Organizing Scientific Knowledge From Energy System Research Using the Open Research Knowledge Graph

Oliver Karras, Jan Göpfert, Patrick Kuckertz, Tristan Pelser, and Sören Auer

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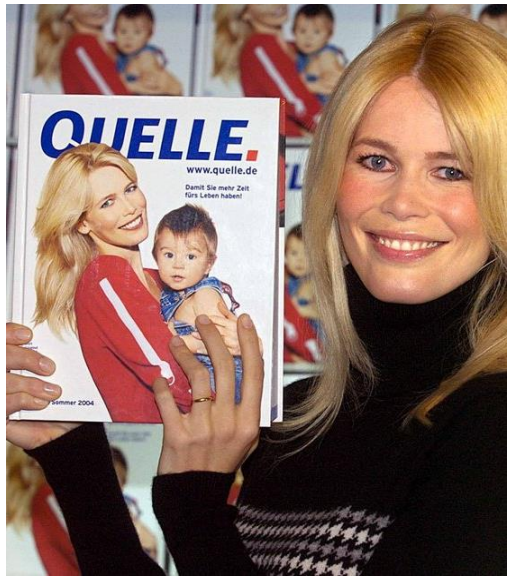
1st NFDI4Energy Conference – Bringing the Community of Energy System Data Management Together

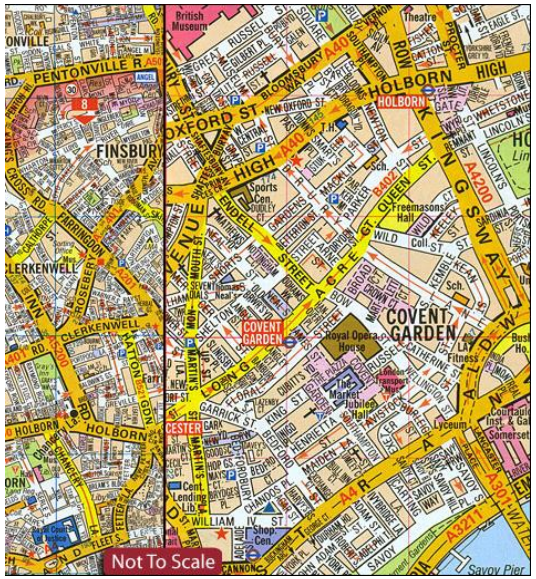
20. – 21.02.2024, Leibnizhaus, Hannover, Germany

Once Upon a Time, we Communicated with Paper...

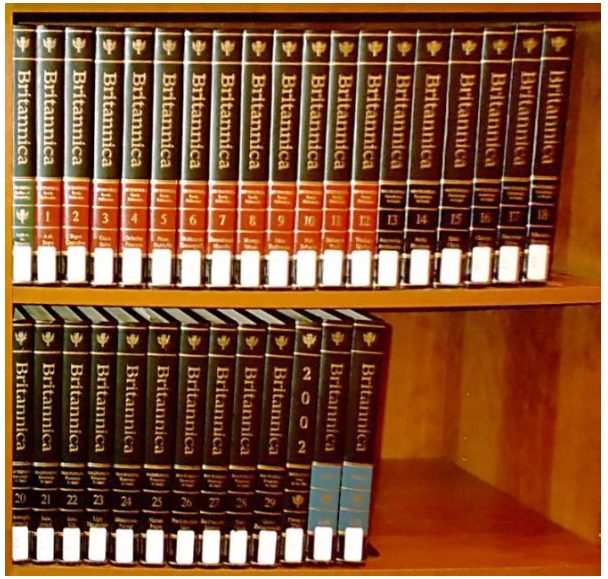
Who still remembers?



Mail order catalogs



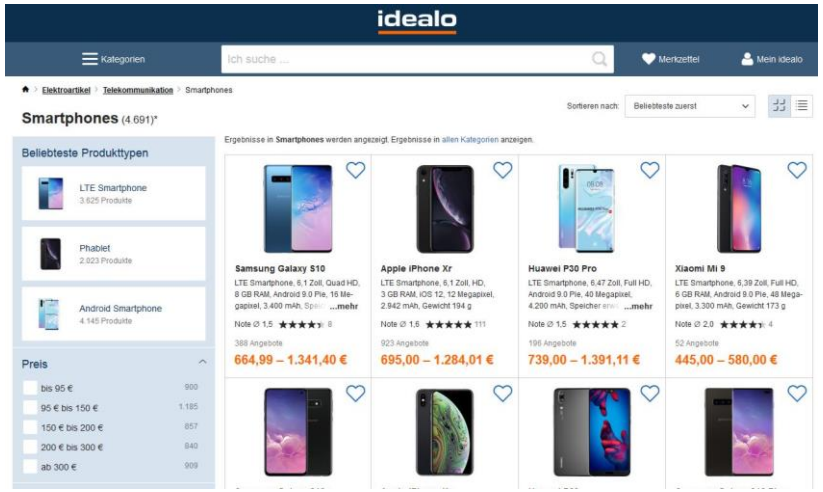
Maps

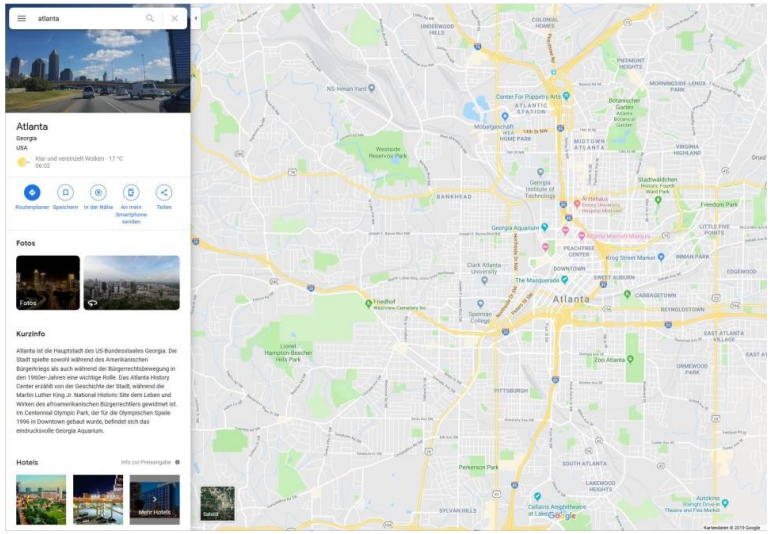


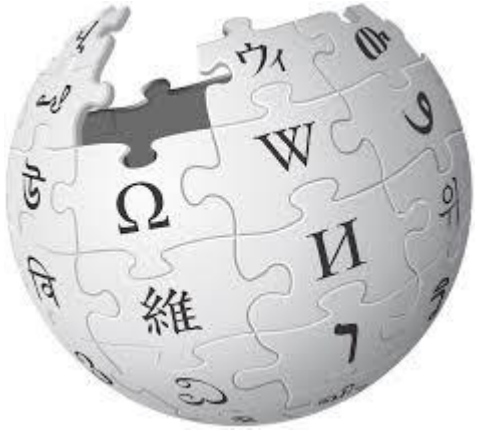
Encyclopedia

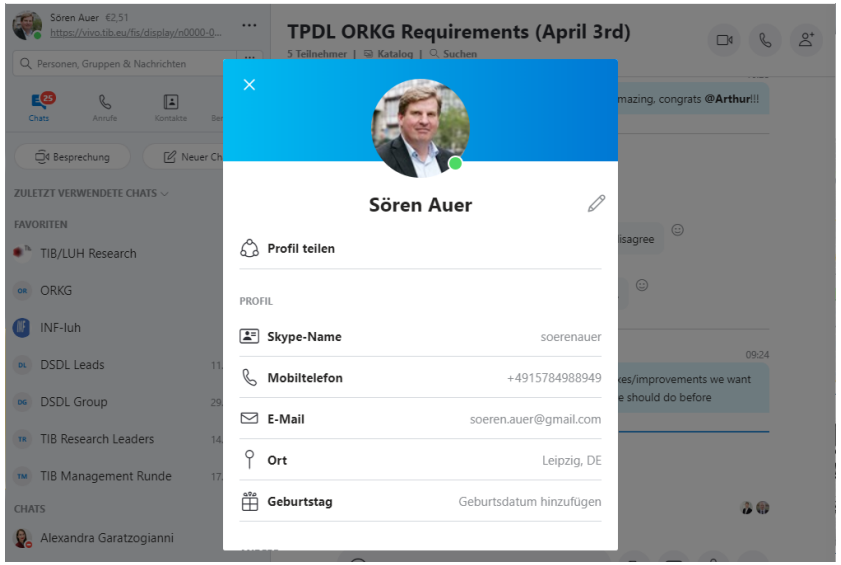
Phone books

… until Digital Transformation (Digitalization)!









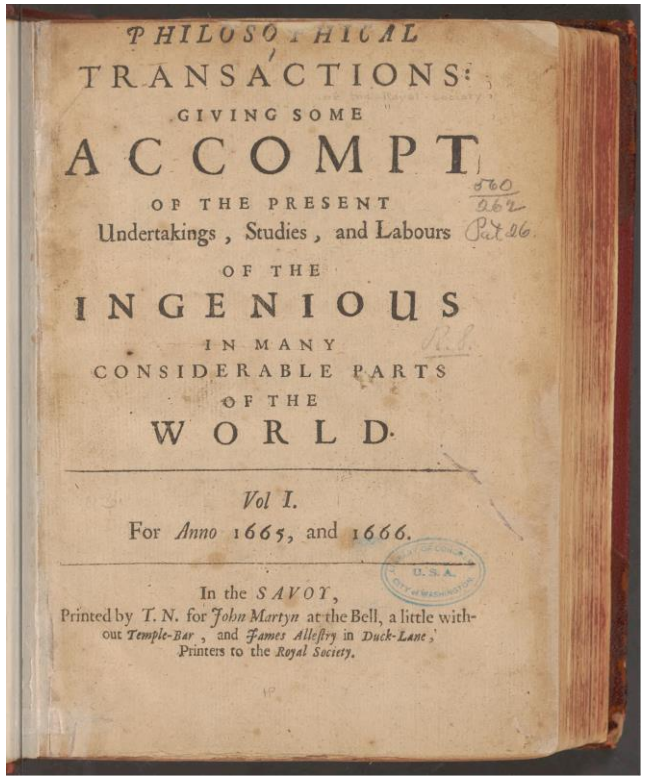
The World of Publishing & Communication has Profundely Changed!

- **New means adapted to the new possibilities**, e.g., platforms
- Completely new **business models**
- More focus on **data, interlinking, services,** and **search**
- **Integration**, **crowdsourcing, and data curation** are important

What has Happened in Academia in Terms of Scholarly Publishing & Communication?

Let's Take a Look

17th century

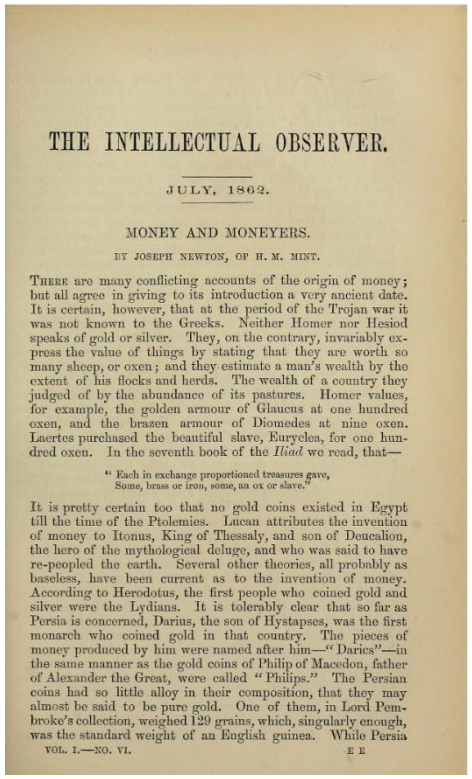


PHILOSOPHICAL
TRANSACTIONS:
GIVING SOME
ACCOMPT
OF THE PRESENT
Undertakings, Studies, and Labours
OF THE
INGENIOUS
IN MANY
CONSIDERABLE PARTS
OF THE
WORLD.

Vol I.
For *Anno* 1665, and 1666.

In the *SAVOY*,
Printed by *T. N.* for *John Martyn* at the Bell, a little without *Temple-Bar*, and *James Allestry* in *Duck-Lane*,
Printers to the *Royal Society*.

19th century



THE INTELLECTUAL OBSERVER.

JULY, 1862.

MONEY AND MONEYERS.

BY JOSEPH NEWTON, OF H. M. MINT.

THERE are many conflicting accounts of the origin of money; but all agree in giving to its introduction a very ancient date. It is certain, however, that at the period of the Trojan war it was not known to the Greeks. Neither Homer nor Hesiod speaks of gold or silver. They, on the contrary, invariably express the value of things by stating that they are worth so many sheep, or oxen; and they estimate a man's wealth by the extent of his flocks and herds. The wealth of a country they judged of by the abundance of its pastures. Homer values, for example, the golden armour of Glaucus at one hundred oxen, and the brazen armour of Diomedes at nine oxen. Laertes purchased the beautiful slave, Eurycles, for one hundred oxen. In the seventh book of the *Iliad* we read, that—

"Each in exchange proportioned treasures gave,
Some, brass or iron, some, an ox or slave."

