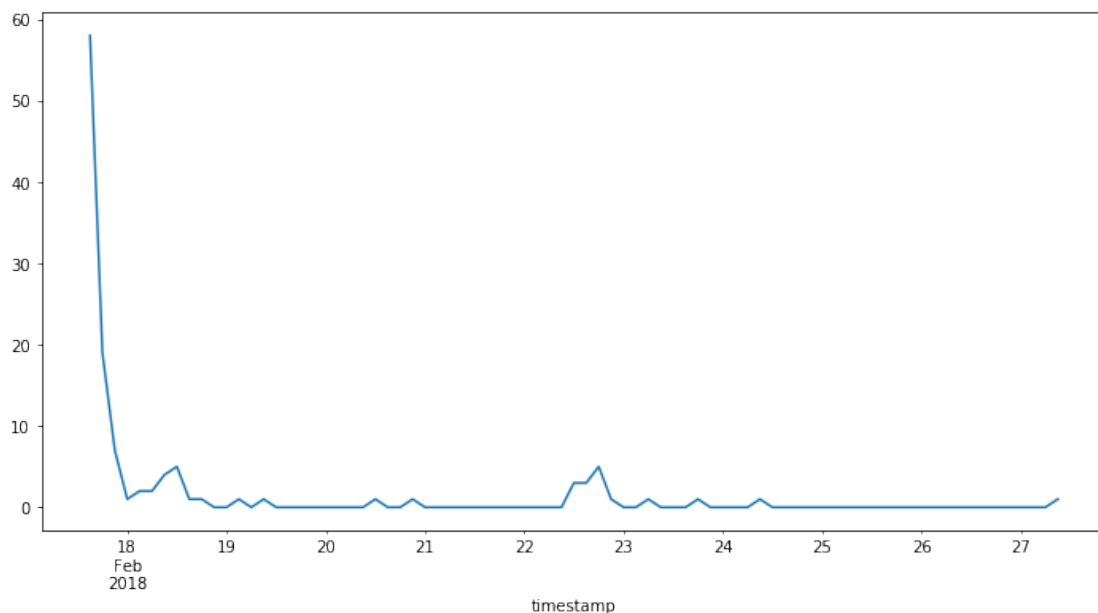
Most responses were made immediately after posting. Over 50 responses of the 120 responses were made within the first 3 hours. This may be partly due to Facebook preference of giving visibility to very recent content.

## 4.2 Printers in use

This question was included mostly to ensure that those that respond actually are potential customers.

```
In [9]: printer_count = cleaned['printers'].value_counts().sort_index()
        printer_count.plot(kind='bar', figsize=(12,6))
        printer_count

Out[9]: 0.0     6
        1.0    65
        2.0    32
        3.0     9
        4.0     3
        5.0     1
        6.0     4
        Name: printers, dtype: int64
```
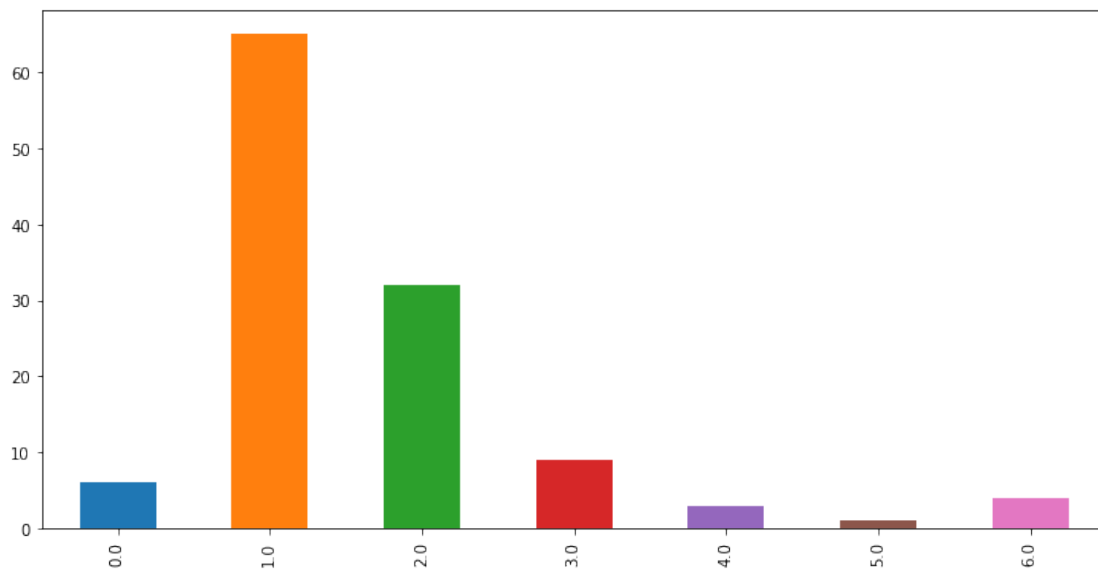


