Greenhouse Gas Mitigation Modelling Tools Webinar Series 2023

Introduction to LEAP:

Low Emissions Analysis Platform

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SEI's Energy Modeling Program

Stockholm Environment Institute

- **Bridging science and policy** – an independent, non-profit research institute focused on sustainable development
- Commitment to **stakeholder inclusion**, **capacity development**, and **transparency**

Energy Modeling Program

- Develop the **Low Emissions Analysis Platform (LEAP)** and **Next Energy Modeling system for Optimization (|nemo)**
- Host and administer **leap.sei.org** (> 62,000 members)
- Conduct **modeling, policy analysis, and capacity building projects** in support of climate mitigation, energy planning, and sustainable development

LEAP | nemo

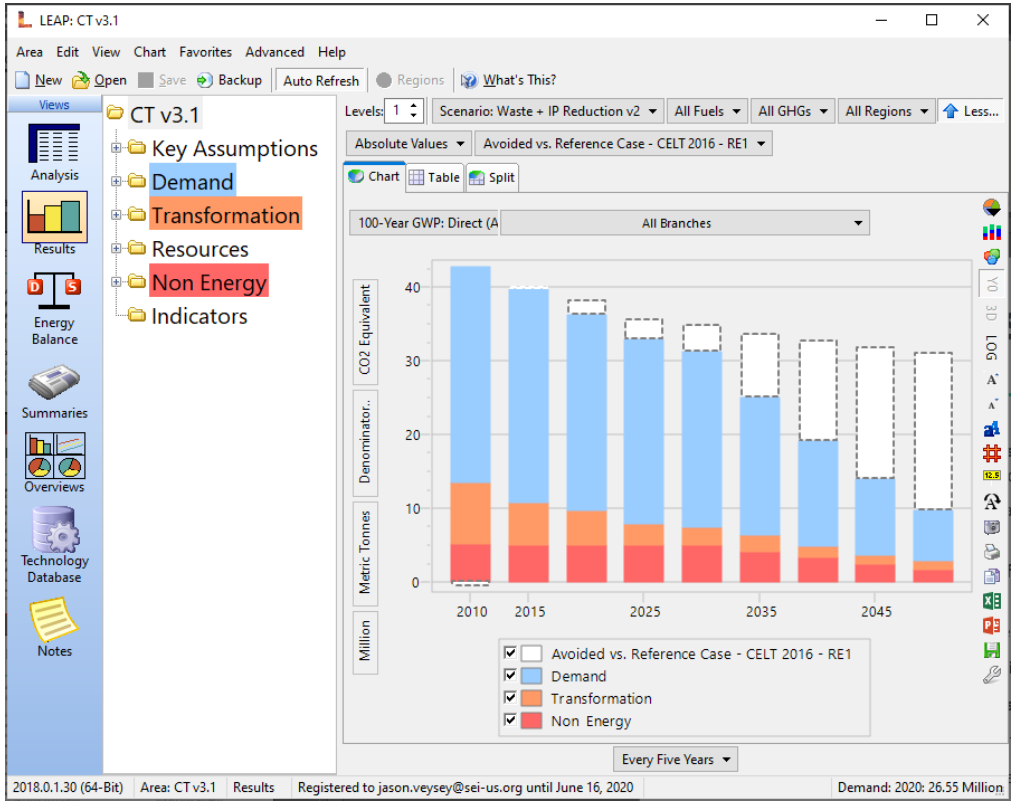
What is LEAP?

- A software tool for **quantitative modeling of energy systems, pollutant emissions from energy and non-energy sources, costs and benefits**, and related externalities
- Created by SEI to **support sustainable development**
  - Inform decision making
  - Empower stakeholders to perform their own analyses
- Well-suited to **medium and long-term planning**
- Supports data management and **documentation**, **visualization** of results, and **stakeholder engagement.**

LEAP is not a model: it's a **tool for creating models**

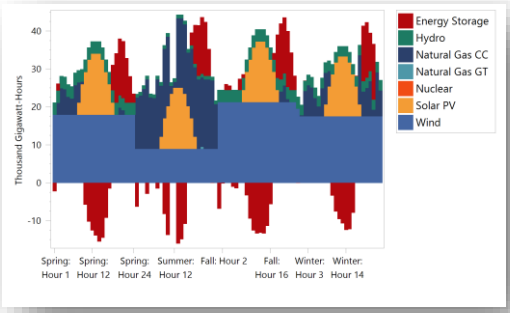
Key characteristics

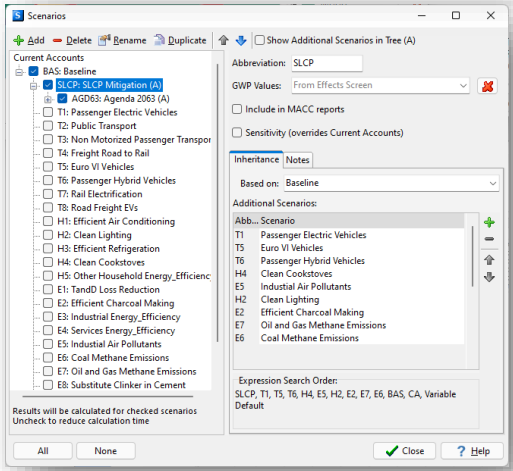
- **Scenario-based**: scenarios for different policies, assumptions, analytical questions
- Useful for **modeling at various scales**: national, subnational, regional, global
- **Designed for planners and decision-makers: not just for expert modelers.**
- Focus is on making relatively **complex modeling as easy as possible:**
  - Graphical user interface, powerful visualizations
  - Broad scope, flexible data structures
  - Capable of providing results in data-scarce environments
  - Important also for capacity building in many countries.
- **Regularly updated** with **support** available via the LEAP web forum.
- Comprehensive **training materials** are available on the website and the LEAP YouTube channel.
- Widely used for energy planning, **national communications**, low emission development strategies, SLCP action plans