It is pretty certain too that no gold coins existed in Egypt till the time of the Ptolemies. Lucan attributes the invention of money to Itonus, King of Thessaly, and son of Deucalion, the hero of the mythological deluge, and who was said to have re-peopled the earth. Several other theories, all probably as baseless, have been current as to the invention of money. According to Herodotus, the first people who coined gold and silver were the Lydians. It is tolerably clear that so far as Persia is concerned, Darius, the son of Hystaspes, was the first monarch who coined gold in that country. The pieces of money produced by him were named after him—"Darics"—in the same manner as the gold coins of Philip of Macedon, father of Alexander the Great, were called "Philips." The Persian coins had so little alloy in their composition, that they may almost be said to be pure gold. One of them, in Lord Pembroke's collection, weighed 129 grains, which, singularly enough, was the standard weight of an English guinea. While Persia

VOL. I.—NO. VI. E E

20th century

Information Retrieval P. BAXENDALE, Editor

A Relational Model of Data for Large Shared Data Banks

E. F. CODD
IBM Research Laboratory, San Jose, California

Future users of large data banks must be protected from having to know how the data is organized in the machine (the internal representation). A prompting service which supplies such information is not a satisfactory solution. Activities of users at terminals and most application programs should remain unaffected when the internal representation of data is changed and even when some aspects of the external representation are changed. Changes in data representation will often be needed as a result of changes in query, update, and report traffic and natural growth in the types of stored information.

Existing noninferential, formatted data systems provide users with tree-structured files or slightly more general network models of the data. In Section 1, inadequacies of these models are discussed. A model based on *n*-ary relations, a normal form for data base relations, and the concept of a universal data sublanguage are introduced. In Section 2, certain operations on relations (other than logical inference) are discussed and applied to the problems of redundancy and consistency in the user's model.

KEY WORDS AND PHRASES: data bank, data base, data structure, data organization, hierarchies of data, networks of data, relations, derivability, redundancy, consistency, composition, join, retrieval language, predicate calculus, security, data integrity
CR CATEGORIES: 3.70, 3.73, 3.75, 4.20, 4.22, 4.29

1. Relational Model and Normal Form

1.1. INTRODUCTION

This paper is concerned with the application of elementary relation theory to systems which provide shared access to large banks of formatted data. Except for a paper by Childs [1], the principal application of relations to data systems has been to deductive question-answering systems. Levein and Maron [2] provide numerous references to work in this area.

In contrast, the problems treated here are those of *data independence*—the independence of application programs and terminal activities from growth in data types and changes in data representation—and certain kinds of *data inconsistency* which are expected to become troublesome even in nondeductive systems.

The relational view (or model) of data described in Section 1 appears to be superior in several respects to the graph or network model [3, 4] presently in vogue for noninferential systems. It provides a means of describing data with its natural structure only—that is, without superimposing any additional structure for machine representation purposes. Accordingly, it provides a basis for a high level data language which will yield maximal independence between programs on the one hand and machine representation and organization of data on the other.

A further advantage of the relational view is that it forms a sound basis for treating derivability, redundancy, and consistency of relations—these are discussed in Section 2. The network model, on the other hand, has spawned a number of confusions, not the least of which is mistaking the derivation of connections for the derivation of relations (see remarks in Section 2 on the "connection trap").

Finally, the relational view permits a clearer evaluation of the scope and logical limitations of present formatted data systems, and also the relative merits (from a logical standpoint) of competing representations of data within a single system. Examples of this clearer perspective are cited in various parts of this paper. Implementations of systems to support the relational model are not discussed.

1.2. DATA DEPENDENCIES IN PRESENT SYSTEMS

The provision of data description tables in recently developed information systems represents a major advance toward the goal of data independence [5, 6, 7]. Such tables facilitate changing certain characteristics of the data representation stored in a data bank. However, the variety of data representation characteristics which can be changed *without logically impairing some application programs* is still quite limited. Further, the model of data with which users interact is still cluttered with representational properties, particularly in regard to the representation of collections of data (as opposed to individual items). Three of the principal kinds of data dependencies which still need to be removed are: ordering dependence, indexing dependence, and access path dependence. In some systems these dependencies are not clearly separable from one another.

1.2.1. *Ordering Dependence.* Elements of data in a data bank may be stored in a variety of ways, some involving no concern for ordering, some permitting each element to participate in one ordering only, others permitting each element to participate in several orderings. Let us consider those existing systems which either require or permit data elements to be stored in at least one total ordering which is closely associated with the hardware-determined ordering of addresses. For example, the records of a file concerning parts might be stored in ascending order by part serial number. Such systems normally permit application programs to assume that the order of presentation of records from such a file is identical to (or is a subordering of) the

21st century

AGDISTIS - Graph-Based Disambiguation of Named Entities Using Linked Data

Ricardo Usbeck[1,2], Axel-Cyrille Ngonga Ngomo[1], Michael Röder[1,2], Daniel Gerber[1], Sandro Athaide Coelho[3], Sören Auer[4], and Andreas Both[2]

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Abstract. Over the last decades, several billion Web pages have been made available on the Web. The ongoing transition from the current Web of unstructured data to the Web of Data yet requires scalable and accurate approaches for the extraction of structured data in RDF (Resource Description Framework) from these websites. One of the key steps towards extracting RDF from text is the disambiguation of named entities. While several approaches aim to tackle this problem, they still achieve poor accuracy. We address this drawback by presenting AGDISTIS, a novel knowledge-base-agnostic approach for named entity disambiguation. Our approach combines the Hypertext-Induced Topic Search (HITS) algorithm with label expansion strategies and string similarity measures. Based on this combination, AGDISTIS can efficiently detect the correct URIs for a given set of named entities within an input text. We evaluate our approach on eight different datasets against state-of-the-art named entity disambiguation frameworks. Our results indicate that we outperform the state-of-the-art approach by up to 29% F-measure.

1 Introduction

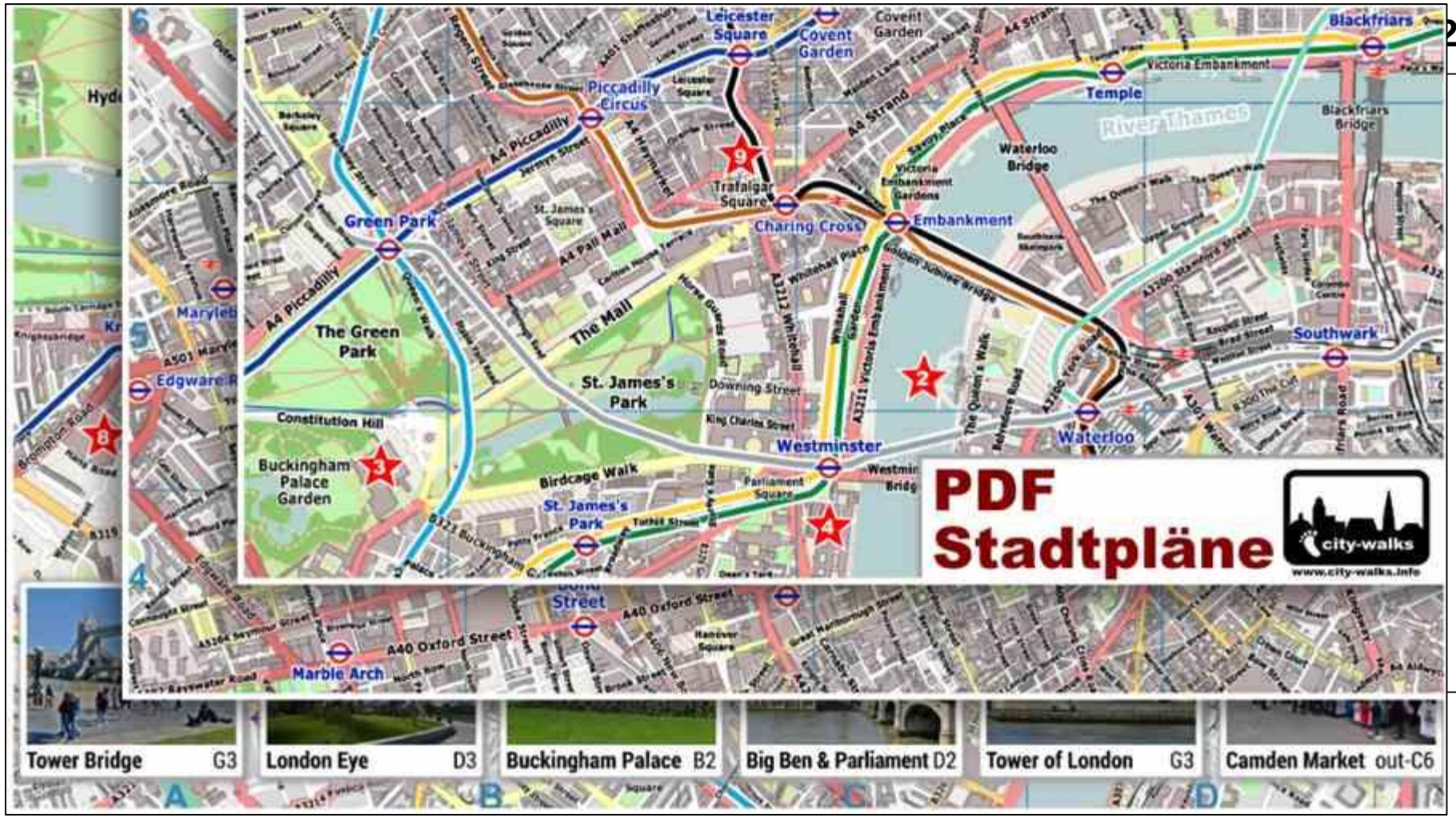
The vision behind the Web of Data is to provide a new machine-readable layer to the Web where the content of Web pages is annotated with structured data (e.g., RDFa [1]). However, the Web in its current form is made up of at least 15 billion Web pages.[1] Most of these websites are unstructured in nature. Realizing the vision of a usable and up-to-date Web of Data thus requires scalable and accurate natural-language-processing approaches that allow extracting RDF from such unstructured data. Three tasks play a central role when extracting RDF from unstructured data: named entity recognition (NER), named entity disambiguation (NED), also known as entity linking [16], and relation extraction (RE). For the first sentence of Example 1, an accurate named entity recognition approach would return the strings `Barack Obama` and `Washington`,

[1] Data gathered from `http://www.worldwidewebsize.com/` on January 4th, 2014.

P. Mika et al. (Eds.) ISWC 2014, Part I, LNCS 8796, pp. 457–471, 2014.

Scholarly Publishing & Communication has **not changed** (much)!

