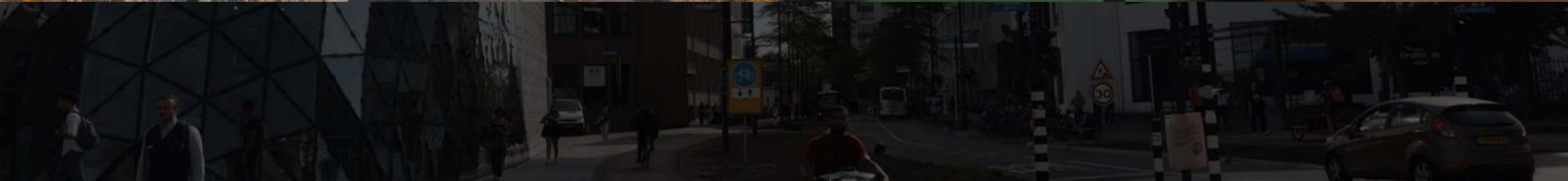
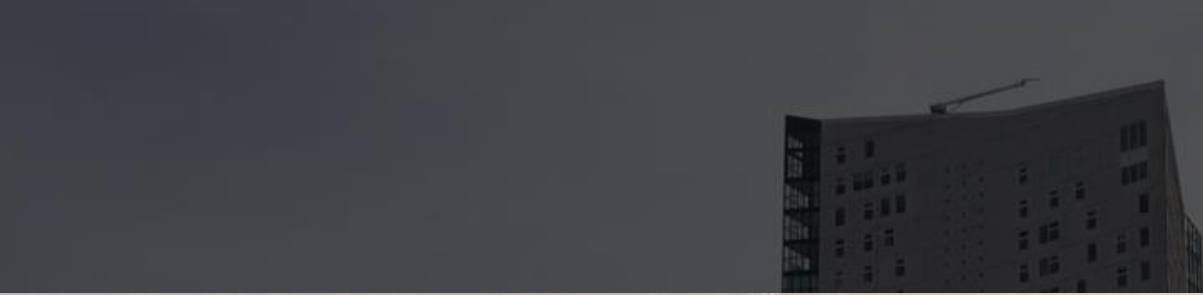
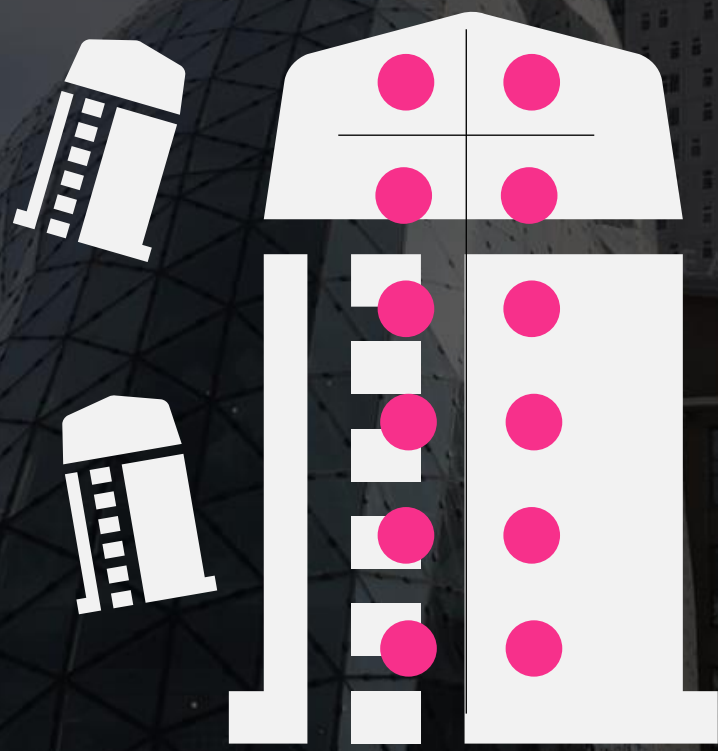
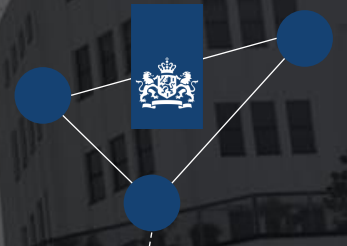
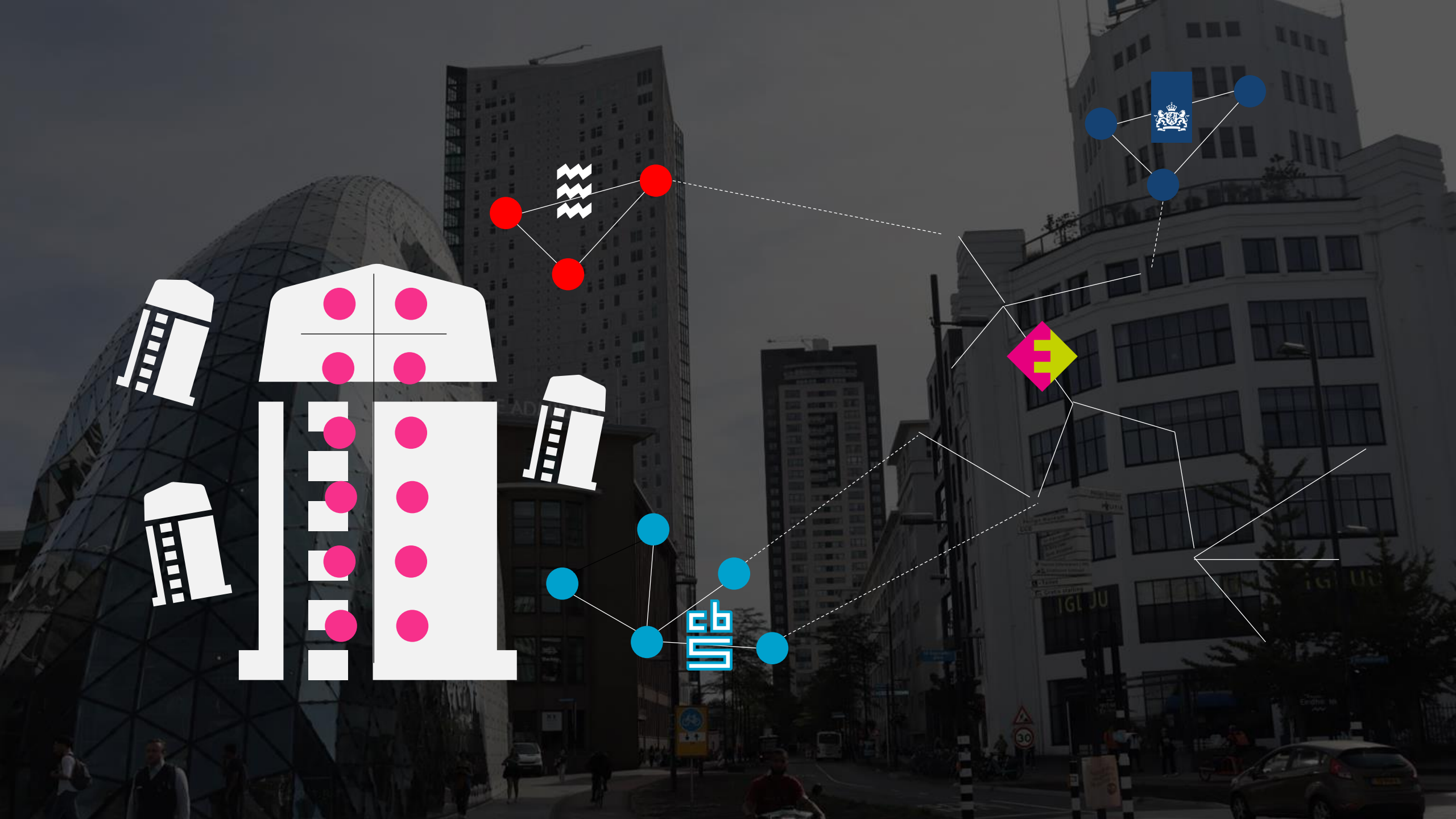