Modeling Capabilities

- Wide **variety of methods** to account for diverse modeling needs and data availability.
- Simulation methods embedded in a **framework of emissions, energy, and cost accounting**
- Highly **flexible and user-editable tree data structure**. Methods can be mixed and matched among sectors. Most aspects optional.
- **Demand** methods include top-down **econometric**, bottom-up **end-use-oriented** models, and detailed **stock-turnover** modeling (e.g. for transport modeling).
- **Transformation** methods range from simple **accounting-based** models to advanced **least-cost optimization** of capacity expansion and dispatch including energy storage and sub-annual time slices. Full energy system optimization modeling coming later this year.
- Optimization modeling utilizes **NEMO**: a high-performance, open-source optimization framework supporting multiple free and commercial solvers.
- The **Integrated Debugging Environment** (IDE) makes it easy to edit, import, and process data, visualize results, and systematically debug models.
    - The expression-based data definition language (DDL) allows input variables to themselves be modeled. E.G.: technology penetration can be specified exogenously or made a function of other variables such as fuel price, device cost, income, etc.
    - LEAP can be extended using its Application Programming Interface (API) and by adding additional user-defined variables.
    - To minimize data entry, LEAP's expressions are inherited across hierarchies of scenarios. Multiple scenario inheritance allows individual "mini" scenarios describing individual policy measures to be packaged into overall integrated strategies.





Brief history

1983: Mainframe model for Kenya Fuelwood project

1985: PC version. Studies in Africa, Asia and Latin America

1992: GHG Emissions modeling

1994: Chinese version

1997: GHG Mitigation Assessments

2000: Windows version

2006: API allowing links to other models

2011: Least-cost optimization modeling

2012: "Energy for a Shared Development Agenda": Global Energy Model

2013: Energy-Water nexus analysis: link to WEAP water planning tool

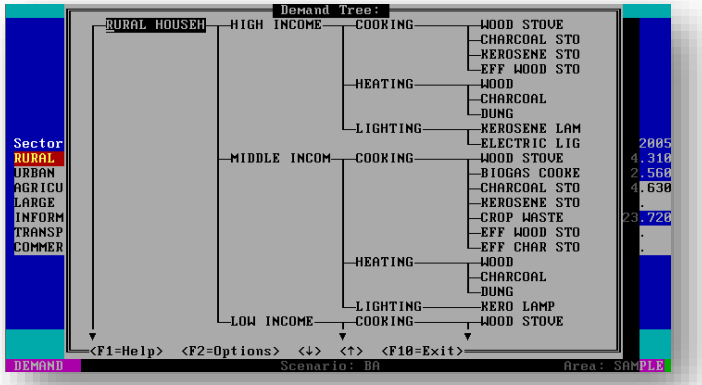
2015: LEAP-IBC**.** 38 Countries Used LEAP to Develop their INDCs for Paris COP

2016: New result visualization capabilities

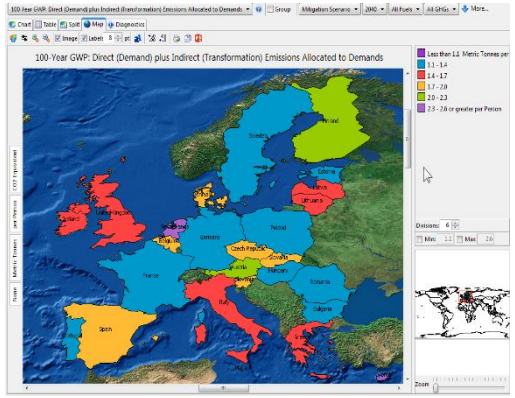
2020: Advanced optimization modeling with NEMO, new visualizations