Let’s Take a Look



21st century

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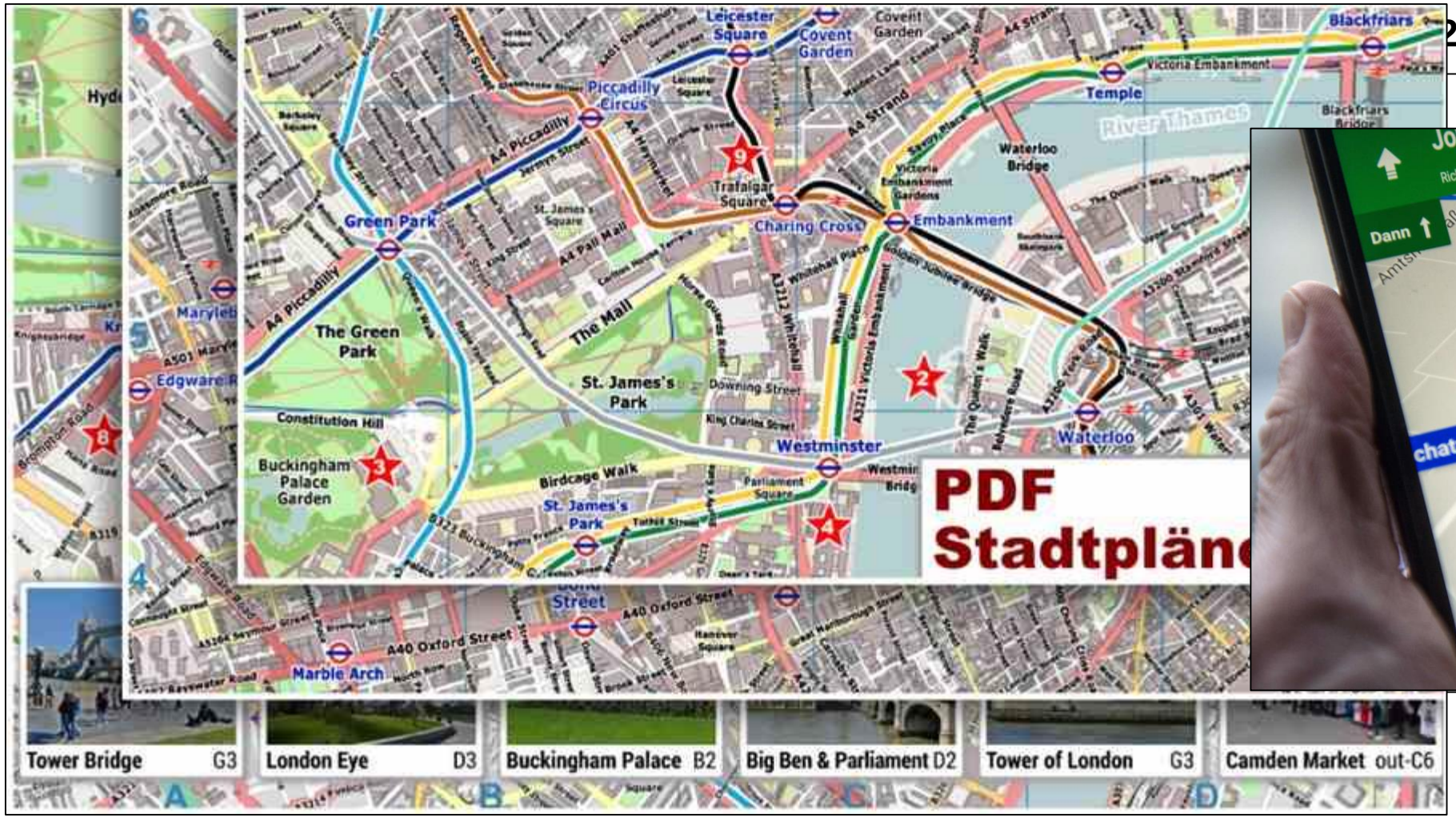
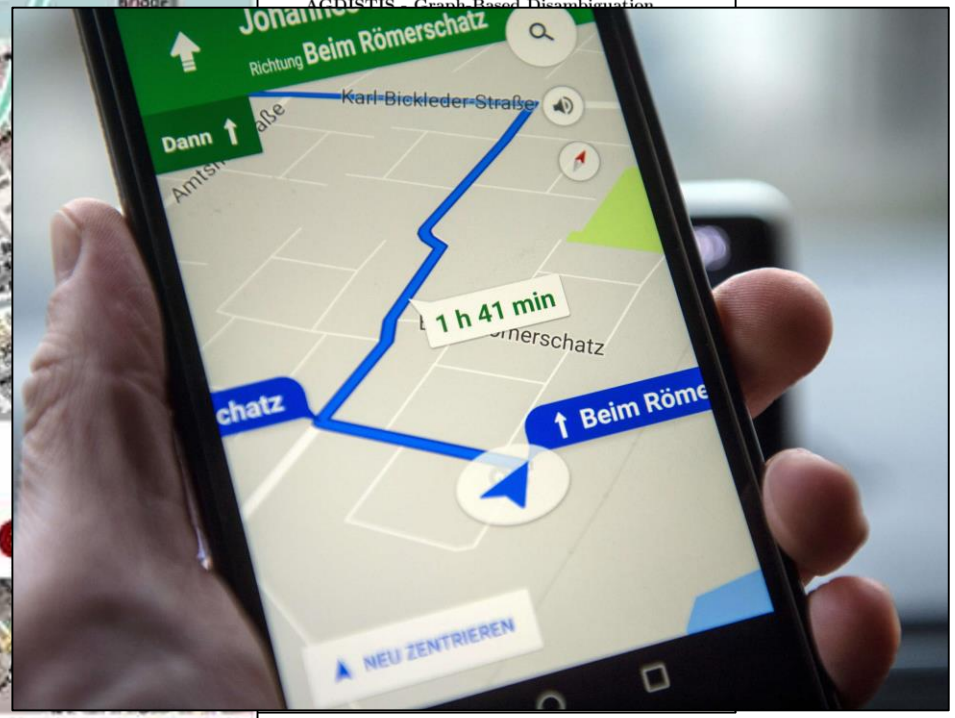
Let's Take a Look

21st century





Rethink How Research is Represented and Communicated

"*The lightbulb was **not** invented by improving the candle.*"

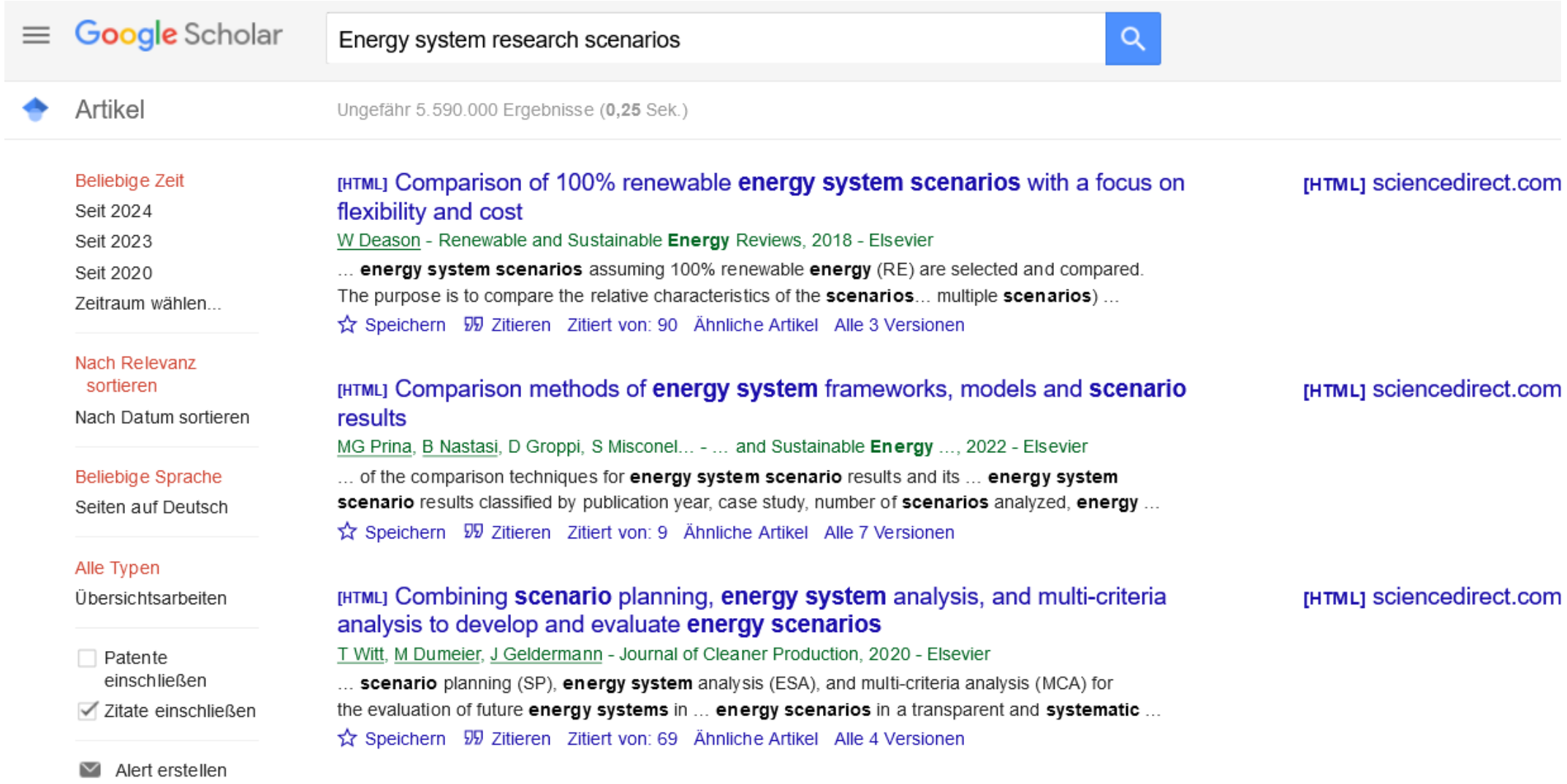
Oren Harari

Digitalization is **more** than just Digitization!

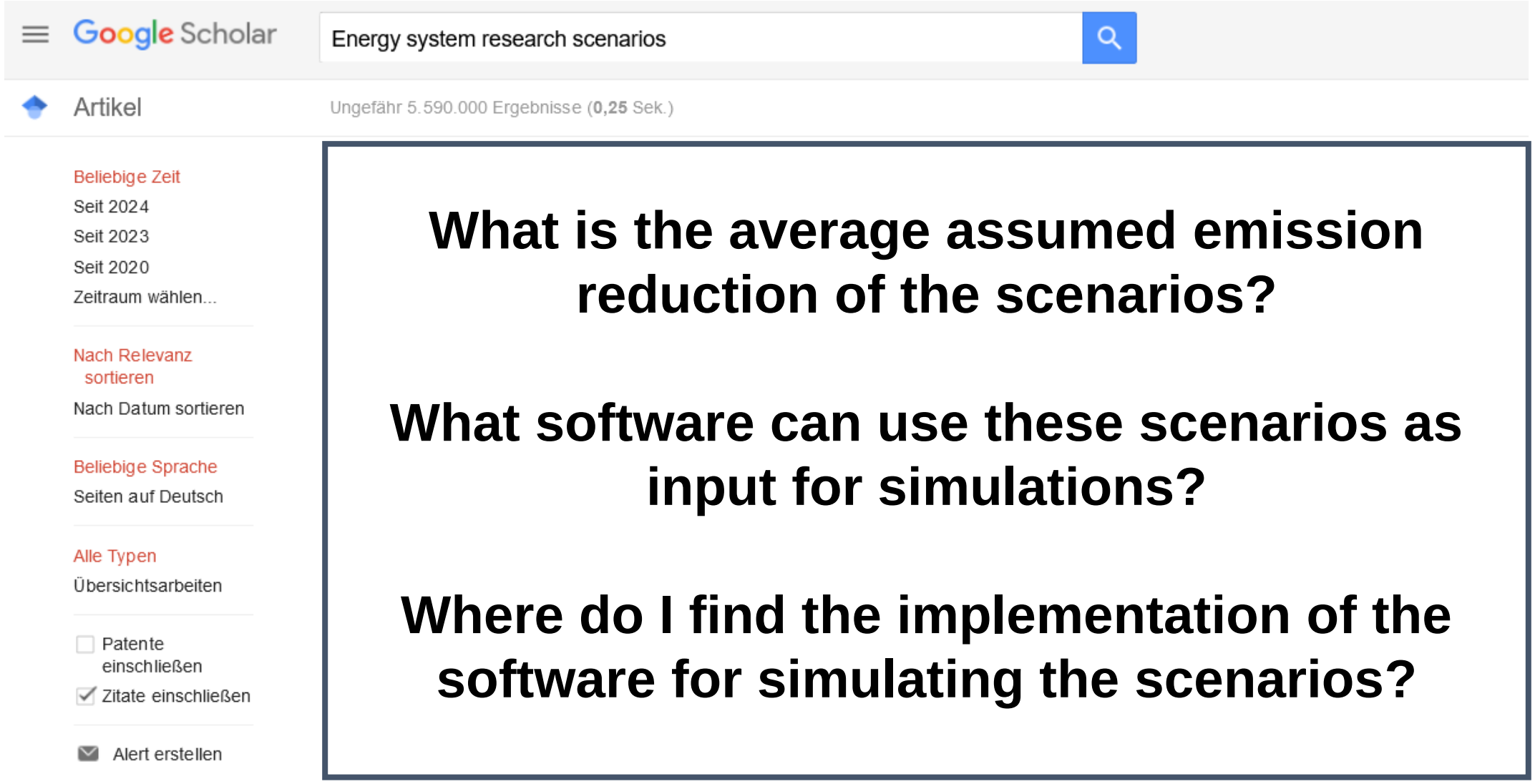
Current and future scientific challenges can not be tackled with an outdated communication system.

Digitalize Knowledge, Not Documents!

