The Long-range Energy Alternatives Planning - Integrated Benefits Calculator (LEAP-IBC)

The Long-range Energy Alternatives Planning (LEAP) - Integrated Benefits Calculator (IBC) is an integrated planning tool to help governments jointly assess greenhouse gases, short-lived climate pollutants (SLCPs) and other air pollutant emissions; build mitigation scenarios; and understand how emission reductions benefit climate, health and crops.

LEAP is a widely-used software tool for energy policy analysis and climate change mitigation assessment, developed by the Stockholm Environment Institute (www.energycommunity.org). It is an integrated, scenario-based modelling tool originally developed to track energy consumption, production and resource extraction in all sectors of an economy. It can account for both energy sector and non-energy sector greenhouse gas (GHG) emission sources and sinks.

Now, LEAP can also analyse emissions patterns of local and regional air pollutants, and assess strategies to address short-lived climate pollutants (SLCPs), making it well-suited for studies on the climate co-benefits of local air pollution emissions reductions, and vice versa.

The Integrated Benefits Calculator (IBC) is a new application of the LEAP system developed by SEI in collaboration with US EPA and Daven Henze at the University of Colorado and with the support of the Climate and Clean Air Coalition (CCAC). LEAP-IBC combines emissions scenarios from LEAP with output from a global atmospheric chemistry transport model and with various exposure-response functions. It then produces national-scale estimates of avoided premature deaths and crop losses; LEAP-IBC also estimates the climate benefits of addressing short-lived climate pollutants (SLCPs), adopting air pollution reduction strategies and implementing greenhouse gas mitigation.

LEAP has thousands of users in more than 190 countries. Its users include government agencies, academics, non-governmental organizations, consulting companies, and energy utilities. It has been used at the city, state, national, regional and global scale. Twelve countries are currently using LEAP-IBC to support national planning for action on short-lived climate pollutants as part of the SNAP Initiative of the Climate and Clean Air Coalition.

Key features in LEAP-IBC

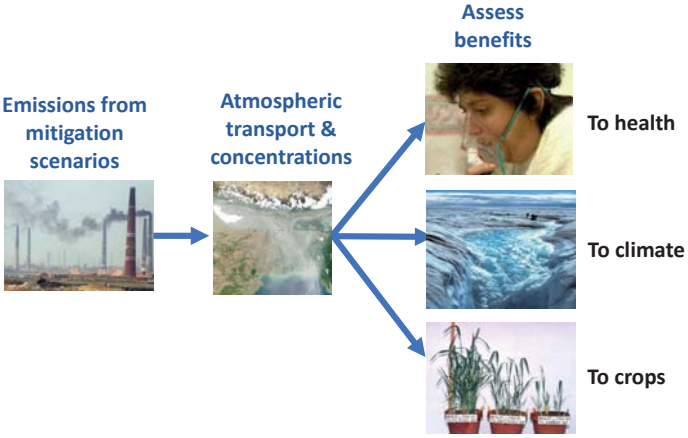
1. **A built-in structure for short-lived climate pollutant assessment**: LEAP-IBC now includes a default architecture that covers all major source sectors of SLCP-relevant emissions. These source sectors include the major energy-consuming emission sources (e.g. residential, transport, industry) and energy transformation sectors (e.g. electricity generation), as well as non-energy emission sources (e.g. agriculture, waste). To calculate emissions from a source sector, the user must input a value for the activity and emission factor, or use the default emission factors. The default architecture can be changed to model a source sector in more or less detail.

2. **The Integrated Bene ts Calculator (IBC)**: this calculates the benefits to human health, crop yield and climate from scenarios implementing particular emission reduction strategies. It does this by deriving the total national emissions of all relevant pollutants and GHGs from LEAP, and then using that total to estimate atmospheric concentrations of fine particulate matter ($PM_{2.5}$), relevant for human health, and surface ozone (O_3), relevant for human health and vegetation. The calculator also uses the total national emissions to calculate the progression of global temperature in annual time-steps.

