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Presented by:

Ben Sadia Ahmed

Arif djamel

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**Forecasting household heating demand using ANN
Algorithms**

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In front of the jury:

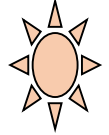
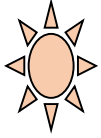
President Pr. BOUBEKRI Abdelghani

Examiner Pr. DOKKAR Boubekour

Supervisor Dr. BELAHYA Hocine

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Thanks



All the people who have made it possible for us to do this work are assured of our gratitude.

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And without forgetting all the students of our promotion.

We extend our thanks to the members of the jury who honored us to participate.

Dedication



I dedicate this modest work:

To my source of happiness:

My father, my mother for their love, their kindness, their sacrifices, their perpetual encouragement, their support. May Allah prolong their lives in happiness.

My brothers my sisters and all my family.

For my friends at university, energy option.

Abstract

In recent years, Algeria has witnessed a remarkable development in terms of energy production and consumption. According to statistics, almost half of this energy is directed to domestic consumption. Statistics also confirms that the share of heating in this consumption is about 46%. That's a big number, so we created a home heating model that we'll evaluate its effectiveness through algorithms. Artificial Intelligence This study aims to reduce the consumption of fossil fuel energy and the exploitation of renewable energy in home heating.

ملخص

عرفت الجزائر في السنوات الأخيرة تطورا ملحوظا من حيث إنتاج الطاقة واستهلاكها. وفقاً للإحصاءات ، يتم توجيه ما يقرب من نصف هذه الطاقة للاستهلاك المحلي. تؤكد الإحصائيات أيضاً أن حصة التدفئة من هذا الاستهلاك تبلغ حوالي 46%. هذا رقم كبير ، لذلك أنشأنا نموذجاً للتدفئة المنزلية سنقيم فعاليته من خلال الخوارزميات. الذكاء الاصطناعي تهدف هذه الدراسة إلى تقليل استهلاك طاقة الوقود الأحفوري واستغلال الطاقة المتجددة في التدفئة المنزلية.

résumé

Ces dernières années, l'Algérie a connu un développement remarquable en termes de production et de consommation d'énergie. Selon les statistiques, près de la moitié de cette énergie est destinée à la consommation domestique. Les statistiques confirment également que la part du chauffage dans cette consommation est d'environ 46 %. C'est un grand nombre, nous avons donc créé un modèle de chauffage domestique dont nous évaluerons l'efficacité grâce à des algorithmes. Intelligence Artificielle Cette étude vise à réduire la consommation d'énergie fossile et l'exploitation des énergies renouvelables dans le chauffage domestique.

Nomenclature

Symbols	Description	Units
<i>Coll_eff</i>	Collector efficiency	/
<i>Q_col</i>	The amount heat of the collector	KJ
<i>I_rad</i>	solar radiation	W/m ²
<i>Area</i>	Solar Collector Area	m ²
<i>HX_eff</i>	Heat Exchanger Efficiency	/
<i>SF</i>	Solar system fraction	/
<i>Q_Aux</i>	Auxiliary heater heat quantity	KJ
<i>P_{pump}</i>	Pump Capacity	L/H
<i>T₁</i>	Hot water inlet	K
<i>T₂</i>	Hot water outlet	K
<i>T₃</i>	Cold water inlet	K
<i>T₄</i>	Cold water outlet	K

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LIST OF ABBREVIATIONS

TRNSYS: Transient System Simulation Tool.

ANN : Artificial Neural Network.

HVAC : heating, ventilating, and air conditioning.

Loos : Mean squared error.

MAE: Mean absolute error.

TMY: Typical meteorological year.

IDE: Integrated development environment.

ELM : Extreme machine learning.

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Introduction general

Heating is an important energy-consuming activity worldwide, particularly for buildings and for providing comfort and warmth during winters or in colder climates. Given the challenges associated with climate change, the Russian-Ukrainian war, and the need to reduce reliance on non-renewable energy sources, finding alternative heating solutions has become imperative. Algeria relies heavily on gas and electricity to heat homes, which burdens citizens financially. Therefore, we propose a solar home heating model that we study using machine learning to address this model's effectiveness.

Machine learning is a branch of artificial intelligence that enables computers to learn from data. It involves developing algorithms and techniques that allow computers to improve their performance through learning. Machine learning tasks are divided into four main categories: supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning. For our work, we chose supervised learning because it aligns with our approach. Supervised learning involves training a model using labeled data (inputs and outputs) to learn and accurately predict output classes for new inputs. We integrate Python with TRNSYS software to simplify our work and save time. Python helps prepare the input array and enter it into the program, replacing the traditional time-consuming process of manual input. We use four algorithms in our study: artificial neural networks (ANN), linear regression algorithm, decision tree algorithm, and random forest algorithm. These algorithms allow us to analyze complex data and generate accurate predictions, helping decision makers make informed choices. Moreover, machine learning makes it possible to generate many models in a short time frame, depending on the available computing power.

Our research is divided into four chapters. The first chapter focuses on energy consumption, while the second chapter discusses the simulated heating model in the TRNSYS program. In the third chapter, we review relevant literature to explain the basic concepts and components of machine learning. We also discuss model simulation using the Python programming language. Finally, the fourth chapter presents the results, their effectiveness, and the effect of the amount of information on prediction accuracy

Chapter one
Research
problem and
methodology
of the study

I.1.introduction:

Home heating accounts for a large proportion of global energy consumption, so it is necessary to search for new sources of home heating that are more efficient and effective and consume less energy.

The design, installation, and components of a home's heating and heating system play an important role in energy consumption. As most countries tend to use renewable energy sources such as solar energy and geothermal heat for heating, this leads to a significant decrease in energy consumption.

I.2.The importance of research:

The importance of the research lies in the fact that it is a first step to help solve the problem of excessive energy consumption in the world and Algeria in particular, and it is a spark and the beginning of an attempt to self-sufficiency in energy and reduce the expenditure of fossil fuel energy by using simulation and modeling of heating systems that use renewable energy and with the great development in technology, Solutions must be found to reduce energy consumption by designing energy-saving heating systems, and its importance is clear in reducing energy consumption in heating the house.

I.3.The aim of the research:

The main objective of this project is to create a home heating demand forecasting model in order to reduce energy consumption.

In addition to testing the validity of the results given to us by artificial intelligence, exploring machine learning techniques, developing data-driven models for predicting home heating energy consumption, and verifying the effectiveness of the model.

In this project, we also aimed to compare machine learning models for home heating forecasting to historical data and to evaluate the performance of the model.

I.4. The problematic:

The problem of excessive energy consumption in home heating is a global problem, as major countries in the world have established research centers in order to find solutions to the problem of energy loss in building heating.

For this, we discuss in this note some solutions that we consider appropriate to reduce excessive energy consumption in home heating, as well as study the effectiveness of these solutions.

I.5. Reference studie:

In this study, residential heating demand was projected in a case study (Baharestan town, Karaj) in Iran based on monthly natural gas consumption data and monthly mean ambient temperature. Three different methods containing Extreme Learning Machine (ELM), Artificial Neural Networks (ANN) and Genetic Programming (GP) were used to predict residential heating demand in the case study and the results of these methods were compared after validation on real data. In fact, the main objective of the current study is to obtain the most accurate technique among these three popular methods in this context. Validation of the prediction results reveals that an important advance in terms of accuracy can be achieved by the ELM method in comparison with ANN and GP. Moreover, the obtained results indicate that the developed ELM models can be used with confidence for further work on formulating a new model predictive strategy for residential heating demand for DHS. The outputs reveal that the new procedure can have adequate performance in large cases and can be learned more quickly compared to other common learning algorithms.[1]

I.6. Research methodology:

To achieve our desired goal and create a home heating forecasting model that gives good results, we must determine the type of data and sources that can be used for this goal. We also simulate the model through TRNSYS software and subject its data to machine learning with the help of Python. Four important stages are taken into account which are data comprehension, preparation, model development and evaluation.

I.7.Expected results:

- ✓ Reduce the error rate of the model that predicts home heating demand.
- ✓ Clarify the effectiveness of the proposed model and compare it with the old models.
- ✓ Examine the change in the home heating model's behavior over the specified time period.
- ✓ Creating a simulator that allows creating databases by integrating several programs using the Python language.

Chapter two

Heating and energy consumption

II.1.Introduction:

The residential sector is one of the main sectors that significantly affect energy consumption in the world, as energy is used extensively in heating buildings and operating lighting and ventilation systems. The operation of these systems requires the consumption of large amounts of electricity and fuel, which increases greenhouse gas emissions and affects the preservation of the environment. In this context, energy consumption in Algeria will be addressed.

Therefore, it has become necessary to focus on reducing energy consumption in the home heating sector to achieve energy efficiency. Business strategies aim to design a building heating model to achieve efficient energy use.

In addition, home heating systems that rely on renewable energy sources such as solar energy can be used to achieve efficient and sustainable heating. Solar panels can be used to generate thermal energy and direct it to the home heating system, which contributes to reducing dependence on traditional fuels and reducing harmful emissions. The process of heating the house will be explained by heating water using solar energy .

II.2.Energy in Algeria:

The energy sector in Algeria is one of the vital sectors that contribute significantly to the economic and social development of the country. Its main role is to meet the long-term national energy needs and to finance economic development through revenues from the export of energy sources.

In 2016, Algeria had about 0.7% of oil reserves and 2.4% of gas [2]. According to the annual report of the Algerian Ministry of Energy and Minerals, more than 99% of the energy mix consists of petroleum products and gas. Commercial primary energy production reached 154.9 million tons in 2015[3]. According to the figure below, natural gas still dominated the structure of primary energy production in 2015 by 52% .

In 2012, the Algerian state began considering environmental solutions by investing in new and renewable energies. According to the Algerian Program for the Development of Renewable Energy and Energy Efficiency (PENREE) of 2012, Algeria aims to have an installed capacity from a renewable source of 22,000 MW by 2030. But after three years of this plan, achievements are still to come. It has installed only 300 megawatts [4].

II.3.Energy consumption in Algeria:

Algeria is witnessing a remarkable increase in energy consumption, and this is due to the increase in population density, the high standard of life, and economic growth. The

standard of life in Algeria has improved significantly in recent years, which has led to an increase in per capita energy consumption in housing, including the use of air conditioning and heating and lighting. In recent years, Algeria has also experienced impressive economic and industrial growth. In order to run factories and supply the growing demand for energy and fuel in a variety of industries, including manufacturing, construction, and transportation, more energy is needed.

It was stated in a report by the Ministry of Energy on energy consumption in Algeria, for the year 2016. The national energy consumption reached 58.3 million tons cubic meters in 2016, almost the same level (+0.1%) as in 2015. It represents more than a third (35.1%) of the total production. Final energy consumption recorded a slight increase (+1.0%) to reach 42.9 million cubic feet, This was driven mainly by electricity (+4.3%) and natural gas (+3.3%). [5]

II.4. Energy use in the Algerian domestic sector [5] :

According to a study issued by the Ministry of Energy, the rate of domestic energy consumption is constantly increasing. Algeria's first energy user is the unproductive but energy-intensive construction industry. As it uses 41% of the total energy. Heating consumption takes the lead at 46%, followed by cooking (22%), hot water production (13%) and electricity use (19%).

Through these statistics, we notice that home heating consumes a large proportion of energy.

