WIRTSCHAFTS UNIVERSITÄT WIEN VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS

EFMD EQUIS ACCREDITED

Open City Data Pipeline

Axel Polleres

formerly: Siemens AG Österreich, now WU Wien, Austria

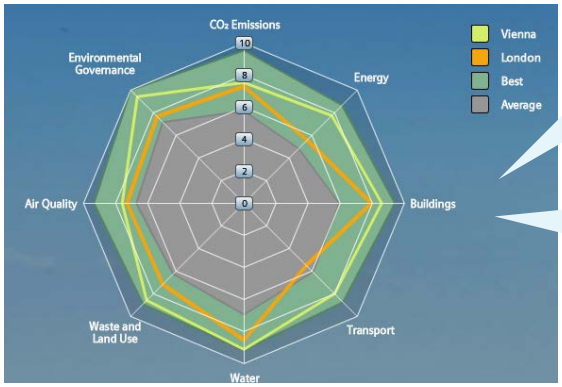
City Data – Important for Infrastructure Providers & for City Decision Makers

- City Assessment and Sustainability reports
- Tailored offerings by Infrastructure Providers

… however, these are often **outdated** before even published!

→Needs **up-to-date City Data** and **calculates City KPIs** in a way that allows to display the current state and run scenarios of different product applications.

e.g. towards a "Dynamic" Green City Index:



Goal (short term):
- Leverage Open Data for calculating a city' performance from public sources on the Web **automatically**

Goal (long term):
- Define and Refine KPI models to assess specific impact of infrastructural investments and gather/check input **automatically**

Current State of Data and Benchmarking System

- **Collecting Data for City Assessment and Benchmarking:**
- Data collection for various studies within Siemens is a manual, time-intensive process, using statistical data as well as questionnaires to city stakeholders.
- **Much of this data is available online:**
- City Open Data Initiatives publish more and more data with frequent updates

UNdata A world of information | THE WORLD BANK Open Data | DBpedia | wien.at | NYC OpenData | london.gov.uk

- City data format standards and regulations are developing:

INSPIRE - Infrastructure for Spatial Information in Europe

e.g. EU INSPIRE directive, or

European Commission eurostat Your key to European statistics

eurostat's UrbanAudit Collection of city indicators

- **Benchmarking Systems and KPIs** The Green City Index | MOST LIVEABLE CITIES
  - City Indexes benchmark cities based on top down data (example: tax income from petrol, tax/L→ Car CO_2 emissions). Bottom up approaches only if no top down data available, for approximation (example: No. cars, average distance driven per year, Emission factor → Car CO_2 emissions)
  - Approaches allowing scenario comparison and calculations of system impacts only on a city specific case study base.

Leveraging Open Data:
Openly available urban indicators frameworks (already available in Linked Data!)

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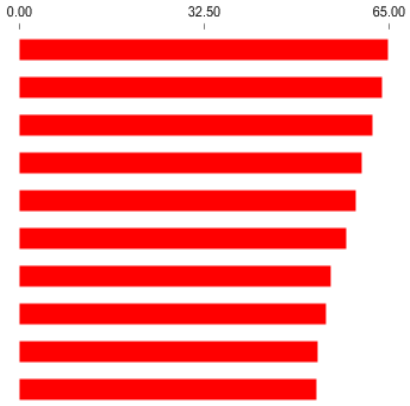
- Data example: Urban Audit
- (ca. 300 indicators for European
- 330 cities, maintained by Eurostat)

Cost of a monthly ticket for public transport (for 5-10 km)

Average : 46.59 High : 65 Low : 32.5

You are on page 1 of 4 (37 records)

Rank	City	Score
1	Weimar (DE)	65.00
2	Berlin (DE)	64.00
3	Frankfurt am Main (DE)	62.30
4	Augsburg (DE)	60.30
5	Wiesbaden (DE)	59.40
6	Mainz (DE)	57.60
7	Hannover (DE)	55.00
8	Bochum (DE)	54.00
9	Düsseldorf (DE)	52.60
10	Koblenz (DE)	52.30

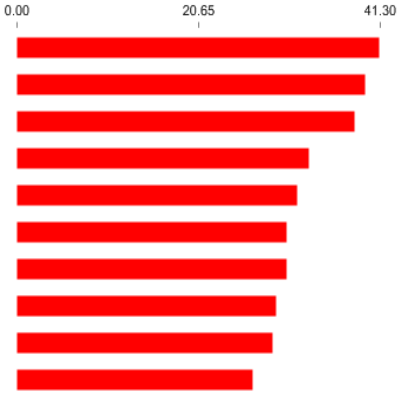


Proportion of journeys to work by public transport (rail, metro, bus, tram)

Average : 20.25 High : 41.3 Low : 4.9

You are on page 1 of 4 (40 records)

Rank	City	Score
1	München (DE)	41.30
2	Berlin (DE)	39.70
3	Frankfurt am Main (DE)	38.50
4	Hamburg (DE)	33.30
5	Stuttgart (DE)	32.00
6	Düsseldorf (DE)	30.80
7	Halle an der Saale (DE)	30.70
8	Nürnberg (DE)	29.60
9	Hannover (DE)	29.20
10	Köln - Cologne (DE)	26.90