# Making Urban Energy Use More Intelligible Using Semantic Digital Twins









**1. Linked data**  
**2. Neo Dash**  
**3. Use cases**



**1. Linked data**

**2. Neo Dash**

**3. Use cases**

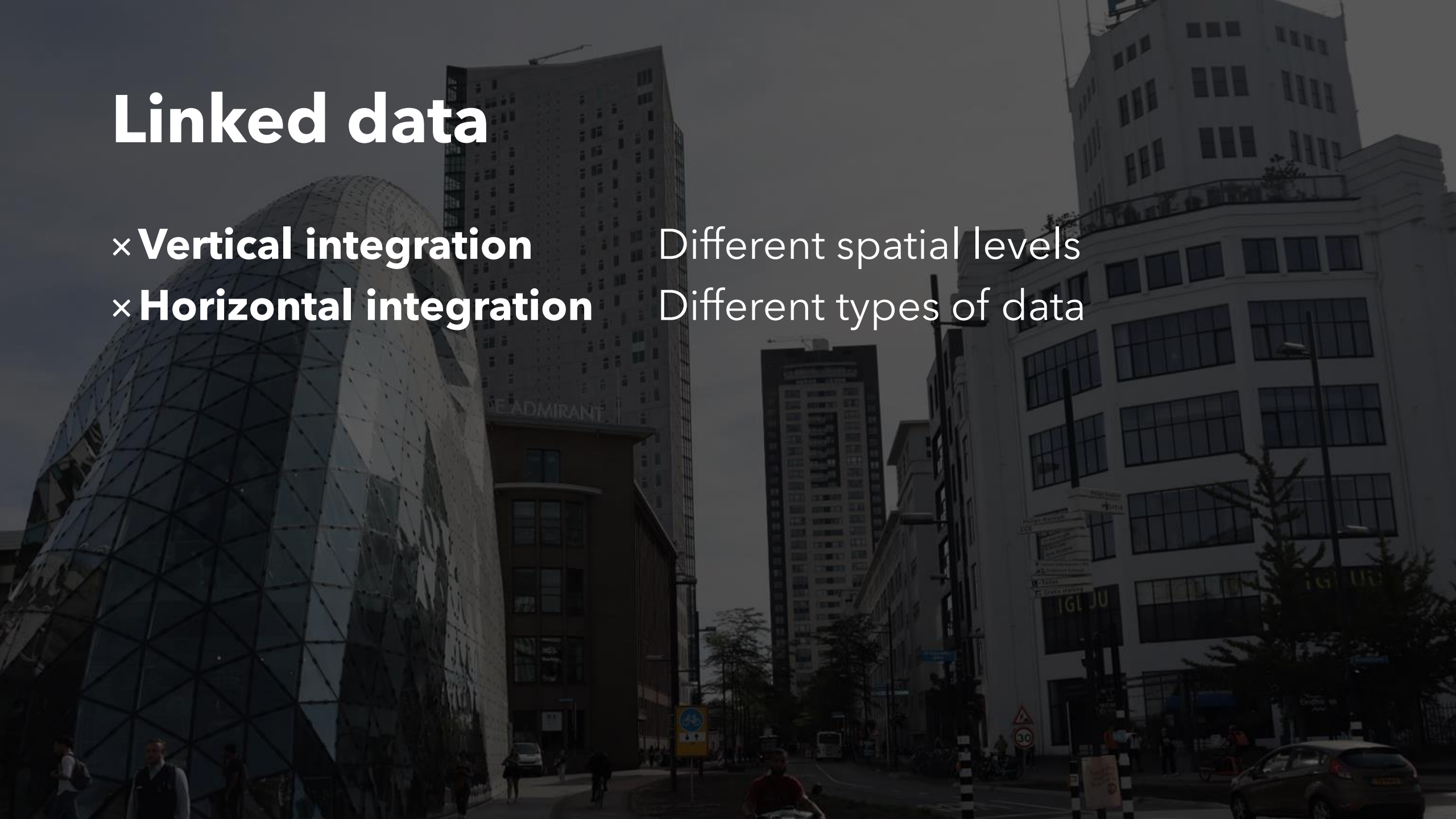
# Linked data

× **Vertical integration**

× **Horizontal integration**

Different spatial levels

Different types of data



# Linked data Vertical integration

- × Extension of BOT
- × Neighborhoods can contain other Neighborhoods



**:NeighborhoodA**

bot:containsZone

**:NeighborhoodB**

bot:containsZone

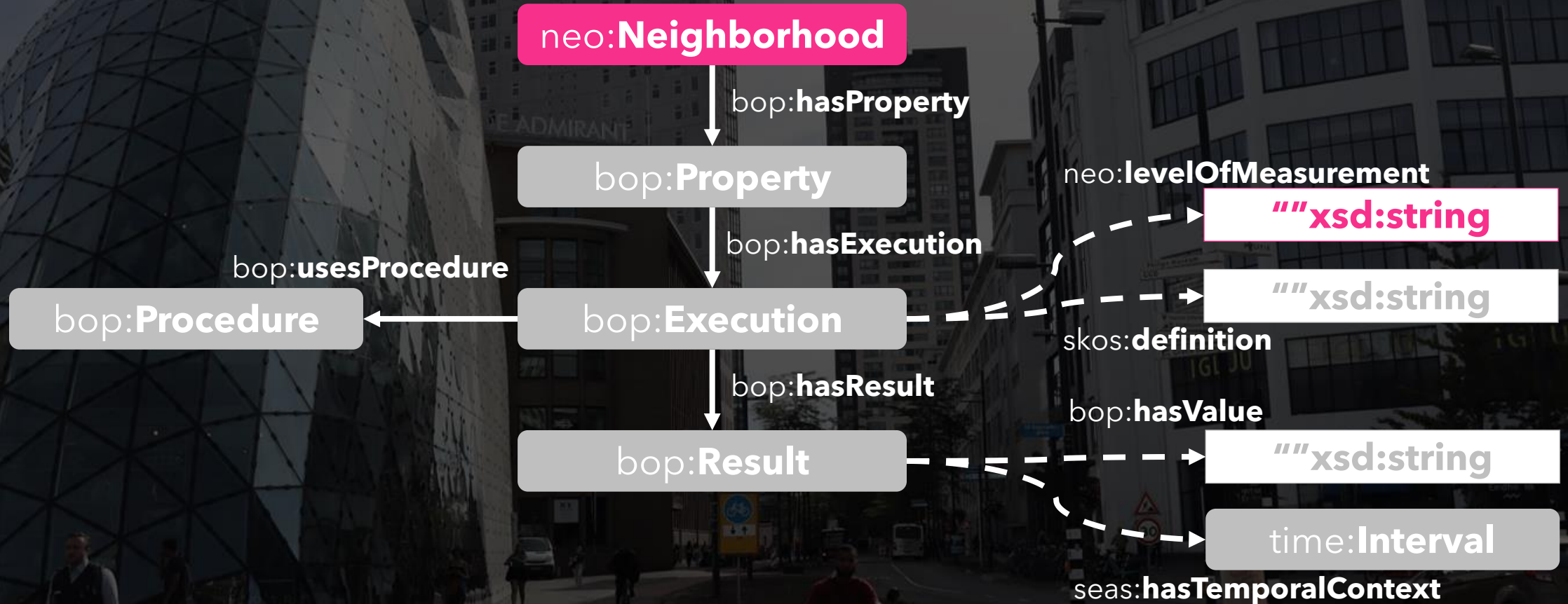
**:NeighborhoodC**

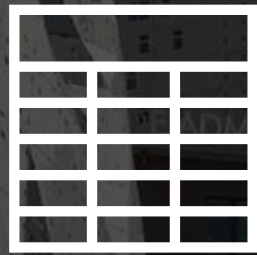
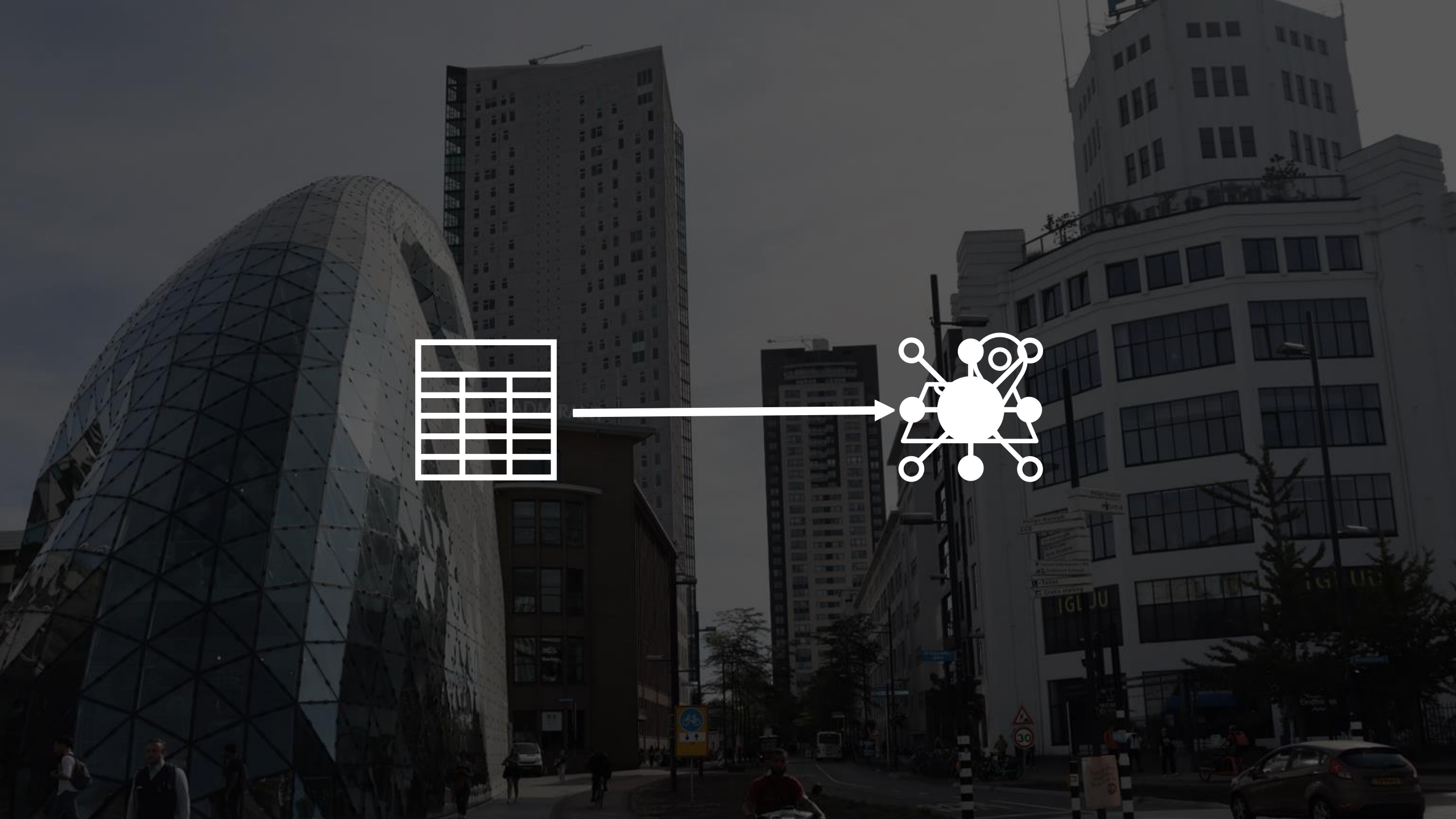




# Linked data Horizontal integration

× Reusing BOP to describe properties of neighborhoods







**1. Linked data**

**2. Neo Dash**

**3. Use cases**

Map

Disable Neighborhoods Disable Geometry **Reset view**



Table

Maximize View Show Results Export

Graph

Maximize View Data Graph No Location Selected