1980 1985 1990 1995 2000 2005 2010 2015 2020

2023: Major new release with full energy system optimization and other features

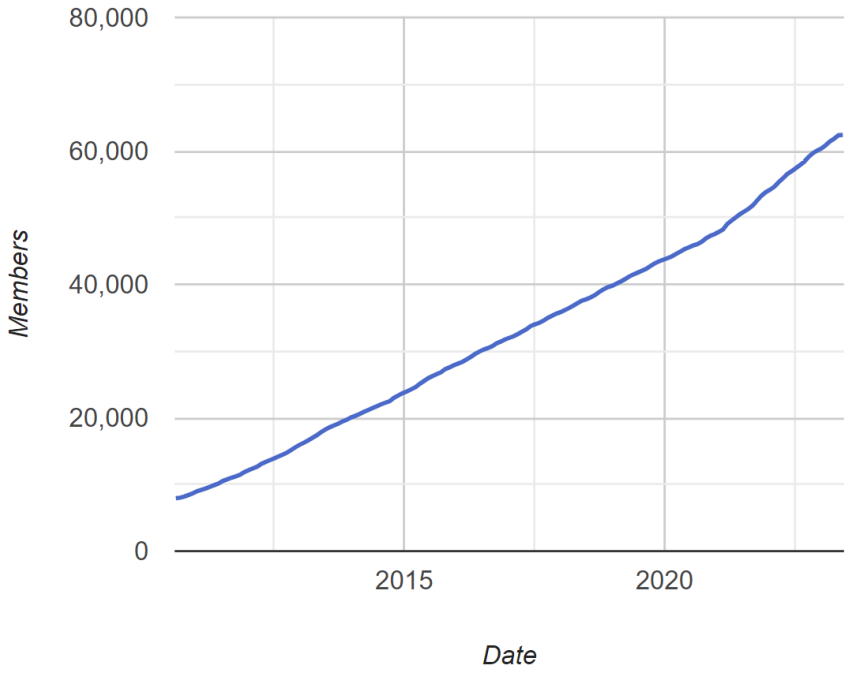


Four decades of development and implementation

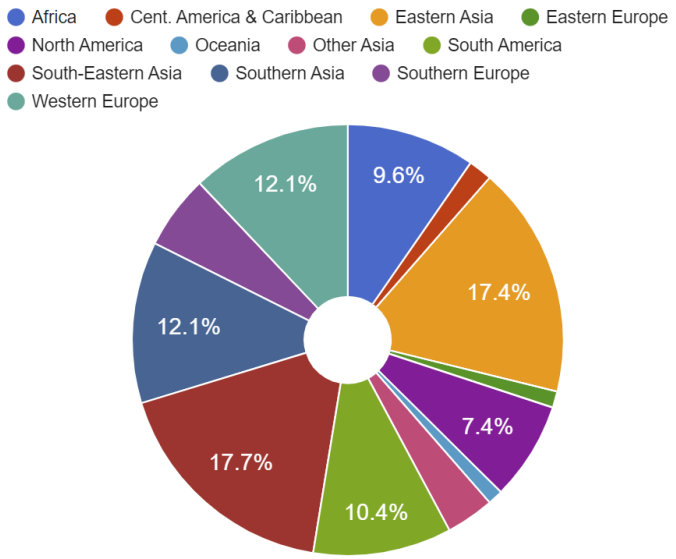


Community of practice

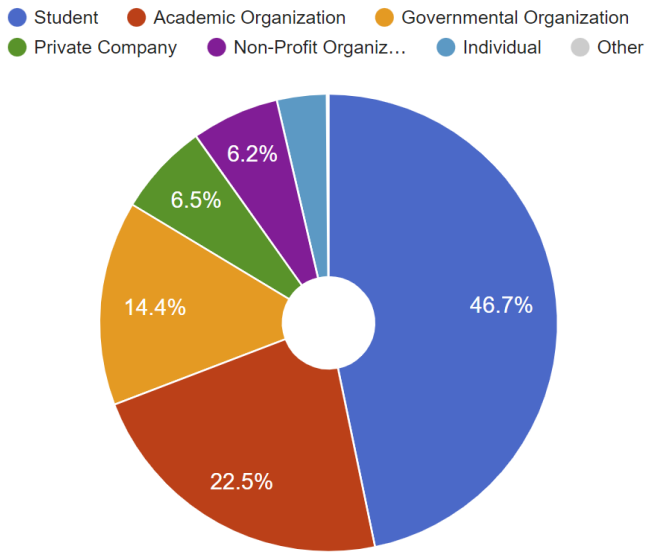
Number of LEAP users over time



Users by region



Types of users



Use for GHG Mitigation Analysis

At least 60 countries have used LEAP in their NDCs		
Armenia	Ghana	Mozambique
Albania	Haiti	Myanmar
Antigua & Barbuda	Iraq	Niger
Azerbaijan	Israel	Nigeria
Bahamas	Jamaica	Palau
Bangladesh	Jordania	Palestina
Belarus	Líbano	Filipinas
Bosnia Herzegovina	Liberia	Serbia
Bostwana	Mauritania	Uganda
Cambodia	México	Vietnam
Chile	Mongolia	Yemen
Ecuador	Montenegro	Zambia
Micronesia	Marruecos	Zimbabwe

Widely used for Nationally Determined Contributions, National Communications and Biennial Update Reports

Other countries haved used LEAP to develop:

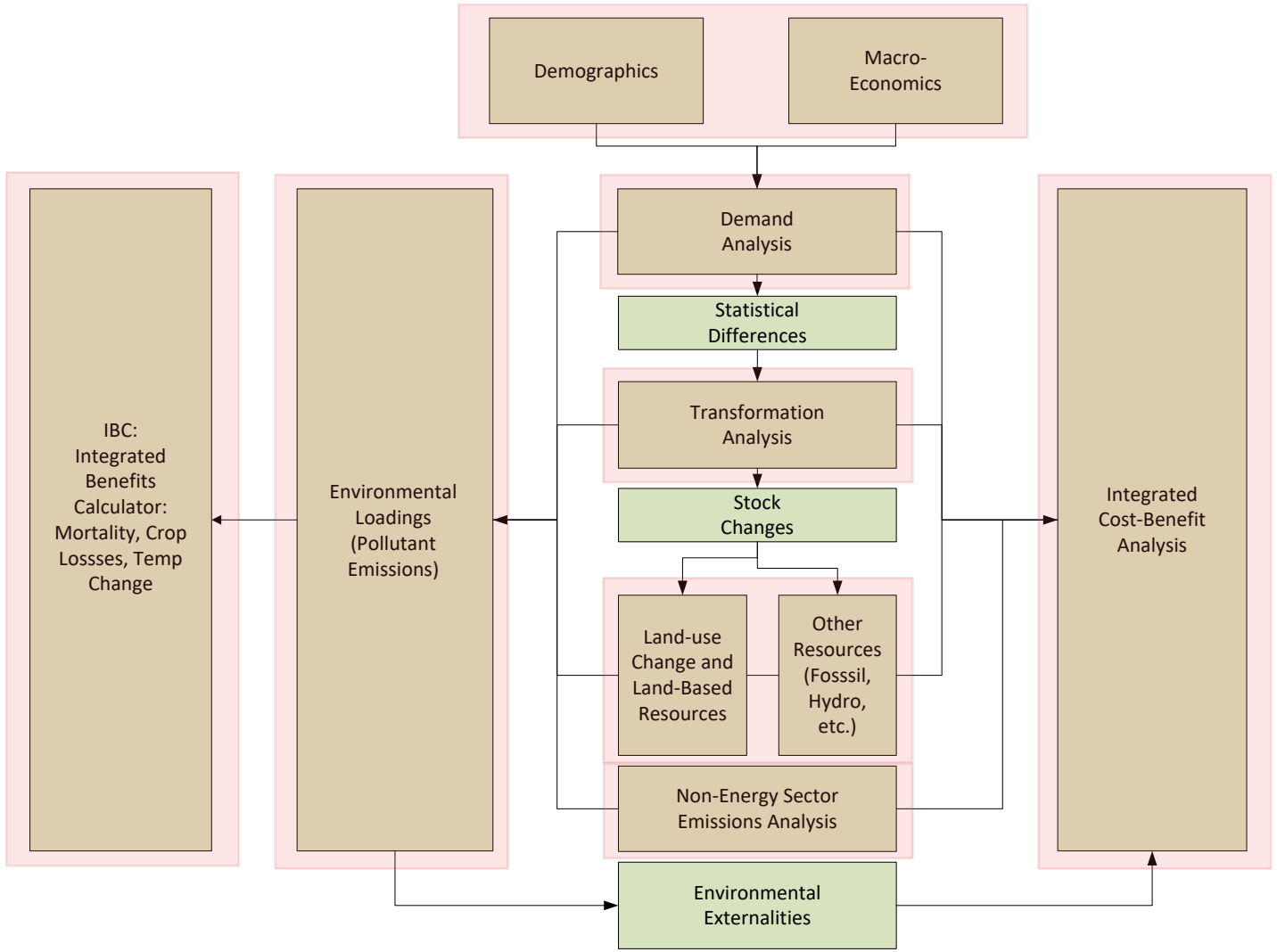
- National Communications (NCs)
- Biennial Update Reports (BURs)
- Low Emission Development Strategies (LEDS)
- Nationally Appropriate Mitigation Actions (NAMAs)
- SLCP Action Plans
- Other

Distribution

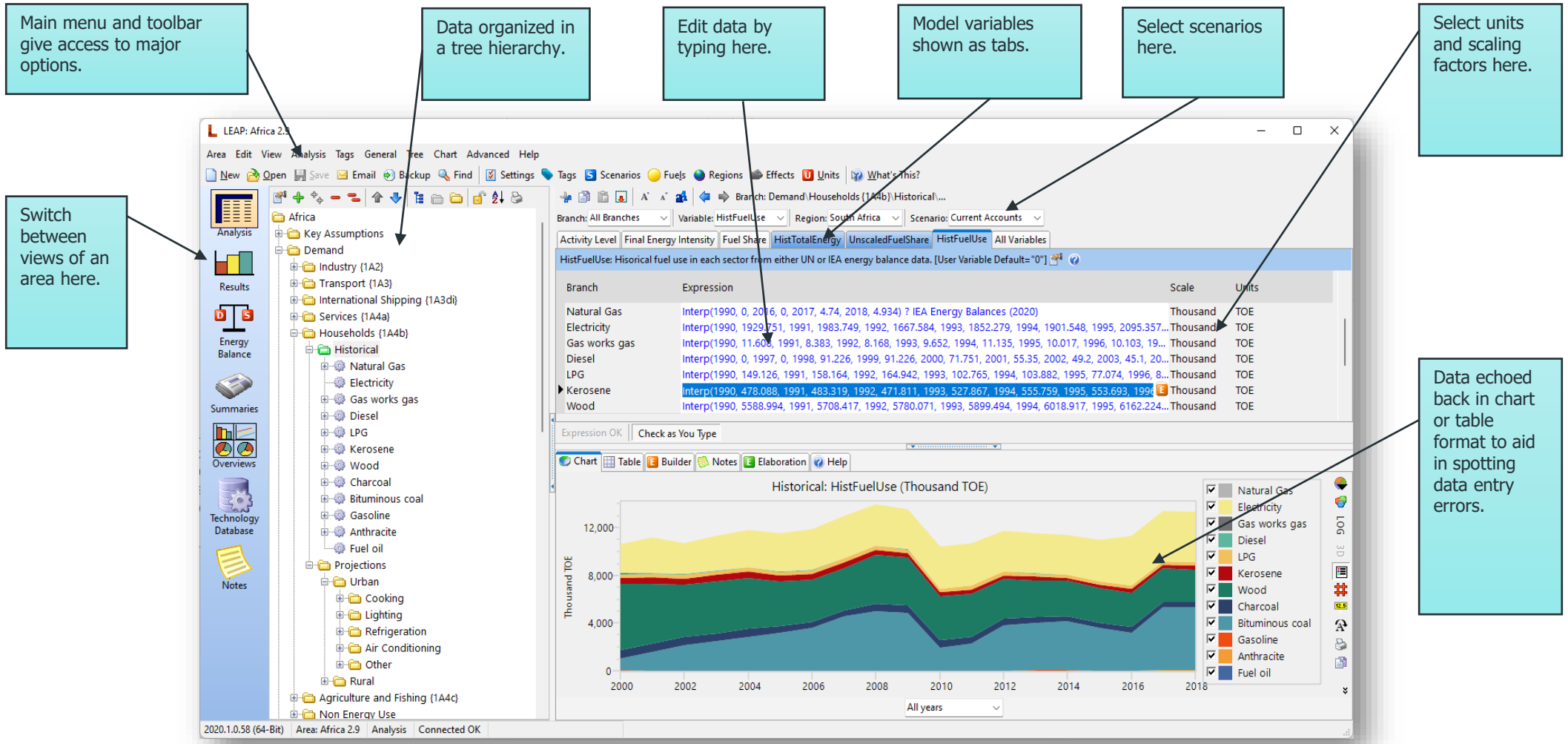
Access via the LEAP website: https://leap.sei.org/

