

CASE STUDY OPEN ACCESS

DeepGreen—A Data Hub for the Distribution of Scholarly Articles From Publishers to Open Access Repositories in Germany

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1 | Introduction

Open access is shaped as part of the innovation policy in the European Union and has been promoted by the European Commission (2018) and member states (Council of the European Union 2023) through various policy measures. The goal is to publish the scholarly output of research institutions, namely publicly funded universities and non-university research institutions, as open access.

In Germany, open access is supported by a wide range of activities. Beginning with the signing of the “Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities” in 2003 (Max-Planck-Gesellschaft 2003), all major German research organisations have committed to the promotion of open access. Since the early 2000s, libraries have started operating open access repositories and publication platforms, establishing open access as a service at scientific institutions (Scholze 2005). Since the mid-2010s, with the increasing provision of open-access journals from commercial publishers, the financing of Article Processing Charges (APCs) has come into focus for research institutions in Germany (Eppelin et al. 2012). Many institutions also operate institutional open access publishing services, such as presses and platforms for open access journals (Arning et al. 2024).

Politically, Open Access is supported by the federal government and the states in Germany. The “Joint Guidelines of the Federal Government and the Länder” published in 2023 outlines the political framework and emphasises the importance of cooperation in implementing the open access transformation (Bundesministerium für Bildung und Forschung 2023). Several federal states in Germany have adopted dedicated open access strategies. In some cases, specific indicators have also been formulated. The Federal Ministry of Education and Research plans that by the year 2025, 70% of all new scientific publications in Germany will be published exclusively or additionally via open access (Bundesministerium für Bildung und Forschung 2019). Both gold open access and green open access are recognised as complementary and equally valuable strategies for open access in Germany (Bundesministerium für Bildung und Forschung 2016).

Due to federalism in science policy, some federal states have established their own open access policies. One example is the open access policy of the state of Berlin from 2016, which defined an open access indicator for the academic institutions in Berlin. The target was a 60% share of open access publications in the publication output of academic institutions in Berlin in 2020 (Senat von Berlin 2015).

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Summary

- DeepGreen is an automated delivery service for open access articles. Originally conceived to take advantage of the so-called open access component—a secondary publication right in Alliance and National licences in Germany to promote green open access—it aims to streamline open access processes by automating the distribution of full-text articles and metadata from publishers to repositories.
- The service, developed by a consortium and funded by the German Research Foundation (DFG) in its initial phase, has successfully established itself as a national service, facilitating open access content distribution and contributing to Germany's open access infrastructure.
- As of December 2024, DeepGreen distributes articles from 14 publishers to 84 institutional repositories and 6 subject-specific repositories.
- This article describes the role of the DeepGreen service in Germany, its collaboration with publishers and the potential of automated processes for storing articles in open access repositories, which, as publicly owned institutional infrastructures, ensure sustainable access and provide secure, redundant storage.

Currently, the organisation of the transformation process is central to open access activities at universities and non-university research institutions. The recommendation of the German Science and Humanities Council, which advises the federal government and the states on matters of science policies, serves as an important reference document for these open access activities (German Science And Humanities Council 2022).

The promotion of open access also involves coordinating research institutions within Germany's federal system of research funding. This cooperation has been implemented by the Alliance of Science Organisations in Germany for many years. To promote open access in scientific institutions, the “Digital Information” priority initiative of the Alliance Science Organizations in Germany was launched in 2008 (Alliance of Science Organisations in Germany 2008; Kleiner 2010). The Alliance is an association of the most important science and research organizations in Germany. It regularly issues statements on issues of science policy, research funding, and the structural development of the German science system (Allianz der Wissenschaftsorganisationen n.d.). Since 2024, this initiative has been operating under the title “Alliance Focus ‘Digitality in Science’” (Bertelmann et al. 2023). Within this initiative, the science organisations coordinate their Open Science activities. The initiative aims to optimise the supply of information in science. This initiative also includes measures related to contracts between scientific institutions and publishers, negotiated within a distributed system in Germany (Pampel et al. 2022). Based on common principles, individual libraries negotiate opt-in contracts, which scientific institutions join according to the needs of their researchers. These framework agreements are a central component of scientific information provision in Germany. They are

based on a historically developed, distributed system of information supply through libraries (Mittermaier and Stanek 2024).

