Open Research Knowledge Graph
- A Lighthouse in the Publication Flood -

Anna-Lena Lorenz & Oliver Karras

Helmholtz Open Science Seminar

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Digitalization in everyday life

Navigation to TIB Hannover

50 years ago

Now

+ New Features:
  → Zoom in
  → Traffic jam warning
  → Opening hours
  → Interesting places around
Similar in other domains….

Who still remembers?

Mail order catalogs
Encyclopedias
Phone books

Whole industries got disrupted and our lives were significantly changed
What about Science?

Over 300 years ago

100 years ago

20 years ago

Today

Science does not harvest the full potential of digitalization

Not much has changed!
A Consequence of Document Centered Information Flows: The Publication Flood

- ~ 2.5 Mio new publications per year
- Researchers lack overview, even in small fields
- Loss of knowledge
- Answering questions is like looking for a needle in the haystack
An Example – CRISPR

Almost half a million results

Specific research questions:

- Who applied CRISPR to butterflies?
- How to apply CRISPR with minimal costs?
- How do different genome editing techniques compare?
The Publication Flood – More than just an Inconvenience for Scientists

• Globally almost $1,700,000,000,000 (1.7 trillion) spent on research & development

• Large share wasted in inefficient system

→ Costs time & money!
Further Challenges of Document-Orientation

- Reproducibility Crisis
- Deficiency of Peer-Review
- Lack of machine assistance
- Predatory Publishing
Time to Rethink Scholarly Communication!

The solution is not „better pdfs“…

“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Current and future scientific challenges can not be tackled with an outdated communication system.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!
As the name already suggests, ORKG is a knowledge graph.
Knowledge Graphs are widely used in industry…

Fine, but what is such a knowledge graph?

Why not use them for (open) science as well?

https://www.slideshare.net/Frank.van.Harmelen/adoption-of-knowledge-graphs-late-2019
There is a lot of information in a text...

- Metadata
- Research problem
- Methods
- Material
- Results
- …
There is a lot of information in a text…

…that can unfortunately not be understood by a machine.
Knowledge Representation in Graphs

From papers…

…To Knowledge

A practical guide to CRISPR/Cas9 genome editing in Lepidoptera
doi.org/10.1101/130344

R. D. Reed
orcid.org/0000-0002-6065-6728

Genome editing in Lepidoptera
wikidata.org/wiki/Q24630389

Genome editing

Experimental Data
doi.org/10.5281/zenodo.896916

CRISPR/cas9
Advantages of a Graph-Based Approach

• Machine-actionable

• Automated finding and linking of research contributions towards a specific problem

• Natural language question answering possible e.g. „How do different genome editing techniques compare?“

• Explore knowledge in entirely new ways
An Example: SARS-CoV 2 Basic Reproduction Number
<table>
<thead>
<tr>
<th>Properties</th>
<th>Lombardy, Italy</th>
<th>Iran</th>
<th>Iran</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time period</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Basic reproduction number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has value</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence interval (95%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower confidence limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper confidence limit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**The early phase of the COVID-19 outbreak in Lombardy, Italy**

- **Time interval**: 2020-01-14 to 2020-03-08
- **Basic reproduction number**: 3.1
- **Confidence interval (95%)**: 2.9 to 3.2
- **Method**: Generalized growth model

**Transmission potential of COVID-19 in Iran**

- **Time interval**: 2020-02-19 to 2020-02-29
- **Basic reproduction number**: 3.6
- **Confidence interval (95%)**: 3.4 to 4.2

**Transmission potential of COVID-19 in Iran**

- **Time interval**: 2020-02-19 to 2020-02-29
- **Basic reproduction number**: 3.58
- **Confidence interval (95%)**: 1.29 to 8.46

**Estimating the generation interval for COVID-19 based on symptom onset data**

- **Time interval**: 2020-01-21 to 2020-02-26
- **Basic reproduction number**: 1.27
- **Confidence interval (95%)**: 1.19 to 1.36

Based on the calculation of the epidemic's doubling time: estimated epidemic doubling time of 1.20 (95% CI, 1.05, 1.44) days.
ORKG’s Objectives

Foster collaboration

Provide overview over the state-of-the-art for specific research problems

Focus on scientific content rather than document

Make research FAIR

Tackle interdisciplinary challenges such as climate change research, disease prevention, etc.