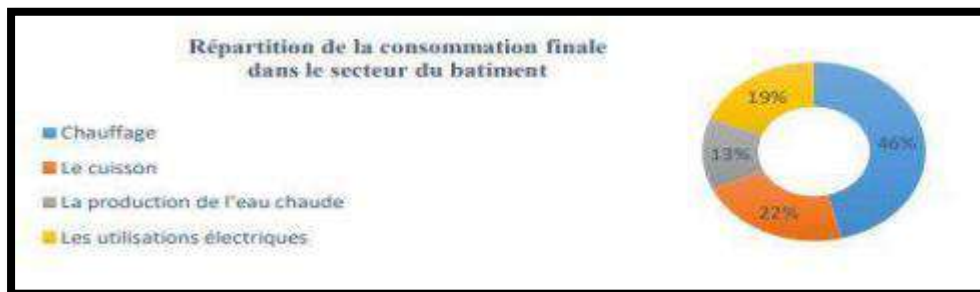


Figure II. 1: The energy consumption in buildings [15].

II.5. Electricity consumption in Ouargla [6]:

The average use of electrical energy per subscriber in the city of Ouargla is steadily rising, according to statistics collected by SONELGAZ. The graphs (Figure 2) show the evolution of annual consumption from 260,000,000 GWh in 2010 to nearly 450,000,000 GWh in 2020.

This rise in electricity use is a sign that the city's need for electrical services is increasing, and could result from a number of factors, including population growth and the expansion of commercial and industrial activity in the area. It is crucial that the concerned authorities monitor this rise in consumption and take appropriate action to meet the growing demand for energy and maintain the scalability of the city's electrical infrastructure.

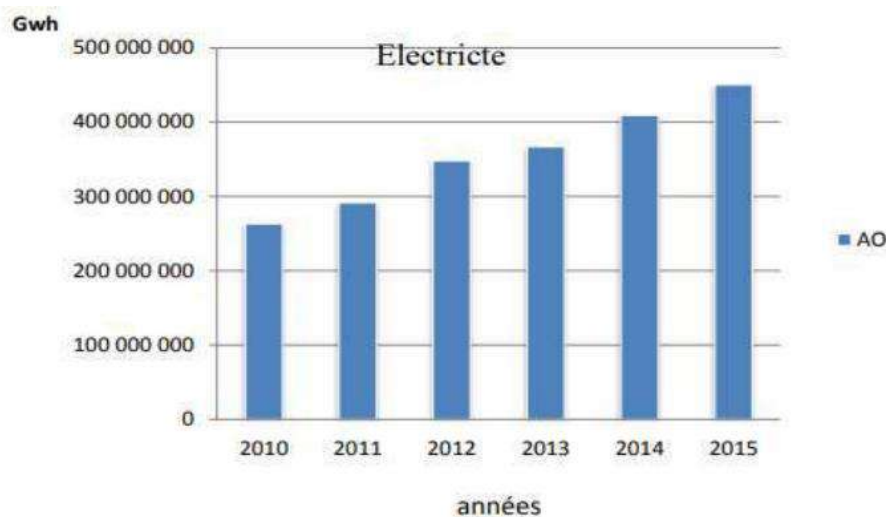


Figure II. 2:Electricity consumption in the city of Ouargla period: 2010-2015 [15]

II.6. Renewable energy in Algeria

Renewable energy is the long-term energy source that is renewable in nature. Solar, wind, geothermal, microbial, organic waste and other renewable energy sources are just a few examples.

Algeria's renewable energy potential is enormous, particularly in the field of solar and wind energy. The nation offers plenty of natural resources, including winds in different places and sunshine throughout the year. Although Algeria is implementing solar and wind energy projects, there is still a lot of untapped potential.

Algeria should invest in the required infrastructure and technology, pass the necessary laws and regulations, and promote domestic and international investment in the renewable energy industry. In addition, it calls for increasing knowledge of the benefits of renewable energy and promoting its application in a number of industries, including transportation, heating and energy.

II.7.Home heating:

Home heating is the process of providing heat and comfort inside homes and dwellings during periods of cool and cold weather. The home heating system aims to provide a comfortable and suitable temperature for the occupants inside the home.

A heat source is connected to various rooms, hallways, and kitchen areas of the house to provide home heating. Space heaters, underfloor heating systems, electric heaters, central heating systems, and other components and technologies are all included in home heating systems.

The heat sources utilized for house heating can range from solar energy to electricity to biofuels (like wood or wood pellets) to natural gas fuel. The choice of heat source is influenced by variables like fuel price, nearby supply, environmental concerns, and energy effectiveness.

Home heating systems not only produce heat, but they also have distribution and control components that make sure it is delivered properly and efficiently throughout the house. By employing thermal insulation and upgrading the windows and doors of the house to stop heat leakage and energy loss, the effectiveness of the home heating system is increased.

II.8.Types of domestic heating:

Home heating refers to the heating systems used in residential dwellings to maintain a pleasant indoor temperature. There are several types of commonly used home heating systems:

II.8.1.Domestic gas heating:

Gas heating consisting of a gas fired boiler, central heating system and radiators or underfloor heating. Natural gas or propane depending on the type of supply is required to operate this system.

In fact, the boiler uses gas combustion for heating. The latter is thus directed to the burners that are installed in the heating device body. This process enables the heat from the

water to be transferred later into the central heating system to heat the radiators or the heated floor.

II.8.2.Electric heating:

The electric heater can be installed quite easily. However, it is more expensive to use it as a heating medium. As a result, you should only consider using this type of heating if your property is well insulated and, ideally, if you combine it with transmitters that have a programming system.

The choice of heat emitters, such as convectors, inertial or storage radiators, underfloor heating, etc., has a great influence on the efficiency of electric heating.



Figure II. 3:shows a type of electric heating.

II.8.3.Wood heating:

Definition of wood heating: Using wood to heat your home can be a smart way to balance comfort, energy efficiency, and cost-consciousness. On the other hand, it is not universally adaptable. There are several kinds of wood heating available, including:

- The insert, also known as a closed hearth, is far more efficient than a conventional open fireplace. Most versions use logs, while some variants also support pellets.
- The wood, pellet, or storage stove: while normally less expensive, prices greatly vary depending on the model's aesthetics.
- The log or storage boiler: It permits full combustion of the wood, and the most contemporary versions are low-polluting and extremely energy-efficient (and hence cost-effective).[3]

II.8.3.Solar heating:

By definition, it is progressing. This heating technology generates heat using sunlight, which is a sustainable energy source. Although it is a very expensive device, it can be very cost effective when you use it. It usually meets 20 to 50 percent of a household's requirements for hot water and heating.

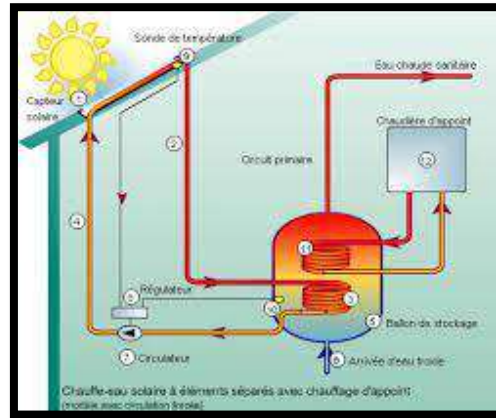


Figure II. 4: The home heating by using solar energy.

II.9.Solar water heating (the idea of a solar heater) [7] :

II.9.1.Definition of solar heater:

A solar heater is a device that converts solar energy into energy that is used to heat water directly and not to generate electricity as in the case of solar panels. This hot water can be used for showering, heating swimming pools, solar heating or even solar cooling. Solar thermal also uses heated water to generate electricity.

Solar heaters have existed for more than a hundred years, but in the last two decades the technology of solar heaters has developed significantly and significantly. photovoltaic, as it cannot convert more than 21% of the solar energy falling on it into electricity, in the best types solar energy panels.

II.9.2.Advantages of using solar water heaters:

Solar water heaters have many important advantages that qualify them to be the ideal alternative Exploitation of one of the most important alternative energy sources, which is solar energy with high efficiency, as it is safe and environmentally friendly Insulation High

technology in it by using Polyurethane inside Evacuated tubes, which lead to long-term heat retention In addition to the following features:

- The internal tank and the external connection pipes are made of stainless steel, which is resistant to corrosion and various weather conditions. All rubber parts and internal connections are made of non-toxic materials that do not affect the properties of the water passing through them. These heaters are characterized by ease of installation and simplicity, even in the worst conditions. Circumstances When an evacuated tube is broken by force, the broken tube should simply be removed by releasing its clamp and a new tube should be easily replaced.
- Solar heaters are a means of exploiting the thermal energy generated from the sun's rays to heat water for homes and commercial purposes. These systems achieve a higher economic feasibility than solar photovoltaic energy, as 30% of the household electricity bill can be saved at a cost that will be recovered within 3 years only.
- The solar heater heats the water and stores it during the day for use throughout the day 24 hours, unlike the traditional electric heater that can heat at any time of the day or night and therefore the capacity of the solar heater is much larger, for example if an average apartment needs electric heaters with a total capacity of 50-70 liters , the same apartment will need a solar heater capacity of 300-250 liters.
- Solar collectors can utilize more than 50% of the solar energy falling on them.
- The more the place is exposed to the intensity of solar radiation and the temperature is high, the more we can get more energy without solar collectors that can exploit more than 50% of the solar energy falling on them. Restrictions, as in the case of solar energy panels to generate electricity, whose efficiency decreases as the temperature rises.
- The smaller ones for household consumption are not very expensive.
- Its lifespan is long, but it needs maintenance approximately every 3 years.

II.9.3.Types of solar heaters

There are several types of solar water heating systems, including:

✓ **Non-pressurized vacuum tubes:**

This technology relies on vacuum tubes that absorb thermal energy and convert it into thermal energy to heat water. Each vacuum tube consists of two glass tubes, one inside the other, and they are made of borosilicate glass.

✓ **Flat solar heaters:**

The solar collector in these heaters is an absorption surface consisting of a very thin absorber plate greased with a material that absorbs the sun's rays, and the water flows from aluminum or copper to be heated in copper pipes inside these panels, so that heat exchange occurs, and it is preferable to use this system In normal domestic and administrative applications and the implementation of a pump to pressurize hot water pipes.

✓ **Vacuum heat pipes:**

The main difference between this type and the previously explained normal vacuum tubes is that in this type there is a copper tube inside the glass tubes, which is pure and of high quality. Inside it is a small amount of thermal liquid, and air is emptied to obtain low pressure and rapid boiling of the thermal liquid at high temperatures. Low, as the boiling point of the liquid is at a temperature of 30 degrees, and if it exceeds this temperature, the thermal liquid evaporates and rushes towards the top of the tube, where the temperature decreases with it, and when it reaches the top of the tube, the heat is transmitted from the end of the copper pipe to the water to be heated, and it condenses Steam flows down the copper tube again, and this process is repeated continuously and leads to heating the water.

II.10.Conclusion:

The increase in global energy demand, the scarcity of fossil energy resources, and the climate change that has begun in recent decades are undeniable facts. In this energy context, the implementation of measures and procedures to reduce energy consumption and provide other sources of energy production, the residential sector occupies the first place in energy consumption, as we find that heating takes the largest share.

For this, old heating types must be abandoned and heating types that work on renewable energy must be exploited because they are pure energy and do not harm the environment.

Chapter three

Simulation TRNSYS

III.1.Introduction:

In this chapter, TRNSYS software, which is the most widely used simulation of these systems, will be used to analyze the solar home heating model in this chapter. There will be an explanation and illustration of the characteristics of the heating model, including the variables and values that will be used in the simulation.

It will be explained how to create the model and identify the main elements of the heating system, including solar panels, energy storage and the indoor heating system. How the model adjusts for these factors will be dealt with as well as expected climatic variables and their effects on system performance, such as changes in temperature and availability of solar radiation that are taken from the meteorological program. In which an overview of the TRNSYS program will be presented.

