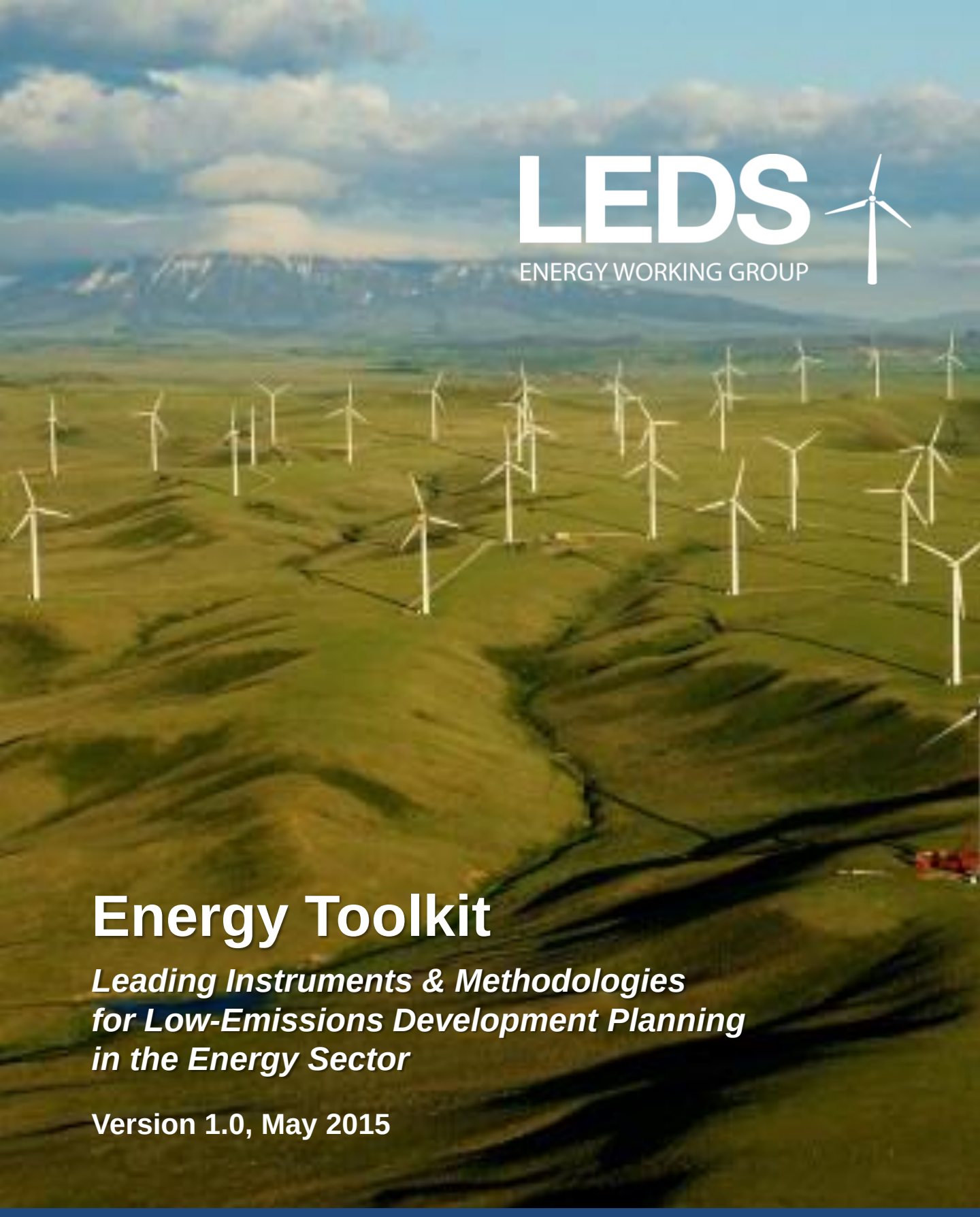

Energy Toolkit

Leading Instruments & Methodologies for Low-Emissions Development Planning in the Energy Sector

Version 1.0, May 2015

Energy Toolkit

An Overview of LEDS Planning Instruments

Attached please find the first version of the Energy Toolkit, a collection of leading instruments and methodologies for low-emission, climate-resilient development planning in the energy sector. By no means does it make a claim to be complete. The goal has been to offer energy practitioners, policymakers, and experts a quick reference guide for well-established low-emissions development strategies planning tools that are available at no or low cost.

The result is a compilation of tools from different originations and agencies around the world. Produced as a team effort with the many members of the Low-Emissions Development Strategies Global Partnership (LEDS GP), and in particular its Energy Working Group (LEDS EWG), the Worldwatch Institute cooperated with the working group's regional co-chairs to select and compile the tools presented in the Energy Toolkit.

The LEDS GP was founded to enhance coordination, information exchange, and cooperation among countries and international programs working to advance low-emission, climate-resilient growth. Launched in early 2011, the LEDS GP has made significant progress advancing collaboration and learning across more than 120 developing and developed country governments, technical institutes, and multilateral organizations engaged in low-emission, climate-resilient development.

The LEDS EWG promotes low-emission and climate-resilient development in the energy sector through a work program focused on learning and information exchange, sharing best practices, advisory services, and providing enhanced opportunities for coordination and collaboration.

We hope to regularly update the toolkit if it proves useful. If you have developed a low-emissions energy modelling tool or know of one that should be featured here, please tell us about it.

Alexander Ochs, Worldwatch Institute, EWG Chair, aochs@worldwatch.org
Ana Maria Majano, INCAE, EWG LAC co-Chair, ana.majano@incae.edu
John Yeboah, ECREEE, EWG Africa co-Chair, jyeboah@ecreee.org
S.S. Krishnan, CSTEP, EWG Asia co-Chair, ssk@cstep.in

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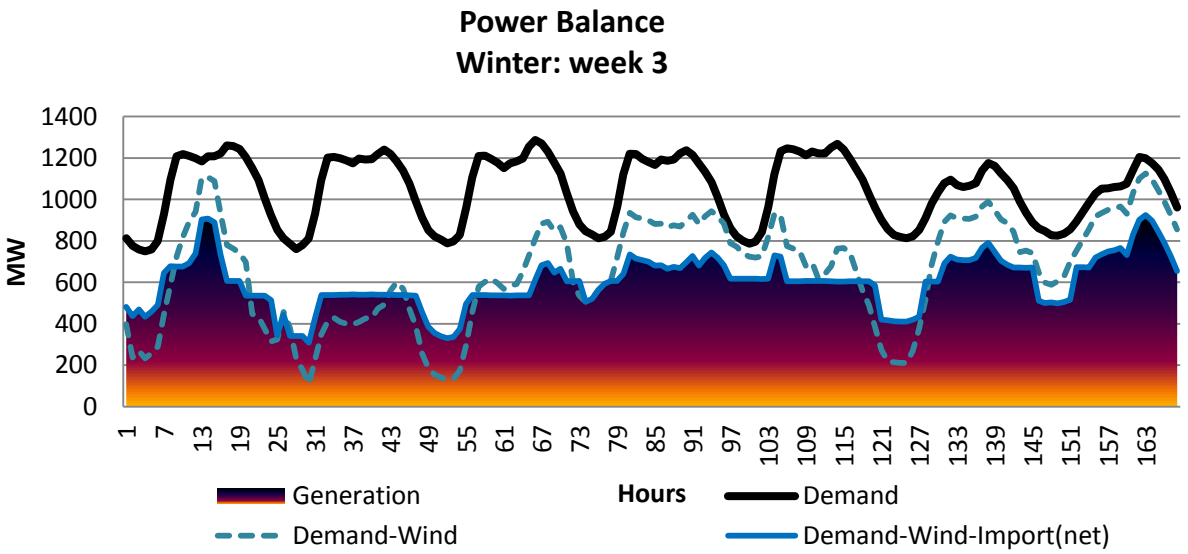
Balmorel

Energy system model

Supporting modelling and analyses of the energy sector



Typical Clients

- Energy ministries and agencies
- Universities and research institutions
- Consulting companies
- System operators

Current & Past Users

- Ea Energy Analyses
- Technical University of Denmark
- Elering TSO
- China Electric Power Research Institute
- And more around the world

Associated Costs

The GAMS code is open source and may be used and modified under open source conditions.

More Information

http://www.balmorel.com

Contact Information:

Hans Ravn, hans.ravn@aeblevangen.dk

Balmorel

Energy system model

What is it?

