

GIZ's Clean Affordable and Secure Energy for Southeast Asia

# Phase 2 LEAP Training

29-31 October 2024  
Jakarta, Indonesia

**Jason Veysey**

Director

Energy Modeling Program, SEI US

[jason.veysey@sei.org](mailto:jason.veysey@sei.org)

**Charlotte Wagner, PhD**

Scientist

Energy Modeling Program, SEI US

[charlotte.wagner@sei.org](mailto:charlotte.wagner@sei.org)



# Presenters

---



**Taylor Binnington**

Scientist and LEAP Trainer  
Energy Modeling Program, SEI US



**Charlotte Wagner**

Scientist and LEAP Trainer  
Energy Modeling Program, SEI US



# Today's Agenda

- Introduction to LEAP 2024 – what's new
- *Short break*
- Energy demand (review)
- Energy requirements, transformation, and energy balances
- Introduction to afternoon assignment



# Coming Up...

- Other LEAP branch types
- Environmental loadings
- Cost-benefit analyses using scenarios
- Introduction to LEAP-IBC
- Walkthrough of Asiana sample dataset

# Workshop Learning Goals

---

1. Open, run, and examine existing LEAP models to get a “feel” for them,
2. Create new scenarios in existing LEAP models by revising energy, emissions or cost assumptions, or by adding new technologies,
3. Navigate scenario results,
4. Feel equipped to add new components or sectors to a LEAP model, or to rework the modeling of existing sectors,
5. Diagnose simple problems with existing LEAP models, and know how to ask for help.

# Logistics

---

**Questions:** Raise your hand, and if we don't notice, please flag down one of the in-person facilitators

**Chat screen:** *Not monitored*

**File sharing:** <https://tinyurl.com/Phase2GIZTraining>

# Software Registration

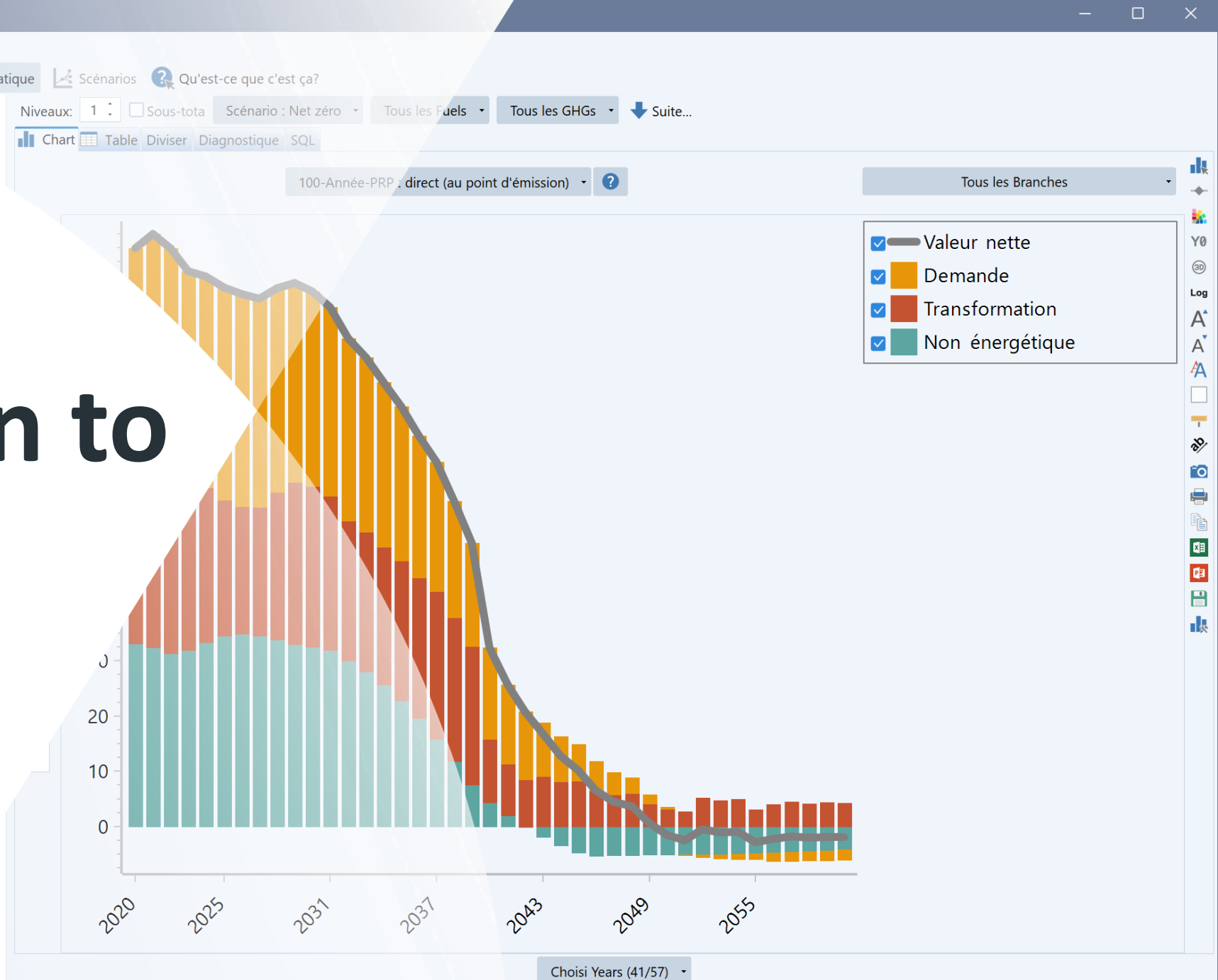
---

**Username:** CASE Phase 2 Training

**Password:** 897-734-988-095-426

Enter the above in LEAP by selecting **Help:Register** (not Help:Register Online). You may "skip" any request to enter your email address or username.

# Introduction to LEAP 2024





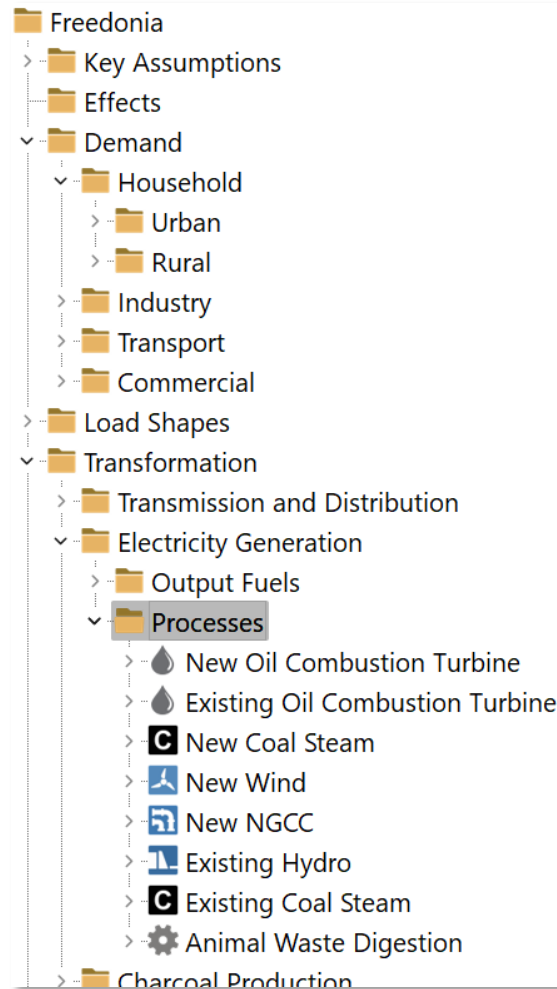


# What Is **LEAP**? (A quick reminder)

- A Windows-based software tool for energy, climate change mitigation, and air pollution planning, with a focus on scenario analysis.
- Widely applied by thousands of users in almost every country at multiple scales: global, continental, national, subnational, city-scale.
- Covers all fuels, all sectors, and all pollutants: including both energy and non-energy sectors.
- Not just for modeling – also supports data management, results visualization and stakeholder engagement.
- Promotes a needs-based and end-use oriented approach to modeling with flexible data structures and a wide choice of modeling methods.

# The LEAP Tree

---



- **Defines a model's structure** – organizes input data and results
- Made up of **branches**; each branch contains context-dependent **variables**
- LEAP sets top-level branches depending on model's scope; other branches generally **determined by user**
- Supports standard graphical user interface interactions – copy & paste, click & drag

# Tree Branch Typology

---



- **Categories:** often for organizing other branches or specifying energy consumption of a group of fuels together

- **Technology** branches represent devices or processes which produce/consume fuel. Three basic types:



- **Activity Level Analysis (on demand side) or Transformation Process (on supply side)**



- **Transport Analysis (demand side only)**



- **...other branch types**



- **Key Assumptions:** independent variables (demographic, macroeconomic, etc.)



- **Fuels**



- **Effects:** environmental loadings (emissions) or other environmental externalities



- **Indicators:** custom output variables – used to store complex expressions or perform calculations which are not part of LEAP's default results

# Expressions

---

ptions

on

old Size

olds

Growth\_Rate

wth\_Rate

Key Assumptions

Key Assumptions: Macroeconomic, demographic or other variables not entered elsewhere. [Default="0"] ?

