MEASURE OF ENERGY CONSUMPTION USING AI

```
import energyusage


# user function to be evaluated
def recursive_fib(n):
   if (n <= 2): return 1
   else: return recursive_fib(n-1) + recursive_fib(n-2)

energyusage.evaluate(recursive_fib, 40, pdf=True)
# returns 102,334,155
```

It will return the value of your function, while also printing out the energy usage report on the command line. Optional keyword arguments:

pdf(default = False): generates a PDF report, alongside the command-line utility
powerLoss (default = 0.8): accounts for PSU loss, can be set by user if known for higher accuracy of results
energyOutput (default = False): prints amount of energy used by the process and time taken. The order is time, energy used, return of function
printToScreen (default = True): controls whether there is a terminal printout of the package running
energyOutput (default = False): determines whether the energy used and time taken are output. When set to true the order is time used, energy used, return value of function.
locations (default = ["Mongolia", "Iceland", "Switzerland"]): allows selecting the countries in the emissions comparison section for the terminal printout and pdf. These can be set to the name of any country or US state.
year (default = 2016): controls the year for the data. Default is 2016 as that is currently the most recent year of data from both of our sources. Note that only this year of data is included in the package installation but more can be added in a process described later.With a connected site, energy systems can be managed and orchestrated to prioritize or engage particular power sources or actions, reducing operational expenses. For example, AI-powered applications can tell the power systems to switch to using the batteries during times when tariffs are higher (peak load shifting), or when the grid power usage reaches a certain power grid alternating current limit (AC limit).With advanced network design and optimization services, AI is already making a big impact on energy performance in hardware and software. When it comes to network design, the functionalities are centered on planning – using different AI models to give communication service providers (CSPs) a deeper understanding of the network and its users, enabling them to build with precision. Every network and site is unique, so it’s important for energy-efficient solutions (such as Ericsson’s 5G radio access network (RAN) portfolio) to provide a wide range of products adapted to each radio site’s needs.
CSPs want to deploy sites – and services – where the customer demand is. With AI insights, they can identify which locations 5G sites, new carrier additions or other resources should be deployed, so they can be used where they will be most efficient.

Network optimization services, however, represent the area with the biggest impact. As we described in a recent Ericsson Technology Review article on AI and ensuring energy-efficient networks, AI predictions – coupled with energy-saving functionalities – can make vital decisions based on the network’s needs. They can decide what resources will be needed in the coming hours and if all the capacity in the frequency bands within the Radio Access Network (RAN) will be needed during that time. They can then dynamically turn off or on different frequency bands or resources according to upcoming demand, saving energy when demand is low.

Artificial intelligence (AI) and energy-saving features can help CSPs reduce energy consumption and operating costs. Here we explore the benefits of AI for sustainable networks – and why connecting all site equipment to the management system is key for energy efficiency and unlocking new revenues.

Most of the companies try to reduce energy consumption and costs by implementing various energy conservation measures. This is important for two main goals: (1) decreasing costs and (2) reducing carbon emission for the planet.

In order to save energy, energy data should be analyzed comprehensively, and actions should be taken in light of the insights from the analyzed data. However, basic statistical techniques have become insufficient to analyze energy consumption and to give meaningful insights. Hopefully, there are state-of-art applications or more complex techniques such as Machine Learning and Artificial Intelligence methods. Machine Learning is a branch of Artificial Intelligence (AI) focused on building an application that learns from data and improves its accuracy over time without being programmed to do so.[1] That means AI learns from data by analyzing it and therefore does not need a human to give insights.

Recent studies have shown that AI and ML can be used in different domains with different kinds of datasets. One of the applications of machine learning is forecasting which is basically predicting future values. In light of these studies, predicting the energy consumption of the future is possible and could be very useful for energy savings and budgeting. So the question here would be "How can we use AI for forecasting energy consumption?"

AI in Forecasting Energy Consumption

The energy consumption data is gathered in different time intervals and these data are called as time-series data. Since the AI learns from data, it is very crucial to collect data in a healthy way. Therefore, the data should be cleaned and transformed to desired datasets properly for training the AI model to forecast energy consumption precisely. Then, energy data is preprocessed, models are evaluated again and again, selected model are trained and the forecasting results are visualized.

The energy consumption of buildings and facilities commonly consists of periodic consumption behaviors, trends and patterns. Analyzing these consumption data with these pieces allows forecasting future energy consumption information. At that point, ML algorithms help to analyze historical data and develop forecasting applications.

Machine Learning algorithms and frameworks become significantly important to extract knowledge and insights into the energy industry. Plenty of tasks and techniques developed and studied due to that purpose and one of those is time series forecasting. Time series forecasting is an approximation task which is aiming to estimate future values of observations based on current and past values of the sequence and developing a model describing the underlying relationship.

There is a lot of research and different methods and techniques about time series forecasting. The methods are based on analyzing the time series data to develop a model describing the relationship between past and current data. There are Machine Learning techniques such as Autoregressive Integrated Moving Average (ARIMA) and Artificial Neural Networks (ANN) which are two of the several techniques in forecasting tasks.

Artificial Neural Networks (ANN) that are suitable for building data-driven models, can handle nonlinear relationships in the energy consumption dataset. ANN algorithms are very popular over the last decades. There is a lot of research about the usage of ANN as a time series forecasting technique and there are also ANN algorithms such as Recurrent Neural Networks (RNN) and Long-Short Term Memory networks (LSTM) as time series forecasting techniques.

How Forecasting Creates Value?

As Faradai, we are developing SaaS products for energy management. Faradai Platform has various modules to analyze energy usage or energy production, and Energy Consumption Forecasting is one of these tools.

Forecasting is crucial for energy managers to track the success of energy conservation projects and to calculate the feasibility of energy saving investments. It is also important for energy budget managers to prepare highly accurate budgets for the next quarter or year and to procure cost-effective energy tariffs.

Energy consumption forecasting also allows facility or building managers to track energy consumption trends, forecast future energy consumptions, take actions and reschedule operations beforehand. Precautions make it possible to decrease energy usage and billing costs.

For example, with machine learning and deep learning techniques, it is possible to forecast future loads and combine that forecasting results with the dynamic hourly market price. That helps the technical staff to be aware of the future invoice of each hour and to be able to decide the schedule of loads and to plan to shut down or shifting of the unnecessary loads to the cost-effective periods. By estimating the total consumption and shiftable loads of the facility and matching them with the dynamic tariff, the savings potential is calculated and the facility officials are informed in advanced through our application.

Besides from economical benefits of energy forecasting, there are obvious advantages from an environmental point of view. The reduction of energy consumption and carbon emission represents a crucial goal for a healthy planet. For this purpose, forecasting renewable energy production with AI is also quite possible.

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