Example: Energy System Research Scenarios



Example: Energy System Research Scenarios



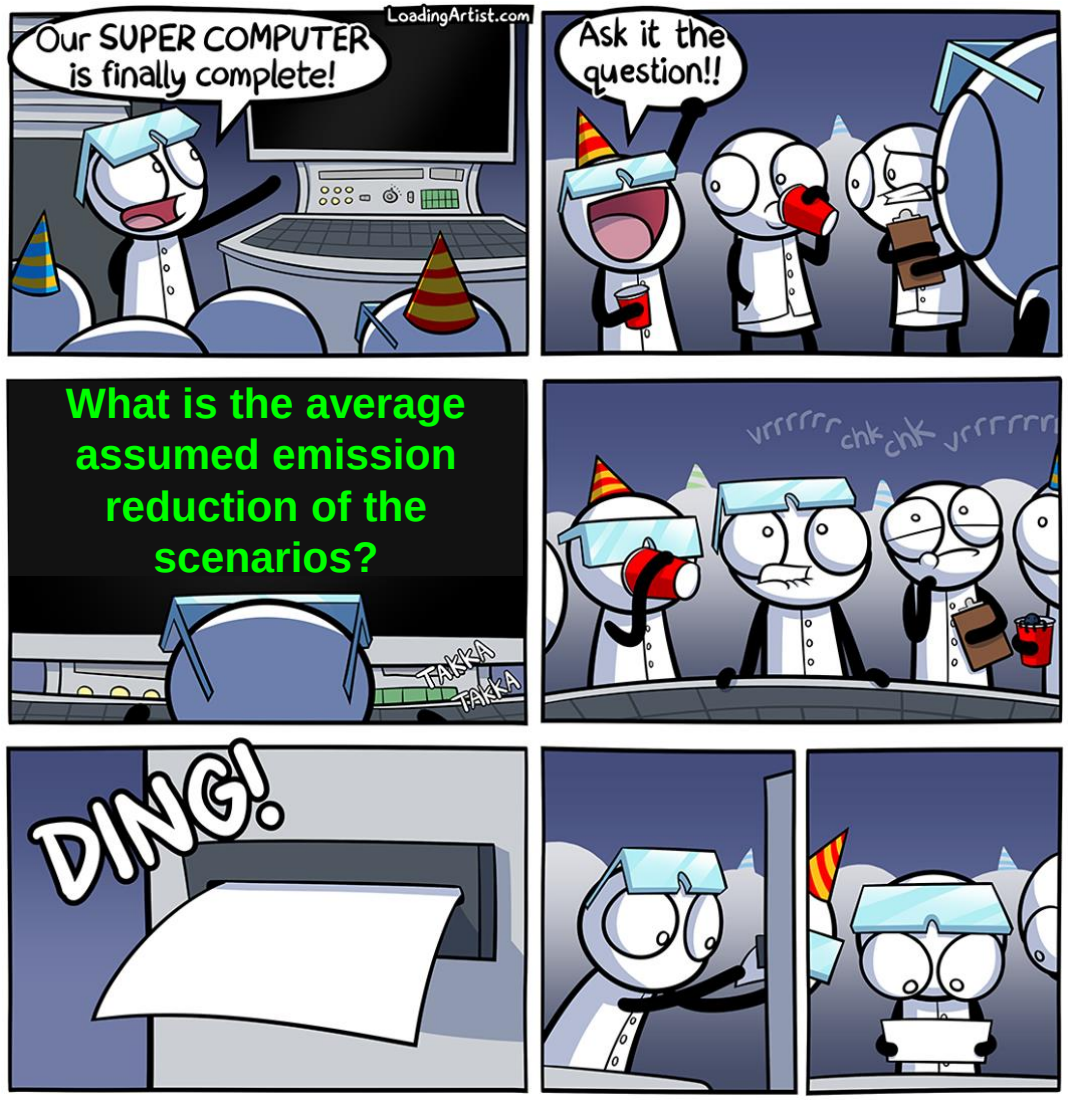
What is the average assumed emission reduction of the scenarios?

What software can use these scenarios as input for simulations?

Where do I find the implementation of the software for simulating the scenarios?

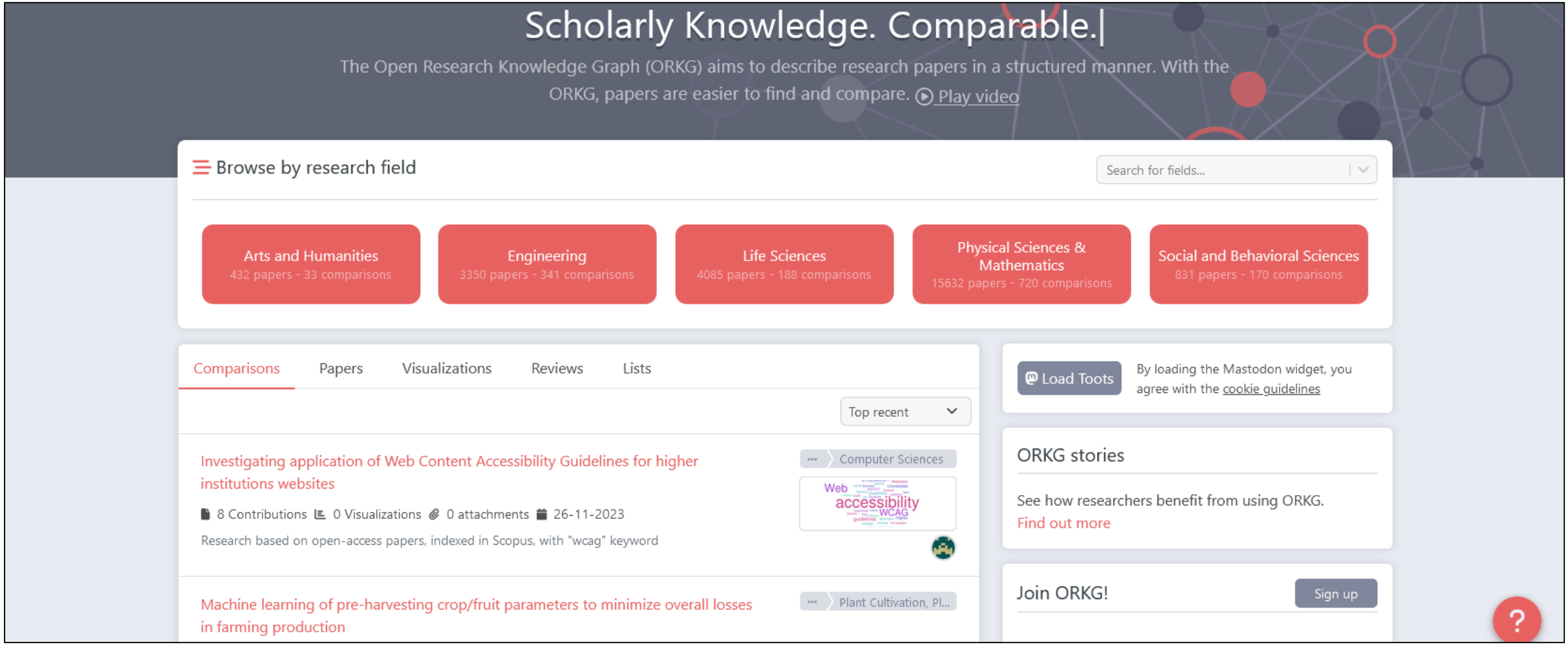
How do we answer these questions so far?

Wouldn’t it be Great if we could ask the Computer?



How can we achieve this goal?

Open Research Knowledge Graph (ORKG)



Two Examples from NFDI4Ing – TA Ellen

14 Scenario Factsheets from the Open Energy Platform

- Szenariorahmen zum NEP 2035 (Szenario A 2035)
- Szenariorahmen zum NEP 2035 (Szenario B 2035 und 2040)
- Szenariorahmen zum NEP 2035 (Szenario C 2035)
- Paris Agreement Compatible (PAC) energy scenario
- Untersuchungen zur Energiestrategie Brandenburgs (appBBB_gruene2030)
- Untersuchungen zur Energiestrategie Brandenburgs (appBBB_ES2030)
- Analysis of the energy system of Brandenburg and Berlin (Szenario 2)
- Analysis of the energy system of Brandenburg and Berlin (Szenario 1)
- Klimaschutzszenario 80 (KS80)
- Aktuelle-Maßnahmen-Szenario 2012
- Germany: With additional measures scenario (WAM)
- Germany: With existing measures scenario (WEM)
- Klimaschutzszenario 95 (KS95)
- Waste heat recovery

25 Studies on Germany's Energy Supply in 2050

Example 1: Scenario Factsheets form OEP

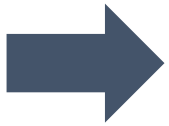
Study

Empirical Data

Assumptions

Energy savings	23% until 2030
Potential energy saving	not estimated
Emission reductions	72% until 2030
Share RE (heat sector)	not estimated
Share RE (mobility sector)	not estimated
Share RE (power sector)	not estimated
Share RE (total energy supply)	not estimated
Cost development	capex, opex, constant
Technological innovations ?	spread of electromobility, heat pumps and solar thermal heat;
Potential wind	other, potential wind other text
Potential solar electric	goal of "Energiestrategie 2030"
Potential solar thermal	goal of "Energiestrategie 2030"
Potential biomass	goal of "Energiestrategie 2030"
Potential geothermal	other, potential geothermal othertext
Potential hydro power	-
Social developement ?	-
Economic development ?	42 TWh export
Development of environmental aspects ?	-
Post-processing ?	✔
Further assumptions for post-processing ?	✖

Results



Untersuchungen zur Energiestrategie Brandenburgs (appBBB_ES2030)

Energy Systems | Elisa Gaudchau | Birgit Schachler | Berit Müller

Scenario

Research problems

Add to comparison

Future energy and emission scenario predictions

Contribution data

← Back | Scen | hasF | hasA | *Emission reduction* → Emission reductions

Has value	72.0 xsd:decimal
Has unit	percent
Time frame	2030 xsd:integer
Has description	72% until 2030 xsd:string

Example 1: Scenario Factsheets form OEP

E. Gaudchau, B. Schachler, and B. Müller: Untersuchungen zur Energiestrategie Brandenburgs (appBBB_ES2030)

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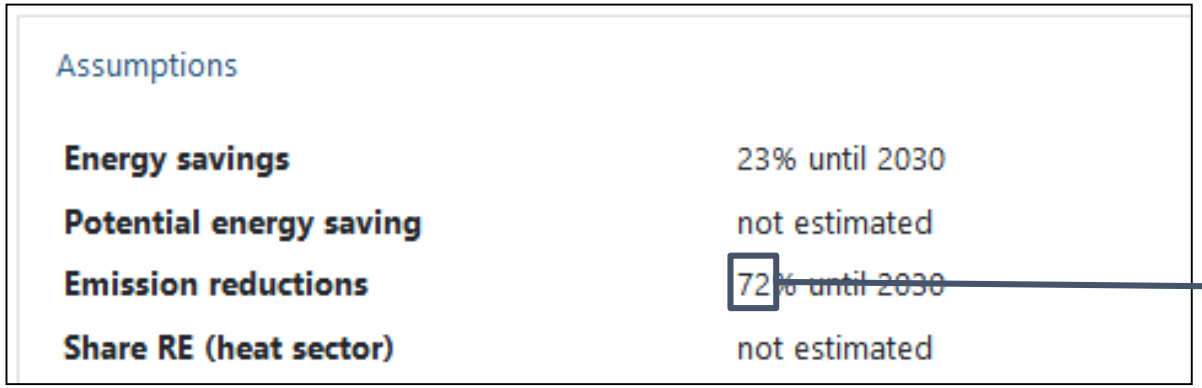

