Wijklabels

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```
import pandas as pd
import numpy as np

from wijklabels.woningtype import Bouwperiode
```

! TODO

- ☐ add BAG extract version download link

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2 Introduction

woon2018

voorbeeldwoningen 2022

challanges: - the position of a VBO is not known in a pand

! TODO

3 Preparing the input

! TODO

Overview table of all:

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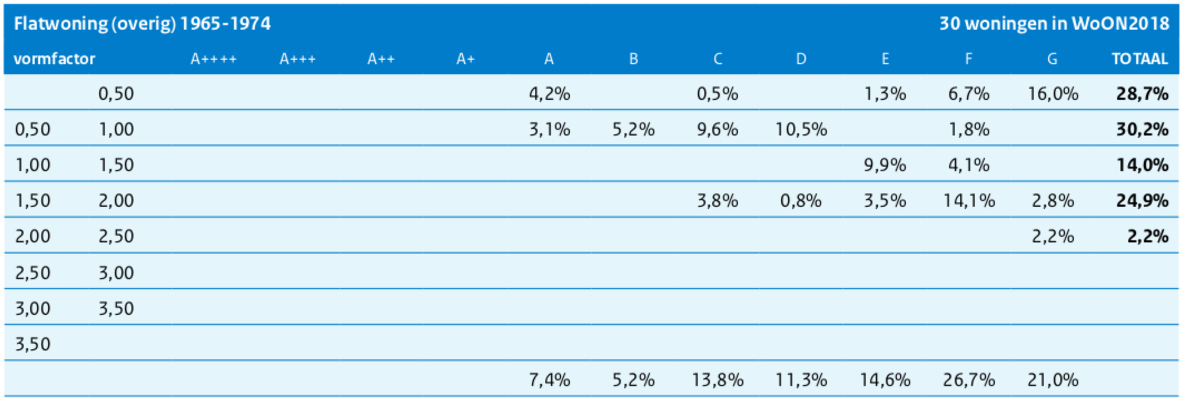
3.1 Spreiding van energielabels

The RVO (2022) study provides a representative sample of energy label distributions per dwelling type and construction period. The distribution is two-dimensional, one dimension is the energy label, the second dimension is the vormfactor of the dwelling. However, the described distributions are not continuous. For example, in case of Flatwoningen from the period 1965-1974, there is no data in the vormfactor range 1,00-1,50 and labels A+++-D, see Figure 1. Such gaps have a significant impact on the quality of our results.

The energy label distributions were extracted from the Excel file `Illustraties spreiding Energielabel in WoON2018 per Voorbeeldwoning 2022 - 2023 01 25.xlsx`, which we received from RVO.



Flatwoning (overig) 1965-1974												30 woningen in WoON2018	
vormfactor		A++++	A+++	A++	A+	A	B	C	D	E	F	G	TOTAAL
	0,50					4,2%		0,5%		1,3%	6,7%	16,0%	**28,7%**
0,50	1,00					3,1%	5,2%	9,6%	10,5%		1,8%		**30,2%**
1,00	1,50									9,9%	4,1%		**14,0%**
1,50	2,00							3,8%	0,8%	3,5%	14,1%	2,8%	**24,9%**
2,00	2,50											2,2%	**2,2%**
2,50	3,00												
3,00	3,50												
3,50													
						7,4%	5,2%	13,8%	11,3%	14,6%	26,7%	21,0%	

Figure 1: Energy label distribution of flatwoningen, RVO (2022)

3.2 BAG and 3DBAG

We used the 3DBAG version `2023.10.08`. The 3DBAG `2023.10.08` is based on the BAG 2.0 Extract with a release date of *08.09.2023*. The BAG contains two object types that are relevant for this study, *Pand* and *Verblijfsobject (VBO)*. Each VBO contains information about its usage in the `gebruiksdoel` attribute. For this study, only those VBO are usere which usage includes `woonfunctie`.

In the span of 2023, the project “Levering databestand 3D-BAG” funded by the Rijksdienst voor Ondernemend Nederland, extended the 3DBAG with 3D surface areas. The surface information is included in the 3DBAG since version `2023.10.08`. However, we used the CSV file (`3dbag_v20231008_rvo_export.csv`) that was delivered directly to RVO. The reason for using the CSV file is purely to simplify the data preparation process.

3.3 Number of floors

The number of floors of a Pand is required for distributing the VBO-s across the floors in a meergezinswoning. We compute the number of floors by dividing the gebruiksoppervlakte by the area of the roofprint taken from the 3DBAG. The gebruiksoppervlakte is the sum of each VBO's `oppervlakte` of a Pand in the BAG. The roofprint area is the totale oppervlakte begane grond, without any underground parts. The resulting value is rounded up to the nearest whole number, which gives us the number of floors.