In addition, the model programming process in TRNSYS will be demonstrated. How to enter appropriate input data and run simulations to analyze system performance will be explained..

III.2.Home heating:

Home heating is a vital issue on a global level, as many countries face challenges in providing comfortable and efficient heating for homes, especially in areas that suffer from harsh winters and low temperatures. The world is facing environmental and economic challenges with regard to heating homes, and providing them in sustainable and energy-saving ways.

In many countries, too much reliance is made on fossil fuels to heat homes, leading to high greenhouse gas emissions and air pollution. Therefore, there is a global movement towards adopting sustainable and regenerative heating systems that rely on clean energy sources.

Solar energy is one of the most popular and sustainable options for home heating globally. Where solar panels can be used to convert the sun's energy into electricity that is used to operate electric heating systems or to heat water. Solar energy can also be stored using thermal storage systems to provide heat during cold nights or periods that are not sunny.

In addition to solar energy, other renewable energy sources such as geothermal energy, biothermal energy, and marine thermal energy are used in some countries to heat homes.

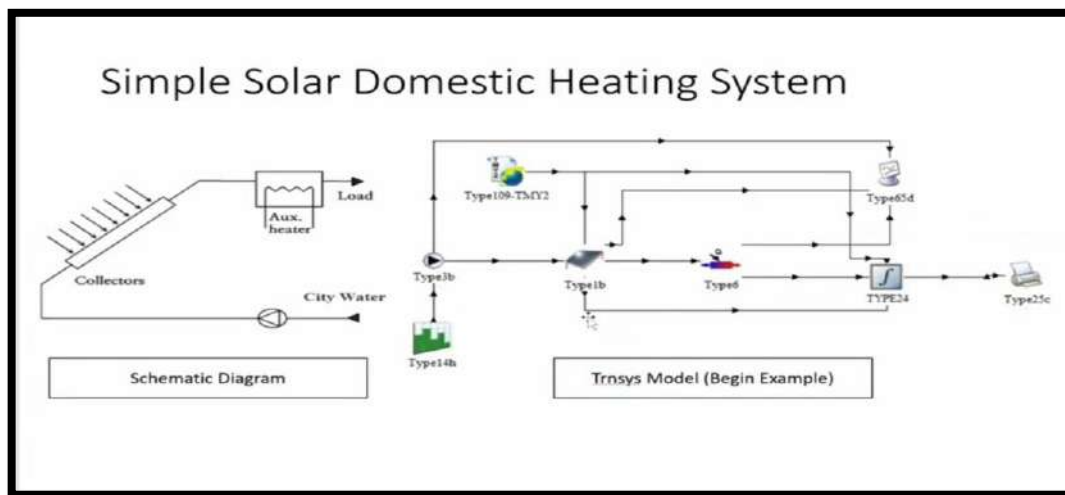
III.3.Simple solar home heating system:

This simple home heating system consists of a solar collector, storage tank and heat exchanger and these are the standard components of a solar home heating system. The collector is used to capture sunlight and convert it into heat ,they are often placed on the roof or on an adjacent building. A liquid (often water or a water-glycol mixture) is then heated and pumped through the accumulator by means of a pump as shown in Figure III.1.

Next, a storage tank is used to hold the hot liquid until later. To reduce heat loss, the storage tank is often hermetically insulated. The liquid is transferred from the storage tank to a heat exchanger where it provides heat to the water in the domestic hot water system when hot water is needed. In a storage tank, the heat exchanger can be a coil of tubes, or it can be a distinct device with a separate water storage tank.

The size of the collector and storage tank should be appropriate according to the hot water demand, dwelling size, and local climate to ensure the system performs well. In addition, in times of insufficient sunlight or high demand, a back-up heating system (such as a gas or electric water heater) may be required to supplement the solar heating.

In general, especially in sunny locations, a direct solar home heating system may be an efficient and sustainable way to heat water for a home. Before spending money to create such a system, it is necessary to weigh its costs and benefits.[8].



Figuer III.1: a schematic diagram of a simple solar home heating system simulated in TRNSYS.

III.4. Definition of home heating model:

The model we created is based on using solar energy to heat the water, and then using it to heat the house. It consists of a group of components similar to the solar energy collector and two pumps to distribute water within the system in addition to each of the heat exchangers and the additional heater that we use to raise the water temperature in the event that it does not reach the required degree.

First, the solar collector is installed on the roof of the house, taking into account the angle of inclination of the collector, as well as the direction to which it is usually directed in Algeria, which is to the south. Then the collector is connected to the first pump, where it transfers the water and passes it through the collector, and in turn the collector transfers the hot water to the heat exchanger, and at the same time from the other side, the second pump transfers the cold water to the exchanger, and here the heat transfer takes place from the hot water to the cold, and then it is transferred to the additional heater from In order to raise the hot water temperature to the required degree in heating the house. As illustrated by Figure III.2:

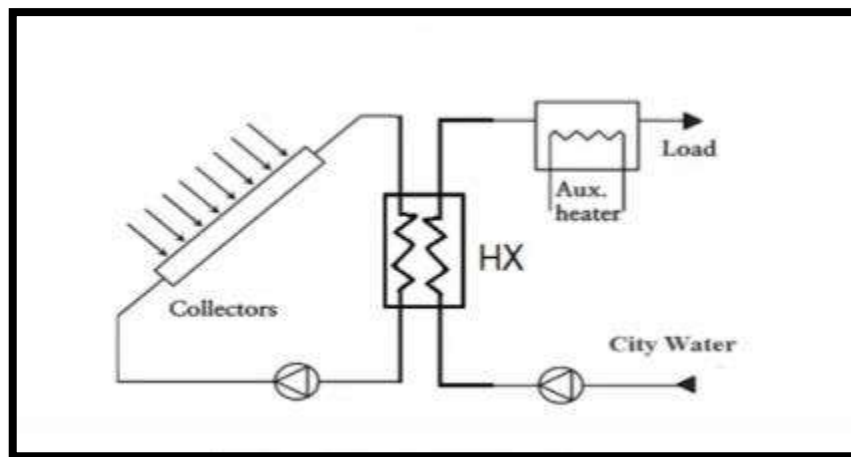


Figure III.2: The solar home heating model

III.4.1. components of this form:

➤ **Solar collector:**

A flat plate collector is a device used to collect and use heat energy from sunlight. The flat thermal collector consists of a flat solar panel made of a transparent material such as glass or plastic, and contains tubes or pipe systems inside through which water passes as well as calculates or gives data related to the liquid temperature and solar radiation. The efficiency of the collector is calculated as follows:

$$Coll_eff = \frac{Q_col}{I_rad * Area}$$

➤ **Heat exchanger**

The heat exchanger consists of two inlets and two outlets through which both cold and hot water pass, where the temperature transfer process takes place to cold water, where the maximum possible heat transfer is calculated based on the minimum fluid capacity rate, cold side and hot side fluid inlet temperatures. The heat exchanger efficiency is calculated as follows:

$$\eta = \frac{T_1 - T_2}{T_1 - T_4}$$

➤ **Auxiliary heaters**

Auxiliary heaters, also referred to as backup heaters, are secondary heating systems that work with the main heating system to supplement additional heat when necessary. In times of extreme cold or when the main heating system is unable to meet space heating needs, it acts as a backup or additional source of heat. To heat a home, you raise the indoor temperature.

➤ **Pumps:**

Pumps 1 and 2 move hot and cold water into the system, and we can control the water flow during a specified period of time.

III.4.2. The working principle of the home heating model:

The principle of the solar heating system for the home is based on using the available energy from the sun to heat the water and air inside the house. The solar collector absorbs the sun's rays and converts them into heat. The heat is then transferred to a liquid (water) which is circulated through the accumulator by pump 01.

After that, the heated liquid is transferred to the heat exchanger, which is a simple coil of tubes in the storage tank, where it transfers the heat of the hot water to the water pumped by the pump 02, after which the hot water is transferred to the auxiliary heater. In order to bring its temperature up to the desired degree, it is then pumped into a home heating system. To ensure that the system works efficiently, it is important to determine the area and size of the solar collector, the size of the house and the number of people in the house, and to take into account the climate of the area.

III.5.Meteonorm [9]:

A popular piece of software in the fields of meteorology and renewable energy is Meteonorm-8.0.2. It is made to deliver precise and trustworthy weather information for every place on Earth. METEOTEST, a business with a basis in Switzerland that specializes in meteorological data and climate analysis, created and maintains the program.

Meteonorm-8.0.2's main objective is to produce data for a typical meteorological year (TMY). The long-term weather conditions for a certain place are represented by TMY data, which is a collection of meteorological factors including solar radiation, temperature, humidity, wind speed, and precipitation. Numerous applications in agriculture, renewable energy, architectural design, and environmental research all depend on this data.

The following are some of the primary attributes and functionalities of Meteonorm:

- Meteonorm's global coverage enables users to get meteorological information for any location in the world.
- Data Sources: A variety of data sources, such as satellite observations, on-the-ground measurements, and weather stations, are combined and coordinated by the program.
- Data: Meteonorm offers a thorough collection of meteorological data, including direct, diffuse, and global solar radiation components, temperature, humidity, wind direction and speed, precipitation, and air pressure.
- Data Formats: A wide range of data formats, including CSV, TMY, EPW (Energy plus Weather), and many more, are supported by the program. Users may import and export data to other modeling software and tools thanks to this.
- Graphical User Interface: Meteonorm has an intuitive graphical user interface that makes it simple for users to engage with the program. Provides capabilities for charting, exporting data reports, and visualizing data.
- Customization: Users have the option to alter the data's temporal precision (hourly, daily, or monthly), choose certain meteorological factors of interest, and produce TMY data according to their own requirements.
- Professionals and academics from a variety of fields, such as solar planning, building design, climate studies, and environmental impact assessments, frequently utilize Meteonorm-8.0.2. It offers useful meteorological information that is used as the foundation for precise simulation, modeling, and analysis in various areas

III.6.TRNSYS:

It is a software that models and evaluates the operation of HVAC systems and various types of building systems and renewable energy systems, the software application TRNSYS (short for “Transient System Simulation Tool”) is used. The software has a

modular design and offers a wide range of pre-built simulation modules that may be interconnected to build sophisticated system models.

The Solar Laboratory at the University of Wisconsin-Madison initially created TRNSYS in the 1970s [10] , and since then, many universities and organizations from around the world have continued to update and improve it. The software is frequently used by researchers, engineers, and architects in the areas of sustainable building design, energy management, and renewable energy systems.

By dragging and dropping pre-built modules onto a canvas and linking them together, TRNSYS GUI users can design and modify system models. In addition, the software comes with a scripting language that users can use to build native modules and modify pre-existing modules.

The performance of a variety of building systems and renewable energy technologies, such as solar thermal systems, photovoltaic systems, geothermal systems, and more, can be simulated using TRNSYS. The application can be used to examine how well these systems perform in various weather scenarios, under variable building loads, and in other situations, as well as to optimize system setup and operation.

TRNSYS is a powerful software often used in academic, engineering and architecture research to model and evaluate the performance of renewable energy systems and building systems.

TRNSYS provides a flexible platform for modeling and simulating various types of home heating systems, allowing for customization based on specific components, climate conditions and control strategies. It is widely used by researchers, engineers, and designers to improve the design and operation of solar thermal power systems .

III.6.1.Main categories of components:

The Standard Component Library is organized in 14 categories:

- Controllers
- Electrical
- Heat Exchangers
- HVAC
- Hydrogen Systems .
- Hydronics .
- Loads and Structures .
- Obsolete .
- Output .
- Physical Phenomena .