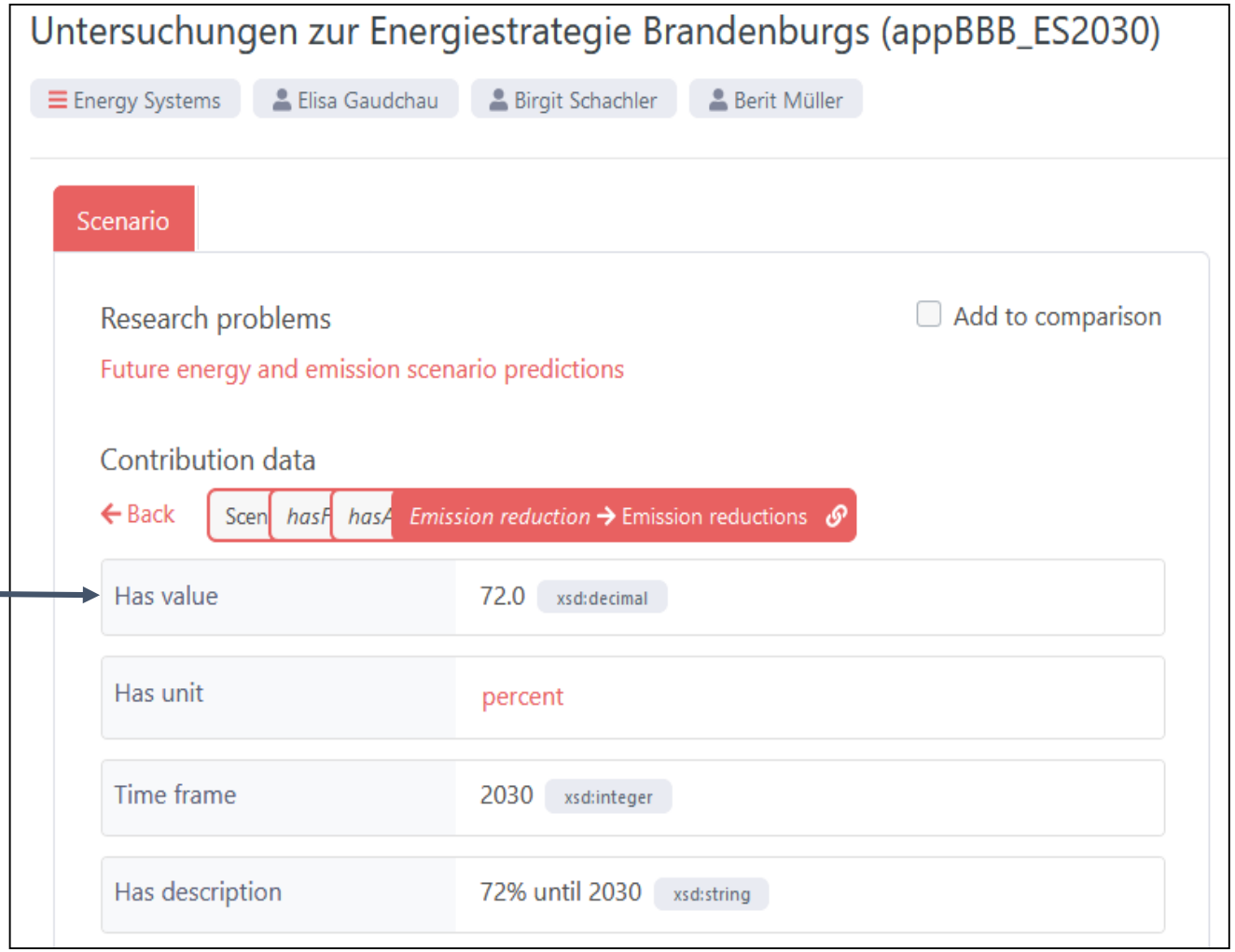

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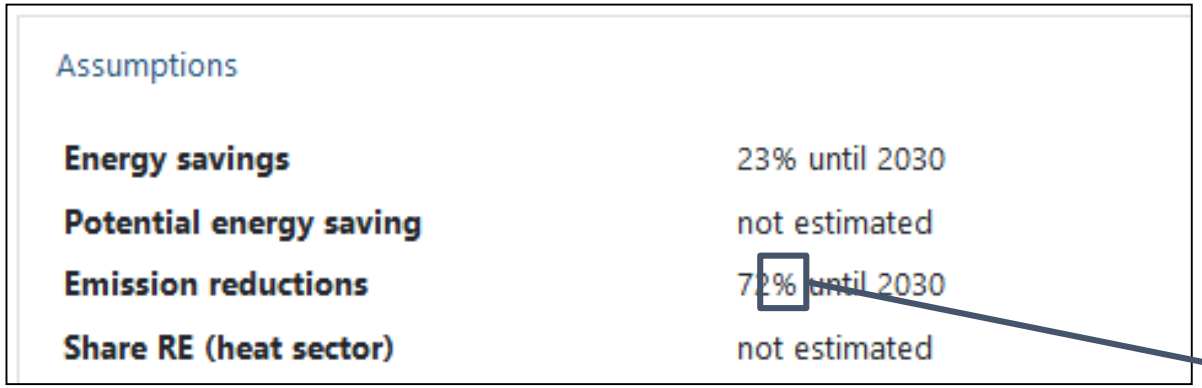

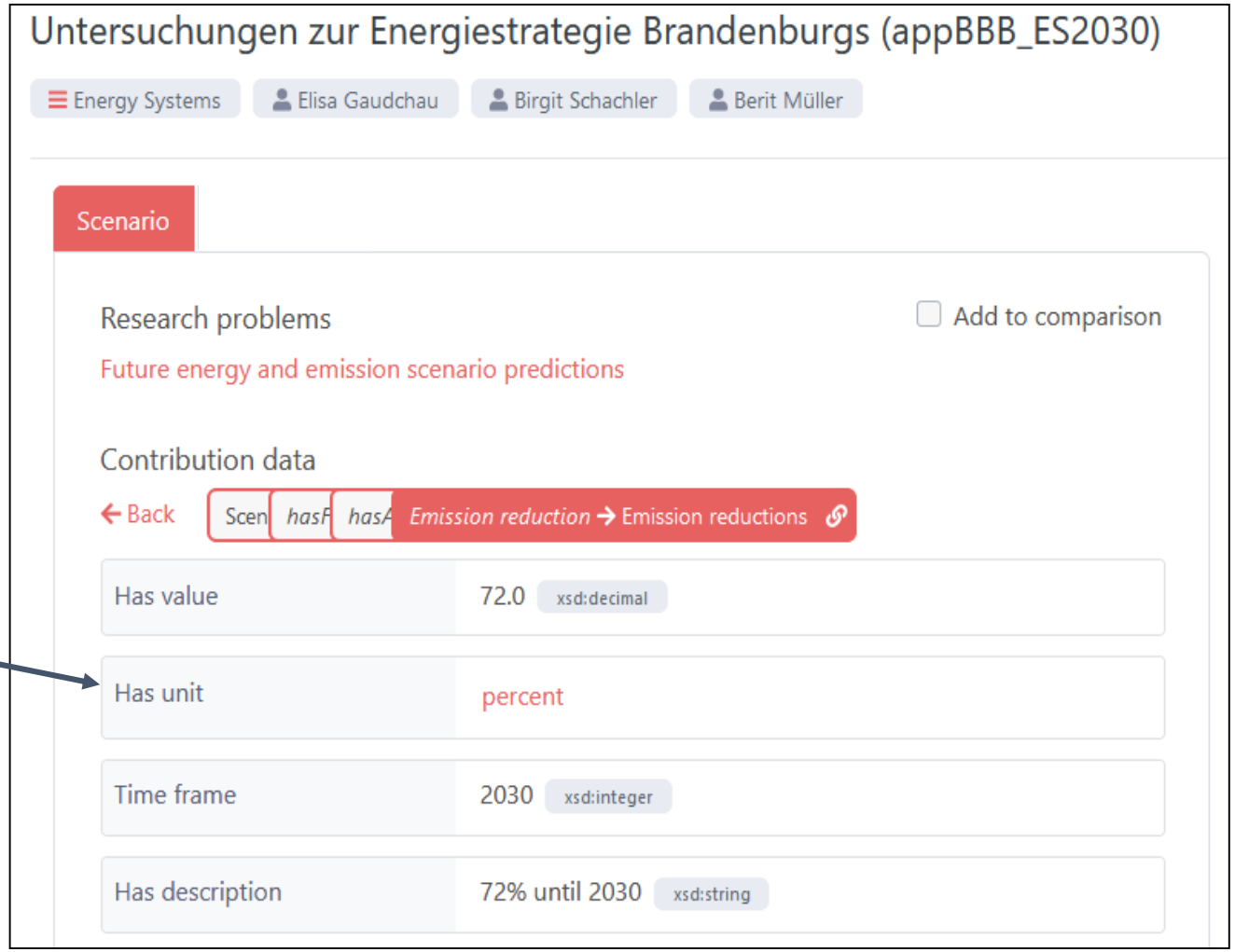

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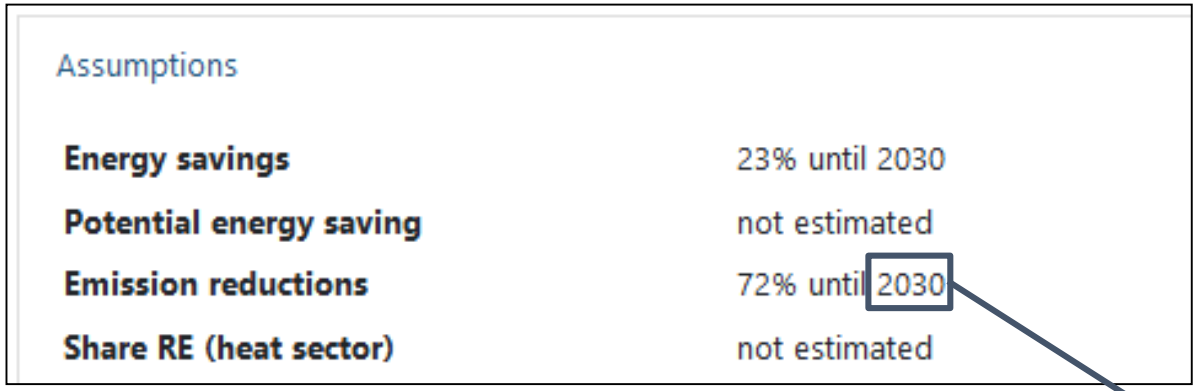

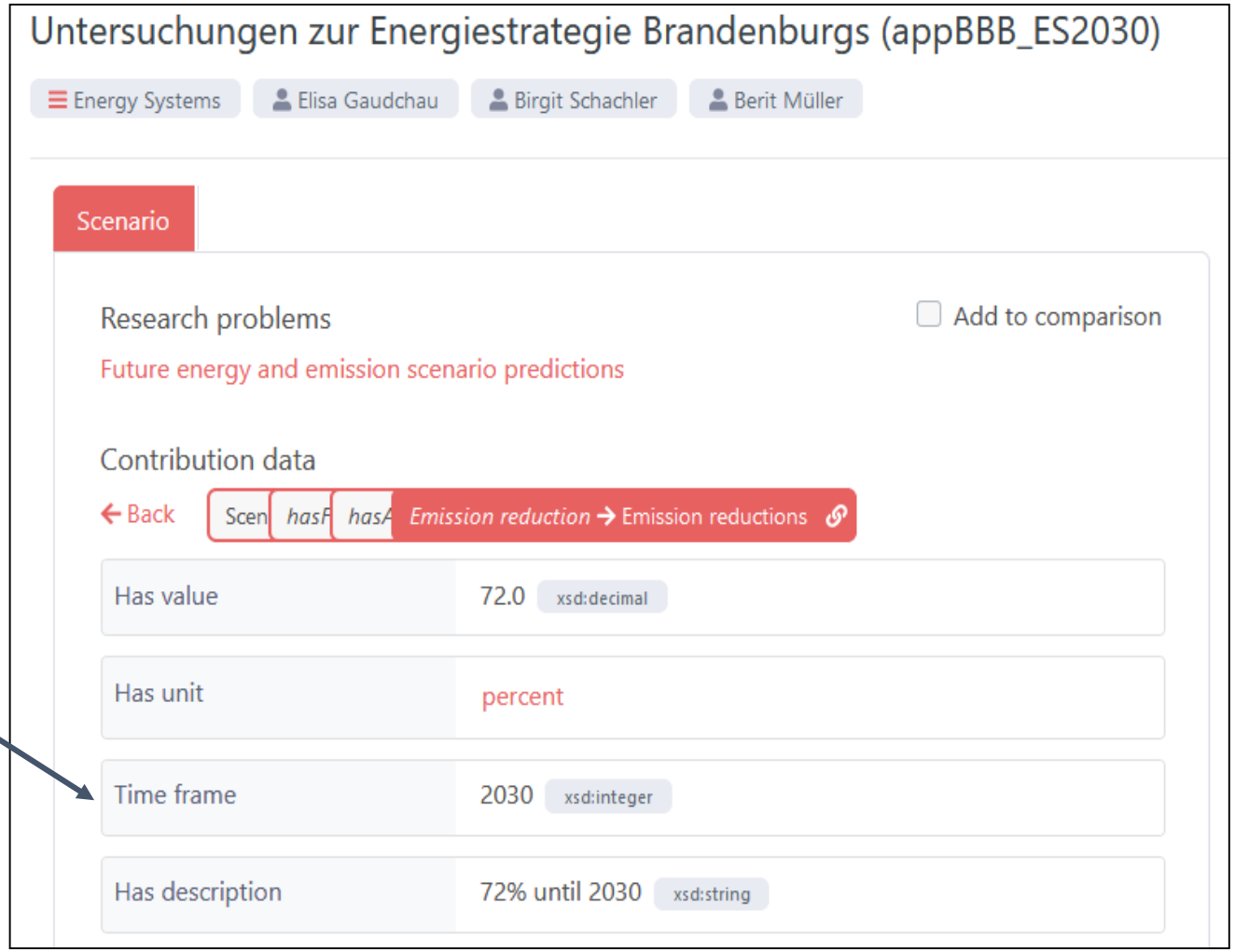

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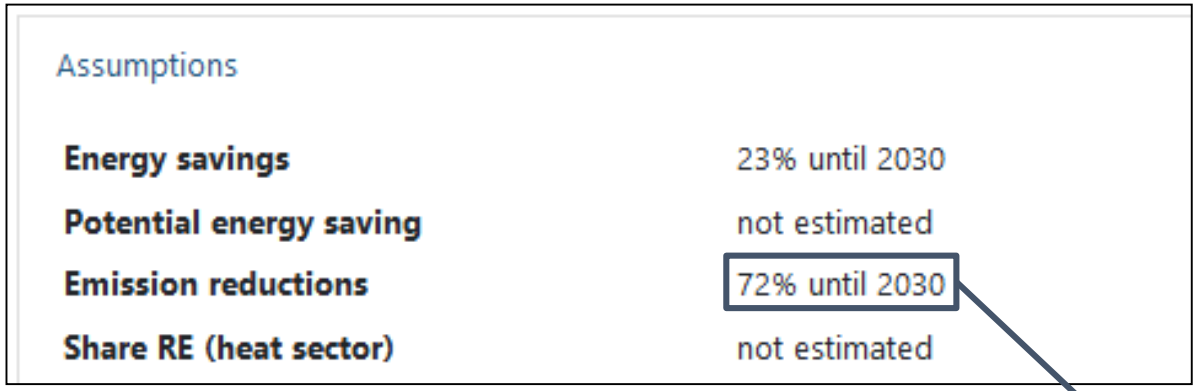

