Environmental impact assessment reports in Wikidata and a Wikibase

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Abstract
Environmental impact assessment (EIA) is a required process for projects in many countries, which results in the preparation and publication of a detailed report. Such EIA reports describe impacts on, e.g., humans and the environment. In this paper, we describe our efforts in modeling the metadata of EIA reports and their description of environmental impacts and mitigations with Wikidata and Wikibase. We show that it is possible to record the bibliographic metadata of Danish EIA reports and in doing so link it to the rest of the Wikidata knowledge graph, allowing multilingual search. With our dedicated instance of a Wikibase, we show how EIA reports and their associated projects along with activities, impacts, recipients, and mitigations can be represented and how we can show aggregated views of the data based on SPARQL templates so that users can explore the data and make efficient use of it.

Keywords
Environmental impact assessment, Wikibase, Wikidata

1. Introduction

When a new project is planned, e.g., a solar farm, a motorway, or an overhead power line, an environmental impact assessment (EIA) may be required. In the Europe Union, rules about the EIA process are described in Directive 2011/92/EU of the European Parliament[1] and its amendments in Directive 2014/52/EU.[2] The directive is mirrored in the Danish *Miljøvurderingslov*.[3] Some guidance for writing an EIA report is available [1]. For instance, the directive states that significant effects should be identified, described, and assessed on factors such as population, human health, biodiversity, and cultural heritage. The key result of an EIA process is an EIA report that describe the impact the project will have on the environment. Despite the availability of guidelines describing the scope of the content of such a report, it may be formatted in a variety of ways.

Digitalization of the various parts of the environmental assessment process is in place, ongoing, or upcoming in some countries throughout the world [2]. In Denmark, reports are currently published as PDF files. Curation, indexing, and analysis have been lacking and a public central repository of EIA reports did not exist, which inspired the work described in this paper.

The project *Digitally supported Environmental Assessment for Sustainable Development Goals* (DREAMS)[4] focuses on EIA and Strategic Environmental Assessment (SEA) of plans and programs. It aims to establish a public collection of Danish EIA and SEA reports. *Danmarks Miljøportal*[5] provides a portal for

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[1]http://data.europa.eu/eli/dir/2011/92/oj.
[2]http://data.europa.eu/eli/dir/2014/52/oj.
[3]The most recent change in the Danish law is from March 2023: https://www.retsinformation.dk/eli/lta/2023/4.
[4]https://dreamsproject.dk.
[5]https://www.miljoeportal.dk/.

environmental data, and within the DREAMS project, the EIA reports have now been stored as PDF files and made available.

Part of the DREAMS project is to establish a system capturing the specific environmental effects and mitigations that are described in the EIA reports — an effect assessment tool we refer to as *CAUSA*. The relations for environmental effects and mitigations are often not just a simple triple relation, but may be of higher order and form a small chain or graph. The project also explores how the Sustainable Development Goals (SDG) can be integrated into EIA processes [3] and sets out to establish links between impacts identified through the EIA process and the SDGs. We have annotated a set of EIA reports with the cloud service tagtog[6] which can handle PDF files and link relations between annotated text pieces [4]. The annotation can be exported as JSON and we have further converted it to a spreadsheet format.

Wikidata [5] is a knowledge base closely linked to Wikipedia. With the Wikicite initiative, see, e.g., [6], metadata about publications have been added to Wikidata so that a considerable and growing part of Wikidata is now publications. At Wikicite.org, the estimated fraction in Wikidata of items about publications grew to 42% in 2022, corresponding to almost 42 million items.[7] As of 2023, over 38 million Wikidata items are tagged as scholarly articles.[8]

Wikidata is continuously converted to a Semantic Web representation that is downloadable as well as query-able through the Wikidata Query Service (WDQS) using the SPARQL query language.[9] The conversion to a Semantic Web representation also entails a complex structure with qualifiers and references [7].