- **User name and password** required to fully enable software. Available on completion of a **license** agreement
- License cost
  - Free for all students
  - **Free for non-profit, academic, and governmental institutions in low-income and lower-middle-income countries**
  - Nominal cost for non-profit, academic, and government users in upper-middle income countries
  - Full-cost license for all other users
- Simple and quick to apply for a license online
- **Technical support** available though LEAP website or leap@sei-us.org

Structure of a representative LEAP analysis

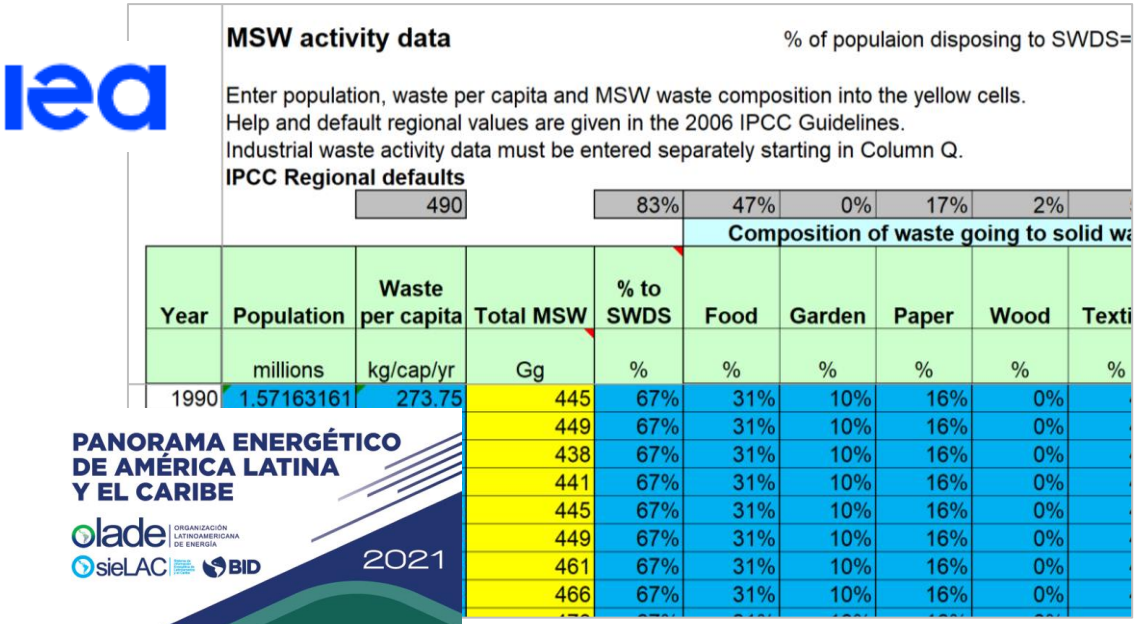


User interface



Typical inputs…

- Demographic and macroeconomic data and projections
- Energy balances, surveys, and audits
- GHG inventories
  - Activity data
  - Emission factors
  - Emission totals
- Grid operator reports
- Equipment stock, sales, and performance data
- Natural resource reserves and potentials
- Plans and policies
  - Climate
  - Energy
  - Air pollution
- Costs
  - Equipment capital, operation and maintenance
  - Fuel and other consumables
  - Policy implementation



MSW activity data % of populaion disposing to SWDS=

Enter population, waste per capita and MSW waste composition into the yellow cells.
Help and default regional values are given in the 2006 IPCC Guidelines.
Industrial waste activity data must be entered separately starting in Column Q.