When and why you should use LEAP-IBC

With this tool, countries will be able to:

- characterize national emissions of greenhouse gases, short-lived climate pollutants and other air pollutants
- explore alternative emission reduction scenarios
- calculate country-level health, agriculture and global climate benefits
- compare results across alternative scenarios
- inform nationally appropriate action on climate, air quality and SLCPs



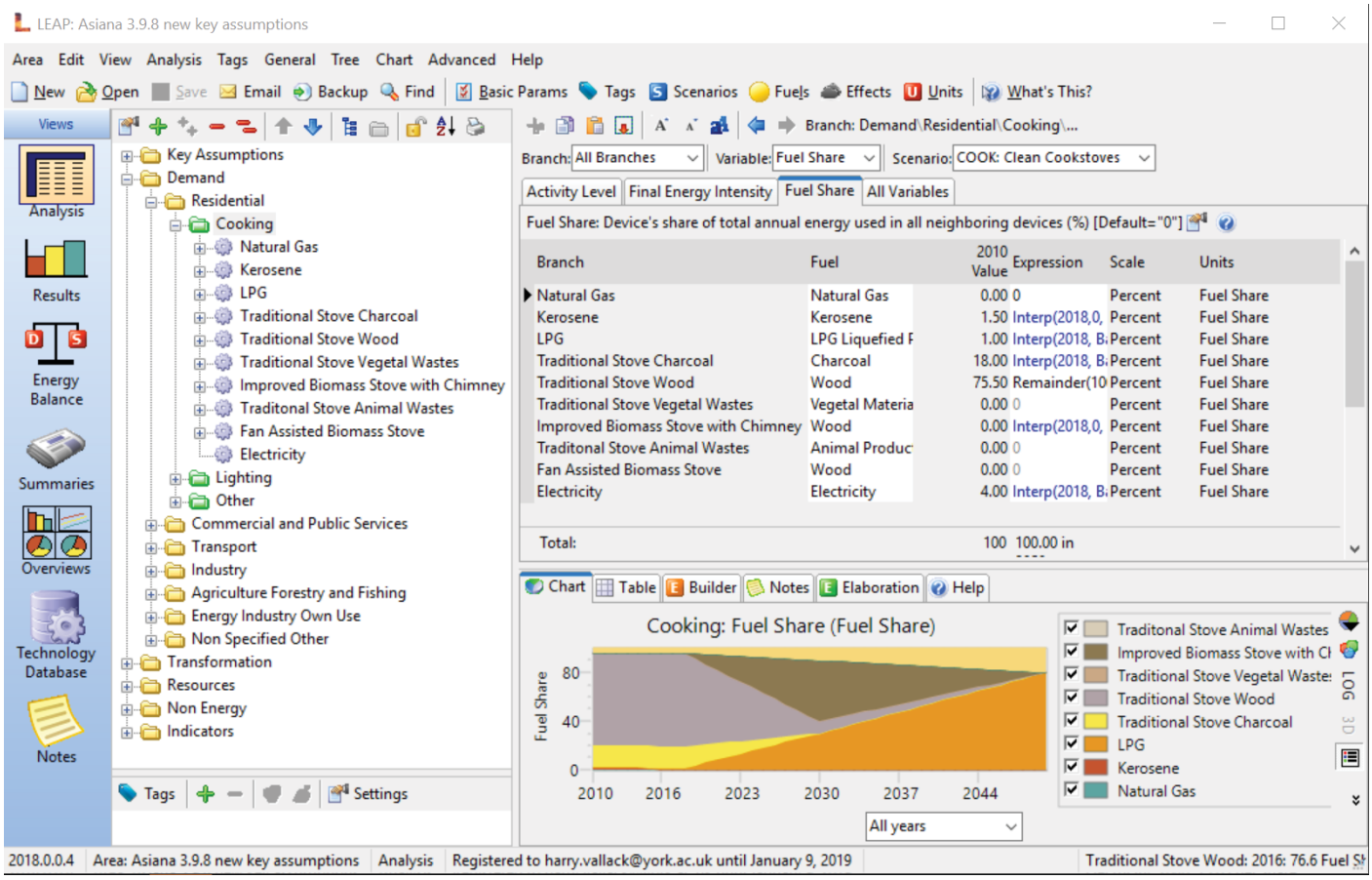


Figure 1: A snapshot of LEAP-IBC showing the structure of sectors for energy-related and non-energy related GHG and air pollution emissions

What can you do with LEAP-IBC?

1. Characterize national emissions of greenhouse gases, short-lived climate pollutants and other air-pollutants

LEAP allows you to calculate emission inventories for current and future years for all relevant pollutants. To calculate emissions you need to input activity data for a particular source. For each source default emission factors for BC, OC, other $PM_{2.5}$, SO_2, NH_3, NO_X, NMVOCs, CO, CH_4 and CO_2 are included, and emissions are estimated from Activity x Emission Factors.

As part of the CCAC Supporting National Action & Planning Initiative, participating countries are provided with a LEAP-IBC version that already includes internationally available data covering about 70% of the data necessary to undertake an SLCP assessment. These data can be replaced with more accurate national information, and source sectors can be modelled in greater detail depending on the level of data available, and the mitigation scenarios that will be evaluated.

