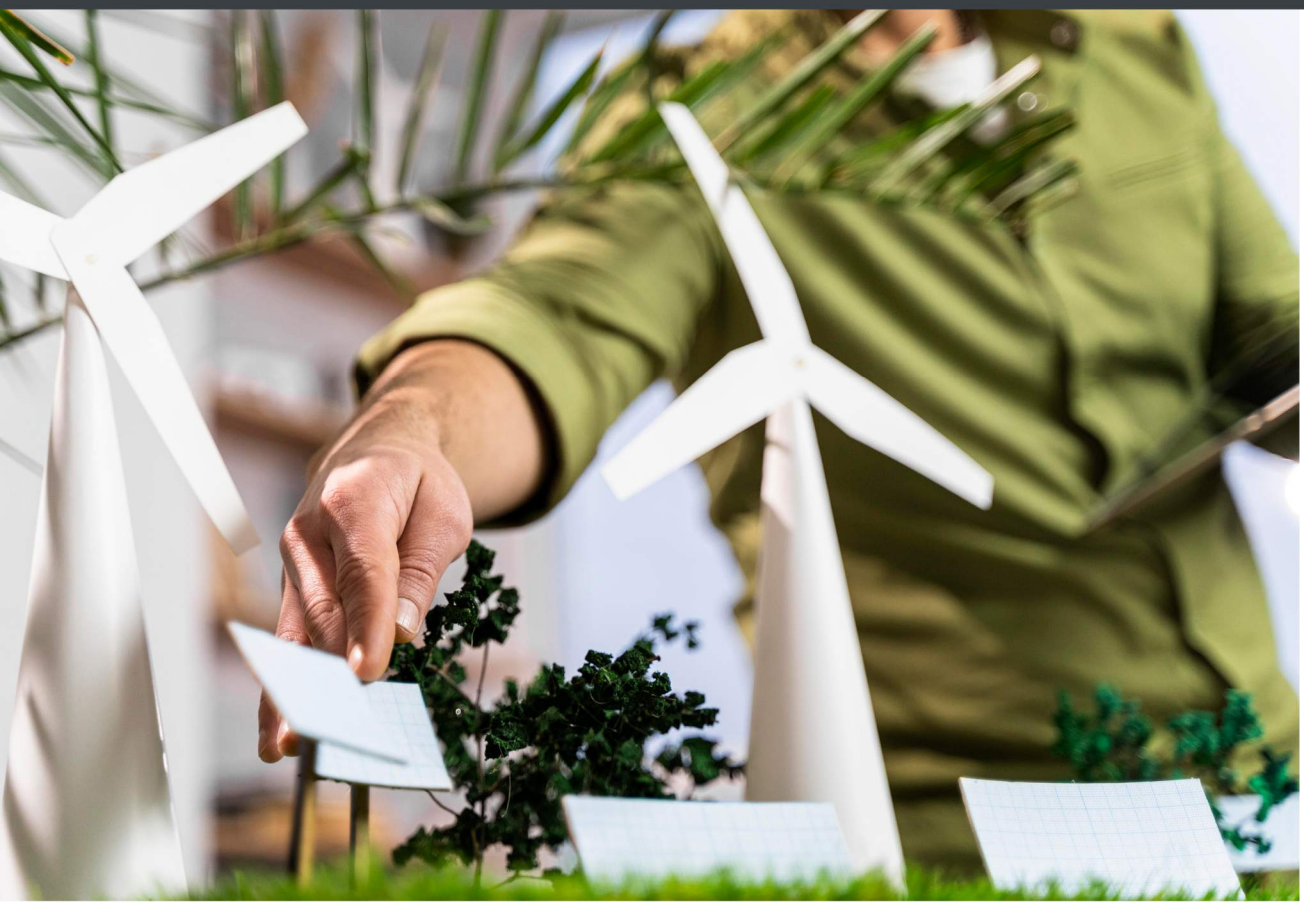
INGENIOUS 4 ISSUE 1

Editor-in-Chief: Prof. Asoc. Dr. Teuta XHINDI/ Scientific Journal of the Faculty of Engineering, Informatics and Architecture / No. 4, issue 1/ 2024

ISSN 2789-4800



EMPOWERING ALBANIA

Embracing the Renewable Energy Revolution

Prof. Asoc. Dr. Teuta **XHINDI**/ MSc. Ing. Armaldela **KËRNAJA**/
Prof. Dr. Ing. Angjelin **SHTJEFNI**/ Dr. Ing. Kreshnik **HAKRAMA**/
MSc. Ing. Hasimin **KEÇI**/ Eliona **SKENDERAJ**/ MSc. Ing. Anius **KOTORRI**/
Msc. El. Ing. Jani **PETRO**/ Jugerta **GURABARDHI**, Lediano **DOSKU**

UETPRESS

INGENIOUS

No. 4, issue 1/2024

JOURNAL OF THE FACULTY OF ENGINEERING, INFORMATICS AND ARCHITECTURE

ISSN 2789-4800

UETPRESS

Published under the series “ACADEMIC JOURNALS”.

The journal has been catalogued at the National Library of Albania and the Library of the European University of Tirana, Albania.

(print ISSN: 2789-4800/ online ISSN: 2958-888X)

ingenious@uet.edu.al
www.uet.edu.al/ingenious

UETPRESS

Published by:
EUROPEAN UNIVERSITY OF TIRANA / ALBANIA

content

EDITORIAL

Empowering Albania: Embracing the Renewable Energy Revolution

Prof. Asoc. Dr. Teuta XHINDI

Albania is blessed with a diverse range of renewable energy resources, offering a rich tapestry for sustainable energy production. As the world grapples with the urgent need to transition towards sustainable energy sources, Albania possesses immense potential in renewable energy. With abundant natural resources and a strategic geographical location, Albania can harness renewable energy to not only meet its domestic needs but also become a key player in the global clean energy revolution.

In Albania, the country's mountainous terrain and ample sunshine provide ideal conditions for solar power generation. With approximately 300 days of sunshine per year, Albania boasts significant solar energy potential, particularly in the southern regions. Furthermore, its numerous rivers and streams present ample opportunities for hydropower generation, historically accounting for a substantial portion of Albania's electricity production. Actually, Albania produces about 1% of its energy from the sun, while the rest of the needs are met by hydropower plants and imports.

At least 44% of the energy consumed in Albania in 2022 came from renewable sources.

This figure is almost two times higher than the average amount of renewable energy consumed in the European Union. Although this keeps Albania above the EU average, it certainly exposes it to the risk of energy security when the hydro years are not so favorable, something that has recently encouraged a trend towards diversification and projects mainly related to photovoltaics and wind turbines.

Additionally, Albania's windy coastal areas offer favorable conditions for wind energy projects, further diversifying its renewable energy portfolio.

The transition towards renewable energy not only aligns with global sustainability goals but also offers substantial economic benefits for Albania. By

investing in renewable energy infrastructure, Albania can enhance energy security and mitigate the volatility of global energy markets. Moreover, the development of renewable energy projects can catalyze economic growth, create jobs, and attract foreign investment, bolstering Albania's economy in the long run.

Furthermore, the adoption of renewable energy technologies can significantly reduce greenhouse gas emissions, mitigating the adverse effects of climate change. Albania has committed to reducing its carbon footprint as part of international agreements, and embracing renewable energy is crucial in achieving these ambitious targets. By transitioning away from fossil fuels, Albania can contribute to global efforts to combat climate change while simultaneously improving air quality and public health domestically.

To fully realize its renewable energy potential, Albania must establish a conducive policy and regulatory framework that fosters investment and innovation in the sector. This includes implementing supportive policies such as feed-in tariffs, tax incentives, and streamlined permitting processes to incentivize private sector involvement in renewable energy projects. Additionally, strengthening institutional capacity and ensuring transparent and predictable regulations are essential to attract domestic and foreign investors.

Furthermore, Albania should prioritize the integration of renewable energy into its energy mix through strategic planning and infrastructure development. This involves modernizing and expanding the national grid to accommodate increased renewable energy capacity and implementing energy storage solutions to address intermittent issues associated with solar and wind power. Moreover, fostering collaboration with international partners and leveraging financing mechanisms such as grants, loans, and public-private partnerships can facilitate the deployment of renewable energy projects at scale.

As a conclusion, the potential of renewable energy in Albania is vast and multifaceted, offering a pathway towards sustainable development, economic growth, and environmental stewardship. By capitalizing on its abundant natural resources and embracing innovative technologies, Albania can position itself as a regional leader in renewable energy production and contribute to global efforts to combat climate change. However, realizing this potential requires bold policy decisions, strategic investments, and collaboration between government, industry, and civil society.

The Use of Photovoltaic Technology in Albania

MSc. Ing. Armaldela KËRNAJA
European University of Tirana
akernaja@uet.edu.al

Prof. Dr. Ing. Angjelin SHTJEFNI
European University of Tirana
angjelin.shtjefni@uet.edu.al

Dr. Ing. Kreshnik HAKRAMA
European University of Tirana
kreshnik.hakrama@uet.edu.al

MSc. Ing. Hasimin KEÇI
European University of Tirana
hasimin.keci@uet.edu.al

Abstract

Over the past decade, technological advances have led to the development of more economically feasible photovoltaic systems. These systems are ideal for areas where there is no electricity. Due to growing environmental concerns, new energy sources have been developed that are more sustainable and economically feasible. This means that photovoltaic energy will play a vital role in the production of electricity in industry. The purpose of this study is to understand more about the use of photovoltaic energy in Albania, the installation costs of a photovoltaic energy production system, are these systems assembled and installed according to the IEC 62116 standard. The objective of this study is to identify the models of photovoltaic energy systems that

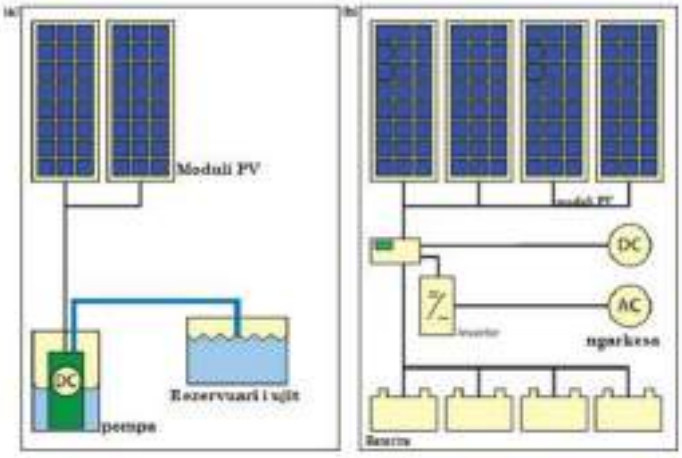
are marketed in Albania, if these systems are according to the European standard IEC 62116, to show the types and installation costs of these systems as well as to understand the amount of annual energy generated by a photovoltaic system that is used in Albania. The methodology used in this study is that of a qualitative and quantitative descriptive research. Descriptive research includes surveys and fact-finding investigations of various kinds. We used the qualitative description when we talked about the types of systems, when we talked about the use of PV systems in Albania, but also when we talked about the use of systems according to the European standard IEC 62116. We used the quantitative description when we calculated the costs of installing the PV system in Albania but, and along the calculation of the amount of annual energy generated by a PV system that is used in Albania.

Keywords: *Photovoltaic (PV) systems, Photovoltaic inverters, Active method, Passive method, Utility level methods, IEC 62116.*

Types of PV systems

A simple PV system consists of a single module and a load. For example, in this case, we are getting the energy needed to run a water pump, which only works when the sun is shining.

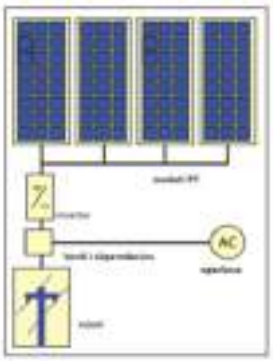
FIGURE 1*:* A brief introduction to a DC-to-PV system powering a water pump. b) A more complicated system, including batteries and charging in AC and DC "Planning and installation of PV generation"



Source: Study of the Project of the apartment taken under review

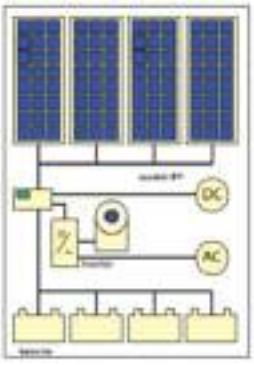
A home that requires energy must have a functional PV system that runs day and night. It can also provide backup power, which can be used to supplement AC and DC loads. Before we talk about the different types of PV systems, let's first discuss their configuration. An off-grid PV system can operate smoothly and provide power even when it is not connected to the electricity distribution network. Sometimes, a battery is required to store the energy the panels produce. A standard ON-GRID system connects the inverter to the electricity distribution network. This type of system requires batteries as excess energy from the panels is used to generate electricity to the grid, which then activates the energy meter in the other direction. This type of system works as long as it is connected to the network. It is simple to install and has a lower cost.

FIGURE 2: Presentation of an ON GRID system
"Planning and installation of PV generation"



Source: Study of the Project of the apartment taken under review

FIGURE 3: Presentation of a HYBRID system "Planning and installation of PV generation"



Source: Study of the Project of the apartment taken under review

A hybrid system consists of a battery and a photovoltaic panel and requires a connection to the grid. Excess power from the panels is then stored in batteries and once they are fully charged, the remaining power is transferred to the grid.

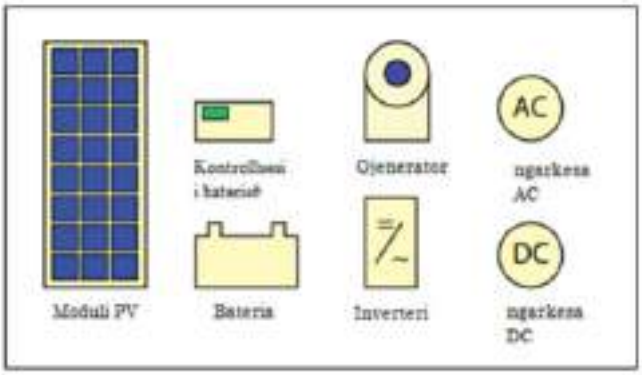
Although the basic elements of photovoltaic systems remain the same, they can be modified to meet specific requirements.

Components of a PV system

A solar cell can convert the energy it produces into electricity. Since it can handle a limited amount of power, it can be used for devices that require fixed current or voltage conditions. To make solar panels, several solar cells must be connected. Although solar panels are the main components of a PV system, other parts are also needed to operate it. These are referred to as Balance of System components and are located in the system we use. Some of these components are part of the ON Grid system, while others are part of the Off Grid system. The most important components of BOS (Balance Of System) are:

1. ***Rising structure*** - used to adjust the direction of the module so that it is directed by the sun.
2. ***Energy storage (battery)*** - is an important part of the OFF Grid system because it enables energy supply at night.
3. ***DC-DC converter*** - used to convert the output of the module, which will have a different voltage depending on the time, day, and weather conditions.
4. ***DC-AC inverter*** - used to convert DC to AC which can then feed the grid.
5. ***Cables*** - connect components (thickness should be sufficient to avoid losses).

FIGURE 4: A schematic representation of the components of a PV system "Planning and installing PV generation"



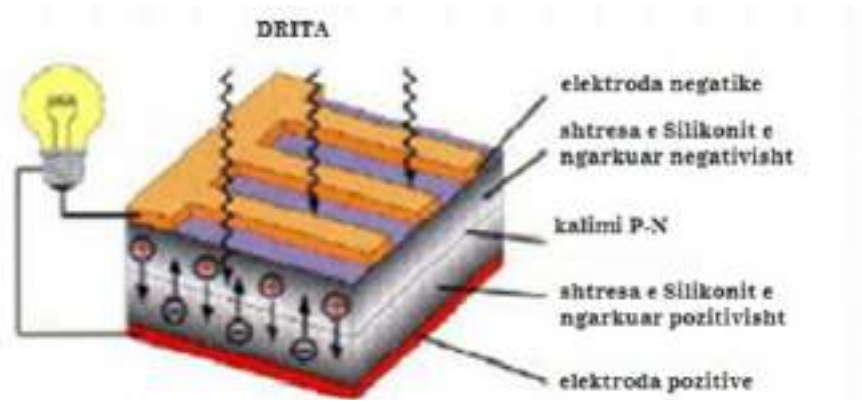
Source: Study of the Project of the apartment taken under review

Types of panels and their characteristics

Design and operation of a crystalline silicon solar cell

A solar cell consists of two layers of silicon, both of which are charged. One of them faces the sun and the other is made of phosphorus. The bottom layer is made of boron and is also positively charged. An electric current is then created between the two layers. Through this field, electrons can be created in the layers of a solar cell. Conductors are then connected to both layers to receive energy from the sun. The contact layer, which is made of aluminum, is placed at the bottom. An anti-reflective coating is then added to the top layer. The top layer of a solar cell is designed to absorb as much radiation as possible. This layer has the characteristics of a structure or network. When light hits a solar cell, it creates an electric field by separating holes and electrons. If the two layers are connected, then an electric current can be generated.

FIGURE 5: Schematic representation of the parts of a solar cell "Solar Energy, Fundamentals, Technology, and Systems"



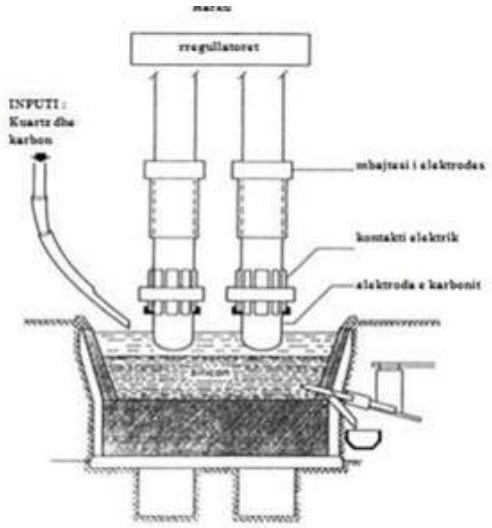
Source: Study of the Project of the apartment taken under review

The energy loss experienced by solar cells is due to reflection and shadows. For example, the energy balance of a solar cell is shown below. Most of the energy loss is caused by reflections and shadows. Shortwave radiation causes the production of high-energy photons. Recombination losses are 8%, 20%, and 5%. Also, there are losses in ohmic resistances, which are about 0.5%.

