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Overview of selected open-source solutions in the field of Sustainable Technology

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Abstract

This article is an overview of actively developed open code solutions in the field of Sustainable Technology. There are many open source solutions in the field of Sustainable Technology. The review covers selected solutions from the categories of Renewable Energy, Energy Storage, Energy Demand and Efficiency, Energy Systems, Emissions, Ecological Footprint, Biosphere, Natural Resources, and Business Development. Open source is a type of computer software in which the source code is made available under a license whereby the copyright owner grants users the rights to examine, change, and distribute the software under a free software license. There are many business models for open source software developers. In addition to free sharing, it can be sold and used commercially. By using the open source model, solutions can be improved day by day and volunteers help in the work, which makes the development of such projects faster, which can increase reliability and bring many additional benefits. It is important to keep an eye on the developments in the area of open source solutions in Sustainable Technology as they can be helpful for other research projects in this field.

Keywords: open source, renewable energy, energy storage, overview

Introduction

Open source code and sustainable technologies are concepts that can go hand in hand. In this paper, actively developed projects pursuing sustainable technology goals with open source code are presented. Project development based on the open source model has, until recently, been seen as something that does not deliver value [1], but projects such as Wikipedia have shown that there is a demand for solutions that are available to all without charge, with content that is quality.

Open source software is a type of computer software in which the source code is made available under a license whereby the copyright holder grants users the rights to change, and distribute the software under a free software license. [2]. There are sites like Github.com or Gitlab.com that allow people to share code and work together to further develop such a project. These services offer free publishing of code repositories, all projects presented here have code shared by one of the platforms.

Selected actively developed projects are presented, this means that the project should have changes in code at least from the last year. The projects presented are in the fields of: Renewable Energy, Energy Storage, Energy Demand and Efficiency, Energy Systems, Emissions, Ecological Footprint, Biosphere, Natural Resources, and Business Development.

Renewable Energy

The first open-code renewable energy solution is the Global Solar Energy Estimator. It is a solar energy simulation library for fast energy balancing calculations [3]. The library allows simulation of hourly energy production from wind and solar power plants located anywhere in the world which is demonstrated in the Renewables.ninja platform that uses the library [4]. Renewables.ninja is a collaboration between Stefan Pfenninger and Iain Staffell, who study the effects of integrating renewable technologies into energy systems. The tool was created to help make scientific quality energy and weather data available to the wider community.

Another solution is the PyWake library. It is an open code tool for simulating energy production, calculating flow fields and annual energy production, wind farms [5]. The library provides a unified interface to wind farm models. The library provides plugins, both commercial and free. The library was used to study the verification of induction zone models to estimate the annual energy production of wind farms [6]. The study allowed optimization, solution and is an example of the validity of developing tools in an open code format.

Wave Energy Converter SIMulator is a software for the simulation of wave energy converters. The software is developed as a library for MATLAB/SIMULINK using the Simscape Multibody dynamics solver [7]. The solution allows modeling of devices that consist of joints and bodies of mooring systems. This library is well known in the research world, many publications over the last five years have used this solution to perform experiments, one of which is an implementation of passive deflection that was developed, validated and studied using this tool [8].

Energy Storage

Developed by Sandia National Laboratories, the QuESt solution is a Python-based application suite for energy storage analysis and simulation [9]. The solution is designed to give users access to energy storage models and analyses used and developed by the organization that produced the package. The solution was designed so that one does not need to know the formulas behind the models, the whole can be used through a graphical interface in the program window. The library was used to determine the revenue opportunities for electric storage resources in the Southwest Power Pool Integrated market [10].

Electric cars that are powered by batteries have become popular in recent years. Optimizing energy storage in automotive batteries is also possible with open code solutions such as Emobpy. It is a Python tool that allows you to create time series for battery electric vehicles [11]. Four types of time series can be created: driving electricity consumption time series, vehicle mobility time series, grid electricity demand time series, and grid availability time series. Vehicle mobility time series are constructed based on mobility statistics. For the driving electricity consumption time series, vehicle characteristics can be selected from a database containing several real battery-electric vehicle models. The tool is presented in detail in the developed paper "An open tool for creating battery electric vehicle time series from empirical data, emobpy" [12].