Map

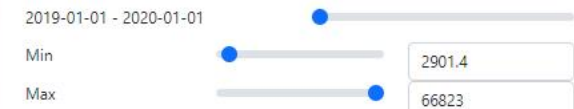
Disable Neighborhoods Disable Geometry **Reset view**



Query

SPARQL X

**Variable:** electricityUse (kWh)  
**Definition:** Average electricity use per connection to the grid in the area.  
**Postal Code Level:** 6



Undo Visualization Remove

Select Energy Variable ▾

**Variable:** urbanDensity (adres/km2)  
**Definition:** Urban density based on the amount of adrees per kilometer  
**Postal Code Level:** 5



Visualize Results Remove

Select Query Variable ▾

- 2901.6 - 9269.07
- 9269.07 - 15636.54
- 15636.54 - 22004.01
- 22004.01 - 28371.48
- 28371.48 - 34738.94

Table

Maximize View Show Results Export

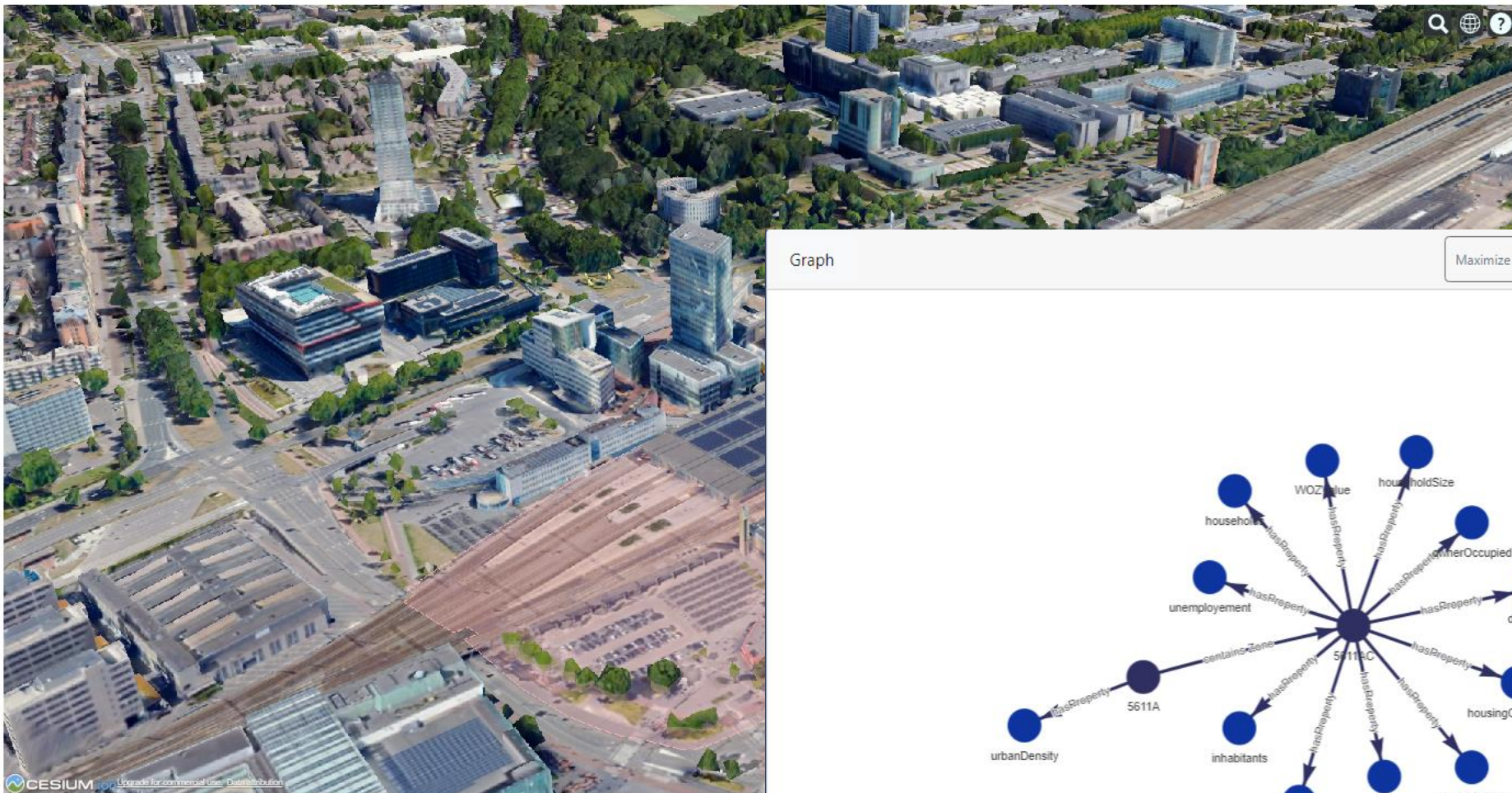
Graph

Maximize View Data Graph No Location Selected

Map

Disable Neighborhoods Disable Geometry Reset view

Query SPARQL X



**Variable:** electricityUse (kWh)  
**Definition:** Average electricity use per connection to the grid in the area.  
**Postal Code Level:** 6