- Solar Thermal Collectors .
- Thermal Storage .
- Utility .
- Weather Data Reading and Processing [11].

III.6.2.Program areas of use:

III.6.2.1.Building Energy Simulation:

TRNSYS software is capable of modeling and simulating the energy performance of buildings, including heating, cooling and ventilation systems. It can be used to predict energy use, indoor comfort, and predict the results of energy saving initiatives.

III.6.2.2.Renewable Energy Systems:

TRNSYS program has the ability to simulate and model renewable energy sources including solar energy, wind energy, energy, etc. It can be used to study project effectiveness and optimal design of renewable energy systems.

III.6.2.3.Simulation of industrial processes:

TRNSYS software can be used to model the energy requirements of industrial processes such as manufacturing, chemical synthesis, etc. It can also be used to maximize the energy efficiency of these processes and to find areas where energy can be saved.

III.6.2.4.District Energy Systems:

TRNSYS software is capable of simulating and modeling district energy systems, which transfer power from a central station to a number of buildings. It can be used to evaluate the energy and financial performance of district power systems and to enhance their design.

III.6.2.5.HVAC Systems:

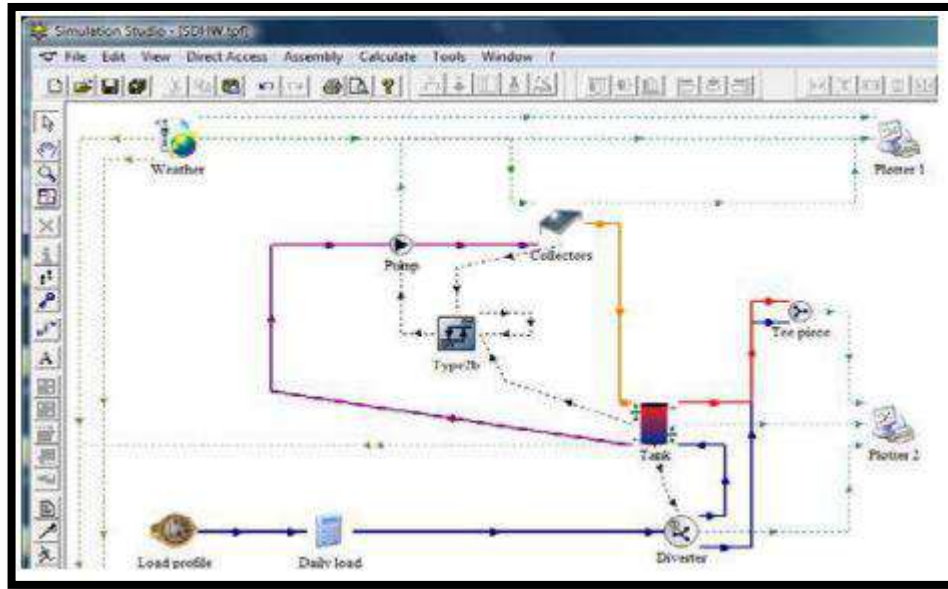
TRNSYS is capable of simulating and modeling several types of HVAC systems. It can be used to evaluate the effectiveness of HVAC systems and optimize their design for occupant comfort and energy economy.

III.6.3.Simulation tool from TRNSYS

TRNSYS Simulation Studio, serving as the primary visual interface. Drag and drop components into the workspace, link them, and adjust global simulation settings to create projects from there.

Project data is saved by Simulation Studio as Trnsys Project File (*.tpf). The studio also creates a TRNSYS input file when a simulation is run, which is a text file that contains all simulation data but no graphics.

Simulation studio also has a log/error manager that enables you to examine details of what happened during the simulation as well as an output manager that lets you define embedded, printed, and/or drawn variables [12].



Figuer III.3: Simulation tool from TRNSYS.

III.7.Home heating model simulation in TRNSYS:

To simulate our home heating model in TRNSYS, we follow these steps:

❖ We define the components: the basic components of our home heating system are heat exchanger type91, solar collector typeb1, two pumps type3b, auxiliary heater type6, weather data reader type 109-TMY2, time control element type14h and assembler collects data, type24, as well as plugins such as type65d for plotting data, type25a for writing and printing results, and the Equa component, with which we modify simulation data and equations.

❖ System Configuration: We use the TRNSYS graphical interface where we place all the components of the home heating system. We connect the components together according to the actual arrangement of the heating system like the following pictures:

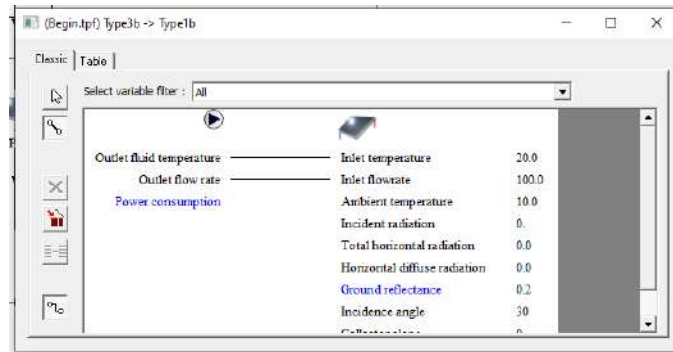


Figure III.4: The connection between the pump1 and the solar collector.

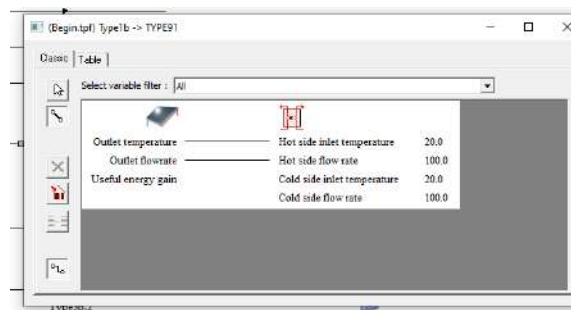


Figure III.5: The connection between the solar collector and the heat exchanger.

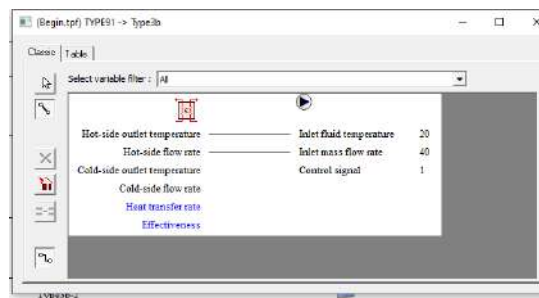


Figure III.6: The connection between the heat exchanger and the second pump.1

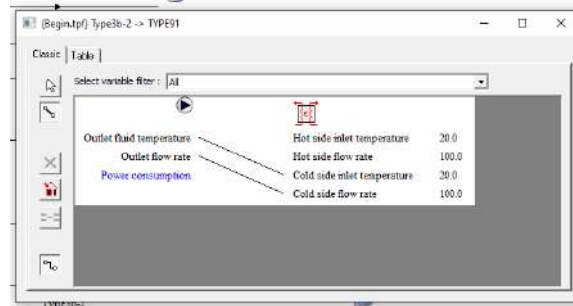


Figure III.7: The connection between the heat exchanger and the pump.2

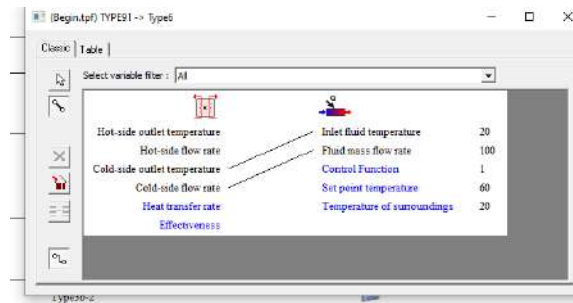


Figure III.8: The connection between the heat exchanger and the auxiliary heater.

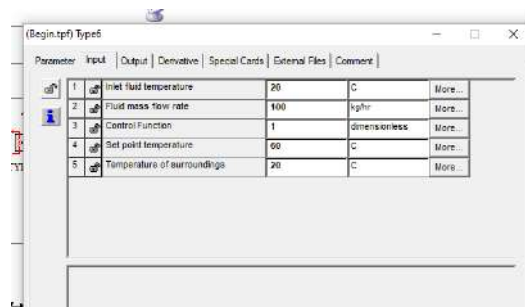


Figure III.9: The location of the additional heater temperature control, the degree that we studied in the model $T = 60$ C.



Figure III.10: The link between the weather data and the solar collector.

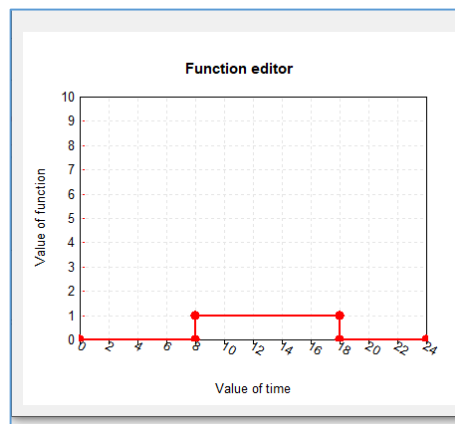


Figure III.11: Hours of operation of the pumps.

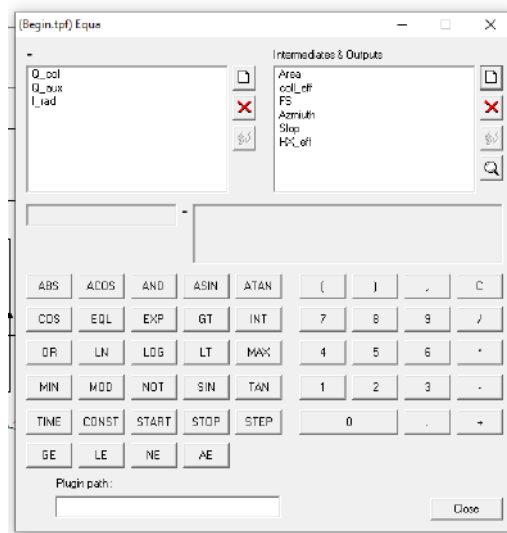
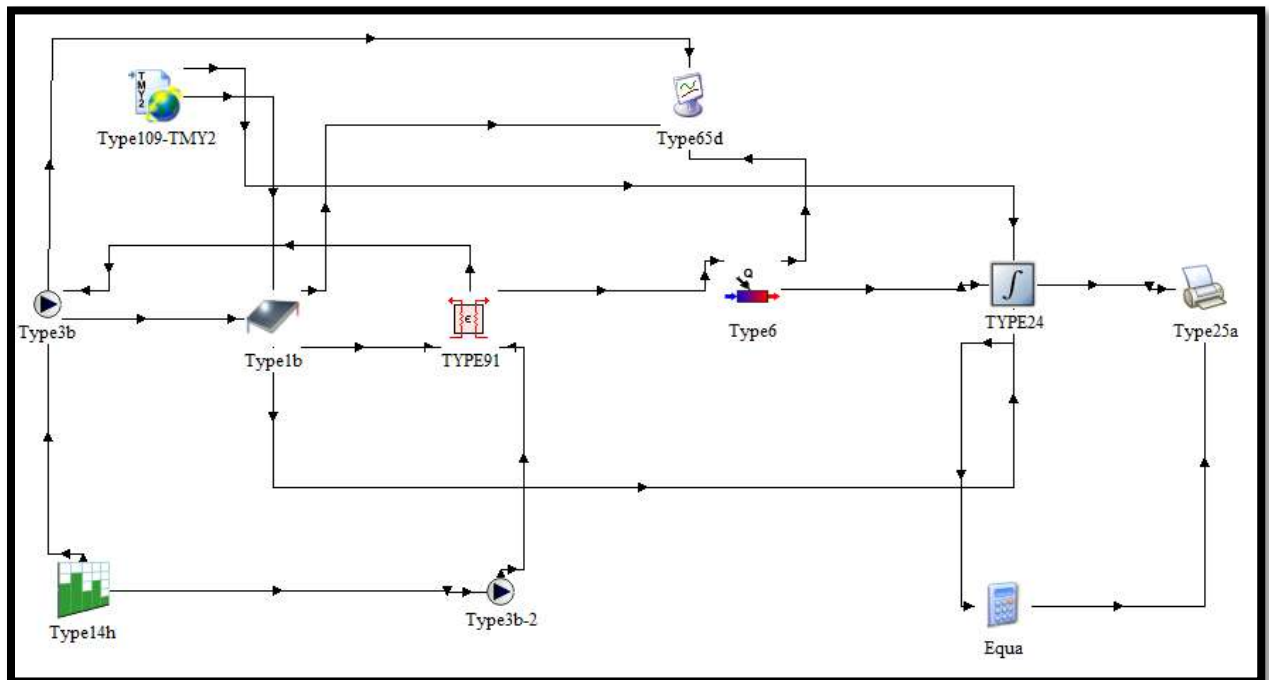