The HyRAM suite is a comprehensive solution that interprets deterministic and probabilistic models to quantify accident scenarios, predict physical effects, and characterize the impact of hydrogen hazards on people and structures [13]. HyRAM combines generic equipment failure probabilities and probabilistic models of heat flux effects on people and structures with computationally and experimentally validated models of hydrogen release and flame physics. Authors Katrina M. Groth and Ethan S. Hecht presented details of how the tool works in a 2016 paper when the first version was published, and the solution has been continuously developed since then [14].

Energy Demand and Efficiency

EnergyPlus™ is a whole building energy simulation program. The software is used by architects, engineers, and researchers. The application is used to model water and energy consumption in buildings [15]. The tool is free due to its open code formula, however, a study has been done comparing the simulation results of this tool with a commercial tool, where a similar but licensed system was shown to perform more accurately [16].

Open Charge Map is a global registry of electric vehicle charging locations. The registry was founded in 2011 and aims to create a high quality, well-maintained open data set with as much coverage as possible. Data is entered manually as well as imported from open data sources (such as government registries and

charging networks with open data licenses). The system makes the data freely available to interested users including drivers as well as researchers and analysts. The solution runs in the openchargemap.org domain, and the code for which is available on the Github.com platform [17].

Global GHG emissions in the technology sector are equal to or greater than in the aviation industry, at about 3% for ICT and 2% for aviation, respectively. In the ICT sector, data centers consume about 1% of GHG emissions and global electricity consumption [18]. The Cloud Carbon Footprint project is a tool to estimate energy consumption in kilowatt hours and carbon emissions in metric tons of CO2e, from public cloud use [19]. The tool calculates consumption for three cloud providers, Amazon Web Services, Google Cloud, and Azure.

Energy Systems

Energy Sparks is an open source application that was designed to help schools improve their energy efficiency [20]. The application collects and presents gas and electricity consumption data clearly using a graphical interface in a web browser. The application demonstrates how turning off lights affects energy consumption. The schools using the solution are in the UK, but the open source code model allows the tool to be installed and configured as required. The project has been in active development for five years.

The EmonCMS application is a software for processing, recording and visualizing energy, temperature and other environmental data, which is part of the OpenEnergyMonitor project [21]. The solution is used in IoT projects. Research on the design of a low-cost energy consumption recorder for smart homes, uses this application for data acquisition [22].

An open platform called OpenNem is used to aggregate data from the National Electricity Market and make this collection available through visualization [23]. The project is available at the “opennem.org.au” domain address and aims to make the vast amount of public data on the National Electricity Market available to a wide audience. The code for the presented visualization, is available on the Github.com platform and the whole consists of several actively developed projects.

Emissions

The "Cdr-database" repository reports on carbon removal projects and technologies [24]. The project operates in the “carbonplan.org” domain address, as one of many open-code applications in the Carbon Plan project. The project aims to spread knowledge and data for carbon dioxide removal as well as climate change solutions. Each recorded report is visualized in a clear way so that the metrics of the implementation of a particular project are visible.

The Firecam tool is a browser-based application to diagnose and study regional differences in fire emissions from five global fire emissions inventories available to the public. [25]. A description of the problem that the application solves along with the development process is presented in a paper examining variance and uncertainty in global fire inventories in Indonesia [26].

Emissions Web API is used for easy access to satellite emissions data [27]. This project is aimed at developers who want to build their own services based on Copernicus satellite data, but don't want to work directly with huge amounts of scientific data, all available at the “emissions-api.org” domain address. The mission of the Emissions API is to provide easy access to this data without having to be an expert in satellite data analysis and without having to process terabytes of data yourself. The project provides examples and libraries to get you started quickly without having to be an expert in satellite data analysis.

Ecological Footprint

The OpenLCA tool is a Sustainability and Life Cycle Assessment software with the following features: fast and reliable calculations of Sustainability and/or Life Cycle Assessments, detailed insight into the results of calculations and analyses; or identification of key factors [28]. The tool is used in scientific studies of recent years and has allowed to demonstrate the harmfulness of ABS plastic over PLA polymer plastic [29].

OpenLitterMap is an open, interactive and accessible database of litter and plastic pollution around the world [30]. The system rewards users with coins for creating open litter data. Open data on the geospatial characteristics of litter provides a means to elicit and evaluate responses to plastic pollution. The solution currently runs as a web application in the “openlittermap.com” domain for all devices, and native mobile applications will likely be developed in the future as developers declare in the documentation.