Various tools have taken advantage of the data in Wikidata available through WDQS. One such tool is Scholia which was originally designed to display the metadata of scientific publications [8]. It has now been extended to display information about, e.g., taxa, biological pathways, and chemicals, see, e.g., [9]. Currently, Scholia does not support other languages than English, other Wikibases with other SPARQL endpoints than the WDQS, and other specialized data that would not be appropriate to enter into Wikidata. In our case, the issues are an obstacle as we would like to support Danish and specialized data from EIA reports.

Wikibase[10] is the software that runs Wikidata. Knowledge workers may download the software and run it locally or use a cloud service where Wikibase is set up. One cloud Wikibase service provider is Wikimedia Deutschland which provides its service from https://wikibase.cloud. Wikibase instances may be used by organizations to manage their data — either public or private.

The Wikibase set up at Wikibase.cloud is bundled together with a triple store, a Blazegraph instance, corresponding to the Wikidata Query Service for Wikidata. Data from the Wikibase are continually piped into the triple store so the data in a Wikibase.cloud Wikibase instance is available via SPARQL queries to the endpoint.

Compared to Wikidata the curation in (another) Wikibase can be tailored to the data of the organization with specialized properties and items that would not usually appear in Wikidata. Furthermore, editing may be restricted to those with authorization.

2. Contributions

In this paper, we describe our efforts to model EIA reports within Wikidata and Wikibase as well as supporting ontologies and modeling the environmental effects with what we call an *effect pattern*. We also present a new method for displaying the information from the wiki via SPARQL queries, the

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[6]https://www.tagtog.com/.

[7]http://wikicite.org/statistics.html

[8]https://scholia.toolforge.org/statistics

[9]https://query.wikidata.org/

[10]https://wikiba.se

Wikibase pages, and a simple webpage with Javascript. Our efforts are available in the DREAMS Wiki, which is a Wikibase.cloud instance at https://dreams.wikibase.cloud/.

3. Related research

Garrido and Requena described an ontology for environmental impact assessment [10]. The ontology features classes such as Impact, VisualImpact, NoiseImpact, TrafficChanges, and Amphibian. An OWL file is available[11] and the authors also described a web application to display the ontology.

The SuperPattern Ontology has been suggested for the representation of individual scientific claims [11]. This ontology is a scheme with five slots: classes for context, subject, qualifier, relation, and object. The ontology has been used to express a scientific claim such as "strong static magnetic field generally affects cell cortex in the context of dejellied fertilizable stage VI Xenopus laevis oocyte" [12].

Wikidata can represent cause and effect between entities with the *has effect* (P1542) and *has cause* (P828) properties. This data and the textual data in Wikipedia has been used to build a knowledge graph of events and consequences [13]. Articles describe using Wikibase, e.g., for a food composition knowledge base [14], an enslavement resource [15], and for biological collection information [16].

4. Ontologies

We established several ontologies on the DREAMS Wiki. The items of these ontologies are typically linked hierarchically with a *subclass of* property. The ontologies we consider are project types, report types, significance types, taxa, effects, and SDGs.

An ontology of **project types** was created from the itemized hierarchy of the Danish environment assessment law. For instance, the project type "elektricitetstransportprojekt (bilag 2, 3c)" refers to the project description of the electricity transport in appendix 2, item 3.c of the Danish law. The corresponding item in Directive 2011/92/EU is part of annex II, item 3.b. Each report links to one or more project types. The project types are linked together with *subclass of* with the *project* item as the top entity. Some entities do not correspond to entities in the law, e.g., (the generic) *electricity transport project* aggregates two items from different appendixes in the law.

Our **taxa** ontology records species and other taxa, but also some aggregated entities, such as "annex IV species or species group", which is an aggregated group of protected species and species groups. A small ontology for **report types** was created with just four entities: report, environment assessment report, environmental report, and combined environmental and environmental assessment report as the only entities. Another small ontology records the **significance types**, where instances are, e.g., "not significant and negative impact" or "significant and positive impact". We create an ontology of possible **effects**. Items in this ontology are, for example, "wind turbine noise", subclass of "noise", subclass of "physical/environmental determinant", subclass of "human health impact", finally subclass of "impact". An ontology for **SDGs** is set up for the 17 SDG goals and a selection of the corresponding targets (as a subclass to an SDG goal). Effects of an activity may link to one or more targets. Identifying relevant SDG targets was based on the SDG targets provided in [17].