Balmorel is a model for analyzing the electricity and combined heat and power sectors in an international perspective. It is highly versatile and may be applied for long range planning as well as shorter time operational analysis. The user may modify the source code and model according to specific requirements, making the model suited for a broad range of projects within the focus parts of the energy system.

Key Goals

The purpose of the Balmorel project is to support modelling and analyses of the energy sector with emphasis on the electricity and combined heat and power sectors. Underlying the Balmorel project is the idea that data and modelling should be common to all parties dealing with common problems. The process is best supported if the model is fully transparent; this is provided by the available source code.

Data Inputs

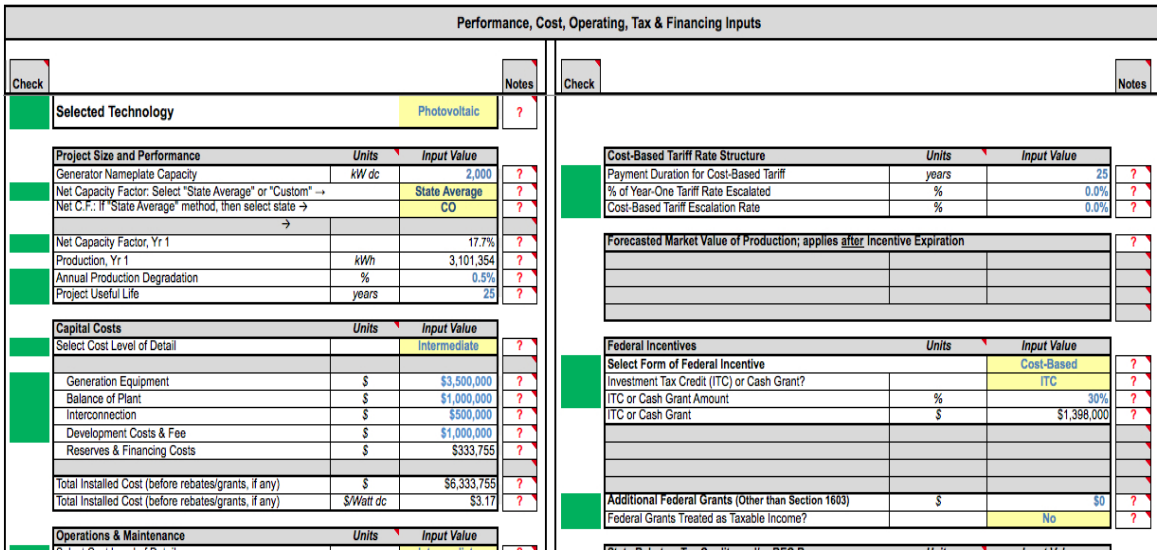
- Electricity and heat demand (price responsive)
- A number of energy technology types
- Electricity transmission with capacities, losses and costs
- Capacity expansion in energy technology and transmission
- Electricity and heat distribution costs and losses
- Fuels types and prices
- Taxes, subsidies
- Environmental restrictions, penalties, incentives and mechanisms

Outcomes

- Energy technology and transmission expansion
- Electricity and heat generation
- Fuel consumption
- Electricity transmission
- GHG emissions
- Electricity and heat prices
- Amount of taxes and subsidies

Cost of Renewable Energy Spreadsheet Tool (CREST)

User-friendly cost of energy calculator for solar, wind, geothermal, biomass, and fuel cell projects



Performance, Cost, Operating, Tax & Financing Inputs

Check			Notes
	Selected Technology	Photovoltaic	?

	Project Size and Performance	Units	Input Value	
	Generator Nameplate Capacity	kW dc	2,000	?
	Net Capacity Factor: Select "State Average" or "Custom" →		State Average	?
	Net C.F.: If "State Average" method, then select state →		CO	?
	→			
	Net Capacity Factor, Yr 1		17.7%	?
	Production, Yr 1	kWh	3,101,354	?
	Annual Production Degradation	%	0.5%	?
	Project Useful Life	years	25	?

	Capital Costs	Units	Input Value	
	Select Cost Level of Detail		Intermediate	?
	Generation Equipment	$	$3,500,000	?
	Balance of Plant	$	$1,000,000	?
	Interconnection	$	$500,000	?
	Development Costs & Fee	$	$1,000,000	?
	Reserves & Financing Costs	$	$333,755	?
	Total Installed Cost (before rebates/grants, if any)	$	$6,333,755	?
	Total Installed Cost (before rebates/grants, if any)	$/Watt dc	$3.17	?

	Operations & Maintenance	Units	Input Value

Check				Notes

	Cost-Based Tariff Rate Structure	Units	Input Value	
	Payment Duration for Cost-Based Tariff	years	25	?
	% of Year-One Tariff Rate Escalated	%	0.0%	?
	Cost-Based Tariff Escalation Rate	%	0.0%	?

	Forecasted Market Value of Production; applies after Incentive Expiration			
				?

	Federal Incentives	Units	Input Value	
	Select Form of Federal Incentive		Cost-Based	?
	Investment Tax Credit (ITC) or Cash Grant?		ITC	?
	ITC or Cash Grant Amount	%	30%	?
	ITC or Cash Grant	$	$1,398,000	?
	Additional Federal Grants (Other than Section 1603)	$	$0	?
	Federal Grants Treated as Taxable Income?		No	?

Typical Clients

- Policymakers
- Regulators
- Researchers
- Beginning developers and financiers

Current & Past Users

- Government of Rhode Island
- Apex Consulting
- VenLogic

Associated Costs

Publicly available

More Information

https://financere.nrel.gov/finance/content/crest-cost-energy-models

Contact Information:

Travis Lowder – Energy Analyst (travis.lowder@nrel.gov)

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Cost of Renewable Energy Spreadsheet Tool (CREST)

What is it?

An Excel-based cost of energy and pro forma model to perform back-of-the envelope calculations for wind, solar, geothermal, biomass, and fuel cell projects. Can also be used by government to set feed-in tariff rates and other incentive levels.

Key Goals

CREST assists policymakers in the design of cost-based incentives to support renewable energy development in their jurisdictions. It has been used by a much wider range of stakeholders than just governments, however, including developers, utilities, regulators, investors, consultancies, and others

Data Inputs

- Project data, including size, expected performance, and capital costs
- Financial data, including debt and equity terms, and tax information
- Ongoing costs, including O&M, operating capex, and debt service

Outcomes

- Year one cost of energy
- Cash flows over project lifetime
- Pro forma analysis

LEDS
ENERGY WORKING GROUP

Energy Forecasting Framework and Emissions Consensus Tool (EFFECT)

An open tool for forecasting GHG emissions in low carbon development

Typical Clients

Governments

Current & Past Users

Governments of Brazil, Georgia, India, Macedonia, Nigeria, Poland, Vietnam, China, Indonesia, Philippines, Thailand

Associated Costs

EFFECT can be downloaded from http://esmap.org/EFFECT for free

More Information

- http://esmap.org/EFFECT
- https://www.climatesmartplanning.org/dataset/energy-forecasting-framework-and-emissions-consensus-effect-tool

Contact Information:

Pedzi Makumbe – esmap@worldbank.org

Energy Forecasting Framework and Emissions Consensus Tool (EFFECT)

What is it?

The Energy Forecasting Framework and Emissions Consensus Tool (EFFECT) is an open and transparent modeling tool used to forecast greenhouse gas (GHG) emissions from a range of development scenarios. It focuses on sectors that contribute to and are expected to experience a rapid growth in emissions. The model was initially developed by the World Bank while working with the Government of India on an analysis of their national energy plan.

Key Goals

EFFECT forecasts GHG emissions for given development scenarios or policy choices. In addition to forecasting GHG Emissions, EFFECT enables consensus building among disparate government departments, and forecasts energy balances and amounts of energy generating/consuming assets in a country or sector. EFFECT also produces results for individual sectors such as road transport, agriculture, power, industry, household and non-residential sectors.

