Kia kaha! Stay strong!

Update on open-source energy system modeling in the global south and including Africa

Energy developer room

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Robbie Morrison
robbie.morrison@posteo.de
Schillerstraße 85, 10627 Berlin, Germany

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Abstract

Energy system models are simulations of future energy systems that can be used to test scenarios. More specifically, such models can explore a range of net-zero options in an integrated fashion, determine which scenarios are indeed feasible, and then report on system development trajectories, detailed and aggregate costs, and related attributes for further consideration. Many of the underlying modeling frameworks are now fully-fledged open-source projects. In addition, there are several nascent initiatives to develop coherent databanks and also the overarching data standards they require, with both endeavors suitably open licensed.

These various efforts are now starting to spill into the global south generally and sub-Saharan Africa in particular. A number of potential benefits then arise from this kind of open analysis. The first is the zero monetary cost of course. The next is organic knowledge transfer both northward and southward within the various project communities. A third is doubtless that a greater range of scenarios will be placed on the table — indeed I sense that the multilateral agencies working in Africa have settled on a selected set of solutions and that suggestions that fall outside the prevailing orthodoxy are unwarranted and unwanted. A fourth potential advantage is local engagement, and further, the prospects of improved local autonomy — and while there are no examples of model-mediated public processes in the global south as yet, that concept is being trialed in the global north.

The use of open analysis in the global south will offer distinctive challenges nonetheless. The most obvious difficulty is data availability and a number of proxy solutions have been developed. The next is how best to channel these efforts into public policy formation and then on to live projects. Also critical will be the necessity of finding new ways of interacting between official agencies and these clearly informal modeling communities.

Two of the leading open-source framework projects, OSeMOSYS and PyPSA, have begun significant efforts to broaden into the global south. These two initiative will be reviewed (I am not directly involved in either).

Clearly early days still but sufficient progress has been made to warrant an update at FOSDEM'23.

□

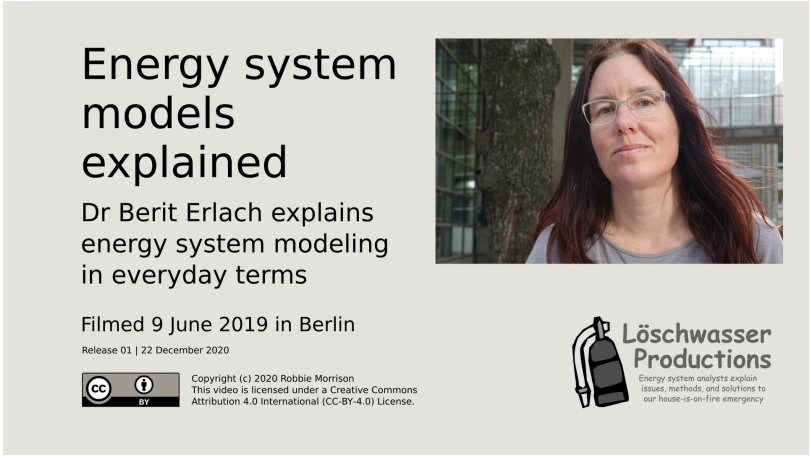
Preamble

Some background

- 1990 : began campaigning on global warming in a personal capacity
- 1995 : modeling national energy systems: multi-sector, high-resolution, contiguous time
- 2003 : added the GPL-2.0 license to *deeco* and attempted to build an online community
- 2010 : completed a hybrid recursive dynamic agent-based framework called *xeona*
- 2016 : joined the Open Energy Modelling Initiative (openmod)
- 2017 : joined the Free Software Foundation Europe (FSFE) Legal Network (LN)
- 2017 : began advocating for genuinely open data of public interest
- 2022 : complete sea change in terms of domain interest from my perspective