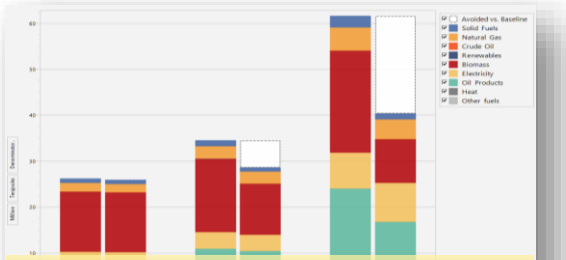
IPCC Regional defaults

		490		83%	47%	0%	17%	2%	
					Composition of waste going to solid wa				
Year	Population	Waste per capita	Total MSW	% to SWDS	Food	Garden	Paper	Wood	Texti
	millions	kg/cap/yr	Gg	%	%	%	%	%	%
1990	1.57163161	273.75	445	67%	31%	10%	16%	0%	
			449	67%	31%	10%	16%	0%	
			438	67%	31%	10%	16%	0%	
			441	67%	31%	10%	16%	0%	
			445	67%	31%	10%	16%	0%	
			449	67%	31%	10%	16%	0%	
			461	67%	31%	10%	16%	0%	
			466	67%	31%	10%	16%	0%	

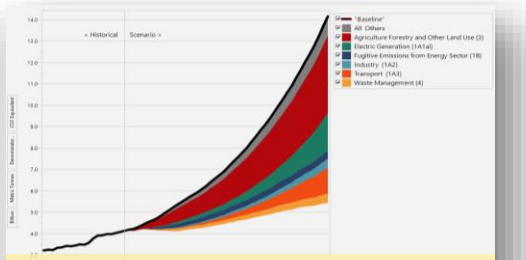
THE CENTRAL STATISTICAL OFFICE OF SAINT LUCIA

DEPICTING FACTS; DEFINING THE FUTURE.

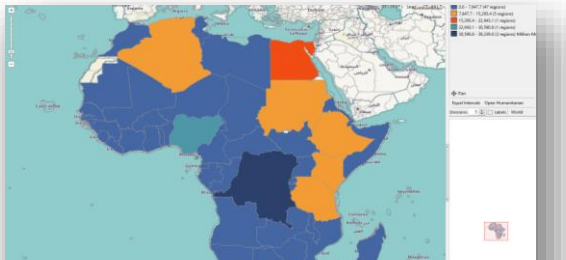
Wide range of interactive results visualizations



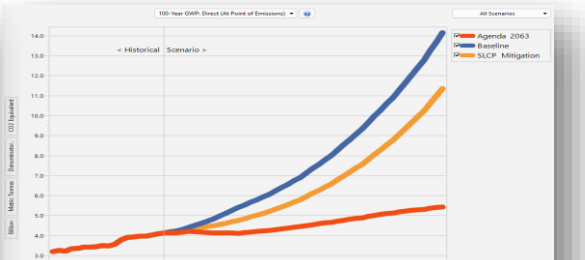
Bar charts showing results across multiple dimensions (e.g. scenarios, years & fuels)



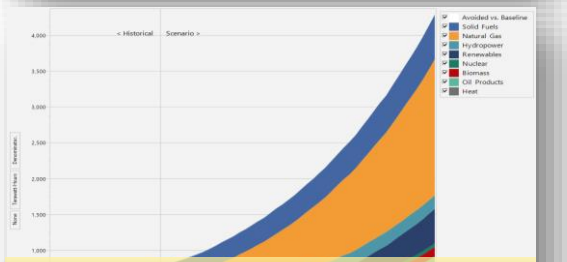
Wedge charts showing contribution of measures to policy goals



Gradient maps showing results by region

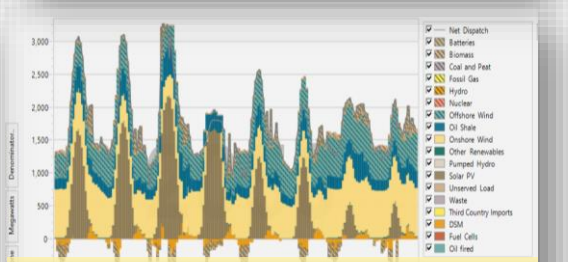


Line graphs tracking overall scenario progress

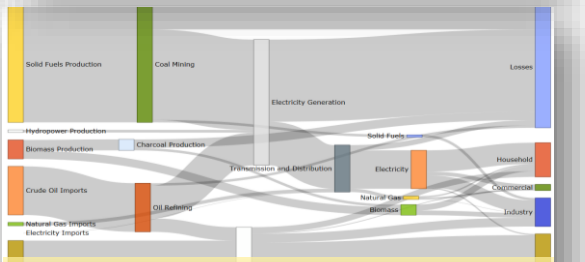


Area charts showing evolution of electric sector generation mix

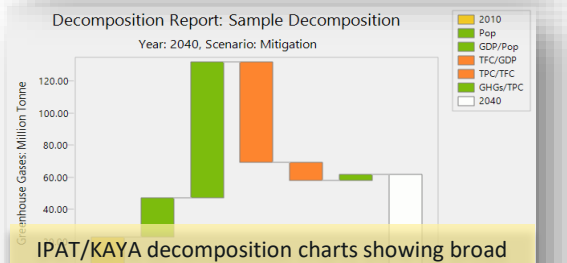
Detailed tables showing sectoral, sub-sectoral & end-use subtotals