Finally bring scholarly communication to the 21st century!
ORKG: Lighthouse in the Publication Flood
What can you do with the ORKG?
Let’s have a look at the content!
Current Status

- ~ 25.000 Papers described
- ~ 1200 Comparisons
- ~ 5.000 Research questions/ problems
- ~ 1200 Users

...could be more!

So how do we get more content?
Who creates ORKG content?

Machines?
Not precise enough!

R. D. Reed
orcid.org/0000-0002-6065-6728

Genome editing in Lepidoptera
wikidata.org/wiki/Q24630389

CRISPR/cas9

Experimental Data
doi.org/10.5281/zenodo.896916

Genome editing
wikidata.org/wiki/Q24630389
Who creates ORKG content?

Übersetzung

Better: Scientific Communities!

A practical guide to CRISPR/Cas9

New Results

CRISPR/Cas9 genome editing has rev

and is having an especially strong imp

recent advances in applying CRISPRX

practical advice on the entire process i

genotyping. We also describe success

butterflies. Finally, we provide a comp
butterflies.

Abstract

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CRISPR/cas9

Experimental Data

doi.org/10.5281/zenodo.896916

doi.org/10.1101/130344

Genome editing in Lepidoptera

Genome editing

wikidata.org/wiki/Q24630389

Better: Scientific Communities!
Who creates ORKG content?

Crowd-based approach for the curation process

Following the principle of Wikipedia: **Everyone** can create, edit, add, complement, reuse, etc.

- Library community
- Researchers
- ORKG
- Software Developers
- Users
How to get out the most of ORKG for your discipline?
ORKG Curation – Different Expertise

**Domain experts**
- Scientific Communities -
  + Field specific knowledge
  + Knowledge of requirements

**Data Curators**
- Library Communities -
  + Knowledge on data modelling
  + Software Development competence
Observatories: Taking the Lead in Content Curation

Organize research in your field

Ensure high quality standard

Create templates and simplify using ORKG for beginners

Promote ORKG

Stay in contact with development team: Issues & Requests will be prioritized

Build a community knowledge graph for your discipline
Summary

Rethink scholarly communication

Machine-actionable knowledge representation

Crowd-based approach

Learn more: orkg.org
Contact us: info@orkg.org
Follow us: @orkg_org
The Open Research Knowledge Graph – A Lighthouse in the Publication Flood:
ORKG Use Case: NFDI4Ing – TA ELLEN

Dr. rer. nat. Oliver Karras
November 6, 2023
67th Helmholtz Open Science Online Seminar 2023
“NFDI4Ing brings together the engineering communities. It offers a unique method-oriented and user centered approach in order to make engineering research data FAIR – findable, accessible, interoperable, and re-usable.”
Structure of NFDI4Ing

3.2 ALEX
bespoke experiments with high variability of hardware and research software setups

3.3 BETTY
engineering research software

3.4 CADEN
provenance tracking of samples and data workflows

3.5 DORIS
high performance measurement and computing for very large data

3.6 ELLEN
assessable data: interacting with know data sources and identification of sources

3.7 FRANK
many simultaneously involved participants and end-user-devices

3.8 GOLQ
field data and distributed system

3.9 Base Services
quality assurance & metrics, research software development, terminology & metadata, repositories & storage, data security & sovereignty, training, and data & knowledge discovery