2. Understand likely future trends in emissions (baseline scenario)

LEAP can be used to develop a baseline scenario by describing how activity and emission factors within different sectors are likely to change in the future, and hence how emissions from each sector are likely to change in the future. These variables can be linked to changes in key socio-economic drivers such as GDP growth or population.

3. Explore alternative emission reduction scenarios

Using LEAP, policy analysts can create and then evaluate alternative mitigation scenarios by comparing their energy requirements, their social costs and benefits, and their environmental impacts.

Mitigation actions can be described in LEAP related to implementing technological changes (e.g. fitting diesel particle filters to trucks in the transport sector), efficiency improvements (e.g. improving the fuel efficiency of the vehicle fleet), or policies affecting the level of activity in a sector (e.g. modelling the shift from people using passenger cars to using buses due to a public transport policy).

Mitigation actions can be combined to look at the effect of multiple measures as part of an overall strategy for reducing SLCPs, air pollutants and/or greenhouse gases.

4. Calculate pollutant concentrations and radiative forcing using the Integrated Benefits Calculator

Using emissions from LEAP-IBC multiplied by the output from the GEOS-Chem global atmospheric chemistry transport model[1], the Integrated Benefits Calculator

1 The GEOS-Chem global atmospheric chemistry transport model quantifies how sensitive $PM_{2.5}$ and ozone concentrations in a particular country are to emissions emitted in different parts of the world (the globe is separated into 2 x 2.5 grids). To calculate these sensitivities requires country-specific model runs, and for a LEAP-IBC dataset to be assigned to a particular country. Therefore, while LEAP-IBC is currently available for 71 countries, additional GEOS-Chem runs will extend the number of countries in which LEAP-IBC can be applied. The LEAP platform (without calculation of air pollution concentration using IBC) can be applied in all countries, and at regional and urban scales.