Figure III.12: The EQAU component through which to enter data and relationships

- ❖ Define Weather Data: Provide the weather data required for the simulation, such as solar radiation, temperature, etc., by selecting the area using Meteonorm software. TRNSYS provides different weather data formats and allows you to enter standard or synthetic weather data. In this simulation we select the region of Ouargla.
- ❖ Run the simulation: After connecting the components and entering the variables via EQUA, we save the model and run the simulation in TRNSYS. We also define the time period over the months January, February, March, November and December, then the program calculates the performance of the system over a specified period.
- ❖ Analyze the results: Once the simulation is complete, we take the results obtained by TRNSYS and save the results for use in the Python AI simulation.



Figuer III.13 The solar home heating model simulated in TRNSYS.

III.7.1.Data and input home heating form:

III.7.1.1.Solar Collector Area :

The effective area of solar panels or solar collectors used to absorb and convert solar energy into heat. The area of a solar collector is usually measured in square meters.

III.7.1.2.Pump Capacity:

The capacity required for the pump to pump and move the thermal fluid to and from the solar collector and heating system. Pump capacity unit L/H.

III.7.1.3.Amount of Solar Heat:

This is the heat that has been produced in the solar collector as a result of solar energy being absorbed. Its w or kw measurement depends on the solar collector's area, efficiency, and solar radiation availability.

III.7.1.4.Collector efficiency:

It is the ratio of the actual heat absorbed by the solar collector over the product of the collected area multiplied by the available solar radiation. We express it with the following relation:

$$Coll_eff = \frac{Q_col}{(I_rad * Area)}$$

III.7.1.5.Solar system fraction:

It is the percentage of thermal energy produced by the solar collector dividing the total energy added or consumed in the system by all energy sources such as the amount of heat from the additional heater, the amount of heat from the solar collector and the energy generated by the pump. We express it with the following relation:

$$SF = \frac{Q_col}{Q_col + Q_Aux + P_pump}$$

III.7.1.6.Solar radiation:

Solar radiation is the amount of solar energy that reaches the earth's surface in a given time period and area. The unit of measure for the intensity of solar radiation is (W/m²). Many variables affect the intensity of solar radiation, including the time of day, season, location, and weather.

III.7.1.7.Heat Exchanger Efficiency:

Is a measure used to evaluate the performance of a heat exchanger in transferring heat between two waters of different temperatures, hot and cold. We express it with the following relation:

$$\eta = \frac{T_1 - T_2}{T_1 - T_4}$$

III.7.2.Variables and inputs:

The inputs that we perform model simulations in TRNSYS are as follows:

- Slop (It is the inclination of the solar collector)
- Azimuth (The orientation of the solar collector towards the south)
- HX_eff

The following table specifies the values with which we ran the simulation:

Azimuth	Slop	HX_eff
-10	20	0.3
-5	25	0.4
0	30	0.5
5	35	0.6
10	40	0.7

Table II.1: the table shows the values of the variables.

III.7.3.Simulation results:

By simulating the model, we obtained the following results: the efficiency values of each solar collector and part of the solar system for the following months: January, February, March, November, and December, in addition to the values of solar radiation, the amount of solar heat collector, and the amount of heat generated by the auxiliary heater every hour over the five The most famous of these results will be used in the artificial neural networks described in the last chapter.

III.8.Conclusion:

In this chapter the solar powered heating model is studied. Through this study we came to a set of conclusions as follows: First, the solar collector cannot heat the water to the required degree without the help of the auxiliary heater. Also, the higher the efficiency of the heat exchanger, the more effective the model gives. Also, it was introduced to the TRNSYS program, in addition, we showed how to simulate a home heating model.

Chapter Three

Machine Learning

IV.1. Introduction:

One of the newer methods that can be used to simulate solar home heating models is machine learning. The basis of machine learning lies in the ability of computers to learn from data, acquire information, and make judgments based on that knowledge. It is common to use the Python language in machine learning.

Home and heating system performance and solar energy consumed are all factors taken into consideration when machine learning is used to simulate a home heating model. The computer gains knowledge from this data and creates a model that predicts home heating efficiency based on many factors, including outdoor temperature and solar energy use. The effectiveness of solar home heating is examined by analyzing available data and identifying patterns and trends. Based on these trends, an intelligent model is created that can predict heating efficiency and energy use. The design and operation of solar heating systems can be optimized using this model, which can also provide suggestions for the best course of action to enhance efficiency and reduce energy use.

The ability to continuously adjust and improve home heating models is another advantage of machine learning. Over time, the accuracy and performance of the model can be improved as it can be modified in response to new data and practical experiments.

Improvements in energy efficiency, energy savings, and overall heating system performance can be achieved by simulating a solar home heating model using machine learning. In addition, it can be used to give residents individual advice on how to operate the system and take advantage of the solar energy available to them.

IV.2. Artificial intelligence:

Artificial intelligence is a field of computer science, electrical engineering, and mathematics that studies the design and development of computer systems that have the ability to perform tasks that require human intelligence. This includes the use of computational techniques, machine learning, deep learning, neural networks, natural language interaction, robotics, simulation, computer visualization, and general intelligence.

The idea of AI revolves around using computers to analyze and extract information from data, and systems learn from mistakes and past experiences and apply them to new tasks. Artificial intelligence applications are divided into many areas such as big data

analysis, robotics development, and the development of artificial intelligence in the medical, educational, industrial, and other fields.

Modern technologies used in artificial intelligence can be used to create systems based on machine learning and artificial intelligence in various fields, and to improve the performance of many processes and tasks. Advanced technologies can be used to develop self-learning systems that can improve their performance over time and enhance their capabilities in various fields [13].

IV.3. Machine learning:

Artificial intelligence's machine learning field uses data to create mathematical models and algorithms that let computer systems learn and get better over time without explicit programming. The system is enhanced by performance analysis after being trained using training data. It is employed in several applications, including categorization, forecasting, data analysis, and more. Machine learning plays an important role in modern technological advances and improving decisions and performance in a wide range of fields and industries.

IV.4. components machine learning : [14]

IV.4.1.Data Machine learning:

Any sort of data that is used to develop, test, and enhance machine learning models is referred to as machine learning data. It may take on a variety of shapes, including text, pictures, music, video, numbers, and more.

Machine learning data often comes in three different forms:

➤ **Training Data:**

It is the data used to train the machine learning model, where it is a set of examples from which the machine learning model learns and is used to achieve better performance when predicting the values of the dependent variable for new data. Where the data that we trained the model with is as follows: 80% of the estimated size was determined by 54,374 lines of data.

➤ **Validation Data:**

Part of the training data is used as validation data to evaluate the performance of the model and modify its hyperparameters. 20% of our data volume, estimated at 54,374 lines of data, was used for performance validation.

➤ **Test Data:**

This entirely different dataset is used to gauge how well the machine learning model ultimately performs.

IV.4.2. Features:

In machine learning, features, which are often referred to as parameters or variables, describe all the inputs that are accessible to the model. These characteristics, which are a key point of emphasis to be used in the learning process, might include the type, size, direction, and recurrence of a certain word in the text. Depending on the requirements of the work and the type of data provided, these characteristics are categorised and arranged. In general, features help to extract relevant information from data and display it in a way that the educational model can manage and evaluate. The model learns from and makes use of these attributes to gain knowledge and perform well in various tasks.

IV.4.3 Algorithms:

Algorithms are understood in mathematics and computer science as a limited set of precise computer instructions that are typically utilized to carry out calculations or solve certain problems. Algorithms are straightforward, specialized methods for handling data, carrying out computations, automating inference, and doing other operations.

Heuristics, on the other hand, are used to solve issues and rely on practical approaches or various hypotheses to arrive at answers that, while they might not be ideal, are adequate given the circumstances. Inference technology uses inference techniques to address issues that may be challenging or impossible for conventional algorithms to solve at a reasonable time.

In conclusion, algorithms provide precise instructions for problem-solving, whereas inference technology relies on quick fixes or educated guesses to find workable answers.

➤ **Linear regression:**

The value of one variable can be predicted using linear regression analysis based on the value of another variable. Dependent variable refers to the variable you wish to forecast. The independent variable is the one you use to make a prediction about the value of the other variable. This analytical model computes the coefficients of a linear equation that contains one or more independent variables, each of which serves as the best predictor of the value of the dependent variable. The surface or straight-line approach that lessens disparities between output values is excellent for linear regression.

Actual and anticipated. The 'least squares' approach is used by several straightforward linear regression calculators to identify the best fit line for a collection of related data. The value of the (X dependent variable) is then estimated using the (Y independent variable).

To put it simply, we may say that in linear regression, the inputs are added and then multiplied by certain constants to get the result.

The general equation can be written as follows:

$$Y = a + b(X).$$

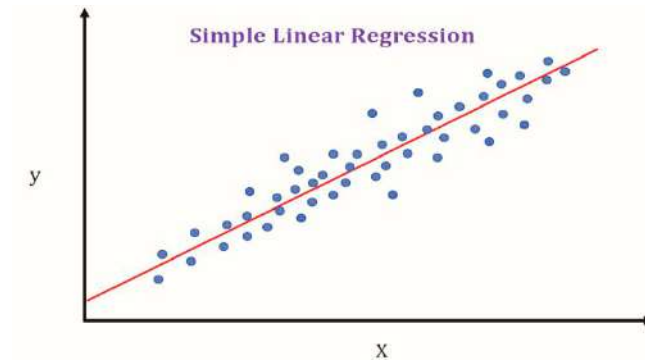


Figure IV.1: is an example of linear regression analysis of variables.

Linear Regression

```
Linear model = Linear Regression ()  
linear_model.fit(X_train_scaled, y_train)  
Linear predictions = linear_model.predict(X_test_scaled)  
linear_mse = mean_squared_error(y_test, linear_predictions)  
linear_mae = mean_absolute_error(y_test, linear_predictions)  
Print ('Linear Regression:')  
Print ('Mean squared error: ' linear_mse)  
Print ('Mean absolute error: ' linear_mae)
```

➤ Decision tree Regression:

We will describe the decision tree and how it is created in order to better comprehend the model in issue. A decision tree is a type of machine learning model that forecasts outcomes based on variables in a dataset. Decision nodes and leafy nodes make up the tree. A paper node establishes a forecast value, but the decision node indicates a particular condition in the data.