Branch	2020 Baseline Scenario	Value	Expression	Scale
Income	3.0		Growth(Income Growth_Rate[%]/100)	Thou

Expression OK Check as You Type

Chart Table Builder Notes Elaboration Help

Switch Restore Date Search Variable All Function Time Series Wizard Growth

Growth(Income Growth\_Rate[%]/100)

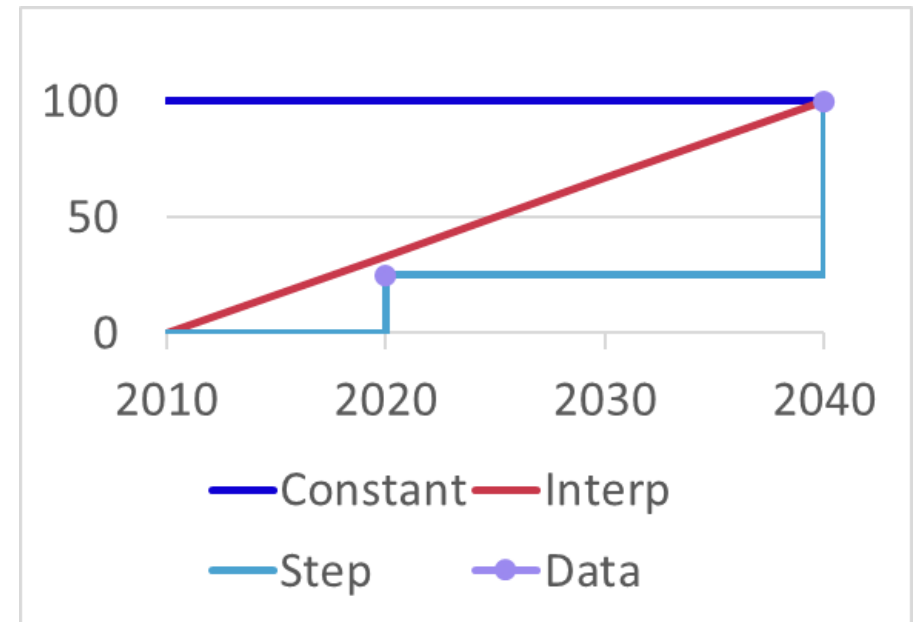
## A good analogy: Excel formulas

- Expressions resolve to a numerical value for all years, or a special instruction to LEAP
- Expressions can include:
  - Numbers
  - Built-in functions
  - References to other variables elsewhere in the model
  - References to values outside the model

# Expressions and Time Series Data

An expression in LEAP defines a value for a branch, variable, and region in each year of a scenario

- **100** => constant value in all years
- **Interp(2010, 0, 2040, 100)** => linear interpolation between specified points
- **Step(2010, 0, 2020, 25, 2040, 100)** => step-wise interpolation between specified points
- **Data(2020, 25, 2040, 100)** => specified points only (0 in all other years)



# Expressions: Ways to Edit

## In Analysis view...

- **Type** to directly edit an expression
- Use **Expression Builder** to make an expression by dragging and dropping functions and variables
- Choose **Function Wizard** for help selecting a built-in function
- Use **Time-Series Wizard** to enter time-series functions and data (Interp, Step, etc.)
- There are also multiple ways to import and export data from/to **Excel**

The screenshot displays the LEAP: Freedonia software interface. The main window shows the 'Analysis' view with a tree structure of 'Key Assumptions' including Income, Population, Household Size, Households, GDP, Income Growth\_Rate, Pop Growth\_Rate, and End Year Urbanization. The 'Income' variable is selected, and its value expression is shown as  $3.0 \text{Growth}(\text{Income Growth\_Rate}\%)/100$ . The 'Expression Builder' is open, showing the same expression. The 'Function Wizard' is also open, showing the 'Growth' function selected. The 'Time-Series Wizard' is open, showing the 'Interpolate' function selected. Red arrows point from the text in the list to the corresponding elements in the software interface.

# LEAP Glossary

---

## Area

- A LEAP model or the system being modeled. Areas may be divided into multiple geographic regions.

## View

- A screen in the LEAP interface used to perform a set of related functions (e.g. Analysis, Results).

## Current Accounts

- A special “scenario” containing historical data beginning in the **Base Year**. Every model includes Current Accounts.

## Scenario

- A set of model inputs and results corresponding to a possible state of the world. Scenarios begin in the **First Scenario Year**, and end in the **End Year**.

## Tree

- A hierarchical data structure that organizes a model’s inputs and results.

## Branch

- An item in the tree: categories, technologies, modules, processes, key assumptions, etc.

## Variable

- An input variable for a model, contained in a branch. Branches may have multiple variables, which are shown in tabs on screen.

## Expression

- A formula that specifies time-series values of a variable for a given branch, scenario, and region.

# Why a New Version?

---

- At SEI, we aim to boost energy, climate & air pollution policy-making by making policy-relevant analyses
  - easier to undertake,
  - more accessible
  - more rigorous
  - more credible
  - more inclusive
  - better able to address important emerging concerns
- New version of LEAP pushes forward over all these dimensions.

## New version FAQ

- **Compatibility:** New version is fully backwards compatible with earlier versions.
- **Hardware/software requirements:** any standard Windows-based PC with 2 GB RAM. 32-bit or 64-bit.
- Can also be used on an Apple Mac via a Windows virtual machine (e.g., VMWare Fusion or Parallels).
- **Use with existing LEAP License?** Yes! No charge to upgrade.
- **Licensing:** All users require a license. Licenses are available at no cost to Governments, NGOs and academics in low-income and lower-middle-income countries and substantially discounted for these users in upper-middle-income countries. Free for students worldwide.



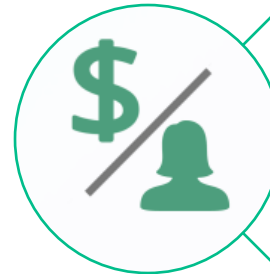
# Introducing the New Features

---



## Full Energy System Optimization Modeling

- Powerful and easy-to-use methods for modeling holistic decarbonization pathways.



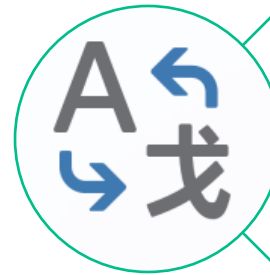
## Energy Affordability Analysis

- A new approach for studying the affordability of pathways for marginalized communities: helping to highlight social and environmental justice concerns.



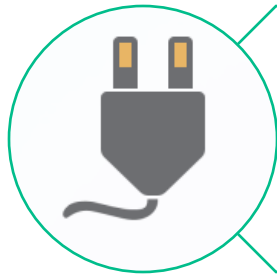
## The LEAP Cloud Data Server (LCDS)

- Simplifying data collection and model maintenance.



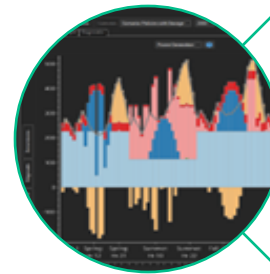
## Accessibility

- New translations of the LEAP user interface in 14 languages: making it more accessible and helping to improve engagement between modelers and stakeholders.



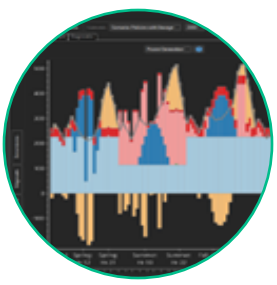
## Plugins

- Simpler, more modular, and more community-based model development.



## User Interface (UI)

- Major revamp of the user interface making it easier and more enjoyable to use, while still being immediately recognizable for existing users.

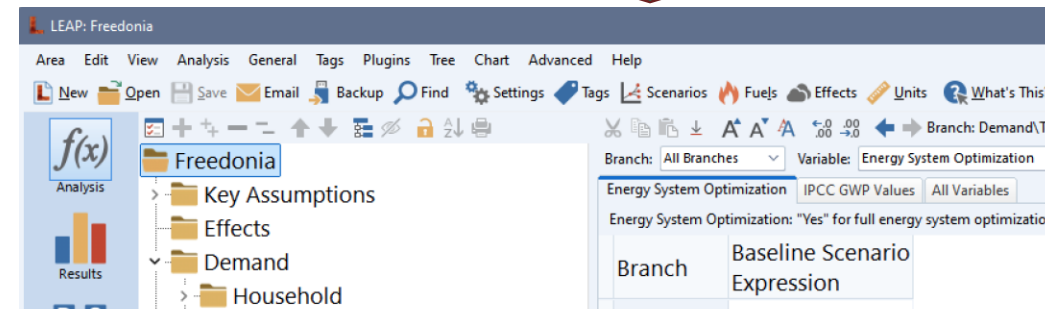
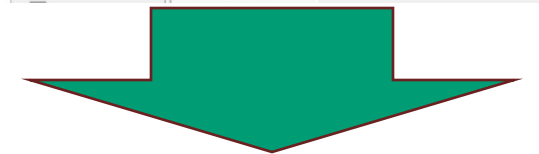
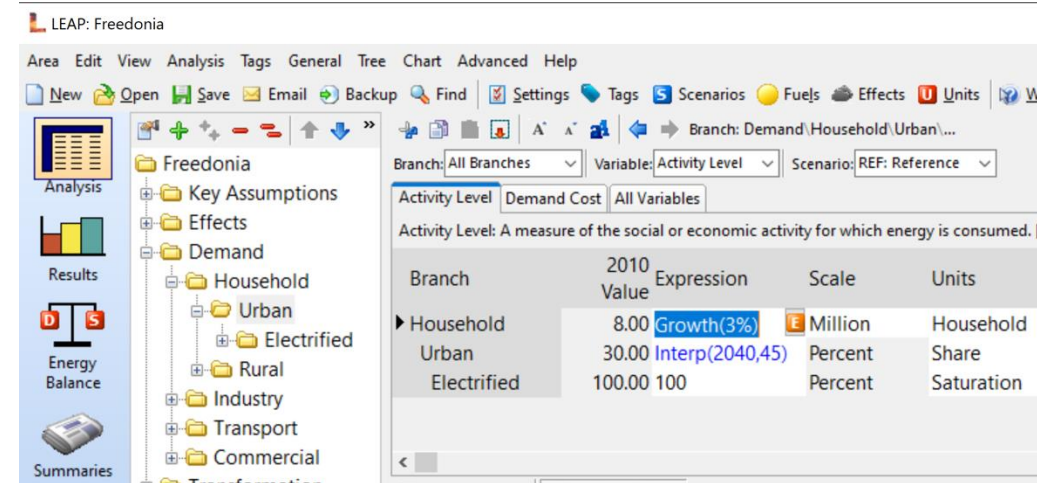


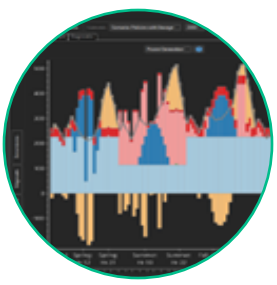
# A Modern User Interface

## Major user interface (UI) revamp

Making it more professional looking, more configurable, and easier and more enjoyable to use:

- updated icons
- support for the latest high-resolution monitors
- better use of color
- support for both light and dark themes





# A Modern User Interface

---



Bookmarks to make navigating within your models more convenient



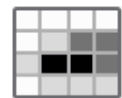
Improved editing and documentation features



An expanded “view bar” highlighting LEAP’s analysis and results visualization abilities



A brand-new online context-sensitive help system reflecting all the recent changes to LEAP



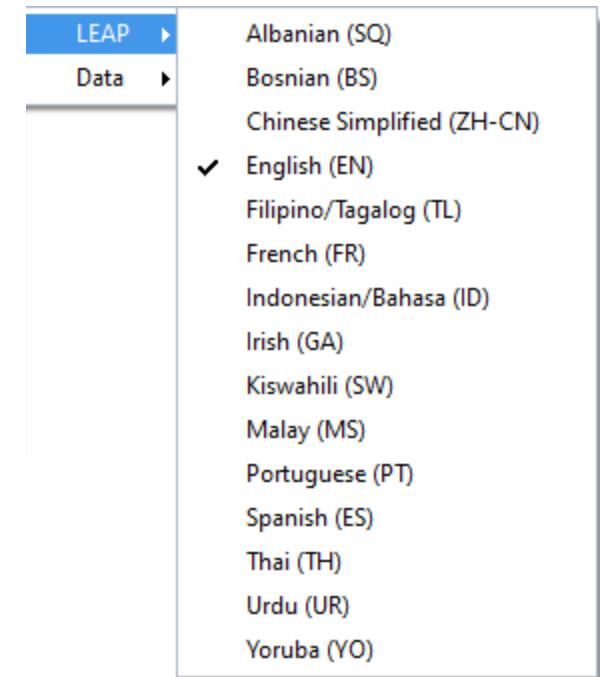
Heat maps to help you quickly identify the most important numbers in your analysis.



# Accessibility

Translations of the UI and data structures make it more accessible and help improve engagement.

- Software translations in 14 languages (more to come!)
- Uses Google Translate and volunteer review.
- Your own model (branch names, fuels, scenarios...) can also be Google Translated to any language and you can easily switch among languages.





# Accessibility

How to use?

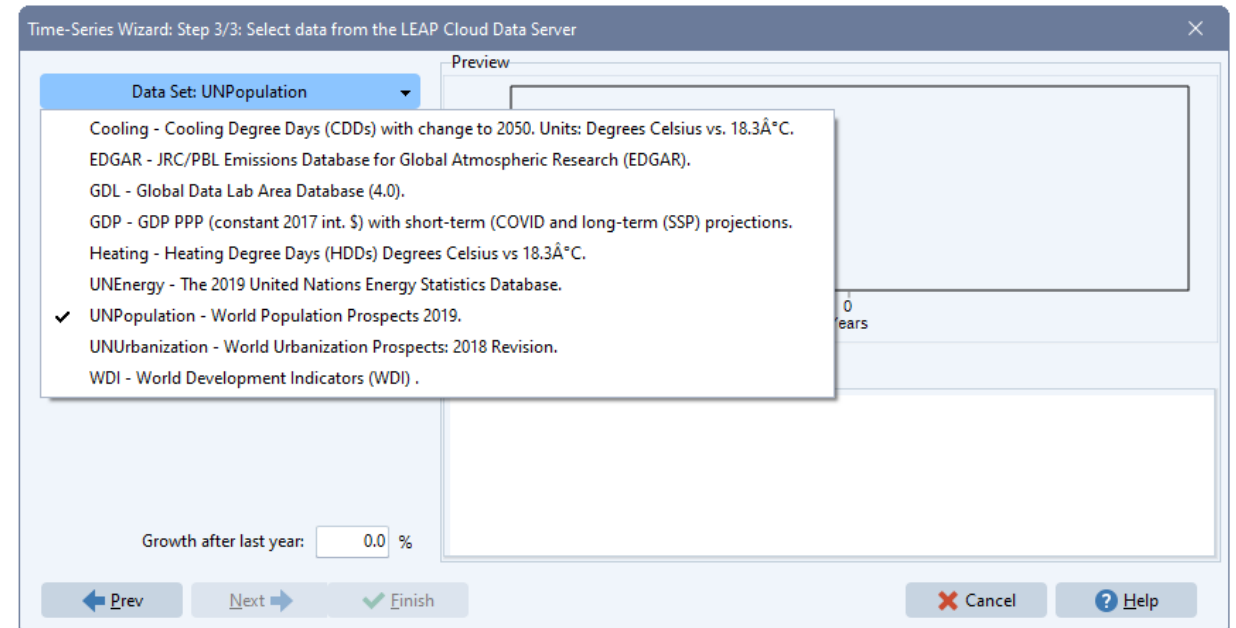
The screenshot displays the LEAP software interface for 'Freedonia'. The 'Area' menu is open, showing options like 'New', 'Open', 'Save', and 'Language'. The 'Language' sub-menu is also open, listing various languages such as 'Albanian (SQ)', 'English (EN)', and 'Indonesian/Bahasa (ID)'. The 'Indonesian/Bahasa (ID)' option is currently selected. The background shows the main software interface with a toolbar and a data entry field for 'Module Costs'.



# The LEAP Cloud Data Server (LCDS)

A new easy-to-use system for connecting LEAP models to an internet-hosted database containing international open-source data covering energy, emissions, and development topics.

- Simplifies model development, data collection and model maintenance
- **Phase 1 (available):** nationally-oriented statistics useful to energy modelers
- **Phase 2 (coming next):** technology-oriented data





# The LEAP Cloud Data Server (LCDS)

## How to use?

- Set country in settings
- Create variables that shall link to database
- Open Time Series Wizard
  - In Window 2/3 select LEAP Cloud Data Server
  - Choose dataset from list
- Available databases : UNPopulation, UNEnergy, UNUrbanisation, Edgar, Cooling and Heating Degree Days
- Download requires internet connection, but afterwards data is cached on local machine
- LEAP will notify you of updates

LEAP: affordability\_demo

Area Edit View Analysis General Tags Plugins Tree Chart Advanced Help

New Open Save Email Backup Find Settings Tags Scenarios Fuels Regions Eff

Branch: Key Assumptions

Branch: All Branches Variable: Key Assumption Region: Regi

Key Assumptions

Key Assumptions: Macroeconomic, demographic or other variables not en

Branch 2020 Baseline Scenario Scale Uni

Value Expression

Time-Series Wizard: Step 2/3: Select Data Source

Keyboard

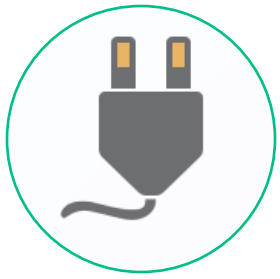
Excel

LEAP Cloud Data Server

Preview

Interp

Prev Next Finish



# Plugins

---

**A new modular and community-based architecture for LEAP models, streamlining model development with easy-to-integrate “mini models”.**

- Plugins contain suggested data structures and default data.
- Helps promote standardized methodologies for modeling particular sectors or industries.
- Developed and maintained by subject-matter experts and shared with the wider LEAP community via an online repository (coming soon!).
- When used with LCDS can include default data that varies by country.

Demo: <https://tinyurl.com/LEAPclouddata>





# Energy System Optimization Modeling

---

- For many years LEAP has supported a wide choice of methods including both simulation and optimization
- Until now, LEAP was limited to doing partial optimization of only a single sector in an energy system (e.g., electric generation). **Now, LEAP supports full least-cost energy system optimization**
  - takes full advantage of the capabilities of NEMO (LEAP's companion optimization modeling tool)
  - allows optimizing selected demand end uses, and can model pipeline & transmission networks, in addition to optimizing all of Transformation
  - makes full use of the data already entered in a LEAP model – allowing you use LEAP's scenario management and data definition language
  - all results can be viewed directly within LEAP in standard formats familiar to planners.
  - can be conducted for specific scenarios and results compared to those calculated in simulation- or partial optimization-based scenarios.
  - Enables specification for overall constraints on GHGs and other pollutant emissions and calculation of least-cost energy system configuration that meets those constraints

**Key for modeling deep decarbonization & net zero pathways**



# Energy System Optimization Modeling

## How to use?

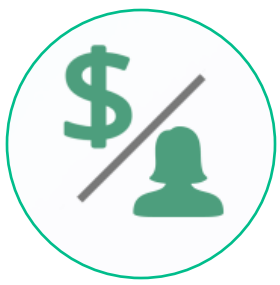
- Install LEAP and NEMO (NEMO is a requirement)
- Set up your LEAP model
- Turn on full energy optimization for your model (partial energy system optimization is still possible)
- Choose optimization algorithm (*Highs* is recommended)
- Where necessary, add additional data into additional variable relevant for optimization
  - Costs
  - Lifetime
  - Capacity addition size
  - ....
- Possibility to set system wide prices for carbon or other pollutants (externality cost)

Demo: <https://tinyurl.com/LEAPoptim>

The screenshot displays the LEAP: Freedonia software interface. The main window shows a tree view of the model structure, including folders for Key Assumptions, Effects, Demand, Load Shapes, Transformation, Transmission and Distribution, Electricity Generation, Charcoal Production, Oil Refining, Coal Mining, Resources, and Non Energy. The Transformation folder is expanded, showing sub-folders for Processes, Electricity Generation, Charcoal Production, Oil Refining, and Coal Mining. The Transmission and Distribution folder is also expanded, showing sub-folders for Processes, Electricity Generation, Charcoal Production, Oil Refining, and Coal Mining. The interface includes a menu bar with options like Area, Edit, View, Analysis, General, Tags, Plugins, Tree, Chart, Advanced, and Help. A toolbar contains icons for New, Open, Save, Email, Backup, Find, Settings, and Tags. The main workspace shows a table with the following content:

Branch	Baseline Scenario	Expression
Freedonia	No	

Below the table, there are buttons for "Expression OK" and "Check as You Type". The interface also features a sidebar with various analysis and visualization tools, including Analysis (f(x)), Results (bar chart), Energy Balance (D/S), Sankey Diagram, and Cost-Benefit (+\$/\$).



