RECENT

Renewable Community Empowerment in Northern Territories

REVIEW OF ENERGY ASSESSMENT TOOLS

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2016

ENERGY ASSESSMENT TOOLS

Various modelling tools have been developed for the assessment of small-scale renewable energy systems. Energy modelling tools help the decision-makers to allocate energy production better, especially in the case of sustainable energies, as the tools are cost-effective for local energy or decentralized production modelling. There are many types of such tools, for example, renewable energy models, optimization models and energy supply-demand models. (Jebaraj S & Iniyan S 2006)

In table 1, the energy assessment tools are introduced. The Table shows the majority of energy assessment tools, their availability, and how many times they have been downloaded so far. It is worth to notice, that the ones that are used most are free to download – in some cases they require only a registration. Compared to others, RETScreen software is by far the most used one. This is maybe because RETScreen can be used for any size of system, while the others are limited to national- or micro-scale, for example. Some of the tools concentrate on one technology or on a certain geographical area. For example, BCHP Screening tool assesses combined heat and power in buildings while In*vert* focuses on the heat sector on a national scale. (Connolly *et al.* 2010)

In tis report, three different energy assessment tools are presented and examples of their usage are given. The tools are; RETScreen, LEAP and energyPLAN. The reason why these three were chosen is because they are easily accessible and offer a good variety of options. The maximum scenario timeframe for EnergyPLAN is one year, whereas RETScreen has 50 years and LEAP has no limit. EnergyPLAN, RETScreen and LEAP, all have different time-steps when calculating: hourly, monthly and yearly steps, respectively. The chosen tools are free to download, kept up-to-date and have training material and community support available. (Connolly *et al.* 2010; EnergyPLAN 2015, Heaps 2012, RETScreen International 2015)

Table 1. List of assessment tools and number of their availability and downloads. (Based on Connolly *et al.* 2010)

TOOL	**Availability**	**Downloads**
Very high number of users		
RETScreen	Free to download	> 200 000
HOMER	Free to download	> 28 000
LEAP	Free for students and developing countries	> 5000
BCHP Screening Tool	Free to download	> 2000
energyPRO	Commercial	> 1000
High number of users		
EnergyPLAN	Free to download	100-1000
In*vert*	Free to download	100-1000
MARKAL/TIMES	Commercial	100-1000
MESSAGE	Not available at the moment	100-1000
ORCED	Free to download	100-1000
TRNSYS16	Commercial	100-1000
WASP	Free for IAEA members states	100-1000
Medium number of users		
EMCAS	Commercial	20-50
EMPS	Commercial	20-50
ENPEP-BALANCE	Free to download	20-50
GTMax	Commercial	20-50
Low number of users		
AEOLIUS	Commercial	1-20
COMPOSE	Free to download	1-20
IKARUS	Commercial	1-20
INFORSE	Only available for NGO's	1-20
Mesap PlaNet	Commercial	1-20
Not specified		
BALMOREL	Free to download	Not specified
E4cast	Commercial	Not specified
H2RES	Not available	Not specified
HYDROGEMS	Commercial	Not specified
MiniCAM	Free, once contacted	Not specified

RETScreen

RETScreen 'Clean Energy Project Analysis Software' is a free-of-charge tool for clean energy assessment. Software is provided by the Government of Canada and it is one of the most used tool for analyzing energy systems (Connolly *et al.* 2010). It can evaluate for example energy production, costs and financial viability for many types of renewable energy and energy efficient - technologies. It is designed to speed-up the implementation of renewable energy by making it simpler to know the pros and cons of a certain system. Software is downloaded by a thousand people weekly and there are over 200 000 downloads so far. It is also available in 35 different languages, which makes it even more popular. (RETScreen International 2015)

In practice, RETScreen (Renewable Energy Technology Screen) helps to make a decision. The software answers to questions like "should I use wind or solar energy?" and based on the data it gets, it will determine which solution fits better (NASA 2010). It compares the proposed energy system to a base case system that is defined by the user. The software model consists of five steps: energy model, cost analysis, greenhouse gas analysis, financial summary, and sensitivity and risk analysis. It also holds meteorological data of various areas and product data of specific equipment. Areas, where there are no meteorological data or such ready, the software uses data obtained from NASA Surface Meteorology and Solar Energy (SSE). (RETScreen International 2004)