The promotion of open access has been advanced since the beginning of the priority initiative “Digital Information” through numerous measures. Two developments stand out to illustrate that scholarly organisations in Germany are working together to promote open access as part of this initiative:

(1) Alliance Licences: From 2004 to 2010, national licences for selected e-journal packages were negotiated with publishers in Germany on the basis of the common requirements of the scholarly organisations and with the financial support of the German Research Foundation (DFG). The idea behind the national licences was to provide nationwide access to the licensed content for all academic institutions in Germany, as well as for interested private individuals.

With the growing development of open access, from 2010 to 2020, the idea of national licences was further developed under the term Alliance Licences. The title indicates a shift in funding. While the national licences were funded by the German Research Foundation (DFG), the Alliance licences are supported through cooperative funding by the institutions participating in them. A key innovation of these Alliance Licences is the integration of an Open Access component (Rusch et al. 2019). This open access component is defined in the guidelines for the Alliance licences:

Authors from authorised institutions are permitted, free of charge, to promptly add their articles that have appeared in licensed journals to institutional or discipline-specific repositories of their choice and to make them available via open access, generally in the form published by the publisher (e.g., PDF). The authorised institutions to which the authors belong have the same right. (Deutsche Forschungsgemeinschaft 2015, 7–8).

This open access component often exceeds the open access policies of publishers listed in Sherpa Romeo. It allows any institution participating in a contract to publish a version of record (VoR) of the articles of their affiliated scientists after a shortened embargo period, however some of the participating publishers only allow the use of the author's accepted manuscript (AAM) in open access in their (institutional and/or subject-specific) repository (Hillenkötter 2012; Stöber 2012).

(2) DEAL: Subsequent to the establishment of the Alliance Licences, efforts to develop alternative licensing models began in 2013. The Alliance of Science Organisations in Germany aimed to achieve structural improvements in the licensing of electronic content (Mittermaier 2023a, 124). A “national approach should be used to achieve noticeable financial and structural improvements in the licensing of electronic content.” The specific goal was to: “achieve a significant change in the currently, particularly regarding certain publishers, disadvantageous status quo for scientific institutions and thus to significantly improve the literature supply of German science through comprehensive licensing [and] to further consolidate the market power on the

demand side” (translation by the authors) (Mittermaier 2023a, 124). Part of this endeavour was also to promote open access. This initiative was implemented in 2015 under the term DEAL. The results of the DEAL initiative, now spanning over 10 years, are national contracts with Elsevier, Springer Nature and Wiley (“Agreements,” DEAL Konsortium n.d.). These contracts are categorised as transformative contracts and ensure that the publication output of the participating scientific institutions is published in open access (Mittermaier 2023a, 2023b). In addition, with the support of a working group of academic libraries, called Forum 13+ (Arbeitskreis Forum 13+ n.d.), a variety of other national options for gold open access and open access transformation agreements have been negotiated.

These initiatives are not standalone efforts, but are part of a broad portfolio of open access measures in Germany. In July 2024, the “German Open Access Monitor” showed an open access share of 66.5% in the national publication output in journals¹ (Mittermaier et al. 2018).

2 | Potential for a Data Hub

The negotiation of Alliance Licences, with their open access component, offered new opportunities for scientific institutions to publish affiliated scientists’ publications in open access repositories. However, few institutions utilised this option due to the authors’ lack of detailed knowledge about the legal conditions of the open access component. In 2013, 2 years after the signing of the first Alliance Licence agreements, the Bavarian State Library surveyed the use of this open access component. The results showed a very low application rate of the open access component in practice (Koch et al. 2016), resulting in a limited number of articles made accessible based on the open access component in open access repositories.