# Energy Affordability Analysis

---

**Considering environmental justice implications of different energy and climate policy options is key to achieving a just clean energy transition**

## **New Affordability Feature:**

- Study the affordability of policy pathways for different groups
- Examine impacts on:
  - Total energy costs
  - Total device costs
  - Energy affordability (typical threshold is 4% of annual income)
  - Energy uses and prices by group
- Enables specification of targeted subsidies or tariffs for specific groups, fuels, and technologies



# Energy Affordability Analysis

## How to use

- Turn on Affordability analysis in *Settings* and *Fuels* database
- Set up demand structure to represent different user groups and turn on Affordability branch in Properties
- New variables annual income, fuel prices and customer costs and demand costs allow specification of differential investment costs and energy prices
- New *Tariff()*-function enables specification of differential energy tariffs for different users under Energy Costs
- Key results are presented in Affordability View and can be used to analyse affordability

Demo: <https://tinyurl.com/LEAPaffordability>

LEAP: affordability\_demo

Area Edit View Advanced Help

New Open Save Email Scenarios What's This?

Summary: Affordability Summary Edit Manage Summaries Units: U

Branches: All Columns: Every Five Years Scenario: Bas

Chart Table

	Affordability: Annual Energy Costs Every Five Years, 2020-2035			
Branch	2020	2025	2030	2035
Household:Low income				
Energy Costs				
Electricity	\$164.0	\$82.0	\$82.0	\$82.0
Kerosene	-	-	-	-
LPG	\$232.3	\$232.3	\$232.3	\$232.3
Wood	\$146.6	\$146.6	\$146.6	\$146.6
Charcoal	\$32.2	\$32.2	\$32.2	\$32.2
Total Energy Costs	\$575.1	\$493.1	\$493.1	\$493.1
Device Costs				
Electricity	\$58.4	\$57.6	\$57.6	\$57.6
Kerosene	\$1.5	\$1.5	\$1.5	\$1.5
LPG	\$53.4	\$53.4	\$53.4	\$53.4
Wood	-	-	-	-
Charcoal	\$0.2	\$0.2	\$0.2	\$0.2
Total Device Costs	\$113.5	\$112.7	\$112.7	\$112.7
Additional Customer Costs	-	-	-	-

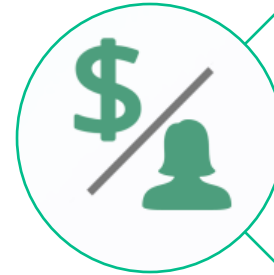
# Recap: New Features

---



## Full Energy System Optimization Modeling

- Powerful and easy-to-use methods for modeling holistic decarbonization pathways.



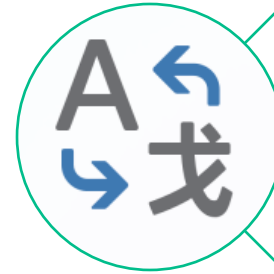
## Energy Affordability Analysis

- A new approach for studying the affordability of pathways for marginalized communities: helping to highlight social and environmental justice concerns.



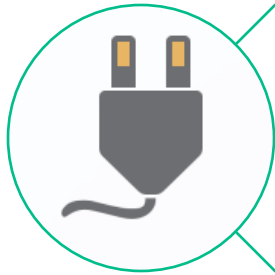
## The LEAP Cloud Data Server (LCDS)

- Simplifying data collection and model maintenance.



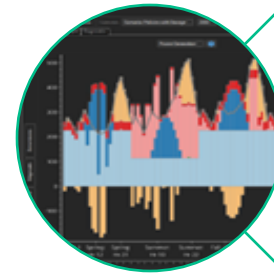
## Accessibility

- New translations of the LEAP user interface in 14 languages making it more accessible and helping to improve engagement among modelers and stakeholders.



## Plugins

- Simpler, more modular, and more community-based model development.



## User Interface

- Major revamp of the user interface making it easier and more enjoyable to use, while still being immediately recognizable for existing users.

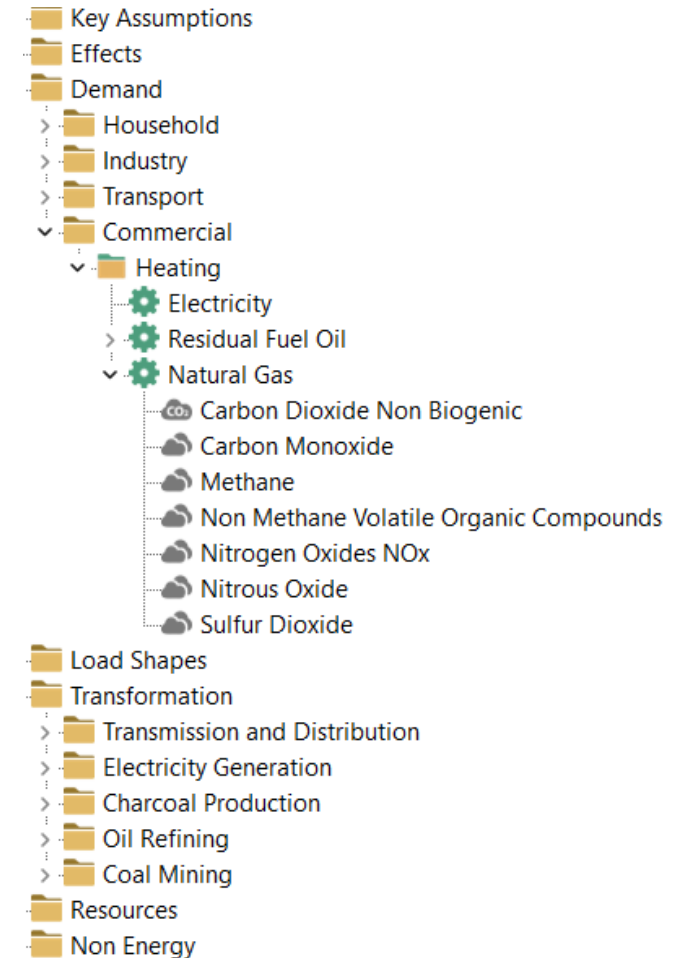


# **Demand Analysis in LEAP: Quick Review**

# Demand Modeling Overview

---

- Final energy consumption of each fuel represented within LEAP's Demand branches
- Significant flexibility in representing final energy demands in model. Demand branches may be used to:
  - Include additional levels of disaggregation
  - Represent individual technologies or whole categories of fuel consumption
  - Organize different projection methods



# Activity Analysis

Energy demand calculated as follows:

$$E = AI$$

- Where:  $E$  is energy demand,  $A$  is activity level, and  $I$  is energy intensity (energy per unit of activity)
- For example – energy demand in the cement industry can depend on changes in both the quantity of cement produced, and the energy required to produce each tonne of cement.

Add Branch Under: Rail ✕

Name:

Type:

Options:

Energy Demand:

Fuel:

Add Branch Under: Commercial ✕

Name:

Type:

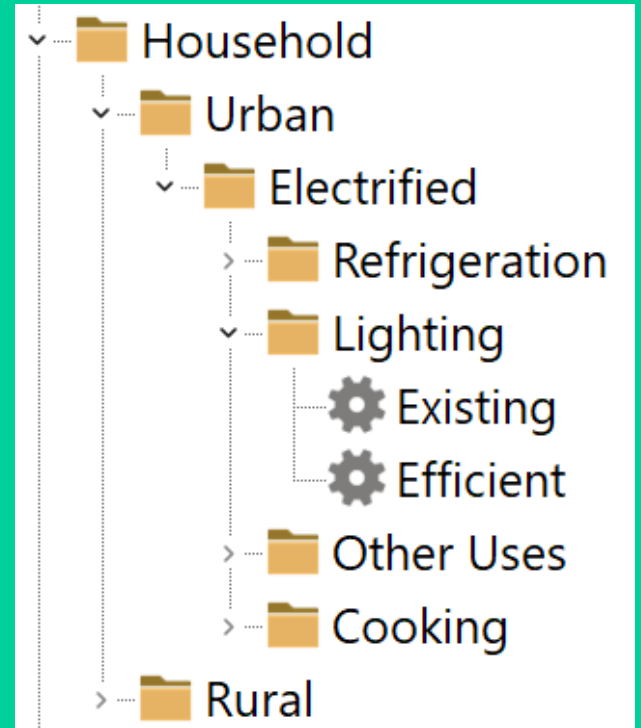
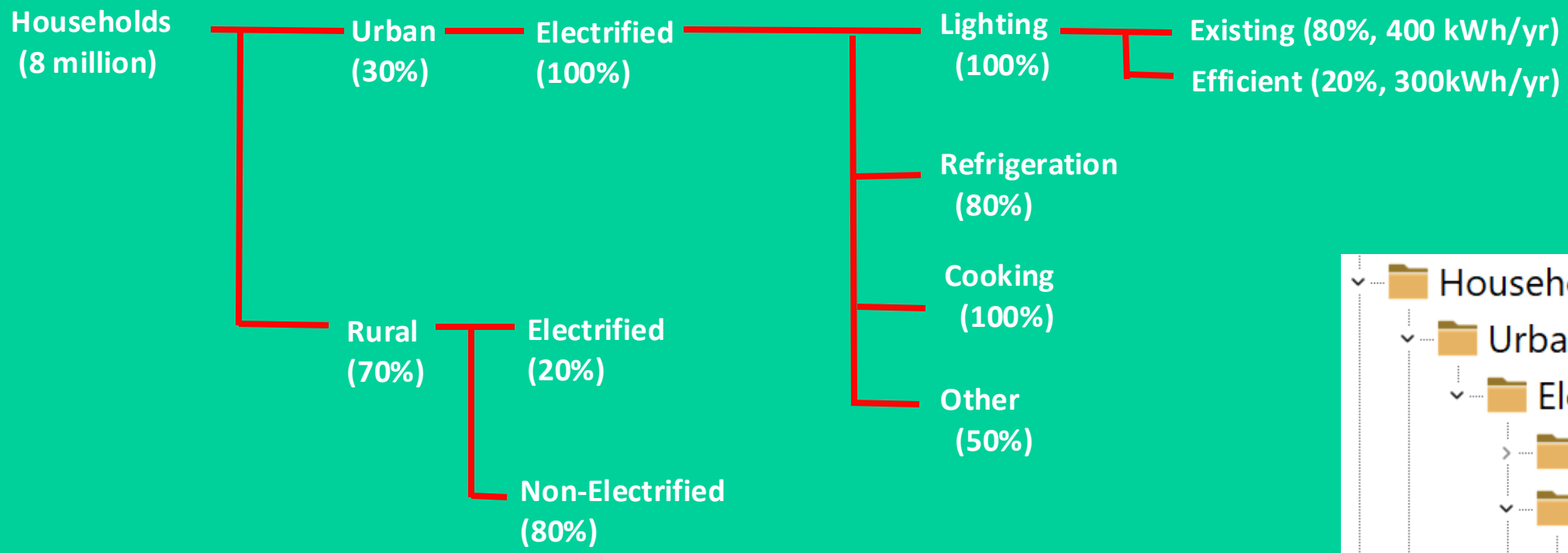
Options:

Useful Energy Analysis

Final Energy Intensities in Current Accounts



# A Simple Demand Data Structure



# A Transport Example

---

Gasoline demand  $M$  from motorbikes may depend on...

