Tools paragraphs

CLEWs (Introduction to CLEWs)

Climate, land-use, energy and water systems (CLEWs) models are tools for simultaneous consideration of food, energy and water security. They are designed to assess how production and use of these resources may contribute to climate change, and how climate change may affect the resource systems. By comparing different technologies and value chains, such models can identify pressure points, and indicate synergies and trade-offs to reach several development goals simultaneously. CLEWs can analyse policy decisions on issues such as the promotion of clean energy, competition for water and agricultural modernization and can identify paths for policy coherence.

There are several ways of building a CLEWs model. Entry-level models can be created by representing several resource systems together with the same tool, using for example OSeMOSYS. Data regarding the structure of the energy system, land use and agriculture and water supply are needed for such purpose.

Key publications:

Ramos et al., 2021, https://iopscience.iop.org/article/10.1088/1748-9326/abd34f/meta
Howells et al., 2013, https://www.nature.com/articles/nclimate1789
Welsch et al., 2014,
https://www.sciencedirect.com/science/article/pii/S0306261913007277?via%3Dihub

OnSSET (OnSSET/The Global Electrification Platform)

Geospatial electrification models aim to find where grid, mini-grids or stand-alone technologies can be used to increase access to electricity in a country or region, at the lowest cost. To do so, these models combine GIS data with demographic and techno-economic information. Key results of a geospatial electrification model include the investments/capacity required, the share of population to be served by each technology, and maps illustrating the distribution of these results over the area of interest. In this course you will be introduced to the Open Source Spatial Electrification Tool (OnSSET), QGIS and the Global Electrification Platform (GEP):

- OnSSET is an open-source framework one can use to conduct a geospatial electrification analysis from scratch,
- QGIS is used to work with GIS data and visualizations,
- The GEP provides pre-existing electrification results (using OnSSET) for 58 countries; it may be used for policy development.

Key publications and websites:

OnSSET: www.onsset.org
The Global Electrification Platform: https://electrifynow.energydata.info/
Mentis et al. 2017. https://doi.org/10.1088/1748-9326/aa7b29
Korkovelos et al. 2019. https://doi.org/10.3390/en12071395

MAED and EBS (Energy demand assessment and scenarios: MAED and EBS tools)

The Model for Analysis of Energy Demand (MAED) evaluates future energy demand based on a set of consistent assumptions on medium to long term socioeconomic, technological and demographic developments in a country or a region.

Future energy needs are linked to the production and consumption of goods and services; technology and infrastructure innovation, lifestyle changes caused by increasing personal incomes; and mobility needs. Energy demand is computed for a host of end use activities in three main 'demand sectors': household, services, and industry and transport.

MAED provides a systematic framework for mapping trends and anticipating change in energy needs, particularly as these correspond to alternative scenarios for socioeconomic development.

The Energy Balance Studio (EBS) is an effective tool for providing a systematic framework in organizing the energy statistics data that can be used for constructing inputs for energy planning models like MAED and MESSAGE.

Key publications:

A quantitative model for forecasting energy demand and CO_2 emissions in Pakistan, towards a sustainable energy system
https://www.researchgate.net/publication/348136923_A_quantitative_model_for_forecasting_energy_demand_and_CO_2_emissions_in_Pakistan_towards_a_sustainable_energy_system

Lesotho electricity demand profile from 2010 to 2030
http://www.scielo.org.za/scielo.php?pid=S1021-447X2021000100004&script=sci_arttext&tlng=es

Scenarios simulation and analysis on electric power planning based on multi-scale forecast: a case study of Taoussa, Mali from 2020 to 2035
https://www.mdpi.com/1996-1073/14/24/8515/htm

Energy Demand Modelling of Developing Economies Using MAED-2 with Sectoral Decomposition: Bangladesh Case Study
(PDF) Energy Demand Modelling of Developing Economies Using MAED-2 with Sectoral Decomposition: Bangladesh Case Study (researchgate.net)

OSeMOSYS and FlexTool (Energy and Flexibility Modelling: OSeMOSYS & FlexTool)