The unused open access component represented an untapped potential for making journal articles openly accessible. In discussing the reasons for this circumstance, two obstacles became apparent: (1) the challenge of identifying authors who have published with Alliance Licence publishers, and (2) identifying individual articles that qualify for Open Access publication. Both tasks were described by libraries as very resource-intensive.

3 | Implementation of DeepGreen

Against this background, a consortium was formed in Germany to develop automated processes for implementing the open access components of the Alliance Licences, and later for other types of agreements. The aim was to create automated procedures that would allow journal articles to be automatically delivered from publishers to repositories based on licensing terms. The idea was to reduce the workload for libraries by establishing a national data hub that acts as an intermediary, facilitating the distribution of articles from publishers to open access repositories, thus increasing the number of articles stored in repositories. These considerations were also driven by similar developments in other countries at that time. Schmidt and Shearer 2012 provide an insightful overview of the activities during this time, mentioning examples from Germany as well

as France and the UK, where open access was integrated into licensing practices. To promote dialogue between national initiatives, the Confederation of Open Access Repositories (COAR) established the “Open Access Agreements and Licenses Task Force” in 2012.

In 2015, a consortium named DeepGreen was formed in Germany, consisting of libraries, information infrastructure services and research institutions. Their aim was to create a data hub with publishers to streamline and automate the distribution of articles to open access repositories. This involved negotiating contracts with publishers for open access components, in line with the implementation within the Alliance Licences.

An important aspect in designing an automated process was to ensure a legally secure procedure. The goal was to include only those articles in the process that, according to the Alliance Licences or another legal agreement—such as later with the DEAL agreements—could be made accessible in an open access repository. For this purpose, the Electronic Journals Library (EZB) was incorporated into the design of the DeepGreen service. The EZB is a comprehensive database used by most academic libraries in Germany to manage licensing conditions and access rights for journals. Researchers can use this database to check which journals have been licensed by which libraries (Hutzler and Weisheit 2015).

The establishment of the DeepGreen data hub was guided by the following objectives:

1. Identify the necessary contractual prerequisites between the DeepGreen data hub and a publisher, leveraging information from the EZB.
2. Account for the specific contractual conditions of the open access components.
3. Consider the requirements for using specific types of repositories and the status of the articles.
4. Ensure the availability of high-quality metadata for the publications.

In Germany, in addition to the Gold Open Access Agreements, the Alliance Licences, some National Licences, FID Licences², and transformative agreements such as DEAL meet the above requirements and allow eligible institutions to authorise DeepGreen for machine processing and thus to efficiently exercise their rights.

The conception and realisation of the data hub DeepGreen were carried out by a consortium of the following institutions from 2016 to 2020: Cooperative Library Network Berlin-Brandenburg (KOBV), Bavarian State Library (BSB), Library Network of Bavaria (BVB), University Library of Friedrich-Alexander University Erlangen-Nürnberg (FAU), Helmholtz Open Science Office of the Helmholtz Association, and University Library of the Technical University Berlin.

The core idea of the project was as follows: DeepGreen aims to provide an automated solution to assist institutions and researchers in exercising their open access rights more easily. In its

early stage the project envisioned primarily the automated distribution of publications available via the Alliance Licences, but gradually it also began to include other types of licences, such as transformative agreements like the DEAL contracts. The project was funded by the German Research Foundation (DFG) in two funding phases. The work carried out in these two phases is presented in the following section.

3.1 | DeepGreen 1 (2016–2017)

During the first phase of the project (Koch et al. 2016), initial discussions were held with the 14 Alliance Licence publishers to determine the requirements for a potential metadata schema for the technical platform (Becker et al. 2016). After considering whether to completely develop the required technical infrastructure in-house or to reuse existing software from similar projects, the decision was finally made to use the software of the Publications Event Router, released openly on GitHub in 2015 by Jisc from the UK (Jisc n.d.). The use of this software by the project was not planned during the conceptual phase. At that time, JISC's initiative to develop software that distributes content to repositories based on the SWORD protocol was not yet known.