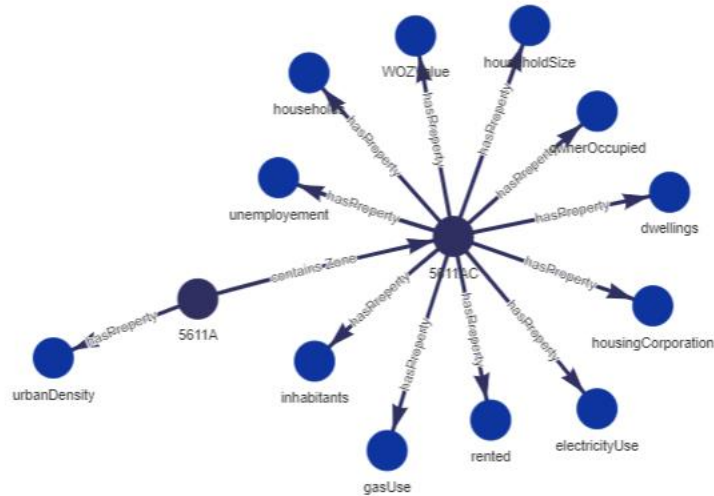
2019-01-01 - 2020-01-01

Min 2901.4  
 Max 66823

Undo Visualization Remove

Graph

Maximize View Data Graph Hide 5611AC Graph



the amount of adrees per kilometer

2287.5  
 4687

Table

Postal Code	electricityUse	urbanDensity
5611AC	14995.29	4297.0
5611AD	14995.29	4297.0

view Data Graph Hide 5611AC Graph

Map

Disable Neighborhoods Disable Geometry **Reset view**



5611AC



Electricity Use Areas Gas Use Areas Neighborhood Postal Code 4 Postal Code 5 Postal Code 6

Property	Value	Procedure	Begin	End
electricityUse	14995.29 (kWh)	average	2019-01-01T00:00:00	2020-01-01T00:00:00
electricityUse	14243.79 (kWh)	average	2021-01-01T00:00:00	2022-01-01T00:00:00
electricityUse	15302.86 (kWh)	average	2020-01-01T00:00:00	2021-01-01T00:00:00
electricityUse	10766.36 (kWh)	average	2022-01-01T00:00:00	2023-01-01T00:00:00

Table

Maximize View Show Results Export

Graph

Maximize View Data Graph 5611AC Graph



**Let's  
use  
this!**





**1. Linked data**  
**2. Neo Dash**  
**3. Use cases**



Energy data



Energy Poverty



Energy data



Energy Poverty

Map

Disable Neighborhoods Disable Geometry Reset view

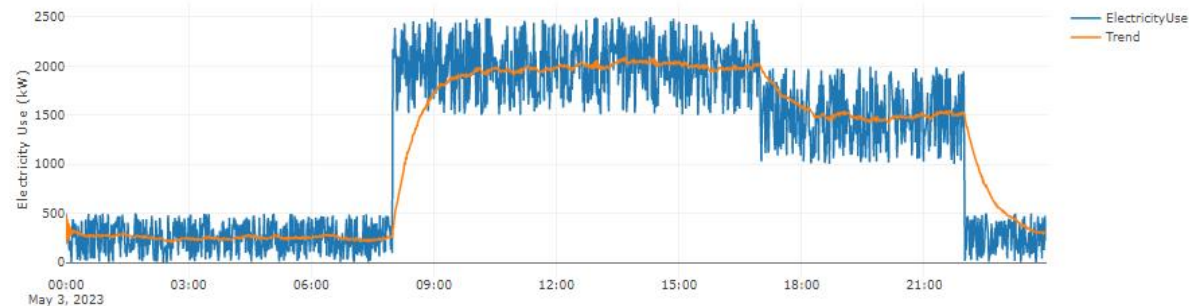


Selected Building

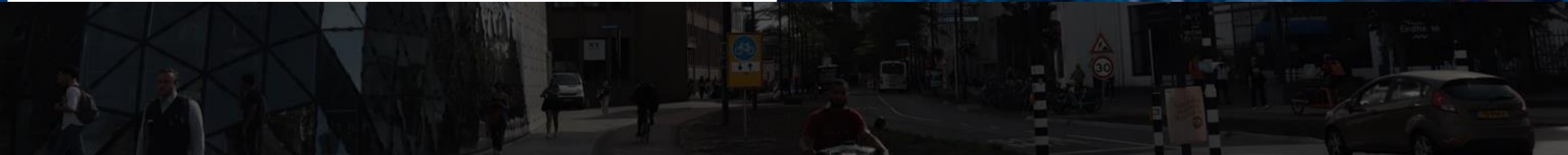
X

Electricity Use Areas Gas Use Areas Neighborhood Postal Code 4 Postal Code 5 Postal Code 6

Energy Data



#	Postal-code	House Number	Area (m2)	Build Year	Purpose of Use
<a href="#">0772100001003373</a>	5612AV	6	23859	2001	<a href="#">Onderwijsfunctie</a>



Map

Disable Neighborhoods Disable Geometry **Reset view**



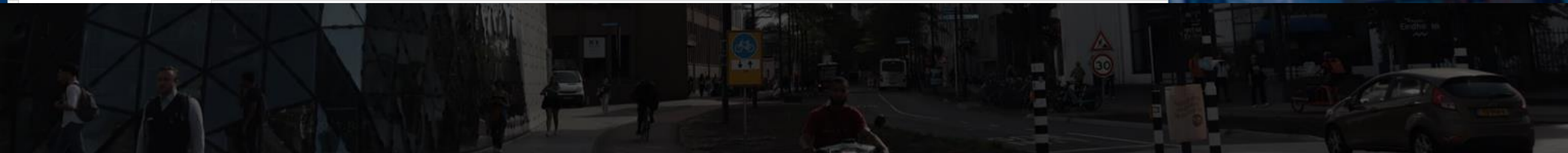
Time Series ✕

Time Series Electricity Use Postal Code Electricity Use Use Combination

Time Series

Start Date: 2023-05-03T00:00:00Z

End Date: 2023-05-03T23:59:00Z



Map

Disable Neighborhoods Disable Geometry **Reset view**

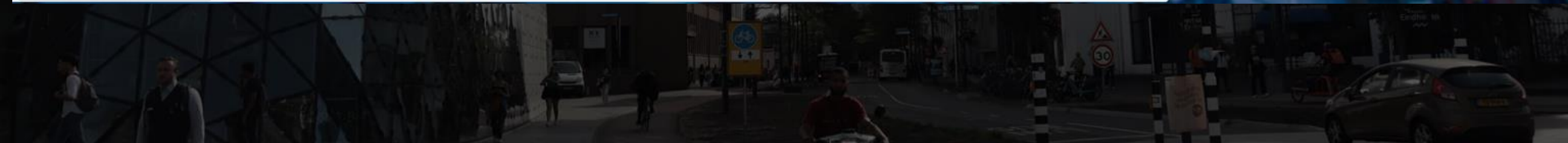


761 - 9296.12
9296.12 - 17831.24
17831.24 - 26366.36
26366.36 - 34901.48
34901.48 - 43436.62