OSeMOSYS and FlexTool are two tools commonly paired together for long-term energy system analysis. OSeMOSYS calculates the cheapest way of producing energy to meet a pre-defined demand given a set of power generation technologies. In OSeMOSYS, technologies are defined by their costs, technical parameters (e.g. capacity factor, life time), and production potential. Various constraints can be applied to the model, and thus many scenarios of how a country can produce its energy in the long term can be analyzed. The scenario results from OSeMOSYS can then be fed into FlexTool to assess the flexibility of the energy system, as well as find ways to overcome potential loss of load and/or curtailment

Key publications:

C. Taliotis *et al.*, “An indicative analysis of investment opportunities in the African electricity supply sector — Using TEMBA (The Electricity Model Base for Africa),” *Energy Sustain. Dev.*, vol. 31, pp. 50–66, Apr. 2016, doi: 10.1016/J.ESD.2015.12.001. Available at: https://www.sciencedirect.com/science/article/pii/S0973082615300065?casa_token=IuhW7k4I0WQAAAAA:JGqAJfhklF37WK2eTQSmaQwYm8cBTSuH7SZsQcbvTp-3uQEFu3_ZW71lR7GmnfA9TfMdGN8Y

K. Löffler, K. Hainsch, T. Burandt, P. Y. Oei, C. Kemfert, and C. Von Hirschhausen, “Designing a Model for the Global Energy System—GENeSYS-MOD: An Application of the Open-Source Energy Modeling System (OSeMOSYS),” *Energies 2017, Vol. 10, Page 1468*, vol. 10, no. 10, p. 1468, Sep. 2017, doi: 10.3390/EN10101468. Available at: https://www.mdpi.com/1996-1073/10/10/1468

G. Godínez-Zamora *et al.*, “Decarbonising the transport and energy sectors: Technical feasibility and socioeconomic impacts in Costa Rica” *Energy Strateg. Rev.*, vol. 32, p. 100573, Nov. 2020, doi: 10.1016/J.ESR.2020.100573. Available at: https://www.sciencedirect.com/science/article/pii/S2211467X20301267

FinPlan (Financial Analysis of Power Sector Projects Using the FinPlan Model)

Financial constraints are often the most important challenge to the implementation of an economically optimal electricity expansion plan. FINPLAN is particularly helpful for analysing such constraints, as it allows taking a closer look at the financial performance of power plant projects over their lifetime. Within FINPLAN, the various cost components of a project during its construction and operation are compared with the available funding sources, the associated financing costs and income streams generated by the project. Cash-flow and other financial statements as well as ratios are calculated to evaluate performance and associate risk. This enables a comprehensive financial assessment, providing a better understanding of the financial viability of a project.

Key publication:

Shafiqul, I.M. and Bhuiyan, T.H., 2020. Assessment of costs of nuclear power in Bangladesh. *Nuclear Energy and Technology*, *6*, p.181. Available at: https://nucet.pensoft.net/article/54003/download/pdf/

The Net Zero Playbook

Electricity networks are essential for the energy transition. Delivering high volumes of renewable and low carbon electricity is the only way to keep 1.5 degrees in sight and have a functioning global economy. Put simply, "there is no transition without transmission". Yet no country has managed to make the switch to a fully clean grid. There are, however, examples where elements of the problem have been solved. This course will guide participants through the key steps required to successfully deliver an electricity system transition. It will use an engaging "lectures and case studies" approach to set out how to create a long term vision for the electricity mix, and build understanding on the key elements of political support, policy and regulatory delivery mechanisms, network infrastructure and operational requirements, all framed by enabling technologies, supply chain and workforce needs and consumer and public buy-in. Participants will also bring their own case study (e.g. a country or region) to the course, to work on collaboratively with ICTP convenors and other participants, which will bring the course material to life and ensure practical value when returning home.

Energy Access Explorer: A Data-driven, Integrated and Inclusive Approach to Planning for Achieving Universal Access to Energy for Equitable Development

Energy Access Explorer (EAE) is the first ,open-source, online and interactive geospatial platform that enables clean energy entrepreneurs, energy planners, donors, and development-oriented institutions to identify **high-priority areas for energy access interventions**. Using spatial data to link energy supply with growing or unmet demand is essential to gaining a better picture of energy access and expanding energy services to those who need it the most. Furthermore, EAE functions as a dynamic information system and data repository, reducing software engineering and data transaction costs for both data providers and users.