Crystalline silicon

When it comes to solar cells, crystalline silicon is the most important element. It is abundant on Earth and is second only to oxygen in terms of its abundance. Although silicon can be impure, it can be found in mixtures of chemical compounds such as sand or quartz. The first step in separating the unwanted oxygen from the compound known as silicon dioxide is combining quartz with carbon dioxide and coke. This mixture, which is then subjected to an electric arc furnace, produces a type of pure silicon known as metallurgical silicon. In addition to being used in solar cells, raw silicon can also be used in chemical processes to make other electronic components. When mixed with hydrogen chloride, it forms trichlorosilane and hydrogen chloride, which boil at 310 degrees Celsius. In the initial stages, the liquid is distilled to produce a level of impurities required for its manufacture. The process that enables the production of trichlorosilane and hydrogen from water is called the SIEMENS process. It involves throwing both gases into a reactor, where they will be exposed to high temperatures.

FIGURE 6: Schematic representation of the silicon extraction process from quartz and carbon, "Springer Series in Photonics"



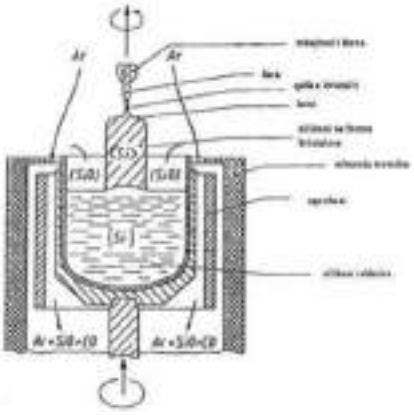
Source: Study of the Project of the apartment taken under review

This process produces polycrystalline silicon, which is commonly called polysilicon. The diameter of the rods can be increased from 10 to 15 centimeters. These are then broken into pieces to form mirrors, which are used in solar cells.

Monocrystalline panels - silicon

For a long time, monocrystalline panels have been the standard for electricity generation. These are very efficient and can be distinguished from other types by their color. Each module consists of a single silicon crystal, which makes them easy to identify. The manufacturing process of monocrystalline panels is similar to that of other types of panels. It involves the use of a certain method known as Czochralski, which allows the production of pure silicon crystals. This is useful for semiconductor manufacturing. The origins of the Czochralski method can be traced back to 1915 when a Polish scientist named Jan Czochralski discovered it while studying the crystallization of various metals. In this process, an entire silicon crystal is placed inside a molten silicon reservoir. The initial crystal is then spun and removed, and a small amount of Boron is then introduced into the process. This process then produces a round silicon rod, which is filled with pure silicon. The lines on the rod are then wound and placed in a fire to ignite them after the phosphorus gas is released. The phosphorus atoms then enter the silicon, which is a more porous material due to its proximity to becoming a liquid. The time and temperature are controlled by the outside temperature.

FIGURE 7: Schematic representation of the CZOCHRALSKI process, "Springer Series in Photonics"

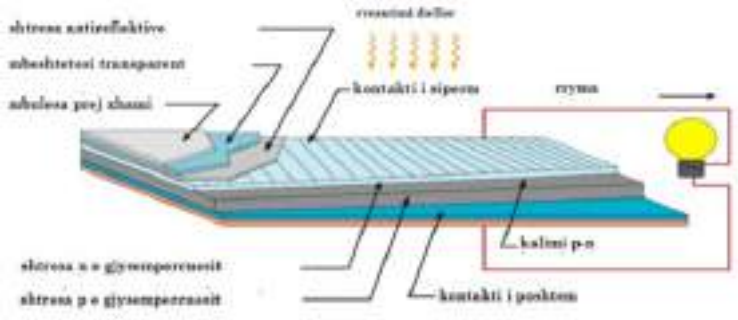


Source: Study of the Project of the apartment taken under review

Construction and operation of monocrystalline

We have previously explained how we obtained pure silicon through the Czochracski process. After that, various steps are taken to produce monocrystalline solar cells. These cells are then connected and provide a ready-made photovoltaic panel.

FIGURE 8: Representation of the component layers of a monocrystalline panel



Source: Study of the Project of the apartment taken under review

To move from semiconductors to panels, we need to understand how light falls on the mirror of a panel. When this happens, the electrons in the semiconductor are excited, which makes it possible for Levizin to create an electron-hole pair. The electric field between the two semiconductor layers is shown in Figure 8. This allows electrons to move over the wires that are connected to the two semiconductors. This process then generates an electric current. This is why we switch from solar to electric.

Global formula for calculating the energy generated by a PV system

The global formula for calculating the energy generated by a PV system is:

E – Energy (kWh)
A – total area of the panel (m2)
r – panel production efficiency (%)
H – average annual solar radiation on the panel (not including shadows)
PR – performance ratio, loss ratio (range between 0.5 and 0.9, selected value 0.75)

Let's explain each in turn. R is the output of a solar panel, which is given by the ratio of the electrical energy (in kEp) of a single panel divided by the others. ¨

Example:

The output of a PV module, with 250 Wp, with an area of 1.6m2, is 15.6% (this ratio is provided by STC). Radiation = 100¨e/m2; Cell temperature = 250C; Wind speed = 1m/s; AM=1.5; . The combination of the nominal power of this panel under these conditions is called WATT PEAK Wp or kWp=1000Wp or MEp = 1000000Wp; As we said above, H is the average annual solar radiation on the panels. It has a value between 200 kWh/m2 in Norway and 2600 kW in Saudi

Arabia. The performance ratio is a very important value to evaluate the quality of a PV installation because it performs an installation independent of orientation. Includes all losses.

Electricity calculation

We have considered a terrace area of a villa as in the figure below.

FIGURE 9: Schematic representation of a villa

Source: Study of the Project of the apartment taken under review

We have taken into account the various household appliances located in the apartment above. The labels on these devices show the power value P (Watt). We then determine the usage time of these devices by measuring how long they have been plugged in. We are interested in learning how much energy they consume per day or month. A relationship can be established by considering the usage time and power of different household appliances. Then we calculate the energy consumed by these devices.

E = P xt(kW h)(10)

Table 1 shows how much energy a household appliance with power P(W) consumes for a time of use (hours). In the table below, we have presented the daily, monthly, and annual consumption of household appliances, and at the end, we have calculated the total for each. For the following calculations, we used the following formulas: (daily consumption) E = P tx(3.2) (monthly consumption) E(month) = Ex30 = (P tx)x30(3.3) (annual consumption) E(year) = E (month)x12.

TABLE 1 : how much energy a household appliance with power P(W) consumes for a time of use

Appliance	Power Rating	Hours per Day	Common Power Use in a Day	Percentage of Power for the Day
Split System Air Con	1200W	6	6 kWh	18.0%
Pool Pump	1100W	8	8.8 kWh	26.5%
Electric Hot Water	3600W	1.5	5.4 kWh	16.2%
Electric Cooktop	2400W/element	1	4.8 kWh	14.4%
Fridge	150W	12	1.8 kWh	5.4%
Toaster	900W	0.2	0.18 kWh	0.5%
Microwave	1200W	0.2	0.24 kWh	0.7%
Kettle	2400W	0.2	0.48 kWh	1.4%
TV	200W	5	1.0 kWh	3.0%
Sound System	60W	4	0.24 kWh	0.7%
Phone Chargers	15W x 2	5	0.15 kWh	0.5%
Laptop	100W	2	0.2 kWh	0.6%
Combined Lighting	130W (LED)	5	0.65 kWh	2.0%
Bathroom Fan	60W	0.5	0.03 kWh	0.1%
Washing Machine	2400W	4 hrs / week	1.37 kWh	4.1%
Standby Appliances	120W	16	1.92 kWh	5.8%
TOTAL			**33.3 kWh per Day**	

Mounting a PV system on a terrace surface

In total, this apartment for a year consumes 979.41 kW of electricity per month, at a cost of approximately 9800 ALL (per month/year). The process of setting up a utility-scale solar system begins with designing the site where the plant will be located. After that, the terrain where the plant will be erected was analyzed. The

calculation of the efficiency of the plant is carried out after the consumption of the customer has been determined.

FIGURE 10: Schematic representation of the method of placing panels, inverters, controllers, and electrical boxes in a house, "SolarON"

To produce a plant with a total area of 75.95 square meters, a total of 28 solar panels and an inverter with a capacity of 7.0 kWp are needed. These products will be used in a project that is online. Other components that will be needed include a metal structure with a multi-angle 30 regulator and an MC4 connector. The excess energy produced by the consumer is fed into the system and used at night and during days when the weather conditions are unfavorable. Data collected by the Data Logger will be used to monitor energy production. If the customer has a Fronius inverter, then the Data Logger will also be able to control the energy production. The control method for this system is similar to a regular monitoring page. The area required for this project is 60.4 square meters. Due to the structure used, the plant will take up more space. The cost of this system is 8600 euros. The products used for this project have different performance guarantees. For example, the panels come with a 15-year warranty and a 25-year warranty. The metal structure has a 5-year warranty and a 12-year warranty. In case we have an off-grid system, the plant will have to have a capacity of 7.55 kW. The 28 solar panels that are being used for this project are from the German company Luxor. Other products being used include a metal structure 30 with many angles, a battery, and a regulator. The battery calculation shows that they are only half used, which voids their warranty. For example, the panels and battery have a 15-year and 25-year warranty, respectively. On the other hand, the inverter battery has a 5-year warranty. High battery costs are the main reasons why off-grid systems are not ideal for large plants. This type of system can be very expensive to install, especially when the facilities are not connected to the grid and there is no other means of power supply.

Why should we make such an investment?

The monthly electricity consumption is equal to a cost of 1000 ALL. We will then compare this to the energy generated by the panels over the year.

Ee = AHrP H = 13833kW

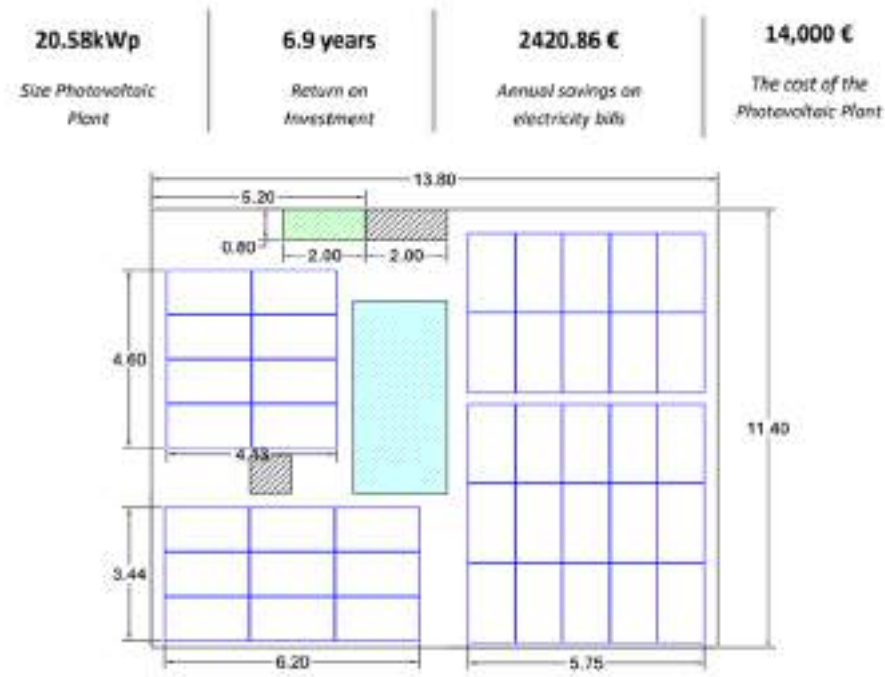
The cost of the panels that are part of the ONGRID system is around 8,600 euros. This amount includes the cost of the panels and the 15-year warranty. For the monthly payment, we received 47.7 euros. Based on this, we can estimate that the panels will consume approximately 1,811,200 ALL of electricity in 15 years. To achieve a total saving of 800,000 ALL in 15 years, we must first compare the costs of the panels with those of a PV system. Let's analyze the energy consumption of the panels during the year and their production. In addition, taking into account the shortened working hours, we can get an estimate of the energy efficiency of the panels. For a year, the panels consume 8656.92 kilowatt hours of electricity. On the other hand, the PV system produces 13833 kilowatt hours of electricity. This means we have about 5,000-kilowatt hours of extra energy to use for a year.

For how many years do these panels cover the investment?

The energy consumption of the panels is the first step in calculating the cost of the system. For one year we will have to pay about 120 thousand ALL. For the next eight years, we will spend about 10 million ALL for the panels. After that, we will have free electricity for seven years. Using the language of energy, we can deduce that the panels have generated 831 kW of free power. The following tables will explain it more clearly.

FIGURE 11: Return on investment after using the panels

Source: Study of the Project of the apartment taken under review



According to calculations made by experts, a photovoltaic plant capable of producing 20.58 kWp can be placed on the roof of a building. There are 42 panels on the surface of the building. These panels are designed to produce a maximum power of 490 Wp. They will be connected to an efficient 20 kVA electric vehicle. The 490 Wp photovoltaic panel measures 2054x1134 mm and weighs 27.4. When considering the different distances between which the panels will be mounted, the total area that will be used for their installation is approximately 125 m2. The energy production of the photovoltaic plant is expected to reach 24627.34-kilowatt hours per year. The excess power that the system generates is then sent to OSHEE's grid.

Bibliography

Borbely, M.A. & Kreider, F.J. (2001).Distributed Generation The Power Paradigm for the New Millenium. United States of America: CRC Press, ch 11.

Jenkins, N., Ron, A., Crossley, P., Kirschen, D., Strbac,G.(2000). "Embedded Generation". London, United Kingdom, The Institution of Electrical Engineers.

Stråth, N.(2005). Islanding in Power System, Licentiate Thesis. Department of Industrial Electrical Engineering and Automation, Lund Institute of Technology, 2005 Manuals.

Photovoltaic systems – characteristics of the utility interface.(2004). IEC international standard 61727. Available at: https://webstore.iec.ch/publication/5736

Power System Protection IEC Vocabulary.(1995). Chapter 448, IEC. https://webstore.iec.ch/publication/211

Powering Health. (2020).

Available at http://www.poweringhealth.org/index.php/topics/technology/solar-pv

Deliverable 1.1 + 1.2.(2005). Interconnection of Decentralised Energy Generation, A Review of Standards, Technical Requirements and Procedures in the EU-15, ELEP, EIE/04/175/S07.38664.

IEA International Energy Agency.(2002).Evaluation of islanding detection methods for photovoltaic utility-interactive power systems.Report IEA- PVPS T5-09:2002. Available at: https://iea-pvps.org/wp-content/uploads/2020/01/rep5_09.pdf

IEEE Recommended Practise for Utility Interface of Photovoltaic (PV) Systems.(2000). IEEE standard 929.

IEEE Standard for Interconnecting Distributed Resources with Electric Power System.(2003). IEEE standard 1547.

Inverters, Converters, and controllers for Use in Independent Power Systems.(2001).UL standard 1741.

Increasing performance in large capacity databases

Eliona SKENDERAJ
European University of Tirana

Abstract

The daily activity of companies is closely related to data. Databases are growing and demand for data per unit of time is increasing and high performance is required to meet this demand. Big data is a collection of large volumes of complex data that exceeds the processing capacity of traditional database architecture. They are also so difficult to administer and organize, and for this reason, the best aim is to find the best and most effective solution. The purpose of this work is to identify the main performance issues that appear while working with databases with large capacities and to propose solutions for such cases. DBMS systems have implemented techniques and tools that monitor data activity and help to improve performance. One of the main directions that focuses on the work of the topic is that of writing requests "query design" in such a way that regardless of the size of the data required, these requests are not delayed and fail. The goal is that, regardless of the proposed writing method, it provides recommendations that will be practically applied in a data warehouse system. In this way, the benefit in performance will be compared. In the end of this paper, it was possible to find very effective and clear solutions.

Key words: Database, SQL, query, performance, large capacities

Introduction

Nowadays data is everywhere. We are generating a large amount of data. The growth of data is surprising in how deeply it affects businesses. For years, companies have been using their transactional data to make informed business decisions. Decrease in the cost of storage and computing power has made companies interested in storing user-generated content in social networks, e-mail, sensors, photos, and incoming message servers that can be used for information. useful. Traditional database management systems, such as relational databases, proved to be good for structured data, but in case of semi-structured and unstructured data it breaks down. However, data comes from different data sources in different formats, and most of this data is unstructured or semi-structured. Additionally, database systems are also pushed to their storage capacity limit. As a result, organizations are struggling to extract useful information from the unpredictable explosion of data captured from inside and outside their organization. This explosion of data is referred to as "big data".

Big data is a collection of large volume of complex data that exceeds the processing capacity of traditional database and data warehouse technologies do not support billions of rows of data and cannot effectively store unstructured and semi-structured data. From 2005 to 2023, the amount of information created and copied in the world will increase by a factor of 300, from 130 exabytes to 40,000 exabytes (more than 5200 gigabytes for every man, woman and child) (IDC Digital Universe, 2020). Big Data technologies describe a new generation of technologies and architectures to extract economic value from very large volumes of wide variety of data, enabling high speed capture, discovery and analysis. The McKinsey Global institute estimates that data is growing at 40% for year and this percentage will grow further. To address this challenge, we must choose an alternative way to process data.

Google was the first that included MapReduce structure computing, The Google File System (GFS), and closed distributed services. Amazon created a new moment in the big data storage space. Over the past few years resource tools and technologies including Hadoop, HBase, MongoDB, Cassandra, Storm and many other projects have been added to the big data space.