- $A$ , the total annual number of passenger-kilometres traveled
- $B$ , the fraction of all passenger transport delivered by motorbikes
- $C$ , the load factor for motorbikes [people/motorcycle]
- $D$ , the fuel economy of motorcycles [gasoline use per vehicle-km]

...so that  $M = A * B / C * D$

# Useful Energy Analysis

---

$$E = AD / \eta$$

- Where:  $E$  is energy demand,  $A$  is activity level, and  $D$  is useful energy intensity of a device,  $\eta$  is the efficiency of that device
- For example – energy demand for heating can depend on the size of the heated area, the amount of heat needed per m<sup>2</sup> of heated area, and the efficiency of heating equipment.

Add Branch Under: Commercial ×

Name:

Type:

Options:

Useful Energy Analysis

Final Energy Intensities in Current Accounts


# Stock Turnover Modeling

---

- Simulates the evolution of a fleet of vehicles or devices based on sales and retirements
- Separately tracks each vintage of vehicles/devices – i.e., vehicles/devices sold in a given year
- Allows the characteristics of a vintage to change with age (emission factors, specific energy consumption, usage)
- Supports probabilistic retirement functions and user-defined expressions for sales, scrappage, and more

Add Branch Under: Test ✕

Name:


Type:  Transport Technology (Stock Turnover Method) ▾

Options:

Fuel:  ▾

Add Branch Under: Test ✕

Name:

Type:  Other Technology (Stock Turnover Method) ▾

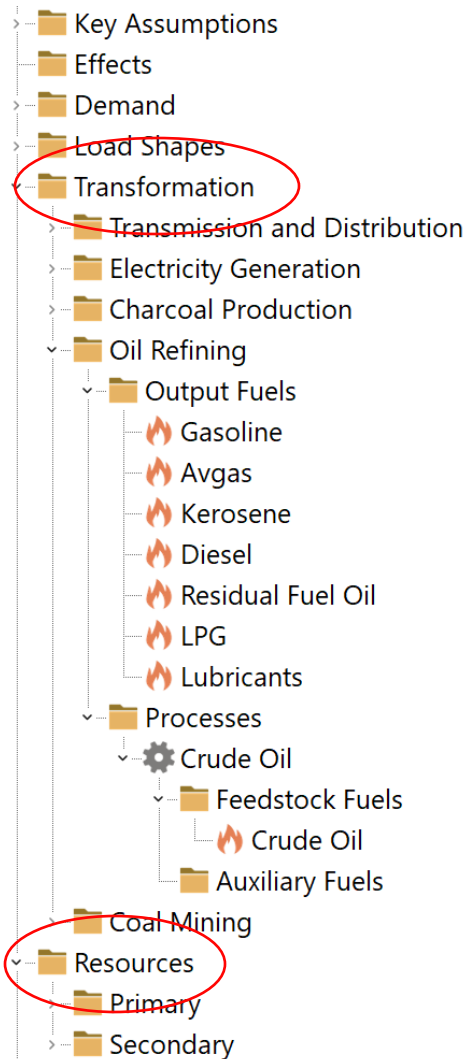
Options:

Fuel:  ▾



# Energy Supply Analysis in LEAP

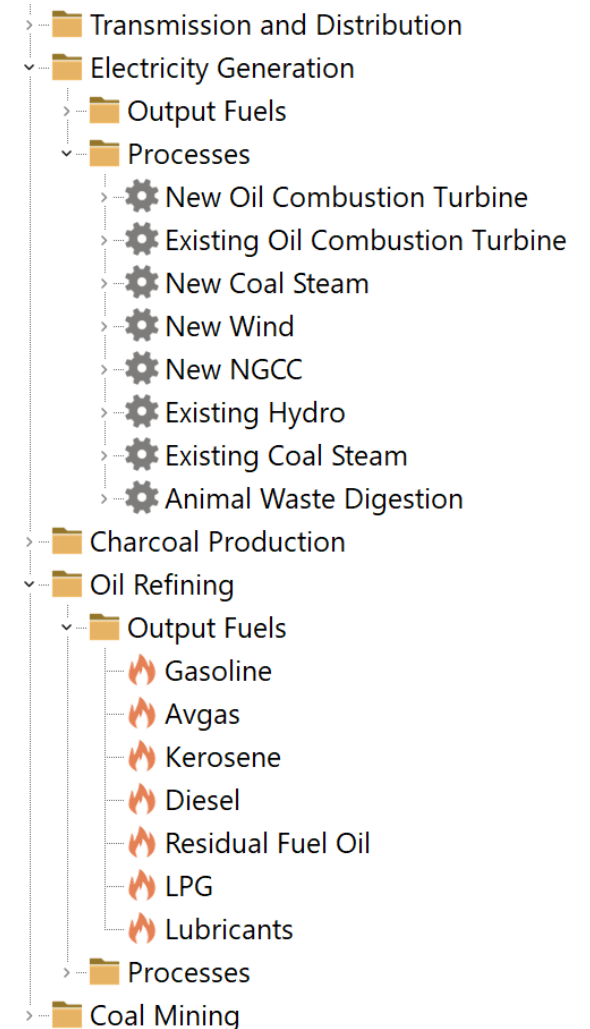
# Supply Modeling Overview



- LEAP supports modeling all links in the energy supply chain, from resource extraction to energy trade, energy conversion, and delivery to end-users
- Two main branches in LEAP tree: **Resources** and **Transformation**
  - Resources – Extraction of primary energy resources, imports and exports
  - Transformation – Conversion of one fuel (energy carrier) to another; transport, transmission, and distribution of fuels
- **Total primary energy supply**, primary resource **reserves** (non-renewable) and **annual yields** (renewable), imports and exports are all tracked in the Resources branch
- Transformation structure: **modules** (energy-producing sectors), each containing one or more **processes**
  - Processes use feedstock (input) fuels to produce output fuels

# Transformation Modules

- Supply “modules” respond to fuel requirements in every “time slice”, by transforming feedstock fuels into outputs
- In scenarios, LEAP uses supply modules to respond to two key questions:
  - **Capacity Expansion:** Is capacity limited? How much capacity to build and when?
  - **Energy Production/Dispatch:** How should the capacity be operated in each time slice?



# Enabling Supply Modeling

The screenshot shows the 'Settings' dialog box with the 'Scope & Scale' tab selected. The 'Area' section is set to 'Freedonia' with a 'Remember View' checkbox checked. The 'Scope' section has several options checked: 'Demand', 'Load Shapes: Electricity' (circled in red), 'Transformation & Resources', 'Costs', and 'Energy Effects'. The 'Scale' section has 'National' selected. The 'Country' dropdown is set to 'Fictitious or Example Data'.

Settings

Scope & Scale | Years | Costs | Calculations | Optimization | Internet | Folders | Scripts | User

Area:

Name: Sample LEAP data set for fictional country "Freedonia". Use in conjunction with the LEAP Training Exercises.

Freedonia

Remember View

Scope:

Demand

Affordability

Load Shapes: Electricity

Transformation & Resources

Land-Use Change & Land-Based Resources

Statistical Differences & Stock Changes

Costs

Energy Effects

Non-Energy Effects

Complex Effects

Health, Ecosystem & Climate Impacts (IBC)

Extraction-Based Accounting of Effects

Grid-based Mapping

Indicators

Scale:

Global

Multinational

National

Sub-National

Undefined

Country: Fictitious or Example Data

*IBC not available.*

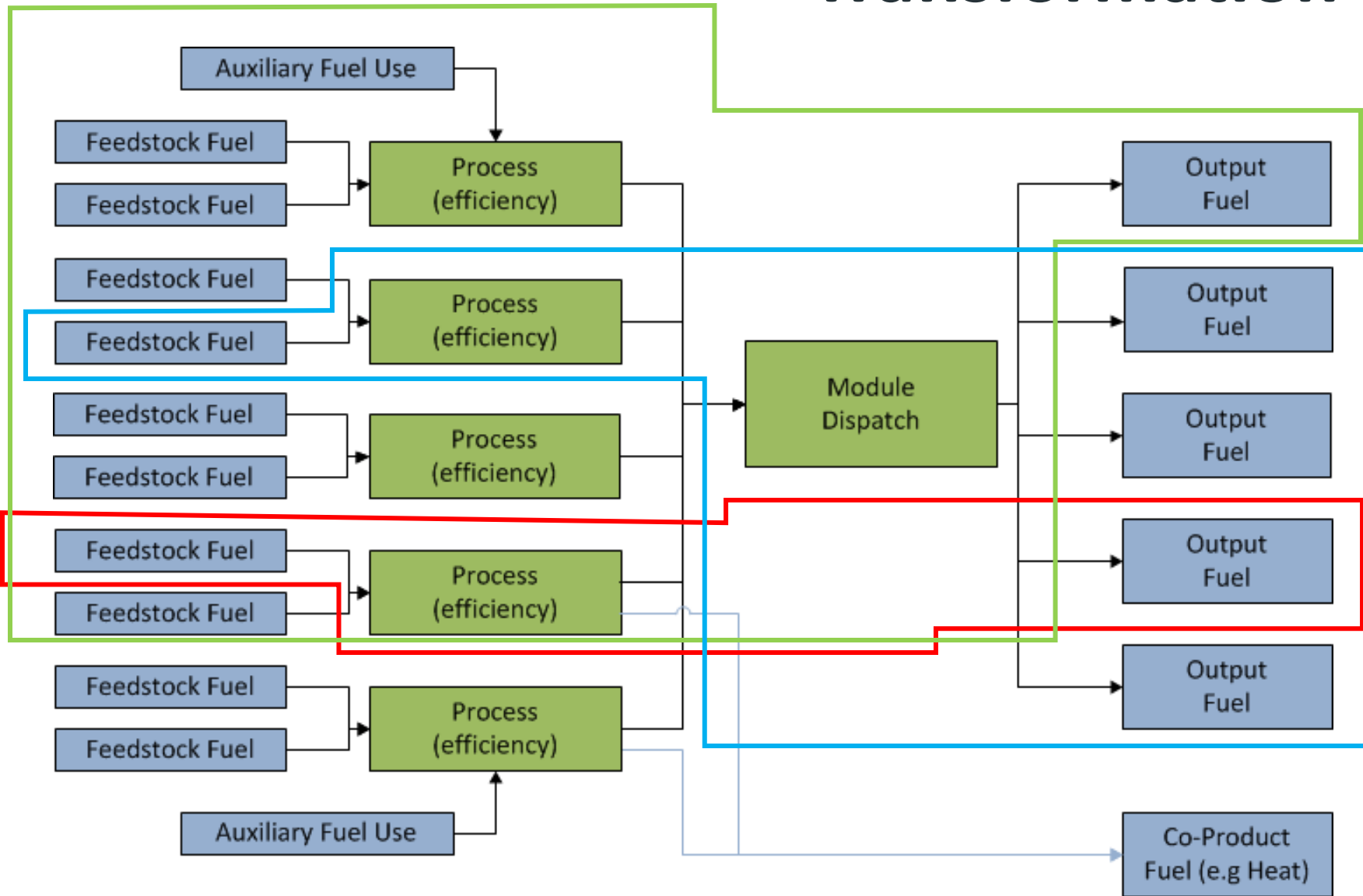
Results to Save:

All  Selected: [Choose](#)

Close Help



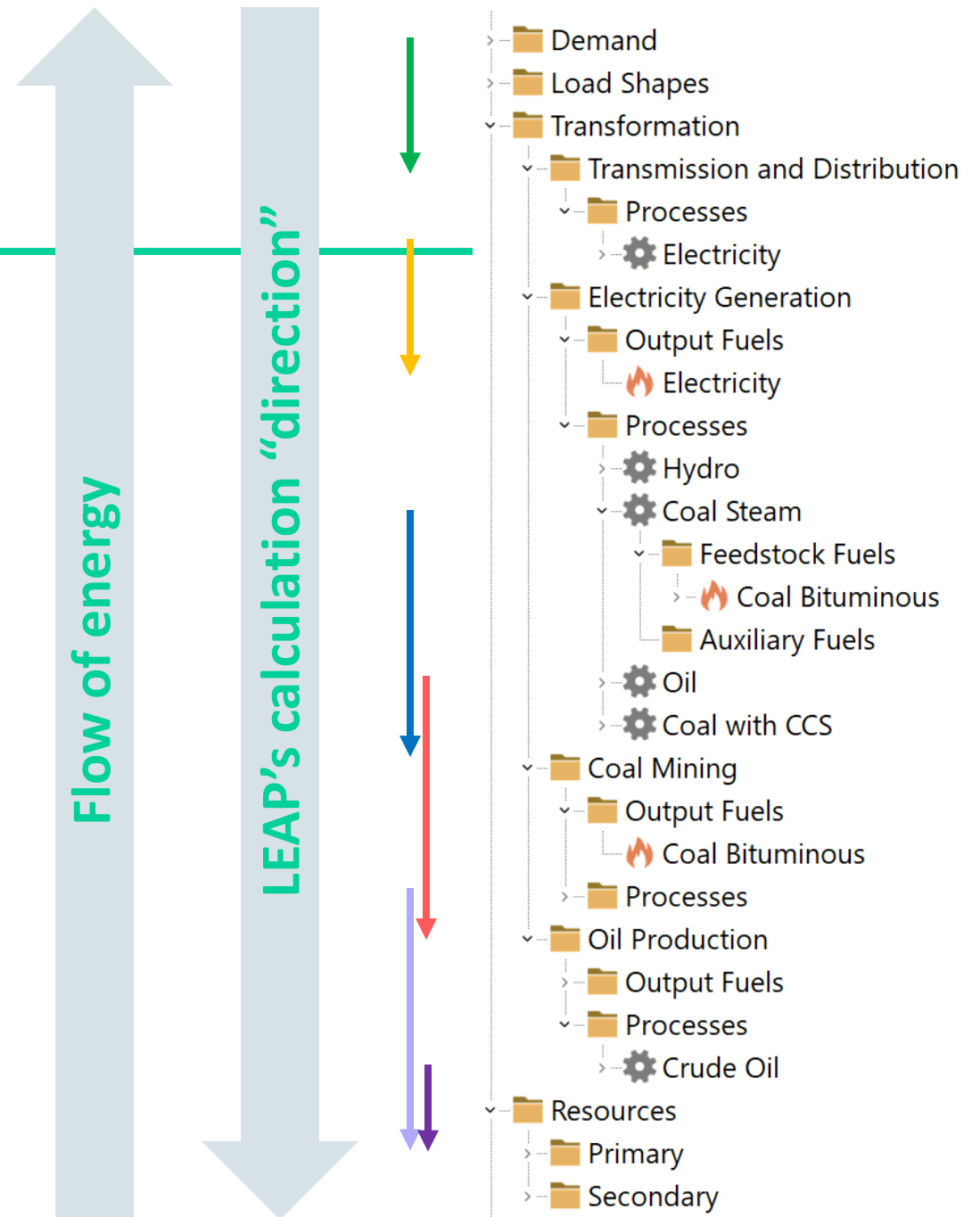
# Transformation Module Layout



- Simple (e.g., transmission lines)
- Multi-output (e.g., petroleum refining)
- Multi-process (e.g., electricity generation)

# Module Ordering

- Energy requirements are imposed on transformation modules from higher-level branches, starting with final energy demand
- Modules satisfy all requirements imposed on them, subject to capacity limits
- Multiple modules can produce the same fuel



# Follow Along

---

1. Locate and open **follow\_along\_1.leap** in the Shared Materials directory.
2. Using the Results View, find the total final electricity demand in the year 2030.
3. In that year, how much electricity is produced (output) by the Transmission and Distribution module?
4. How much electricity is “transformed by” (input into) the Transmission and Distribution module?
5. What are the annual electricity requirements in 2030 for the Electricity Generation module?
6. How much bituminous coal is “transformed by” (input into) the Electricity Generation module?
7. What is the total primary energy supply of bituminous coal, in 2030?

# Modeling Electricity Generation in LEAP

---

Two major issues to consider:

## Capacity Expansion

- **Capacity needs must be met:** How much capacity to build and when? (MW)

## Dispatch

- **Energy needs must be met:** Once built, how should capacity be operated? (MWh)

# Capacity Expansion

---

## “Simulation” or rules-based

**Exogenous Capacity:** User specifies current and future capacity of plants including retirements.

**Endogenous Capacity:** User specifies types of plants to be built but LEAP decides *when* to add plants to maintain a specified planning reserve margin.

## Optimization (using NEMO)

**Exogenous Capacity:** User specifies current and future capacity of plants including retirements.

**Optimized New Capacity:** NEMO decides how to add capacity, obeying constraints such as planning reserve margin. Capacity expansion and dispatch are co-optimized to *minimize the net present value of all projected electricity production costs*.

# Dispatch

---

## “Simulation” or rules-based

Follows **Dispatch Rule**: Users can assign dispatch priorities (merits), dispatch for a fixed percentage of requirements, dispatch all available capacity, etc.

## Optimization (using NEMO)

LEAP decides how to dispatch processes, obeying constraints. Capacity expansion and dispatch are co-optimized to *minimize the net present value of all projected electricity production costs*.

# Dispatch

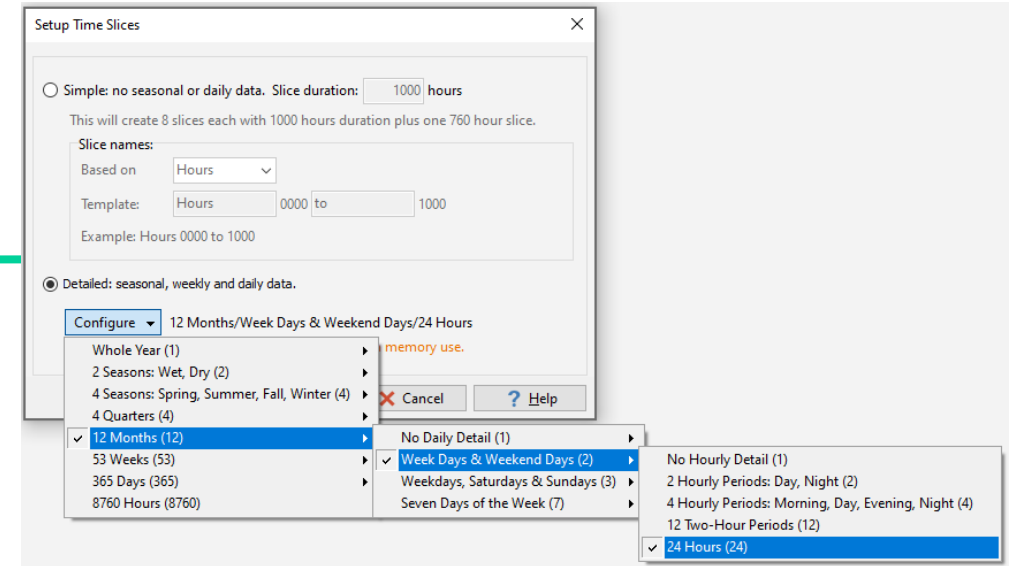
---

Transformation processes are called upon to meet energy and power requirements in each **time slice**. The time-sliced requirements are based on annual demand and the system's load curve.