Data Inputs

- National data on economic indicators (total GDP, GDP contribution by sector)
- Expected demand growth of the power sector
- General demographics (rural and urban population, electrification rates, etc.), and more

Outcomes

•Greenhouse gas emissions for given development scenarios or policy choices
•Forecasts of energy balances and amounts of energy-generating/consuming assets in a country or sector
• Results for individual sectors such as road transport, agriculture, power, industry, household and non-residential

Financial Analysis of Electric Sector Expansion Plans (FINPLAN)

Typical Clients

- Energy Ministries
- Environment Ministries
- Utilities & Energy Planning Agencies
- Universities & Research institutions

Current & Past Users

- Planners and Researchers in over 40 countries
- 4 international/regional organizations

Associated Costs

Free to Government/Public Sector organisations, Research and non-profit Institutions; and to international/ regional organisations

More Information

https://www.iaea.org/OurWork/ST/NE/Pess/capacitybuilding.html

Contact Information:

Mr Ahmed Irej Jalal, Unit Head, Planning and Capacity Building Unit (PESS.Contact-Point@iaea.org)

Financial Analysis of Electric Sector Expansion Plans (FINPLAN)

What is it?

FINPLAN evaluates the financial implications of an expansion plan for a power generating system. The model helps establish financial feasibility of electricity generation projects by computing important financial indicators while taking into account all costs, financing options, revenues, taxes, etc.

Key Goals

FINPLAN was designed to help energy analysts and decision makers in analysing the financial implications of a power project. The model treats all expenditures in a foreign and the local currency. The cash flows for all expenditures in the respective currencies are maintained and the impact of future exchange rate changes is analysed. The model helps to analyse the impact of assumed future conditions that affect the financial health of a company.

Data Inputs

- Investment programme for capacity additions and operating expenses
- Economic and fiscal parameters (inflation, escalation, exchange rates, taxes)
- Financial data (export credits, loans, bonds…)

Outcomes

For each year:

- Cash flows
- Balance Sheet
- Statement of Sources
- Applications of Funds
- Financial Ratios:
  - ✓ Working Capital Ratio
  - ✓ Leverage ratio
  - ✓ Debt Repayment Ratio
  - ✓ Global Ratio

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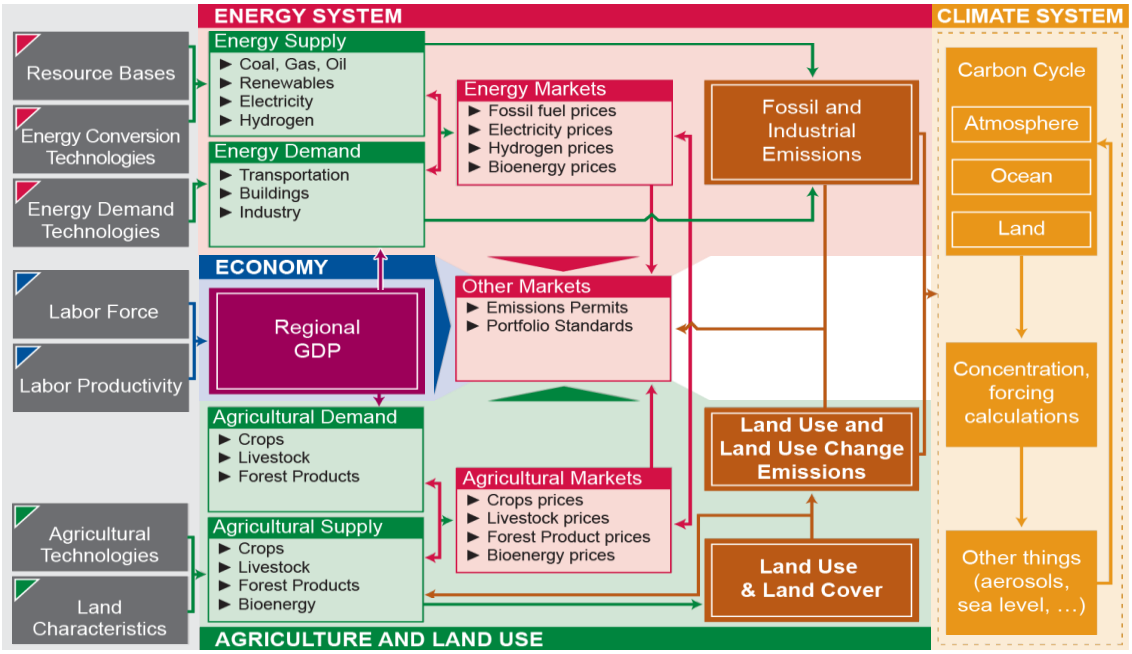
Global Change Assessment Model (GCAM)

A community, regional to global integrated assessment model



Typical Clients

- Energy Ministries
- Environmental Ministries
- Research Organizations
- Universities
- NGOs
- International agencies

Current & Past Users

- GCAM is used for integrated research at PNNL and partner institutions, with community users in over 50 countries and 250 institutions.

Associated Costs

- None. Open-source software

More Information

- www.globalchange.umd.edu/models/gcam/
- wiki.umd.edu/gcam/

Contact Information:

Leon Clarke – Manager, Integrated Modeling and Energy, JGCRI, PNNL, Leon.Clarke@pnnl.gov

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Global Change Assessment Model (GCAM)

What is it?

Simulation model that combines representations of the economy, energy supply, transformation and demand; agriculture and land use; and climate to examine the scenarios of the coming decades and beyond. The model has been used to inform technology and policy strategy decisions and to create scenarios used in every major IPCC assessment since 1990. GCAM is global, but several regional versions have been constructed.

Key Goals

GCAM is designed to explore a wide range of interactions including the energy, emission, land-use, and water consequences of policy options for climate mitigation, and emerging energy supply and demand technologies. The model is increasingly being used to explore the implications of climate change on energy, water, and land-use systems.

Data Inputs

GCAM is released with a comprehensive input dataset that includes socio-economic drivers, base-year energy and agricultural technology characteristics, greenhouse gas and pollutant emissions, and a reference scenario for future developments in all these areas.

The data input requirements depend on user needs. Adding climate policy scenarios requires few input assumptions, while more complex changes would require lager efforts.

Outcomes

GCAM produces a wide range of variables contingent on input assumptions for future population, economy, technology, and environmental policies. These include:

- Energy supply and demand by sector, technology, and fuel for 32 geo-political regions.
- Land-use and crop production for 283 land regions
- Endogenous price paths for energy and agricultural goods
- Greenhouse gas and pollutant emissions
- Climate policy costs

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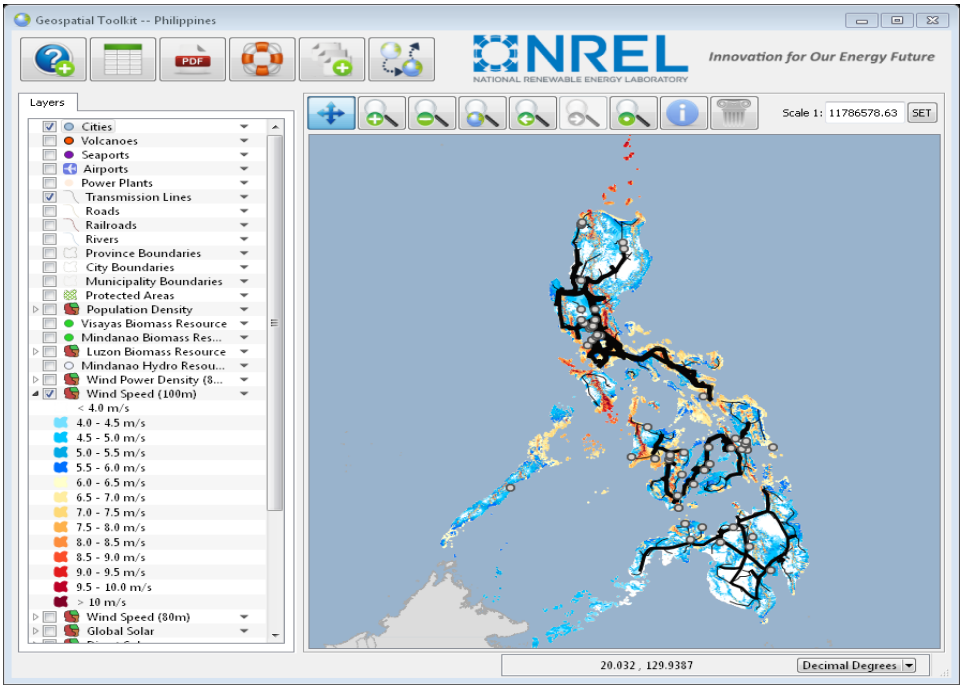
The Geospatial Toolkit (GsT)

Enabling the exploration of renewable energy potential



Typical Clients

- National & local governments
- Renewable energy developers
- Renewable energy investors
- Academia & experts
- International organizations

Current & Past Users

Numerous users in the 20+ countries or regions supported by the tool, including the Governments of Vietnam and Philippines and the provincial government of Thanh Hoa

Associated Costs

Free and open source

More Information

http://www.nrel.gov/international/geospatial_toolkits.html

Contact Information:

Donna Heimiller – Senior GIS Analyst (donna.heimiller@nrel.gov)
Jessica Katz – Analyst (jessica.katz@nrel.gov)

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The Geospatial Toolkit (GsT)

What is it?