Description of the problem

The fast growth and the complexity of data in various fields, such as scientific research, business analysis and online platforms, has presented an

important challenge in the efficient management and analysis of large-scale data. To address this challenge, there is a need to explore ways to improve the performance of data processing and analysis on big data platforms. The problem that we are facing is to improve the performance of data operations on large datasets. Traditional methods and tools often struggle to handle the volume, velocity and type of big data, landing to problems such as slow query speed, high latency, and dissatisfaction. As a result, organizations and researchers face different types of problems such as problem in finding valid notes and taking informed decisions. This problem requires the identification of innovative techniques and strategies that can optimize the performance of big data processing. Solutions may include advances in hardware infrastructure, parallel computing, data sharing, indexing, and algorithmic optimizations. Aim is to develop approaches that can effectively handle large data sets and improve the speed and efficiency enabling users to obtain timely and accurate results from their data analyses. The challenge to improve performance in big data processing has consequences in different sectors. Improving efficiency in data operations can empower business to get.

The aim of the work

The aim of this study is to propose techniques that increase the performance of data warehouse systems.

If we look at the challenge of how to improve performance this is one of the most important things in big data and that has important consequences in various sectors. Improving efficiency in data operations can empower businesses to make important decisions for their success.

Objective

The objective of this paper is to demonstrate that:

- The large size of database affects the efficiency of database.
- The large size of the database has a positive effect on increasing the speed and the performance of databases.
- Improved performance of big data databases brings relief to complex statistic reports that produce complex analysis for businesses with high data flows.
- There is a fair relationship between performance increases in large databases with advances in technology.

Hypothesis

The use of clustered index and non-clustered index increases the performance of data warehouse systems.

Performance analysis of indexes in MSSQL Server

In this Fraction we will show the basics of MSSQL Server for using pages, B-tree, clustered and non-clustered index. To show all of this we will use tempdb database and create an index on the table.

Use tempdb Go

-- B+ Trees në SQL Server

CREATE TABLE Indexing (ID INT IDENTITY (1,1), Name CHAR (4000), Company CHAR(4000), Pay INT) .

This table has 4 columns defined, ID INT as a column and two data char 4000 with column names "Name" and "Company" in this particular table. This means that we have one row, which is close to 8000 bytes. This ensures that each row is in one page and a page cannot contain more than one row. This script is executed and the table is created.

Definitions

SELECT OBJECT_NAME(object_id) TableName, ISNULL(name,OBJECT_NAME(object_id)) IndexName, Index_Id, Type_desc FROM sys.indexes WHERE OBJECT_NAME(object_id = we continue and we use sys.indexes DMVThis show to us that table index is Heap. 'Indexing') GO

Let's go ahead and use sys.indexes DMV. This tells us that the index of the table is Heap.

FIGURE 1. SQL Server: Index Heap

As we can see in the figure above, INT ID is zero. As we defined earlier if INT ID is zero it means it is a heap.

To continue with the demonstration, we need to establish a condition: SET NOCOUNT ON. No-count on is used to stop displaying messages for rows affected by changes and this comes as part of the SQL Server Management studio output.

Let's add some values to the table.

INSERT INTO indexing VALUES ('Eliona," Information technology ',10000)

Nodes will be created in this table. Now we use status check DMV which gives us the opportunity to see object, type of indexes, levels, if it is root, intermediate nodes and leaf node levels. We will also look at page count and fragmentation if it is needed and this is given by the DMV of DB index physical status.

- Status check (DMV of DB index physical stats)

```
SELECT
OBJECT_NAME(object_id) Name,
Index_type_desc AS INDEX_TYPE,
Alloc_unit_type_desc as DATA_TYPE,
Index_id as INDEX_ID,
Index_depth AS DEPTH,
Index_level AS IND_Level,
Record_count AS RecordCount,
Page_count AS PageCount,
Fragment_count AS Fragmentation FROM sys.dm_db_index_physical_stats(DB_ID(), OBJECT_ID('Indexing'), NULL , NULL , 'DETAILED');
GO
```

FIGURE 2. SQL Server: Indexing Types and Levels (DMV)

In this case you are seeing that the indexing of the table is heap and contains in it 'in row data', which means it can fit within a page that's why it's inside the row. It has a depth level equal to one and a record count equal to one. Later we will go ahead and add two more rows to particular table.

```
INSERT INTO Indexing Values
('Arild","Manolia',15000),
('Ardit","NetTrade',13000)
GO
```

After adding the rows again, let's check the status using the same DMV.

FIGURE 3. SQL Server: Status check

We get the same data again, but the number of records has changed.
INSERT INTO Indexing
VALUES
('Albano','NetTrade',11000)
GO 100

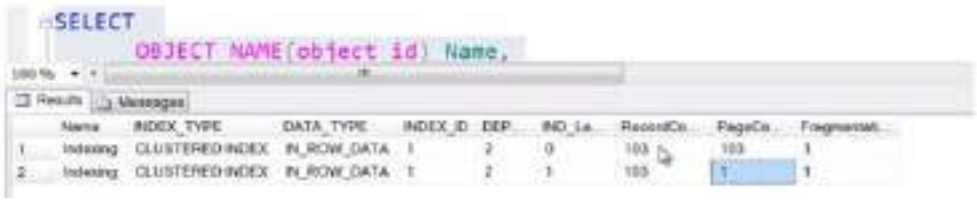
FIGURE 4. SQL Server: DMV with 100 additional records

Now we need to create a clustered index to not have again INDEX_ID equal to zero.

- clustered Index

CREATE clustered INDEX CI_IndexingID ON Indexing (ID) GO

FIGURE 5. SQL Server: Creating the cluster index



What we notice is that in our table we have created an index of type clustered index and it is defined in row data. In it we have index_ID equal to a Depth_level equal to two. At IND_level equal to zero we have 103 records and the number of pages is 103.To manage these 103 records we have another page, which has these 103 records but on a single page. Intermediate root nodes and the root node mentioned earlier is exactly what is being shown. This tells us so clearly the structure of B-tree.

Performance in Non-clustered Index

Non-clustered index is a special type of index that rearranges the way data is recorded in the table. Therefore, the table can only have one cluster index.

FIGURE 6. Table with one cluster index

The DMV status check comes up with the non-clustered index in columns 4 and 5. It is interesting to note that it is slightly different from the clustered index. You can see that the 803 records are stored on two pages, and we have one more root page which stores two pages which store the 803 records on the page. Non-clustered index stores only the key and not the data.

Conclusions

The increase of performance in databases with large capacities contains inside many directions to make possible the increase in performance. Here we can include hardware architecture construction, database architecture construction, improvement technique from the smallest data to table level till up to database level. The main purpose of this topic was to propose different ways of writing the index, different techniques and developing controls, which when applied to a data warehouse system bring an increase in performance. The first concept was that of clustered index and non-clustered index. Clustered index means that a table is physically stored according to the order of the specified index. While the concept of non-clustered index is something different. Non-clustered index is a logical index that tries to group according to a logical relation. The difference between them is

that clustered index can be created just one time and non-clustered index can be created so many times. At the end we conclude that: the indexes are absolutely necessary for modeling and speeding up a database because of their architecture in tree-form. The second concept was that of index performance maintenance. This concept is related to index duplication, how it could be detected, and what disadvantages it brought us. What this duplicated index brings is the anomalies through which the database system would go, bringing a big loss in SQL Server, problems in processing, causing poor database performance. The difficulty of maintaining them is that SQL Server itself cannot prevent the re-creation of such an index because you can create one with a different name.

References

Bernhardt, L.V. (2015). Data, data everywhere: Bringing All the Data Together for Continuous School, second edition Improvement. Routledge.

Carter, P. (2011). Big data analytics: future architectures skills and roadmaps for the cio. International Data Corporation.

Criticism, N. (2003). Data are Everywhere. Narrative Analysis: Studying the Development of Individuals in Society, p. 63.

Dumbill, E. (2012). Planning for Big Data. O'Reilly Media, Inc.

Han, J., Haihong, E., Le, G., Du, J. (2011). Survey on NoSQL database.6th International Conference on Pervasive Computing and Applications (ICPCA), pp. 363–366.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., and A. H. Byers, H.A. (2011). Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute, pp. 1–137.

Marz, N., & Warren, J. (2015). Big Data Principles and best practices of scalable realtime data systems. First edition, Manning Publications.

Tripp, L.T. (2023). SQL Server: Indexing for Performance. Available at: https://www.pluralsight.com/courses/sqlserver-indexing-for-performance

Randal, P. (2023). SQL Server: Index Fragmentation Internals, Analysis, and Solutions. Available at: https://www.pluralsight.com/courses/sqlserver-index-fragmentation-internals-analysis-solutions

Shashanka, M. & Giering, M. (2009). Mining Retail Transaction Data for Targeting Customers with Headroom-A Case Study. Artificial Intelligence Applications and Innovations III, pp. 347–355.

Harvesting Albania's Potential: The Case for Implementing a Wind-Solar Hybrid Park

MSc. Ing. Anius KOTORRI
European University of Tirana
akotorri3@uet.edu.al

Prof. Dr. Angjelin SHTJEFNI
European University of Tirana
angjelin.shtjefni@uet.edu.al

MSc. Ing. Hasimin KEÇI
European University of Tirana
hasimin.keci@uet.edu.al

Abstract

This theoretical study delves into the conceptual underpinnings and theoretical frameworks essential for the establishment of a wind-solar hybrid park in Albania. Drawing upon established theories in renewable energy integration, this research examines the fundamental principles of wind and solar technologies, emphasizing their complementary attributes within a hybrid park setting. Theoretical models elucidating the integration, coordination, and optimization of these renewable sources are explored, aiming to address challenges such as intermittency and grid stability. The study further investigates theoretical frameworks concerning economic feasibility, policy support, and environmental sustainability, crucial for the successful implementation of such an initiative in Albania's energy landscape. By synthesizing theoretical foundations, this study offers insights into the theoretical groundwork

necessary to inform and guide the practical realization of a wind-solar hybrid park in Albania.

***Keywords**: Wind-solar hybrid park, Renewable Energy, Feasibility, Electrical energy, Frameworks*

Wind Energy Potential in Albania

The main wind directions in our country are northwest-southeast and southwest-northeast, with a predominant direction towards the ground. Within the territory, the direction and intensity of the wind vary significantly from one area to another over time. The measurements from the hydrometeorological institute, for many years, have aimed primarily to provide meteorological data on weather to the aviation and maritime services. Quite high speeds have been recorded at the stations in Pukë, Vlorë, Borsh, Kryevidh, Gllava, Xarrë, Sheqeras, and Durrës. For these stations, values lower than 3 m/s have not been recorded in any case. In other areas like Tirana, Rrëshen, etc., low average speeds have also been recorded during the cold season. Analyzing the average distribution of annual wind hours, it turns out that relatively high speeds are not only recorded during midday but also during mornings when the wind normally registers lower speeds. Analyzing the results in areas with high wind flow, it's observed that the average speed exceeding 3m/s is present throughout the year and that exceeding 5m/s occurs during midday. It's worth mentioning that current wind energy production technology has developed turbines that automatically orient themselves according to the wind direction. Observations of anemometer diagrams for several stations have calculated the time intervals during which the wind speed throughout a year is greater than 5m/s. Considering that wind power is proportional to its cubic value, it results that suitable conditions for energy resources are offered in many parts of our territory. Based on the data from the Hydrometeorological Institute in Table 1, an overview of wind speed and energy density for the areas surrounding the proposed zone is presented, allowing us to assess the wind potential with performance indicators of 10-30%.

In Albania, the prevailing winds throughout the year are those from the northern quadrant, followed by those from the southern quadrant. Winds from the western and eastern quadrants occur less frequently. The origin of these winds lies beyond Albania's borders, except for locally characterized winds, such as sea and land breezes, valley winds, etc.

Another characteristic is the absence of prevailing winds from the west in any location. The prevalence of south and southwest directions is observed only in

specific areas (southern in Erseke, while southwest in Korca). Due to the highly fragmented relief caused by valleys and gorges, the winds experience significant deflections throughout the year.

TABLE 1: Annual Distribution of wind direction in %

Meteorological Stacions	Q	N	NE	E	SE	S	SW	W	NW
Shkoder-A	58.5	0.7	2.6	12.4	7.2	6.1	4.1	4.8	3.6
Durres	6.2	27.8	4.3	3.8	21.9	7.6	6.6	13.3	8.5
Tirane-A	39.3	3.7	3	3.3	18.2	5.2	7.8	4.2	15.2
Elbasan	40.1	2.4	18.2	12.5	3.1	2.5	11.2	4.9	5.1
Lushnje	36	6.9	11.8	17.9	4.1	1.9	3.3	6.4	11.6
Kucove	41.8	2.8	1.8	2.4	26.4	2.8	2	6.8	13.1
Fier	19.9	5.4	5.9	15.4	20.2	5.8	6.6	7.8	13
Vlore	40.2	3.5	6.7	17.1	3.2	7.6	5.3	6.5	9.8
Borsh	14.7	22.3	10.3	0.5	4.6	8.7	12.4	3.5	23
Sarande	12.4	7.6	31.5	8.1	8.2	10.1	12.4	6.9	2.5
Burrel	44.8	6.7	2.3	6.3	4.8	8.7	7.1	7.5	11.7
Gjirokaster	43	3	0.3	1	15.4	10.9	3.3	7.6	15.2
Kukes	58.2	12	10.1	0.6	0.7	8.5	8	1	0.9
Peshkopi	44.5	1.7	4.7	9.5	11.9	4	6.7	9.5	7.4
Pogradec	49.8	14.5	4.5	0.8	4	11.2	6.1	5.1	3.8
Korce	51.2	10.3	5.5	7.1	5.8	2.2	13.2	2.4	2.3
Voskopoje	35	5.7	5.3	9.4	10.2	4.2	5.4	7.9	16.8
Erseke	48.3	10	3.3	2.6	3.6	13.4	7.9	4.4	6.5

A Wind Speed

Various forms of relief influence not only the direction but also the speed of the wind. Primarily, wind speed is determined by baric gradient. In the specific conditions of our country, wind speed increases or decreases depending on different relief forms. While the seasonal pattern in wind direction is not pronounced, there are noticeable changes from region to region. Overall, wind speed during autumn and summer tends to be lower compared to other seasons.

Extensive material analysis on wind speed reveals variations month by month. Generally, higher speeds are observed during winter months. The characteristics of winter months persist in March. In some regions, these characteristics endure into April as well.

TABLE 2: Average Wind Speed in m/s

Seasons	Shkoder-A	Durres	Tirane-A	Elbasan	Lushnje	Kucove	Fier	Vlore	Borsh	Sarande	Burrel	Gjirokaster	Kukes	Peshkopi	Pogradec	Korce	Voskopoje	Erseke
Winter	0.2	4.6	1.8	3.1	0.2	2.3	3	3.1	3.5	3.9	1.8	2.1	3.5	1.8	2.1	2.4	2.7	2.6
Spring	2.2	3.9	1.8	2.3	2.7	2.2	3.1	2.6	2.8	3.4	1.8	2.6	3.1	2.2	1.6	2.7	2.7	2.5
Summer	1.9	3.3	1.7	1.7	2.7	2	2.6	2.1	2.5	3	1.7	2.9	2.3	1.8	1.1	1.7	2.1	1.5
Autumn	1.8	3.7	1.5	1.7	2.7	1.8	2.5	2.3	2.9	3.6	1.5	1.7	2.3	1.7	1.6	2.2	2.2	1.9
Annual	**2**	**3.8**	**1.7**	**2.2**	**2.8**	**2.1**	**2.8**	**2.5**	**2.9**	**3.4**	**1.7**	**2.4**	**2.8**	**1.8**	**1.6**	**2.2**	**2.4**	**2.2**

Solar energy in Albania

Albania has a favorable geographical position in the Mediterranean basin and very favorable climatic conditions for the use of solar energy, with a high intensity of solar radiation, a duration of this radiation, temperature, humidity, etc. Mediterranean climate with a mild and humid winter and a hot and dry summer determines a higher energy potential than the average energy potential for the use of solar energy, with a high intensity of solar radiation, estimated at slightly more than 1300-1500 kWh/m2/year. The country has an average of 2400 hours of sunshine. However, its western and southwestern parts can reach up to 2550 hours of sunshine. The selected and evaluated land, deemed quite favorable to produce electrical energy through solar panels, is in the city of Fier in western Albania.

TABLE 3: Solar Radiation for some cities of Albania (IGJEUM)

Month/ City	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	55.3	68.0	102.4	128.9	162.9		200.0	174.6	135.5		64.4	55.8
Shkodra	9	7	2	8	9	182.7	4	6	7	91.24	2	1
	60.9	72.7	103.8	130.6		194.8	207.3	189.6	142.1	102.1	67.9	60.1
Tirana	7	9	5	1	172.7	3	1	7	6	1	8	2
	67.3	***77.9***	***121.7***	***156.2***	***196.2***	***215.1***	***226.3***		***157.9***	***112.1***	***76.1***	***67.1***
Fier	***2***	***9***	***9***	***5***	***3***	***4***	***2***	***212.1***	***6***	***6***	***2***	***5***
	70.0	71.2	101.9	144.3	179.9	204.4	221.6	208.8	163.2	118.2	83.4	79.3
Vlora	6	2	7	8	8	4	9	9	1	2	1	4
	70.6	77.0	102.5	142.9	174.0	192.4	214.4	200.1	166.6	118.2	79.9	71.7
Durres	1	2	6	1	7	4	5	7	2	2	2	9
	70.6	74.7		137.4	175.4	195.1	213.8	199.5	161.6	111.2		72.9
Kucova	4	1	97.91	9	1	1	2	4	2	7	77.6	6

The assessments show that the most favored regions for natural energy potential are again the western regions. Therefore, every square meter of horizontal surface in these areas during the period from November to March receives up to 380 kWh/ year, while the territorial average for this period is around 340 kWh/year. The distribution of sunlight (number of sunshine hours) and especially that of annual sunlight, which in these cases is used as an indicator of brightness, is around 2400 hours throughout the territory, while in the western part, it's over 2500 hours and

in the Myzeqe area, it reaches over 2700 hours. The highest values of daily sunlight intensity are observed during the warm period of the year and especially in the summer months. To be more specific, in December, the daily sunlight intensity is around 2.3 kWh/m2 per day, while in July, this value is around 8.030 kWh/m2 per day. The daily sunshine in the western part of Albania is more than 5.5 hours. The only exceptions are the three winter months. In the practical use of solar energy, "good days" are considered those with daily sunshine of no less than 5.5 hours. Calculations have also been made for "bad days" (these days are those in which daily sunshine is less than 1.5 hours). The analysis of this parameter confirms that the western part of Albania is more favorable than the inland part in terms of using solar energy. In our country, the number of sunny days ranges from an average of 240-260 days per year to a maximum of 280-300 days. However, areas proposed for the diversification of renewable natural resource utilization also have satisfying sunlight radiation. A table with solar radiation for 26 meteorological stations, is provided below in Table No.4.