The root node, which is the tallest node in the tree, is where the construction of the tree starts. The parent dataset is split into two subsets according to the best predictor (best condition). Each subgroup goes through this procedure again, with the best condition being

picked once again to divide it into fresh subgroups. This cycle is continued until a predetermined stop standard is reached.

Decision Tree

```
tree_model = DecisionTreeRegressor()  
tree_model.fit(X_train_scaled, y_train)  
tree_predictions = tree_model.predict(X_test_scaled)  
tree_mse = mean_squared_error(y_test, tree_predictions)  
tree_mae = mean_absolute_error(y_test, tree_predictions)  
print('Decision Tree:')  
print('Mean squared error: ', tree_mse)  
print('Mean absolute error: ', tree_mae)
```

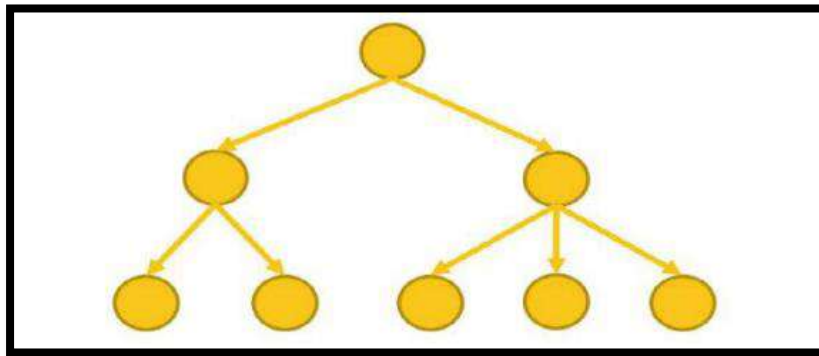


Figure III.2: Single decision tree. [15]

➤ **Random Forest Regression:**

A machine learning model called stochastic regression is utilized for differential prediction and analysis. It is based on a collection of independent sub tree forecasts. A random selection of variations and samples is used to create trees. The final prediction is created by combining the tree forecasts. It provides a clear understanding of the significance of variables and is effective in coping with noise and uneven data. It is utilized for many things, including projecting prices, determining real estate values, examining business processes, and predicting sales.

Random Forest

```
forest_model = RandomForestRegressor()  
forest_model.fit(X_train_scaled, y_train)
```

```

forest_predictions = forest_model.predict(X_test_scaled)
forest_mse = mean_squared_error(y_test, forest_predictions)
forest_mae = mean_absolute_error(y_test, forest_predictions)
print('Random Forest:')
print('Mean squared error: ', forest_mse)
print('Mean absolute error: ', forest_mae)

```

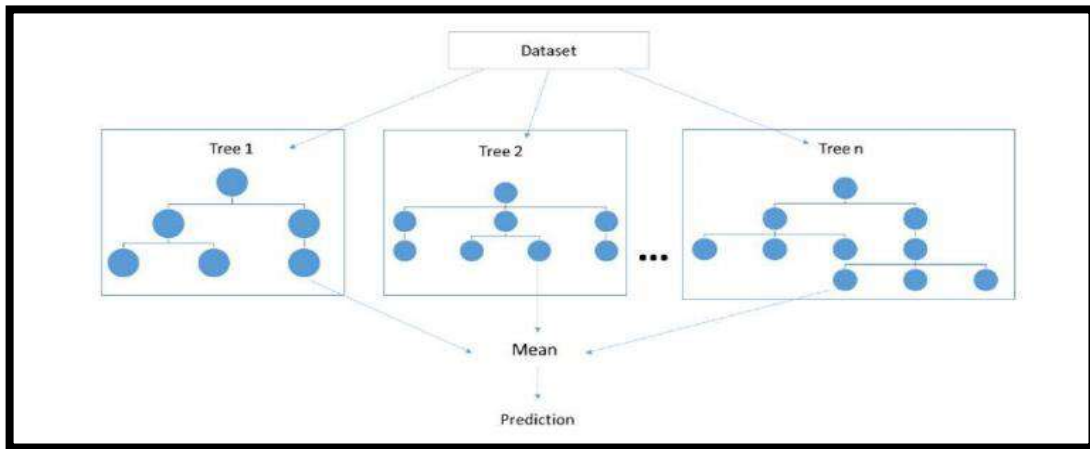


Figure III.3: Random Forest Action.

IV.5.Types of machine learning: [15]

IV.5.1.Deep Learning:

Deep Learning is a significant advancement in the science of machine learning since it uses deep neural networks to identify patterns and extract knowledge from data. It is distinguished by its capacity to manage complex data, including text, audio, and image data. It is commonly utilized in applications like machine translation, natural language processing, audio analysis, and picture recognition.

IV.5.2.Reinforcement learning:

Reinforcement learning teaches models how to make judgments sequentially in changing situations. The model picks up new information through its interactions with the environment and how it reacts to rewards and punishments. It is employed in fields including robot control, video games, and enhancing gaming techniques.

IV.5.3.Supervised learning:

Another kind of machine learning is supervised learning. It is distinguished by the availability of a collection of training examples that comprise inputs and the intended outputs that they correspond to.

In supervised learning, the model is supervised and led by an established training group as it learns. The model is trained using inputs and outputs that match, and it is then

applied to fresh, unknown inputs to forecast results. Another kind of machine learning is supervised learning. It is distinguished by the availability of a collection of training examples that comprise inputs and the intended outputs that they correspond to.

In supervised learning, the model is supervised and led by an established training group as it learns. The model is trained using inputs and outputs that match, and it is then applied to fresh, unknown inputs to forecast results. In supervised learning, a goal function, which specifies the model describing the data, is inductively learned by the system. A dependent variable or group of dependent variables, which might be input variables, attributes, or features, are predicted by the system using the goal function.

A function's domain, or the range of potential input values, is referred to as its instances. A dataset's states are each characterized by a collection of characteristics or features. A subset of all the examples known as Training Data is distinguished by having known output variable values. To more accurately infer and enhance the target task, training data is used.

In this perspective, there are two primary categories of learning tasks:

Classification: The categorization model aims to forecast separate categories. For instance, a model may be trained to sort comparable data into distinct categories. The category to which the data belongs is the dependent variable in this situation.

Regression: Models that use regression try to forecast new numerical values. For instance, using past data, the model may learn to forecast temperature. The expected numerical value is the dependent variable in this situation.

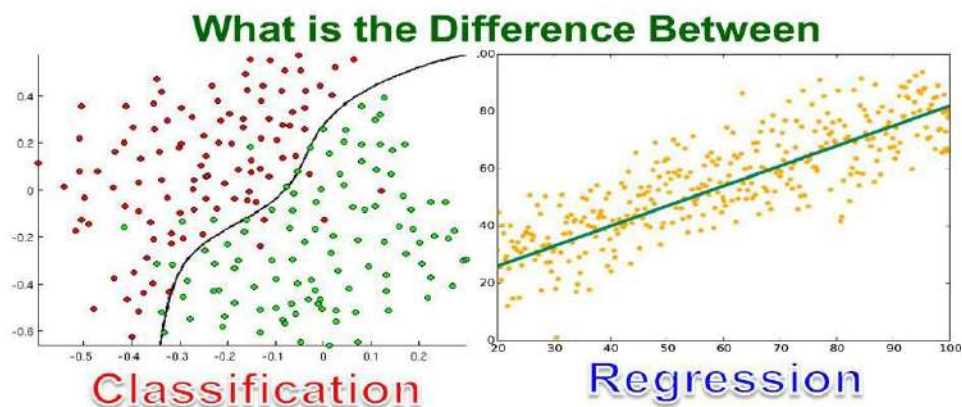


Figure III.4: Difference between classification and regression.[15]

IV.6.Using Python for machine learning:

The most widely used programming language for machine learning research and development right now is Python. Compared to other AI languages like R, Java, Scala, Julia, etc., interest in Python for machine learning has reached a completely new level.

Python is an accessible and straightforward programming language for both novices and seasoned programmers. Python is simple to understand, refreshingly explicit, and has a vibrant community that offers a wealth of online tutorials and support. Python is the greatest programming language for machine learning since it is the major language utilized in many machine learning research and development projects.

IV.7.Program Spyder: [16]

The Python programming language-specific integrated development environment (IDE) Spyder was created. Spyder is a strong and complete tool that aids analysts, data scientists, and developers in writing and analyzing code effectively.

A number of windows, including a code editor, file explorer, variable explorer window, and IPython terminal window, make up Spyder's simple-to-use user interface. The editor has capabilities like grammatical mistake correction, code supplementing, code formatting, and photosynthesis coloring.

Users may quickly execute graphical analysis and data processing with Spyder because to its interaction with well-known Python libraries like NumPy, Pandas, and Matplotlib. You may run interactive commands, test the code, and see results right away using the IPython terminal.

Additionally, Spyder has project management capabilities, making it simple to handle files, directories, and code all in one location. Spyder may be used to track changes and manage source code copies using Git.

In summary, Spyder is a practical and potent application that offers a selection of features and tools for creating and examining Python code, and it is extensively utilized in a variety of industries.

IV.8.libraries for Python [17]

It has a lot of machine language libraries and functions:

- **Librarie NumPy**: is a fundamental Python module for doing scientific computations. In applications involving machine learning, NumPy offers strong mathematical data structures and functions.

- **Librarie Pandas:** is a powerful data analysis and manipulation package. provides resources for preparing data for machine learning by organizing, analyzing, and extracting usable information from it.
- **Librarie Matplotlib:** database It is a versatile and simple library for making graphs and visualizations, such as mathematical or statistical charts.
- **Librarie Keras:** A high-level interface called Keras, which runs on top of TensorFlow, makes it simple to create and train neural models. For those new to the subject of machine learning, Keras is the best option.
- **Librarie The Scikit-learn package:** which implements a broad variety of algorithms, is one of the most significant libraries in the Python programming language.

Machine learning permits the usage of a variety of functions and makes it simple to integrate it into real-world applications. such as model selection, regression, clustering, pre-processing, classification, etc.

IV.9.Advantages of Python: [18]

Python is a powerful and high-level programming language with a number of benefits, such as:

1. Python is one of the programming languages that is simple to understand and utilize. This is one of the reasons it is so well-liked by new programmers.
2. Operating system compatibility: Python is compatible with a wide range of platforms, including Windows, Linux, and Mac.
3. Scalability: Python may be used by programmers in a variety of contexts, such as the creation of online applications, data analysis, gaming, and artificial intelligence.
4. Accessibility of open source libraries and tools: Python offers a wide range of open source libraries and tools that may be utilized to streamline development and coding.
5. Quick code writing: Python enables programmers to create code rapidly, enabling them to finish tasks more quickly.
6. Python's support for object-oriented programming features enables programmers to reuse code more effectively and arrange it more effectively.
7. Large developer community: Python has a sizable development community worldwide, which aids.

IV.10.the artificial neural network (ANN): [19]

An artificial intelligence tool that mimics the functioning of the human brain is the artificial neural network (ANN). ANN is employed to approximate nonlinear interactions between a complicated system's input variables and output. The neural network's capacity for self-learning defines it. ANN was used to forecast energy use in buildings and performed better than more conventional techniques like regression models and time series. The majority of neural network models now in use, however, are static in nature; that is, they are pre-set using past data and stay static going forward when new data becomes available.

When fresher data or new patterns emerge, this form can become incorrect. Therefore, neural networks require ongoing updates and modifications in order to handle new data and patterns that may surface in the future.