Time Series ✕

Time Series Electricity Use Postal Code Electricity Use Use Combination

**Time Series**  
**TStart Date** 2023-05-03T00:00:00Z  
**TEnd Date** 2023-05-03T23:59:00Z  
**Time Series**  
**Start Date:** 2022-01-01T00:00:00  
**End Date:** 2023-01-01T00:00:00



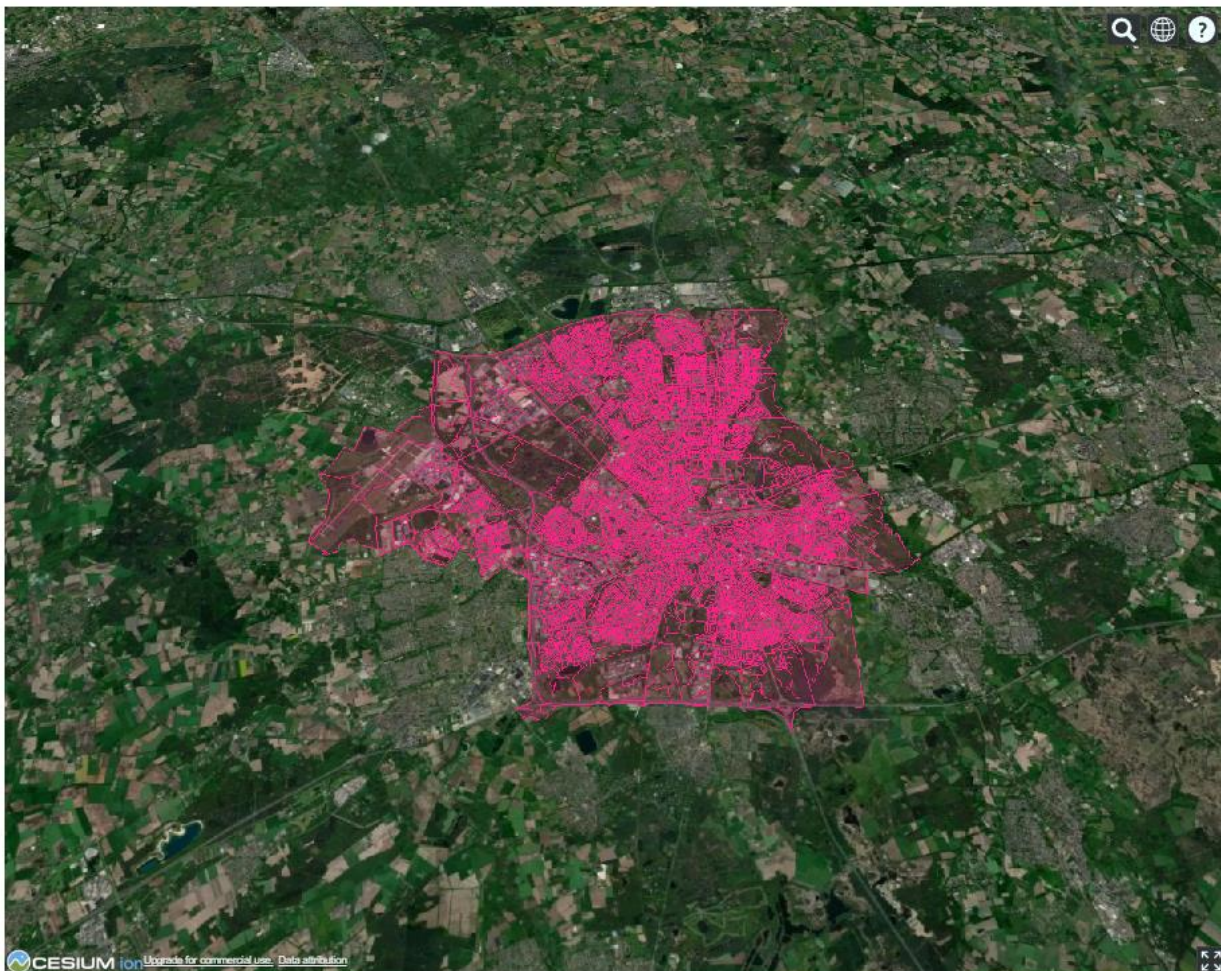


Time-series data



Energy Poverty

Map

[Disable Neighborhoods](#) [Disable Geometry](#) [Reset view](#)

Energy Poverty Analysis

X

10% of Income

LHE

LLEK

- × If you spend more than **10% of your annual income** on energy
- × If your income is within **130% of the poverty line**, and your **energy cost is above the median**
- × If your income is within **130% of the poverty line**, and your **energy cost is above the median** and your dwelling has an **energy label of D or worse**.



Map

Disable Neighborhoods Disable Geometry Reset view



### Energy Poverty Analysis

10% of Income

10% of Income

LIHE

LILEK

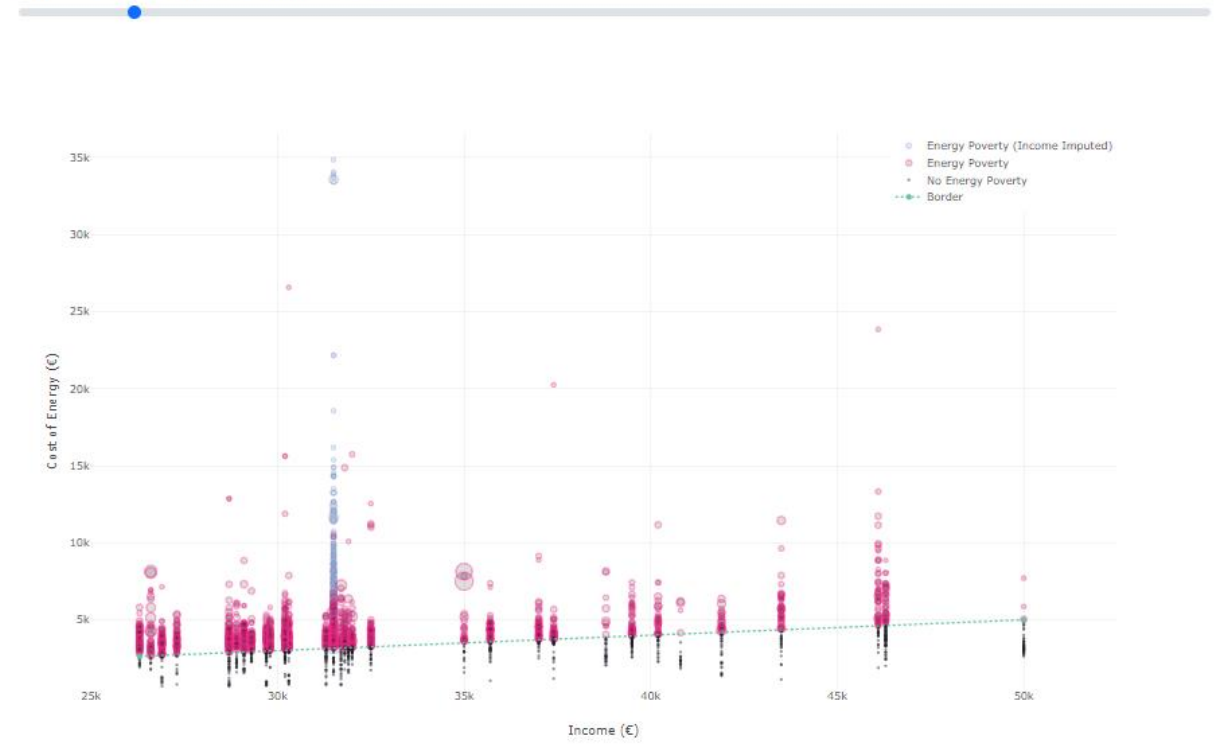
This analysis defines energy poverty as spending more than 10% of annual income on energy.

**Horizontal Axis:** This axis shows the annual income of the neighborhood. Income data is from 2021 and gathered from CBS. If no income was registered, the median income of Eindhoven is used (€31500).