The Geospatial Toolkit (GsT) is a map-based software application that provides an intuitive, user-friendly interface for visualizing and quantifying a country or region's renewable energy potential.

Key Goals

The GsT is intended to enable users without expertise in GIS to explore renewable energy resource potential in their country or region. The GsT: 1) provides a platform for integrating data on renewable energy resources and the physical or geographic factors that influence their development; 2) visualizes this data in map-based form; and 3) enables targeted quantitative analysis of solar, wind, and biomass potential under a variety of user-defined scenarios.

Data Inputs

The GsT is an out-of-the-box tool prepackaged with a combination of global and local datasets for each of the 20+ countries or regions for which a tool exists. Users do not need to input additional data, but may add their own custom GIS data to the GsT if desired. Typical data in a GsT include spatial distribution of renewable energy resources (e.g., solar and wind), infrastructure (transmission lines and roads), land use, protected areas, elevation, administrative boundaries, and other factors that influence renewable energy development.

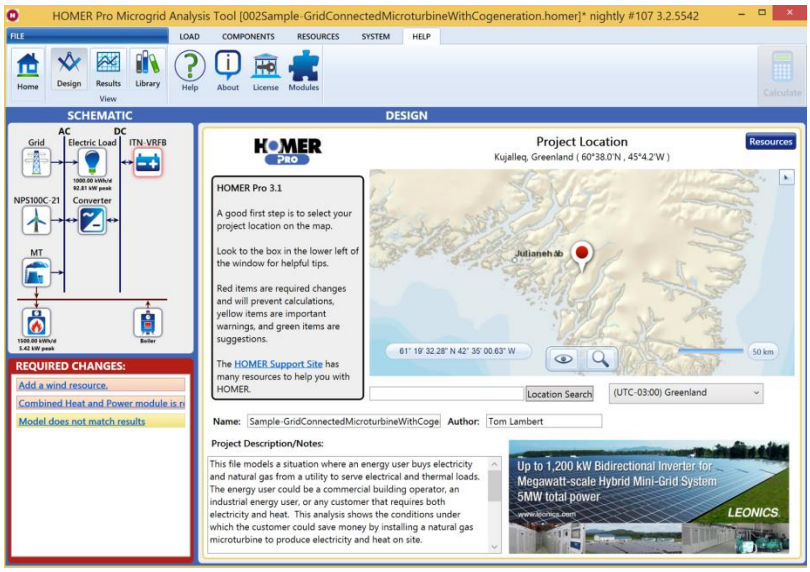
Outcomes

The GsT is a high-level screening tool that can be used to:

- Estimate wind, solar, and biomass potential under different constraints to inform targets.
- Identify tradeoffs and synergies between sustainable land use and clean energy.
- Identify areas where clean energy supports development priorities.
- Screen for potential renewable energy development zones.
- Screen for potential project sites.
- Identify sites for long-term solar or wind measurement stations.

Hybrid Optimization of Multiple Energy Resources (HOMER)

HOMER software model provides rapid assessment of least-cost solutions for clean power



Typical Clients

- Government Agencies and NGO's
- EPC's and Integrators
- Component Manufacturers
- Project Owners, Financiers, and Utilities
- Universities and Research Organizations

Associated Costs

- HOMER Quickstart – Free
- HOMER Pro $500 - $1000 per seat. Discounts for academic users

Current & Past Users

- ABB, Schneider Electric, Northern Power Systems, Energy Authority, Office of Naval Research, US AID, World Bank, Carbon War Room
- 120,000 users world wide

More Information

http://www.homerenergy.com

Contact Information:

info@homerenergy.com +1-720-565-4046

Hybrid Optimization of Multiple Energy Resources (HOMER)

What is it?

HOMER® is a software program originally developed by the National Renewable Energy Laboratory for modeling and optimizing least cost microgrid design in all sectors, from village power and island utilities to grid-connected campuses and military bases. HOMER allows the user to sort the feasible systems by dozens of variables. HOMER's optimization can consider interest rates, tariffs or sell-back rates, emissions goals, renewable resources, fuel prices, renewable goals, equipment prices and performance, and much more.

Key Goals

HOMER helps decision makers determine the best multiple resource energy system designs which can meet their estimated or actual annual energy loads along with economic and environmental objectives.

Data Inputs

System design data utilizing the many built in resources and technologies listed below:

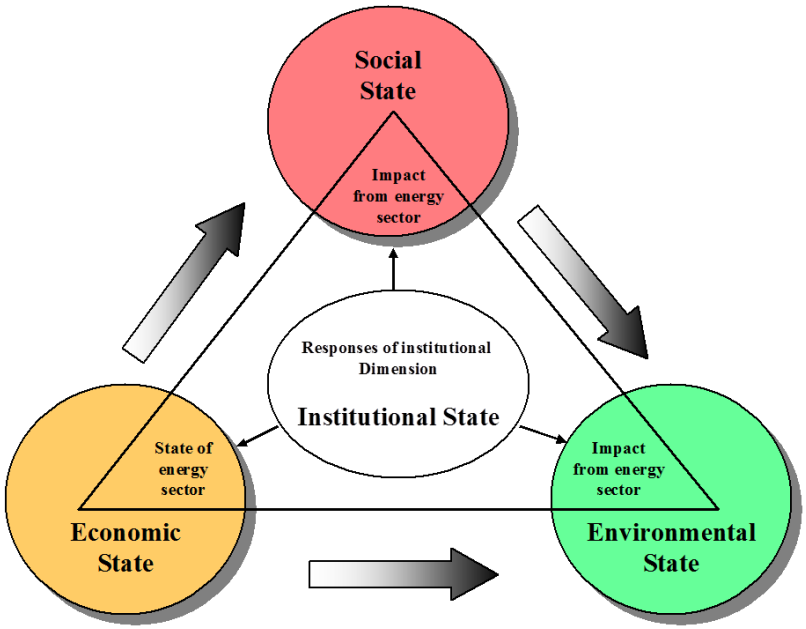
- Hourly or minute-by-minute electric loads (AC & DC)
- Generators (diesel, natural gas, and more)
- Biomass generators
- Fuel cells
- Solar photovoltaic (PV)
- Wind turbines
- Hydrokinetic turbines
- Run-of-river hydro
- Connections to other grids (tariffs, capacities)
- Batteries (lead acid, lithium ion, flow batteries, and more)
- Flywheels
- Inverter/rectifiers
- Hydrogen systems
- Demand-side management
- Energy efficiency
- Thermal loads

Outcomes

Optimized system designs and reports based on multiple criteria:

- Best mix of resources and technologies
- Cost of energy
- Return on Investment
- Net present cost
- Initial capital
- Operating costs
- Emissions
- Fuel costs
- Generator run-time
- Storage cycling
- Chronological results
- And more

Framework of Indicators for Sustainable Energy Development (ISED)



Typical Clients

- Energy Ministries
- Environment Ministries
- Utilities & Energy Planning Agencies
- Universities & Research institutions

Current & Past Users

- Planners and Researchers in over 30 countries
- 5 international/regional organizations

Associated Costs

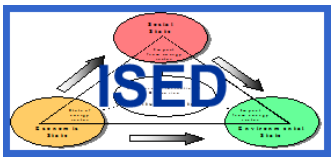
- Free to Government/Public Sector organisations, Research and non-profit Institutions; and to international/ regional organisations

More Information

https://www.iaea.org/OurWork/ST/NE/Pess/capacitybuilding.html

Contact Information:

Mr Ahmed Irej Jalal, Unit Head, Planning and Capacity Building Unit (PESS.Contact-Point@iaea.org)



Framework of Indicators for Sustainable Energy Development (ISED)

What is it?