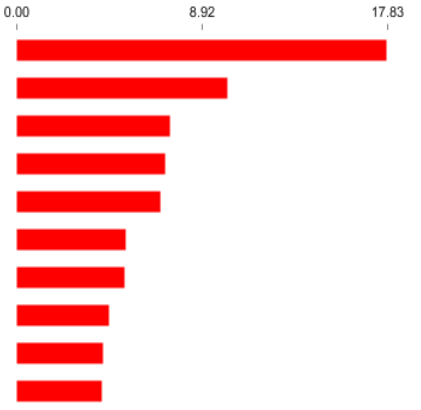


Number of stops of public transport per km2

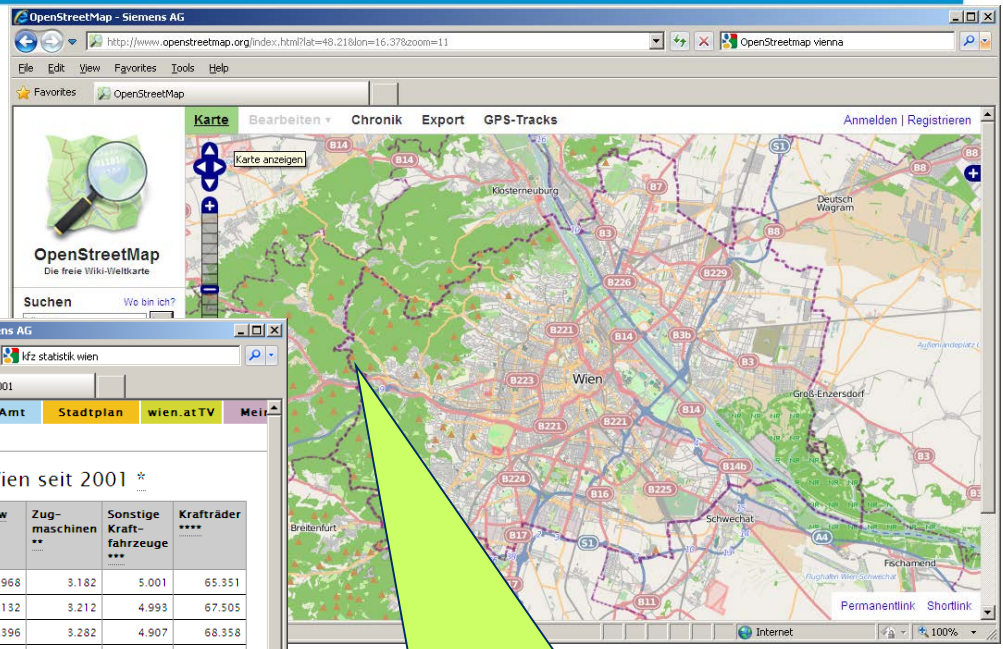
Average : 3.88 High : 17.83 Low : 1.4

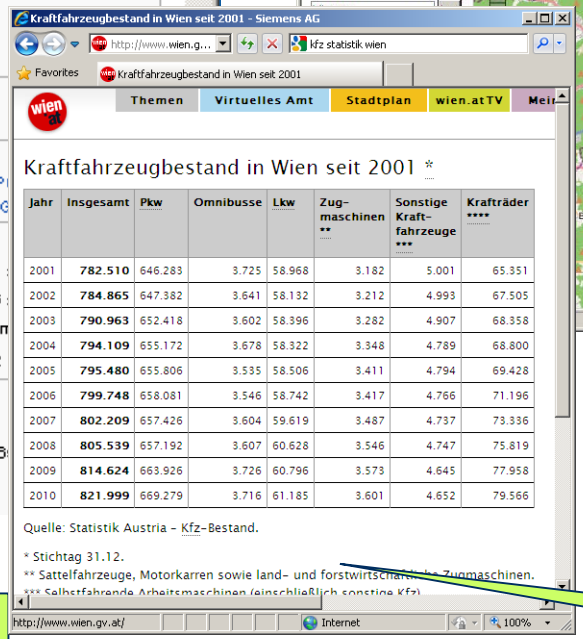
You are on page 1 of 4 (38 records)

Rank	City	Score
1	Stuttgart (DE)	17.83
2	Wuppertal (DE)	10.17
3	Berlin (DE)	7.38
4	Düsseldorf (DE)	7.13
5	Kiel (DE)	6.93
6	Halle an der Saale (DE)	5.25
7	Augsburg (DE)	5.22
8	Dresden (DE)	4.47
9	Mainz (DE)	4.18
10	Göttingen (DE)	4.09



Leveraging Open Data: Other Open Data Sources





Jahr	Insgesamt	Pkw	Omnibusse	Lkw	Zug-maschinen **	Sonstige Kraft-fahrzeuge ***	Krafträder ****
2001	**782.510**	646.283	3.725	58.968	3.182	5.001	65.351
2002	**784.865**	647.382	3.641	58.132	3.212	4.993	67.505
2003	**790.963**	652.418	3.602	58.396	3.282	4.907	68.358
2004	**794.109**	655.172	3.678	58.322	3.348	4.789	68.800
2005	**795.480**	655.806	3.535	58.506	3.411	4.794	69.428
2006	**799.748**	658.081	3.546	58.742	3.417	4.766	71.196
2007	**802.209**	657.426	3.604	59.619	3.487	4.737	73.336
2008	**805.539**	657.192	3.607	60.628	3.546	4.747	75.819
2009	**814.624**	663.926	3.726	60.796	3.573	4.645	77.958
2010	**821.999**	669.279	3.716	61.185	3.601	4.652	79.566

Structured information on most cities in the world (base indicators: population, economy, climate, ...)

Free GIS data for most cities in the world (base information: area, land-use, administrative districts, ...)

Open Government Data

City Data Pipeline: Overview

Dynamic Calculation of KPIs at variable Granularity (City, District, Neighbourhood, Building)

Extensible CityData Model

Cities:

Berlin, Vienna, London, ..

+

Open Data:

THE WORLD BANK

DBpedia Open Data

UNdata

A world of information

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1. Periodic Data Gathering of registered sources (“Focused Crawler”):
Various Formats (CSV, HTML, XML …) & Granularity (monthly, annual, daily)

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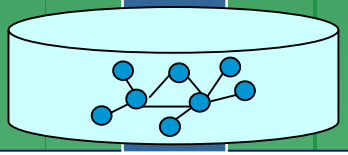
Statistical Methods, Semantic Technologies, Constraints



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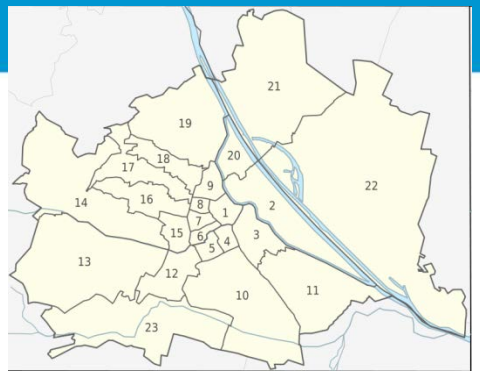

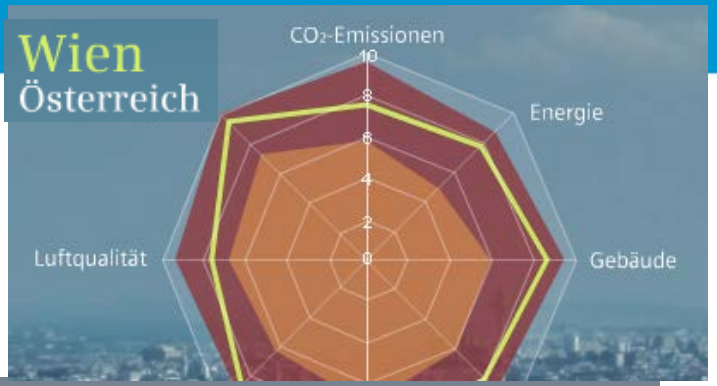

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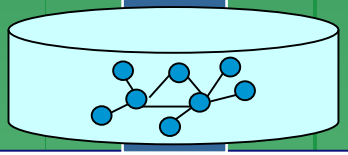

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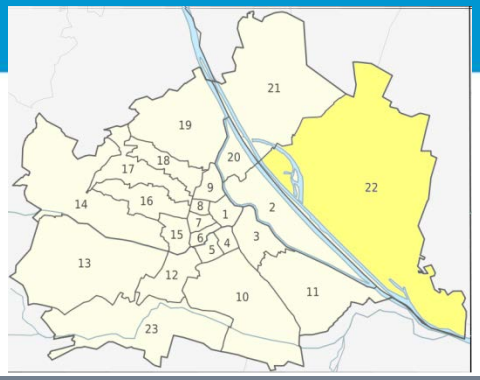

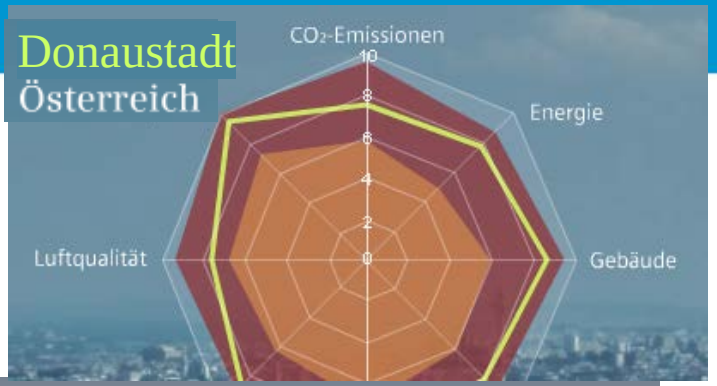

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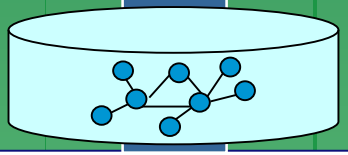

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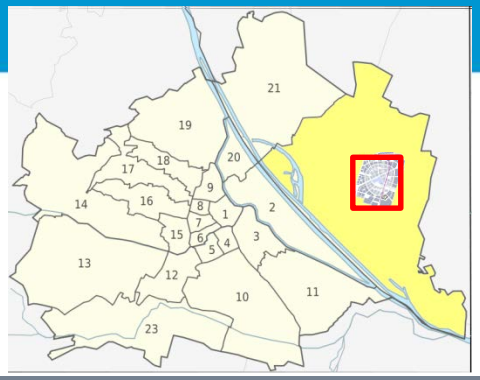