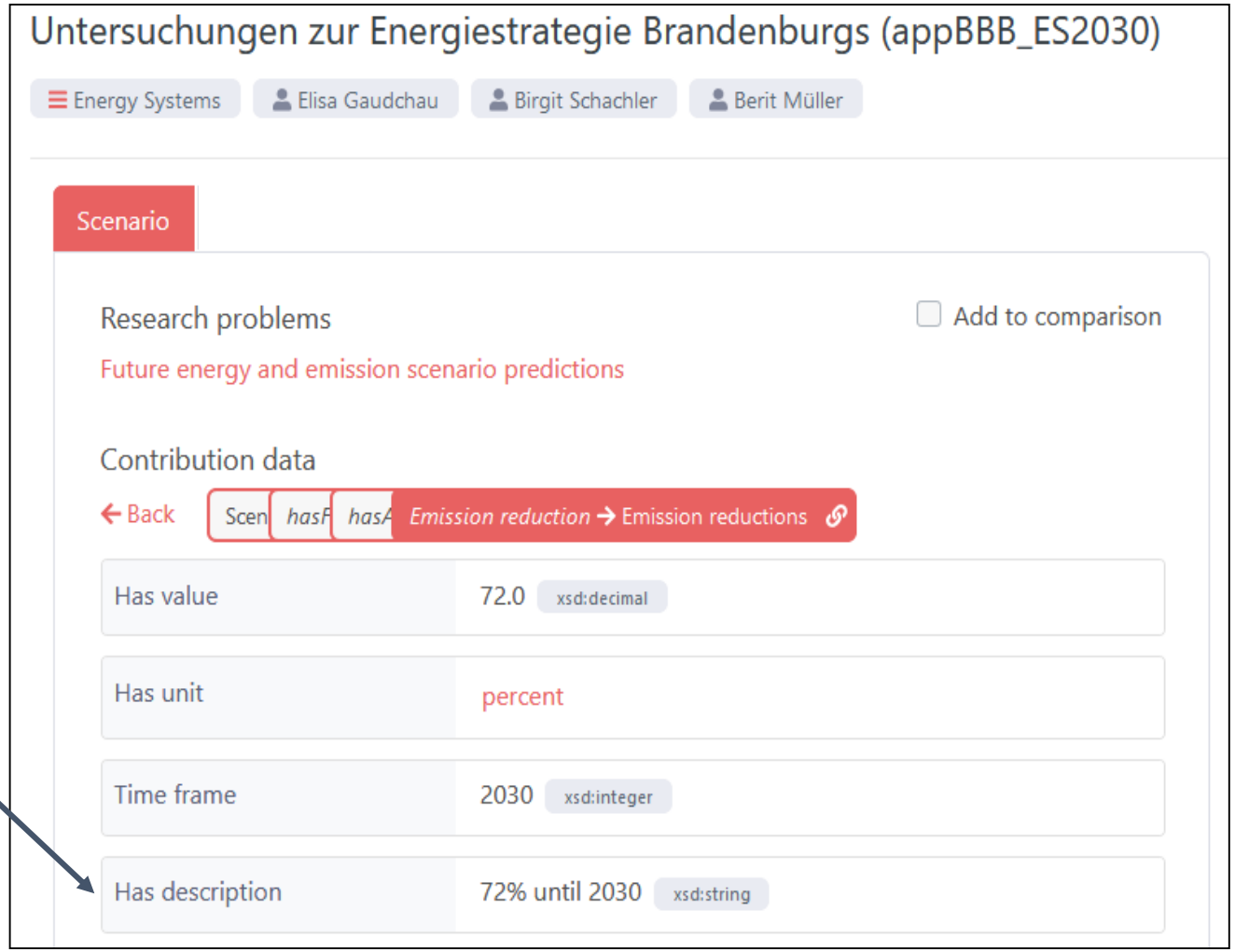

Example 1: Open Energy Ontology & Terminology Service

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Potential solar thermal	goal of "Energiestrategie 2030"
Potential biomass	goal of "Energiestrategie 2030"
Potential geothermal	other, potential geothermal othertext
Potential hydro power	-
Social developement ?	-
Economic development ?	42 TWh export
Development of environmental aspects ?	-
Post-processing ?	✔
Further assumptions for post-processing ?	✖

Results

models energy sector	Electricity sector C20081, C20091, C20090
	Heat sector C20081
models demand sector	Commercial sector C20083, C20081, C20086

TIB TERMINOLOGY SERVICE

HOME COLLECTIONS ONTOLOGIES HELP API ABOUT

sector Search

Exact Match Obsolete terms

Repository for the Open Energy Ontology (OEO)

http://openenergy-platform.org/ontology/oeo/

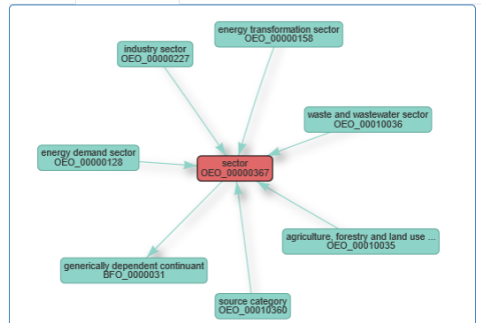
Overview Class Tree Property Tree Individuals Class List

Jump to type your target term ...

Reset Show Obsoletes Full Tree Show Siblings

entity
continuant
generically dependent continuant
sector
agriculture, forestry and land use sector
energy demand sector
energy transformation sector
industry sector
source category
waste and wastewater sector

Detail Graph View



Legend

Relation Color Visibility

Extended nodes (*) -

is a ☑

is about ☐

Select/Deselect all ☐

List of extended nodes (*):

- sector (OEO_00000367)

Example 1: Behind the Scenes

Scientific knowledge becomes **machine-actionable** and **FAIR**.

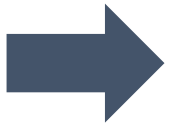
Study

Empirical Data

Assumptions

Energy savings	23% until 2030
Potential energy saving	not estimated
Emission reductions	72% until 2030
Share RE (heat sector)	not estimated
Share RE (mobility sector)	not estimated
Share RE (power sector)	not estimated
Share RE (total energy supply)	not estimated
Cost development	capex, opex, constant
Technological innovations ?	spread of electromobility, heat pumps and solar thermal heat;
Potential wind	other, potential wind other text
Potential solar electric	goal of "Energiestrategie 2030"
Potential solar thermal	goal of "Energiestrategie 2030"
Potential biomass	goal of "Energiestrategie 2030"
Potential geothermal	other, potential geothermal othertext
Potential hydro power	-
Social developement ?	-
Economic development ?	42 TWh export
Development of environmental aspects ?	-
Post-processing ?	✔
Further assumptions for post-processing ?	✖

Results



Untersuchungen zur Energiestrategie Brandenburgs (appBBB_ES2030)

Energy Systems | Elisa Gaudchau | Birgit Schachler | Berit Müller

Scenario

Research problems

Add to comparison

Future energy and emission scenario predictions

Contribution data

← Back | Scen | hasF | hasA | Emission reduction → Emission reductions

Has value	72.0 xsd:decimal
Has unit	percent
Time frame	2030 xsd:integer
Has description	72% until 2030 xsd:string

Example 1: Behind the Scenes

Scientific knowledge becomes **machine-actionable** and **FAIR**.

Study

Empirical Data

Assumptions

Energy savings	23% until 2030
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Potential wind	other, potential wind other text
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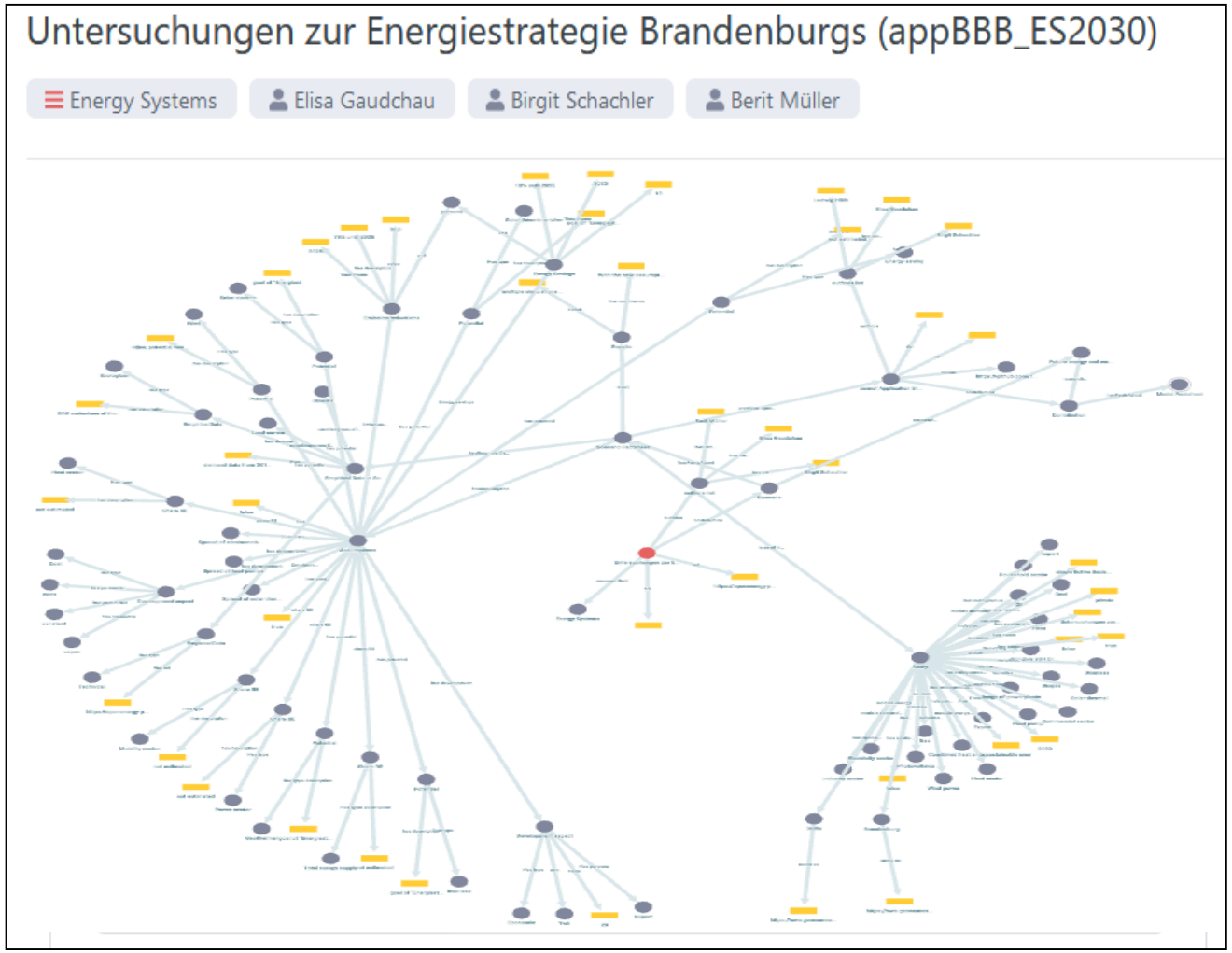
Potential solar thermal	goal of "Energiestrategie 2030"
Potential biomass	goal of "Energiestrategie 2030"
Potential geothermal	other, potential geothermal othertext
Potential hydro power	-
Social developement ?	-
Economic development ?	42 TWh export
Development of environmental aspects ?	-
Post-processing ?	✔
Further assumptions for post-processing ?	✖

Results



Example 1: Using FAIR Scientific Knowledge

Study

Empirical Data

Assumptions

Energy savings	23% until 2030
Potential energy saving	not estimated
Emission reductions	72% until 2030
Share RE (heat sector)	not estimated
Share RE (mobility sector)	not estimated
Share RE (power sector)	not estimated
Share RE (total energy supply)	not estimated
Cost development	capex, opex, constant
Technological innovations ?	spread of electromobility, heat pumps and solar thermal heat;
Potential wind	other, potential wind other text
Potential solar electric	goal of "Energiestrategie 2030"
Potential solar thermal	goal of "Energiestrategie 2030"
Potential biomass	goal of "Energiestrategie 2030"
Potential geothermal	other, potential geothermal othertext
Potential hydro power	-
Social developement ?	-
Economic development ?	42 TWh export
Development of environmental aspects ?	-
Post-processing ?	✔
Further assumptions for post-processing ?	✘

Results

What is the avg. assumed emission reduction of the scenarios?