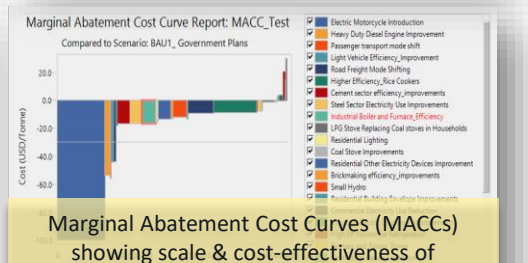
Sub-annual electric demands and generation dispatch including energy storage



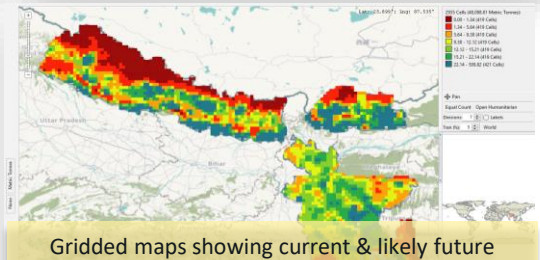
Sankey diagrams showing snapshot of annual energy flows in an energy system



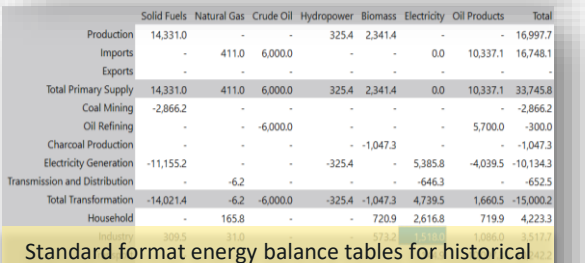
IPAT/KAYA decomposition charts showing broad trends driving scenarios



Marginal Abatement Cost Curves (MACCs) showing scale & cost-effectiveness of measures



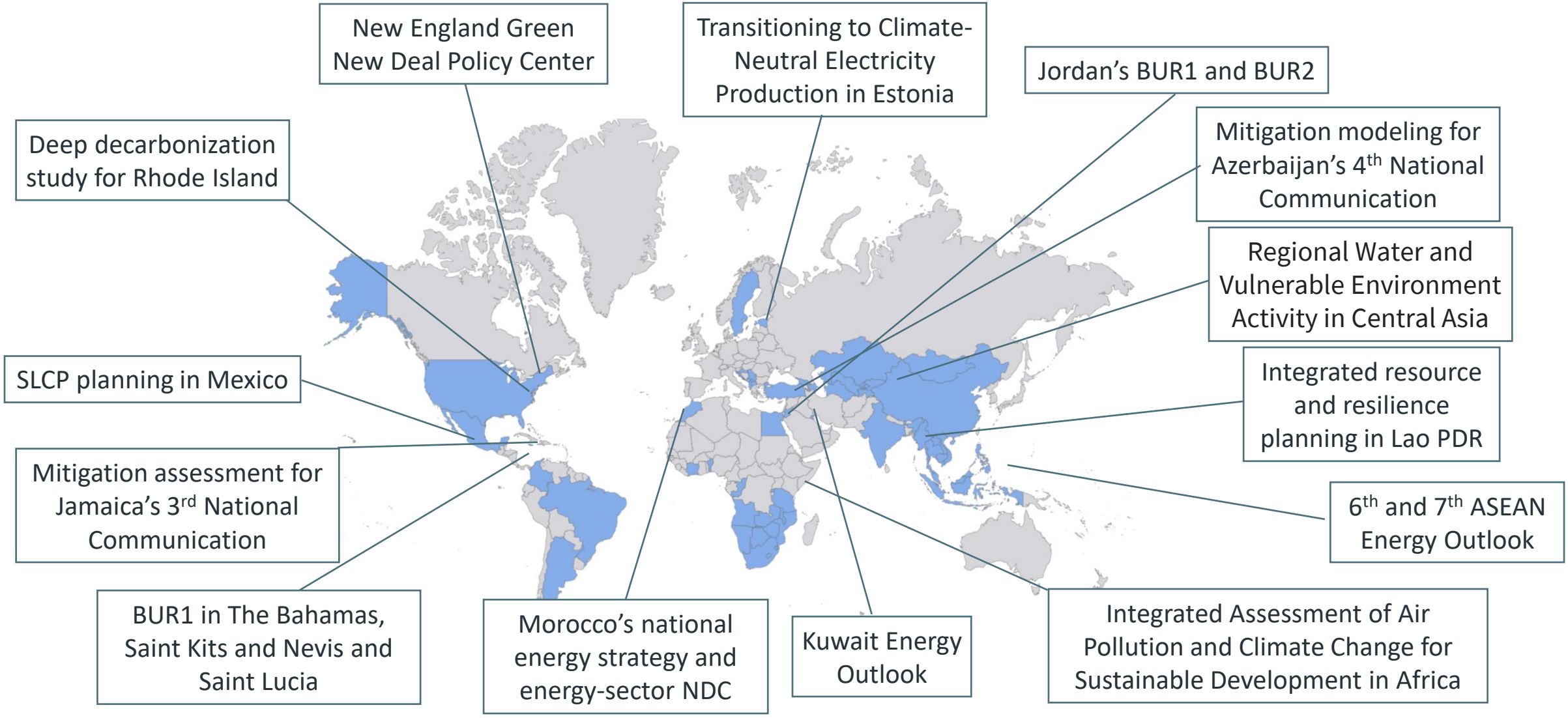
Gridded maps showing current & likely future emission hot spots