3.4 Dwelling types

Dwellings are classified into distinct types. The current classification, as used by the NTA8800 method, is listed in Table 1. In case of appartements, hoek/tussen refers to the horizontal position of the appartement in the building, while vloer/midden/dak/dakvloer refers to its vertical position. For the sake of simplicity, we refer to this classification as **NTA8800-types**.

Table 1: Dwelling types used by the NTA8800 method

Eengezinswoningen	Meergezinswoningen
vrijstaande woning	appartement - hoekvloer
2 onder 1 kap	appartement - hoekmidden
rijwoning tussen	appartement - hoekdak
rijwoning hoek	appartement - hoekdakvloer
	appartement - tussenvloer
	appartement - tussenmidden
	appartement - tussendak
	appartement - tussendakvloer

Before the introduction of the NTA8800 method, dwellings were classified slightly differently, see Table 2. This is the classification used by the RVO (2022) study. For the sake of simplicity, we refer to this classification as **pre-NTA8800-types**.

Table 2: Dwelling types used in RVO (2022)

Eengezinswoningen	Meergezinswoningen
vrijstaande woning	maisonette
2 onder 1 kap	galerij
rijwoning tussen	portiek
rijwoning hoek	flat (overig)

The types of the single family houses are equivalent before and after NTA8800. On the other hand, there is no relation between the types of the meergezingswoningen before and after NTA8800.

This work requires that we know both the *NTA8800* and the *pre-NTA8800* type of each dwelling. The *pre-NTA8800* type is needed, because that is used by RVO (2022), and the *NTA8800* type is needed, because that is used by the validation data on EP-Online.

We first estimate the *NTA8800* type and then convert that to a *pre-NTA8800* type. The method for classifying the een- and meergezinswoningen differs significantly.

3.4.1 Classification of a Pand

Each BAG Pand are classified by clustering the intersecting BAG geometries. For example, a row of five row-houses forms one cluster, because they form a group of connected objects. We determine the types *vrijstaand/2 onder 1 kap/rijwoning* from the number of buildings in the cluster. In case of a *rijwoning*, we determine its position *hoek/tussen* from the number intersections with other buildings in the cluster.

Misclassification occurs if the intersections are incorrectly determined, usually, because there is a small gap between BAG polygons that are supposed to be touching. Thus, in order to improve the classification of eengezinswoningen, the BAG polygons need topological correction so the gaps and overlaps are corrected.

3.4.2 Eengezinswoningen

If a pand only contains a single VBO, then we consider the VBO an *eengezinswoning* and the VBO receives the classification of the Pand.

3.4.3 Meergezinswoningen

The meergezingswoningen consist of a single main type, *appartement*. If a Pand contains more than one VBO, then all of its VBOs are classified as *appartement*.

The *appartement* subtypes are determined from the vertical and horizonal position of the VBO within the pand. Firstly, the VBO-s are distributed across the floors (see Section 3.3) of the Pand to determine their vertical position. Each floor is assigned the same number of appartements, which is calculated by dividing the number of VBO-s by the number of floors. We call the *number of appartements per floor* `N`. Then the total appartements in the pand are distributed so that the first `N` is assigned to the ground floor (*vloer*), the second `N` is assigned to the top floor (*dak*) and the rest is distributed evenly across the floors in between (*midden*). If a Pand has the same *number of appartements per floor* as the total number of appartements, then the appartements are classified as *dakvloer*.

Secondly, the appartements are distributed horizontally on each floor. We assume two configurations for the layout of the appartements, single row or double row. The choice between single or double row depends on the number of appartements per floor and a random choice. If the number of appartements per floor is less than or equal three, then a single row layout is chosen, otherwise there is a 50% chance for a double row layout. Additionally, the number of *hoek* appartements are estimated based on the classification of the pand and the previously determined layout. If there are remaining appartements on the floor that are not classified as *hoek*, they are classified as *tussen*.

3.4.4 Conversion of appartement types to pre-NTA8800 types

The RVO (2022) study uses the pre-NTA8800 dwelling types, while the EP-Online database uses the NTA8800 dwelling types for the energy labels that are calculated with the NTA8800 method. This work relies on the results of the RVO (2022) study to estimate the energy label of dwellings, therefore we convert the previously determined NTA8800 appartement type to pre-NTA8800 types. Since there is no direct relation between the two classification, we can only estimate the pre-NTA8800 types.

We assign the pre-NTA8800 type to the appartement based on the distribution of pre-NTA8800 types in the EP-Online database and the construction date of the dwelling, see Figure 2. For example, if the dwelling was built in the period of 1965-1974, there is an 84% chance that it receives the *flatwoning (overig)* pre-NTA8800 type.