Majority of respondents have 1 printer in use. However over 40% have more than one.

## 4.3 Filament purchase

Per year

```
In [10]: filament_purchase_counts = cleaned['filament purchased'].value_counts().sort_index()
         filament_purchase_counts.plot(kind='bar', figsize=(12, 6), title='Filament purchased
         filament_purchase_counts.median()
```

Out[10]: 7.0

Filament purchased (kg per year)
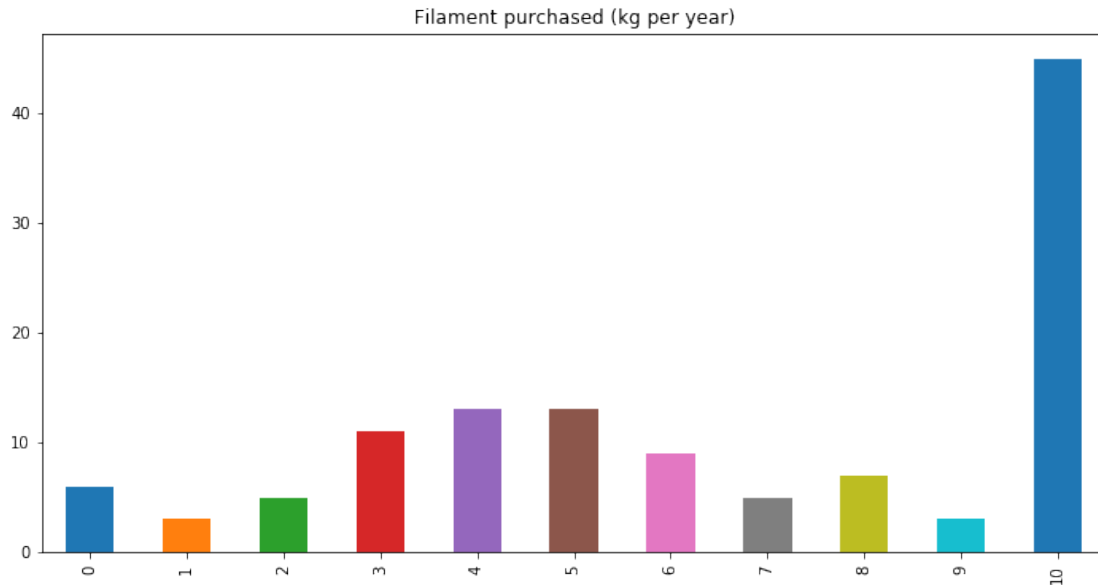


A large amount of respondents say they buy more than 10kg/year, and the median is 7 kg/year.

```
In [11]: cleaned['filament purchased'].sum()
```

Out[11]: 785

Just by providing these 120 respondends with *parts* of their consumption can cover 100++ kg/yearly. With targeted marketing in the communities the survey was shared with, it could be possible to sell 1000 kg/yearly.

### 4.4 Filament for recycling

```
In [15]: filament_recycle_counts = cleaned['filament for recycling'].value_counts().sort_index
         filament_recycle_counts.plot(kind='bar', figsize=(12, 6), title='Filament for recyling
```