Our ontologies in the wiki were set up from information from experts recorded in tabular format in documents and gradually expanded and modified based on annotated EIA reports. We record possible aliases for ontology entities in the DREAMS Wiki, e.g., noise, which in Danish is "støj", would have aliases such as "støjpåvirkning", "støjen", "Støj" and "støjbidrag" reflecting inflections and compounds. We use these aliases for semi-automated entity linking.

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[11]https://github.com/julian-garrido/EAonto/blob/master/eia.owl

Property	DW	WD	Example
class	P2	P31	environmental impact assessment report
title	P1	P1476	"Energiparken ved Vennerslund Energi- og Naturpark"
main topic	—	P921	Vennerslund, wind farm, PV system
country of origin	—	P495	Denmark
language	P11	P407	Danish
publication date	P6	P577	"2020"
number of pages	P27	P1104	"441"
project type	P16	—	photovoltaic system project, project with wind turbine
Miljørapporter ID	P40	P10930	377355e9-9db6-4163-aad0-cf0e5a0004e5
Wikidata ID	P3	—	Q112506586
citations	—	P2860	Dansk pattedyrs atlas, Behavior of Scandinavian Bats during …

Table 1
Some of the document-level metadata for environmental impact assessment reports. Property identifiers are for DW: DREAMS Wiki and WD: Wikidata. The example is from "Energiparken ved Vennerslund Energi- og Naturpark. Miljørapport og Miljøkonsekvensrapport" at https://www.wikidata.org/wiki/Q112506586 and https://dreams.wikibase.cloud/wiki/Item:Q406

5. Describing EIA reports

We represent metadata about an EIA report on a page in the DREAMS Wiki, see Table 1. The properties we consider are, e.g., *instance of* for the class of the report, title, author, language (always Danish), publication date, project type, and an identifier for the report in *Danmarks Miljøportal*. Some of these property values are set up from information obtained for entry in *Danmarks Miljøportal* while others have been manually entered — optionally and not systematically. We have currently recorded 632 reports in the DREAMS Wiki.[12]

We also represent the EIA report in Wikidata with properties such as *instance of*, title, main subject, country of origin (always Denmark), language (always Danish), date of publication, number of pages, and *Miljørapporter File ID* that links to the report at *Danmarks Miljøportal*. The DREAMS Wiki has a link to the report entity in Wikidata. Some EIA reports contain references — often a highly diverse set of references, where the target of the reference may include databases, various reports, scholarly articles, and books. We have added some references to Wikidata.

Geographic entities described in a report might not yet exist, e.g., "Veddum Kær" (Veddum marsh) is not (yet) found in Wikidata. Other resources, such as OpenStreetMap or Geonames also return no results. Reports may describe projects that are pointlike (e.g., small plants), lines (e.g., railway tracks), or areas (e.g., wind turbine park). Projects may also detail multiple alternative solutions for alternative routes, e.g., alternative routes for a new railway line.

Document identifiers are not commonly used in Danish EIA reports. When the EIA reports are represented in *Danmarks Miljøportal* they are each assigned a unique identifier and we can use that. Both Wikidata and the DREAMS Wiki each as a property for that identifier.

6. Describing environmental effects

Inspired by the SuperPattern Ontology, we developed a scheme for the DREAMS Wiki to represent the individual environmental effect relations described in an EIA report. Our initial experiments defined a scheme with subject class, object class, context class, and relation type properties closely following

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[12]SPARQL query to the DREAMS Wiki Query Service: https://tinyurl.com/2jygv2o5