3.5 Construction year

The RVO (2022) study determines at most seven construction year periods, depending on the dwelling type. We used the *energy label distributions data* as a reference for the periods.

```python
df = pd.read_csv(
    '/home/balazs/Development/wijklabels/tests/data/output/labels_individual.csv',
    usecols=["bouwperiode", "woningtype", "woningtype_pre_nta8800"],
    converters={
      "bouwperiode": Bouwperiode.from_str
    }
)
total = df.count().iloc[0]  # count non-NA (!) cells
pt_crosstab = pd.crosstab(
    df["bouwperiode"],
    columns=df["woningtype_pre_nta8800"],
    margins=True,
    margins_name="Totaal"
)
```

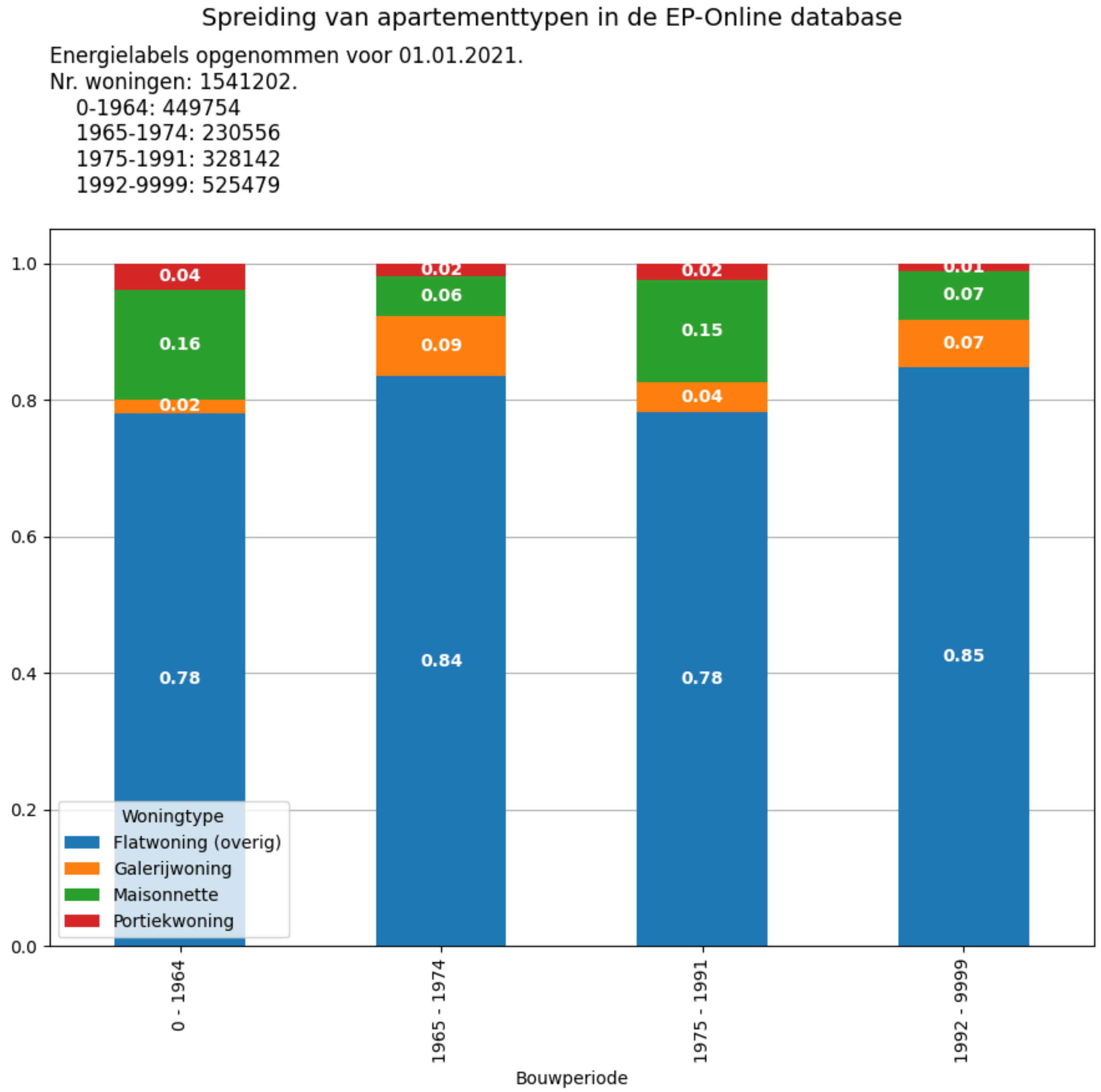


Figure 2: Spreiding van pre-NTA8800 meergezinswoningtypen in de EP-Online database, “EP-Online” (2023)

```
ct = pt_crosstab.apply(
    lambda col: list(map(lambda cnt: f"{cnt} ({round(cnt / total * 100)}%)", col))
).replace(
    "0 (0%)", ""
).reset_index(
    drop=False
)
ct.columns.name = "Woningtype"
ct["Bouwperiode"] = ct["bouwperiode"].apply(
    lambda bp: bp.format_pretty() if bp != "Totaal" else bp
)
ct.drop("bouwperiode", axis=1, inplace=True)
ct.set_index("Bouwperiode", inplace=True)
ct
```

Table 3: Antaal (en percentage) van woningen per bouwperiode en wonin

Woningtype Bouwperiode	2 onder 1 kap	galerij	maisonnette	overig	portiek	rijwoning hoek	rijwoning
< 1945					236 (1%)	648 (3%)	1669 (6%
< 1964	328 (1%)	273 (1%)	2313 (9%)	11007 (43%)			
1946 - 1964					372 (1%)	212 (1%)	474 (2%)
1965 - 1974	16 (0%)	269 (1%)	168 (1%)	2394 (9%)	50 (0%)	193 (1%)	629 (2%)
1975 - 1991	10 (0%)	70 (0%)	285 (1%)	1473 (6%)	51 (0%)	59 (0%)	138 (1%)
1992 - 2005	8 (0%)					64 (0%)	221 (1%)
2006 - 2014	2 (0%)					14 (0%)	35 (0%)
2015 <	35 (0%)					43 (0%)	100 (0%)
1992 <		140 (1%)	108 (0%)	1418 (6%)	15 (0%)		
Totaal	399 (2%)	752 (3%)	2874 (11%)	16292 (63%)	724 (3%)	1233 (5%)	3266 (13

3.6 Vormfactor

The vormfactor is calculated as the fraction of the verliesoppervlakte and gebruiksoppervlakte. The verliesoppervlakte is the sum of all sufrace areas that envelope the dwelling, except the surfaces that are shared with another dwelling. The gebruiksoppervlakte is the area that is registered for the VBO in the BAG (VBO's `oppervlakte`).

We compute the vormfactor for each Pand. The required surface areas for calculating the verliesoppervlakte are part of the 3DBAG since version `2023.10.08`. The vormfactor of an eengezinswoning is equivalent to the vormfactor of the Pand.