TABLE 4. Average Values of Solar Radiation kWh/m2

Stations	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
Rezen	52.7	64.6	98.10	123.90	159.80	174.10	197.50	173.70	119.60	90.80	54.40	45.90	1365.00
Dhoden	53.8	66.7	103.60	132.90	168.70	186.50	208.70	179.00	121.3	92.9	55.2	47.1	1416.5
Kelen	44.3	55.5	88.30	115.00	149.40	162.90	188.30	172.10	115.9	83.2	48.3	38.9	1318.4
Pula	53.1	64.9	101.90	126.70	176.50	158.80	202.70	162.60	115.8	91.2	56.1	46.2	1388.7
Lepha	55.5	68.3	106.00	107.40	173.70	199.10	213.90	188.60	109.8	96.2	59.7	49.8	1487
Pashtrepi	50	60.9	100.10	129.90	164.40	104.60	109.90	175.90	120.7	92.3	54.4	43.3	1291.1
Mamurras	69.6	68.9	104.60	134.50	168.90	188.20	208.20	180.10	116.3	93.6	58.8	48.6	1431.2
Borrel	54.8	67.6	103.70	132.60	171.20	185.50	203.10	175.40	132.7	94.1	57.1	46.7	1421.7
Kamza	58	71.3	104.70	136.10	174.00	189.40	211.80	184.60	138.8	100.1	60.9	49.2	1488
Treeq	56.7	69.7	103.70	134.00	173.70	194.30	232.00	183.70	138.9	98.9	59.4	47.9	1473.3
Durres	57	72.3	108.60	140.80	177.60	196.70	232.90	188.90	142.3	100.9	60.5	48.6	1503.8
Elbasan	58.4	71.6	103.5	132.5	168.1	187.9	221.1	180.9	135.3	98.2	60.9	50.1	1468.5
Lushnje	56.1	72.5	107.2	136.4	178	198.7	211.6	184.2	137.3	95.5	60	48.9	1490.5
Pogradec	53.8	68.3	101.3	134.7	170.8	193.3	208.1	182.2	135.3	93.5	58.9	47.3	1468.8
Kucove	59.2	73	108.5	139.4	175.3	190.5	211.4	187.5	137.4	98.8	61.8	51.3	1502.8
Fier	**60.2**	**75**	**111.3**	**141.9**	**181.7**	**206.4**	**223.3**	**197.3**	**144.7**	**103**	**64.9**	**52.9**	**1572.2**
Shkoder	55.6	69.1	103.3	135.6	171.1	188.6	207.3	183.3	137.3	95.9	59.2	48.8	1454.5
Vaskopoja	53.3	67.4	99.8	133.3	171.4	193.7	208.2	182.9	133.2	94.2	57.6	47.2	1441.2
Kavaje	53.8	69.4	102.3	135.8	167.4	188.8	203.6	178.8	132.8	93.9	58.2	47.1	1430.6
Gjirokaster	57.9	71.6	104.4	127.3	164.8	180.3	193.8	176	124.8	97.2	61.7	50.8	1423
Vlore	58.9	74	109.6	142.7	181.6	202.6	216.9	191.9	144.3	103.1	63.8	52.1	1540.4
Erseke	57.7	73.5	105.9	134	170.2	191.3	208.8	179.8	135.6	97.3	62.9	51.9	1468.2
Gjirokaster	55.2	69.7	104.2	133.8	176.4	198	211	188	136.8	96	58.8	47.3	1479.3
Berat	29.5	71.9	104.2	134.5	166.2	192.3	203.8	183	136.8	97.6	62	50.4	1561.9
Sarande	60.1	74	109.3	138.8	178.7	197.3	209.8	186.2	140	100.8	65.9	54.1	1514
Vlore	62	74.5	110.8	140.4	181.4	201.3	212.2	188.7	142.8	103.7	66.9	55.5	1537.7

Hybrid Park

Hybrid parks, combining wind and solar energy, offer several advantages that make them an attractive choice for energy generation:

- Resource Complementarity: Wind and solar energy sources often complement each other. Wind tends to blow more strongly during certain times of the day or year when sunlight might be less available. By combining both, the system can generate power more consistently throughout the day and across seasons.
- Stable Energy Production: When one source experiences fluctuations or downtime due to weather conditions (e.g., low wind or night-time for solar), the other source might still be active. This helps maintain a more consistent power supply.
- Maximized Land Use: Combining wind and solar in a single location optimizes land use. The land can be utilized effectively to generate both types of renewable energy, reducing the need for additional space and land clearance.
- Redundancy and Reliability: Hybrid systems provide a level of redundancy in power generation. If one system encounters issues, the other can continue producing electricity, enhancing overall system reliability.
- Diversification of Energy Sources: Relying on multiple sources of renewable energy reduces dependency on a single technology or energy source. This diversification helps mitigate risks associated with intermittent and maximizes energy production.
- Economic Efficiency: In certain regions, a combination of wind and solar might capture various government incentives, subsidies, or support programs for renewable energy, making the project economically viable.
- Optimized Infrastructure: Some infrastructure components, such as grid connections or storage solutions, can be shared between wind and solar systems, reducing overall infrastructure costs.
- Environmental Benefits: Both wind and solar energy are clean and renewable sources, contributing to lower greenhouse gas emissions and reducing the environmental impact of energy generation.

The combination of these factors makes hybrid wind-solar parks an attractive choice for meeting energy demands sustainably, efficiently, and reliably, especially in areas where both wind and solar resources are available.

A Technical Analyses

Calculating the expected energy output from different renewable sources like solar panels and wind turbines. Formulas involve factors like average sun hours, wind speed, efficiency ratings of equipment, etc.

- *Energy output formula for solar panels:*

$$P = S_i A \eta t$$

Where:
P – Energy Output
S_i – Solar irradiance
A - Area of Solar Panels
η - efficiency of the solar panels in converting sunlight into electricity
t - Time is the duration for which the solar panels are operational

- *Energy output formula for wind turbines:*

$$P = \frac{1}{2} C_p \rho A U^3$$

Where:

ρ - the density of air
C_p - power coefficient
A – rotor swept area
U – free wind speed

Investment Analysis

There are several methods for the economic and financial evaluation of a project, among which the most used are the Net Present Value (NPV) and the Internal Rate of Return (IRR). These methods take into consideration numerous factors, particularly designed to facilitate the valuation of money over time. NPV is a figure that expresses the value of an investment in current monetary terms. A project should only be considered when the NPV results in a positive value. The formula for calculating NPV is as follows.

$$\text{NPV} = \sum_{i=1}^{i=n} \frac{R_i - \left(I_i + O_i + M_i\right)}{\left(1+r\right)^i} + V_r$$

Where:

- Ii = investment in period i
- Ri = revenues in period i
- Oi = operating expenses in period i
- Mi = maintenance expenses in period i
- V = residual value of the investment over time, where the equipment's lifespan exceeds the project's duration
- r = periodic inflation
- n = project lifespan

IRR or Internal Rate of Return determines the interest rate that is equivalent to the expected rate of return from the project. When this interest rate is known, it is compared to the interest rate that would be earned by investing this money in other projects or investments. If the IRR is lower than the cost of borrowed capital for investing in the project, the project would financially fail. However, in such projects, the IRR value should be several points above the borrowing interest rate to compensate for risk, time, and issues accompanying the project.

Financial Analysis

The investment made will involve both cost expenses and revenue generated from energy production. Cost expenses include a fixed component comprising capital costs, insurance, various taxes, and a variable component primarily represented by operating and maintenance expenses, wages, income taxes (profit tax, VAT), etc. At the end of the project, the remaining value after summing expenses and revenues should typically be positive in favor of the revenues generated from the sale of electrical energy. Economic-financial analysis is precisely a comparison of costs and economic benefits that provides the investor with necessary information to decide whether to proceed with the project or abandon it. Such a choice can also be made among different projects so that the investor selects the one yielding the greatest economic benefits.

Economic-financial analysis can be conducted either by including the effects of inflation or by disregarding them. Working with a constant monetary value has the advantage of conducting an analysis independent of inflation. However, if there are

reasons to believe that certain factors will cause inflationary effects, these should be treated with different inflation values. For example, assuming that electricity tariffs will increase 3% less than the inflation rate while other factors remain constant in value, the price of electricity would show a 3% decrease annually in the economic analysis.

The evaluation of investment costs, determined through the implementation budget estimates, including civil construction works and the procurement and installation of equipment, constitutes the first step of an economic assessment. Further evaluation of other expenses such as operational costs (labor), various taxes, revenues, and taxes on them are essential for conducting an economic-financial analysis to decide whether the project will proceed or be abandoned.

Theoretically, there are several methods for the economic-financial valuation of a specific investment based on concession, including:

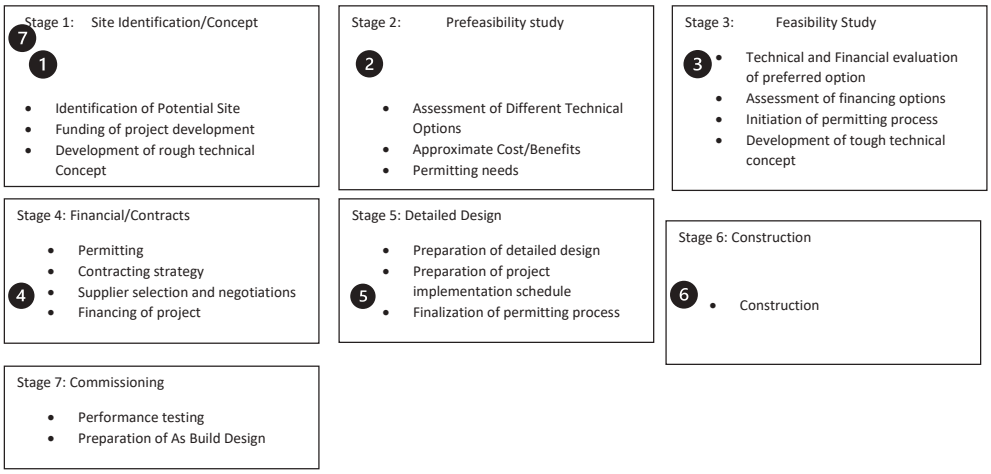
- *Time value of money method*: It represents the concept that 1 (one) EURO received today is more valuable than 1 (one) EURO received in the future because the EURO received today can be invested to earn interest. This analysis generally involves a relationship between a certain amount of money, a specific time, and a specified interest rate.
- *Payback method*: It is a static method that represents the number of years required for the invested capital to be compensated by the income resulting from the sale of goods, in our case, the sale of electrical energy.
- *Return on Investment method (ROI):* It is another static method based on the calculation of average annual incomes, net annual costs, such as depreciation as a percentage of the original investment value.

$$ROI = \left(\frac{\text{Net Profit}}{Investment\ cost}\right) \times 100$$

- *Net Present Value (NPV) Method*: It is a dynamic method that compares the sum of the present values of income each year with the initial investment.
- *Internal Rate of Return (IRR) Method*: It is a dynamic method where the discount rate equals the present value of income (e.g., revenue from selling electrical energy) with the initial investment of the project, making NPV=0.
- Benefit – Cost Ratio Method: It is a dynamic method based on comparing the net present value of benefits and investment based on a ratio.

Project development stages

Exploring the sequential stages involved in Developing hybrid farms that combine wind and solar energy systems, it starts with ideation and site selection. Progressing through meticulous planning and execution, emphasis lies on integrating both energy sources. The importance of constant monitoring for optimization is highlighted, concluding with the collaborative journey toward sustainable energy production in hybrid parks.



The legal framework for new generation power plants in Albania is primarily governed by several key laws and regulations related to energy, environment, and investment. Here are some of the important elements of the legal framework for establishing new generation power plants in Albania:

Energy Sector Laws and Regulations

- Law on the Electricity Sector: Defines the legal framework for the generation, transmission, distribution, and supply of electricity. It outlines licensing procedures, market rules, and regulatory oversight.
- Renewable Energy Laws: Specific laws or regulations that promote and regulate renewable energy sources, offering incentives, feed-in tariffs, or other support mechanisms to encourage investment in clean energy generation.

Environmental Legislation

- Environmental Protection Law: Sets standards for environmental impact assessments (EIAs), emission controls, and compliance requirements for power plants to ensure minimal environmental impact.
- Environmental Impact Assessment (EIA) Regulations: Mandate the assessment and approval process for proposed projects to evaluate potential environmental effects and mitigation measures.

Licensing and Permitting

- Energy Regulatory Authority (ERE): Responsible for issuing licenses, regulating tariffs, and overseeing compliance in the energy sector.
- Generation License: Required for power plant operators to legally generate and sell electricity, outlining technical, financial, and operational requirements.

Grid Connection and System Operation

- Transmission System Operator (TSO): Manages the transmission grid and ensures the connection of new generation plants to the grid in compliance with technical standards and regulations.
- Connection Agreement: Specifies the technical and commercial conditions for connecting the power plant to the national grid.

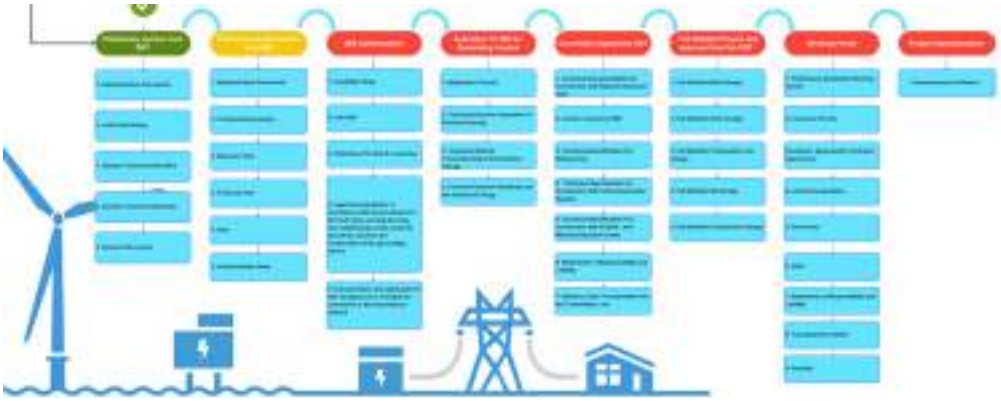
Investment and Contracts

- Investment Promotion Legislation: Laws promoting foreign investment and providing incentives for energy projects.
- Power Purchase Agreements (PPAs): Contracts between power producers and off-takers (utilities or consumers) defining terms for selling electricity, pricing, and other commercial aspects.

Regulatory Stability and Dispute Resolution

- Stability Agreements: Some countries offer stability agreements that assure investors of stability in regulations and protect them from adverse changes in laws.

FIGURE 1. Project Development Milestones for Albania Legal Framework



Actual Electro-energetic situation of Albania

The total consumption of electrical energy (EE) in the country during this period has been covered by EE generation from KESH sh.a (Albanian Power Corporation), independent EE producers, priority EE producers, as well as EE imports.

For the year 2022, domestic EE generation was 7,002 GWh, while the total EE consumption in our country was 7,924 GWh, with a net EE import difference of 921 GWh. The net balance of electrical energy exchange for this period, amounting to 921 GWh, results from an export difference of 2,123 GWh and an import realized at 3,044 GWh. This difference is understandable due to the Albanian electricity system being based on hydropower resources. During periods with abundant rainfall, EE is exported, while during periods with low rainfall, EE is imported to meet demand.

In conclusion, it can be stated that in our country, the profile of EE generation does not always align with consumption. Therefore, diversification of EE generation resources will influence reducing the quantity of imported EE. The losses of EE in the distribution network during the year 2022 were 19.7%, with a slight increase of 0.1% compared to the target set in Decision of the Council of Ministers no. 758, dated 09.12.2021. The total losses for the year 2021 in the distribution system reached 20.62%. The year 2022 resulted in a lower level of losses compared to 2021.

The level of losses in the transmission system for the year 2022 was 199,994 MWh or 2.09% of the transmitted electrical energy. This level of electrical energy losses in the transmission system for the year 2022 resulted in a slight decrease compared to 2021, which was 2.13%.

Bibliography

Bebi, E., Alcani, M., Malka, L., & Leskoviku, A.(2022). An evaluation of wind energy potential in Topoja area, Albania. International Scientific Journals of Scientific Technical Union of Mechanical Engineering "Industry 4.0", Vol. 7 (2022), Issue 1, pg(s) 21-25.

Jenkins, N., Bossanyi, E., Sharpe, D., Graham, M. (2021). Wind Energy Handbook, Third edition. Wiley.

Malollari, I. (2021). Alternativa të energjisë së ripërtëritshme.Botim i Akademisë së Shkencave të Shqipërisë.

Mathew, S. (2006). Wind Energy. Fundamentals, Resource Analyses and Economics. Springer.

Paloka, A. (2011). Burimet e ripërteritshme të energjisë. SHBLU, Tiranë.

Sumathi, S., Ashok Kumar, L., Surekha, P. (2015). Solar PV and Wind Energy Conversion Systems. Springer.

Vasili, P. (2003). Centralet termike diellore për prodhimin e energjisë elektrike. Botimet Uegen, Tiranë.