Property	Description	Example
instance of	item class	(always) effect pattern (Q263)
described with	report entity	Energiparken ved Vennerslund Energi- og Naturpark (Q406)
subject text	text with effector	"Solcellepanelerne"
subject class	effector entity	photovoltaic system (Q681)
object text	text	"lysrefleksioner"
object class	entity	light impact (Q80)
recipient text	text	"naboer"
recipient class	entity	neighbor (Q949)
degree of impact text	text	
degree of impact	degree of impact entity	not significant and negative impact (Q852)
mitigation text	text	"beplantningsbælter"
mitigation class	entity	vegetation zone (Q229)
project type	project type entity	photovoltaic system project (Q5580)
project phase	project phase entity	operational phase (Q98)
quote	paragraph in PDF	"Ved de øvrige beboelser, som ligger øst for sol-celleanlægget, vil der potentielt …"
page	page number in PDF	"101"
pattern number	number used during tagtog input	"3"

Table 2

Effect pattern. The example column is from a photovoltaic system project recorded in our DREAMS Wiki at https://dreams.wikibase.cloud/wiki/Item:Q922. The Q-identifiers reference the entity identifiers on the wiki, while the quotation marks indicate Danish text annotated in the report and represented in the wiki.

the SuperPattern Ontology scheme. However, to incorporate recipient and mitigation in a chain of environmental effects, we extended the scheme with recipient and mitigation classes and omitted the context class. Furthermore, we omit the relation type as the relationship between subject, object, recipient and mitigation are implicitly given, e.g., the relation from the subject would in most cases correspond to "affects" in the SuperPattern Ontology scheme. We call our scheme an *effect pattern*. This effect pattern also contains an identifier (the Q-identifier of the Wikibase page) a link to the entity of the EIA report, a quote from the PDF, page, an indication of the significance of the effect, and link to the entity of the project phase class (e.g., planning, construction, operation and/or decommissioning). The four essential parts of the environmental effect chain are subject (usually a physical construction or an activity), object (also called impact), recipient, and mitigation. These four parts may be represented with both a string and an entity link: From the manual annotation extracted from tagtog, we get the string. Using the ontology of effects we manually or semi-automatically—with the aliases presented in the wiki—make the entity linking for the string to the entities.

Mitigation in one effect pattern can be a subject in another effect pattern, e.g., a road (subject) causes noise (object/impact) which affects neighbors (recipient) and can be mitigated by a noise wall (mitigation). The noise wall (subject in another effect pattern), in turn, causes a visual impact (object) that affects neighbors (recipient).

Table 2 displays an example of an effect pattern from an EIA report about a specific photovoltaic system and wind turbine project. The effect pattern represents that the report describes that the specific planned photovoltaic system creates a light impact (reflections) that affects the neighbors with a "not significant and negative impact". Any effect is mitigated with a vegetation zone and the effect is present

Vis All linjer   Søg søg..