For appartements, we assign a portion of the surface areas to each appartement, depending on their type (see Section 3.4.3). The total roof surface area is divided equally among the appartements on the roof floor. Only 95% of the total wall surface area is used to account for wall surfaces that cover hallways and other non-dwelling spaces in the pand. The wall surface area is then divided among each appartement in a way that the appartements on the hoek are assigned approximately 3x the wall surface area of a tussen appartement. The total ground surface area is divided equally among the appartements on the ground floor.

3.7 Neighborhoods

The neighborhood boundaries are retrieved from the Centraal Bureau voor de Statistiek. The BAG Pand objects are assigned to a neighborhood with an intersection test. Every BAG Pand is assigned to only one neighborhood.

Version of CBS Wijken en Buurten: 2022 v1, link to data

3.8 Energy labels from EP-Online

"EP-Online is de officiële landelijke database waarin energielabels en energieprestatie-indicatoren van gebouwen zijn opgenomen." "EP-Online" (2023) We use the energy labels from EP-Online as "ground truth" for the validation of our estimated labels. Therefore, we assessed if we can consider the set of dwellings with a registered label on EP-Online a reliable reliable reference for comparison.

The EP-Online database contains energy labels that were determined using different methods. We only use the labels that were determined with the NTA8800 method. That is, the `Pand_berekeningstype` contains `NTA 8800`. In total, these records constitue to *1.284.241* VBOs.

Figure 3 shows that both the BAG and the EP-Online data set have a very similar distribution of dwellings across all construction year periods. This indicates that the registered energy labels in EP-Online represent well the complete set of dwellings in the Netherlands, when considering the construction period.

Figure 4 shows that both the BAG and the EP-Online data set have a very similar distribution of dwellings across all dwelling types. This indicates that the registered energy labels in EP-Online represent well the complete set of dwellings in the Netherlands, when considering the dwelling types. However, there are two caveats that need to be considered here. Firstly, the comparison does not include the apartment subtypes, only the main *apartement* type. This is, because there is no reliable method for determining the apartment subtypes for the complete BAG data set. Secondly, the dwelling types of the BAG were estimated by ourselves, because there is no authoritative dwelling type information for the whole BAG data set (see Section 3.4).