Natural language question → **Answer**

Properties	Paris Agreement Compatible (PAC) Energy Scenario *Scenario*	Untersuchungen zur Energiestrategie Brandenburgs (appBBB_gruene2030) *Scenario*
Hasfactsabout/scenario factsheet/is used in study/study/has name*	Building a Paris Agreement Compatible (PAC) energy scenario	Untersuchungen zur Energiestrategie Brandenburgs
Hasfactsabout/scenario factsheet/is used in study/study/sensitivity*	✘	✘
Hasfactsabout/scenario factsheet/is used in	✔	✔

Visualizations

Example 1: Publishing State-of-the-Art Comparison

Comparison of Scenario Factsheets from the Open Energy Platform

November 2021 | Jan Göpfert | Oliver Karras

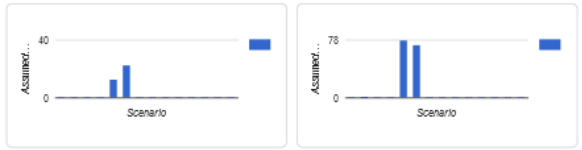
This comparison provides an overview of the current scenario factsheets available in the Open Energy Platform. These factsheets are a standardized collection and presentation of information about scenarios used in climate and energy system modelling. The factsheets are intended to summarize the key points of the respective scenarios concisely.In studies of climate and energy system modelling domain, models simulate these scenarios with different modified input data and assumptions to calculate and compare their simulation results. The authors would like to thank the German Federal Government, the German State Governments, and the Joint Science Conference (GWK) for their funding and support as part of the NFDI4Ing consortium. Funded by the German Research Foundation (DFG) - project number: 442146713. This work was also supported by the Helmholtz Association under the program "Energy System Design".

DOI: https://doi.org/10.48366/r150337

NFDi4Ing

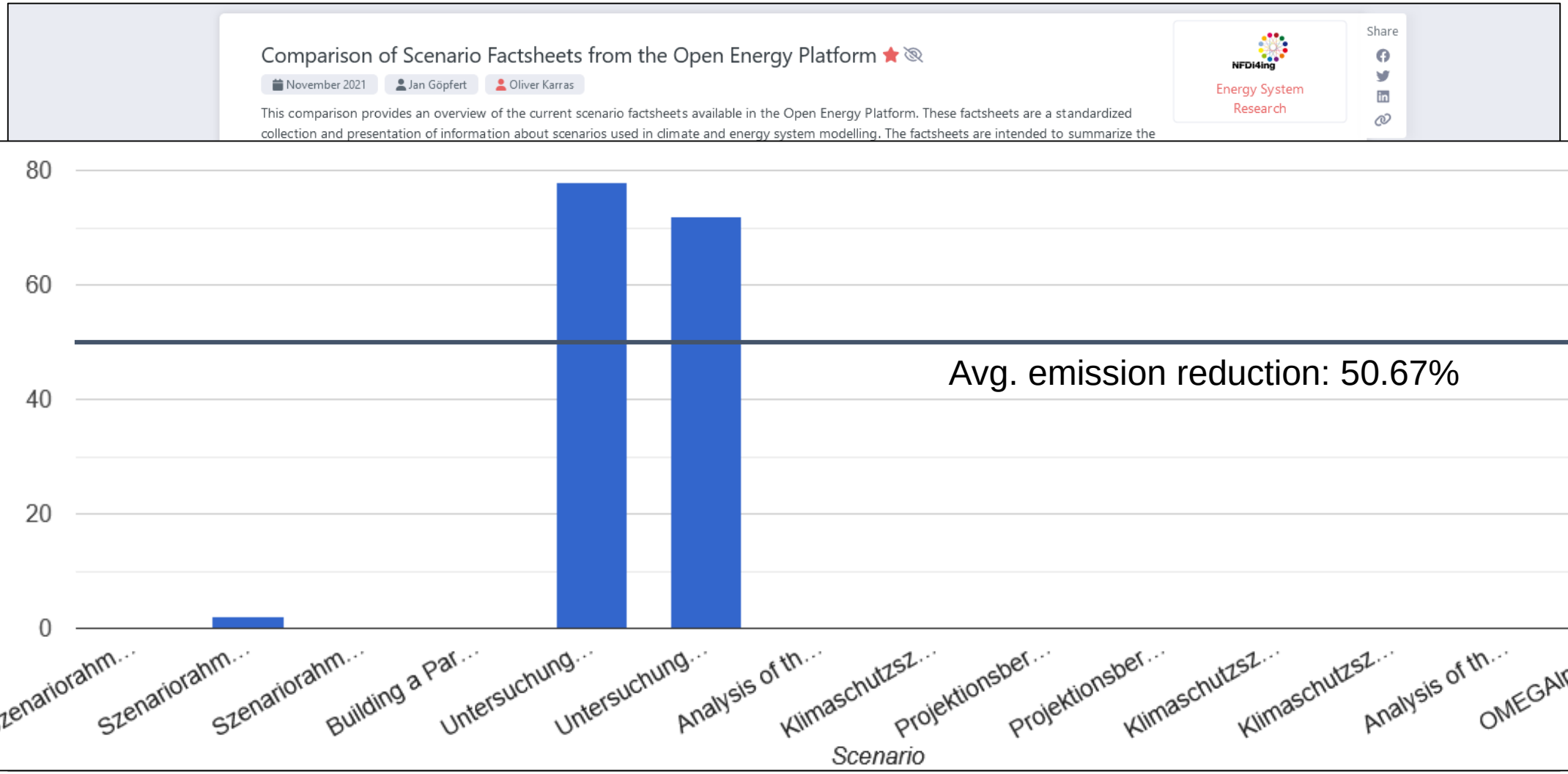
Energy System Research

Share



Properties	Szenariorahmen zum NEP 2035 (Szenario A 2035) *Scenario - 2021*	Szenariorahmen zum NEP 2035 (Szenario B 2035 und 2040) *Scenario - 2021*	Szenariorahmen zum NEP 2035 (Szenario C 2035) *Scenario - 2021*	Paris Agreement Compatible (PAC) Energy Scenario *Scenario*	Untersuchungen zur Energiestrategie Brandenburgs (appBBB_gruene2030) *Scenario*	Untersuchungen zur Energiestrategie Brandenburgs (appBBB_ES2030) *Scenario*
hasfactsabout/scenario factsheet						
is used in study/study						
has name*	Szenariorahmen zum NEP 2035 (2021)	Szenariorahmen zum NEP 2035 (2021)	Szenariorahmen zum NEP 2035 (2021)	Building a Paris Agreement Compatible (PAC) energy scenario	Untersuchungen zur Energiestrategie Brandenburgs	Untersuchungen zur Energiestrategie Brandenburgs
sensitivity*	✗	✗	✗	✗	✗	✗
has target year*	✓	✓	✓	✓	✓	✓
time frame*	2035	2035	2035	2050	2030	2030

Example 1: Visualization of Avg. Assumed Emission Reduction



Example 2: Studies on Germany's Energy Supply in 2050

Comparison of Studies on Germany's Energy Supply in 2050

November 2021 | Felix Kullmann | Jan Göpfert | Oliver Karras | Patrick Kuckertz | Sören Auer | Markus Stocker | Peter Markewitz | Leander Kotzur | Detlef Stolten

NFDI4Ing Energy System Research

Share

This comparison compiles the results from various studies analyzing a future low-carbon energy system for Germany. The focus of this study comparison is electricity generation. In the future, however, other essential characteristics of the respective energy system designs in the individual studies will be listed. Installed capacity is given in GW and electricity generation is given in TWh. The authors would like to thank the German Federal Government, the German State Governments, and the Joint Science Conference (GWK) for their funding and support as part of the NFDI4Ing consortium. Funded by the German Research Foundation (DFG) - project number: 442146713. This work was also supported by the Helmholtz Association under the program "Energy System Design".

DOI: https://doi.org/10.48366/r153801

Properties	Klimaneutrales Deutschland *Contribution - 2020*	Wasserstoff-Roadmap Nordrhein-Westfalen *Contribution - 2020*	Wege zu einem klimaneutralen Energiesystem *Contribution - 2020*	Wege für die Energiewende *Contribution - 2019*	Den Weg zu einem treibhausgasneutralen Deutschland ressourcenschonend gestalten *Contribution 1 - 2019*
has energy sources	all sources	all sources	all sources	all sources	all sources
	bioenergy	bioenergy	bioenergy	bioenergy	bioenergy
	geothermics	geothermics	geothermics	geothermics	geothermics
	hydropower	hydropower	hydropower	hydropower	hydropower
	import	import	import	import	import
	net import	net import	net import	net import	net import

Example 2: Studies on Germany's Energy Supply in 2050

So far so good, but…

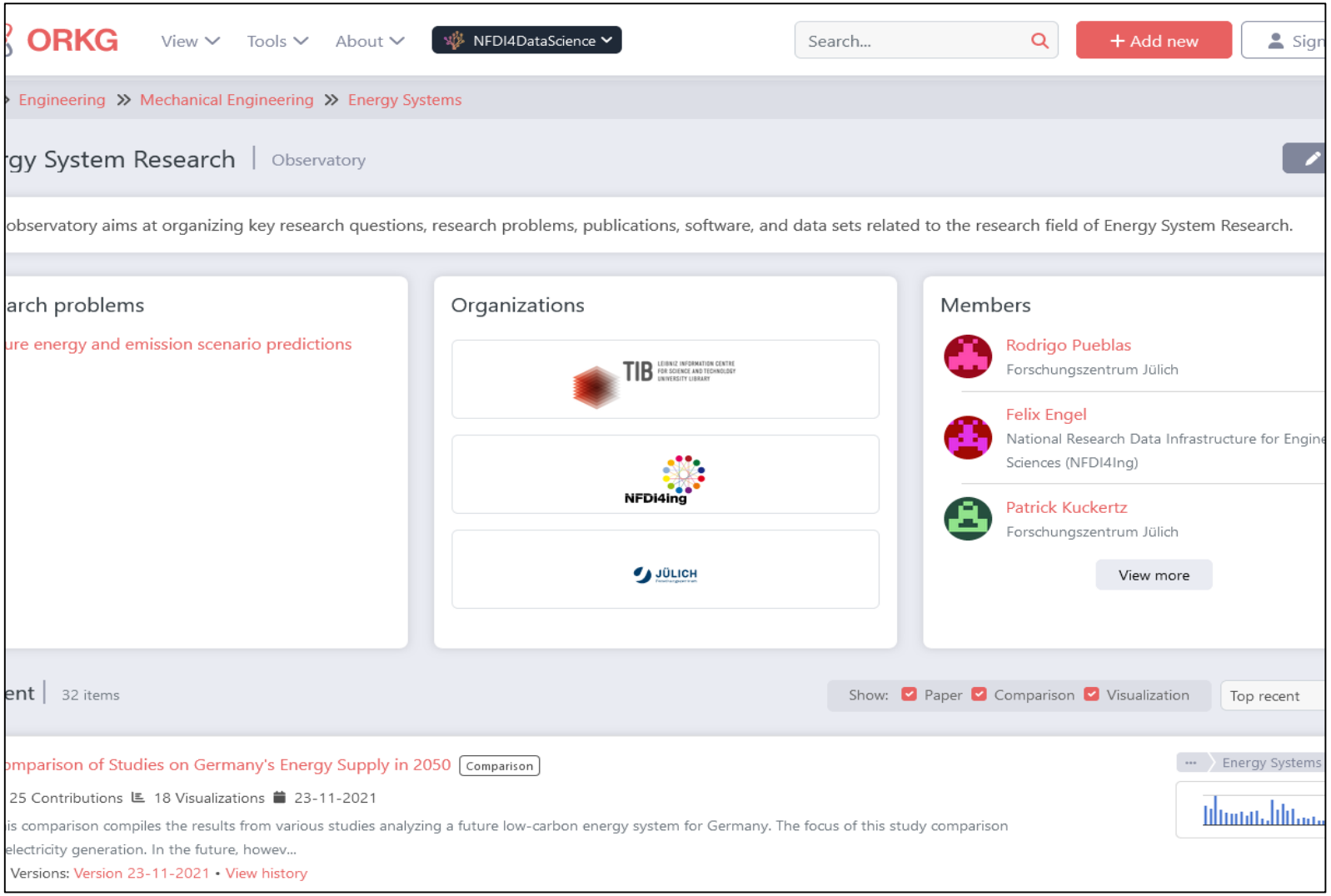
…what can we do with machine-actionable scientific knowledge?

Anything we want!

1. Papers, contributions, comparisons, and visualizations in the ORKG are **available for (re-)use and extension to anyone**
2. The ORKG provides several **access points** for processing all data, e.g., to develop novel search, retrieval, mining, and assistance applications

{ REST : API }

ORKG Observatory on Energy System Research



- Central **access point** to all related curated papers, contributions, comparisons, and visualizations
- **Collaboration** between NFDI4Ing and NFDI4Energy in the future
- **(RE-)use** by others

(Re-)use by Auer et al. [1]

How has the **average energy supply** (in TWh) **per energy source** changed in **5-year intervals** in the comparison “Comparison of studies on Germany’s energy supply in 2050”?

[1] S. Auer, D. A. C. Barone, C. Bartz, *et al.*, “The SciQA Scientific Question Answering Benchmark for Scholarly Knowledge”, *Nature Scientific Reports*, vol. 13, no. 7240, 2023. DOI: 10.1038/s41598-023-33607-z.