Out[15]: 5.5

Filament for recyling (kg per year)
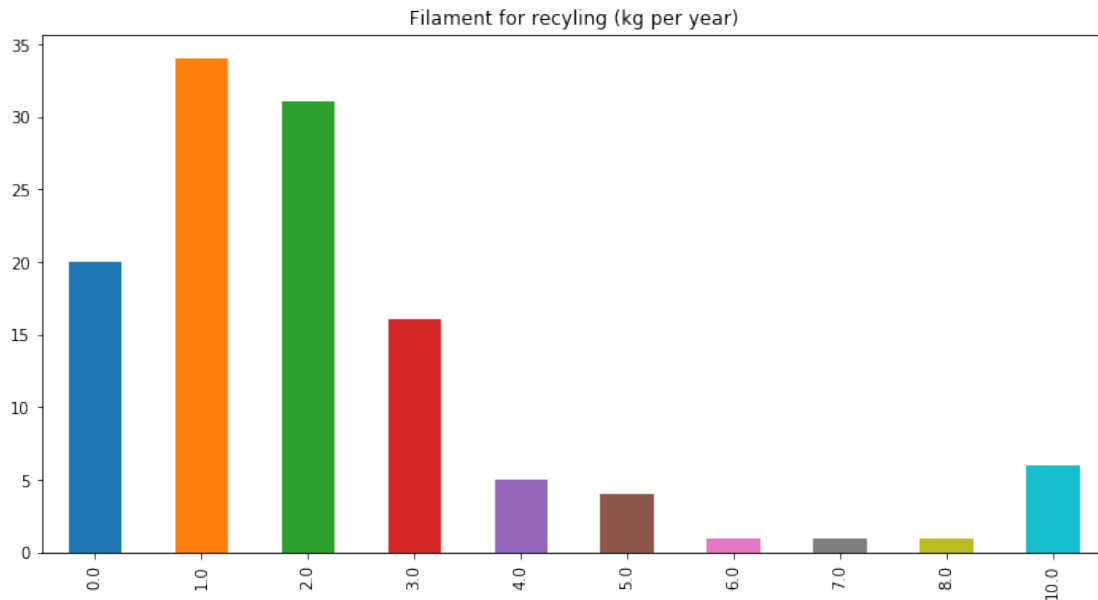
```
In [19]: cleaned['filament for recycling'].sum()

Out[19]: 265.0
```

The amount of filament people say they have for recycling is naturally significantly less than what they buy.

Nevertheless, for these 120 respondents, the sum is estimated to nearly 300 kg. Assuming 300 NOK/kg for the filament purchase price, that is an economic waste of 80'000 NOK yearly.