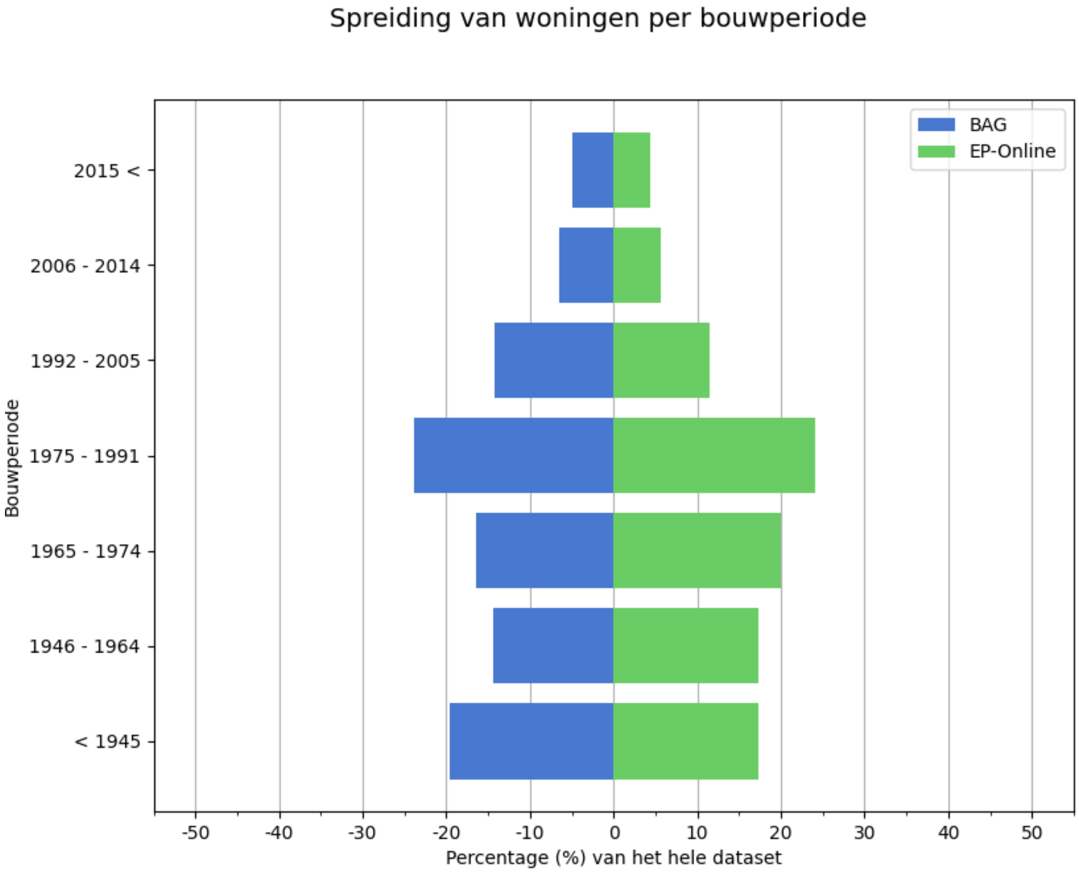


Figure 3: Spreiding van woningen per bouwperiode in de BAG en in de EP-Online gegevens

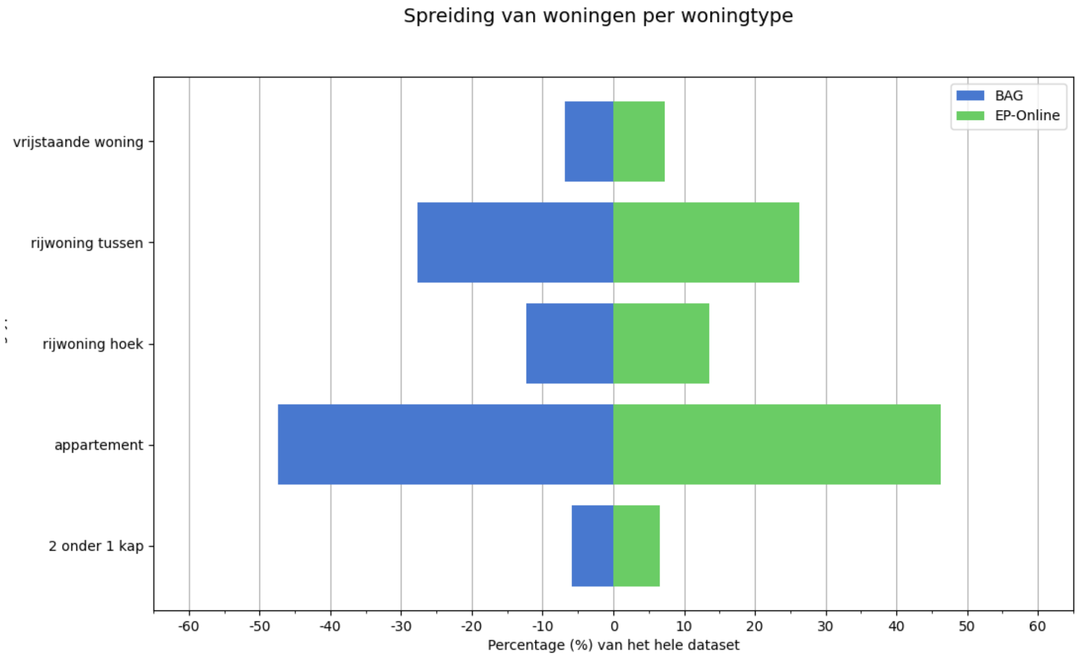


Figure 4: Spreiding van woningen per woningtype in de BAG en in de EP-Online gegevens

Figure 5 shows that 75% of neighborhoods have a coverage of 4-19%, while 50% of the neighborhoods has 8% coverage or less. Nearly all neighborhoods have at least 3% coverage. This indicates that nearly all neighborhoods have reference labels available in the EP-Online data set.