Heterogeneous Raw Research Data

3.10 Community Clusters (initialisation, education, activation & collaboration, participation, standardisation, journal)

3.11 Management (administrative coordination, project management, support & consulting, quality management)
Structure of NFDI4Ing

- **3.2 Alex**: Bespoke experiments, high variance, high hardware requirements, research setup
- **3.3 Betty**: Bespoke experiments
- **3.4 Caden**: Engineering research software
- **3.5 Doris**: Provenance tracking of physical samples and data samples
- **3.6 Ellen**: High performance measurement and computation with very large data
- **3.7 Frank**: Extensive and heterogeneous data requirements
- **3.8 Golfo**: Many participants and simultaneous devices, field data and distributed systems
TA ELLEN: Extensive & Heterogeneous Data Requirements

Reuse of research software in complex software workflows

- ELLEN:
  - Performing model-based **simulations** and **optimization** calculations

- Input: **Scenarios**
  - Data-intensive
  - Require a lot of different information from heterogeneous disciplines

- Tool: Research **Software**
  - Algorithms from computer science & statistics
Reuse of research software in complex software workflows

ELLEN:
- Performing model-based simulations and optimization calculations
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Reuse of research software in complex software workflows

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  - **Tool:** Research *Software*
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Reuse of research software in complex software workflows

ELLEN:

- Performing model-based **simulations** and **optimization** calculations

<table>
<thead>
<tr>
<th>Software workflow</th>
</tr>
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<tbody>
<tr>
<td>Software → Data → Software</td>
</tr>
</tbody>
</table>

- **Input:** Scenarios
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  - Data-intensive
  - Require a lot of different information from heterogeneous disciplines
- Tool: Research Software
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Transformation patterns of the worldwide energy system-scenarios for the century with the POLES model
A Kikouz, P. Crippa, E Bellevat, B Chateau - The Energy Journal, 2010 - iaeo.org
... the worldwide energy system in scenarios ranging from a baseline to a very low greenhouse gas stabilization, using the energy model POLES. ... This study has been performed using the POLES World energy model, a recursive simulation model of the World energy system that ...

Combining scenario planning, energy system analysis, and multi-criteria analysis to develop and evaluate energy scenarios
T Witt, M Dumajer, J Galdernann - Journal of Cleaner Production, 2020 - Elsevier
... needs to be applied to evaluate alternatives in more scenarios. Furthermore, in accordance with the system boundaries, the different energy system models in this case study only represent selected parts of the power supply system and, consequently, the criteria hierarchy and ...

NSON-DK energy system scenarios—Edition 2
MJ Koniszt, J Gea-Bermudez - 2016 - orbit.dtu.dk
... This chapter describes the Balmoral energy system model used in scenario modelling, as well as the specific aspects related to NSON-DK scenario analysis. Balmoral is used to carry out investment optimization for the North Sea region in focus, while taking into account also ...
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)

Scholarly Knowledge. Structured.

The Open Research Knowledge Graph (ORKG) aims to describe research papers in a structured manner. With the ORKG, papers are easier to find and compare.

Browse by research field

- Arts and Humanities: 36 papers
- Engineering: 547 papers
- Life Sciences: 1791 papers
- Physical Sciences & Mathematics: 3210 papers
- Social and Behavioral Sciences: 264 papers

Join ORKG!

Get cited
Supplementary material of software for simulations in climate and energy system modeling

<table>
<thead>
<tr>
<th>Scenario Factsheets from the Open Energy Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the average assumed emission reduction of the scenarios?</td>
</tr>
<tr>
<td>What software can use these scenarios as input for simulations?</td>
</tr>
<tr>
<td>Where do I find the implementation of the software for simulating the scenarios?</td>
</tr>
</tbody>
</table>

- Szenariohahmen zum NEP 2035 (Szenario A 2035)
- Szenariohahmen zum NEP 2035 (Szenario B 2035 und 2040)
- Szenariohahmen 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
Curation of Scenario Factsheets