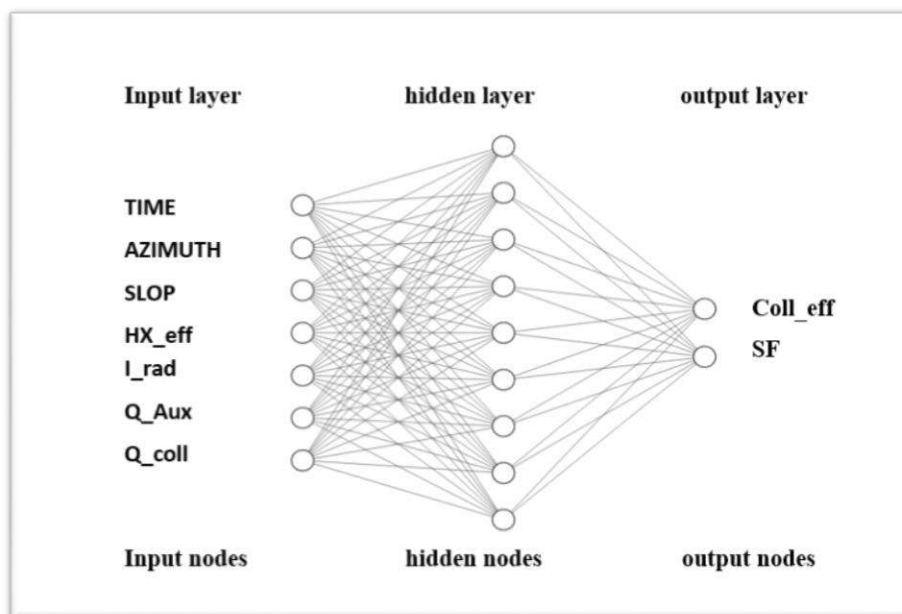


Figure IV.5: Diagram of a neural network (ANN).

Prerequisites for the implementation of an artificial neural network Here are the libraries and programs that we will need in order to implement ANN:

1. Python 3.9 or developed
2. Spyder or Jupiter notebook Program
3. Library Panda
4. Library Numbi

5. library Tensorflow
6. Library Scikit
7. Library Sklearn
8. Library Keras

IV.11.Using Python to simulate model performance:

After gathering a set of unique data for home heating, which we consider to be the model's input, we enter this data into the Python model, run the simulation, and then take the results. In light of the terrible scientific development, we have been able to perform many simulations of the model and it gives effective results in a short time compared to the classical methods, which used to give inaccurate results and take a lot of time with simulation errors.

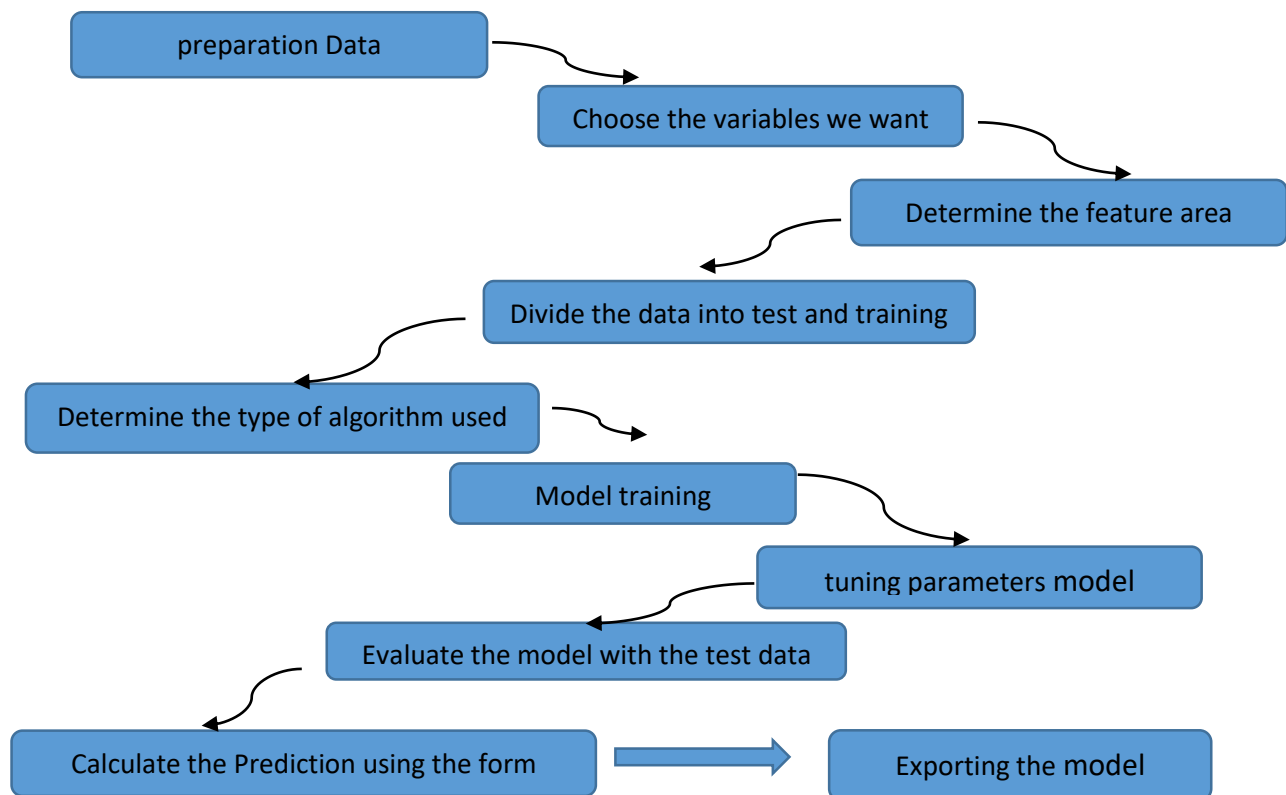


Figure III.6: Diagram showing the steps of Python work .

The simulation wheel's use of Python may be summed up as follows (Leidinger and Jones 2010):

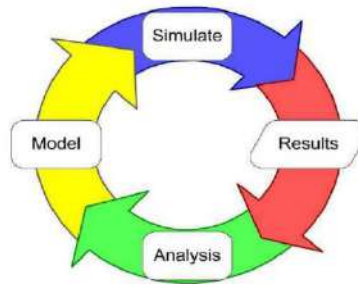


Figure III.7: Simulation wheel .

inputs and outputs

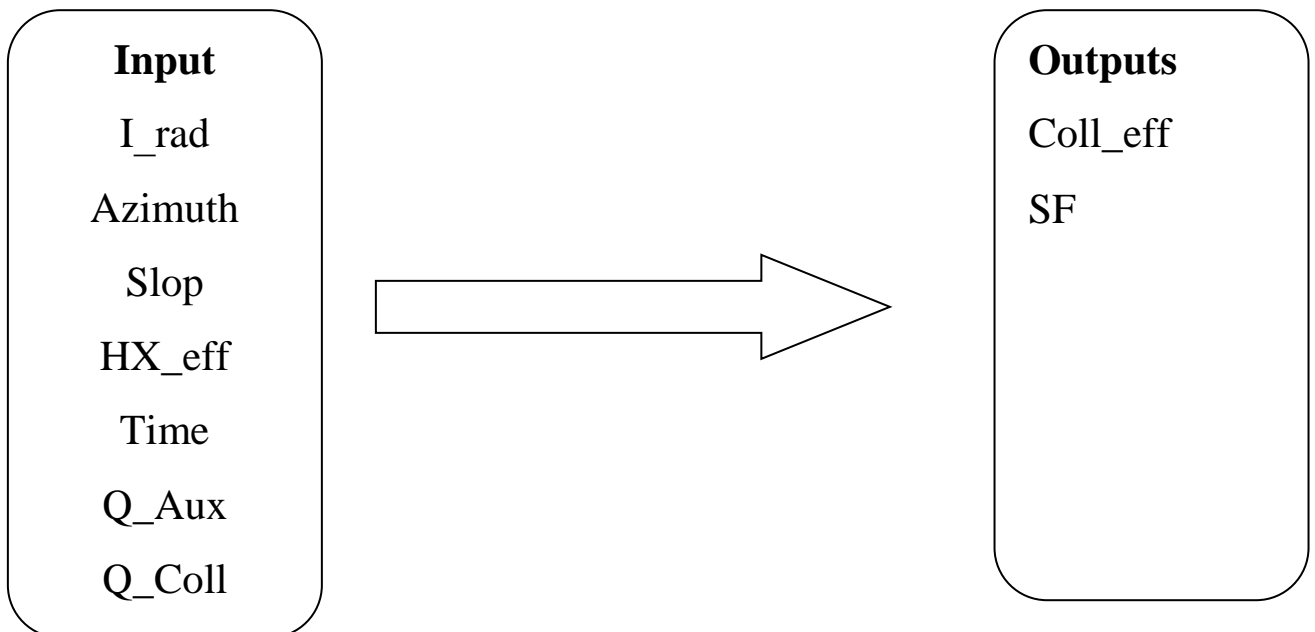


Figure III.8: The input and output parameters of the work

IV.12.Conclusion:

In this chapter, a type of artificial intelligence has been identified, especially machine learning, where its types and components have been identified. Python, the core language of artificial intelligence, is also explained. How to simulate a heating model in Python using the Spider code editor The simulation results have been extracted as well as showing the most important element on which artificial intelligence is built is the neural network.

The five
Chapter
Discuss The
Results

V.1.introduction :

In this chapter, the data processing and results obtained with the pooled simulations referred to in the previous two chapters, using the Python programming language together with the TRNSYS simulation software, are addressed in a home heating model simulation. We also used many AI algorithms.

V.2. Analysis and discussion of Python results:

The square of the error is calculated by the following equality :

$$R^2 = (Y_A - Y_P)^2$$

where Y_A is the actual value of both Coll_eff and SF.

where Y_P represents the prediction value of both Coll_eff and SF.

V.2.1.First results:

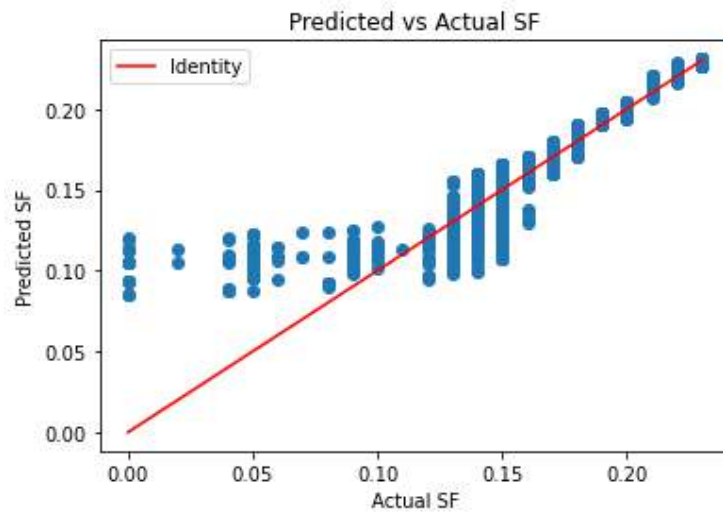


Figure V.1: The mean square error R for SF.