## 4.5 Color options

```
In [173]: colors.sort_values(by='colors', ascending=False).plot(kind='bar', figsize=(10, 5));
```
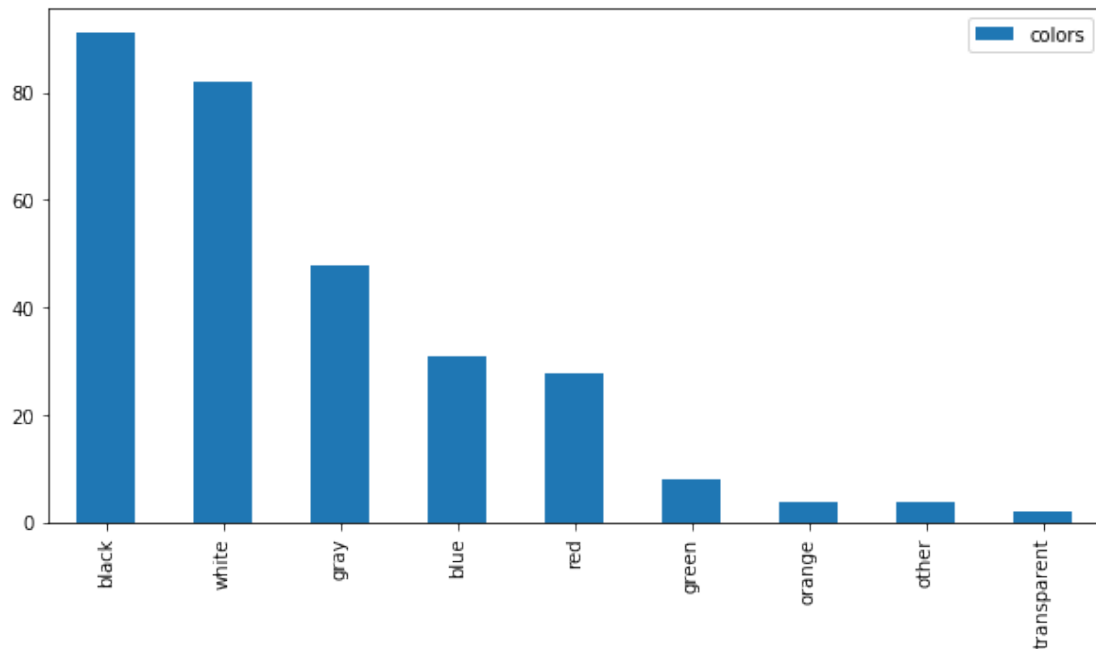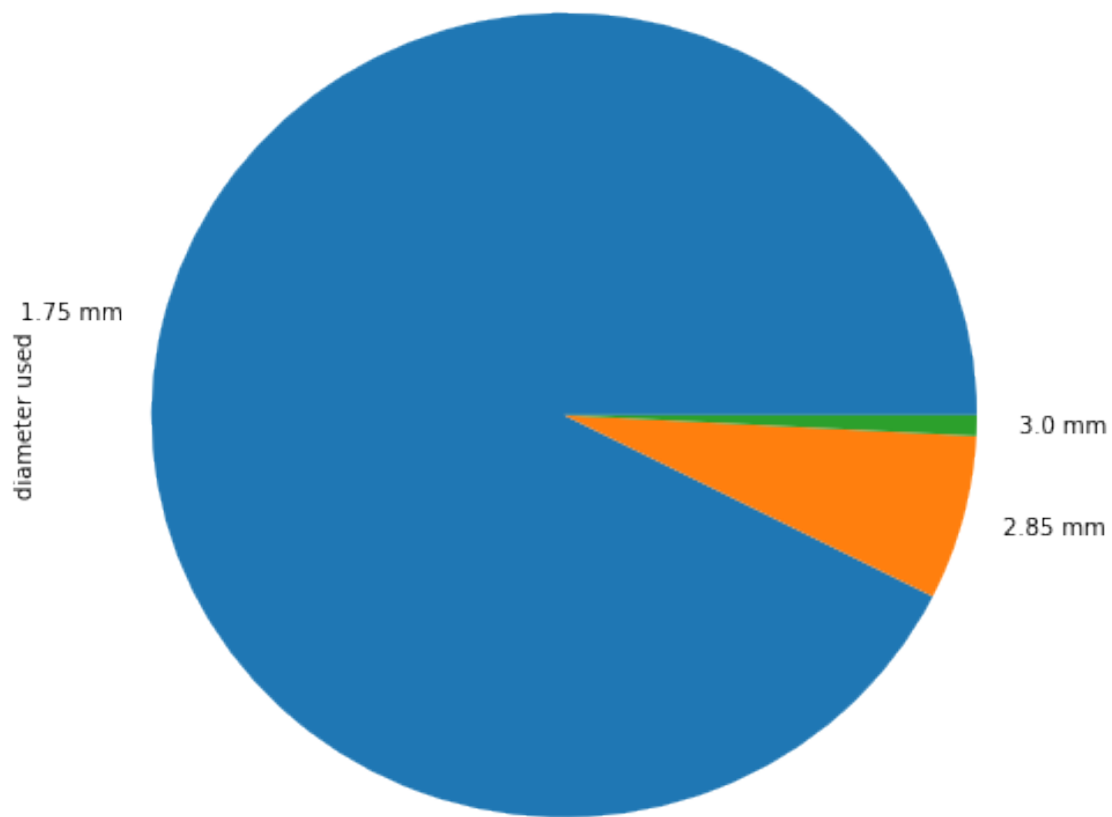
Most used are black,white and gray. It looks like one could do OK by offering just 2-3 filament colors.

## 4.6 Diameter options

```
In [103]: cleaned['diameter used'].value_counts().plot(kind='pie', figsize=(8,8))
          cleaned['diameter used'].value_counts(normalize=True)

Out[103]: 1.75 mm    0.925620
          2.85 mm    0.066116
          3.0 mm     0.008264
          Name: diameter used, dtype: float64
```

Over 90% used 1.75 mm filament. It should be OK to only offer this variant.