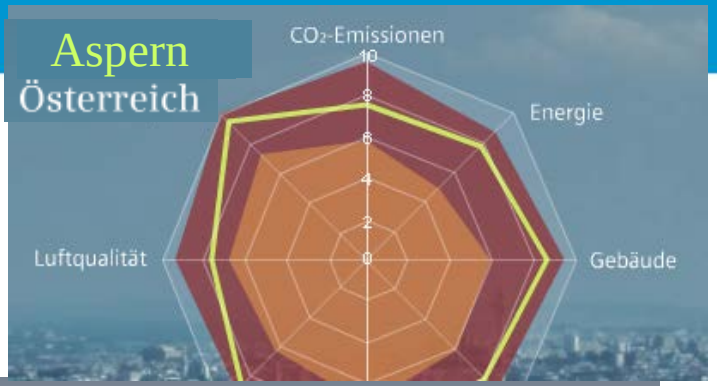

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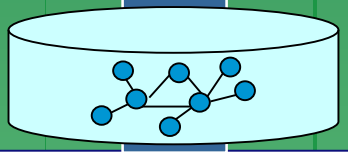

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We have developed a data pipeline to
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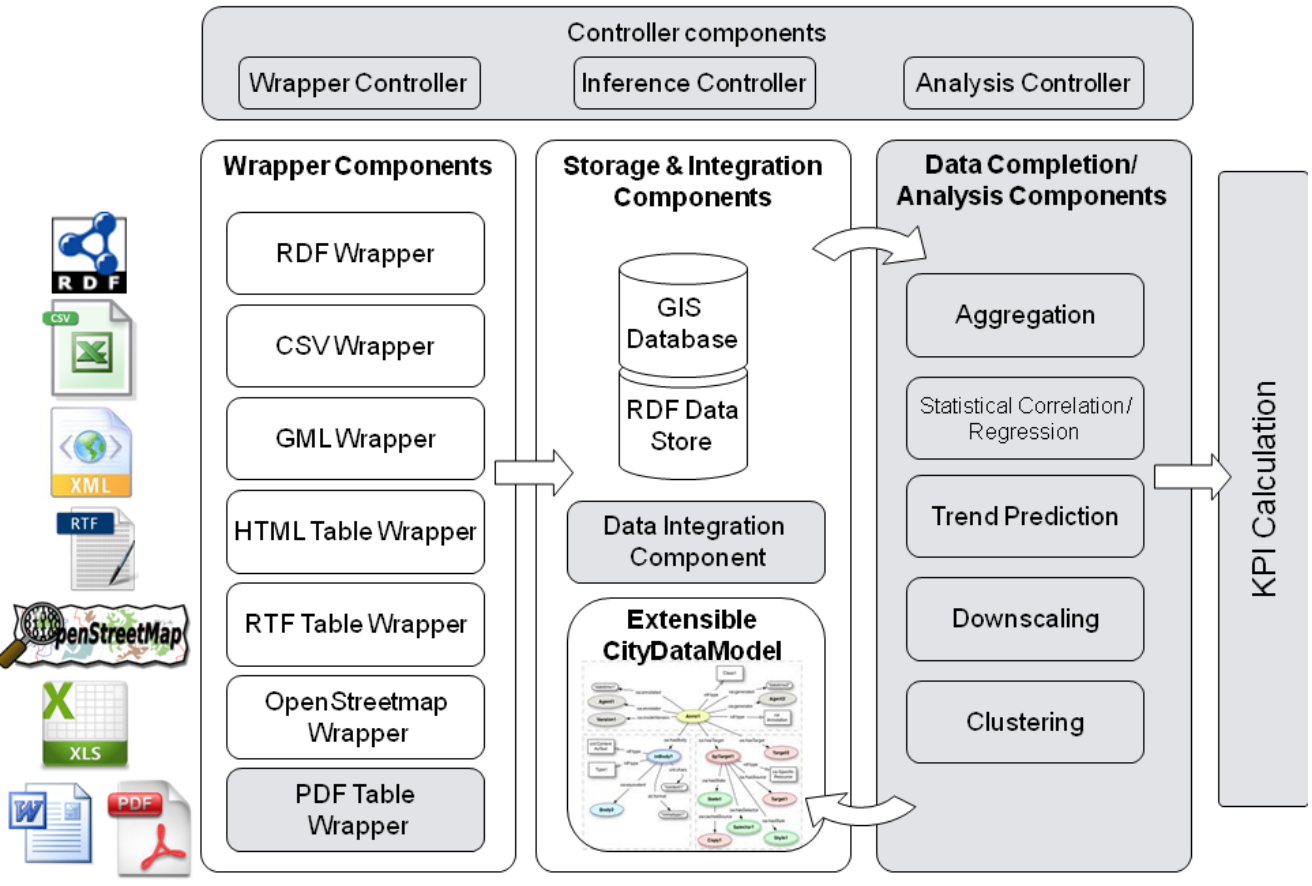
(2) compose and calculate complex city KPIs from the collected data



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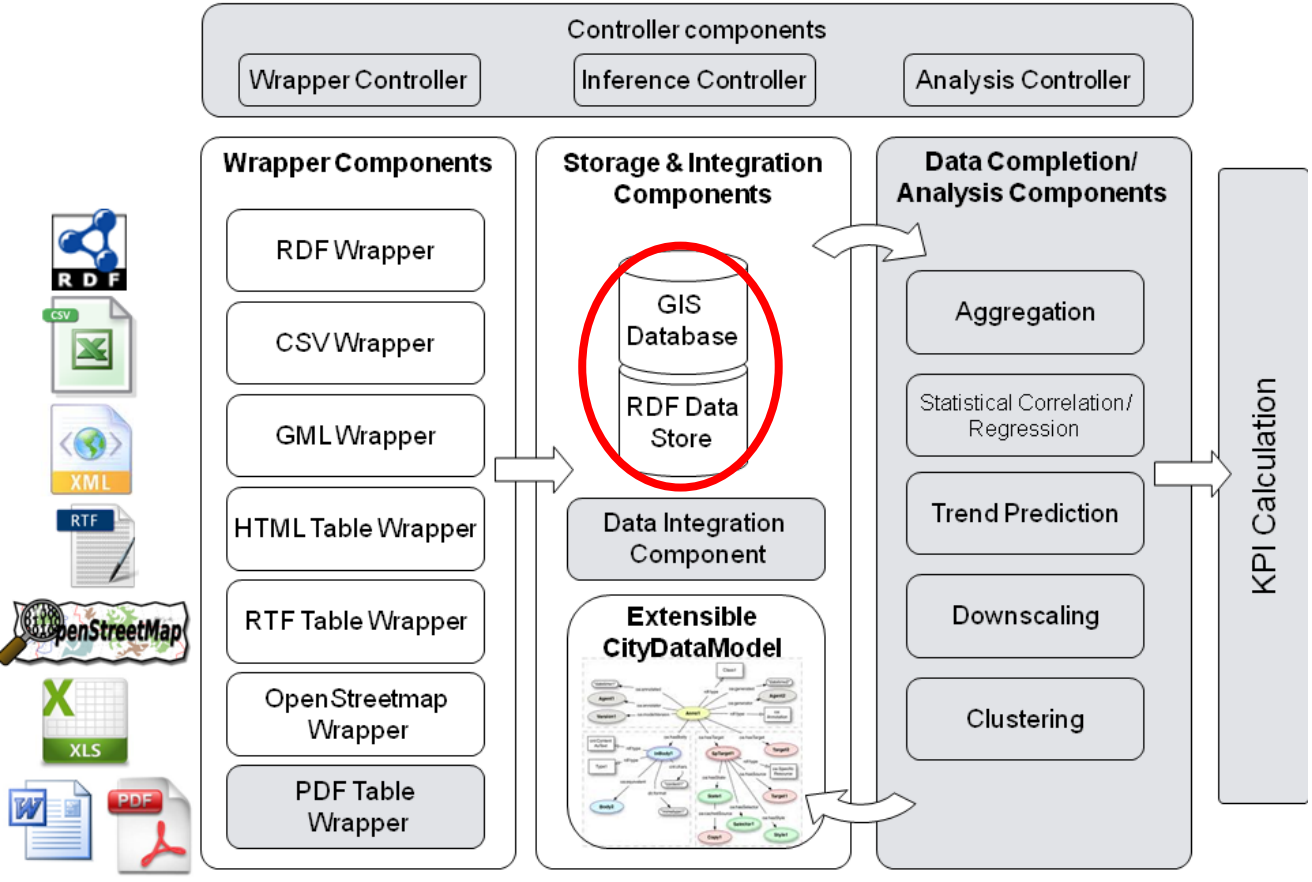