Based on this open source software, the prototype of the DeepGreen data hub was developed and implemented in the first phase of the project. Agreements were made with the first publishers. At the end of the first phase of the project, the data hub prototype was successfully tested with the repositories of the partner institutions and presented to the scholarly communications community.

3.2 | DeepGreen 2 (2018–2020)

In 2018, the DFG approved a second grant for the project, allowing DeepGreen to embark on an additional two-year funding phase (Koch et al. 2018). This second phase of the project had two main objectives. Firstly, DeepGreen was to

be established as a national service, with a focus on Alliance Licences, and a sustainable business and operating model. Additionally, the project consortium aimed to explore other suitable licence models for DeepGreen, such as the licences currently being negotiated for specialist information services (FID licences) or various consortium licences that do not explicitly include a green open access component. The potential of DEAL contracts as an approach for DeepGreen was also to be assessed. Efforts were made to recruit more publishers for cooperation. The project planned to serve not only institutional repositories but also subject-specific repositories. Moreover, enabling the integration of gold open access publishers was a key goal. Alongside these objectives, continuous consolidation and further development of the DeepGreen data hub were undertaken.

4 | DeepGreen as a National Service

At the end of the second project phase, DeepGreen was successfully established as a national service. In the period between 2020 and 2023 DeepGreen distributed a total number of 163.750 articles to the participating repositories. The year 2019 is not included in the calculation, because the numbers are unreliable due to delivery errors during the testing process. A detailed annual overview of the number of distributed articles is presented in Figure 1. The figure also reflects the growing number of publishers involved as partners in DeepGreen.³

As of December 2024, there are 84 institutional repositories, 6 subject-specific repositories and 14 publishers cooperating with DeepGreen. Negotiations with other publishers about potential cooperations are ongoing. At the end of 2023 two new national DEAL contracts were signed with Elsevier and Wiley. A similar new DEAL contract with Springer Nature was signed in November 2023. It is noteworthy that DeepGreen is defined as an official partner for the distribution of journal articles in both contracts. The integration of DeepGreen within the DEAL agreements has given the service further momentum, as DeepGreen

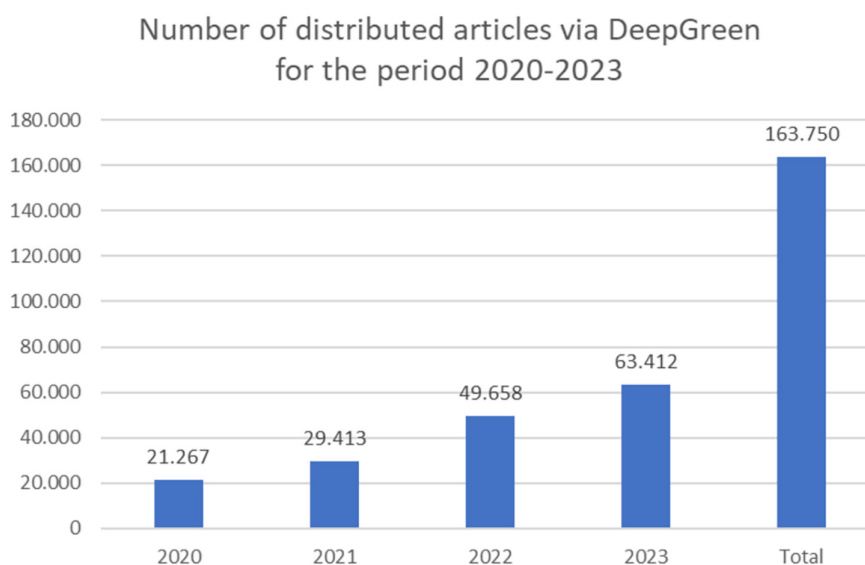
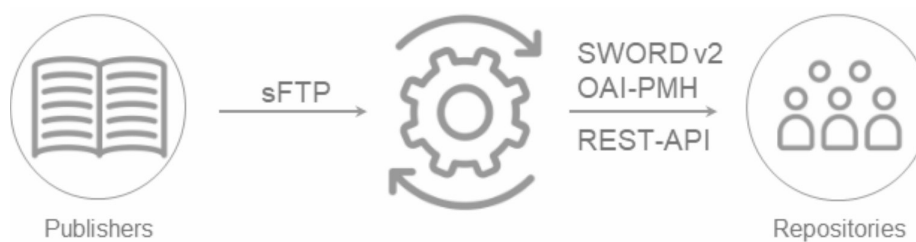