The first step, energy model, consists of specifying parameters concerning location, type of the system, technology that is going to be utilized, loads if possible, and the resources of renewable energy. Given the data, RETScreen will calculate energy production or energy savings for one year. In the second step, cost analysis, user will enter different costs for the suggested system and also avoided costs. In this step, it can be determined whether to use less detailed or more detailed analysis; less detailed requires less data than the more accurate one. Third step, greenhouse gas (GHG) analysis, is optional. It is used to calculate the reduction of GHG emissions when using the proposed technology in the place of the existing or base case system. The fourth step, financial summary, can be considered to be the last obligatory step because fifth step is optional as well. In the fourth step, user will specify financial parameters concerning avoided cost of energy, production credits and taxes and so on. Based on these parameters, RETScreen calculates whether or not, the project is financially viable. Last step, sensitivity and risk analysis, is to determine the uncertainty of the model. It shows how the given parameters have effect on the project outcome. (RETScreen International 2005)

RETScreen has been used in many energy projects worldwide (RETScreen International 2004). For example in Algeria, the software was used to assess the energy potential of wind farm. The tool calculated economics of 30 wind turbines based on wind speed data collected from the area. It also calculated the reduction of GHG emissions when wind was used as a source of energy, payback period, return on investment and more. (Himri *et al.* 2009)

LEAP

The LEAP tool, 'Long range Energy Alternatives Planning system', is used for energy policy analysis and mitigation of climate change. Its scale is nationwide and it can be used to analyze energy consumption, production, and resource extraction in every sector (Connolly *et al.* 2010). LEAP is used in hundreds of organizations in over 190 countries. It is not used to model a particular energy system but rather, to model multiple energy systems and it has been used from city-scale to global-scale. The main purpose in the software is to locate GHG emission sources and sinks as well as analyze emissions of local air pollutants. LEAP is free for students and users in certain countries. (Heaps 2012)

The time frame of the software is flexible. Most of the calculations are done on an annual step and it can be extended without limits. Majority of the studies done with LEAP are periods between 20 to 50 years. However, the software allows the user to split a year into different slices, for example to seasons, or even a certain time of a certain day can be simulated. All in all, LEAP is not designed for short period of time; it is best used when simulating long-range scenarios. The scenarios, what the software produces, are storylines of how a certain energy system might develop in a specified time frame. One essential benefit when using LEAP is the low data requirements. Many of the data fields are optional and the data can be added later for more detailed simulation. (Heaps 2012)

LEAP has been used and is used among many government agencies, NGOs, consulting companies and academic organizations and so on. It is used in many different tasks including: energy forecasting, GHG mitigation analysis and energy scenario studies. For example, LEAP was used to analyze how China's energy sector should be changed in the next 40 years to meet the set goals for GHG emission reduction. Software developed two scenarios: baseline scenario, where there are no substantial policy changes designed for CO_2 reduction, and a deep carbon reduction scenario (DCRS), where the CO_2 emissions are to be reduced dramatically until year 2050. (SEI 2015)

Another similar project was called 'Long-term energy and development pathways for India'. Three scenarios were developed for forecasting how greenhouse gas emissions will change in India by year 2030. First scenario, baseline scenario, assumes that there will be no major changes to the energy sector, so GHG emissions keep growing. In second scenario, low carbon (LC) scenario, GHG emissions will match the goals set up in 2005 until year 2030. The third scenario, low carbon inclusive growth, had the same goal as the LC scenario, but it focused more on the energy use of the poor and rural population. Based on these examples, it can be seen that LEAP is a tool used for large scale and therefore, it is not meant to be used for model single energy utilities. (SEI 2015)

EnergyPLAN

The EnergyPLAN tool was developed in 1999 in Denmark. It has been continuously updated since, and has been downloaded by more than 1200 people. The purpose of the tool is to simulate an entire energy-system which takes into account heat and electricity supply as well as transportation and others. EnergyPLAN can model all renewable, thermal, storage, transport and costs of a system. It is free to download and there are plenty of training material available. (Connolly *et al.* 2010)