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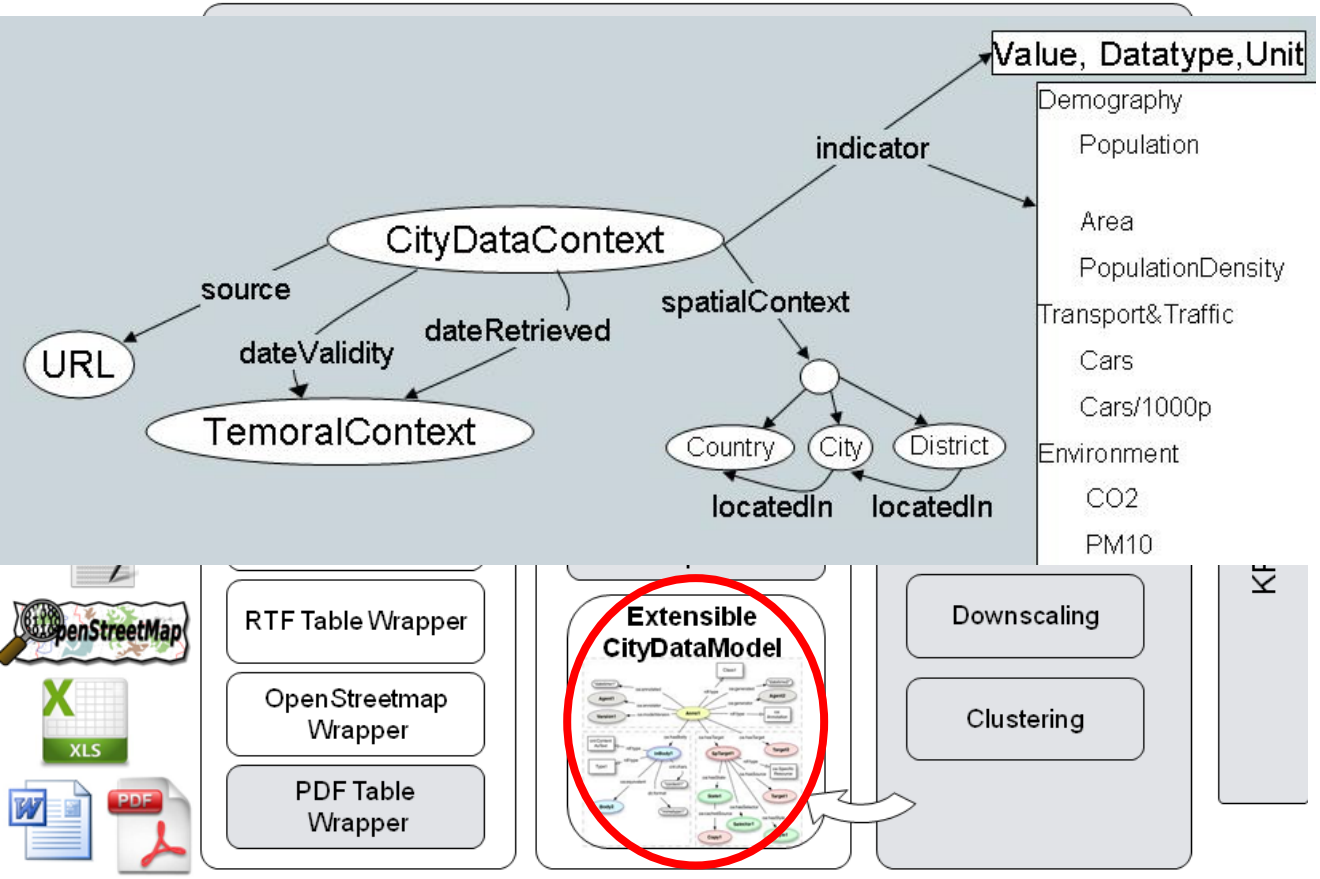

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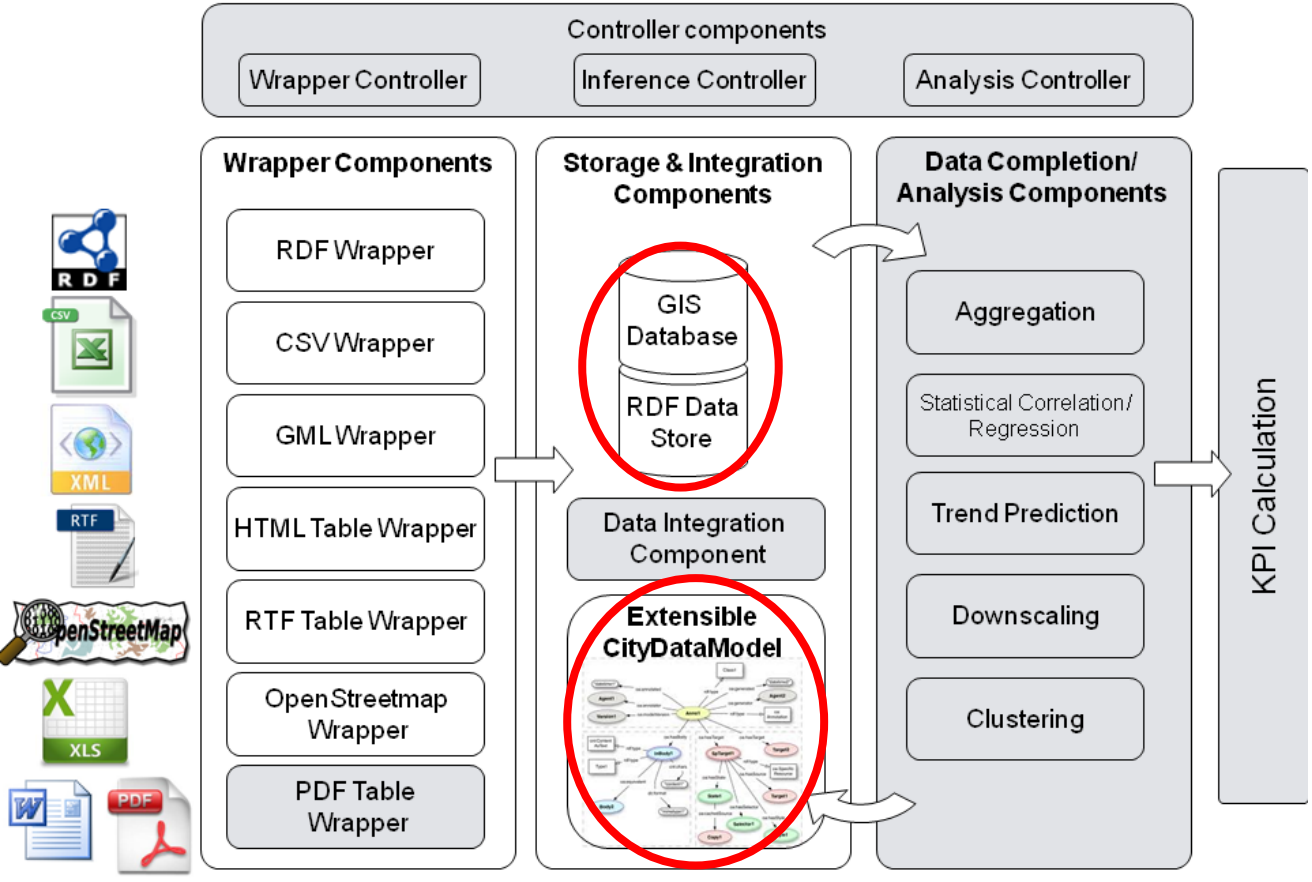

