Climate Compatible Growth

COP29

CCG COP29 POLICY BRIEF SERIES

Leveraging Open Source Tools for Enhanced Climate Transition Analytics

Will Usher [1], Naomi Tan [2]

Summary

We discuss what open source software offers international organisations engaged in project finance and technical assistance in low- and middle-income country (LMIC) contexts with a focus on energy tools. The benefits include the low initial cost, the ability to leverage an existing community of active developers, the possibility for independent experts and academics from LMICs to reshape parts to include indigenous knowledge, and the option to extend or use an existing tool rather than developing in-house. With open source, international organisations can benefit from and influence the growing ecosystem of open source energy and climate models to enhance transparency, improve decision-making processes, and reduce costs, while remaining adaptable to the evolving regulatory landscape.

Key Policy Recommendations

- International organisations should consider increased use of open source models rather than creating their own new proprietary tools to increase engagement with LMICs
- International organisations should partner with academics working with open source tools to enhance legitimacy and transparency
- Support for adoption of open source tools in LMICs can remove barriers to entry, leverage local knowledge, and enable stronger buy-in from stakeholders

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BOX 1: Untangling Open Source, Open Data, Open Access

Terms such as “open source ", “open data” or “open access” are often used loosely or wrongly treated as interchangeable, giving rise to some confusion. In general, the “open” prefix means that the asset is available under a permissive open license which allows re-use of the asset.

Open source refers to software source code made publicly available under a permissive licence. This enables users to access, modify, and distribute the code freely. An open source licence provides specific warranties and permissions for the reuse of the code and associated improvements, fostering collaboration and innovation. Open source code underpins much of the technology we use daily, from smartphones to the internet. From a financial perspective, open source tools can offer cost-effective and transparent alternatives to proprietary software solutions. Open data refers to data which are published under an open licence such as the Creative Commons or UK’s Open Government Licence.

Open access refers to publications that are released under an open licence, allowing anyone to view and re-use the material under the terms covered by the licence. There are also other “open” assets, such as open hardware, open infrastructure, and open educational resources.

BOX 2: The CCG Curated Suite of open source Tools and Frameworks

CCG curates a collection of open source modelling tools and frameworks, created by members of the OpTIMUS Community[1] (listed in the table on the following page), that support the energy planning process for the climate transition in low- and middle-income countries (LMICs). These tools support countries moving along the investment pipeline from ‘Data-to-Deal'. The term ‘Data-to-Deal' refers to a process that runs from data collection and system modelling, through development planning and national financing strategies, to project finance arrangements and, ultimately, to the agreement of a deal for investment, all driven by a strong stakeholder engagement process [7]. While CCG supports a wider range of tools, those listed in **Table 1** are directly part of the Data-to-Deal process. The table provides brief descriptions of each modelling tool and framework.

[1] The Open Tools, Integrated Modelling and Upskilling for Sustainable Development (OpTIMUS) Community is a global community of practice which aims to advance open source software, knowledge development, and capacity building for modelling tools for sustainable development. Climate Compatible Growth is one of several international organisations that is a member: http://www.optimus.community/.

***Table 1:** List of the CCG-curated open source modelling tools and frameworks. * = denotes a modelling framework and not a modelling tool.*