The Figure IV.1 represents the changes in the actual values of SF in terms of prediction values, where we note that the actual SF values are not equal to the prediction values and there is a significant and clear difference, which is confirmed by the squared error ratio.

$$R^2 = \text{R-squared for SF: } 0.9170935874821887$$

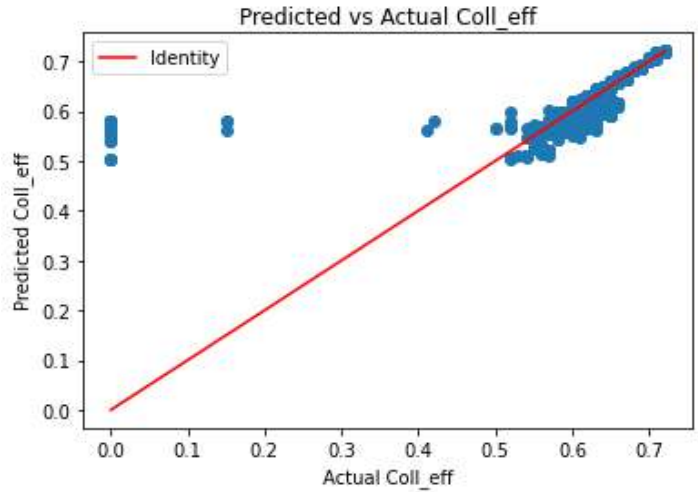


Figure V.2: The mean squared error R for Coll_eff

The Figure IV.2 represents the changes in the actual values of Coll_eff in terms of prediction values, where we note that the actual Coll_eff values are not equal to the prediction values and there is a significant and clear difference, and this is confirmed by the squared error ratio.

$R^2 = R$ squared for Coll_eff: 0.6725346956523963

Algorithms	Error	
	Loss (Mean squared error)	MAE (Mean absolute error)
Neural Network	0.00045	0.00546
Linear Regression	0.00055	0.00849
Decision Tree	2.712643678160e-07	2.71264368125e-05
Random Forest	1.8196965517241e-07	3.120919541132e-05

Table V.1: comparison between the algorithms.

Through the results mentioned in the table V.1, the algorithm (Random forest) recorded the best result compared to other algorithms in terms of square error.

In terms of absolute error, Algorithm scored Decision Tree the best result compared to other algorithms

V.2.2.Second results:

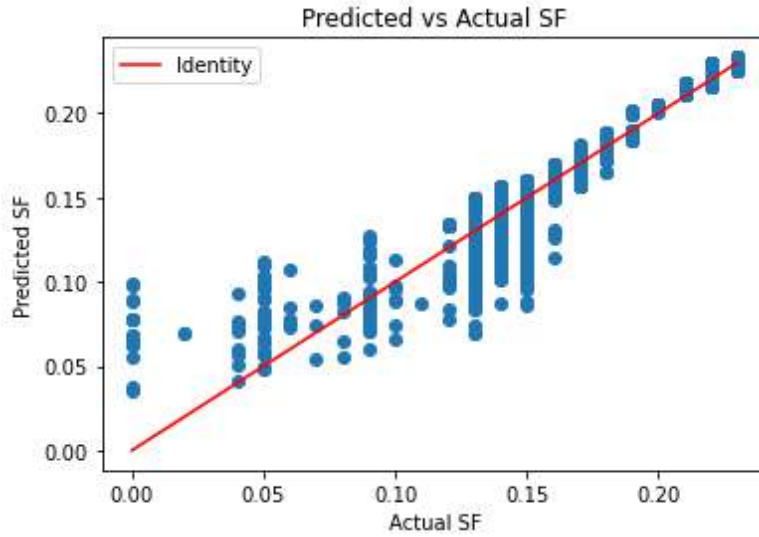


Figure V.3: The mean square error R for SF

The Figure V.3 represents the changes in the actual SF values in terms of prediction values, where we note that the actual SF values are not equal to the prediction values and where the difference is kind of less compared to the first results, which is confirmed by the squared error ratio.

$R^2 = R\text{-squared for SF: } 0.9423706131500793$

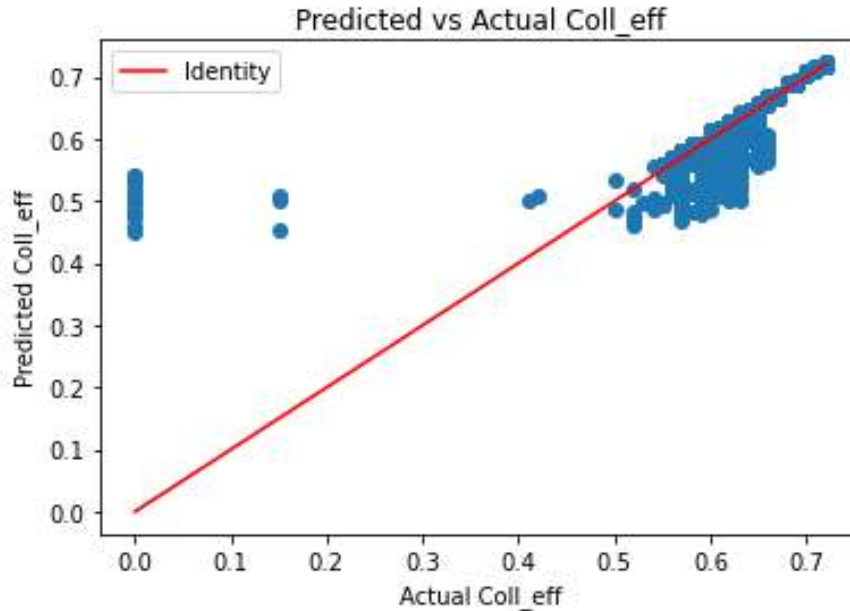


Figure V.4: The mean squared error R for Coll_eff

The Figure V.4 represents the changes in the actual values of Coll_eff in terms of prediction values, where we note that the actual Coll_eff values are not equal to the

prediction values and there is a significant improvement compared to the previous results, and this is confirmed by the mean squared error.

$R^2 =$ R-squared for Coll_eff: 0.7070119502431207

Algorithms	Error	
	Loss (Mean squared error)	MAE (Mean absolute error)
Neural Network	0.00039	0.00586
Linear Regression	0.00056	0.00849
Decision Tree	2.8045977011494E-07	2.80459770424367E-05
Random Forest	1.86040919540234E-07	3.1572413801764E-05

Table V.2: comparison between the algorithms.

Through the results mentioned in the table IV.2 , the algorithm (Random forest) recorded the best result compared to other algorithms in terms of square error.

In terms of absolute error, Algorithm scored Decision Tree the best result compared to other algorithms

V.2.3.Third results:

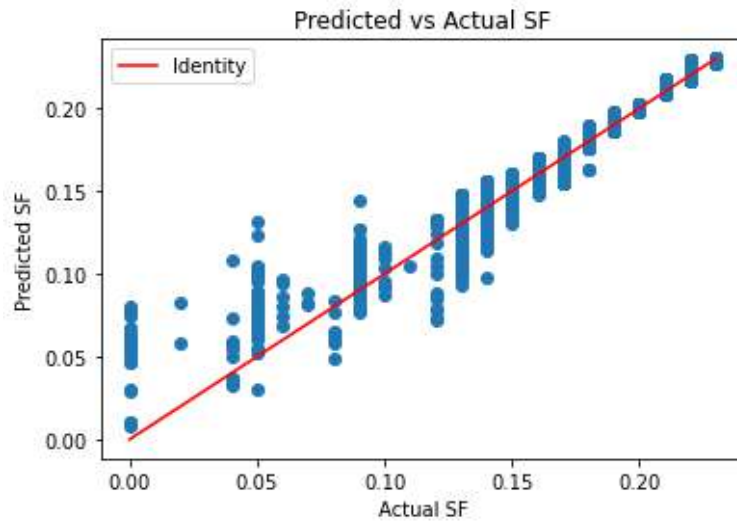


Figure V.5: The mean square error R for SF

The Figure V.5 represents the changes in the actual values of SF in terms of prediction values, where we note that the actual SF values are not equal to the prediction values and there is a clear convergence between the two values, which is confirmed by the squared error ratio.

R^2 = R-squared for SF: 0.9613956426464008

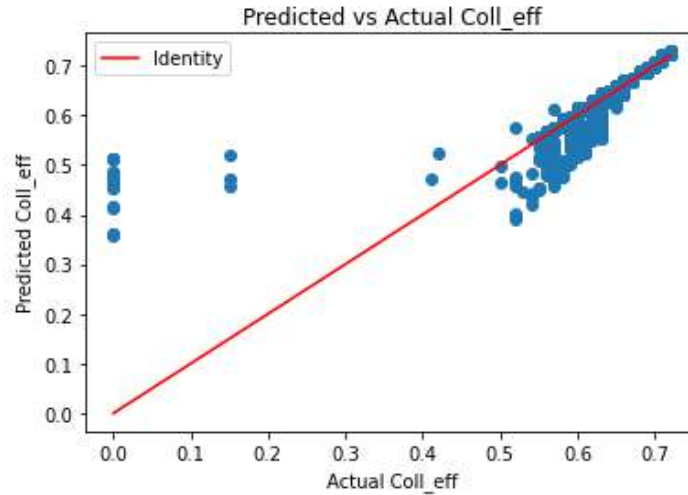


Figure V.6: The mean squared error R for Coll_eff

The Figure V. 6 represents the changes in the actual values of Coll_eff in terms of prediction values, where we note that the actual Coll_eff values are not equal to the prediction values and there is a clear convergence between the two values, which is confirmed by the squared error ratio.

R^2 =R-squared for Coll_eff: 0.7613458953783646

Algorithms	Error	
	Loss (Mean squared error)	MAE (Mean absolute error)
Neural Network	0.000315	0.00462
Linear Regression	0.00056	0.00849
Decision Tree	2.62068965517240E-07	2.62068965697117E-05
Random Forest	1.83662988505751E-07	3.12965517327575E-05

Table V.3: comparison between the algorithms.

Through the results mentioned in the table V.3 ,the algorithm (Random forest) recorded the best result compared to other algorithms in terms of square error.

In terms of absolute error, Algorithm scored Decision Tree the best result compared to other algorithms.

V.3.conclusion

According to the results obtained, it can be said that the performance of the model was negative, especially in the last result, as the error ratio for both Coll_eff and SF recorded good results compared to the first and second results. It can be said that the home heating model needs more training and a large number of simulations that may reach tens or hundreds of thousands, and this leads us to exit machine learning and enter deep learning by increasing the number of neural network layers.

General conclusion

In light of climate change and increasing global demand, we conclude that energy use in residential heating is an important concern. A solar home heating model has been created. This is a crucial measure to create environmental harmony and reduce energy use.

TRNSYS software, one of the well-known tools used in modeling renewable energy systems, was used to simulate this model. The variables and values used in the simulation are specified, and the operation of the heating model is described. Includes a comprehensive description of how to create and analyze a home heating model using the TRNSYS application.

In addition, the importance of artificial intelligence, especially machine learning, in achieving model effectiveness was emphasized. It has been shown that neural networks are the basic building block of artificial intelligence, and that using them may help predict model effectiveness more accurately and achieve the best results.

Model performance can be improved using machine learning techniques, and accurate predictions of energy efficiency and performance of the solar home heating system can be generated.

Preliminary results from the model simulation revealed disappointing results. Regarding the latest results, there has been a noticeable improvement, but they are still not satisfactory due to the need for more simulations, which is what drives us to deep learning (deep learning). For those interested in this topic, we recommend a supplement to this study.

The purpose of the work was to clearly conceptualize a model that could provide information regarding energy consumption through approximate local predictions of a home heating model. This framework can help end users take action by analyzing the impact of energy consumption and identifying potential anomalies that may need to be addressed. While this proposed model is designed mainly to be applied at the expense of each region because each region and its climatic characteristics.

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