Vasili, P. (2004). Prodhimi i energjisë elektrike me anë të energjsë së erës, Botimet Uegen, Tiranë.

ERE Raport Vjetore. Available at: www.ere.gov.al.

International Finance Corporation. (2015). Utility-Scale Solar Photovoltaic Power Plants. Project Developer Guide.

Sustainable and Inclusive Urban Development through the Implementation of Smart Cities

Msc. El. Ing. Jani PETRO
European University of Tirana

Abstract

Smart cities can promote sustainable urban development amidst urbanization and climate change. Urban planning and innovation are crucial to address global challenges. Smart urbanization emphasizes community involvement and sustainable resource use. Technology must consider its impact on daily life and the environment for climate-resilient cities.

Smart cities improve infrastructure and public services, requiring supportive policies for inclusivity. Citizens actively contribute to finding solutions in a smart city. Smart cities are more than just technological concepts; they foster innovation and enhance daily life. By adopting a multidisciplinary approach, they address current and future challenges for sustainable and inclusive urban development. A sustainable and participatory vision is needed for shaping the cities of the future.

The purpose of the article on intelligent urban areas is to clarify the notion of intelligent urban areas, to examine their benefits and challenges, to utilize specific instances to demonstrate the use of technology in the development of intelligent urban areas, and to offer a critical perspective on their impact on the lives of residents and the environment. Furthermore, it highlights the significance of scholarly research and knowledge in this field, emphasizing the role of academic inquiry in advancing our comprehension of intelligent urban area dynamics, identifying optimal methods, and addressing potential issues.

Introduction

A smart city uses advanced technologies and data-driven solutions to improve the efficiency, sustainability, and quality of life for residents. It integrates Information and Communication Technologies (ICT), the Internet of Things (IoT), and innovative digital infrastructure to optimize resources and address urban challenges.

A smart city gathers real-time data through interconnected devices and sensors in the urban landscape. This data includes traffic patterns, energy consumption, waste management, air quality, and citizen behavior. By using analytics and Artificial Intelligence (AI), city planners and administrators can make well-informed decisions (Alawadhi et al., 2012).

The pillars of a smart city include smart governance, mobility, energy management, infrastructure, and healthcare. Technology enhances civic engagement, public services, and communication between the government and its constituents. Intelligent transportation systems reduce congestion and environmental impact (Hollands, 2008).

The academic discourse on smart cities is also growing and becoming a dynamic field of study. It is driven by important themes like energy efficiency, economic development, and citizens' well-being. Smart cities are a focal point for addressing urban challenges caused by rapid urbanization, climate change, and resource constraints.

Smart cities are a popular topic in academia because they combine energy efficiency, economic development, and technology to solve urban problems. The focus on citizens' well-being aligns technological advancements with the goal of creating livable and sustainable urban environments. Academic projects and initiatives are increasingly focused on smart cities to prepare future experts and students to tackle urban challenges. By understanding the complexities of smart cities, academic institutions can help create a workforce capable of finding innovative solutions. By educating professionals in smart city initiatives, academia contributes to creating a talent pool that can drive positive change in urban ecosystems. This empowers individuals to actively engage with and contribute to the evolving narrative of smart cities, ensuring a sustainable and resilient urban future.

Literature review

Smart cities represent a shift in urban development that utilizes advanced technologies to improve efficiency, sustainability, and the overall quality of life for citizens. This review of literature examines influential works that have shaped our understanding of smart cities, encompassing perspectives from technological, social, and economic dimensions.

Samith, in his comprehensive exploration of "Smart Cities and Internet of Things," delves into the intricate relationship between smart cities and the Internet of Things (IoT). He emphasizes the pivotal role of IoT in shaping urban landscapes and highlights the integration of technology to optimize services and infrastructure.

Lee provides a nuanced perspective in "Smart City as a Social Transition towards Inclusive Development through Technology." This article explores the transformative potential of smart cities in fostering inclusive development. Lee navigates the interplay between technology and social equity, presenting a compelling argument for smart cities as catalysts for societal progress.

Alawadhi et al.'s seminal work, "Building Understanding of Smart City Initiatives," lays the foundation for comprehending the multifaceted nature of smart city initiatives. The authors analyze the core components of smart cities and emphasize the importance of a holistic understanding for effective implementation.

Hollands' work, "Will the Real Smart City Please Stand Up?" critically examines the conceptual landscape of smart cities. The author explores various interpretations and urges clarity in defining the essence of smart cities, crucial for effective urban planning.

In conclusion, the literature presented offers a diverse range of perspectives on smart cities, highlighting the importance of a holistic understanding that encompasses technological innovation, social equity, and sustainable urban development. These insights contribute to the ongoing discourse on the evolution and impact of smart cities in shaping future urban landscapes.

Analysis

The idea of the "Smart City" has become widely popular in academic literature and global policy discussions, as it harnesses a range of rapidly advancing Information Technology (IT) innovations to transform cities into more intelligent and responsive environments for their residents. It is important to note that cities and urban areas now accommodate roughly half of the world's population (Bakıcı,

Almirall, & Wareham, 2013), and the substantial increase in urban populations in recent decades has presented challenges in terms of both quantity and quality of services provided to citizens. In response to these challenges, the emergence of smart cities has been seen as a strategic solution to effectively address them.

Both governmental and private sector entities have taken various initiatives to develop smart cities, which has led to the integration of Information and Communication Technologies (ICT). The goal of this integration is to create sustainable, efficient, and effective solutions to the numerous challenges faced by urban areas (Caragliu, Del Bo, & Nijkamp, 2011; Su, Jie, & Hongbo, 2011). These challenges encompass a wide range of areas, including education, healthcare, traffic management, energy consumption, waste disposal, unemployment, and crime (Chourabi et al., 2012). The deployment of ICT in these sectors signifies a collective effort to improve urban living conditions and meet the evolving needs of growing city populations.

The concept of the "Smart City" originated in the 1990s and can be traced back to that time, when the primary focus was on comprehending the impact of emerging Information and Communication Technologies on the urban infrastructures of modern cities. During this period, the California Institute for Smart Communities played a pioneering role in this field, dedicating its efforts to strategically planning cities in a way that incorporates information technologies and transforms communities into smart entities (Alawadhi et al., 2012). Following this, the Center of Governance at the University of Ottawa expressed concerns about the excessive emphasis on technical aspects within the notion of smart cities and advocated for a more comprehensive approach.

In more recent years, there has been a shift in focus that has led researchers to call upon actual smart cities to step forward and shed light on the multifaceted dimensions that are hidden behind the broad term "smart city" (Hollands, 2008). It is important to note that the term "smart city" is often used interchangeably with related expressions such as "intelligent city" or "digital city" (Albino, Berardi, & Dangelico, 2015). This change in terminology reflects an ongoing exploration and improvement of the conceptual understanding of cities that embrace advanced technologies to enhance urban living.

Components of a smart city

In the context of densely populated urban environments such as cities and capital cities, there is an increasing recognition of the necessity for integrated subsystems that operate collectively and have intelligence embedded in each of them. Supporters of this integrated perspective emphasize the natural integration

of different subsystems within a city, including transportation, energy, education, healthcare, buildings, physical infrastructure, and public safety. The aim is to create a unified system that embodies the concept of a smart city (Gurdgiev & Keeling, 2010; Kanter & Litow, 2009). Giffinger et al. (2007) and Perera et al. (2014) have put forward six possible characteristics of a smart city: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living.

Lombardi et al. (2012) have associated these characteristics with various aspects of urban life, emphasizing the interconnected nature of these elements. Nam and Pardo (2011) have presented a framework that highlights three factors - technology, people, and institutions - as integral to the concept of a smart city. According to this framework, a city can be considered smart when investments in human social capital and IT infrastructure contribute to sustainable growth and an improved quality of life through participatory governance.

The Human Category within this framework underscores elements such as creativity, social learning, and education. It includes a commitment to lifelong learning, social and ethnic diversity, flexibility, creativity, cosmopolitanism, open-mindedness, and active participation in public life (Lombardi et al., 2012; Nam & Pardo, 2011).

Governance is a fundamental element within the institutional factor of the framework. A smarter government is characterized by dynamic interactions with citizens, communities, and businesses in real-time, which fosters growth, innovation, and progress.

Taking these insights into consideration, a recommended model is the Giffinger and Rudolf model, as it effectively categorizes indicators into three components. This approach stands in contrast to the more complex measures and assessments proposed by Nam and Pardo (Nam & Pardo, 2011). The model encompasses various components and their major indicators, thereby providing a comprehensive framework for understanding and evaluating smart city initiatives (Albino et al., 2015).

FIGURE 1- Components of a smart city

To have a more complete understanding of the concept of a smart city, it is crucial to define and explain each of the foundational pillars that together make up a smart city. Describing these pillars is an important effort to provide insight into the many aspects that define and differentiate the complex structure of a smart city. This analytical breakdown not only helps us understand the different elements involved, but also adds to the academic discussion about the changing approach to urban development.

Information and Communication Infrastructure in the Context of Smart Cities

The Information and Communication Infrastructure (ICI) is vital for smart cities, as it enables the use of data from devices and resources in these urban environments. Advanced networks and information technologies connect and harmonize data, leading to practical applications. The Internet of Things (IoT) connects everyday objects to create a network that collects real-time data. High-level telecommunications technologies ensure fast and reliable connections for all users. New technologies like 5G networks and Cloud Computing enhance data utilization. The application of ICI technologies improves urban life and transforms cities towards intelligence and sustainability.

Intelligent Transportation in Smart Cities

Intelligent transportation is essential for smart cities, using technology to enhance public transportation efficiency and reduce traffic congestion. Technologies like artificial intelligence and sensors help monitor and manage transportation. Real-time information and traffic predictions empower users to plan their trips better. Connected technologies and applications share traffic information, suggest alternate routes, and improve mobility. Ride-sharing apps, electric bikes, and smart buses contribute to user-friendly transportation. Intelligent transportation integrates diverse transportation data for analysis and predictions, preventing congestion and improving resource distribution. It also fosters innovative solutions for urban transportation. In conclusion, studying intelligent transportation in smart cities improves the quality and efficiency of urban mobility.

Resource Management in Smart Cities

Efficient management of natural resources like water and energy is crucial for smart cities. Technology helps preserve these resources and protect the environment.

Advanced technologies monitor and manage natural resources in smart cities. Smart sensors and monitoring systems observe water levels and ensure its quality. This prevents losses and minimizes the impact of urban activities on water resources. Smart grids and automated systems optimize energy usage and reduce wastage. Sustainable sources like solar panels and wind turbines are utilized efficiently.

Monitoring systems and information technologies provide detailed analyses and predictions of resource performance. This helps cities address present and future resource management challenges. Resource management in smart cities goes beyond technical and economic efficiency. It also aligns with sustainable development goals and environmental conservation.

FIGURE 2- Resource Management in smart cities

Technology establishes an integrated infrastructure for a better urban life and a cleaner environment for future generations.

Citizen Services in Smart Cities

Smart cities use technology and innovation to improve urban services and make them more efficient and transparent. This includes healthcare, education, public transportation, and other public services. In healthcare, technology is used to monitor and improve services, with personalized care and prevention being emphasized. The integration of 5G technology ensures fast and reliable healthcare information distribution. Education in smart cities is enhanced through digital platforms and technology, benefiting both students and teachers. Other services like online payments reduce bureaucracy and improve the relationship between citizens and the government. Overall, technology greatly improves urban daily life in smart cities, creating a more advanced and inclusive community.

Smart cities use technology to improve the safety of their citizens, including monitoring crime and reducing risks. Intelligent initiatives promote economic development by fostering innovation and creating business opportunities.

Smart cities employ monitoring technology to identify and respond to dangerous situations. Security camera systems linked with artificial intelligence monitor suspicious activities, aiding in the prevention and resolution of crime. Analyzing big data helps identify patterns and trends in criminal incidents, enabling proactive responses.

Smart cities prioritize economic development by creating an environment that encourages innovation and supports new businesses. Internet of Things (IoT) platforms offer opportunities for innovative projects and services. Local governments intervene using artificial intelligence data and supporting initiatives to foster growth and create jobs.

Economic development in smart cities includes sustainable energy and responsible resource management. Green energy infrastructure, low-carbon transportation, and businesses that prioritize sustainability are promoted.

The relationship between security and economic development in smart cities shows the impact of technology in creating safer and more economically developed urban environments. Advanced technology and innovative strategies drive positive societal and economic changes.

Example of smart cities

Let us now turn our attention to a few compelling instances of smart cities that have gained widespread recognition for their exceptional advancements in technology, which in turn have provided effective solutions to the prevailing and forthcoming challenges faced by their inhabitants. These cities have managed to distinguish themselves by adopting an inventive approach that skillfully integrates state-of-the-art technology, thereby effectively tackling urgent issues and providing a tantalizing glimpse into the future of urban living.

One example that stands out prominently is Singapore, a sovereign city-state that has unquestionably emerged as a global frontrunner in the realm of smart urban solutions. Singapore has astutely harnessed the power of extensive data analytics, the Internet of Things (IoT), and Information and Communication Technologies (ICT) to optimize various aspects of city management, including traffic flow management, waste reduction, and public safety (Thales 2023).

Barcelona, located in Spain, is another exemplary city that has successfully transformed itself into a smart city, showcasing a comprehensive strategy that encompasses multiple areas such as intelligent parking systems, efficient waste management, and meticulous environmental monitoring. Moreover, Barcelona's unwavering focus on fostering citizen engagement through digital platforms has further bolstered its reputation as an innovative and forward-thinking urban center (Reimer, 2020).

Moving on to Dubai, located in the United Arab Emirates, we find yet another prime example of a city that has strategically positioned itself as a leading smart city through groundbreaking initiatives such as the Smart Dubai project. By adroitly integrating transformative technologies like blockchain, artificial intelligence (AI), and the Internet of Things (IoT), Dubai has successfully enhanced various aspects of governance, sustainability, and innovation within the city (Riadh AL-Dabbagh, REES, 2022).

Individuals have the capacity to play a pivotal role in precipitating transformative change towards the development of smart cities, even amidst the grandeur of large-scale projects showcasing state-of-the-art technology, advanced methods of communication, and transportation. The realization of this potential became apparent during my visit to Oslo, Norway, within the framework of the SmartWB project.

The primary aim of the SmartWB project is to deepen and enhance the standard of higher education in the field of intelligent urban development, with a focus on climate considerations. The overarching objective is to reinforce the importance of this domain in the job market and wider society. Additionally, the project aims to strengthen connections and relationships between higher education institutions in partner countries, which include Albania, Bosnia and Herzegovina, and Montenegro. This endeavor is intricately woven into the economic and social fabric.

This strategic vision will be brought to fruition through the establishment of a technological platform designed to facilitate collaboration and the exchange of knowledge, experiences, and best practices. Furthermore, the project envisions the modernization of university curricula, aligning them with the standards and trends endorsed by the European Union. Simultaneously, there is a deliberate emphasis on enhancing the competence and skills of the teaching staff.

These orchestrated efforts are poised to have a positive impact on the advancement of knowledge and the intelligent development of urban landscapes with a climate-conscious perspective. The result will be the creation of a sophisticated and conducive environment, benefiting both students and society.

FIGURE 3- SmartWB Project

During our trip to Oslo, we had the opportunity to inspect the recently renovated Voldsløkka Secondary School, which had undertaken a highly innovative rainwater management project throughout its premises. This initiative was particularly important due to the difficulties caused by high water levels in the surrounding area during rainfall and storms. The execution of this project was inherently intricate, as it required adhering to specific criteria:

Permeable Coverage: Thirty percent of the outdoor spaces need to be covered with surfaces that allow to penetrate water or natural elements. Development of a Schoolyard Resembling a Park: The schoolyard was designed to resemble a park, with a wide variety of plants at different heights. Open and Local Treatment of Stormwater: Stormwater had to be treated in an open and local manner, with secure pathways established in anticipation of flooding (Landezine, 2023)

The stormwater management plan consisted of three main stages:

Handling Light Rainfall: Involving the capture and penetration of light showers. Managing Heavy Rainfall: Including the collection and storage of water during heavy rain. Addressing Intense Rain Events or Bursts: Establishing reliable flood paths for significant rain events.

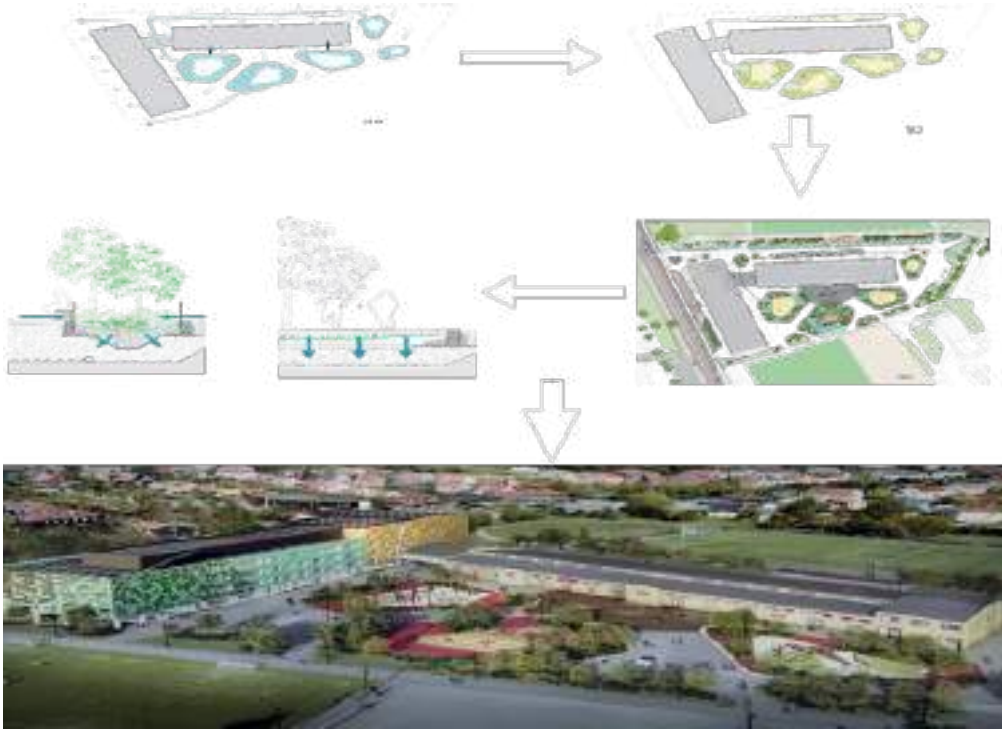
The project also had to find a balance between durable and sustainable surfaces for recreational activities and permeable and green surfaces for effective stormwater management. The commitment to addressing these challenges highlighted the school's dedication to implementing environmentally conscious and resilient urban development solutions (Landezine, 2023)

The impediments were resolved, and the project was executed by carefully selecting materials and implementing a multi-layered strategy. This effort involved skilled engineers, architects, academics, and students from NMBU University, adding an academic aspect to the project.