The load curve can be specified exogenously or built up from load profiles associated with individual demands.

# Time Slices

- Time slices **divide the year into sub-annual periods**
- **Only one set of time slices can be defined per model** – this same configuration is applied to every modeled year and region.
- **Various input variables** (e.g., maximum availability, merit order) and results (e.g. power generation, peak power requirements, curtailed energy production) **can be time sliced**
- **Module output requirements can also be time sliced**



Time Slices: Detailed: 576 slices: 12 Months/Week Days & Weekend Days/24 Hours

Setup Export Import Settings

Seasons: <All> Weekly Detail: <All> Daily Detail: <All>

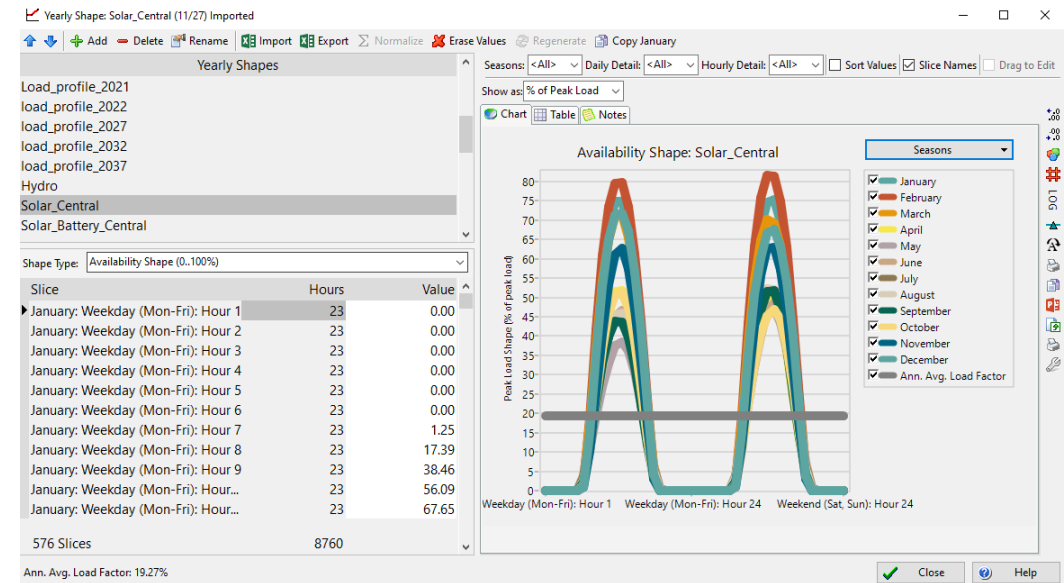
Time Slice	Hours	Seasonal Grouping	Daily Grouping	Hourly Grouping
▶ January: Weekday (Mon-Fri): Hour 1	23	January	Weekday (Mon-Fri)	Hour 1
January: Weekday (Mon-Fri): Hour 2	23	January	Weekday (Mon-Fri)	Hour 2
January: Weekday (Mon-Fri): Hour 3	23	January	Weekday (Mon-Fri)	Hour 3
January: Weekday (Mon-Fri): Hour 4	23	January	Weekday (Mon-Fri)	Hour 4
January: Weekday (Mon-Fri): Hour 5	23	January	Weekday (Mon-Fri)	Hour 5
January: Weekday (Mon-Fri): Hour 6	23	January	Weekday (Mon-Fri)	Hour 6
January: Weekday (Mon-Fri): Hour 7	23	January	Weekday (Mon-Fri)	Hour 7
January: Weekday (Mon-Fri): Hour 8	23	January	Weekday (Mon-Fri)	Hour 8
January: Weekday (Mon-Fri): Hour 9	23	January	Weekday (Mon-Fri)	Hour 9
January: Weekday (Mon-Fri): Hour 10	23	January	Weekday (Mon-Fri)	Hour 10
January: Weekday (Mon-Fri): Hour 11	23	January	Weekday (Mon-Fri)	Hour 11
January: Weekday (Mon-Fri): Hour 12	23	January	Weekday (Mon-Fri)	Hour 12
January: Weekday (Mon-Fri): Hour 13	23	January	Weekday (Mon-Fri)	Hour 13
January: Weekday (Mon-Fri): Hour 14	23	January	Weekday (Mon-Fri)	Hour 14
January: Weekday (Mon-Fri): Hour 15	23	January	Weekday (Mon-Fri)	Hour 15
January: Weekday (Mon-Fri): Hour 16	23	January	Weekday (Mon-Fri)	Hour 16
January: Weekday (Mon-Fri): Hour 17	23	January	Weekday (Mon-Fri)	Hour 17
January: Weekday (Mon-Fri): Hour 18	23	January	Weekday (Mon-Fri)	Hour 18
January: Weekday (Mon-Fri): Hour 19	23	January	Weekday (Mon-Fri)	Hour 19
January: Weekday (Mon-Fri): Hour 20	23	January	Weekday (Mon-Fri)	Hour 20
576 time slices	8,760			

Close Help



# Yearly Shapes

- The yearly shapes screen in LEAP is used to view and edit a **library** of any number of different shapes that can be used to specify **how values vary by time slice**.
- Yearly shapes can be created by **manually** entering data, or by **importing** time-sliced or hourly data (which LEAP aggregates based on the selected time-slice configuration).
- You can create four different types of yearly shapes:
  - **Peak Load Shapes** (% of peak load)
  - **Energy Load Shapes** (% of annual energy load)
  - **Availability shapes** (% availability 0..100%) used to describe the fraction of time a transformation process is available in each time slice
  - **Merit Order shapes** (integer values 0,1,2,...N) used to describe the merit order of dispatch of transformation processes



# Determining Capacity Needs

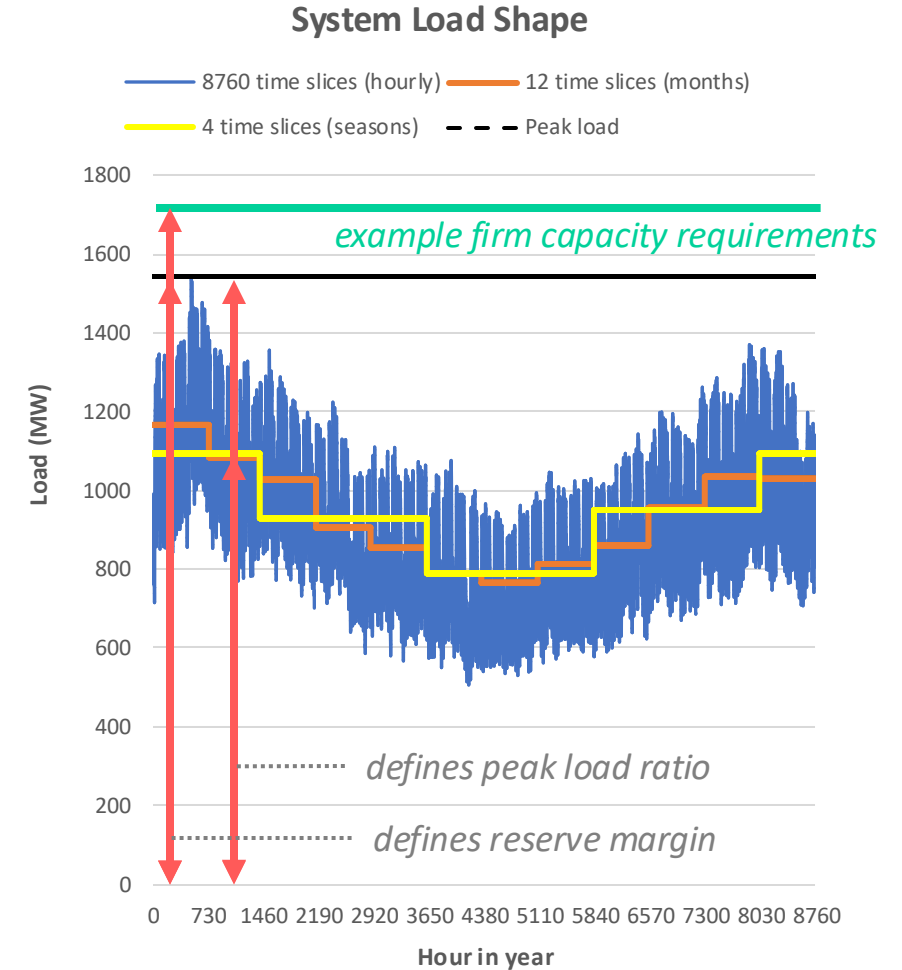
In each year:

$$\underbrace{\frac{\text{firm capacity} - \text{peak load}}{\text{peak load}}}_{\text{reserve margin}} \geq \text{planning reserve margin}$$

where:

$$\text{peak load} = (\text{load in highest-load time slice}) / (\text{peak load ratio})$$

$$\text{firm capacity} = \sum_p (\text{installed capacity})_p (\text{capacity credit})_p$$



# Calculating the Reserve Margin

---

Important inputs include:

- **Peak Load Ratio**, which may be entered manually or determined endogenously using LEAP's `PeakLoadValueFromYearlyShape()` function
- **Capacity Credit** captures characteristics of individual processes; should be defined in a way consistent with LEAP's calculation of reserve margin
  - Assignment of capacity credits can be subjective
  - In general, dispatchable generators often assigned a higher capacity credit than non-dispatchable generators, not to exceed generators' annual average maximum availability

# Follow Along

---

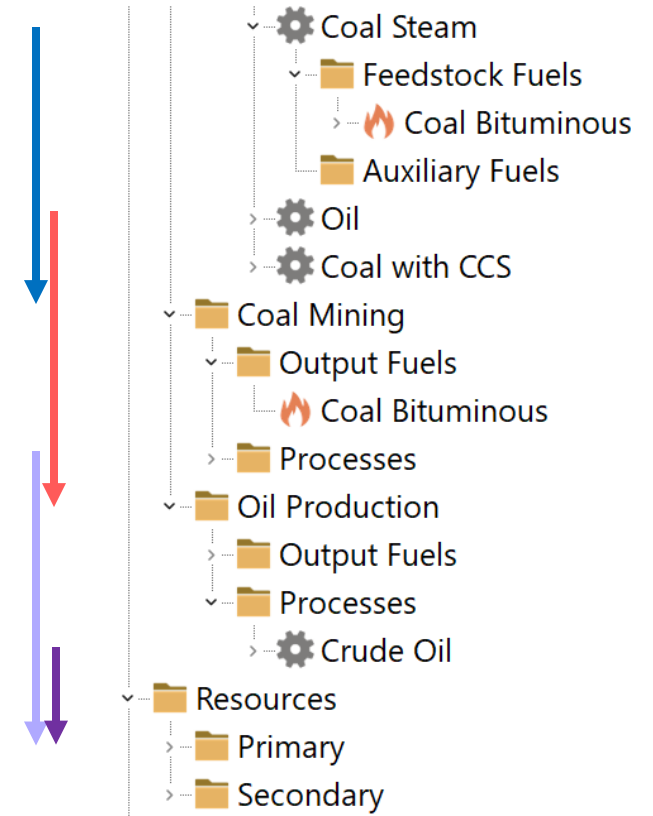
1. Continue using **follow\_along\_1.leap** in the Shared Materials directory.
2. How are the model's time slices established? How many time slices are used?
3. What is the name of the time slice that contains the highest load? What percentage of peak load is this?