# 5 Price preference

```
In [108]: price_counts = cleaned['price preference'].value_counts().sort_index()
          price_counts.plot(kind='bar', figsize=(10,6))
          cleaned['price preference'].value_counts(normalize=True)

Out[108]: 299 kr/kg or less    0.330579
          300 kr / kg          0.314050
          350 kr / kg          0.214876
          400 kr / kg          0.099174
          500 kr / kg          0.024793
          501 kr/kg or more    0.008264
          450 kr / kg          0.008264
          Name: price preference, dtype: float64
```
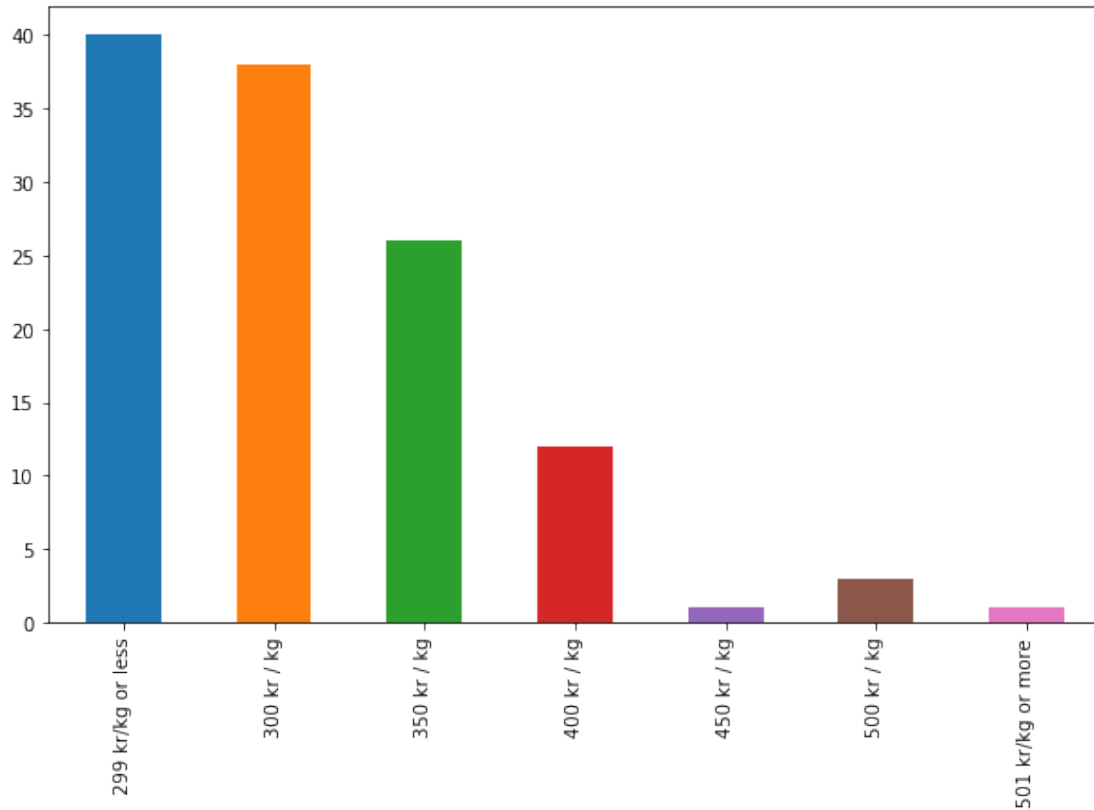
People have a **very strong preference for cheap filament**, with two thirds choosing the two lowest options.

There is **no indication that people are willing to pay more for locally produced filament**.

# 6 Conclusions

The high amount of respondents, and high amount of filament purchased by respondents indicate it is possible to sell an amount of filament needed for a micro business (NNN-NNNN kilos/year).

However there is no support for the thesis that consumers are willing to pay a premium for 'locally produced' (filament from raw pellets). This means that without other differentiation, one has to compete on price alone. As prices are likely to drop in the future, this seems a rather weak position.

More data would be needed on the production side in order to determine whether there could be sufficient margin to operate. However the prices indicated here suggest a low margin.

## 6.1 Quality concerns

The quality of product needed for 3d-printing filament is very high. Tolerances of diameter variation, foreign substances, plastic properties that stay over time (ex: low brittleness).

Attempting to recyle material means trying to deliver needed quality from a material stream with many varying parameters. One also needs to get the material to facilities. Without a price

preference, all this must be should be achievable at prices comparable to that of pure PLA material, currently below 50 NOK/kg.

So to enable a circular lifecycle with recycled inputs, it would be better to find less quality-critical uses for the plastic.