The solution involved creating islands that were centrally constructed with materials allowing water to pass through to the lower layers. These islands combined with rainfall collected from the surrounding green areas. To optimize the water flow from the courtyard to the central islands, small bridges were built over the green zones using water-permeable materials. This intricate engineering not only addressed the main challenge but also ensured efficient water movement.

However, the resolution did not stop with these structural interventions. There was still a challenge with precipitation in the courtyard that could inconvenience students and academic staff. The solution involved the strategic implementation of guiding channels to direct the water around the green spaces surrounding the islands. This innovative approach effectively tackled technical and environmental challenges and showcased pioneering research and advanced methodologies in urban development and water resource management.

FIGURE 4- Voldsløkka Secondary School



Conclusions

The rise of smart cities signifies a transformative shift in urban development, utilizing advanced technologies like Information and Communication Technologies (ICT) and the Internet of Things (IoT) to improve efficiency, sustainability, and overall quality of life for urban residents.

Smart cities aim to address urban challenges such as traffic congestion, energy inefficiency, waste management, and healthcare provision using real-time data and cutting-edge technologies.

Smart governance promotes civic engagement, transparent communication, and operational efficiency in delivering public services by integrating technology. Smart cities focus on environmental sustainability by integrating renewable energy sources, intelligent transportation systems, and resilient infrastructure. The rise of smart cities raises ethical concerns and privacy issues due to the extensive collection and processing of data.

Smart city projects need to foster inclusivity across diverse socioeconomic backgrounds to ensure accessibility and equity. The educational aspect of smart cities is crucial for driving innovation and managing the transition to intelligent urban environments.

Collaborative efforts between government, academia, and industry stakeholders are pivotal in implementing smart city paradigms.

The Voldsløkka school project demonstrates the strategic utilization of public spaces to improve citizens' well-being and mitigate flood-related vulnerabilities.

The symbiotic partnership between academic and non-academic institutions plays an important role in addressing urban challenges and improving the quality of life for citizens.

Collaboration between academic and non-academic institutions is crucial for sustainable development and societal progress. The trajectory of smart cities has great potential to improve urban challenges and enhance the human experience. However, careful consideration of ethical, social, and economic factors is necessary to ensure that technological advancements contribute responsibly to a sustainable and inclusive urban future.

References

Alawadhi, S., Aldama-Nalda, A., Chourabi, H., Gil-Garcia, J. R., Leung, S., Mellouli, S., Walker, S. (2012). Building understanding of smart city initiatives. Electronic Government, pp 40–53.

Amsterdam Institute for Advanced Metropolitan Solutions. (2017). *Urban living labs: A living lab way of working*. Delft: Delft University of Technology.

An, Y., & Wan, L. (2018). Modelling industrial firm relocation with impacts of spatial dependence. *International Journal of Urban Sciences*, *22*(1), 80–103.

Cardullo, P., & Kitchin, R. (2019). Smart urbanism and smart citizenship: The neoliberal logic of 'citizen-focused' smart cities in Europe. *Environment and Planning C: Politics and Space*, *37*(5), 813–830.

Chang, V., Kuo, Yen-Hung., Li, Chung-Sheng., Ramachandran, M., Yao, Y. (2016). A resiliency framework for an enterprise cloud. International Journal of Information Management, 36(1), 155–166. Doi: 10.1016/j.ijinfomgt.2015.09.008

Hall, P. (2000). Creative cities and economic development. Urban Studies, 37(4), 639–649. doi:10.1080/00420980050003946

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive, or entrepreneurial? City, 12(3), 303–320. doi:10.1080/13604810802479126

Jasmine Reimer, J. (2020). Why Barcelona is a smart city beyond its tech. Available at: https://www.here.com/learn/blog/barcelona-smart-city-2020

Lee, J. (2022). Smart city as a social transition towards inclusive development through technology. Available at: https://www.tandfonline.com/doi/full/10.1080/12265934.2022.2074076

Riadh AL-Dabbagh. (2022). Dubai, the sustainable, smart city. Renewable Energy and Environmental Sustainability Journal. DOI: https://doi.org/10.1051/rees/2021049 Available at: https://www.rees-journal.org/articles/rees/full_html/2022/01/rees210053/rees210053.html

Samith, H. (2019). Smart cities and internet of things. Available at: https://doi.org/10.1080/15228053.2019.1587572

Singapore: The World's Smartest City. Available at: https://www.thalesgroup.com/en/worldwide-digital-identity-and-security/iot/magazine/singapore-worlds-smartest-city

SmartWB. Available at: https://www.smartwb.ucg.ac.me/index.php

Voldsløkka Secondary School. Available at: https://landezine.com/voldslokka-secondary-school-by-ostengen-bergo-as/

Analysis of student performance through data mining techniques. Study case: Learning management system at UET

Jugerta GURABARDHI
European University of Tirana, Tirana, Albania
jgarabardhi@uet.edu.al

Teuta XHINDI
European University of Tirana, Tirana, Albania
teuta.xhindi@uet.edu.al

Abstract

Industry 4.0, like in any other field, also in education, has made it possible for the activities of teaching to continue to develop and the efforts made are for distance learning or e-learning. This is related to the integration of systems that synchronize with computers, mobile phones and technology that can manage the learning system electronically.

Nowadays, modeling user preferences is one of the most important tasks challenging in e-learning systems. This research aims to use Data Mining (DM) for it analyzed the data collected from the learning management system (LMS) used in e-learning systems. The main goal is to predict the individual learning style by using the Moodle LMS platform and analyze the data through Data Mining techniques. With a large volume of data, such as the time spent on the page, as well as the actions taken by students on the platform, it is intended to adapt models to their current preferences.

In this context, the research focuses on the use of Data Mining to improve the quality of education and identify models in educational environments. For her to accomplish this, the study uses well-known data mining techniques and uses an environment analysis called RapidMiner. The study describes how RapidMiner can be used to extract information from the raw data of students in the management system to the students. This paper uses student data captured in the UET LMS management system online teaching and analyzes different algorithms to choose the most suitable ones for the given model. In particular, the analysis of 10 million data records was carried out usage collected from the Learning Management System in 450 online university courses from the period March-June.

Keywords: *Student Performance, Data Mining, Learning Management System, Analysis, Forecasting, RapidMiner, LMS.*

Introduction

We witness the importance of modern education in people's lives. The growing need for an educated workforce in society requires education to be a leader in economic reform. Educational organizations store their data in electronic form and the amount of information does grow every day. To analyze this data, a process is needed which includes inspection, data cleaning, transformation, and modeling. This process is called Educational Data Mining (EDM) in the educational field and converts raw student data from systems educational into useful information for the educational process.

The methodology of online learning in higher education requires the analysis of a large volume of its data generated by planned activities in different subjects. This data is stored in dedicated spaces and includes various interactions such as log files associated with communication between the system and students. To deal with this huge volume of data, data mining techniques provide a way to analyze and extract knowledge from them. This knowledge has a significant impact on the process of decision making.

According to the number of students and activities in the analyzed subjects, we encounter a large volume of data that cannot be analyzed by traditional methods, be they automated or manual analysis. This is why data extraction techniques, such as data mining, including the logic model for knowledge extraction, provide a clear visualization of the results of user application. This knowledge makes an important contribution to the process of decision making. In many bibliographic sources, the classifications of extraction techniques data, such as classification and clustering, allow the creation of data sets, especially

when the analyzed group is large. In this paper, we aim to describe the most widely used, accessible and powerful available to researchers or practitioners of Educational Data Mining (EDM) or Learning Analytics (LA). The discussion in this paper will follow a course like that of a research question or analysis. In the context of extracting educational data, as well as in other areas of data science, the main challenge is the transformation of the data unstructured and integrated into comprehensible variables. Often, data comes in the form of formats that are not ready for parsing. To make it possible, not only should are transformed into a more understandable format but must also be developed into variables meaningful (see section 3.3 in Baker, 2015 or Veeramachaneni et al., 2015, for discussion of details of this process).

In addition, the data must often be cleaned to eliminate unusual cases and values. After cleaning the data, transforming it into a better format fit and feature engineering, the next question that presents itself to EDM or LA researchers are that of analysis - what tests can be performed, what models can be built, what relationships can be mapped and explored, and how can we validate our results?

Methodology

This paper emphasizes the necessity of improving the e-learning method of education to effectively align it with rapid technological advances, especially after pandemic interruptions in the teaching process.

The main objective is to explore the application of EDM in e-learning systems from a perspective 'improving', considering the need to improve e-learning.

Question questions:

- Can EDM be applied to e-learning to improve the design of e-learning systems?
- How to predict student engagement and performance in e-learning systems?
- What are the possible areas in e-learning where educational institutions should focus?

The methodology used in this study is analytical, using data available in e-learning platform (UET LMS) to draw conclusions and create models that help to improve the student learning experience. Hence, this paper highlights the increased necessity for applying EDM techniques to improve e-learning systems in the future.

Literature review

E-Learning: Learning Management System (LMS)

Recently, the field of E-Learning has served as an opportunity not only to reflect on the role of technologies in the teaching process, but also to review the way we conceive the learning process itself. E-Learning brings an important difference in comparison with traditional learning environments offering the possibility to track the actions of users while exploring Electronic Learning Environments (ELEs). These data are unique and expressed in numerical form. Therefore, data-driven approaches should experiment to be analyzed.

Specifically, the Learning Management System (LMS) was developed to improve independent learning of students. LMS is a software used for presentation of materials teaching, management of learning activities and assessment of results based on the web. LMS includes administration, content delivery, assessment, tracking and monitoring, cooperation and communication. LMS users can be educators, students, and administrators. The development of the Learning Management System aims to help students in the process of learning. There has been a wide spread of LMS applications in the business world, but still are not fully utilized. A way that can be used to evaluate the use of this application is the activity of users, such as students and lecturers who use it, and the results they get. Through the LMS, the lecturer can distribute the syllabus of his courses, manage files, create exam questions, quizzes, assignments, monitor student activity, deliver assessment, communicate with students through forums and email, and to follow the progress of students. Through the LMS, students can access the program curriculum, materials, submit assignments, view assessment results, solve problems, quizzes, manage files, communicate with other students and lecturers through forums and sending e-mail. While through the LMS administrator, you can register the course, define the faculty and courses, register and manage the internet pages for data storage.

In the literature, there is a growing interest in this topic in different communities' research such as Data Mining, User Modeling and Intelligent Tutoring Systems or E-Learning.

Data Mining

Data Mining is an analytical process used for exploring large amounts of data, usually related to business or market, in search of consistent patterns and systematic relationships between variables. After the discovery of these models,

they are validated by applying the models to new data. This practice has attracted the attention of many researchers and scientists due to the availability of large amounts of data in various forms such as records, texts, files, sounds, images and others.

There is a concern about missing values, noisy data, data e rarity, static data, dynamic data, attractiveness, heterogeneity, importance, size of its data, algorithm efficiency and complexity. The data we have is often large and noisy, meaning they are imprecise and have a complex structure. In this case, purely statistical techniques will not work, so data mining is one solution (Aruna & Butey, 2014).

At a time when processed data is increasingly available and their complexity increases, the acquisition of data and the extraction of knowledge from them are becoming more and more important and useful. This is especially true due to the increase in applications of Internet-connected systems. But applying the mining methods of data, hidden relationships that are not immediately apparent can be discovered and models that help in making decisions. Thus, data mining becomes a vital tool to handle large amounts of data and extract value from it through in-depth analysis and finding useful patterns.

Data mining uses many techniques to extract useful information where the main purpose of these techniques is to discover patterns using algorithms and different methods. The application of DM is wide and includes various fields such as its visualization data, statistics, Machine Learning, database systems and finding information. They can be divided into two main parts: descriptive mining and mining predictors, each with different functions and techniques. Data mining techniques fall into three main groups: statistical techniques, machine learning techniques, and techniques of artificial intelligence. Each of these techniques has its own algorithms to create patterns to get the best solution (Mustafa Abdalrassual Jassim & Abdulwahid, 2021).

In the field of education

In the traditional educational model, lecturers have a key role in the teaching process. They have the duty to share their knowledge and experience with the students, which they are expected to have a certain base of knowledge and skills.

Before the internet age, there were several models of distance education that included programs television, manual or recorded audio/video. In these models, the lecturers were available to resolve issues by phone or mail. Although these models enabled learning from home and had a flexible schedule, lack of interactivity hindered the teaching process.

Today, the education system has changed drastically with the advent of the Internet. Many institutions now offer online courses, taking advantage of the

benefits of the internet. These courses do not are limited to a specific geographic location or regular schedule, which made possible the growth of the number of potential students. This has led to the creation of universities that offer exclusive online education, while traditional universities have expanded their offerings with online courses and hybrid classes.

E-learning promotes a more personalized learning process, where students play an active role. E-learning courses can be offered through the Systems of Learning Management Systems (LMS) such as Moodle, Sakai and ILIAS, or Learning Platforms such as Knewton and Dream Box. A characteristic of these courses is the large amount of data that can be collected. In addition to the student's history and performance data, any action I performed (reading files, participating in forums, sending messages or visiting links recommended, for example) leaves a digital footprint. From a general perspective, it can be argued that EDM focuses more on techniques and methodologies. Therefore, the contributions of this work are:

a) analyze the origins and characteristics of these fields of research.
b) to provide an overview of the accompanying literature.
c) to examine how both fields of knowledge have evolved in recent years and to discuss their possible convergence, and
d) to present some of the new challenges and trends, including those related to Big Data and MOOCs.

E-Learning Data Analysis (EDM) methods are used for analyzing data on learning and behavior of students in educational environments. The application of EDM methods contains a series of steps that include planning the study design, extraction of data from the educational environment, pre-processing of data, modeling data and interpretation of models.

The importance of DATA MINING in education according to the literature

Educational Data Mining (EDM) is an emerging research field that includes the concept of 'Data Mining in Education' (Grigorova et al., 2017). It revolves around four main parties interested: students, teachers, administrators and researchers. EDM involves the use of wide range of Data Mining techniques to analyze large volumes of collected data from educational institutions (Shahiri et al., 2015). As defined by the International Society EDM (The International EDM Society) and (Baker et al. 2010), EDM is a discipline in development focused on developing methods to explore unique educational data and for gain a better understanding of students and their learning environments. His purpose is to extract valuable

hidden information from large educational data sets in all levels, from schools to universities (Bhardwaj and Pal, 2012). EDM plays a role crucial in uncovering accurate information about student behavior and evaluating the effectiveness of the learning process (Sana et al., 2019).

Researchers use EDM in e-learning environments to evaluate the process of teaching and learning and to suggest improvements. Common applications of EDM in e-learning include the analysis and visualization of educational data, the examination of student behavior, predicting student performance, providing feedback related to learning, providing feedback to teachers, curriculum design and planning of school activities (Romero and Ventura, 2010). The goal of education institutions is to improve existing education systems by empowering administrators with better decision-making skills (Silva and Fonseca, 2017).

Currently, EDM research efforts in e-learning mainly focus on four main areas: understanding student learning behaviors, assessing or predicting i student performance/grades, assessment of engagement and satisfaction levels of students and analyzing the reasons for the student dropout rate. There was a growing interest among researchers in the field of e-learning, as evidenced by the growth of papers published on e-learning systems (Fig. 1, based on data from the ScienceDirect database). Educational institutions have increasingly adopted e-learning mechanisms in recent years, which has contributed to the interest in EDM. The figure illustrates an increase of continuous in published papers on e-learning systems in institutions education from 1998 to 2015. However, between 2015 and 2018, there was a decline, potentially due to the shifting focus of researchers towards Artificial Intelligence and Blockchain. However, research on e-learning systems regained momentum after 2018, especially with the renewed attention on EDM techniques following the global impact of the Covid-19 pandemic, which caused a significant transformation in the education sector worldwide.

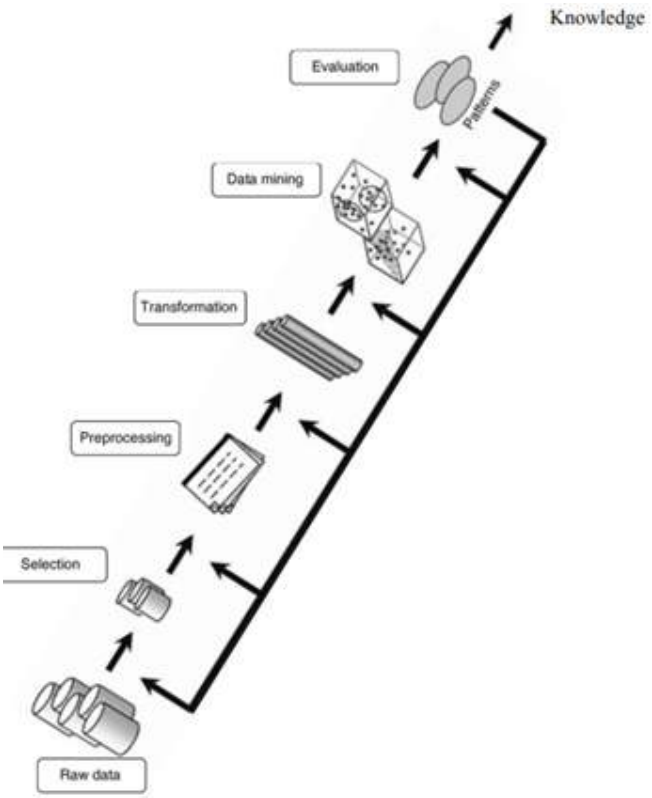
FIGURE 1. Increase of published works
on the E-Learning system in educational institutions.