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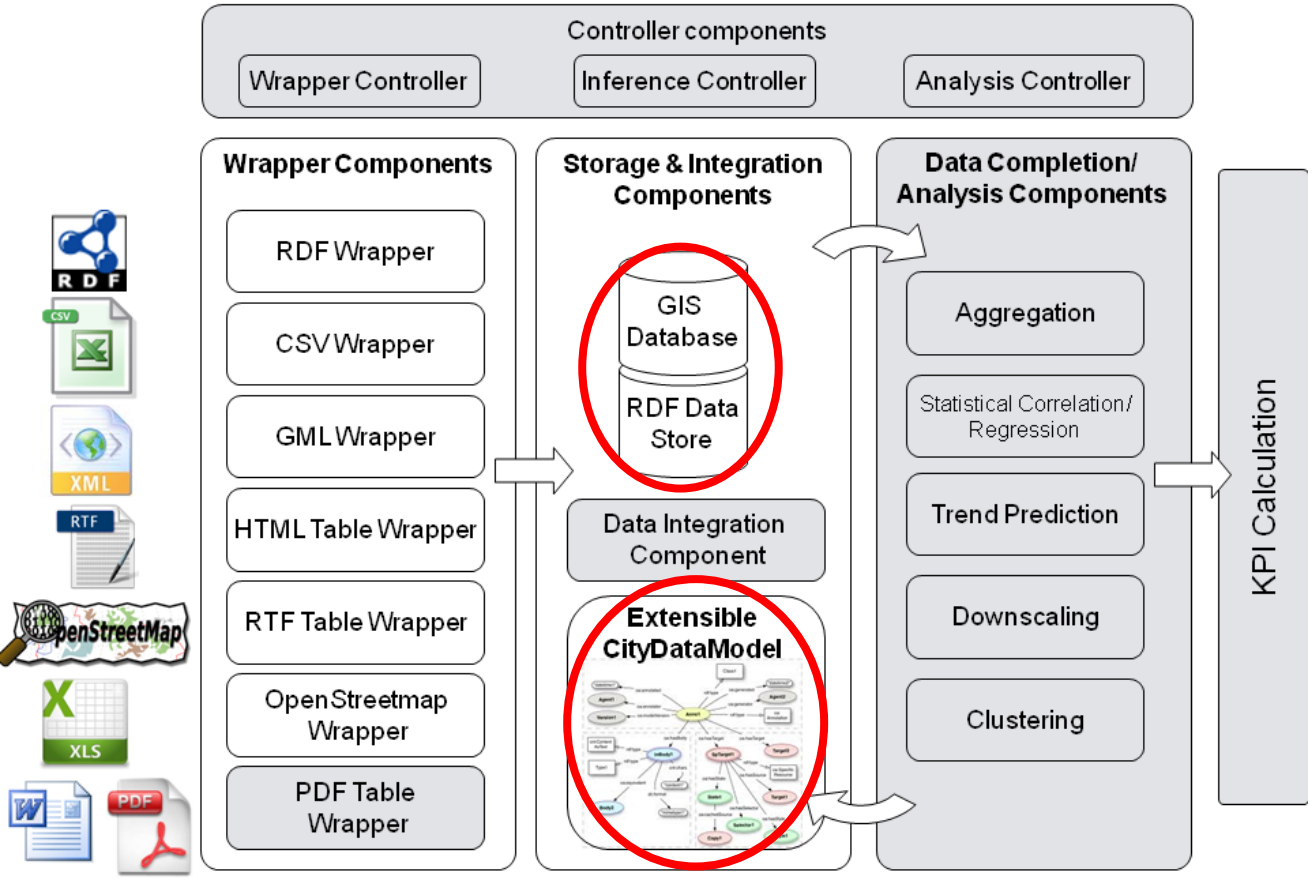

Deploying Semantic Web Standards:

SPARQL W3C

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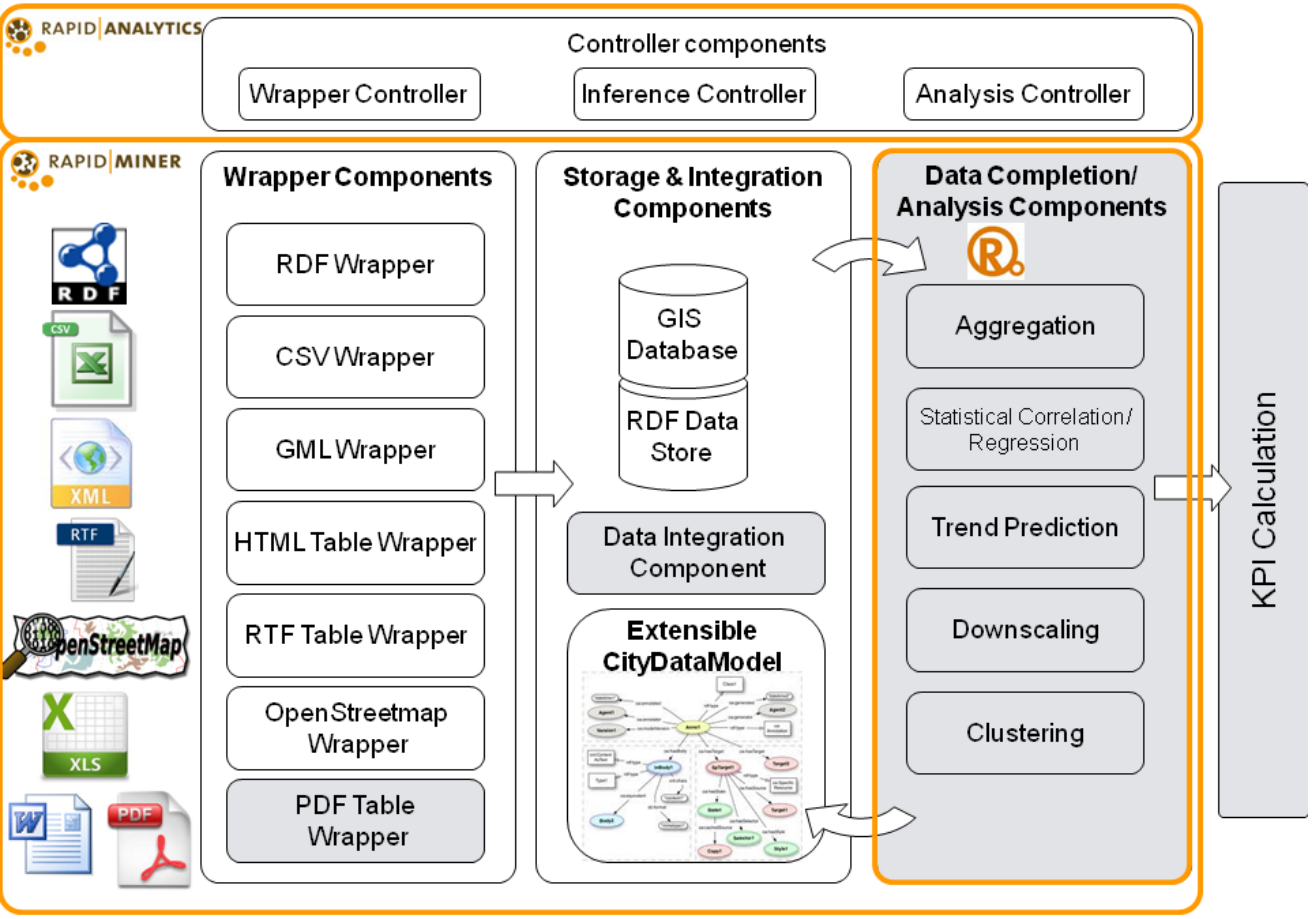

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Deploying Semantic Web Standards:

City Data Pipeline: Current Data - Summary

City Data Pipeline: Current Data - Summary

- Ca. **475** different indicators
  - *Categories: Demography, Geography, Social Aspects, Economy, Environment, etc.*
- from **32** sources (html, CSV, RDF, ...)
  - *Wikipedia, urbanaudit.org, Statistics from City homepages, country Statistics, iea.org*
- Covering **350+** cities in **28** European countries
  - District Data for selected cities (Vienna, Berlin)
  - Mostly snapshots, Partially covering timelines
  - On average ca. **285** facts per city.