From the these analysis we conclude that the EP-Online database is a reliable reference for validating our estimated energy labels.

4 Estimating the energy labels

In order to determine the accurate energy label for a dwelling, the dwelling needs to be surveyed in-person by a qualified professional. This is not feasible to do on a national scale. However, we can estimate the type of the dwelling (Section 3.4) and we know the construction period from the BAG. In addition, we can calculate the vormfactor for eengezinswoningen accurately, and estimate the vormfactor for meergezinswoningen (see Section 3.6). Finally, from RVO (2022) we have a distribution of energy labels for each combination of the three parameters, dwelling type, construction period and vormfactor. Then the energy label of an individual dwelling is selected based on the likelihood of all labels in across the three variables.

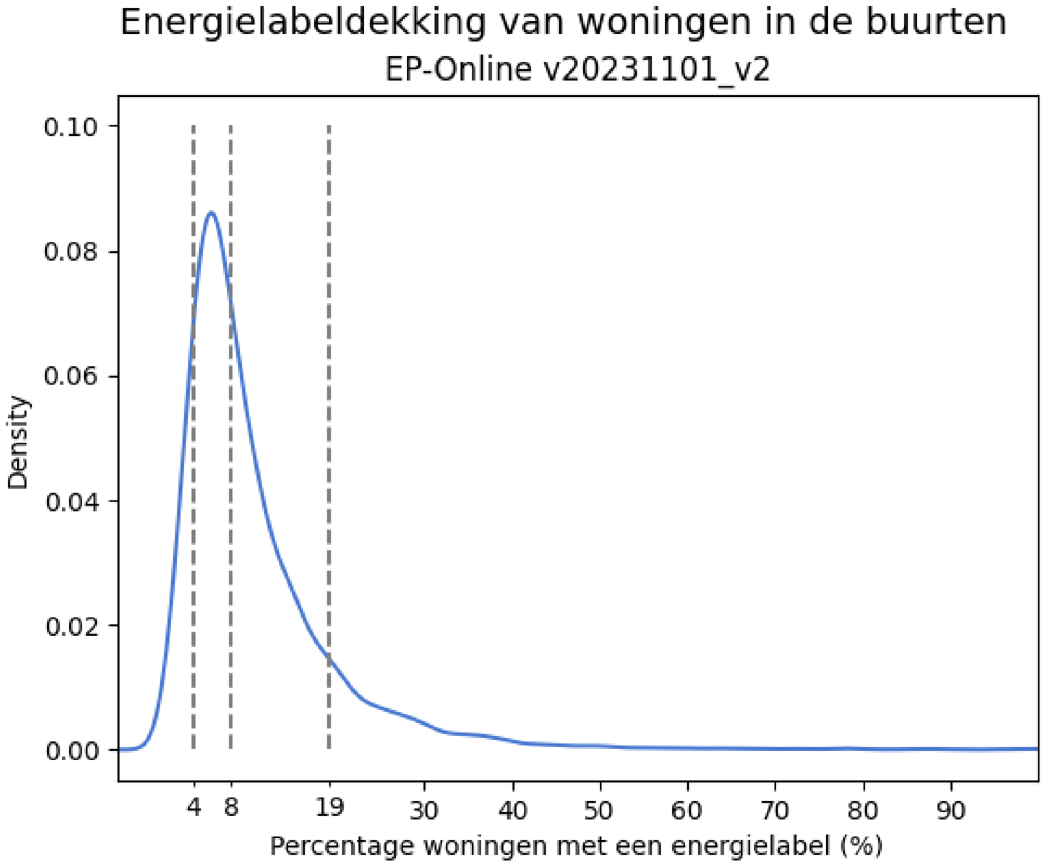


Figure 5: Energielabeldekking van woningen in de buurten

For example, given a dwelling with the parameters of dwelling type *Flatwoning*, construction period of *1965-1974* and a vormfactor in the range of *1,50-2,00*, the estimated energy label for the dwelling depends on the range of available labels, *C-G*, and their probability (see Figure 1).