(Retrived from International Journal of Educational Development 101, 2023)

Definitions and techniques of Data Mining

Data mining, also known as knowledge discovery in the database, involves extracting or "mining" knowledge from a large amount of data. Data mining techniques are used to operate on large volumes of data to discover hidden patterns and relationships useful for the decision-making process. While data mining and discovery knowledge based on data are often treated as synonyms, data mining is a part of the process of discovering knowledge. The sequence of steps identified in extracting knowledge from its data is shown in Figure 8.

FIGURE 2. Steps of extracting knowledge from data



Different algorithms and techniques such as Classification, Clustering, Regression, Artificial Intelligence, Neural Networks, Connection Rules, Decision Trees, The Genetic Algorithm, the Close Unit Method, etc., are used to discover knowledge from the basics of data. These techniques and methods in data mining should be briefly mentioned and better understood.

Discussions and Conclusions

Discutions

Several data mining techniques such as Attribute Weighting have been applied in this study (Weighting by information Gain, Relief, Hi-Squared, Uncertainty), Grouping (K-Means), Classification (Tree Inductions), and Association Mining (Apriori, FPGrowth, Create Association Rules).

The use of clustering methods was aimed at dividing the data into groups of data that naturally form a group. Student actions were grouped together to investigate student behavior patterns in the LMS System. The K-Means algorithm was used to define groups, starting without first knowing the groups in the data. Using prediction techniques, the aim was to develop a model that could predict the expected variables (predicted variables) from the predictor variables (predictors). The Inductive Decision Tree algorithm was chosen as the classification method. The expected variable was the categorical variable of the final assessment (Final Mark). The aim was to determine the variables that have a significant impact on the final evaluation. By implementing ARM (Association Rule Mining), the aim was to discover relationships between variables. Algorithms FPGrowth, Creation of Association Rules (Create Association Rule) and APRIORI as data mining techniques of association rules. The rules of findings can be explained in the form that if a set of certain variables is present, another variable has a high probability of having a specific value.

Conclusions

In this work I have presented research on the implementation of data mining in course management systems, along with a case study about the LMS system. I have described how various data mining techniques can be used to improve courses and student learning. All these techniques can be applied independently in the same system or together in a hybrid system. Although I have described the most popular and general techniques of data mining, there are also other specific data mining techniques that are also used in e-learning, such as unusual value analysis and social network analysis. (They can be as an indication for the work next time).

Also in this research, some concrete models of the mine were proposed data for LMS data based on several techniques (mentioned above). This mining work of educational data allowed the identification and localization of information on

the processes of e-Learning that need improvement, as well as those that perform very well and can be used as good examples. Educational data mining that was investigated in this research allows for better analysis and understanding of learning and teaching processes applying data mining techniques. Experimental results have shown that the presented data mining model was able to obtain comprehensible answers, actionable and logical from the learning management system data describing student learning behavior patterns.

This work was focused on the overall performance of the management system courses at the European University of Tirana and the data mining process of LMS UET. LMS data mining allowed the identification of the most effective ways of the process teaching that can be used to improve the educational process. To test further the effectiveness of the proposed model and to expand the generality of this research, should conduct more extensive experiments using even larger amounts of data course management system.

In the future, it would be very useful to have tools to mine it data oriented specifically for e-learning environments. Today, tools of the mine data drives are usually designed more for power and flexibility than for simplicity. Most of the current data mining tools are too complex to be used by educators and their features exceed the scale of what an educator can to want to do. Therefore, these tools should have a more intuitive and friendly interface to the user, with parameter less data mining algorithms to simplify configuration and execution, and with good visualization services to make the results of understandable for every eLearning leader and designer. Also, it is necessary for the data mining tool to be integrated into e-learning environments as another tool for authors. Thus, all data mining processes can be performed in a single application and the results and feedback gained can be directly applied to the e-learning environment.

Bibliography

Adedoyin-Olowe, M., Gaber, M. M., & Stahl, F. (2014, June 24). A Survey of Data Mining Techniques for Social Media Analysis. Journal of Data Mining & Digital Humanities, 2014.

Alcalá, R., Gacto, M. J., & Alcalá-Fdez, J. (2017). Evolutionary data mining and applications: A revision on the most cited papers from the last 10 years (2007–2017). WIREs Data Mining and Knowledge Discovery, 8(2).

Ali, R. H. (2022). Educational Data Mining for Predicting Academic Student Performance Using Active Classification. Iraqi Journal of Science, 3954–3965.

Amutha, P., & Priya, D. (2018). A survey on educational data mining techniques in predicting student's academic performance. International Journal of Engineering & Technology, 7(3.3), 634.

Altalhi, A. H., Luna, J. M., Vallejo, M. A., & Ventura, S. (2017). Evaluation and comparison of open-source software suits data mining and knowledge discovery. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 7(3), 1204.

Berland, M., Baker, R. S., & Blikstein, P. (2014). Educational Data Mining and Learning Analytics: Applications to Constructionist Research. Technology, Knowledge and Learning, 19(1–2), 205–220.

Caprotti, O. (2017, July 5). Shapes of Educational Data in an Online Calculus Course. Journal of Learning Analytics, 4(2).

Dabhade, P., Agarwal, R., Alameen, K., Fathima, A., Sridharan, R., & Gopakumar, G. (2021). Educational data mining for predicting students' academic performance using machine learning algorithms. Materials Today: Proceedings, 47, 5260–5267.

Dhika, H., Destiawati, F., Surajiyo, & Jaya, M. (2021). Data Mining Approach for Learning management system. IOP Conference Series: Materials Science and Engineering, 1088(1), 012013.

Dhingra, K., & Sardana, K. D. (2017). Educational data mining: a review to its future vision. International Journal of Technology Transfer and Commercialisation, 15(3), 309.

Ghosh, A., & Freitas, A. (2003, December). Guest editorial data mining and knowledge discovery with evolutionary algorithms. IEEE Transactions on Evolutionary Computation, 7(6), 517–518.

Gupta, P., Sharma, A., & Jindal, R. (2016). Scalable machine-learning algorithms for big data analytics: a comprehensive review. Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery, 6(6), 194–214.

Xiahou, X., & Harada, Y. (2022). K-Medoids Clustering Techniques in Predicting Customers Churn: A Case Study in the E-Commerce Industry. International Journal of Computer Trends and Technology, 70(2), 22–28.

Honeypots, for a more secure network

Lediano DOSKU
European University of Tirana

Abstract

The ever-increasing reliance on networked systems has brought about a heightened need for robust network security measures. This diploma thesis aims to explore the effectiveness and practicality of employing honeypots as a means to enhance network security. Honeypots are decoy systems that are strategically deployed to attract potential attackers and gather valuable information about their tactics, techniques, and motives. By analyzing the data collected from honeypots, network administrators can gain crucial insights into emerging threats and vulnerabilities, thereby enabling them to fortify their network defenses. This research project will commence with an in-depth examination of honeypot concepts and classifications. It will delve into the various types of honeypots, including high-interaction, low-interaction, and hybrid honeypots, and their respective strengths and weaknesses. Furthermore, the study will explore the deployment strategies and legal considerations associated with honeypots, addressing ethical concerns and potential implications. Case studies will be conducted to showcase the practical applications of honeypots in real world, that help in detecting, deflecting, and mitigating potential cyber threats. In addition to their defensive capabilities, honeypots can play a vital role in understanding attacker behavior, such as their tactics, motives, and skill levels. This thesis will explore the potential of honeypots as early warning systems, enabling network administrators to proactively adapt their security measures and effectively counteract emerging threats.

***Key words**: high-interaction, low-interaction, hybrid, hacker, firewall, cyber threat, data, log, threat intelligence, false positive, false negative, IPS, IDS, SIEM, OSINT.*

Introduction

Background

In today's interconnected world, network security is of paramount importance. With the increasing frequency and sophistication of cyberattacks, organizations must continually adapt and evolve their security measures to protect their sensitive data and infrastructure. One such security measure is the use of honeypots.

Aim and Hypothesis

This article aims to explore the potential of honeypots in enhancing network security. The hypothesis is as follows:

Hypothesis: Implementing honeypots in a network can enhance its security by detecting and mitigating threats effectively.

This hypothesis forms the foundation for this research, and we will investigate its validity through a comprehensive study of honeypots and their impact on network security.

Research Questions

To test our hypothesis, we will address several research questions. These questions are integral to understanding the role of honeypots in network security and their practical implications.

Research Question 1: How do honeypots work, and what are the different types of honeypots available for network security?

This question provides the fundamental knowledge required to grasp the concept of honeypots and their classification. Exploring the inner workings of honeypots is essential to understanding their potential for network security enhancement.

Research Question 2: What are the primary objectives of deploying honeypots in a network, and how do these objectives contribute to overall network security?

We will delve into the objectives that drive the deployment of honeypots, focusing on their role in improving network security. Understanding these objectives is critical to assessing the effectiveness of honeypots in achieving enhanced security.

Research Question 3: What are the limitations and challenges associated with implementing honeypots in a network for security?

This question acknowledges that honeypots, while valuable, are not without limitations. We will explore the potential drawbacks and challenges that organizations may face when incorporating honeypots into their security strategies.

Research Question 4: What are the legal and ethical considerations related to using honeypots in a network, and how can they be addressed to ensure compliance?

The legal and ethical aspects of honeypot deployment are crucial, as non-compliance can have serious consequences. This research question will examine the legal and ethical implications and explore strategies for ensuring compliance.

Research Question 5: What are the emerging trends and future directions in the field of honeypots and network security, and how can organizations prepare for these changes?

As the landscape of cybersecurity continually evolves, understanding emerging trends in honeypots and network security is vital. We will investigate the future directions of this field and provide insights on how organizations can adapt to stay secure.

Literature review: honeypots, for a more secure network

In response to the escalating complexity of cyber threats, this literature review examines seminal works on honeypots, focusing on their pivotal role in fortifying network security.

Definition and Types of Honeypots

Diogenes and Ozkaya (2018) lay the foundation for understanding honeypots by delving into their definition and types. The comprehensive cybersecurity strategies outlined by the authors provide a holistic view of how honeypots integrate into proactive defense mechanisms.

Challenges in Honeypot Implementation

Highlighted by various sources, including Joshi (2011) and Jones and Martinez (2018), challenges in honeypot implementation, such as false positives and resource consumption, are recognized. Understanding and addressing these challenges are crucial for the successful integration of honeypots into network security.

Effectiveness of Honeypots in Threat Detection

Provos and Holz (2007) and Sanders (2020) contribute to the literature by emphasizing the effectiveness of honeypots in threat detection. Their work underscores how honeypots, through techniques like intrusion detection and deception, play a pivotal role in identifying and mitigating malicious activities.

Integration with Existing Security Measures

Smith et al. (2019) discuss the importance of integrating honeypots with existing security technologies such as firewalls and intrusion detection systems (IDS). This integration enhances overall security measures, creating a layered defense against cyber threats.

Legal and Ethical Considerations

Anderson (2020) and Kabay (2003) contribute to the ethical dimension of honeypots, exploring legal and ethical considerations related to their use. The literature acknowledges the need for responsible deployment of honeypots to ensure compliance with regulations and ethical standards.

In conclusion, this literature review underscores the evolutionary trajectory of honeypot technology and its diverse applications in fortifying network security. From foundational concepts to practical implementations, the synthesized body of work surveyed accentuates the indispensability of honeypots as a critical tool in the contemporary cybersecurity landscape.

Honeypot concepts and types

History of Honeypots

Originating from Winnie the Pooh's honey jar metaphor, honeypots evolved as a cybersecurity tool to attract, block, and monitor cybercriminals. Lawrence Livermore National Laboratories and AT&T Bell Labs used early honeypot concepts in the late 1980s and early 1990s to track hackers penetrating their systems.

Over time, honeypot espionage became widespread, playing a key role in capturing hackers and assisting cybersecurity professionals in gaining extensive knowledge about various cyberattack techniques. It serves as a valuable tool for studying and monitoring different cyber threats, contributing to the development of effective defense strategies.

Types of Honeypots

Honeypots are categorized into several types, including: Low-Interaction Honeypots: Simulate specific targets, such as servers or applications, recording the

actions of potential attackers. They are controllable and secure, providing insights into attacker behavior without affecting the real network.

High-Interaction Honeypots: Sophisticated honeypots emulating fully functional operating systems and applications. They allow in-depth exploration by attackers, capturing detailed information on advanced attack techniques.

Hybrid Honeypots: Combine features of both low and high interaction, offering a flexible and balanced approach to network security. They can mimic a wide range of services and protocols, providing a middle ground between resource efficiency and interaction level.

Honeynet Architecture

The Honeynet architecture is a comprehensive approach to deploying honeypots within a network environment. It involves multiple components:

- *Production Network*: Represents the actual network infrastructure containing legitimate assets that require protection, such as servers and critical data.
- *Honeynet Segment*: Isolates and dedicates a network segment to honeypots, diverting the attention of potential attackers away from the production network.
- *Network Sensors*: Strategically placed within the honeynet segment to monitor and capture network traffic data. This data is crucial for analyzing attacker behavior, identifying new attack techniques, and understanding emerging threats.

Honeypot Deployment Strategies

Effective deployment strategies include:

Honeypot Placement: Strategically distributing honeypots throughout the network diverts attackers' attention from real assets, increasing the chances of detecting and capturing malicious activities.

Network Segmentation: Isolating honeypots in dedicated segments or Virtual LANs (VLANs) ensures their separation from legitimate systems, limiting the potential impact of attacks and minimizing risks to critical assets.

Honeypot Diversity: Deploying various honeypot types, such as low-interaction, high-interaction, and hybrid, enhances the likelihood of capturing different types of attacks and provides comprehensive threat intelligence.

Fake Data and Credentials: Configuring honeypots with fabricated data and enticing credentials lures attackers into engaging with them. Fake user accounts, sensitive documents, or tempting financial information can attract and reveal attackers' motives and techniques.

Monitoring and Alerting: Continuous monitoring of honeypots for suspicious activity, coupled with automated alerts, ensures swift notification of security personnel when an attacker engages with a honeypot. Real-time monitoring enables prompt analysis and mitigation of threats.

Regular Updates and Maintenance: Keeping honeypots up to date with the latest security patches and software updates ensures their stability and resilience against attacks. Regular maintenance tasks, such as log analysis and system integrity checks, help preserve honeypot effectiveness.

Legal and Ethical Considerations

- *Legality*: Honeypots must comply with applicable laws, ensuring adherence to regulations governing network traffic capture and data storage.
- *Privacy*: Organizations should respect privacy laws, anonymizing collected data and preventing unintentional privacy breaches.
- *Informed Consent*: Clear disclosure about honeypots' presence and purpose is crucial, ensuring ethical engagement and informed consent.
- *Data Handling*: Establishing secure data handling policies, including restricted access and defined retention periods, is critical to meet data protection regulations.
- *Misuse and Counterattacks*: Safeguards are necessary to prevent honeypot misuse and counterattacks, protecting other systems from being targeted.
- *Cooperation and Information Sharing*: Ethical practices include responsible information sharing and cooperation, aligning with legal and ethical guidelines.
- *Professionalism and Responsible Use*: Operators must uphold professionalism, using collected data for legitimate security purposes and preventing unauthorized disclosure.

Advantages and challenges of honeypots

Advantages of Honeypots

Early Warning Systems

Early warning systems play a crucial role in proactive security measures, providing alerts for potential threats.

Honeypots, as early warning systems, divert attackers' attention from critical systems, allowing organizations to detect and respond to security incidents before substantial damage occurs.

Information Gathering (Intelligence):

Honeypots serve as effective intelligence-gathering tools, attracting and engaging potential attackers to monitor and capture their activities.

This intelligence helps organizations understand evolving threat trends, identify attack patterns, and strengthen overall defense strategies.

Reducing False Positives:

Minimizing false positives is critical for accurate threat detection.

Strategies include configuring honeypots realistically, implementing powerful anomaly detection mechanisms, and collaborative sharing of threat intelligence to enhance detection accuracy.

Challenges of Honeypots

Resource Requirements:

Adequate hardware resources, network bandwidth, and skilled personnel are essential for effective honeypot deployment.

Regular updates and maintenance of honeypot systems and software are necessary to ensure security.

False Negative Threats:

False negatives pose a significant challenge as they may result in undetected security threats.

Regular updates, active monitoring, collaboration, and supplementing honeypots with broader security controls help minimize the risk of false negatives.

Legal Implications:

Legal implications arise concerning privacy, respecting privacy laws, and handling information gathered by honeypots.

Users must adhere to privacy laws, ensure proper use of collected information, and have clear policies for interacting with law enforcement authorities.

In summary, while honeypots offer early threat detection, intelligence gathering, and the reduction of false positives, challenges include resource requirements, addressing false negatives, and navigating legal considerations to ensure ethical and lawful honeypot usage.

Deployment and configuration of honeypots

Planning and Objectives:

Before deploying honeypots, careful planning is crucial. Organizations need clear objectives and goals, including threat detection, capturing and analyzing attacker techniques, intelligence gathering, and enhancing incident response capabilities.

Planning involves determining the scope and scale of honeypot deployment, choosing appropriate honeypot types based on objectives, and setting a clear timeframe and project management approach.

Honeypot Placement in the Network:

Effective honeypot placement is strategic for network security. Options include placing honeypots at the network perimeter, within internal segments, or alongside critical assets. Strategic placement allows for monitoring and capturing malicious activity, early threat detection, and intelligence gathering. Balancing visibility and risk are essential to avoid unnecessary complications or compromises to overall security.