A tool developed by WWF called the Global Plastic Navigator visualizes the most up-to-date data from current scientific publications on marine plastic pollution from mismanaged waste on land, to emissions from rivers into the oceans, to the concentration of plastic floating in the oceans [31]. The entire solution is available at the domain address “plasticnavigator.wwf.de”. The project aims to continuously show the most up-to-date data on plastic pollution. The main assumption of the project is that scientific publications will be scanned and new data will be updated regularly.

Biosphere

A solution designed by members of the ArcGIS Living Atlas of the World. The team is the SeaIce application, used to display monthly mean sea ice extent for the Arctic and Antarctic along with historical median extent [32]. The solution runs at livingatlas.arcgis.com/sea-ice/ address, and the website presents an application visualizing the ice extent. The application code is available on Github.com and is continuously updated since 2019.

Global Forest Watch is a dynamic online forest monitoring and alert system that enables people around the world to better manage regional forests [33]. The application runs on the ”globalforestwatch.org” domain addres and presents a map, when a location is selected, the application performs a forest cover analysis and presents results about tree loss at that exact location.

The TreeMapper tool enables site-specific data logging through mobile applications, for restoration initiatives [34]. The solution runs in the domain address “a.plant-for-the-planet.org”, and the code repository provides both an iOs and Android app.

Natural Resources

The code repository "OpenFoodFacts-Server" is the server software for Open Food Facts and Open Beauty Facts [35]. Open Food Facts is a database of food products with their ingredients, allergens, nutrition facts and all other interesting facts that we can find on product labels and runs on the domain address “world.openfoodfacts.org”. The platform collects information and data about food products from all over the world.

A solution called Karrot is a tool for citizen initiatives and groups of people who want to coordinate face-to-face activities on a local, voluntary and autonomous level [36]. The solution runs in the domain address “karrot.world” and is designed to build community and support more transparent, democratic and participatory group governance. Thanks to the open source code, the application can be used for private purposes also.

OpenFarm is a free and open database and web application for collecting knowledge about horticulture and agriculture [37]. The solution can be compared with Wikipedia on plant gardening. The main value in

the application is the gardening guide database. The solution runs in the domain address “openfarm.cc”, and the open code allows the solution to be configured in a private organization.

Business Development

The OpenTaps team's repository called "Open-climate-investing" is application code and data for analyzing and structuring portfolios for investing in global climate change solutions [38]. This project aims to make investing in climate change category solutions actionable. In addition to the software, publicly available datasets are being collected to identify relative value trades, optimize portfolios, and structure benchmarks for investing aligned with the climate change solutions market.

Conclusions

The solutions presented are just a small part of open-code projects supporting the field of Sustainability Technology. There are many more interesting projects that are specialized for purposes different than described. Platforms such as Github.com or Gitlab.com provide code search capabilities, allowing to find projects in a specific category for the field of Sustainability Technologies.

The cross-section presented, should attract interest by the open source model applied to the projects, as this will ensure that the code is actively managed. The tools presented should be considered in the world of science when designing solutions beyond the computer.

REFERENCES

Giorgio F. SIGNORINI, “Open Source And Sustainability: The Role Of University”, p. 4, Oct. 2019.

Giorgio F. SIGNORINI, “Open Source And Sustainability: The Role Of University”, p. 2, Oct. 2019.

Global Solar Energy Estimator., 07 December 2021., retrieved from https://github.com/renewables-ninja/gsee

RenewablesNinja., 07 December 2021., retrieved from https://www.renewables.ninja/about

Pywake., 07 December 2021., retrieved from https://topfarm.pages.windenergy.dtu.dk/PyWake/notebooks/Introduction.html

Meyer Forsting, Alexander & Rathmann, OS & van der Laan, M. Paul & Troldborg, N & Gribben, B & Hawkes, G & Branlard, Emmanuel. “Verification of induction zone models for wind farm annual energy production estimation. Journal of Physics Conference Series. 1934.”, May. 2021.