**Vertical Axis:** This axis shows an estimation of the cost of energy for the neighborhood. Energy consumption is taken from Enexis, and represents the average energy use per connection in the area in 2022. Energy price is adopted from the CBS and is taken as the average of 2022.

**Neighborhoods at risk:** 1670 **Households at Risk:** 58380

**Adjust Poverty Line:** Income Spent on Energy (>10%)



× If you spend more than **10% of your annual income** on energy

Map

Disable Neighborhoods Disable Geometry Reset view



CESIUM Libraries for commercial use. Data attribution

### Energy Poverty Analysis

10% of Income

10% of Income

LIFE

LILEK

This analysis defines energy poverty as having an income within 130% of the poverty line, while having an above average energy bill.

**Horizontal Axis:** This axis shows the annual income of the neighborhood. Income data is from 2021 and gathered from CBS.

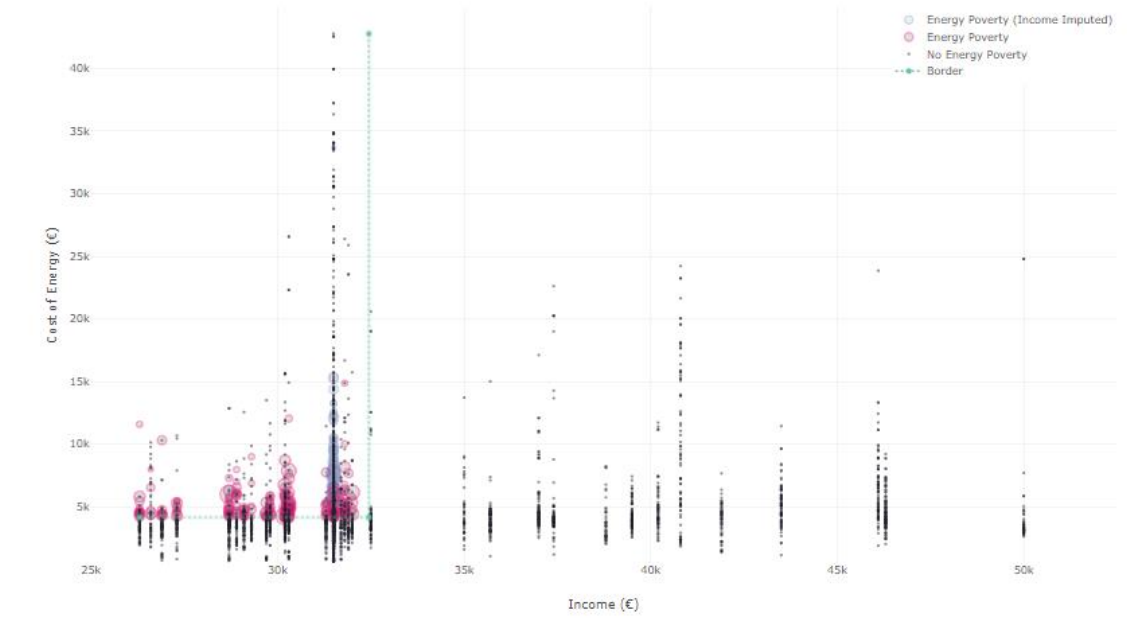
**Vertical Axis:** This axis shows an estimation of the cost of energy for the neighborhood. Energy consumption is taken from Enexis, and represents the average energy use per connection in the area in 2022. Energy price is adopted from the CBS and is taken as the average of 2022.

Neighborhoods at risk: 666 Households at Risk: 11860

Adjust Poverty Line: Income within 130% of poverty line



Adjust Energy Line: Median Energy Cost



× If your income is within **130% of the poverty line**, and your **energy cost is above the median**

Map

Disable Neighborhoods Disable Geometry Reset view



### Energy Poverty Analysis

10% of Income

10% of Income

LIFE

LILEK

This analysis defines energy poverty as having an income within 130% of the poverty line, while having an above average energy bill.

**Horizontal Axis:** This axis shows the annual income of the neighborhood. Income data is from 2021 and gathered from CBS.

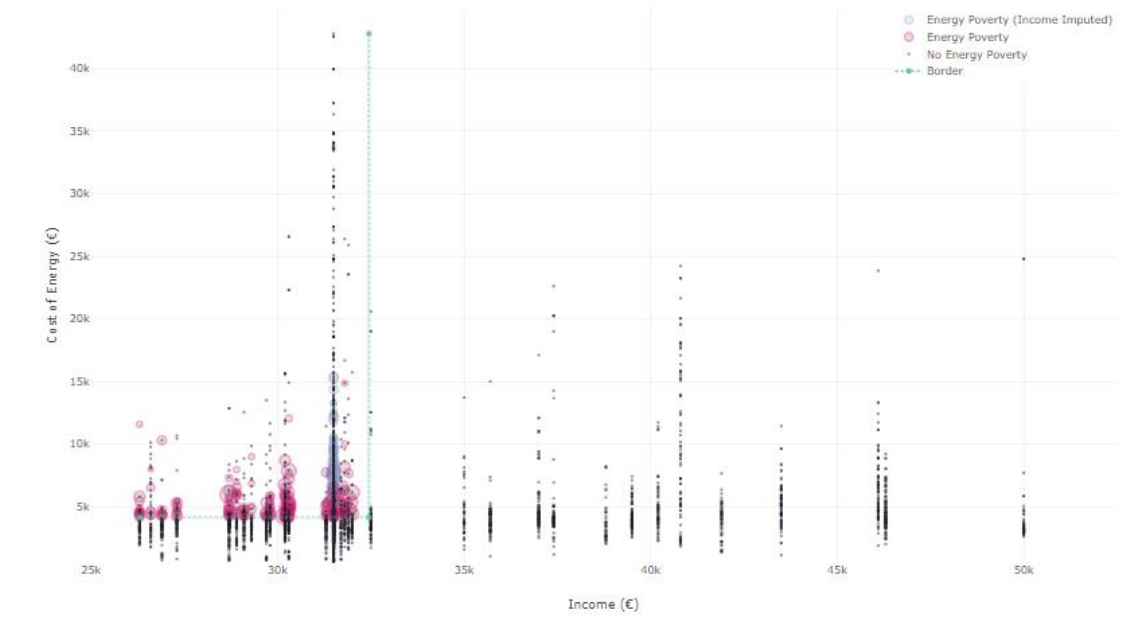
**Vertical Axis:** This axis shows an estimation of the cost of energy for the neighborhood. Energy consumption is taken from Enexis, and represents the average energy use per connection in the area in 2022. Energy price is adopted from the CBS and is taken as the average of 2022.

Neighborhoods at risk: 666 Households at Risk: 11860

Adjust Poverty Line: Income within 130% of poverty line



Adjust Energy Line: Median Energy Cost



× If your income is within **130% of the poverty line**, and your **energy cost is above the median**

Map

Disable Neighborhoods Disable Geometry Reset view



### Energy Poverty Analysis

10% of Income

10% of Income

LIHE

LILEK

This analysis defines energy poverty as having an income within 130% of the poverty line, while having an above average energy bill.