The individual labels are aggregated per neighborhood to estimate the energy label distributions for each neighborhood in the Netherlands.

5 Validating the energy label estimation

We validate our energy label estimation against the energy labels in the "EP-Online" (2023) database. We compare the estimated labels to the EP-Online labels in terms of *deviation*. The *deviation* is calculated as the numeric, signed distance from one label to the reference label. Where the distance from a worse label to a better label is positive. For example, the distance from *A++++* to *G* is *-10*, the distance from *G* to *A++++* is *10*.

The validation process measures the following aspects.

- Number of VBO that did not receive an energy label.
- Percent of labels that match the EP-Online labels exactly. For example the estimated label is *A*, then the EP-Online is also *A* for the selected VBO.
- Percent of labels that match the EP-Online labels with one label deviation. For example the estimated label is *A*, then the EP-Online can be any of *A+*, *A*, *B*.
- The median, mean, standard deviation, minimum and maximum of *deviations* per neighborhood, and for the complete data set.

Due to the gaps in the energy label distributions that are presented in RVO (2022) (see Section 3.1), there are situations where it is impossible to estimate the correct label for a VBO. For example, the VBO has a registered label *B* in EP-Online, however, RVO (2022) does not have data for label *B* and the parameters of the VBO. We consider such labels *impossible*, since with our method and the limitations of the RVO (2022) data, it is not possible to assign the correct label. Measuring the *impossible* labels allows us to evaluate the impact of the gaps in the RVO (2022) data and the sensitivity or our method.

6 Results

6.1 Size of the input set / BAG

The BAG extract of `08.09.2023` contains *10.877.129* Pand objects and *10.144.833* Verblijfsobjecten.

The 3DBAG version `2023.10.08` that is based the mentioned BAG extract, contains *10.360.281* Pand objects.
The party walls dataset, that is based on the 3DBAG, contains *10.363.460* Pand objects.
There are *5.646.848* Pand and *8.721.692* VBO with gebruiksdoel that includes `woonfunctie`.

6.2 Dwelling types

When comparing against the EP-Online data, our dwelling classification shows 87% accuracy for the eengezingswoningen, and 26% accuracy for the meergezinswoningen.

6.3 Energy labels estimation

From the available *5.385.950* input Pand objects, *4.847.298* received an energy label.
Thus, *13%* of objects did not receive a label. The missing labels are caused by the gaps in energy label distributions of the RVO (2022) .

We have compared our energy label estimation to the labels available in "EP-Online" (2023). We have found that the mean deviation from the "EP-Online" (2023) labels is **-1,2**, with a standard deviation of **2,1**.
In other words, on average our estimated labels are about one label below the EP-Online labels, with a standard deviation of two labels.

However, if we look at the deviations per label, we get a more detailed image. Figure 6 shows that our *A+++, A++++* are on average 3-5 labels overestimated, while our *E, F, G* labels are on average 2-4 labels underestimated compared to the EP-Online data.

6.3.1 Considering only possible labels

Due to the gaps in the energy label distributions of the RVO (2022) study, *32%* of the dwellings have a label in EP-Online that is missing from the Voorbeeldwoningen 2022 data (see Section 3.1). In such cases, it is not possible to assign the correct energy label to the dwelling, since there is no probability for the label. If we limit our validation to those dwellings where the correct label does have a probability in energy label distributions, we gain insight on the impact of the gaps in the energy label distributions.

When comparing only the possible labels, the mean deviation from the "EP-Online" (2023) labels is **-0,6**, with a standard deviation of **1,6**.