ISED framework is a series of 'snapshots' of ratios (indicators) reflecting the interaction of energy with the economic, environmental and social pillars of sustainable development over time. The set consists of 30 indicators: 4 for the social dimension, 16 for the economic dimension and 10 for the environmental dimension.

Key Goals

ISED provides a flexible tool for analysts and decision makers at all levels to better understand their national situations and trends, the impacts of recent policies and the potential impacts of policy changes. The IAEA developed the framework for ISED in cooperation with the International Energy Agency (IEA), the European Environmental Agency (EEA), the European Commission's EUROSTAT and the United Nations Department of Economic and Social Affairs (UNDESA).

Data Inputs

- Demographic and social development data
- Economic data
- Energy data
- Environmental data

Outcomes

Among others:

- Accessibility to energy services
- Energy affordability
- Energy disparities
- Energy security
- Overall use of energy and productivity
- Supply efficiency
- Energy end-use
- Diversification (fuel mix)
- Energy prices
- Import dependency
- Strategic fuel stocks
- GHG emission intensities
- Air quality
- Water quality
- Soil quality
- Deforestation rate
- Solid waste generation and management

Long-range Energy Alternatives Planning System (LEAP)

Typical Clients

- Energy Ministries
- Environmental Ministries
- Utilities & Planning Agencies
- Universities
- NGOs
- Consulting Companies
- International agencies

Current & Past Users

Thousands of users in over 190 countries including The World Bank, UNDP, UNEP, IEEJ, APERC, Petrobras, Ramboll, GGGI, Bellona Foundation, etc.

Associated Costs

- Free to Governments, NGOs and Academia in Developing Countries.

More Information

www.energycommunity.org

Contact Information:

Charles Heaps, LEAP Developer (leap@sei-international.org)

Long-range Energy Alternatives Planning system (LEAP)

What is it?

A widely-used software tool for energy policy analysis and climate change mitigation assessment developed at the Stockholm Environment Institute.

Key Goals

LEAP is intended to bring the policy insights of sophisticated scenario-based energy and environmental planning to a much wider audience than the previous generation of energy models by placing powerful data management, sophisticated calculations and flexible and user-friendly reporting tools within a single accessible decision support software tool that is made available for free to target users in developing countries.

Data Inputs

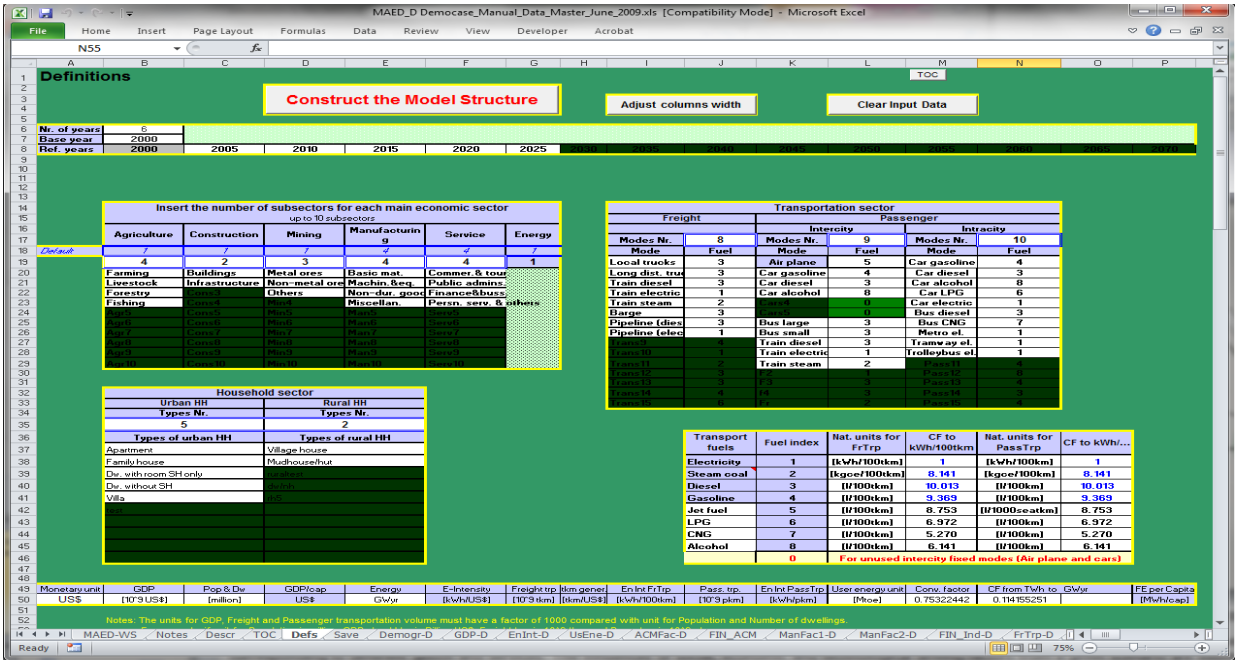
A key feature of LEAP is its low initial data requirements. LEAP provides a choice of methods that let's users start out with readily available energy and economic statistics and default IPCC emission factors, and then gradually progress to more sophisticated methods once better data becomes available and more expertise has been gained.

Outcomes

LEAP allows you to create and evaluate long-range scenarios . It is notable for its powerful and flexible reporting and its outputs include :

- Primary and final energy requirements by sector
- GHG emissions and emissions of local air pollutants and short-lived climate pollutants
- Capital costs ,operating costs, fuel costs and externality costs presented in an easy-to interpret summary of the costs and benefits comparison of scenarios/
- Indicators of energy security including import dependence and diversity of supply.

Model for Analysis of Energy Demand (MAED)



Typical Clients

- Energy Ministries
- Environment Ministries
- Utilities & Energy Planning Agencies
- Universities & Research institutions

Current & Past Users

- Planners and Researchers in over 107 countries
- 12 international/regional organizations

Associated Costs

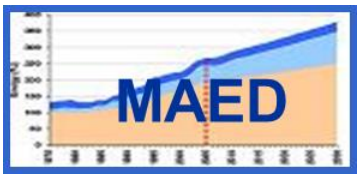
- Free to Government/Public Sector organisations, Research and non-profit Institutions; and to international/ regional organisations

More Information

https://www.iaea.org/OurWork/ST/NE/Pess/capacitybuilding.html

Contact Information:

Mr Ahmed Irej Jalal, Unit Head, Planning and Capacity Building Unit (PESS.Contact-Point@iaea.org)



Model for Analysis of Energy Demand (MAED)

What is it?

A model that provides a systematic framework for mapping trends and anticipating change in energy needs, particularly as they correspond to alternative scenarios for socioeconomic and technological development. It takes into account different types of energy forms (including traditional fuels) in all economic and consuming sectors/subsectors at end-use level.

Key Goals

MAED was designed to help energy analysts and decision makers in analysing future energy demand for building sustainable energy systems. It is a simulation model, best applicable for the medium and long term analysis at country or regional levels, based on the bottom up scenario approach. It reflects the structural changes in energy demand, by means of detailed analysis of social, economic, and technological factors.

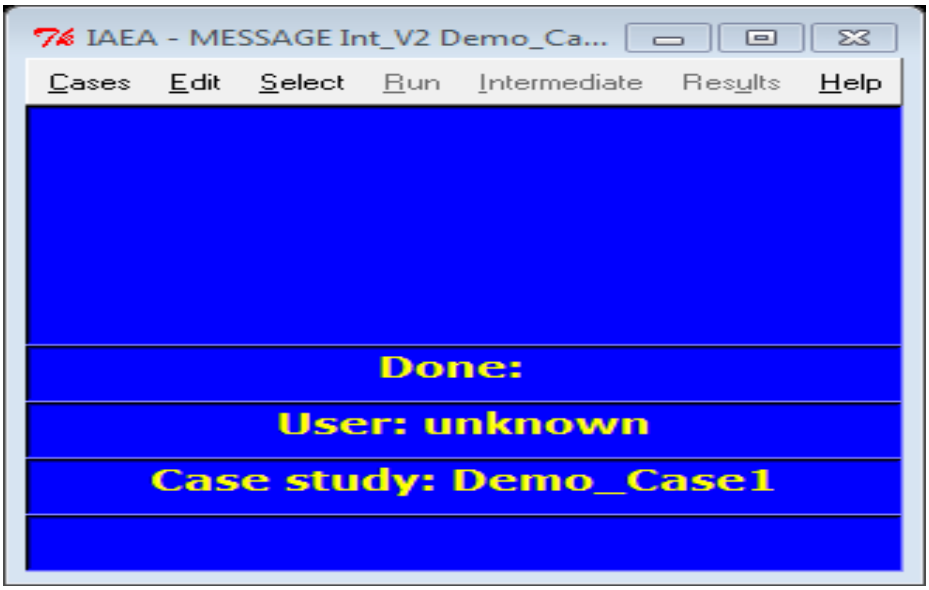
Data Inputs

- Demographic data for rural and urban areas
- Economic data disaggregated by sectors/subsectors
- Energy data disaggregated by:
  - ✓ Household (rural & urban)
  - ✓ economic sectors/ subsectors
  - ✓ End-uses activities
- Penetrations of different energy forms (modern and traditional fuels)
- Scenario assumptions:
  - ✓ Socio-economic
  - ✓ Technological
- Substitutable energy uses
- Efficiencies of end-use technologies and processes
- Electricity consumption patterns and load characteristics for different types of consumers