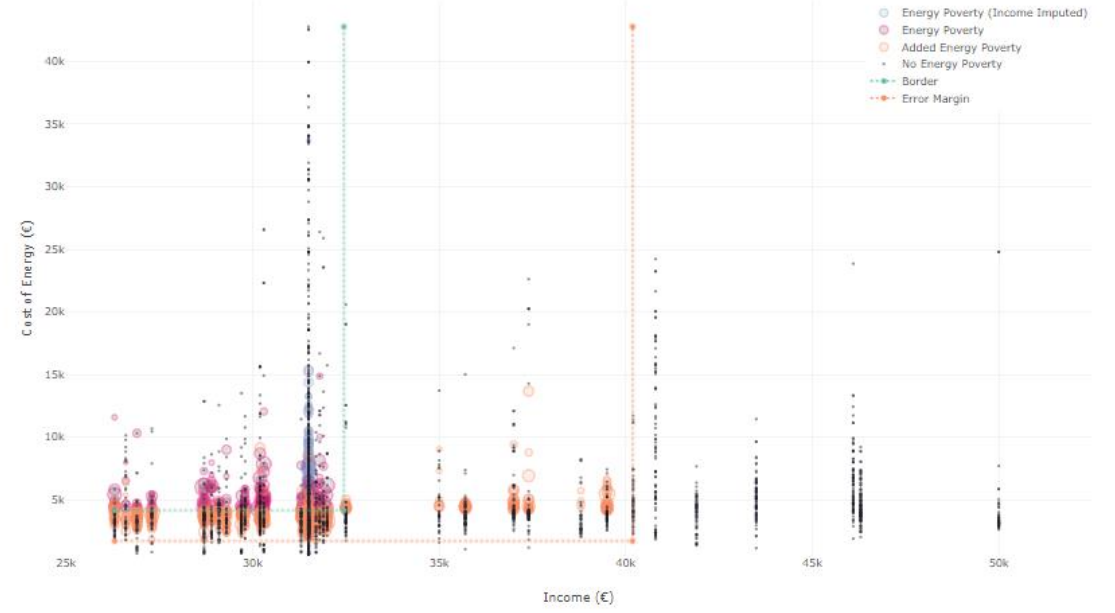
**Horizontal Axis:** This axis shows the annual income of the neighborhood. Income data is from 2021 and gathered from [CBS](#).

**Vertical Axis:** This axis shows an estimation of the cost of energy for the neighborhood. Energy consumption is taken from [Enexis](#), and represents the average energy use per connection in the area in 2022. Energy price is adopted from the [CBS](#) and is taken as the average of 2022.

**Neighborhoods at risk:** 1588 (+922) **Households at Risk:** 16210 (+4350)

**Adjust Poverty Line:** Income within 161% of poverty line

**Adjust Energy Line:** Median Energy Cost -59%



× If your income is within **130% of the poverty line**, and your **energy cost is above the median**

Map Disable Neighborhoods Disable Geometry Reset view



Energy Poverty Analysis 10% of Income Laag Inkomen, Lage Energetische Kwaliteit

10% of Income LIHE LILEK

This analysis defines energy poverty as having an income within 130% of the poverty line, while having an above average energy bill and a dwelling with below average energy performance (i.e. energy label below C).

**Horizontal Axis:** This axis shows the annual income of the neighborhood. Income data is from 2021 and gathered from CBS.

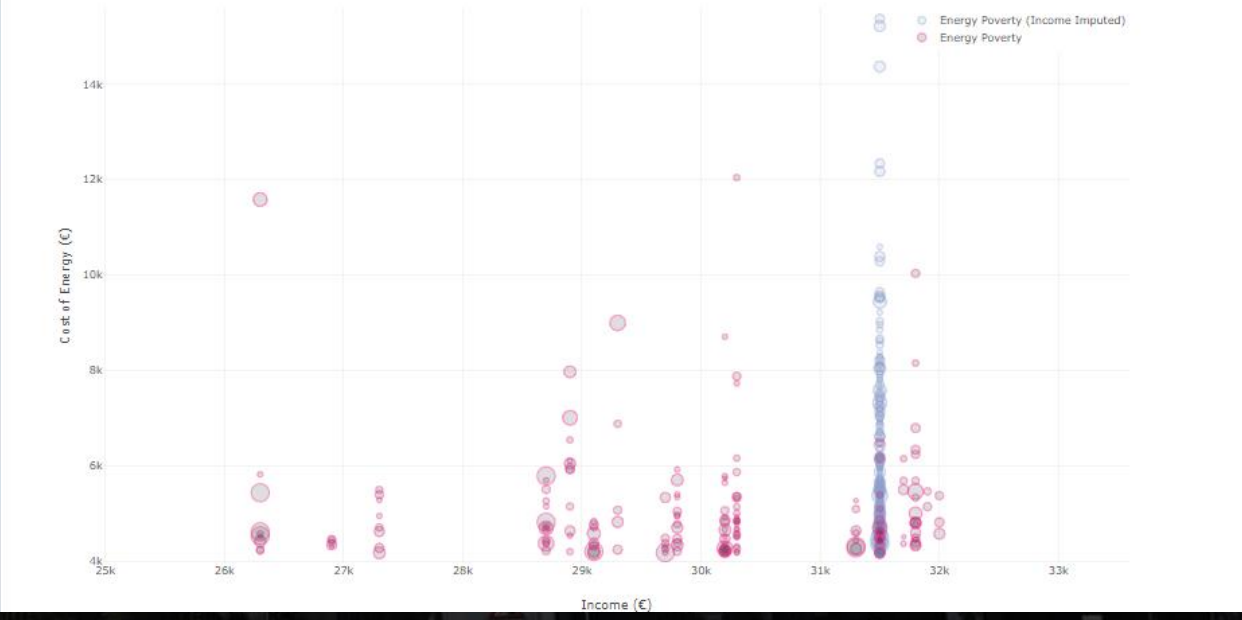
**Vertical Axis:** This axis shows an estimation of the cost of energy for the neighborhood. Energy consumption is taken from Enexis, and represents the average energy use per connection in the area in 2022. Energy price is adopted from the CBS and is taken as the average of 2022.