WEC-Sim., 07 December 2021., retrieved from http://wec-sim.github.io/WEC-Sim/master/index.html

Forbush, Dominic & Ruehl, Kelley & Ogden, David & van Rij, Jennifer & Yu, Yi-Hsiang & Tom, Nathan,. “Development and Validation of Passive Yaw in the Open-Source WEC-Sim”, 2020

SNL-Quest., 07 December 2021., retrieved from https://github.com/snl-quest/snl-quest

Concepcion, Ricky & Wilches-Bernal, Felipe & Byrne, Raymond., Revenue Opportunities for Electric Storage Resources in the Southwest Power Pool Integrated Marketplace., 2019, p. 1-5.

Emobpy., 07 December 2021., retrieved from https://gitlab.com/diw-evu/emobpy/emobpy

Gaete Morales, Carlos & Kramer, Hendrik & Schill, Wolf-Peter & Zerrahn, Alexander., “An open tool for creating battery-electric vehicle time series from empirical data, emobpy.”, 2021

HyRam., 07 December 2021., retrieved from https://github.com/sandialabs/hyram

Groth, Katrina & Hecht, Ethan., “HyRAM: A methodology and toolkit for quantitative risk assessment of hydrogen systems. International Journal of Hydrogen Energy.”, 2016

EnergyPlus., 07 December 2021., retrieved from https://github.com/NREL/EnergyPlus

Brito J., Silva J., Teixeira J., Teixeira S., "Energy Performance of a Service Building: Comparison Between EnergyPlus and TRACE700". In: Gervasi O. et al. (eds) Computational Science and Its Applications – ICCSA 2021., 2021. Lecture Notes in Computer Science, vol 12949. Springer, Cham

Open Charge Map., 07 December 2021., retrieved from https://github.com/openchargemap/ocm-system

Cloud carbon footprint Methodology., 07 December 2021., retrieved from https://www.cloudcarbonfootprint.org/docs/methodology/

Cloud carbon footprint., 07 December 2021., retrieved from https://github.com/cloud-carbon-footprint/cloud-carbon-footprint

Energy sparks., 07 December 2021., retrieved from https://github.com/Energy-Sparks/energy-sparks

EmonCMS., 07 December 2021., retrieved from https://github.com/emoncms/emoncms

Khanna, Pooja & Howells, Gareth & Lazaridis, Pavlos., "Design and Implementation of Low-Cost Real-Time Energy Logger for Industrial and Home Applications. Wireless Personal Communications.", 2021

OpenNem., 07 December 2021., retrieved from https://github.com/opennem/opennem-fe

Carbon removal projects., 07 December 2021., retrieved from https://github.com/carbonplan/cdr-database

Firecam., 07 December 2021., retrieved from https://github.com/tianjialiu/FIRECAM

Liu, T., L.J. Mickley, R.S. DeFries, M.E. Marlier, M.F. Khan, M.T. Latif, and A. Karambelas., "Diagnosing spatial uncertainties and relative biases in global fire emissions inventories: Indonesia as regional case study.", 2020

Emissions API., 07 December 2021., retrieved from https://github.com/emissions-api/emissions-api

Open LCA., 07 December 2021., retrieved from https://github.com/GreenDelta/olca-app

Natarajan, Ganeshan & Kamalakannan, R. & Vijayakumar, R.. "Sustainability analysis on polymers using life cycle assessment tool (OPENLCA). AIP Conference Proceedings. 2311. 070007", 2020

Open Litter map., 07 December 2021., retrieved from https://github.com/OpenLitterMap/openlittermap-web

Marine plastic explorer., 07 December 2021., retrieved from https://github.com/WWF-Deutschland/marine- plastic-explorer

Sea ice., 07 December 2021., retrieved from https://github.com/vannizhang/sea-ice

Global forest watch., 07 December 2021., retrieved from https://github.com/Vizzuality/gfw

Treemapper., 07 December 2021., retrieved from https://github.com/Plant-for-the-Planet-org/treemapper

OpenFoodFacts Server., 07 December 2021., retrieved from https://github.com/openfoodfacts/openfoodfacts-server

OpenFarm., 07 December 2021., retrieved from https://github.com/karrot-dev/karrot-frontend

A., 07 December 2021., retrieved from https://github.com/openfarmcc/OpenFarm

Open climate investing., 07 December 2021., retrieved from https://github.com/opentaps/open-climate-investing.