(Re-)use by Auer et al. [1]

How has the **average energy supply** (in TWh) **per energy source** changed in **5-year intervals** in the comparison “Comparison of studies on Germany’s energy supply in 2050”?

```
PREFIX orkgr: <http://orkg.org/orkg/resource/>
PREFIX orkgc: <http://orkg.org/orkg/class/>
PREFIX orkgp: <http://orkg.org/orkg/predicate/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>

#defaultView:BarChart
SELECT (SAMPLE(?rangeId) AS ?interval)
       (AVG(?value) AS ?average_energy_generation)
       (STR(SAMPLE(?energy_src_label)) AS ?legend)
WHERE {
  orkgr:R153801 orkgp:compareContribution ?contrib.
  ?paper orkgp:P31 ?contrib;
  orkgp:P29 ?year.
  BIND(xsd:int(?year) as ?y)
  VALUES(?rangeId ?min ?max) {
    ("2001-2005" 2001 2005)
    ("2006-2010" 2006 2010)
    ("2011-2015" 2011 2015)
    ("2016-2020" 2016 2020)
  }
  FILTER(?min <= ?y && ?y <= ?max)
  ?contrib orkgp:P43135 ?energy_src.
  ?energy_src rdfs:label ?energy_src_label;
  orkgp:P43134 ?energy_gen.
  ?energy_gen orkgp:HAS_VALUE ?val.
  BIND(xsd:decimal(?val) as ?value)
  FILTER(str(?energy_src_label)!= "all sources")
  FILTER(str(?energy_src_label)!= "net import")
}
GROUP BY ?rangeId ?energy_src_label
ORDER BY ?rangeId
```

[1] S. Auer, D. A. C. Barone, C. Bartz, *et al.*, “The SciQA Scientific Question Answering Benchmark for Scholarly Knowledge”, *Nature Scientific Reports*, vol. 13, no. 7240, 2023. DOI: 10.1038/s41598-023-33607-z.

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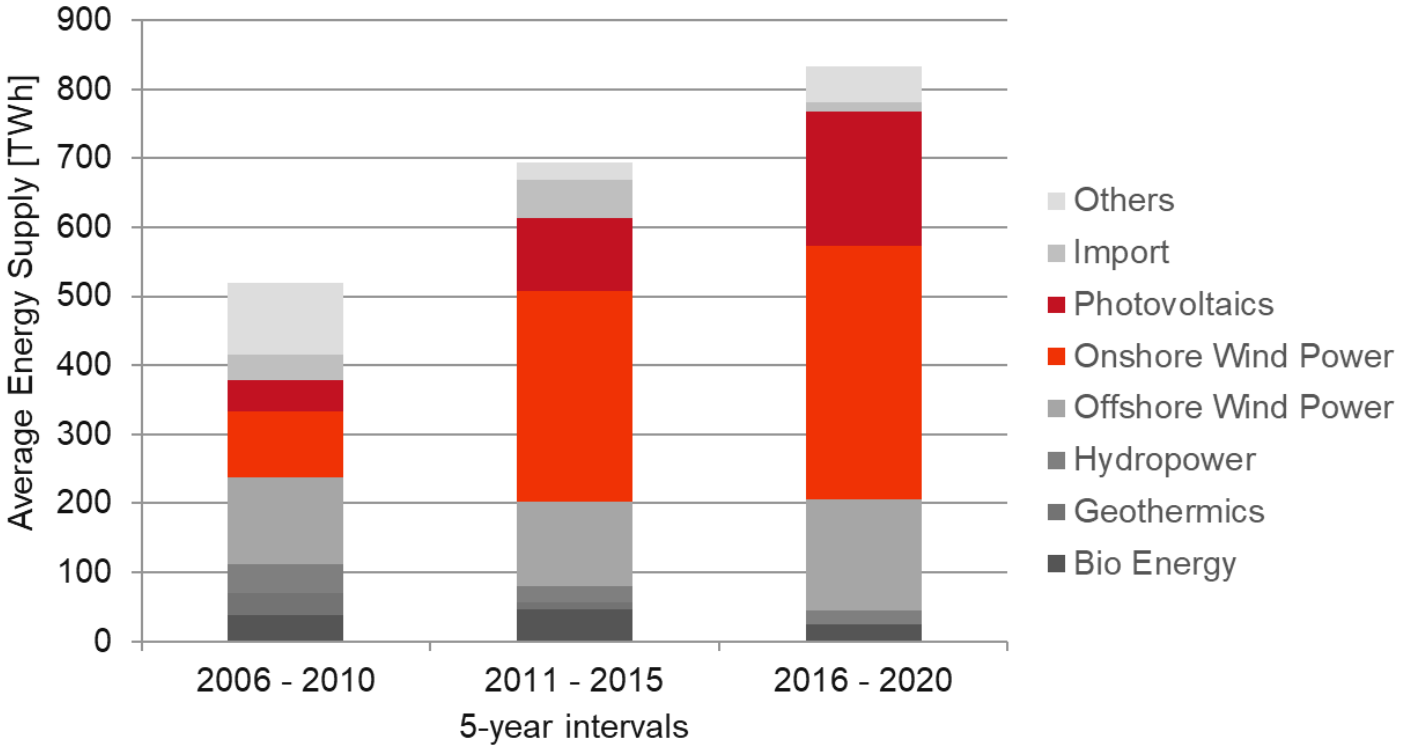


```sparql
PREFIX orkgr: <http://orkg.org/orkg/resource/>
PREFIX orkgc: <http://orkg.org/orkg/class/>
PREFIX orkgp: <http://orkg.org/orkg/predicate/>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
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  VALUES(?rangeId ?min ?max) {
    ("2001-2005" 2001 2005)
    ("2006-2010" 2006 2010)
    ("2011-2015" 2011 2015)
    ("2016-2020" 2016 2020)
  }
  FILTER(?min <= ?y && ?y <= ?max)
  ?contrib orkgp:P43135 ?energy_src.
  ?energy_src rdfs:label ?energy_src_label;
  orkgp:P43134 ?energy_gen.
  ?energy_gen orkgp:HAS_VALUE ?val.
  BIND(xsd:decimal(?val) as ?value)
  FILTER(str(?energy_src_label)!= "all sources")
  FILTER(str(?energy_src_label)!= "net import")
}
GROUP BY ?rangeId ?energy_src_label
ORDER BY ?rangeId
```

[1] S. Auer, D. A. C. Barone, C. Bartz, *et al.*, “The SciQA Scientific Question Answering Benchmark for Scholarly Knowledge”, *Nature Scientific Reports*, vol. 13, no. 7240, 2023. DOI: 10.1038/s41598-023-33607-z.

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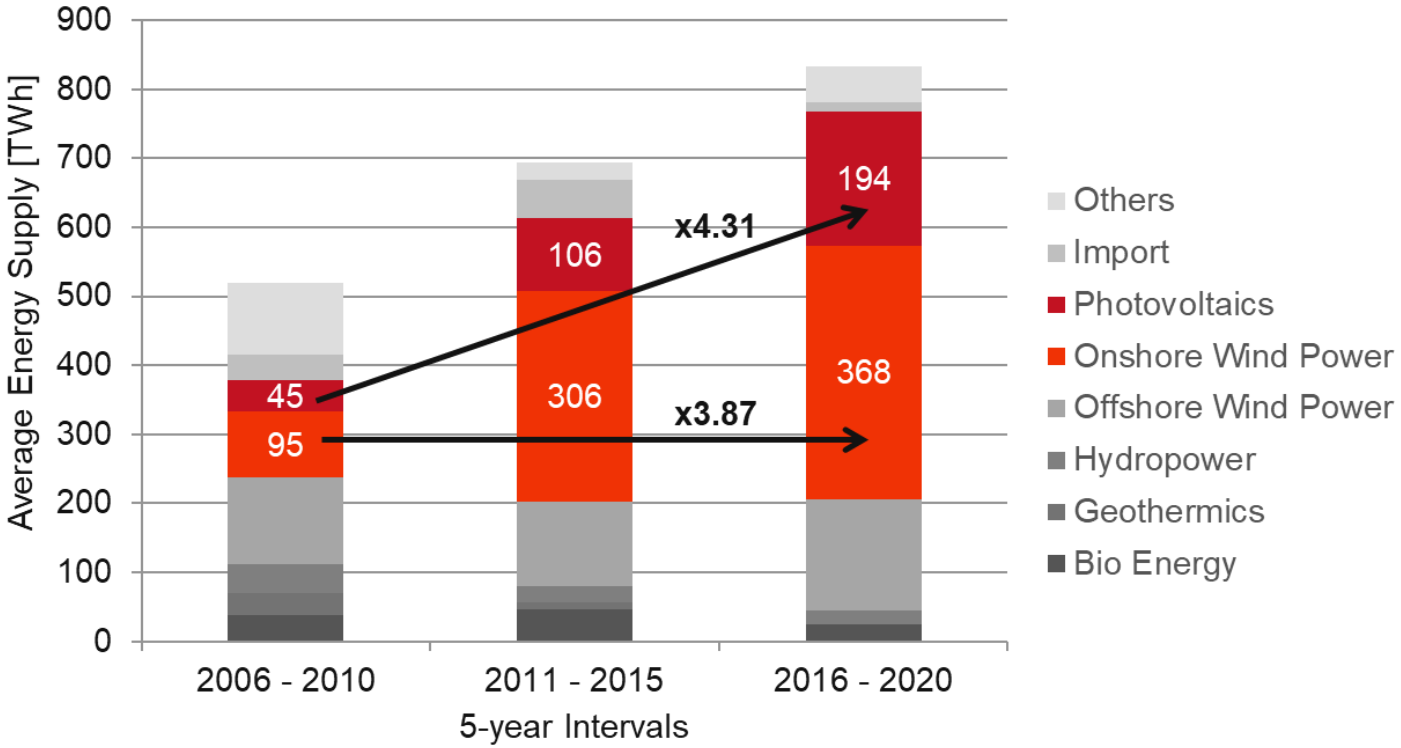


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  BIND(xsd:int(?year) as ?y)
  VALUES(?rangeId ?min ?max) {
    ("2001-2005" 2001 2005)
    ("2006-2010" 2006 2010)
    ("2011-2015" 2011 2015)
    ("2016-2020" 2016 2020)
  }
  FILTER(?min <= ?y && ?y <= ?max)
  ?contrib orkgp:P43135 ?energy_src.
  ?energy_src rdfs:label ?energy_src_label;
  orkgp:P43134 ?energy_gen.
  ?energy_gen orkgp:HAS_VALUE ?val.
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}
GROUP BY ?rangeId ?energy_src_label
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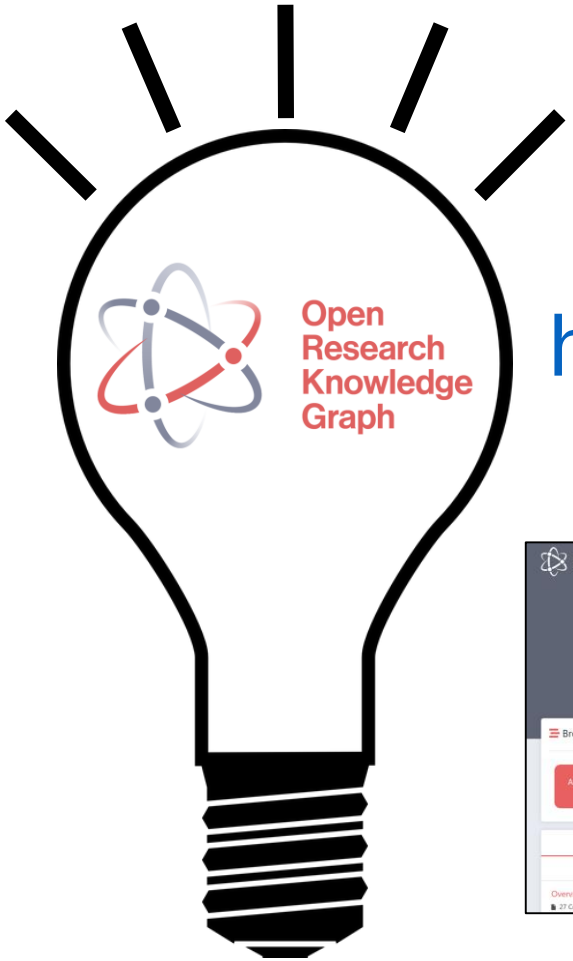
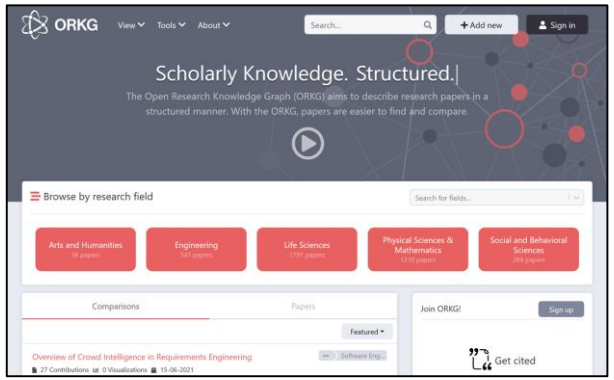
```

[1] S. Auer, D. A. C. Barone, C. Bartz, *et al.*, “The SciQA Scientific Question Answering Benchmark for Scholarly Knowledge”, *Nature Scientific Reports*, vol. 13, no. 7240, 2023. DOI: 10.1038/s41598-023-33607-z.

Conclusion



https://orkg.org



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oliver.karras@tib.eu

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