Tool	Institutional Developer	Brief Description	Model Description Paper	Learning Resources and GitHub
CLEWs* (Climate, Land, Energy and Water Systems)	KTH Royal Institute of Technology, UNDESA, IAEA	Offers an integrated, nexus-based framework encompassing energy, water, land, and climate systems	Integrated analysis of climate change, land-use, energy and water strategies	Course (Windows) GitHub: Not Applicable
FinPlan (Model for Financial Analysis of Electric Sector Expansion Plans)	IAEA	Analyses the financial performance of power plant projects over their lifetime by comparing the cost components with available financing sources	Online Manual	Course (Windows) GitHub
FlexTool	IRENA	Performs least-cost power system flexibility assessments based on national capacity investment plans and forecasts	Methodology	Course (Windows/ Mac) GitHub
MAED (Model for Analysis of Energy Demand)	IAEA	Evaluates future energy demand based on a set of consistent assumptions on medium- to long-term socioeconomic, technological, and demographic developments	Online Manual	OpenLearn Course (Windows) GitHub
MinFin (Model for Informed National Financing)	Imperial College London and University of Oxford	Evaluates energy sector financing gaps based on investment needs from long-term energy planning models and the available cost of capital, and simulates strategies to close the financing gaps	Data-to-Deal: How can Countries in the Global South Afford the Climate Transition?	OpenLearn Course (Windows): Coming soon GitHub: Coming soon
PathCalc (Pathways Calculator)	Imperial College London and Loughborough University	Visualises scenario pathways based on 'levels of ambition' to show how various choices can affect carbon dioxide equivalent emissions	Data-to-Deal: Analytical Workflow Hands-on Exercise. Utilizing OSeMOSYS Outputs as Inputs for ESPEX	Course (Windows): Coming soon GitHub: Coming soon
OnSSET (Open Source Spatial Electrification Tool)	KTH Royal Institute of Technology	Analyses and optimises the expansion of electricity access while considering factors such as geographical locations, energy demand, and infrastructure constraints	Lighting the World: the first application of an open source, spatial electrification tool (OnSSET) on Sub-Saharan Africa	Course (Windows) GitHub
OnStove (Open Source Spatial Clean Cooking Tool)	KTH Royal Institute of Technology	Assesses the impacts, particularly costs and benefits of different cooking solutions, with a focus on clean cooking solutions	A geospatial approach to understanding clean cooking challenges in sub-Saharan Africa	Course (Windows) GitHub
OSeMOSYS (Open Source Energy Modelling System)	KTH Royal Institute of Technology	Optimises and identifies the least-cost capacity expansion plan to meet a pre-defined demand. A variation of this model, OSeMOSYS Global, is specifically designed to evaluate the economics of crossborder power interconnectors and regional power pool integration	OSeMOSYS: The Open Source Energy Modeling System: An introduction to its ethos, structure and development	OpenLearn Course (Windows/Mac) GitHub

Introduction

This policy brief highlights how international organisations engaged in project finance and technical assistance in low- and middle-income countries (LMICs) can capitalise on open source tools and software to reduce costs, improve transparency, trust, and robustness, and create a legacy of embedded knowledge in each LMIC. International organisations rely on analytical tools and models to inform sustainable investment decisions such as in energy and transport infrastructure. The tools covered in this brief span demand forecasting, geospatial planning to support universal access to energy, system capacity planning, flexibility analysis, analysis of the climate-land-water-energy nexus, analysis of emissions pathways, financial analysis of transition plans, and financial analysis of projects. CCG curates one such collection of open source tools, and publishes open datasets, open educational material (courses), and open access publications that support the use of these tools. There is a key role for international organisations in the Data-to-Deal process (described in Box 2) which uses open source tools to create the evidence base for investment.

Moving to open source is a strategic decision which has different implications for both international organisations and LMICs across several operational dimensions. These dimensions include cost, functionality and quality, security and maintenance, confidentiality, and ease-of-use and skills. This brief will review each of these key dimensions of performance, highlighting the pros and cons of adopting open source models from each of the standpoints.

Costs

Low initial cost is one reason that the use of open source software has gained momentum across academia and industry in recent years. For instance, energy system modelling tools such as the widely used OSeMOSYS, TEMOA, MESSAGEIx, Calliope, and PyPSA, among others, have emerged as viable free alternatives to expensive commercial solutions. Commercial tools can often cost tens of thousands of dollars in annual subscriptions, is prohibitive for many LMICs, and may create ancillary problems such as lock-in to proprietary file formats.

While open source tools have no upfront cost, there may be “hidden” costs when integrating these tools into business processes or, for example, developing a graphical user interface to increase usability. However, overall development and maintenance costs may be lower as development effort is spread over the open source community rather than concentrated within a specific organisation. One compelling example of how open source software can enable collaboration between commercial competitors to create shared open source tools is Linux Foundation Energy (LF Energy). LF Energy is an open source foundation focused on creating a technology ecosystem to support rapid decarbonisation that benefits the environment, enables economic prosperity, and leads to social well-being for future generations. It provides “a neutral, collaborative community to build the shared digital investments that will transform the world’s relationship to energy” [1]. Such a collaborative approach enables firms to pool resources, reduce duplication of effort, and benefit from collective expertise while developing high quality and fully developed open source solutions.