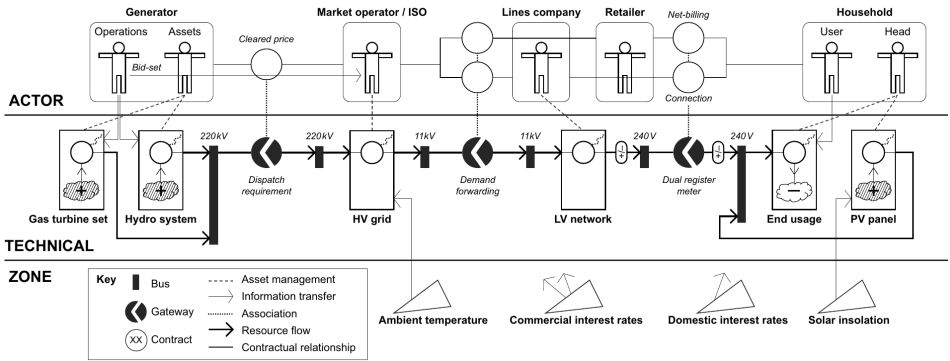
Energy systems modeling

Descriptive YouTube ▪ 13 minutes



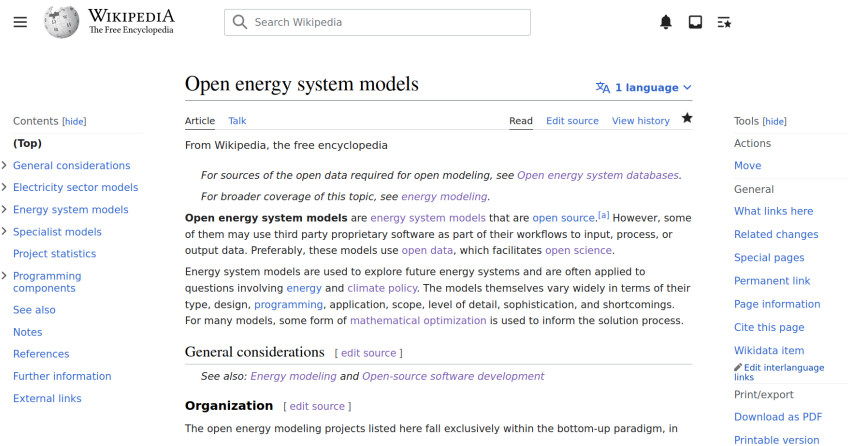
Erlach, Berit (22 December 2020). *Energy system models explained: Dr Berit Erlach explains energy system modeling in everyday terms*. Berlin, Germany: Löschwasser Productions. Video 00:13:17. Filmed 9 June 2019 in Berlin, Germany by Robbie Morrison. Reference LP-001-01. CC-BY-4.0 license.

One quick schematic



Hybrid agent-based/operational energy system optimization model.

Model inventory



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Open energy system models

1 language

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For sources of the open data required for open modeling, see Open energy system databases.

For broader coverage of this topic, see energy modeling.

Open energy system models are energy system models that are open source.[a] However, some of them may use third party proprietary software as part of their workflows to input, process, or output data. Preferably, these models use open data, which facilitates open science.

Energy system models are used to explore future energy systems and are often applied to questions involving energy and climate policy. The models themselves vary widely in terms of their type, design, programming, application, scope, level of detail, sophistication, and shortcomings. For many models, some form of mathematical optimization is used to inform the solution process.

General considerations [edit source]

See also: Energy modeling and Open-source software development

Organization [edit source]

The open energy modeling projects listed here fall exclusively within the bottom-up paradigm, in

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Actions
Move

General
What links here
Related changes
Special pages
Permanent link
Page information
Cite this page
Wikidata item
Edit interlanguage links

Print/export
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Wikipedia EN entry which is about half complete (see Talk page for more candidates)

Operations Research paradigm

- typical framing
  - **set of constraints**, equalities, inequalities, net-zero carbon in 2050
  - **goal function**, minimum aggregate cost
  - **comparative analysis**, novel scenarios compared against selected reference scenario
- high resolution
  - **internal structure**, plant, network, simplified AC power flow
  - **external circumstances**, weather, demand for energy services, economic context
  - **contiguous time**, fallback is representative slices (two weeks in mid-summer and mid-winter)
- degree of foresight
  - **perfect foresight** (future knowledge deemed certain) ... recursive dynamic (stepwise evolution)
- optimization
  - **mixed-integer linear programming** (MILP)
  - non-convex
- conceptual extensions
  - embedded decision-taking using agents
  - multi-criteria optimization, assessment of co-benefits
  - sensitivity to framing, role of uncertainty, exploration of near-optimality