Mønster	Rapport	Subjekt	Påvirkning	Recipient	Signifikans	Afbødning	Citat	Projektfase	Link
🔍	Energiparken ved Vennerslund Energi- og Naturpark	vindmøller (vindmølle)	skyggekast (skyggegene)	naboer (nabo)	🙂 ikke væsentlig og negativ påvirkning	'skyggestop' (vindmøllestop)	Der er beregnet et reelt skyggekast i projekt-forslaget med Vestas-møller på 23 timer og 48 minutter pr år ved nabo O (Froensevej 24), som udsættes for den største påvirkning I alt vil 16 naboeboelser i det åbne land (herunder to boliger ved henholdsvis Vennerslundsvej 16-18 og ved Vennerslundsvej 22-24) påføres mere end 10 timers skyggekast pr år ifølge beregningen	driftsfase	100 ↗
🔍	Energiparken ved Vennerslund Energi- og Naturpark	vindmøller (vindmølle)	støj (støj)	beboelser (nabo)	🙂 ikke væsentlig og negativ påvirkning	støjdæmpning ()	at ingen nabobeboelser i det åbne land bliver udsat for mere end 20 dB(A) lavfrekvent støj indendørs ved vindhastigheder på 6 og 8 m/s, og støjgrænsen vil ligeledes være overholdt indendørs i afgrænsede landsbyer eller tilsvarende områder, som anvendes til eller er udlagt til støjfølsom arealanvendelse	driftsfase	92 ↗
🔍	Solcellepark øst for Bur	Øget aktivitet (solcelleanlæg)	forstyrre (forstyrrelse)	birkemus (birkemus)	🙂 ikke væsentlig og negativ påvirkning	lokal rodfræsning, bevaring af urte- og græsvegetation og begrænsning af maskinkørsel ()	Øget aktivitet i området kan være forstyrrende for eventuelle birkemus i området. Det ønskes i projektet at opsætte solceller på to potentielle levesteder for birkemus.	anlægsfase	98 ↗
🔍	MILJØVURDERING BELYSNING AF DE MILJØMÆSSIGE KONSEKVENSER VED OPSTILLING AF SOLCELLEANLÆG VED KÆRAGERHOLMVEJ,AALBORG KOMMUNE	anlægsfasen (anlægsarbejde)	støvgener (støv)	naboer (befolkning)	🙂 ikke væsentlig og negativ påvirkning	i tørre perioder, kan der foretages støvbegrænsende foranstaltninger som vanding (vanding)	Projektet kan medføre mindre støvgener i anlægsfasen, men disse anses dog at være ubetydelige. Hvis der bliver tale om store støvgener i tørre perioder, kan der foretages støvbegrænsende foranstaltninger som vanding.	anlægsfase	105 ↗
🔍	Energiparken ved Vennerslund Energi- og Naturpark	Solcellepanelerne (solcelleanlæg)	lysrefleksioner (lyspåvirkning)	naboer (nabo)	🙂 ikke væsentlig og negativ påvirkning	beplantningsbælter (beplantningsbælte)	Ved de øvrige beboelser, som ligger øst for solcelleanlægget, vil der potentielt kunne forekomme reflekser om aftenen. I forhold til trafikanter på Sydmotorvejen vil eventuelle lysrefleksioner kunne opleves som kortvarige blink, når man passerer forbi solcelleanlægget.	driftsfase	101 ↗
🔍	Solcellepark øst for Bur	afskærmende beplantning (beplantning)	reducere reflektioner (lyspåvirkning)	naboer (beboelse)	🙂 ikke væsentlig og negativ påvirkning	beplantning (beplantning)	Idet projektet indebærer yderligere forholdsregler om etablering af afskærmende beplantning og anvendelse af antirefleksbehandlede moduler, vurderes det, at påvirkningen af naboer i forhold til refleksioner vil være lille.	driftsfase	76 ↗
🔍	MILJØVURDERING BELYSNING AF DE MILJØMÆSSIGE KONSEKVENSER VED OPSTILLING AF SOLCELLEANLÆG VED KÆRAGERHOLMVEJ,AALBORG KOMMUNE	bygningen nedrives (nedrivning)	påvirke levested (habitat/naturtype)	flagermus (flagermus)	🙂/🔴 ? ukendt og negativ påvirkning	Arbejdet vil desuden blive foretaget uden for flagermusenes yngle- eller dvaleperioder ()	Hvis bygningen nedrives, vil nedrivningen efter tilladelse fra Miljøstyrelsen blive foretaget uden hensyntagen til eventuelle forekomster af flagermus f.eks. ved forudgående udslusning af flagermus eller andre tiltag i samarbejde med den lokale vildtkonsulent, der kan sikre, at der ikke forekommer beskadigelse eller tab af individer af flagermus.	anlægsfase	56 ↗
🔍	Solenergianlæg ved Bjerndrup	opsætning af solcellepaneler (anlægsarbejde)	spildes olie (oliespild)	grundvand (grundvand)	🙂 ikke væsentlig og negativ påvirkning	afgravning af øverste jordlag (afgravning)	Hvis der spildes olie eller lignende fra arbejdsmaskiner og køretøjer under opsæt- ning af solcellepanelerne kan der potentielt være risiko for forurening af grundvand.	anlægsfase	76 ↗

Figure 1: Screenshot from part of a page in a Web application displaying aggregated content from a Wikibase via SPARQL queries currently located at https://people.compute.dtu.dk/faan/dreams.html#projecttype/Q5580. The table displays effect patterns from photovoltaic system projects.