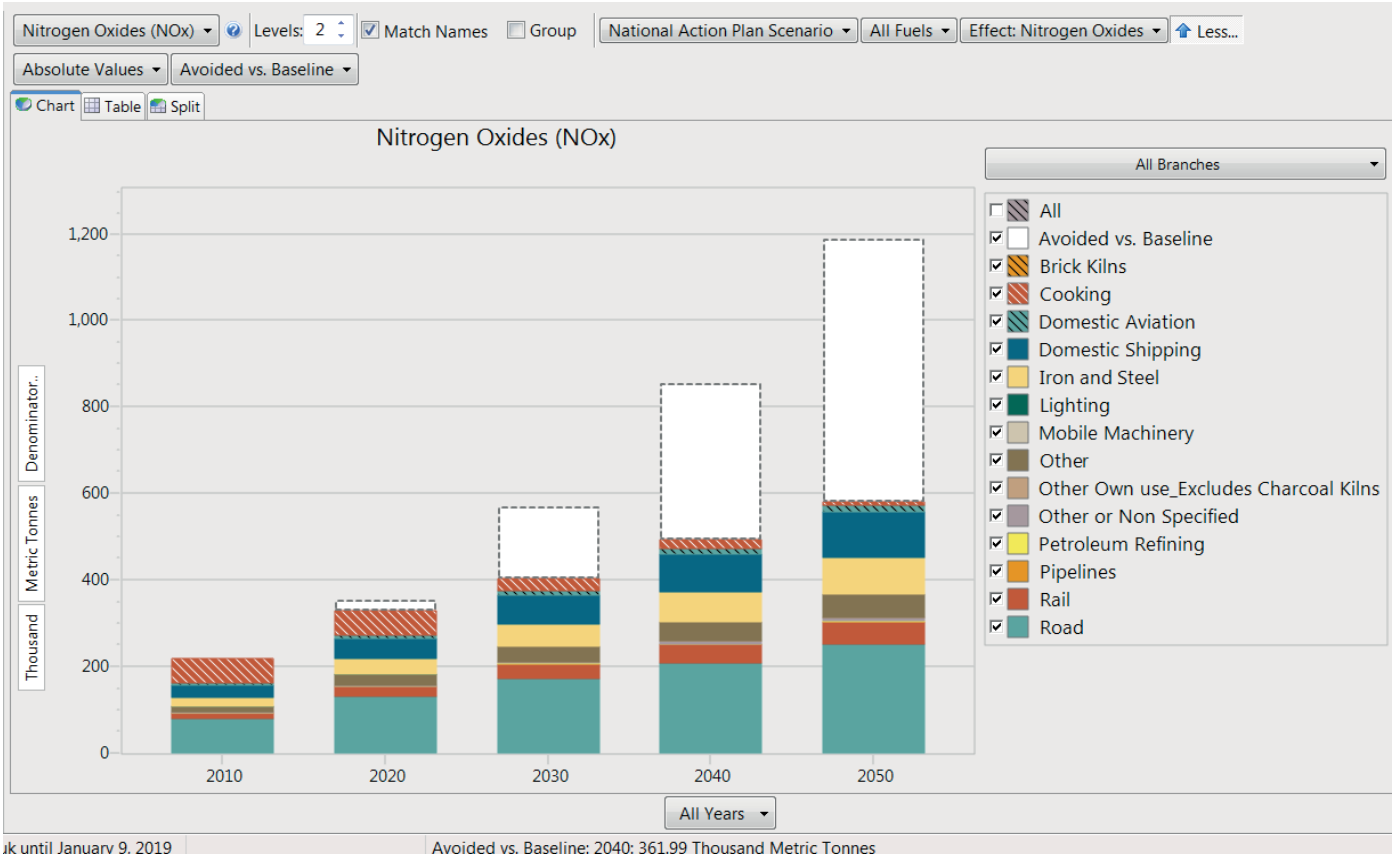


Figure 2: Impact of the mitigation scenario on progression of NO_x emissions, showing emissions avoided