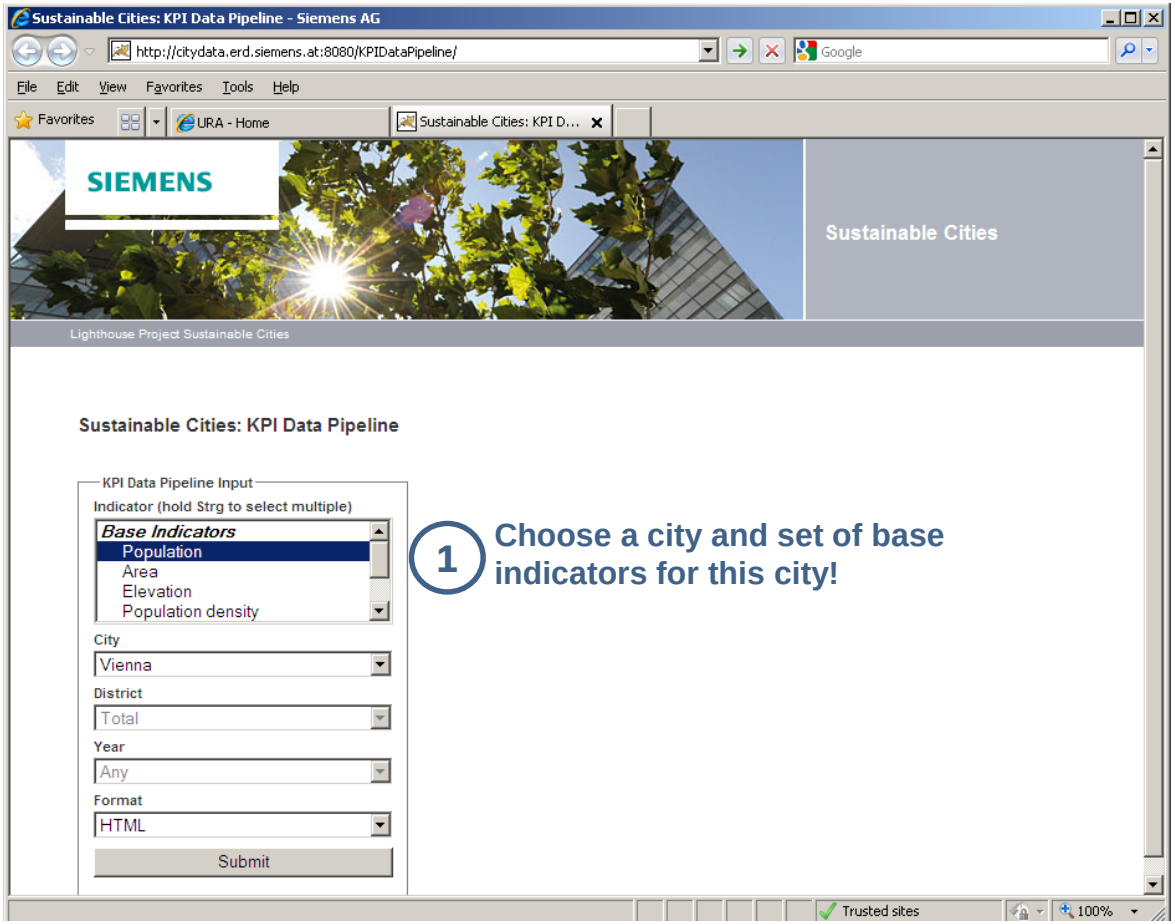
- Examples of sources:
  - UrbanAudit (from http://eurostat.linked-statistics.org)
  - http://geonames.org (population, georeference, elevation)

Further data sources on target to integrate include:

- http://data.worldbank.org/ WorldBank (mostly data at country level)
- www.eea.europa.eu/ European Environmental Agency (weather/climate data)

City Data Pipeline: Web Interface

Our Web interface allows to browse data and download complex composed KPIs as Excel sheets (e.g. “Transport related CO2 emissions for Berlin”):