Outcomes

- Useful and final energy demand by sectors/subsectors and fuels
- Electricity demand
- Hourly electric load
- Load duration curves

Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE)



Typical Clients

- Energy Ministries
- Environment Ministries
- Utilities & Energy Planning Agencies
- Universities & Research institutions

Current & Past Users

- Planners and Researchers in over 88 countries
- 11 international/regional organizations

Associated Costs

Free to Government/Public Sector organisations, Research and non-profit Institutions; and to international/ regional organisations

More Information

https://www.iaea.org/OurWork/ST/NE/Pess/capacitybuilding.html

Contact Information:

Mr Ahmed Irej Jalal, Unit Head, Planning and Capacity Building Unit (PESS.Contact-Point@iaea.org)

Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE)

What is it?

A model designed to formulate and evaluate long term strategies by analysing cost optimal energy mixes consonant with user defined constraints on new investment, market penetration rates for new technologies, fuel availability and trade, environmental emissions, energy supply security, etc. Originally it was develop by IIASA and in 2001, it was acquired by the IAEA. The Agency enhanced it by adding new features and the user interface.

Key Goals

MESSAGE was designed to help energy analysts and decision makers in analysing different supply strategies for building sustainable energy systems. It is an optimization model, applicable for medium and long term analysis at country or regional levels. It can help design long term strategies by analysing cost optimal energy mixes, investment needs and other costs, energy supply security, energy resource utilization, introduction of new technologies, environmental policies, etc.

Data Inputs

- Energy system structure (including vintage of plant and equipment)
- Base year energy flows and prices
- Energy demand projections
- Technology and resource options and their techno-economic performance profiles
- Technical and policy constraints

Outcomes

- Primary and final energy mix
- Emissions and waste streams
- Health and environmental impacts (externalities)
- Resource use
- Land use
- Import dependence
- Investment requirements, O&M costs, fuel costs
- Etc.

Model for Electricity Technology Assessment (META)

Integrating externalities into electricity supply decisions

Typical Clients

Power sector, policy-makers, power system planner

Current & Past Users

Dominica, Egypt, Kosovo, Macedonia, Morocco, and Vietnam (as part of the World Bank's engagement), and by consultants in Haiti and Jamaica

Associated Costs

META can be downloaded from http://esmap.org/META for free

More Information

https://www.esmap.org/META
https://www.climatesmartplanning.org/dataset/model-electricity-technology-assessment-meta

Contact Information:

Bipul Singh – esmap@worldbank.org

Model for Electricity Technology Assessment (META)

What is it?

The Model for Electricity Technology Assessment (META) facilitates the comparative assessment of the economic costs of more than 50 electricity generation and delivery technologies, including conventional generation options (thermal, hydroelectric, etc.), nonconventional options (renewables), and emerging options such as power storage and carbon capture and storage (CCS).

Key Goals

META provides cost assessments for various electricity technology options, and can be used for analysis on:

- Investment Projects
- Energy Policy
- Electricity System Planning
- Sector Studies
- Estimating Environmental Damage Costs

Data Inputs

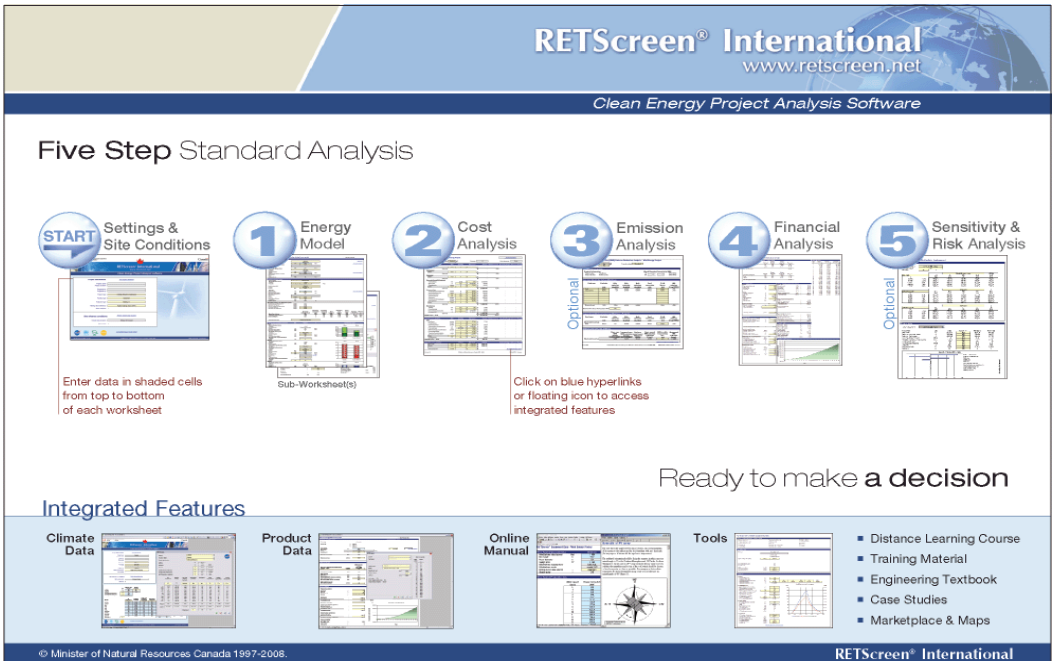
Default performance and cost data inputs are provided, drawn from three representative countries: India, Romania and the USA, which were chosen as proxies for developing, middle-income and developed countries, respectively. Users also have the option of customizing the data for new countries by entering detailed input data directly into model and for as many parameters as they consider necessary.

Outcomes

- Levelized costs for generation, transmission, and distribution for each electricity supply technology option from a relatively few input parameters.
- Integration of environmental externalities, such as local pollution and greenhouse gas emissions.
- Cost analysis of adding or expanding generation from a particular power source if, for example, a carbon price is factored in.

RETScreen Clean Energy Management Software

Empowering cleaner energy decisions



Typical Clients

- Engineers, architects, financial planners
- Post-secondary institutions
- Private companies & utilities
- All levels of government, including multilaterals

Current & Past Users

- As of 2015, over 435,000 users in every country and territory of the world
- 30,000+ new users per year
- Used by over 600 universities for teaching and research

Associated Costs

Software and all training material completely free-of-charge

More Information

More information and free download at:

- www.retscreen.net
- http://www.retscreen.net/ang/what_is_retscreen.php

Contact Information:

RETScreen Customer Support— retscreen@nrcan.gc.ca

RETScreen Clean Energy Management Software

What is it?

- The RETScreen Clean Energy Management Software helps decision-makers quickly and inexpensively determine the technical and financial viability of potential clean energy (renewable energy, energy efficiency, cogeneration) projects as well as engage in ongoing energy performance analysis
- Developed by the Government of Canada with the support of key partners such as REEEP, IESO, NASA, UNEP, and the World Bank
- Data inputs can be made in 36 languages

Key Goals

- To significantly reduce the costs associated with identifying and assessing potential clean and cleaner energy projects in order to help decision-makers understand whether or not such a project makes financial sense.
- By helping to break down barriers that occur at the pre-feasibility, feasibility, development and engineering stages, RETScreen reduces the cost of getting projects on the ground and doing business in clean energy.