The tool is not designed to come up with a 'best' solution, but rather many solutions that can be compared with each other. In this sense, the tool's output will be a variety of options for a certain energy system. Nevertheless, the model is quite simple deterministic input/output model. Inputs can be demands, renewable energy sources, costs, imports or excess electricity production, and outputs fuel consumption, energy balances, production of energy and total costs, for example. (EnergyPLAN 2015)

What makes EnergyPLAN a bit different than other energy tools, is that it is an hour-simulation tool. It can simulate the variances in renewable energy production on the system for one year in total, consisting of different seasons, peak loads of energy use, always hour by hour. However, a longer scenario can also be made if necessary, by connecting the year-long scenarios into one aggregated scenario. Additionally, the aim of the program is to model the future situation rather than the situation today. With that in mind, EnergyPLAN has a rather detailed data about future energy technologies but also some basic models of today's technology. (EnergyPLAN 2015)

Many publications that have used EnergyPLAN as a simulation tool, are about making a certain area more renewable or 100% renewable by implementing different technologies. One example is

a scenario, where whole Europe get all of its energy from renewable sources. The result was that it is technically possible to have a 100% 'smart energy Europe" until year 2050, although it was 10-15% more expensive than the base scenario. Similar scenarios are made for Ireland, Macedonia, and Croatia and so on. Based on these publications, it can be said that EnergyPLAN tool is strongly concentrated on simulating renewable energy technologies. (EnergyPLAN 2015)

Summary

All of the tools have their strengths and weaknesses. One criteria when choosing the tool, is how user-friendly it is. Some of the energy tools require about 2-3 week training and are mostly used by professionals. From this point of view, the RETScreen software stands out from the others. It requires about 1-2 days to learn the basics, and it is straightforward to use. It has the necessary capacity to assess different types of small-scale energy projects; although, is not suitable to assess national energy systems. However, for this project, this has not been the objective. With a small amount of input, it can generate energy potentials, GHG savings and economic potential of the desired system. RETScreen is more about concentrating on one energy system, while LEAP and EnergyPLAN are more about building scenarios. Fort his reason, it is recommended that the RETScreen tool is used for evaluating the pilots in the RECENT project.

References

Connolly D, Lund H, Mathiesen BV & Leahy M (2010) A review of computer tools for analysing the integration of renewable energy into various energy systems. Appl Energy 87(4): 1059-1082

EnergyPLAN (2015) Advanced energy system analysis computer model – Introduction. [Referred 4.11.2015] [Online] Available at: http://www.energyplan.eu/training/introduction/

Heaps C.G (2012) Long-range energy Alternatives Planning (LEAP) system. [Online] Available at: http://www.energycommunity.org/default.asp?action=47

Himri Y, Boudghene Stambouli A & Draoui B (2009) Prospects of wind farm development in Algeria. Desalination 239(1–3): 130-138

Jebaraj S & Iniyan S (2006) A review of energy models. Renewable and Sustainable Energy Reviews 10(4): 281-311

NASA – National Aeronautics and Space Administration (2010) NASA collaboration benefits international priorities of energy management. [Referred 2.11.2015] [Online] Available at: http://www.nasa.gov/centers/langley/news/researchernews/rn_RETscreen.html

RETScreen International (2015) National Resources Canada. [Referred 15.10.2015] [Online] Available at: http://www.retscreen.net/ang/what_is_retscreen.php

RETScreen International (2005) RETScreen Engineering & Cases Textbook. Available at: http://www.retscreen.net/ang/printable_version_textbook.html

RETScreen International (2004) RETScreen International: Results and Impacts 1994-2012. [Online] Available at: http://www.retscreen.net/fichier.php/623/Rapport_Impact.pdf

SEI – Stockholm Environment Institute (2015) LEAP: Applications. [Referred 4.11.2015] [Online] Available at: http://www.energycommunity.org/default.asp?action=45

RECENT PROJECT DESCRIPTION

RECENT is a three-year project of the Northern Periphery and Arctic Programme, which provides a service for small-scale rural communities to improve their energy profile based on the utilization of unused potential through the application renewable energy and energy efficiency solutions. The project is led by the International Resources and Recycling Institute in Scotland, in partnership with Action Renewables in Northern-Ireland, Mayo County Council and Clár-ICH in Ireland, University of Oulu in Finland and Jokkmokk municipality in Sweden.

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Northern Periphery and Arctic Programme 2014–2020

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