From theory to practice, trainees in the EAE track will be introduced to the importance of spatial data & analytics for providing actionable insights regarding the expansion of clean energy services for socio-economic development. Participants will work on practical hands-on activities to identify high priority areas for energy access interventions. That is, through the front-end of the application. They will also be introduced to and work on the backend infrastructure (through the user friendly interface of the dynamic information system) to develop an EAE application for a given geography of interest.

EAE enables:

- **Strategic & Integrated Energy Planning**, where planning agencies are able to link energy access and socio-economic development.
- **Expansion of Clean Energy Markets** where technology suppliers (whether mini grid developers, solar home system providers, clean cooking technology providers) use EAE to get a better understanding of aspects of affordability and level of service needed.
- **Impact Investment:** Donors and development finance institutions use EAE to identify areas where grants and support will have the most impact.
- **Bottom-up Assessment of Energy Needs:** Service delivery institutions in the health, education, agriculture, clean cooking sectors will be able to estimate energy needs associated to development services.

Geospatial data, best practices for collection and management

Geospatial analytics has become an increasingly important element of electrification planning in many countries. The use of geospatial data in energy systems modelling enables us to acquire a better understating of features that will inform the analysis in a detailed manner; for example, visualizing patterns of demographic, economic and social features, locating energy demands, identifying local available resources, and improving the planning of infrastructure to respond to diverse population needs.

The planification units operating within relevant ministries, utilities and other stakeholders need to keep up with the digital transformation of the sector. This course has been designed around the best practices for geospatial data collection, curation and management. The goal is to bring participants' knowledge and skills up to speed with the state-of-the-art geospatial technologies, tools and methodologies that best support their operations across the energy sector.

Participants will get an overview of different types of geospatial data sources that can support their modelling efforts with a focus of open data, data quality standards, best practices and state-of-the-art tools for data collection, manipulation, spatial data infrastructure (SDI) and management, including how to best document the data to allow replication of models and their update when new data becomes available.

This course is targeted to energy planners, utility representatives and IT specialists supporting energy planning efforts.

Input-Output-based Life-Cycle Assessment with MARIO

The main goal of the course is to introduce students to the fundamentals of quantitative impact assessment methods and to the application of such using MARIO, an open-source pyhton-based platform designed to handle and process input-output models. These quantitative models are specifically aimed at assessing the prospective environmental and economic impacts resulting from the application of technological or policy interventions at meso- and macro-scale, comprehensively including supply-chain effects in a Life Cycle perspective.

Basic principles of systems modelling, quantitative impact assessment and Industrial Ecology are introduced and discussed also based on real life examples and case studies. The mathematical background of impact assessment models is then introduced, focusing on Leontief's Input-Output framework, which is then applied to the analysis of energy, environmental and economic national accounting analyses, mapping the structure of national supply chains, hence usually adopted as databases for impact assessment models.

Examples of model use:

- doi: https://doi.org/10.1088/1755-1315/1106/1/012008
- doi: https://doi.org/10.1016/j.resconrec.2023.106900
- doi: https://doi.org/10.3390/en15093071

Geospatial Clean Cooking access modelling, using OnStove

Currently 2.4 billion people globally lack access to clean cooking and instead rely on traditional fuels for their daily cooking needs. The use of traditional fuels has large implications on health, environment and gender equality.

Learn about geospatial clean cooking modelling and how to build your own clean cooking transition scenarios with geospatial data. Explore the possibilities of incorporating the spatial data into your energy modelling to unlock new dimensions and gain additional insight into the challenges and possible solutions.

In this course you will be introduced to OnStove, an open-source spatial clean cooking tool identifying the best cooking solutions across any given area based on their costs and benefits. The track will take you from start to finish, from creating your own spatial repository to modifying your spatial data, calculating the net-benefits of different cooking solutions and lastly visualizing and presenting your results.

Find out more about OnStove: https://onstove-documentation.readthedocs.io/en/latest/ and https://www.nature.com/articles/s41893-022-01039-8