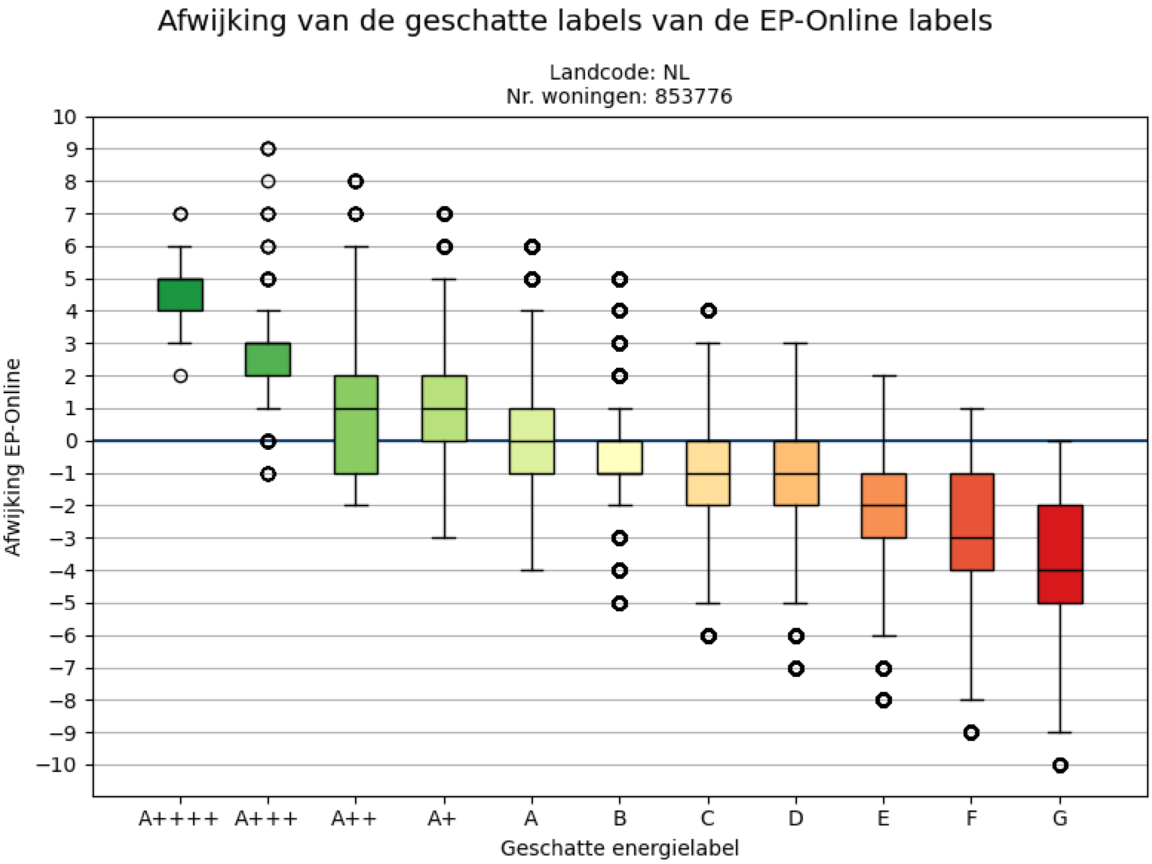


Figure 6: Deviation of the estimated labels from the EP-Online labels

7 Conclusions

This work estimates the vormfactor for individual dwellings and the energy label distribution of neighborhoods of the Netherlands. Due to the lack of suitable, national data, we worked with often severe assumptions on the parameters of a dwelling. The steps for these assumptions are listed below in their order in the energy label estimation process.

1. Estimating the number of floors of a Pand.
2. Estimating the type of a dwelling, both for eengezinswoningen and meergezinswoningen.
3. Converting from a NTA8800 appartament type (e.g. *apartement - hoekdak*) to a pre-NTA8800 appartament type (e.g. *galerij*).
4. Estimating the vormfactor of an appartement. Even if the exact number of floors and the correct appartement type, such as *hoekdak* were known, it wouldn't be possible to exactly calculate the vormfactor appartaments, due to the variations in internal layouts of buildings. However, it would be possible to make a much more accurate estimation.
5. Estimating the energy label of an individual dwelling from the probability of energy labels documented in the Voorbeelwoningen 2022 study.

Our findings indicate that the NTA8800 energy labels in the EP-Online database have sufficient coverage to be used as a validation set for developing large area, national methods in the future. However, the energy labels that were determined with the NTA8800 method use a different appartement classification than what is used by the WoON 2018 and Voorbeeldwoningen 2022 studies. In our method we follow the appartement classification of the NTA8800 labels, therefore a conversion between the two classification is needed. For the conversion we follow the statistical distribution of appartement types that we found in the EP-Online data set, because to the best of our knowledge there is no deterministic method to do this conversion. Therefore, the appartement type conversion in itself adds more uncertainty to the energy label estimation of appartements.

Due to the lack of national data on the 3D location of apartements, our method for estimating the horizontal and vertical position of an appartement is guesswork and thus inaccurate. Therefore in its current state we do not recommend to use results for meergezinswoningen. In our results, 44% of dwellings are appartements.

Our results show that the gaps in the Voorbeeldwoningen 2022 energy label distributions have a significant impact on the accuracy of the estimated labels (see Section 6.3.1). For this reason we recommend to adapt the Voorbeeldwoningen study so that the energy label distributions are as complete as possible.

8 References

"EP-Online." 2023. https://www.ep-online.nl/.

RVO. 2022. “Voorbeeldwoningen 2022 - Bestaande Bouw.” Technical report RVO-231-2022/BR-DUZA. Rijksdienst voor Ondernemend Nederland.