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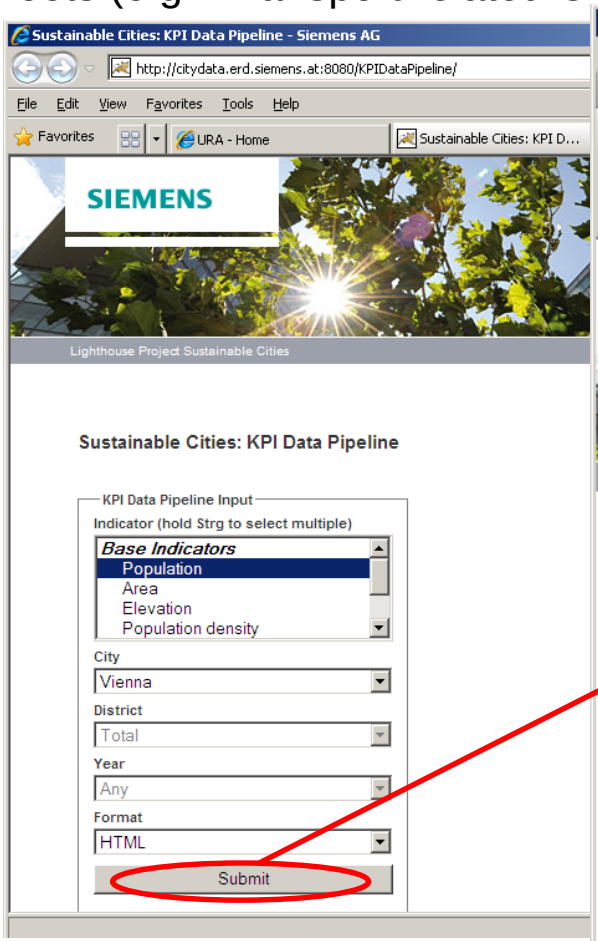
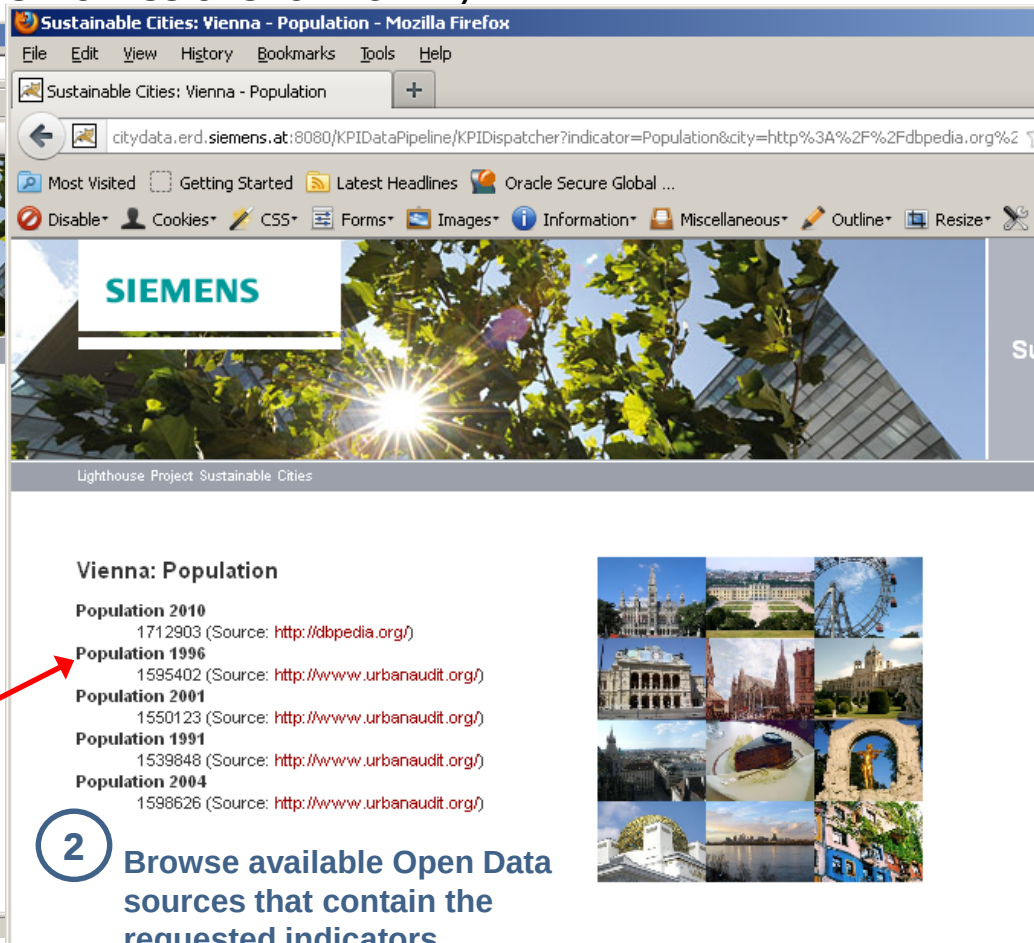
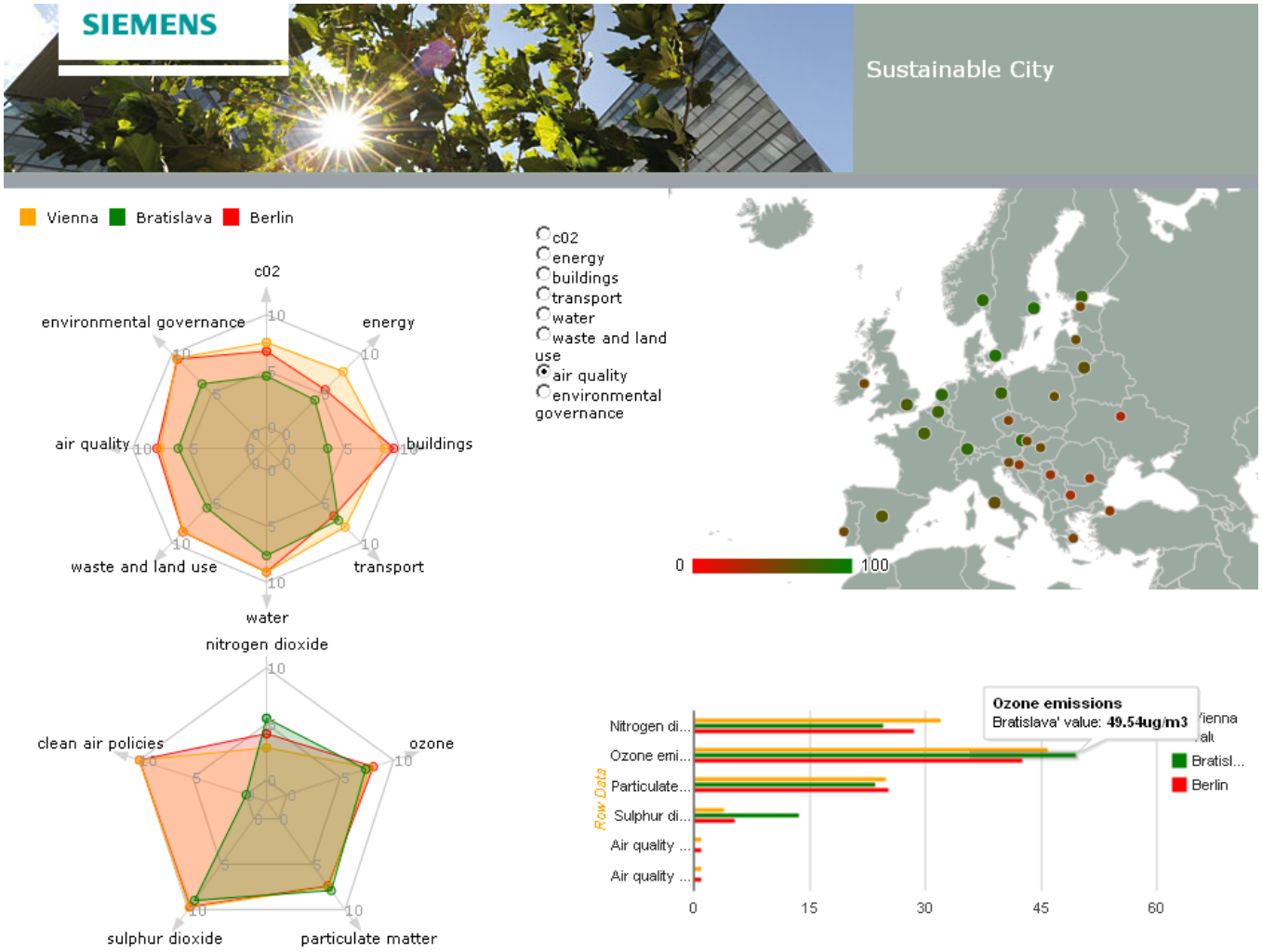




2 **Browse available Open Data sources that contain the requested indicators**

City Data Pipeline: Web Interface



3

Also available: Graphical user interface to visually compare base indicators for different cities.

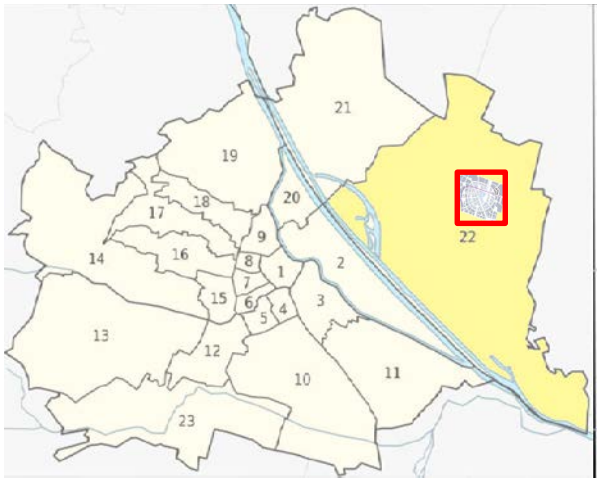
Applications & Challenges

1. **Application: trend prediction - Example “Seestadt Aspern”**
2. Integration & enrichment of “Green City Index” Data
3. Challenges with Open Data Experienced

Data Prediction/Quality: Statistical methods

- Showcase: Estimate how Seestadt Aspern will be developing in comparison to the rest of Vienna

  - Semantic integration of open data in our data pipeline
  - Prediction of indicators for Aspern and Vienna
  - Graphical representation of the results