FIGURE 1 | Number of distributed articles for the period 2020–2023.

TABLE 1 | Participating publishers.

	Publisher	Contents	Recipients	Embargo (in months)	Delivery
1	ACS	Gold open access from gold and hybrid open access journals	All repositories	0	Monthly
2	BMJ	Transformation contract, gold open access journals.	All repositories	0	Daily
3	Copernicus	Gold open access journals	All repositories	0	Daily
4	De Gruyter	Alliance licences LLH1 and LLH2, from 2022 Transformation Agreement.	Only licence participants	0	Daily
5	Frontiers	Entire portfolio	All repositories	0	Daily
6	Future Science Group	FID Licence Pharmacy 2015–2021	Licence participants	0	Weekly
7	Hogrefe	Gold open access content Transformation contract	Institutional repositories, selected subject repositories	0	No fixed
8	IOP	Gold open access	Institutional repositories	0	—
9	Karger	Transformation contract, Alliance Licence, National Licence, Gold open access Journals.	Licence participants, all repositories for CC licence content	12	Weekly
10	MDPI	Entire portfolio	All repositories	0	Monthly
11	RSC	Gold open access from gold and hybrid open access journals	All repositories	0	Daily
12	SAGE	Transformation contract, Alliance licence, National licence.	Licence participants, selected subject repositories	12	Daily
13	Springer Nature	Transformation contract	All repositories, selected subject repositories	0	Tbd.
14	Wiley	Transformation contract	DEAL participants, selected subject repositories	0	Quarterly

**FIGURE 2** | DeepGreen system architecture.

now distributes content from national agreements beyond the Alliance Licences. Consequently, the open access content from the DEAL contracts will create a high demand for automated distribution on the part of the repositories in 2024. An overview of the participating publishers can be found in Table 1.

4.1 | Functionality

From a technical point of view, DeepGreen is designed as a data hub that processes data deliveries from publishers and matches them with eligible repositories according to information

contained in licence agreements. The data packages arrive via sFTP in the NISO JATS format, a common metadata standard for journal articles. The repositories may retrieve their assigned data packages via OAI-PMH, REST-API or SWORD protocols (see Figure 2). Accounting for the fact that repositories use a variety of software solutions, DeepGreen may format the JATS data in METS/MODS or OPUS 4-XML accordingly. This step is only necessary for data deliveries via SWORD.

The routing process (see Figure 3) in which the journal articles are matched to the eligible repositories involves three data flows:

1. articles and metadata from the publishers
2. affiliation information from the participant institutions and licence information from the publishers or the Electronic Journals Library (EZB)
3. articles and metadata to the repositories

The basis for the cooperation between a publisher and DeepGreen is a contract that defines a series of journals. This information is stored in a licence file that is combined with a separate list of participants who have obtained licences for the given content. Managing these licence files is particularly resource-intensive because they require constant updating and maintenance. This is due to fluctuating subscriptions on the part of institutions and changing journal portfolios on the part of publishers. After the contract is signed, the publisher delivers the publications via sFTP to DeepGreen in a ZIP file containing the metadata and the PDF files of the articles. This data delivery is then matched against the ISSNs and the years of publication contained in the licence file and the affiliation variants of the institutions in a separate affiliation file managed by the repositories in their user