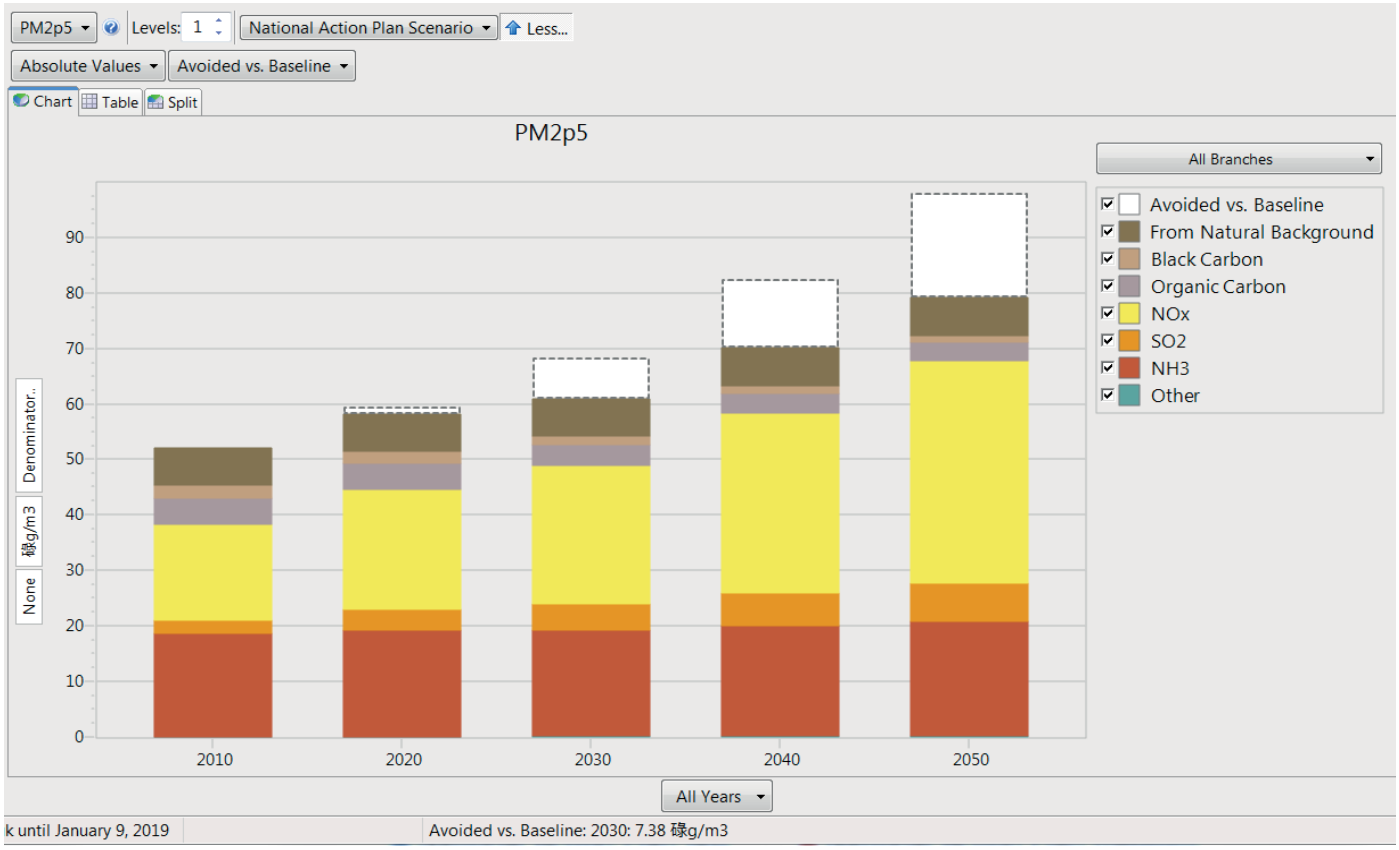


Figure 3: Development of population-weighted $PM_{2.5}$ concentrations, showing composition and pollution avoided by implementing a mitigation scenario

provides an estimate of population-weighted $PM_{2.5}$ and ozone concentrations in the target country. A similar methodology is used to estimate the radiative forcing associated with emissions of short-lived climate forcers from different parts of the world.

5: Estimate the air-pollution-associated health impacts of current emissions and the different scenarios

LEAP-IBC can provide estimates of premature mortality associated with exposure to $PM_{2.5}$ and ozone. For $PM_{2.5}$, this is calculated using the Integrated Exposure Response relationship for mortality from heart disease, stroke, lung cancer and respiratory diseases. Ozone-related deaths use relationships based on epidemiological studies related to respiratory deaths.

Impacts can be viewed by age group, by disease category, by the contribution of emissions of different pollutants, and by contribution of national emissions, and emissions that occur outside the country (e.g. from neighbouring countries).

6: Estimate crop yield loss impacts

LEAP-IBC can also estimate the loss (in tonnes) of wheat, rice, maize and soybean yield due to ozone exposure of current emissions and the different scenarios. The yield losses are calculated using the average of the 7- or 12-hour mean daylight ozone concentrations over the growing season, in combination with experimentally-derived concentration-response functions linking ozone exposure to yield loss.

7: Estimate climate impacts

The global change in radiative forcing (the Earth's energy balance) is estimated for the change in pollutant emissions in the target country, both for short-lived climate forcers, and for long-lived greenhouse gases like CO_2. This is then converted into the global change in temperature in yearly time slices.

Future developments

Urban application: LEAP-IBC Urban is being developed so that the estimated air quality benefits of abatement strategies can be quantified at the city-scale.

More impact metrics: Additional impact indicators are being evaluated for inclusion in LEAP-IBC. These include additional health outcomes, such as the number of years of life lost, and additional vegetation species, including additional crop, as well as the estimated impact of ozone on forest and other natural vegetation.

For more information about the Climate and Clean Air Coalition and its Initiative "Supporting National Action and Planning on short-lived climate pollutants" (CCAC, http://www.ccacoalition.org/en) contact Elsa Lefevre (elsa.lefevre@un.org).

For more information about the GEOS-Chem Adjoint model, contact Daven Henze (http://spot.colorado.edu/~henzed/pubs.html)

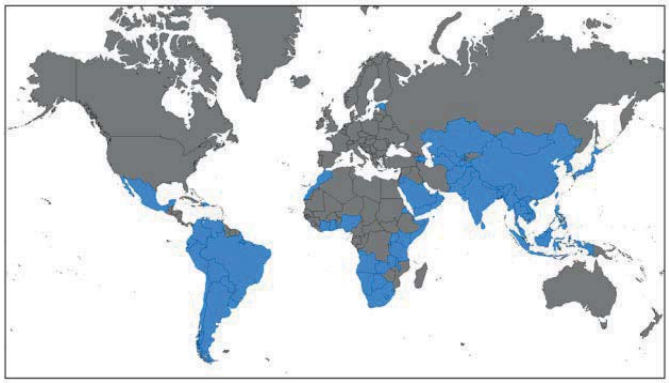
Photo: Howard Cambridge, SEI

Health impacts of air pollution in Asia

Additional data visualisation: LEAP-IBC already allows data and graphs to be output to Microsoft Excel and PowerPoint. Additional future outputs will include gridded maps of emissions across a target country, and maps comparing data between countries.

How to get LEAP-IBC

LEAP-IBC is currently available for 71 countries.



If you are interested in using LEAP-IBC, then you should first register as a user on the LEAP website (www.energycommunity.org), and apply for a LEAP licence. For LEAP support, contact Charlie Heaps (Charlie.heaps@sei-us.org). For LEAP-IBC support contact Chris Malley (chris.malley@york.ac.uk).

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