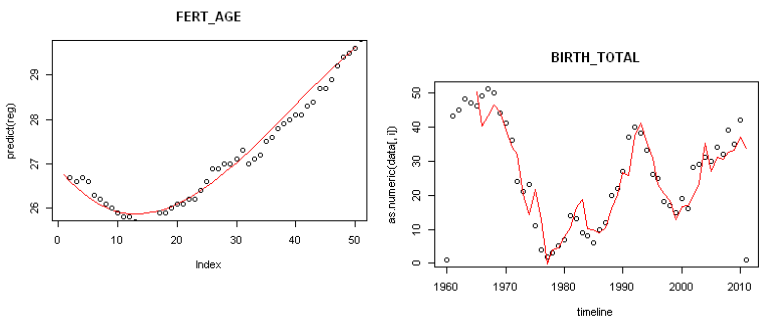


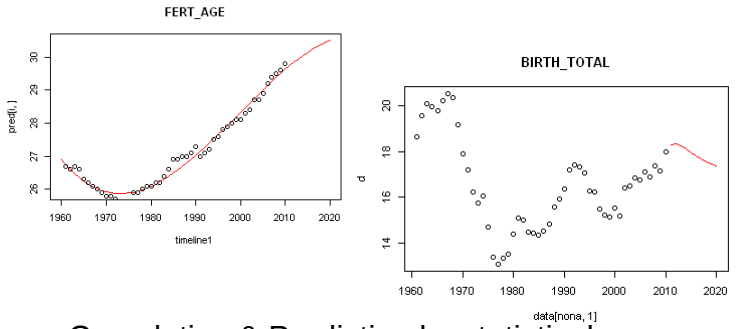
- **Questions:**

- *How will Seestadt Aspern perform in comparison to the other districts of Vienna?*

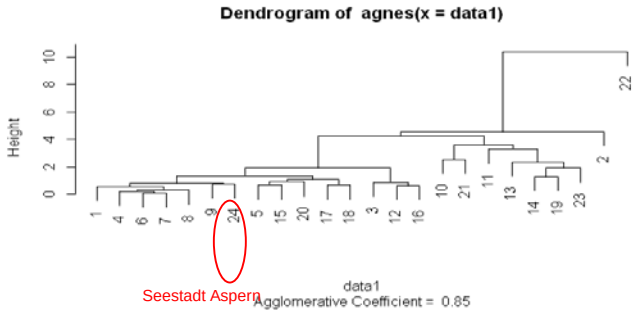
- *How do the goal indicators from the Aspern Masterplan compare with the "typical district behavior" of Vienna?*

Statistical Methods

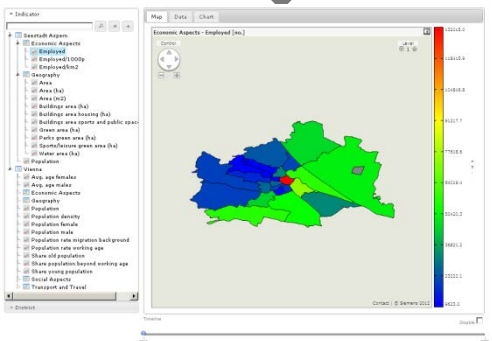




Completion & Prediction by statistical methods



finding patterns in the data



Vienna: districts and Seestadt Aspern

Berlin

Budapest

Vienna

Aim: Monitor development and compare to other cities/districts in order to take most effective infrastructural measures.

Applications & Challenges

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Collected Data vs. Green City Index Data: Overlaps

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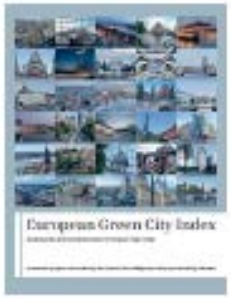
- Together with colleagues from CC, we identified 20 quantitative raw data indicators that are overlapping between the Siemens' "*Green City Index*" and our current Data sources. The picture below visualizes the availability of data for these indicators for the cities of the European GCI:



European Green City Index

City / Raw Indicator	Gre	Re	Po	Are	Lar	GD	GD	GD	Oz	NC	PM	Ho	Jou	Jou	Jou	Jou	Jou	rec	Ler	Ler	Ler	Ler	Ler	Avo
Amsterdam	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
Antwerp	x	x			x	x	x	x	x	x	x		x	x		x			x				x	
Athens	x	x			x				x	x	x					x								x
Belgrade		x	x	x																				
Berlin	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Bratislava	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		
Bremen	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Brussels	x	x	x	x	x	x	x	x	x	x	x		x	x		x			x	x	x	x	x	
Bucharest	x	x	x	x	x	x		x	x	x	x					x								
Budapest	x	x		x	x	x	x	x	x	x	x			x		x	x		x	x	x	x	x	x
Cologne	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Copenhagen	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x		x	x	x
Dublin		x	x	x		x		x	x	x	x		x	x	x									
Essen	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Frankfurt		x		x																				x
Gothenburg	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			x		
Hamburg	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Hanover	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		
Helsinki	x	x			x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x
Istanbul		x																						
Kiev		x	x	x																				
Leipzig	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Lisbon		x	x	x	x	x	x	x	x	x	x		x			x	x	x		x	x		x	
Ljubljana	x	x	x	x	x				x	x	x		x	x		x			x	x	x	x	x	
London		x	x	x	x	x	x	x	x	x	x	x		x		x			x					
Luxembourg_(city)	x	x			x	x	x	x	x	x	x		x	x	x	x			x		x	x	x	
Madrid	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x			x	x	x
Malm%C3%B6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Munich	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Nuremberg	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Oslo		x		x																				x
Paris		x		x	x	x	x	x	x	x	x			x										
Prague	x	x		x	x	x	x	x	x	x	x		x	x	x	x								
Riga	x	x		x	x	x	x	x	x	x	x	x		x		x			x	x	x	x		
Rome	x	x		x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x		x
Rotterdam	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x			
Sofia	x	x	x	x	x	x	x	x	x	x	x			x		x								x
Stockholm	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Stuttgart	x	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x			
Tallinn	x	x	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	
The_Hague	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	
Vienna	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x			x			x		
Vilnius	x	x	x	x	x	x		x	x	x	x			x		x								
Warsaw	x	x	x	x	x	x	x	x	x	x	x			x		x				x	x	x	x	x
Zagreb		x		x																				
Zurich		x		x																				

>65% of raw date could be covered by publically available data that we have collected automatically

Data quality?

- Not all indicators are 100% comparable (different scales, units, etc., sources of different quality)
- for some indicators (e.g. Population) already less than 2% median error.
- The more data we collect, the better the quality!

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Applications & Challenges

1. Application: trend prediction - Example “Seestadt Aspern”
2. Integration & enrichment of “Green City Index” Data
3. **Challenges with Open Data Experienced**

Challenges & Lessons Learnt – Is Open Data fit for industry?

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Base assumption (for our use case):

Added value comes from **comparable** Open datasets being **combined**

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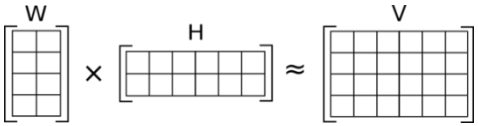
Challenges & Lessons Learnt – Is Open Data fit for industry?

- **Incomplete** Data: can be partially overcome
  - By ontological reasoning (RDF & OWL), by aggregation, or by rules & equations, e.g.
    - *:populationDensity = :population / :area* , cf. **[ESWC2013]**
  - *by statistical methods or Multi-dimensional Matrix Decomposition:*



unfortunately only partially successful, because these algorithms assume normally-distributed data.

- **Incomparable** Data:

dbpedia:populationTotal

dbpedia:populationCensus

- **Heterogeneity** across Open Government Data efforts:
  - Different ***Indicators***, Different Temporal and Spatial ***Granularity***
  - Different ***Licenses*** of Open Data: e.g. CC-BY, OGL (UK), etc.
  - Heterogeneous ***Formats*** (CSV != CSV) … Maybe the W3C CSV on the Web WG will solve this issue)

→Open Data needs stronger standards to be useful

[ESWC2013] Stefan Bischof and Axel Polleres. RDFS with attribute equations via SPARQL rewriting. In *Proc. Of the 10th ESWC*, vol. 7882 of *Lecture Notes in Computer Science (LNCS)*, p. 335-350, May 2013. Springer.