	Solid Fuels	Natural Gas	Crude Oil	Hydropower	Biomass	Electricity	Oil Products	Total
Production	14,331.0	-	-	325.4	2,341.4	-	-	16,997.7
Imports	-	411.0	6,000.0	-	-	0.0	10,337.1	16,748.1
Exports	-	-	-	-	-	-	-	-
Total Primary Supply	14,331.0	411.0	6,000.0	325.4	2,341.4	0.0	10,337.1	33,745.8
Coal Mining	-2,866.2	-	-	-	-	-	-	-2,866.2
Oil Refining	-	-	-6,000.0	-	-	-	5,700.0	-300.0
Charcoal Production	-	-	-	-	-1,047.3	-	-	-1,047.3
Electricity Generation	-11,155.2	-	-	-325.4	-	5,385.8	-4,039.5	-10,134.3
Transmission and Distribution	-	-6.2	-	-	-	-646.3	-	-652.5
Total Transformation	-14,021.4	-6.2	-6,000.0	-325.4	-1,047.3	4,739.5	1,660.5	-15,000.2
Household	-	165.8	-	-	720.9	2,616.8	719.9	4,223.3

Standard format energy balance tables for historical data & future projections.

LEAP applications worldwide



A few of SEI's LEAP applications in the region

Mitigation assessment for The Bahama's BUR1

Capacity Enhancement for Planning and Decision-Support Within the Energy Sector in CARICOM Countries

Mitigation assessment for Saint Kitts and Nevis' BUR1

Mitigation assessment for Saint Lucia's BUR1

Mitigation assessment for Jamaica's 3rd National Communication

Training and Technical support for preparing Barbados' Second National Communication

Many more examples of LEAP applications are available in LEAP's website

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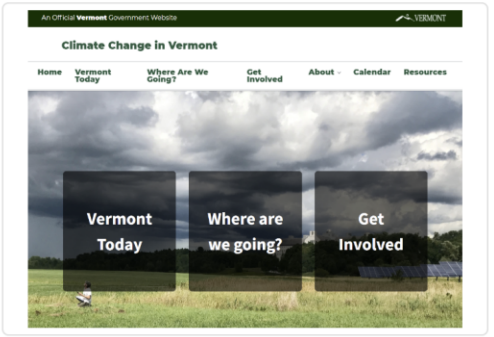
LEAP: Applications (All)

Search All

Yr	Title
2021	Vermont GHG Reduction Pathways
2019	Achieving Sustainable Development Goals in Nigeria's Power Sector
2017	Assessing the Impacts of Transport Policies in Medellín, Colombia.
2017	EnergyVision 2030 (for the Northeast United States)
2017	Thailand Energy Outlook 2016
2016	SAMSET: Supporting African Municipalities in Sustainable Energy Transitions
2016	CCAC SNAP: Supporting National Planning for Action on SLCPs
2016	B-LEADERS Philippines: Building Low Emission Alternatives to Develop Economic Resilienc…
2016	GREAT: The Green Resources & Energy Analysis Tool for China
2016	Long-Term Energy and Climate Mitigation Planning in Morocco
2016	80 Gigawatts of Change: Egypt's Future Electricity Pathways
2016	Reinventing Fire: China - A Roadmap for China's Revolution in Energy to 2050

Vermont GHG Reduction Pathways 2021

Vermont GHG Reduction Pathways



Working with the Northeast States for Coordinated Air Use Management (NESCAUM), Vermont's Agency of Natural Resources, and its Department of Public Service, SEI developed a LEAP model of Vermont to explore scenarios that achieve the GHG reduction targets for 2025, 2030 and 2050 set out in the state's Global Warming Solutions Act.

The resulting LEAP model is available here and can be viewed by anyone using LEAP. Users who wish to explore more deeply (e.g. adjust inputs or calculate results), should obtain the latest versions of LEAP and NEMO (available here). The model is setup to use the commercial CPLEX solver (available separately for purchase), but users can also select one of the other solvers supported by LEAP. We recommend using CBC which is both fast and free.

For additional information, contact Taylor Binnington.

Link to this Application.

What we're working on…

New version planned for 2023. Highlights to include:

- **Plugins:** Support for mini-models developed by subject-matter experts and maintained in online repositories. Will make model development easier and more modular: providing users with new methods and better, geographically-appropriate default data.
- **Energy System Optimization Modeling:** LEAP is currently limited to doing least-cost planning for a single sector (e.g., electric generation). The new version will support full energy system optimization (similar to tools like TIMES & MESSAGE).
- **Cloud-based Data:** A new system for connecting LEAP models to internet-hosted databases. Will simplify data collection and allow users to automatically update their models as new data becomes available. Connects to international open-source databases covering energy, emissions, and development topics (U.N. population prospects, U.N. energy statistics, Word Bank development indicators, etc., plus SEI-developed databases such as default emission factors).
- **Better Accessibility:** new translations of the software, data, training materials, and user manuals in multiple languages.

Coming a bit later:

- **Land Use Change and Forestry:** Can already be used or modeling biomass energy demand & supply and land-use change. Future versions to support modeling of the GHG emissions implications of these sectors, based on the IPCC GHG inventory guidelines.
- **LEAP for the Web:** A new web-based portal will allow users to publish the results of their LEAP models for interactive browsing by a much broader audience, without the need to download, install or license LEAP itself.

Thanks!!

For more information:

https://leap.sei.org

https://leap.sei.org/Facebook

https://leap.sei.org/Youtube