accounts. In the instance of positive matches, the repositories receive routing notifications about article deliveries that they may then transfer into their repositories. The original idea behind DeepGreen, hinted at in the project's name, was to utilise the green open access rights of consortial licence agreements to the full extent, as described above. This type of content is still available and part of the project but it has been outgrown by gold open access content in terms of quantity, especially since the arrival of the DEAL contracts in Germany. From a technical perspective, managing licence files in the DeepGreen router is less time-consuming for gold open access content, as it usually does not require pre-defined subscriber lists to be formatted and maintained. Repositories can conveniently select Gold licences at will using a built-in licence filter in the user interface (see Figure 4).

Nevertheless, there is a strong demand for green open access content from repositories, and the project continues to pursue this open access path in parallel because it offers large amounts of potential content that would otherwise go untapped. This need becomes evident in networking events that promote dialogue with the community of open access repositories in Germany. In user workshops, the DeepGreen service informs about its work and explores the needs of libraries for further development of DeepGreen.

Currently, there are six subject repositories cooperating with DeepGreen. Five of them belong to the network of the 40 DFG-funded Fachinformationsdienste, which are specialised information services. These services provide specialised research literature across Germany and a number of them operate subject specific repositories (Deutsche Forschungsgemeinschaft 2024). The licence management for these subject repositories requires