in the operational phase of the project. We have currently recorded 4303 effect patterns in the DREAMS Wiki.[13]

7. Displaying information from a wikibase

Inspired by Scholia, we created a system for displaying aggregated information from the DREAMS Wiki via SPARQL queries to the endpoint associated with our Wikibase. Instead of a Python/Flask-based approach like Scholia, we employ a serverless single-page Web application (SPA). We mirror Scholia's URL patterns to distinguish different aspects of the data. However, as an SPA we use the URI fragment to control which aspect and entity to show. For instance, the URI fragment `#report/Q153` will display entity Q153 (the report *Vindmøller ved Bjørnstrup*) as a report.

Whereas Scholia stores template SPARQL queries in separate Jinja2 files read during application startup, our present system uses pages on the wiki itself to store the templates with SPARQL queries. For instance, the wikipage *Dreams:report* defines a template for a report corresponding to a URI fragment regular expression pattern of `#report/Q\d+`, while *Dreams:report-index* corresponds to an index page for reports where the URI fragment pattern is `#report`. Likewise, the *Dreams:projecttype* wikipage defines the template for a project type. Other aspects we have defined on the wiki besides report and projecttype are pattern, effect, recipient, sdg, location, taxon, and author. The Web application can display faceted aspects. For instance, `#projecttype/Q264/report` will show reports for wind turbine projects. The DREAMS Wiki Query Service can perform federated SPARQL queries against the Wikidata Query service. We have used that to display "Related works from co-citations" from the citation information present in Wikidata.

When a user visits a new "page" on the SPA, the application reads the URI fragment, determines which template should be downloaded from the wiki, and then builds the HTML page from the

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[13]SPARQL query to the DREAMS Wiki Query Service: https://tinyurl.com/2kczebk3

template. Currently, the SPA recognizes wiki section headers and converts them to HTML headings and SPARQL queries embedded in a MediaWiki template. The SPARQL queries define a target entity that is interpolated with the entity identifier extracted from the URI fragment. The interpolated SPARQL queries are then sent off to the SPARQL endpoint of the wiki. The response from the endpoint is converted by Javascript to an HTML table like the method in Scholia. Like Scholia, we use jQuery and SpryMedia's DataTables library[14] to display the tables. The DataTables library can be configured, so we have switched the language to Danish. The SPARQL query service of the Wikibase.cloud has currently relatively slow response times when multiple simultaneous queries are issued, hence we have limited the number of tables shown on each page — usually to just one or two.

Figure 1 shows a screenshot from a page on the Web application displaying effect patterns for photovoltaic system projects. Each blue text fragment is linked to another page of the Web application, displaying other aspects of the data. The "Citat" (quote) column displays an extracted paragraph, where the effect pattern description originates. The last column in the table is a link to the PDF. With the page number for the quote, we are able to make a URL that will direct the browser to the page with the quote. With property path SPARQL queries we can aggregate information across the hierarchy of our ontologies, e.g., aggregation of all effect patterns from energy industry projects.

8. Discussion

Our manual annotation from tagtog did not correspond exactly to the scheme we settle on for representing the environmental effects in the wiki. Hence manual and time-consuming editing in the wiki has been necessary, particularly around information about recipients. Manual extraction of effect patterns from EIA reports does not scale. Machine learning and large language models could help with relationship extraction and entity linking. However, the integration of machine learning or language models with the Wikibase.cloud system is not straightforward.

The use of on-wiki SPARQL templates makes the development of the Web application for displaying the wiki content more agile. Adding a new aspect requires only the definition of a new wikipage with SPARQL queries, whereas a Flask/Jinja2 approach requires software developer involvement.

Although developed for Danish EIA reports, the approach should also work for environmental impact assessment in other countries. Wikibase is multilingual and some entities in the DREAMS Wiki have been translated from Danish to English. Future development could explore how to improve the response time of the display of data in the web application as well as ensuring that search and navigation within the Web application are efficient for the user.

Acknowledgments

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