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, other, potential wind other text
- Potential wind: goal of “Energiesysteme 2030”
- Potential solar electric: goal of “Energiesysteme 2030”
- Potential solar thermal: goal of “Energiesysteme 2030”
- Potential biomass: goal of “Energiesysteme 2030”
- Potential geothermal: other, potential geothermal other text
- Potential hydro power: -
- Social development: -
- Economic development: 42 TWh export
- Development of environmental aspects: -
- Post-processing: ✓
- Further assumptions for post-processing: ×

Results

Untersuchungen zur Energiestrategie Brandenburgs (appBBB_ES2030)

Scenario

Research problems

Future energy and emission scenario predictions

Contribution data

- Has value: 72.0
- Has unit: percent
- Time frame: 2030
- Has description: 72% until 2030
Semantic Description of Scholarly Contributions

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

<table>
<thead>
<tr>
<th>Assumptions</th>
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</thead>
<tbody>
<tr>
<td>Energy savings</td>
</tr>
<tr>
<td>Potential energy saving</td>
</tr>
<tr>
<td>Emission reductions</td>
</tr>
<tr>
<td>Share RE (heat sector)</td>
</tr>
</tbody>
</table>
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### Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
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<td><strong>Energy savings</strong></td>
<td>23% until 2030</td>
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<tr>
<td><strong>Potential energy saving</strong></td>
<td>not estimated</td>
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<tr>
<td><strong>Emission reductions</strong></td>
<td>72% until 2030</td>
</tr>
<tr>
<td><strong>Share RE (heat sector)</strong></td>
<td>not estimated</td>
</tr>
</tbody>
</table>

### Contribution data

- **Has value**: 72.0, *xsd:decimal*
- **Has unit**: percent
- **Time frame**: 2030, *xsd:integer*
- **Has description**: 72% until 2030, *xsd:string*
Semantic Description of Scholarly Contributions

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- **Energy savings**: 23% until 2030
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Behind the Scenes of the Semantic Description

Scholarly contributions become **machine-actionable and FAIR**.
Scholarly contributions become machine-actionable and FAIR.
Behind the Scenes of the Semantic Description

Scholarly contributions become **machine-actionable** and **FAIR**.
Creating State-of-the-Art Comparison
## State-of-the-Art Comparison

**Scenario Factsheet**

**Properties**
- Has research problem
- Has fact about scenario factsheet has assumption / assumptions / emission reduction
- Has fact about scenario factsheet has assumption / assumptions / emission reduction / emission reductions / has description
- Has fact about scenario factsheet has assumption / assumptions / emission reduction / emission reductions / has unit
- Has fact about scenario factsheet has assumption / assumptions / emission reduction / emission reductions / has value
- Has fact about scenario factsheet has assumption / assumptions / emission reduction / emission reductions / time frame
- Has fact about scenario factsheet is used in study / study / models demand sector
- Has fact about scenario factsheet is used in study / study / models energy sector

**Future energy and emission scenario predictions**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Emission reductions</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>78% until 2025</td>
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</table>

<table>
<thead>
<tr>
<th>Value</th>
<th>78.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time frame</td>
<td>2025</td>
</tr>
</tbody>
</table>

**Demand sector**
- Commercial sector
- Industry sector
- Household sector
- Electricity
- Heat

---

Adding further Scenario Factsheets...

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Seite 27
## Acknowledgement of creators

Possible to assign a DOI

### Interactive comparison

Created visualizations

### Publishing State-of-the-Art Comparison

#### Comparison of Scenario Factsheets from the Open Energy Platform

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.