Data Inputs

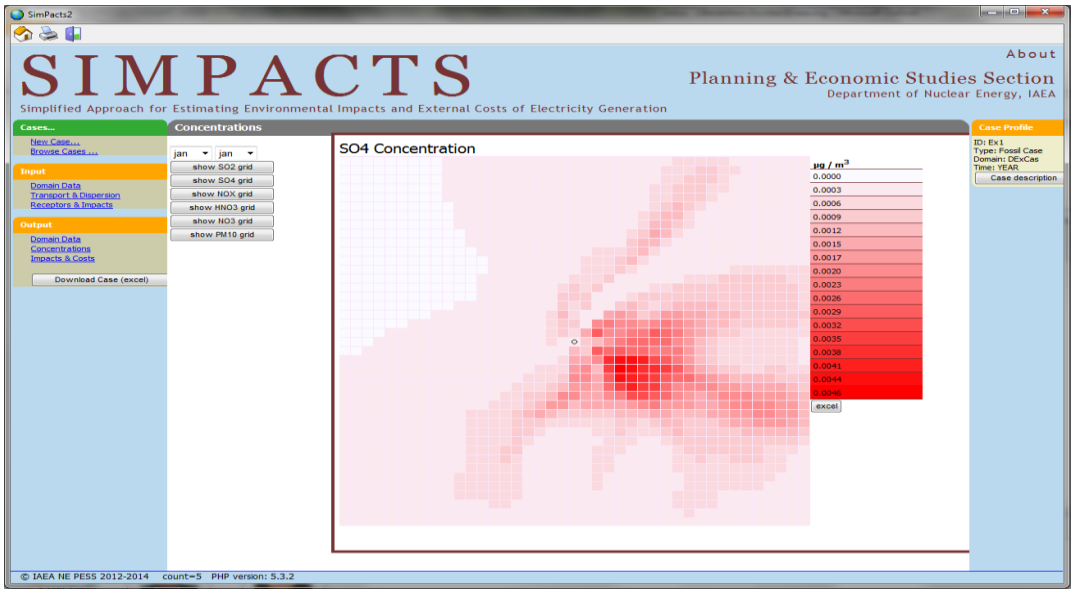
- User has a choice of inputs depending on type of project selected and level of detail required in analysis. Minimum inputs include basic project-specific details (site; energy model details; financial details)
- The user does not need to know exactly what to input. Inputs are prompted/assisted by comprehensive integrated user manual; integrated databases (product, project, hydrology, climate and benchmark); and built-in templates

Outcomes

Simplified inputs give pre-feasibility analysis; more detailed inputs provide feasibility analysis. RETScreen will provide for any type of clean, cleaner, or conventional energy project, a:

- Simplified or Detailed Energy Analysis
- Simplified or Detailed Cost Analysis
- Simplified or Detailed GHG Emission Analysis
- Simplified or Detailed Financial Analysis
- Simplified or Detailed Risk Analysis
- Simplified or Detailed Performance Analysis

Simplified Approach for Estimating Environmental Impacts of Electricity Generation (SIMPACTS)



Typical Clients

- Energy Ministries
- Environment Ministries
- Utilities & Energy Planning Agencies
- Universities & Research institutions

Current & Past Users

- Planners and Researchers in over 53 countries
- 5 international/regional organizations

Associated Costs

Free to Government/Public Sector organisations, Research and non-profit Institutions; and to international/ regional organisations

More Information

https://www.iaea.org/OurWork/ST/NE/Pess/capacitybuilding.html

Contact Information:

Mr Ahmed Irej Jalal, Unit Head, Planning and Capacity Building Unit (PESS.Contact-Point@iaea.org)

Simplified Approach for Estimating Environmental Impacts of Electricity Generation (SIMPACTS)

What is it?

SIMPACTS estimates and quantifies the health and environmental damage costs of different electricity generation technologies.

Key Goals

The model can be used by energy analysts and decision makers for comparing and ranking various electricity generation options in terms of external costs. SIMPACTS covers the major electricity generation sources and most of the associated impacts on human health and the environment. Most important, it provides a simple but accurate tool for estimating external costs associated with electricity generation.

Data Inputs

- Source location (power plant location)
- Technical parameter of the source
- Pollutants emission rates
- Population density within the domain
- Dose response-functions
- Receptors data

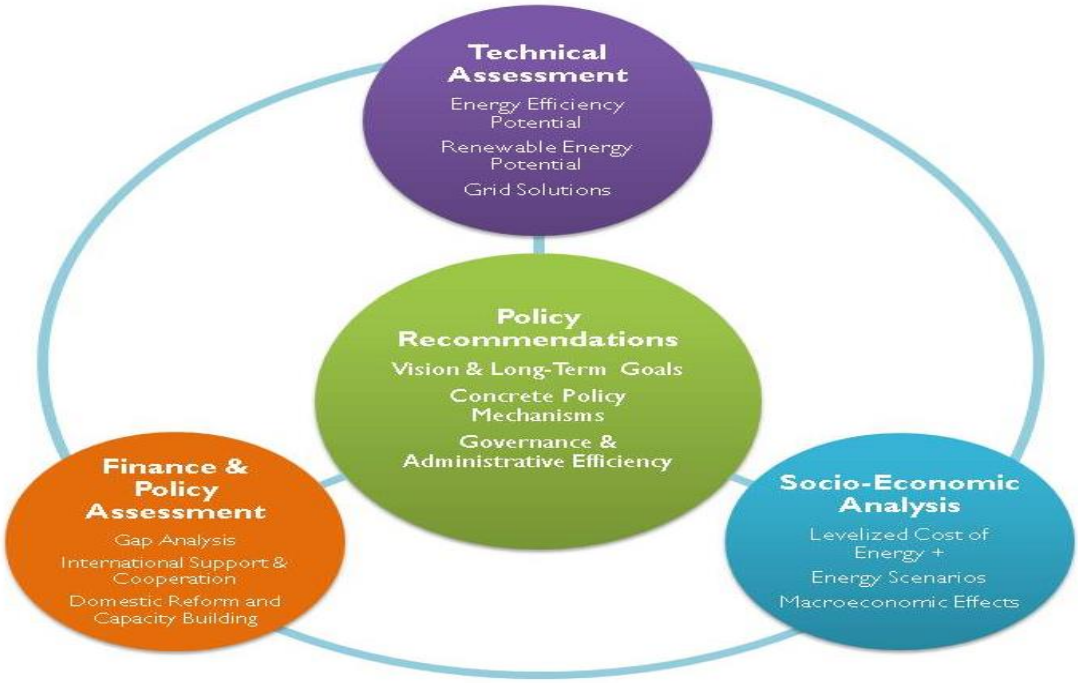
Outcomes

- Domain and meteorological data
- Incremental pollutants concentrations
- Impacts to human health and agricultural products
- External costs

WORLDWATCH INSTITUTE

Sustainable Energy Roadmap

Integrated multi-component planning and implementation methodology guiding energy transitions at any level of government



Typical Clients

- Regional/International Organizations
- National & Local Governments
- Investors & Developers
- Civil Society
- Academia & Experts

Current & Past Users

- Dominican Republic (2015)
- Chhattisgarh/India (2015, proposed)
- CARICOM (2015 & 2013)
- Haiti (2014)
- Jamaica (2013)
- SICA countries (2013)

Associated Costs

Depends on scope and available information

More Information

http://www.worldwatch.org/sustainable-energy-roadmaps

Contact

Alexander Ochs, Director, Climate and Energy Program, aochs@worldwatch.org

WORLDWATCH INSTITUTE

Sustainable Energy Roadmap

What Is It?

A dynamic and comprehensive methodology with multiple tools that analyses the economic and social impacts of alternative technological pathways in the specific context of a municipality, country, or region. It explores existing clean energy business opportunities and recommends concrete policies and measures that improve the given investment environment.

Key Goals

Support governments, utilities, grid operators, IPPs, business leaders, academia, and civil society groups to create a financially, socially, and environmentally sustainable energy system as the basis for climate-compatible, low-emissions development, particularly through designing the right framework conditions for new domestic and international public and private investments.

Data Inputs

- Existing energy data (including electricity end-use by sub-sector, efficiency rates, emissions levels, renewable resource potential, grid infrastructure, fuel source composition, import-export balance, tariffs) are examined for quality and timeliness.
- Where necessary, new data are collected and/or calculated (e.g., through international comparison; new resource assessments through new GIS data mapping).
- Existing sustainable energy finance environment is evaluated.
- Current policies and measures and administrative processes are analyzed.