System modeling specifically

- **system scope and integration**
  - most systems/problems have natural boundaries
  - methods used seek technical synergies
  - projected climate change usually included these days
  - may exhibit undue sensitivity to data quality and system resolution

- **high-resolution integrated systems modeling** to understand the energy sector and further
  - **land-usage**, including bioenergy and renewables potentials
  - **water use**, including cooling of steam plant
  - **industrial sector**, hydrogen, ammonia, thermal integration, steel production
  - **carbon capture**, residual emissions from cement (integrated) and agriculture (direct air)
  - **mobility**, e-vehicle charging
  - **co-benefits**, beyond climate change mitigation

- **embedded economy**
  - *not* energy systems models, preserve of process-based **integrated assessment models** (IAM)
  - in which case prices are endogenous and market equilibrium may or may not be assumed

Beyond open-source . . .

- open modeling founded on **open science**
  - open-source codebases and shared development
  - genuinely open data and communal curation
  - full transparency
  - an engaged **overarching community**
- goal is **commons-based peer production** of public policy analysis
  - rapid decarbonization imperative
  - data as a knowledge commons
  - vast solution space to explore
  - boundless creativity needed
- potential for **public engagement**
  - limited examples to date

Complete and coherent data for public interest analysis

- **high-resolution integrated systems modeling** needs lots of public interest data
  - as complete and coherent **as possible**
  - best genuinely open and subject to communal curation
  - open modelers reject legal encumberance, in-house capture, and data commodification

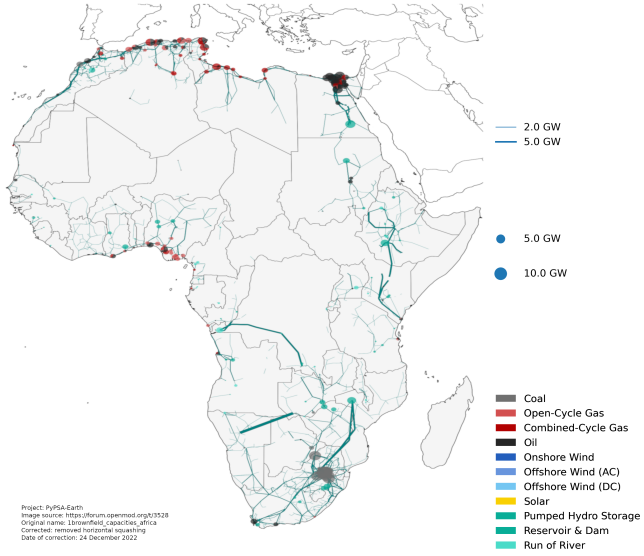
- **data standards**
  - particularly covering **semantics**, see the Open Energy Ontology (OEO)
  - genuinely open and not FRAND, compliant code and data might class as derivative works

- **datasets**
  - definitions for open: Open Knowledge Foundation, EU Open Data Directive recital 16
  - public not necessarily open
  - Creative Commons CC-BY-4.0 licensing offers best legal interoperability
  - metadata under Creative Commons CC0-1.0 for maximum flexibility
  - no **additional contractual override**, such as new restrictions, obligations, waivers

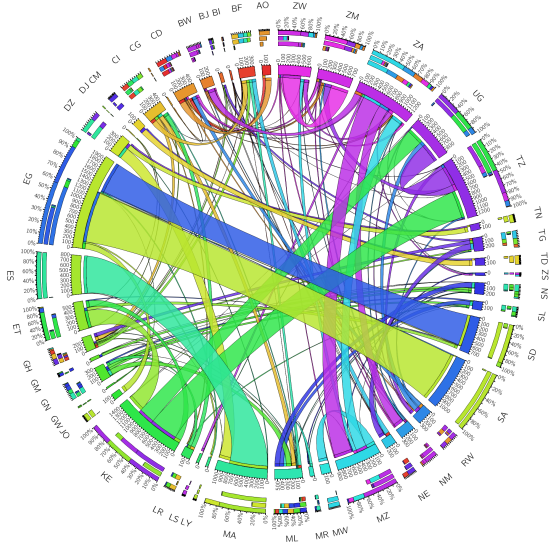
. . . with special reference to the European Union