In the long term, open source solutions can save money through reducing dependence on specific

vendors, providing flexibility in customisation, increasing knowledge sharing, and ensuring a high level of transparency [2]. However, private sector and commercial organisations must balance the advantages of open source software with the need to maintain competitive advantage with proprietary models or methods. In an academic and development setting, such considerations are secondary to the enhanced collaboration enabled by open source. For LMICs, low-cost, interoperable, and customisable open source software provides significant opportunities to save money and maximise use of limited resources.

Functionality and Quality

A common concern regarding open source tools is their *perceived* inferiority to proprietary software in terms of quality and sophistication. While commercial tools are often superior in user *interface design* and *user experience*, open source solutions can match or surpass their commercial counterparts in *technical capability*. One reason for this is the close links between academia and industry enabled by open source. Examples of open source software at this intersection of industry and academia include TensorFlow, the Linux Kernel, Python, and R and QGIS. Through such collaborations, industry gains access to open source implementations at the cutting edge of rigorous and peer-reviewed research, while researchers gain value from software platforms and programming languages that enable research. LMICs can choose open source software with the confidence that it presents a high quality and fully developed alternative to commercial offerings.

In the energy field, the development of open source frameworks for developing energy system models are advanced. Researchers have investigated the usability of open energy models [3] and found that many open source frameworks offer features as complete as commercial alternatives [4]. As such, the discourse has moved on from calling for more openness for reasons of transparency and repeatability [5] to focus on the importance of understandability of analyses that support decisions [6]. Open source supports understandability of evidence-based decisions as it allows public scrutiny of the tools and methods used to create that evidence. The use of open methods also improves continuity, allowing future studies to pick up where the previous ones left off. These characteristics are desirable for international organisations and LMICs seeking to embed modelling skills within their own ministerial energy planning teams. Achieving adequate levels of public scrutiny requires a knowledge base which may require building local capacity.

Security and Maintenance

Any piece of software needs to be maintained as dependencies and software environments evolve. When adopting an existing software, international organisations must assess the potential burden of managing the “technical debt” (the issues that accumulate in any piece of software due to a legacy of design decisions) against the many benefits of using the existing piece of software. Again, the open source community provides an invaluable resource to share the effort of software maintenance, but at the cost of relinquishing absolute control of the software development process.

By virtue of the greater openness and transparency, and the larger number of developers involved in

the maintenance of major open source software packages, security issues and bugs are more likely to be revealed and solved than proprietary efforts with more limited maintenance resources [2].

The open source tools mentioned in **Box 1**, created by the OpTIMUS community and others, have global maintenance and development networks and established roles in the market. With smaller, niche open source software development efforts, support and maintenance may be restricted to a few developers or, in some cases, just one. Maintaining open source software is one of the most difficult things to resource in academia, leading to a long tail of abandoned open source software. This presents a significant market failure as smaller projects can be vulnerable to the loss of a core team member. International organisations can play a key role in providing in-kind developer support to valuable but under-resourced software over a long-term timeframe. Given the global nature of software, targeting support to LMIC developers to participate in key open source software presents an opportunity to develop capacity and maintain tools.

Confidentiality

Adopting open source solutions on a wider scale is often hindered by commercial incentives to patent proprietary tools, institutional reluctance to invest in open source, and intellectual property (IP) concerns. Many private companies prefer to protect their proprietary models and methodologies, seeing them as a source of competitive advantage. Additionally, legal concerns regarding licensing and intellectual property rights may also deter international organisations from fully embracing open source platforms. For example, some Copyleft open source licences effectively prevent commercial use through clauses which require that redistributions of the open source code are licensed under the same terms. Businesses therefore cannot sell software that restricts the freedoms provided by the Copyleft licence.

Nevertheless, many companies have adopted business models incorporating open source code. These include offering dual licensing structures (free for research and paid for commercial use). The aforementioned LF Energy, is a prime example, providing a collaborative environment for developing open source components and specifications tailored for energy markets. The tools shown in **Box 1** are all released under permissive open source licenses, allowing use for commercial and non-commercial purposes.