# The Resources Branch

Energy requirements that originate as final demands, and are transformed through supply processes, must terminate *somewhere*.

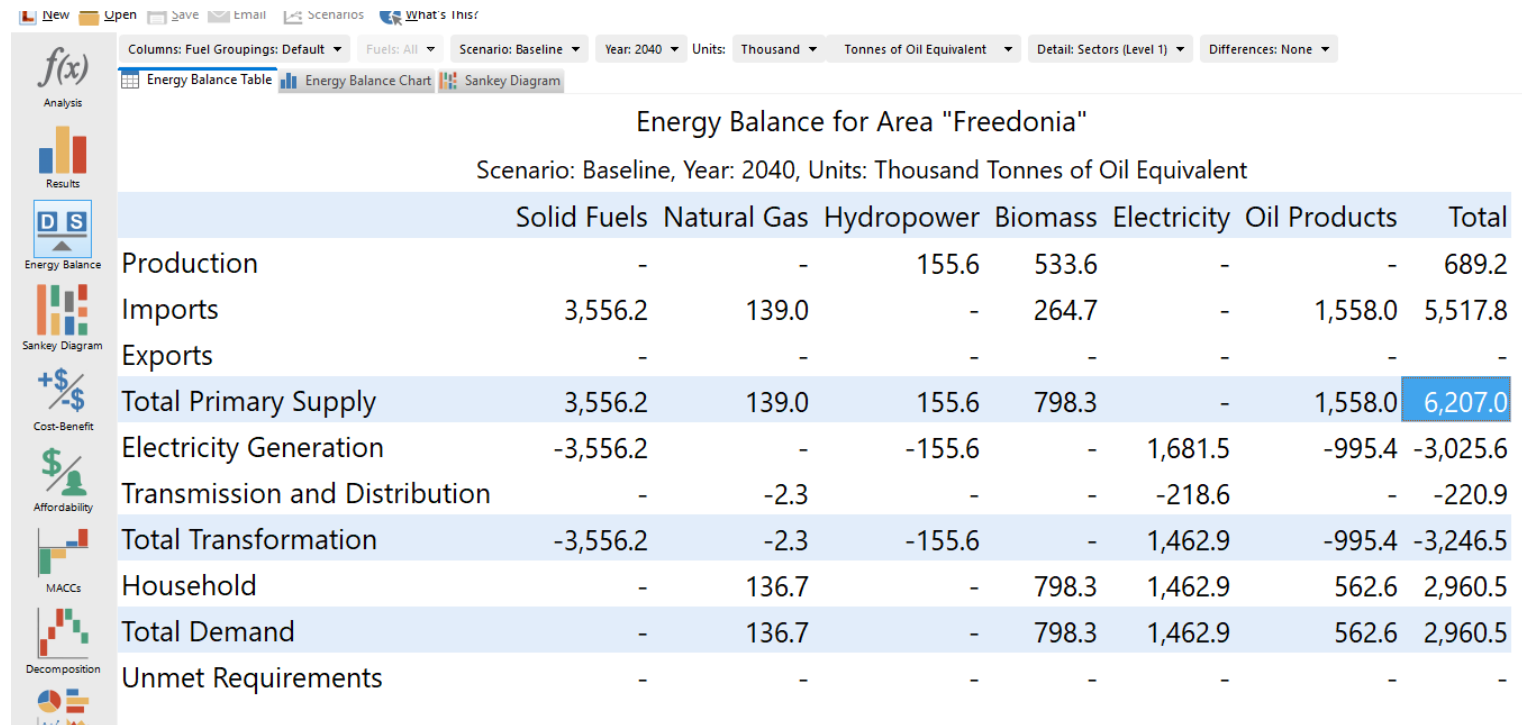
LEAP's Resources branches allow users to choose what happens at the bottom of the tree. Are these fuel requirements:

- Produced or extracted domestically?
- Imported?
- Simply designated "unmet"?



# Energy Balances

An energy balance is an **annual reporting format** that shows the **production, conversion and consumption of energy commodities** in an economy, obeying physical accounting rules.



The screenshot shows a software interface for energy balance analysis. The main window displays a table titled "Energy Balance for Area 'Freedonia'" for the scenario "Baseline" in the year "2040". The units are "Thousand Tonnes of Oil Equivalent". The table lists various energy flows and their components. The "Total Primary Supply" row is highlighted in blue and shows a total of 6,207.0. The "Total Demand" row also shows a total of 2,960.5. The "Unmet Requirements" row shows zero values across all categories.

	Solid Fuels	Natural Gas	Hydropower	Biomass	Electricity	Oil Products	Total
Production	-	-	155.6	533.6	-	-	689.2
Imports	3,556.2	139.0	-	264.7	-	1,558.0	5,517.8
Exports	-	-	-	-	-	-	-
<b>Total Primary Supply</b>	<b>3,556.2</b>	<b>139.0</b>	<b>155.6</b>	<b>798.3</b>	<b>-</b>	<b>1,558.0</b>	<b>6,207.0</b>
Electricity Generation	-3,556.2	-	-155.6	-	1,681.5	-995.4	-3,025.6
Transmission and Distribution	-	-2.3	-	-	-218.6	-	-220.9
<b>Total Transformation</b>	<b>-3,556.2</b>	<b>-2.3</b>	<b>-155.6</b>	<b>-</b>	<b>1,462.9</b>	<b>-995.4</b>	<b>-3,246.5</b>
Household	-	136.7	-	798.3	1,462.9	562.6	2,960.5
<b>Total Demand</b>	<b>-</b>	<b>136.7</b>	<b>-</b>	<b>798.3</b>	<b>1,462.9</b>	<b>562.6</b>	<b>2,960.5</b>
Unmet Requirements	-	-	-	-	-	-	-

# Energy Balances

Commodity  
Flows (rows)

Commodities  
(columns)

The screenshot shows a software interface for energy balance analysis. The main window displays a table titled "Energy Balance for Area 'Freedonia'" for the scenario "Baseline" and year "2040". The units are "Thousand Tonnes of Oil Equivalent". The table lists various energy flows and commodities. A red box highlights the "Natural Gas" column, and a green box highlights the "Exports" row.

	Solid Fuels	Natural Gas	Hydropower	Biomass	Electricity	Oil Products	Total
Production	-	-	155.6	533.6	-	-	689.2
Imports	3,556.2	139.0	-	264.7	-	1,558.0	5,517.8
Exports	-	-	-	-	-	-	-
Total Primary Supply	3,556.2	139.0	155.6	798.3	-	1,558.0	6,207.0
Electricity Generation	-3,556.2	-	-155.6	-	1,681.5	-995.4	-3,025.6
Transmission and Distribution	-	-2.3	-	-	-218.6	-	-220.9
Total Transformation	-3,556.2	-2.3	-155.6	-	1,462.9	-995.4	-3,246.5
Household	-	136.7	-	798.3	1,462.9	562.6	2,960.5
Total Demand	-	136.7	-	798.3	1,462.9	562.6	2,960.5
Unmet Requirements	-	-	-	-	-	-	-

# Total Primary Energy Supply

---

Total primary energy supply

Domestic production

Optional component in LEAP  
– activate in Settings

$$TPES = Production + Imports - Exports \pm Stock Changes$$



# Follow Along

---

1. Continue using **follow\_along\_1.leap** in the Shared Materials directory.
2. Using the Energy Balance View, find the total final electricity demand in the year 2030. Does it match what you found earlier?
3. In that year, how much electricity is lost at the Transmission and Distribution module? How would you calculate how much electricity is “transformed by” (input into) the Transmission and Distribution module?
4. How much bituminous coal is “transformed by” (input into) the Electricity Generation module?
5. What is the total primary energy supply of bituminous coal, in 2030? How much is produced domestically?

# Afternoon Assignment

---

Learning goals:

- Learn to add new transformation modules, and why their ordering matters
- Understand the different uses of a module process
- Learn when to limit process capacity, and when not to bother

# Afternoon Assignment

---

## Steps:

1. Locate and open both **afternoon\_exercise\_1.leap** and **LEAP2024TrainingExercise.pdf** in the Shared Materials directory.
2. Beginning on page 43, follow the instructions.
  - a) *3.1 Charcoal Production*: Add the module according to the instructions. **We'll do this together.**
  - b) *3.2 Electricity Generation*: In Current Accounts, update the Exogenous Capacity and Historical Production variables using the information in the table.
  - c) *3.3 Oil Refining*: Add the module according to the instructions. **We'll begin this together.**
  - d) *3.4 Coal Mining*: Add the module according to the instructions.

# Afternoon Assignment

---

Steps:

3. Section 3.5 *Resources* describes how to add resource reserves or annual yields. **You may skip this, as these steps have already been completed in the LEAP area.**
4. Switch to the Energy Balance View, which will trigger your model to calculate.
  - a) Can you generate the two tables shown on page 46?
  - b) If your calculated values differ, how would you go about identifying the reason for the discrepancy?

**We will briefly take up this assignment at the beginning of tomorrow's session.**