Outcomes

- Energy sector situation and challenges
- Energy efficiency and renewable technologies potentials
- Levelized Cost of Electricity (LCOE) from alternative sources; analysis with and without externalities (pollution, health)
- Projection of costs of alternative energy pathways over certain time frame
- Pathways' impact on jobs and risks and opportunities across economic sectors
- Finance sector reform recommendations
- Suggestions for policy and administrative reform
- Set of concrete next steps for sustainable energy advancement

Energy Technology Systems Analysis Program

The Integrated MARKAL/EFOM System (TIMES)

Typical Clients

- Energy Ministries
- Environmental Ministries
- Utilities & Planning Agencies
- Universities
- NGOs
- Consulting Companies
- International Agencies

Associated Costs

- Model generator source code free
- GAMS/Solver $640-$12,800 academic-commercial
- Model management system (VEDA or ANSWER) $1,800-$12,000 academic-commercial

Current & Past Users

Several hundred users in over 70 countries including most European governments and the European Commission, US Department of Energy and Environmental Projection Agency, and numerous government bodies and universities in developing and transition countries.

More Information

www.iea-etsap.org

Contact Information:

Gary Goldstein, ETSAP Liaison Officer
(gary.a.goldstein@gmail.com)

Energy Technology Systems Analysis Program

The Integrated Markal Efom System (TIMES)

What is it?

A comprehensive energy system optimization platform widely-used to advise energy and climate change mitigation policy formulation. Developed under the auspices of the International Energy Agency's Energy Technology Systems Analysis Program (www.iea-etsap.org), TIMES excels in identifying least-cost pathways for the evolution of .energy systems under alternate futures.

Key Goals

To provide a framework to enables the evaluation from a least-cost perspective of the evolution of energy systems in response to technological progress and alternative policies, in order to identify optimal development pathways. It employs advanced model management tools that oversee all aspects of working with the model to facilitate stewardship and effective use by a range of experts for study areas ranging from local systems to states and countries, integrated into regional and global planning platforms where appropriate.

Data Inputs

Main input include:

- Depiction of the current energy balance along with power plants and demand device/vehicle stock;
- Characterization of ongoing resource supply options (production cost and maximum annual output);
- Characterization of new technologies (investment and operating costs, efficiency and availability factors);
- Projection of future demand for energy services (usually a function of expected GDP and population growth rates), and
- Scenario definitions (e.g., emissions target or price, renewable portfolio and energy reduction policies, energy security goals).

Outcomes

TIMES provides a detailed picture of the evolution of an energy system. It provides a powerful reporting facility that allows for easy assembly of hierarchical tables managed as "smart" dynamic pivot tables to allow aggregating, dissecting and reconfiguring of core results including:

- Primary and final energy requirements by fuel and sector;
- GHG emissions and emissions of local air pollutants and short-lived climate pollutants by fuel and sector;
- Capital stock turnover and new power plant and device purchase timing;
- Capital, operating, fuel and externality costs, as well as the marginal price of fuels, constrained emissions and imposed policies, and
- Indicators of energy security including import dependence and diversity of supply.

Tool for Rapid Assessment of City Energy (TRACE)

A decision support tool for evaluating energy efficiency opportunities in cities

TRACE
Tool for Rapid Assessment of City Energy

Typical Clients

Cities' municipality, cities' officials, cities' authorities

Associated Costs

TRACE can be downloaded from http://esmap.org/
TRACE for free

Current & Past Users

- Cities' municipality in Turkey, Brazil, Vietnam, Romania, Kenya, etc.
- **View full list of cities where TRACE has been deployed**

More Information

- http://esmap.org/TRACE
- https://www.climatesmartplanning.org/dataset/tool-rapid-assessment-city-energy-trace

Contact Information:

Pedzi Makumbe – esmap@worldbank.org

Tool for Rapid Assessment of City Energy (TRACE)

What is it?

The Tool for Rapid Assessment of City Energy (TRACE) is a decision-support tool designed to help cities quickly identify under-performing sectors, evaluate improvement and cost-saving potential, and prioritize sectors and actions for energy efficiency (EE) intervention. It covers six municipal sectors: passenger transport, municipal buildings, water and waste water, public lighting, solid waste, and power and heat.

Key Goals

TRACE is designed with the intention to involve city decision makers in the deployment process. It starts with benchmark data collection, goes through an on-location assessment involving experts and decision makers, and ends with a final report to city authorities with recommendations of EE interventions tailored to the city's individual context.

Data Inputs

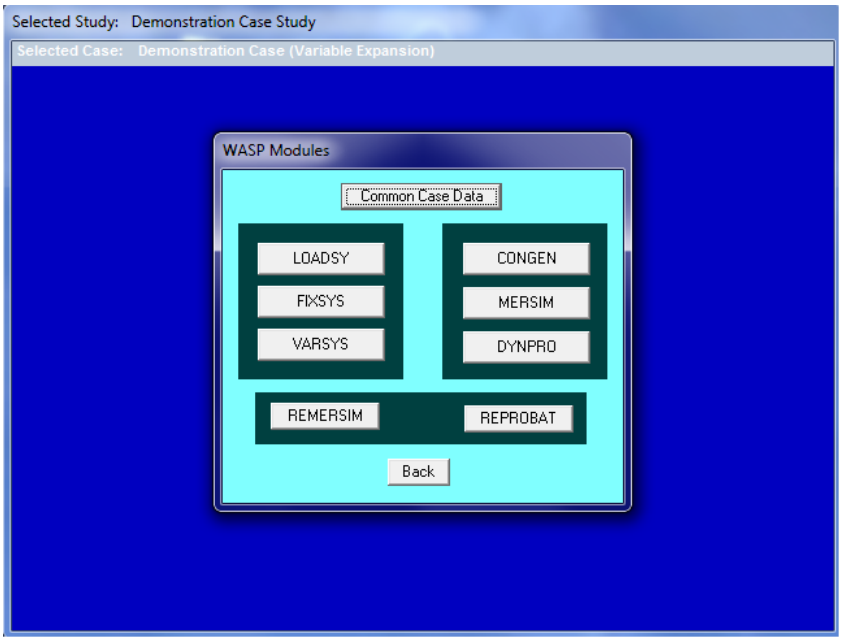
- Data For TRACE's energy benchmarking and intervention functions is provided through a database of 28 key performance indicators from 64 cities. Peer cities may be selected based on city population, climate, and human development index.
- For the sector prioritization function, users provide input data on relative energy intensity, energy sector spending, and city authority control

.

Outcomes

- Benchmarking: Visual depiction of how a city compares with peer cities
- Sector Prioritization: Comprehensive sector prioritization with quantified potential benefits
- Recommendations: A matrix of recommendations based on savings potential, first cost, and speed of implementation

Wien Automatic System Planning Package (WASP)



Typical Clients

- Energy Ministries
- Environment Ministries
- Utilities & Energy Planning Agencies
- Universities & Research institutions

Current & Past Users

- Planners and Researchers in over 107 countries
- 12 international/regional organizations

Associated Costs

- Free to Government/Public Sector organisations, Research and non-profit Institutions; and to international/ regional organisations

More Information

https://www.iaea.org/OurWork/ST/NE/Pess/capacitybuilding.html

Contact Information:

Mr Ahmed Irej Jalal, Unit Head, Planning and Capacity Building Unit (PESS.Contact-Point@iaea.org)

Wien Automatic System Planning Package (WASP)

What is it?

WASP is the IAEA's long-standing model for analysing expansion plans for electricity generation. Initially developed in the 1970s, it has been enhanced and upgraded over time to match emerging needs and allow analysis of contemporary issues. It is one of the most widely use model for developing least-cost expansion plan.

Key Goals

WASP is an exceptionally effective tool for power planning in developing countries. It permits the user to find an optimal expansion plan for power generation over a long period of time and within the constraints identified. This may include fuel availability, emission restrictions, system reliability, etc. Each sequence of power plants that could be added and which meets the constraints, is evaluated by a cost function of capital, fuel, O&M, fuel inventory, salvage value of investments and cost of energy demand not served.

Data Inputs

- Load forecast
- Existing generating infrastructure
- Candidates for new build
- Constraints:
  - ✓ Reliability
  - ✓ Implementation
  - ✓ Fuel
  - ✓ Generation
  - ✓ Emissions

Outcomes

- Build schedule of new generating capacity
- Generating mix
- Fuel mix
- Costs
- Emissions