#### Visualizations

![Visualization](image)

#### Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Paris Agreement Compatible (PAC) Energy Scenario</th>
<th>Untersuchungen zur Energiesystem Brandenburgs (appB88_EU2030) Scenario</th>
<th>Untersuchungen zur Energiesystem Brandenburgs (appB88_EU2030) Scenario</th>
<th>Analysis of the energy system of Brandenburg and Berlin</th>
<th>Klimaschutzscenario 95 (K95) Scenario</th>
</tr>
</thead>
<tbody>
<tr>
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<td>x</td>
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<tr>
<td>Has factsheet/is used in study/study sensitivity*</td>
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<tr>
<td>Has factsheet/is used in study/study has target year*</td>
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<td>2050</td>
<td>2030</td>
<td>2030</td>
<td>2005, 2010, 2020</td>
<td></td>
</tr>
</tbody>
</table>
Another Comparison from NFDI4Ing – TA ELLEN

Comparison of Studies on Germany’s Energy Supply in 2050

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.

Remark: Comparison of 25 contributions

DOI: 10.48366/n153801

Visualizations

Properties

Klimaneutrales Deutschland 2020 - Contribution

Wasserstoff-Roadmap Nordrhein-Westfalen 2020 - Contribution

Wege zu einem klimaneutralen Energiesystem 2019 - Contribution

Wege für die Energiewende 2019 - Contribution

Den Weg zu einem Treibhausgasneutralen Deutschland ressourcenschonend gestalten 2019 - Contribution 1
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Remark: Comparison of 25 contributions

Visualizations

Properties

Klimaneutrales Deutschland 2020 - Contribution

Nordrhein-Westfalen 2020 - Contribution

Weiterer Beitrag: Nordrhein-Westfalen 2020 - Contribution

Zitate insgesamt

Zitiert von: 1

2023

Google Scholar: Artikel

Comparison of studies on Germany’s energy supply in 2050


Publication date: 2021

Edition: FZI-2022-00782

Publisher: Technoökonomische Systemanalyse

Description: 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.

Zitiert von: 1

Similar Articles
So far so good, but…

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

Simply put: Anything we want!

1. **All** papers, scholarly contributions, comparisons, visualizations, lists, and reviews in the ORKG are available for reuse 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 }

- SPARQL
- Python
- RDF
Data Science with Data from the ORKG

How has the average energy generation (in TWh) per energy source changed in 5-year intervals in the comparison “Comparison of Studies on Germany’s Energy Supply in 2050” for the period from 2006 to 2020?
How has the *average energy generation* (in TWh) per energy source changed in *5-year intervals* in the comparison “Comparison of Studies on Germany’s Energy Supply in 2050” for the period from *2006 to 2020*?
Data Science with Data from the ORKG

How has the average energy generation (in TWh) per energy source changed in 5-year intervals in the comparison “Comparison of Studies on Germany’s Energy Supply in 2050” for the period from 2006 to 2020?

```
PREFIX orkg: <http://orkg.org/orkg/resource/>
PREFIX orkgt: <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)
    (SUM(?value) AS ?average_energy_generation)
    (STR(SAMPLE(?energy_src_label)) AS ?legend)
WHERE {
    ?paper orkg:PII ?contrib;
    orkgp:P29 ?year.
    BIND(?yearInt(?)year) as ?y)
    VALUES (?rangeId ?min ?max) {
        (?"2006-2010" 2006 2010)
        (?"2016-2020" 2016 2020)
    }
    FILTER(?min <= ?y && ?y <= ?max)
    ?contrib orkgp:P4313 orkgp:energy_src;
    ?energy_src rdfs:label ?energy_src_label;
    orkgp:P43134 ?energy_gen.
    BIND(?yearDecimal(?yval) AS ?value)
    FILTER(STR(STR(?energy_src_label)) != "all sources")
    FILTER(STR(STR(?energy_src_label)) != "net import")
}
GROUP BY ?rangeId ?energy_src_label
ORDER BY ?rangeId
```
How has the average energy generation (in TWh) per energy source changed in 5-year intervals in the comparison “Comparison of Studies on Germany’s Energy Supply in 2050” for the period from 2006 to 2020?
Conclusion

We want to bring scholarly communication in engineering sciences to the 21st century!
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