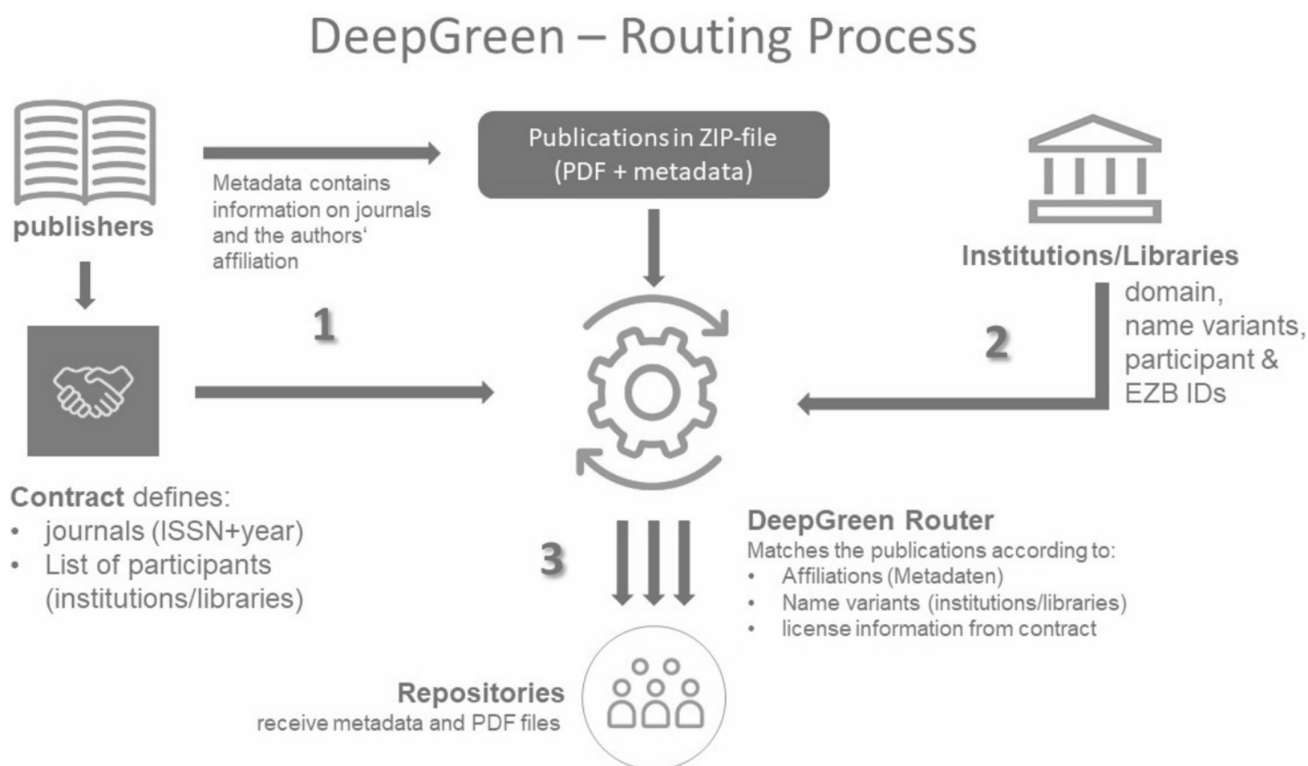


FIGURE 3 | DeepGreen routing process.

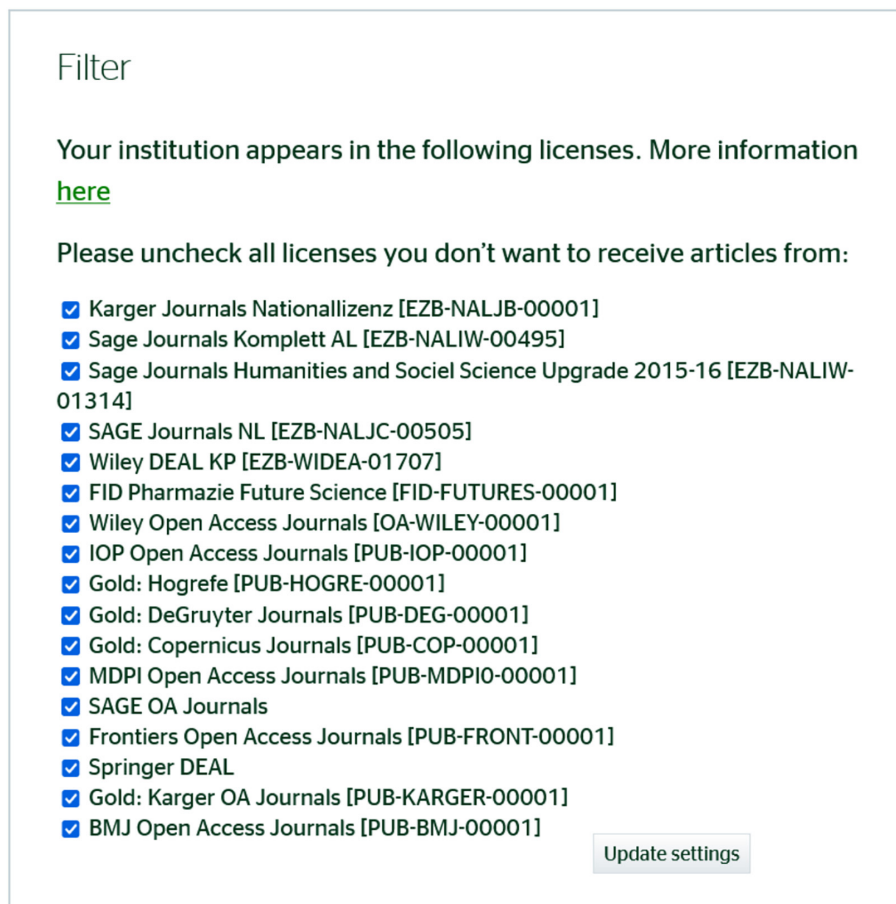


FIGURE 4 | Licence filter in the DeepGreen user interface.

a very different approach, since the routing is not possible via institutional affiliations. Due to licensing issues, subject repositories are only allowed to receive open access content, which they select from a list of journals. This customised list is then deposited in their user accounts and forms the basis for the routing of the content to the subject repositories.

The fact that DeepGreen is, to some extent, an enhanced version of the Jisc Publications Router (extended with a licence management functionality) presents some technical challenges that require continuous improvement. This process is accompanied by constant feedback loops from the repositories. Regular user consultation sessions provide an opportunity to suggest new features and improve existing processes.