- **European Union** is compromised in relation to information of public interest
  - provides automatic **96/9/EC database protection**, offering endless legal uncertainty
  - **statutory reporting** is legally encumbered (see ENTSO-E, EEX)
  - non-interoperable **bespoke data licenses** common within Horizon science projects
  - no carve out for **information of public interest** within the digital single market rubric
  - novel **data producers right** (DPR) still possible under proposed Data Act

Global south



Energy systems on the African continent today (PyPSA meets Earth initiative)



Cumulative electricity trade (2015–2065) among African countries for the reference scenario (TWh) using OSeMOSYS (Pappas *et al* 2022)

Two overarching projects

- **OSeMOSYS Global** project
  - original code from Mark Howells, now ICL and Loughborough University
  - written in GNU MathProg (open high-level mathematical programming language)
  - suite of models including OnSSET
  - good informal connections to official agencies
  - Software Heritage lists 135 forked repositories for OSeMOSYS

- **PyPSA meets Earth** initiative
  - codebase initiated by Tom Brown and Jonas Hörsch
  - written in Python
  - core development at TU Berlin
  - broad community
  - Software Heritage lists 308 forked repositories for PyPSA
  - Davide Fioriti will talk next

Clear activity

- regions
  - central America, Costa Rica
  - south America, Brazil
  - India and region
  - South Africa, sub-Saharan Africa
- context
  - most is early-stage academic research

Interacting with official agencies

- a **clear gulf** between peer produced analysis *and* official agencies
  - potential competition because these agencies also develop their own tooling and workflows
- Oliver Geden (2015:28, *Nature*, 521: 27–28)
  - "Everyday politics is therefore dominated not by evidence-based policy-making but by attempts at '**policy-based evidence-making**' "
- **potential intermediaries**
  - incumbent NGOs
  - new set of foundation-backed think-tanks (two examples: Climate Analytics, TransitionZero)
- official agencies **open-sourcing** their software
  - will they really cross that Rubicon?
  - legacy code is always more problematic
  - some will "openwash" (one organization screens applicants and omits an OSI-approved license)
  - some will simply "throw their code over the wall" (meaning no interest in collaboration, no issues filed, not clear if code will even run)

Clear benefits

- **few cost barriers**
  - commercial solvers out perform open-source solvers
  - remote execution can offer advantages
- **soft technology transfer**
  - bi-directional
  - lightweight
  - associated communities
- **transparent**
  - able to be studied and challenged

Cross-cultural considerations

- **language**
  - English near universal
  - indigenous languages bundle different concepts
- **sovereignty**
  - easy to transgress in inadvertent ways
- **representation**
  - including within projects
- **model scope** and choice of solutions
  - to what degree are these determined by an engineering worldview?

Challenges

- **code maintenance**
  - common to all open-source projects
- building suitable **knowledge commons** in the face of institutional interests
  - the IEA only sell data under non-disclosure
  - the European Union is focused on data commodification
  - scientific institutions are often unnecessarily protective
- addressing **cross-cultural issues**
  - requires sensitivity and dialog
- new ways of **interacting with official agencies**
  - perhaps with think-tanks as intermediaries
- a concluding **quotation** from East German playwright Heiner Müller
  - "Optimism is just a lack of information"

Thanks for your attention

Photographs

Garlic mustard close-up

- description: Garlic mustard (Alliaria petiolata) [Knoblauchrauke], Brandenburg, Germany
- timestamp: 2021-05-29 08:24:22+00:00
- conditions: Sony ILCE-6600 ▪ 45mm (35mm equivalent) ▪ ISO:125 1/60 f4.0
- photographer: Robbie Morrison
- image: STR08402.JPG