Ease of Use and Skills

Transitioning from proprietary software to open source solutions requires significant investment in training and skill development. Organisations may face challenges in selecting the most appropriate tools and may need to develop in-house expertise to extend or adapt open source models. These challenges are largest where companies look to replace low- or no-code solutions (such as spreadsheets) or proprietary languages (such as MATLAB, SAS or Mathematica) with open source tools (for example, written in Python, R, C/C++, JavaScript, Go, or Rust). Where commercial software is often sold in packages which include end-user support, normally no such support is provided for users of open source software (although some

commercial outfits provide end-user support to users of popular open source software such as Linux). However, CCG has launched the Energy Modelling Community (EMC) to provide ongoing support and development for users.

As mentioned earlier, less emphasis is placed upon the provision of a user-friendly graphical user interface (GUI) than in commercial software, (although QGIS proves the exception). Adopting different software (including that which happens to be open source) could result in alienating staff who are perfectly competent operating a spreadsheet, but for whom handling a command-line feels like a step too far.

Ultimately, open source software solutions provide the opportunity to incorporate low-cost functionality into business processes. This will normally require investment in specialist expertise to smoothly integrate with existing processes.

Recommendations

In this brief, we have discussed what open source software offers international organisations with a focus on energy tools. The benefits include the low initial cost, the ability to leverage an existing community of active developers, and to extend or use an existing tool rather than developing in-house. International organisations can benefit from and influence the growing ecosystem of open source energy, transport, and climate models to enhance transparency, improve decision-making processes, and reduce costs, while remaining adaptable to the evolving regulatory landscape in emerging economies.

We make three policy recommendations:

International organisations should increase their use of open source models rather than creating their own new proprietary tools or buying commercially available ones.
Open source removes the barriers to entry for LMICs presented by high-cost commercial software and can provide fast access to high quality, peer-reviewed implementations of cutting-edge research. Adoption of open source software can improve the quality and security of the overall software offer and ensure long-term interoperability, reducing costs in the long run. The challenges relating to intellectual property, licensing, and reskilling can be overcome.

International organisations should partner with academics working with open source tools to enhance legitimacy and transparency
In the energy, climate, and development space, there is an international network of academics developing and using open source software to support energy, transport, and development analyses. International organisations should partner with the academic developers of key open source software and local academic networks to maximise impact. These partnerships could add legitimacy to the tools and influence software development where required to align with standards and norms within development finance.

Support for adoption of open source tools in LMICs can remove barriers to entry, leverage local knowledge, and enable stronger buy-in
International organisations can help increase impact by mandating the use of open source tools in development and consultancy projects to avoid the lock-in of LMICs to expensive commercial alternatives. Open source software enables citizens of LMICs to have a greater stake in the tools used for analysis and planning, and presents opportunities to involve LMIC software developers in designing the tools used to support investment decisions.

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ACKNOWLEDGEMENTS

This material has been produced with support from the Climate Compatible Growth (CCG) programme, which brings together leading research organisations and is led out of the STEER centre, Loughborough University. CCG is funded by UK aid from the UK government. However, the views expressed herein do not necessarily reflect the UK government's official policies. With thanks to Simon Patterson for editing and Sarel Greyling for graphic design.

AUTHOR INFORMATION:

[1] **Will Usher** (KTH Royal Institute of Technology): Conceptualisation, Writing – original draft; Writing – review & editing, ***wusher@kth.se***

[2] **Naomi Tan** (Imperial College London, Loughborough University): Writing – original draft; Writing – review & editing, ***N.Tan@lboro.ac.uk***

EXTERNAL REVIEWER:

Taco Niet (Simon Fraser University): Writing – review & editing, ***taco_niet@sfu.ca***

INTERNAL REVIEWER:

Francesco Gardumi (KTH Royal Institute of Technology): Writing – review & editing

COMMISSIONING EDITOR:

Vivien Foster (Imperial College London): Conceptualization; Writing – review & editing, ***v.foster@imperial.ac.uk***