Since 2020, DeepGreen has been collaborating with Cottage Labs, who are also further developing the Jisc Publications Router. Cottage Labs has since taken on the technical development and maintenance of the software. This collaboration enables cooperative efforts to address general challenges related to the Data Hub and strengthens the international partnership between the projects.

The metadata transformation process still poses challenges for DeepGreen. The root of these challenges lies in the structure of the NISO JATS format, in which full-text articles and their metadata are provided by publishers. The scope of the JATS format is very broad and allows for high variability. Before delivery to

the repositories via SWORD, the publishers' data packages must be transformed into METSMODS or OPUS 4-XML formats, depending on the repository software. This step is still a source of errors that need to be continuously eliminated through feedback from the repositories.

5 | Perspective

With the completion of the second project phase, DeepGreen entered a pilot phase in June 2021, which continues to this day. Currently the project is operated and financed through the funds of three partner institutions: The library network Kooperativer Bibliotheksverbund Berlin-Brandenburg (KOBV) (responsible for the development and the technical infrastructure), the Bayerische Staatsbibliothek (responsible for publisher cooperation and licensing) and the University Library of the Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU) (as technical testing partner). The three partners are working closely together to develop a sustainable operating model for the service.

During the last years, DeepGreen has been increasingly recognised as a relevant component of the open access infrastructure in Germany. In May 2023, for example, a case study on open access infrastructures and services was conducted on behalf of the Alliance of Science Organisations. In this study, DeepGreen was selected as one of 10 projects to be surveyed (Biela et al. 2023). This study describes the importance of national and

international services for the advancement of open access and assigns DeepGreen a role within the open access ecosystem. As another sign of recognition, DeepGreen received the Enter Award for open access initiatives in Germany in July 2024 in the category infrastructure (Boltze 2024).

DeepGreen was also explicitly included in the text of the DEAL contract with Elsevier as a service for the distribution of publications. Since the summer of 2024, DeepGreen has been in discussions with Elsevier regarding the implementation of data distribution for articles covered under the DEAL-Elsevier agreement. The same applies to the second Wiley (2024–2028) and Springer Nature (2024–2028) DEAL contracts. As a consequence, the amount of OA content awaiting distribution is steadily rising. As a service that offers automated distribution of OA content, DeepGreen is especially attractive for institutional repositories and institutional research information systems, as it minimises labour resources and facilitates reporting on the publishing output. Furthermore, it enables a transfer of OA content into publicly owned institutional infrastructures that guarantee sustainable access and redundant storage.

DeepGreen will continue collaborating with libraries and publishers to improve information provision, enhance the visibility of articles, and specifically support libraries in information management. Standardised and machine-readable organisational and funding information presents significant potential for DeepGreen. With the help of persistent identifiers, not only for articles and authors but also for institutions and funders, the automated assignment of articles to academic institutions via the data hub will become even easier in the future. DeepGreen will continue to promote cooperation with all partners in the information supply ecosystem to further professionalise information management and foster open access to scholarly articles.

Author Contributions

Tomasz Stompor and Heinz Pampel wrote the first draft of the manuscript. Julia Boltze-Fütterer and Beate Rusch provided critical feedback and helped shape the manuscript. All authors contributed to the final writing and revision of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

- ¹ Analysis of journal articles in Germany for the last 5 years (2020–2024) based on OpenAlex, Unpaywall, and the journal lists used in the German Open Access Monitor.
- ² A FID licence (Fachinformationsdienst licence) allows academic libraries and researchers in Germany to access specialised content for specific disciplines.
- ³ In 2023 DeepGreen reached an agreement with Springer Nature to distribute articles from their first DEAL contract, although the publisher was not a formal participant in the project. In May 2023, 24,047 articles were processed and 35,015 were delivered to the participating repositories. The latter number is noticeably larger because of multiple deliveries of the same article to different repositories. This is due to the fact that authors have multiple institutional affiliations and that articles are also delivered to subject repositories.

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