**Neighborhoods at risk:** 451 **Households at Risk:** 6775 (-5065)

**Adjust Poverty Line:** Income within 130% of poverty line

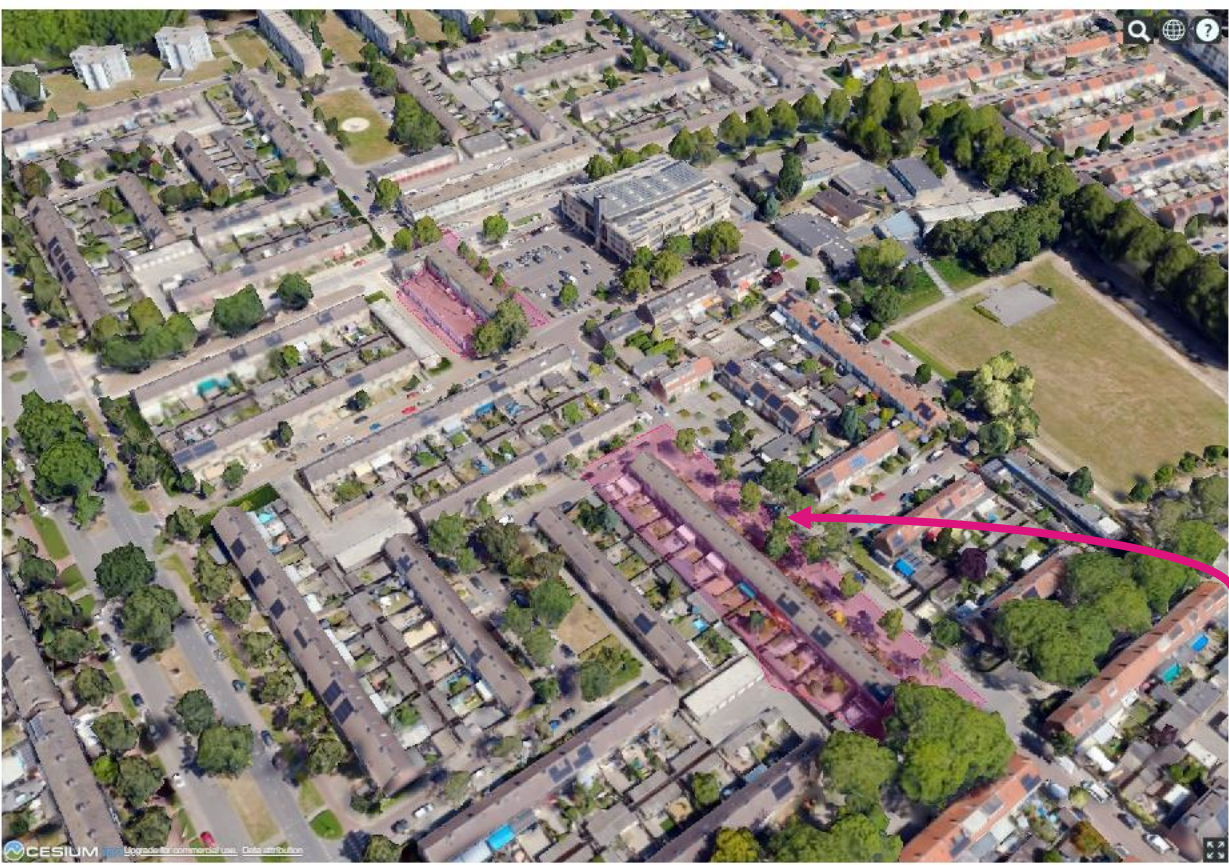


**Adjust Energy Line:** Median Energy Cost

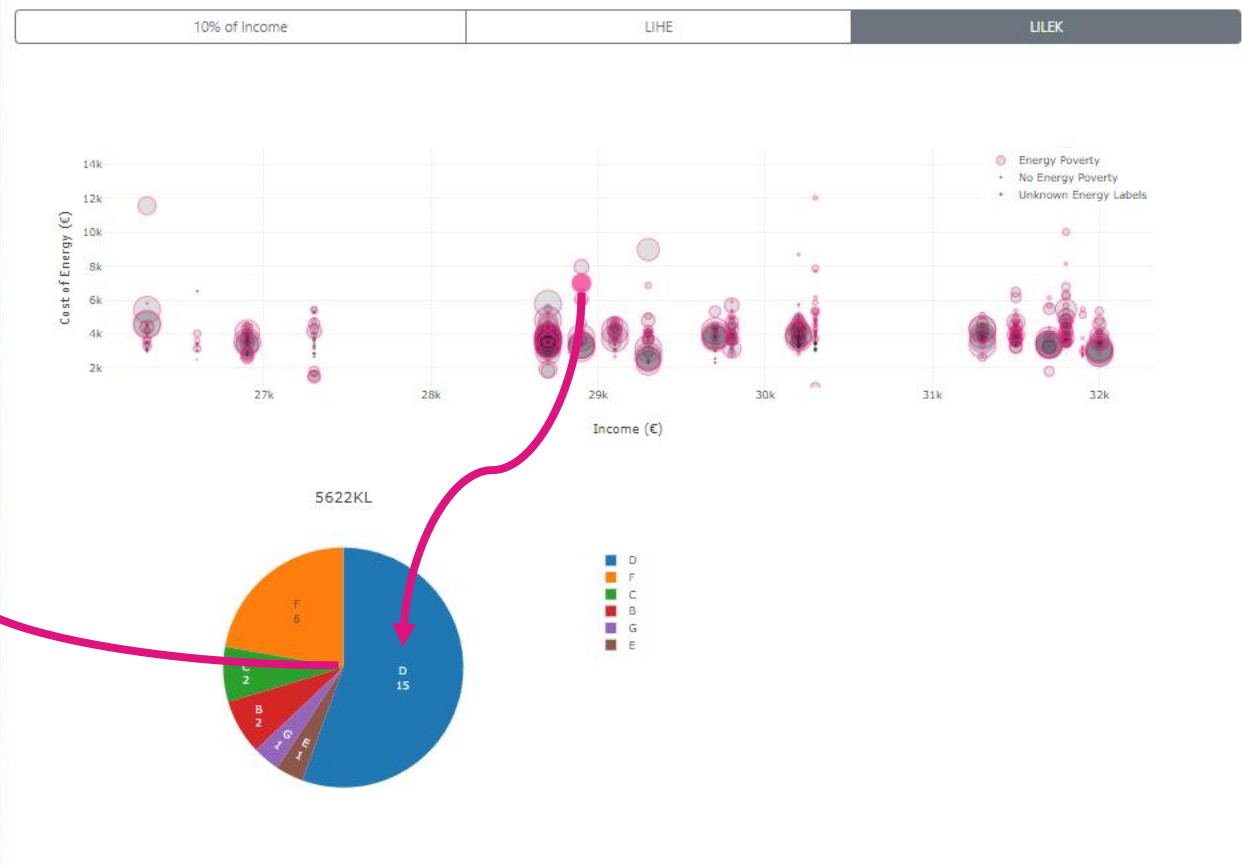


× If your income is within **130% of the poverty line**, and your **energy cost is above the median** and your dwelling has an **energy label of D or worse**.

Map Disable Neighborhoods Disable Geometry Reset view



Energy Poverty Analysis X



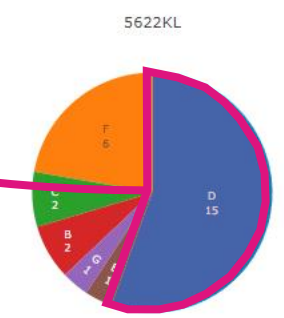
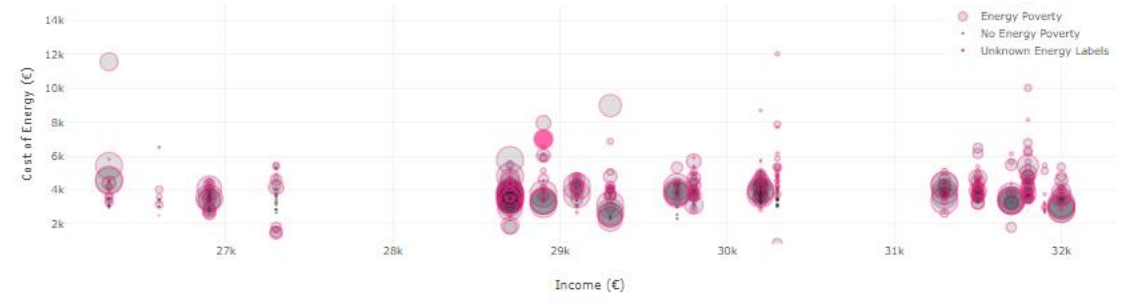
× If your income is within **130% of the poverty line**, and your **energy cost is above the median** and your dwelling has an **energy label of D or worse**.

Map Disable Neighborhoods Disable Geometry Reset view



Energy Poverty Analysis X

10% of Income LIHE LILEK



- D
- F
- C
- B
- G
- E

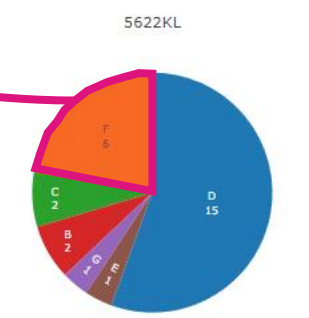
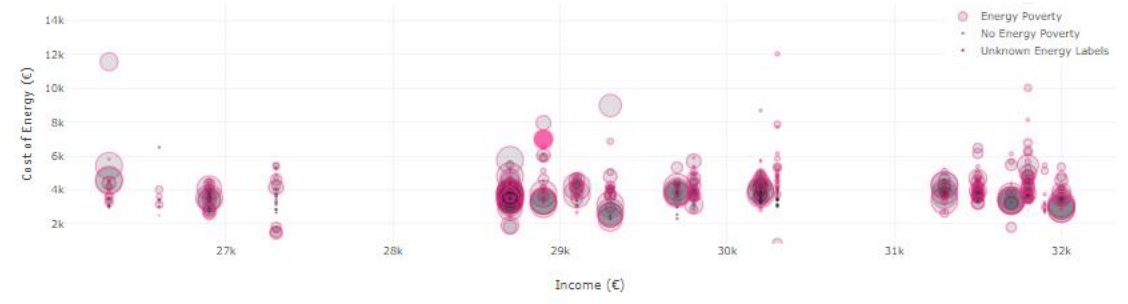
× If your income is within **130% of the poverty line**, and your **energy cost is above the median** and your dwelling has an **energy label of D or worse**.

Map Disable Neighborhoods Disable Geometry Reset view



Energy Poverty Analysis X

10% of Income LIHE LILEK



- D
- F
- C
- B
- G
- E

× If your income is within **130% of the poverty line**, and your **energy cost is above the median** and your dwelling has an **energy label of D or worse**.





**1. Linked data**  
**2. Neo Dash**  
**3. Use cases**

# Making Urban Energy Use More Intelligible Using Semantic Digital Twins