Honeypot Configuration:

Configuring honeypots involves emulating specific services, setting up network configurations, implementing logging mechanisms, and ensuring the honeypot's security. Accurate emulation of targeted services, appropriate network configurations, and robust logging are crucial. Security measures should include regular hardening, credential changes, and deception techniques to minimize the risk of honeypot misuse.

Monitoring and Log Recording:

Monitoring and logging are vital components for capturing and analyzing activities within the honeypot environment. Real-time monitoring allows for early threat detection, while systematic log recording provides valuable forensic evidence. Effective record management practices, including retention periods and secure storage, are essential for analysis and reporting.

Data Analysis and Visualization:

Analyzing and visualizing captured data is crucial for extracting meaningful insights. Data analysis involves examining patterns and trends, while visualization presents findings in an easily interpretable format. Both processes contribute to threat intelligence, aiding in informed decision-making and collaborative sharing of threat information.

Honeypots and network security

Intrusion Detection and Prevention

Intrusion Detection Systems (IDS) and Intrusion Prevention Systems (IPS) are crucial for effective honeypot use. IDS monitors network traffic and system activities within the honeypot to detect and alert on suspicious or malicious behavior. IPS takes proactive measures to prevent or block detected intrusions.

Detection Techniques:

- Signature-Based Detection: Matches against known attack signatures.
- Anomaly Detection: Identifies deviations from normal behavior.
- Behavior Analysis: Monitors how systems and users react to situations.

Threat Intelligence:

Threat intelligence provides valuable knowledge about evolving threats, attack techniques, and adversary behaviors. It aids in creating realistic honeypots by understanding adversary motivations, maximizing capture chances, and enhancing overall security posture.

Threat Intelligence Role:

- Proactive Security Measures.
- Real-time Information on Attack Trends.
- Sharing Threat Intelligence for Collective Defense.

Assessing Effectiveness:

- Assessing honeypot effectiveness involves:
- Identifying Risks.
- Continuous Monitoring and Analysis.
- Evaluating Exploits and New Threats.
- Proving and Simulating Attacks.
- Identifying Effective Security Measures.
- Sharing Threat Intelligence.

Effectiveness Evaluation Aspects:

- Identifying Network Risks.
- Cost and Resource Analysis.
- Strategic Decision-Making.

In conclusion, assessing honeypot effectiveness is critical for organizations to understand how well they fulfill security goals and plan strategic actions based on results. It involves continuous monitoring, threat intelligence utilization, and resource analysis to enhance network security.

Incident Response and Computer Forensics

Honeypots serve as crucial tools in incident response and computer forensics within the realm of cybersecurity. Incident response involves the steps and actions organizations take to address and respond to a security incident. When a potential attacker engages with a honeypot, organizations must have ready procedures and protocols to handle incidents and prevent them from penetrating their actual infrastructure. This includes isolating the incident, analyzing it to understand the attacker's techniques and motives, and taking measures to enhance security through policy and infrastructure changes.

In addition to prevention, computer forensics plays a vital role in honeypot utilization. It encompasses activities essential for handling security incidents from a legal perspective, including:

- Identifying Attackers
- Preparing Evidence
- Forensic Analysis
- Assisting in Legal and Defensive Strategy Formulation

Reduction of Attack Surfaces

Attack surfaces are the areas or weak points in an organization's infrastructure where attackers can potentially enter and carry out attacks. Honeypots are powerful tools for reducing attack surfaces using various action strategies:

- Diminishing Attackers' Abilities to Identify Weak Points
- Advancing Identification of Attackers and Their Investigations
- Redirecting Attackers and Reducing Demands on Core Infrastructure
- Discovering Attackers' Methods and Tactics

The use of honeypots as a tool for reducing attack surfaces ensures that organizations have a better defense against attackers and can prevent potential attacks before they damage their infrastructure. This contributes to establishing a more resilient and secure network against possible threats.

Emerging Trends and Research Directions

Honeypots in Cloud Computing

The integration of honeypots in cloud environments offers flexibility, scalability, and high availability. Positioned strategically within platforms like AWS or Azure, these honeypots enable organizations to gather valuable information on attacks and tactics. While providing insights into threat landscapes in cloud computing, challenges related to data security and access control must be carefully addressed.

Integration with AI and Machine Learning

The fusion of honeypots with AI and machine learning revolutionizes cybersecurity. These advanced technologies empower honeypots to learn, analyze, and enhance their capabilities. Automated analysis of attack data, risk assessment, and real-time interaction create a sophisticated cybersecurity ecosystem. However, challenges include the need for specialized expertise and a robust security framework.

Threat Deception Techniques

Critical to honeypots, Threat Deception involves deceptive strategies to mislead and identify attackers. Distributing honeypots strategically within the infrastructure,

manipulating data, and creating false vulnerabilities thwart attackers and facilitate early threat detection. While offering early threat identification, continuous review and updates are crucial for sustained effectiveness.

Scaling and Automating Honeypots

Scaling honeypots enhances the breadth of attack study, aiding in policy improvement. Automation, guided by AI and scenarios, streamlines honeypot management, ensuring consistent and efficient operations. The combination of scalability and automation accelerates incident response, offering organizations timely and effective security measures against diverse threats.

In conclusion, emerging trends like cloud integration, AI collaboration, advanced threat deception, and automated scaling empower organizations to bolster their cybersecurity posture. Continuous adaptation, expert oversight, and strategic planning are key to harnessing the full potential of these trends and effectively countering evolving cyber threats.

Setup and Configuration of Honeypots

Honeyd

Honeyd Configuration:

Overview: Honeyd is a honeypot software designed to simulate network infrastructure and data exchange services, attracting hackers for monitoring purposes. Key components include the Honeyd Daemon, Virtual Hosts, Virtual Network Stack, Configuration Files, Network Emulation, and Logging/Analysis.

Configuration Steps:

Download Honeyd: Obtain from GitHub or the Honeynet Project, ensuring libraries like libevent, libdnet, libpcap, and optional libpcre for Perl are installed.

Installation: Update repositories and install Honeyd with commands like sudo apt-get update and sudo apt-get install honeyd.

Create Configuration File: Develop a new configuration file, e.g., honeyd.conf, defining network flow and virtual hosts.

Specify Virtual Hosts: In the configuration file, set IP addresses, OS versions, and desired services for each virtual host.

Adapt Services and Responses: Modify the configuration to specify services and responses Honeyd should emulate, such as SSH, HTTP, or FTP.

Start Honeyd: Save the configuration file and launch Honeyd using sudo honeyd -d -f honeyd.conf for debugging and file specification.

Monitor and Analyze: Observe logs and recorded data to analyze potential attacker activity, including connection attempts and executed commands.

Adjust and Update: Regularly review and update Honeyd's configuration to address emerging threats, vulnerabilities, or changes in attack patterns.

Network Settings: Adjust firewall parameters or network configurations to allow incoming connections on the virtual interfaces used by Honeyd.

Care should be taken in maintaining vigilance and adapting configurations to enhance effectiveness, considering new vulnerabilities, service updates, and emerging threats.

Dionaea

Dionaea Configuration:

Dionaea Overview: Dionaea is a widely-used honeypot for analyzing and monitoring network attacks. It simulates a fully functional environment, enticing attackers with services like FTP, SSH, Telnet, and HTTP to gather detailed information on attack tactics and methods.

Key Components:

Dionaea Sensors: Capture and identify attack attempts, recording relevant data for further analysis.

Database Structure: Stores attack data in a dedicated database for accessible and in-depth analysis.

Analysis Tools: Classify and review captured data, aiding in identifying new threats and creating attacker profiles.

Dionaea Configurable: Adjustable parts used to customize Dionaea's behavior by emulating various services.

Monitoring and Reporting System: Tracks activity and generates reports on attacks and attackers, aiding in understanding network risks.

Installation and Configuration:

SSH Connection: Connect to the honeypot via SSH and ensure system updates.

Install Necessary Tools: Install required tools for easy management of Personal Package Archive (PPA) resources.

Add Dionaea PPA: Add Dionaea PPA and update package manager cache.

Install Dionaea: Use the package manager to install Dionaea.

Navigate to Configuration Directory: Change to Dionaea's configuration directory and list its contents.

Configure Dionaea: Modify the general configuration file to suit preferences, considering logging details and enabled modules.

Handlers and Services: Customize incident handlers and enable/disable services like SMB, FTP, and MySQL.

Start Dionaea: Initiate the honeypot using the command **sudo service dionaea start**.

Note: Regularly review and update Dionaea's configuration for enhanced effectiveness, taking into account emerging threats and changes in attack techniques.

Cowrie Honeypot

***Cowrie Overview**:* Cowrie is a widely used honeypot that emulates SSH and Telnet services to attract potential attackers, gathering crucial data on their techniques and behaviors. It is a configurable system allowing users to collect detailed information on attacks, including executed commands, authentication attempts, and file interactions.

Key Features

Configurability: Cowrie is a highly configurable and modifiable system, enabling users to gather in-depth information on attacks.

Data Logging: Records detailed information on attack sessions, aiding in the analysis and identification of new attack patterns.

Security Strategy Development: Users can develop advanced network defense strategies and take necessary measures to prevent future attacks.

Community Support: Cowrie benefits from a dedicated community, continuously evolving to meet new developments in network security.

***Installation and Configuration**:*

SSH Configuration: Change the SSH service port to allow Cowrie to use port 22, then restart the SSH service.

Dependencies Installation: Install required dependencies for managing Cowrie, including Git and Python packages.

User Setup: Create a dedicated user for running the Cowrie honeypot.

Cowrie Installation: Clone Cowrie from GitHub, create a virtual environment, and install necessary Python packages.

SSH Key Generation: Generate an SSH key for Cowrie's use.

Configuration Adjustment: Modify Cowrie's configuration file to specify hostname, listening ports, and enable Telnet support.

File System Customization: Adjust files in the honeys directory to create a fictional file system, changing the username and hostname.

User Authentication Setup: Define user authentication rules by modifying the userdb.txt file.

Auth binds Installation: Install Auth bind to allow Cowrie to listen on ports below 1024 without privileged users.

Cowrie Execution: Start Cowrie using Auth bind and the configured settings.

***Note**:* Regularly review and update Cowrie's configuration to adapt to emerging threats and enhance network security.

Kippo Honeypot

Kippo Overview*:* Kippo is a specialized honeypot designed to capture and monitor attacks on the Secure Shell (SSH) service. It emulates an SSH server, simulating a Linux system based on an old Debian version. Kippo logs and analyzes activities of attackers attempting to connect, aiding in the study of user attacks seeking SSH authorization files or conducting brute-force attacks.

Key Features

SSH Emulator: Core component simulating a fake SSH server, attracting potential attackers.

Activity Monitor: Records and analyzes all attacker activities, including login attempts and command usage.

Database: Stores attack data for later analysis, essential for maintaining attack logs.

Additional Modules*:* Kippo allows the addition of modules to extend functionality, enabling tracking of specific attacks and displaying analysis results.

Installation and Configuration*:*

System Setup: Ensure root or sudo access on a Linux system with a command-line interface.

Python and Twisted Installation: Install Python and Twisted using the package manager.

Kippo Download: Download and extract Kippo from its GitHub source.

Configuration: Copy the default configuration, then edit kippo.cfg to customize parameters such as IP address and listening port.

Start Process Installation: Install a startup process for Kippo, using systemd for newer systems.

Service Activation: Enable and start the Kippo service through systemd.

Monitoring: Kippo is now ready to capture SSH attacks, and its activity can be monitored and analyzed in the configured log directory.

Note*:* Regularly review and adapt Kippo's configuration for evolving threats, ensuring effective monitoring of SSH-based attacks.

Glastopf Honeypot:

Overview*:* Glastopf is a honeypot designed to capture and monitor web application attacks. Its name, a combination of German words "Glas" (glass) and "Topf" (pot), signifies a glass container for capturing attacks.

Key Features:

Internet Application Emulation: Glastopf emulates various internet applications, including web servers and web-based applications, simulating potentially vulnerable targets for attackers.

Attack Capture: Glastopf collects data on attacks against fake applications and emulated internet systems. It identifies attacker actions, recording detailed information such as HTTP requests, URL parameters, and page distribution.

Analysis and Reporting: The honeypot employs an integrated system for analyzing collected attacks, aiding in identifying attack types and compiling reports on discovered attack trends.

Flexibility and Configuration: Glastopf offers high flexibility and configurability. Users can customize internet application emulation and configure different parameters to capture and monitor attacks according to specific needs.

Internet Application Defense: Glastopf assists organizations in identifying and addressing attacks on their internet applications, enhancing overall security.

Architecture Components:

Internet Application Emulator: Designs to emulate various internet applications, configurable to imitate desired applications.

Traffic Sensor: Gathers data on sent requests within the emulated internet space, monitoring and recording detailed information on each attempted attack.

Database: Temporarily stores collected data for analysis, containing information on attacks and attacker activities.

Attack Analysis System: Identifies attack modes, trends, and tactics used by attackers, contributing to a comprehensive analysis of captured attacks.

Configuration Module: Allows users to adjust internet application emulation and monitoring parameters based on specific requirements.

Integration with Information Sharing: Glastopf communicates with security information distribution systems to share data on detected attacks and trends.

Installation and Configuration:

Prerequisites: Ensure a Linux system with required dependencies like Python, pip, libevent, libdnet, libpcap, libyaml, gcc, and make.

Installation: Use pip to install Glastopf and its dependencies.

Configuration: Customize Glastopf parameters using the configuration file located at /etc/glastopf/glastopf.cfg.

Startup: Initiate Glastopf with the command "glastopf-runner."

Monitoring and Analysis: Review activity logs typically stored in /opt/glastopf/log for monitoring and analysis.

Additional Configurations (Optional): Adjust port numbers or network parameters based on specific requirements.

Note: Glastopf serves as a valuable tool to discover and mitigate web application attacks, aiding in the study of attacker tactics and the development of effective security measures for online applications.

Snort Intrusion Detection System

Overview*:* Snort is an open-source Intrusion Detection System (IDS) used to monitor and identify suspicious activity in computer networks. Renowned for its ability to detect attacks based on signatures, Snort creates alerts for potential security events. Suitable for both large and small networks, Snort offers extensive configuration and customization options, allowing users to adapt it to their needs and analyze network traffic to identify potential threats.

Architecture Components

Traffic Sensors (Packet Sniffer): Fundamental components that monitor and collect packets sent across computer networks, recording each packet for in-depth analysis.

IDS Engine: Analyzes network traffic to identify suspicious events or potential attacks, utilizing a database of attack signatures to match traffic packets and identify suspicious activity.

Action Unit: Takes action after detecting a suspicious event or potential attack, including notifications, traffic blocking, event logging, and other measures to prevent or address attacks.

Signatures Database: Uses a database of attack signatures to compare traffic packets with known attack signatures. Regularly updated to include new attack signatures.

Configuration and User Interface: Users can customize Snort through configuration. The system provides a user interface to monitor, analyze, and manage intrusion detection activity.

Installation and Configuration

Installation

Prerequisites: Ensure required packages are installed, including "libpcap," "libpcre," "libdnet," and "libdnet-dev."

Download Snort: Obtain Snort from the official website or use the system package manager for automated installation.

Install Snort: Extract and install Snort using standard commands.

Signatures Installation:

Download Signatures: After Snort installation, download and configure the attack signatures database. Tools like "oinkmaster" or "Pulled Pork" can assist in managing this process.

Configuration:

Create Configuration File: Customize the configuration file located in /etc/snort/ based on system requirements.

Interface Configuration: Use the configuration file to specify the network interface Snort will monitor.

Signatures Configuration: Utilize the downloaded attack signatures database to enable and tailor signatures in the configuration file.

Start Snort:

Initiate Snort using the command:

sudo snort -q -u snort -g snort -c /etc/snort/snort.conf -i <interface>

Where "-c" specifies the configuration file, and "-i" specifies the network interface.

Monitoring and Analysis: Once configured and started, monitor network activity and analyze collected data and alerts for potential threats.

Note: Snort is a robust tool for network intrusion detection, empowering users to strengthen their computer network security by identifying and responding to potential threats effectively.

Conclusion Summary

Key Points

Honeypots enhance network security by luring and capturing attackers, providing insights. Types include low, high, and hybrid honeypots, chosen based on goals and resources. Effective use requires careful planning, considering deployment, configuration, and monitoring. Legal and ethical considerations are crucial in deployment to ensure compliance and privacy. Honeypots serve as early warning systems, offering timely threat information for proactive measures. Scaling and automating honeypots are necessary for managing large infrastructures efficiently. Data analysis, visualization, and integration with AI improve honeypot effectiveness in threat detection. Honeypots contribute to reducing false alarms and improving incident response and cybersecurity hygiene.

Contribution

The article significantly contributes to computer security by thoroughly analyzing honeypots' role and effectiveness, emphasizing their controlled environment's value in threat intelligence.

Recommendations

Professionals are advised to implement various honeypot types, regularly update and maintain them, share intelligence, integrate them into incident response, assess and update security measures, stay informed about legal aspects, invest in training, and collaborate with legal experts.

Opportunities for Future Studies

Future research opportunities include advanced attack detection in honeypots, extensive data analysis for understanding cyber threat patterns, automation of data analysis, investigation of honeypot security in new technology environments, and continuous risk evaluation for effectiveness.

References/bibliography

1.Diogenes, Y., Ozkaya, E. (2018). *Cybersecurity - Attack and Defense Strategies: Infrastructure security with Red Team and Blue Team tactics.*

2.Grimes, R. (2005). *Honeypots for Windows.*

3.Hammer, R. (2021). *Enhancing IDS using, Tiny Honeypot.* Retrieved from: Enhancing IDS using, Tiny Honeypot .

4.Joshi, R. C. (2011). *Honeypots: A New Paradigm to Information Security.*

5.Provos, N., Holz, Th. (2007). *Virtual Honeypots: From Botnet Tracking to Intrusion Detection.*

6.Sanders, Ch. (2020). *Intrusion Detection Honeypots: Detection Through Deception.*

7.Spitzner, L. (2002). *Honeypots: Tracking Hackers.*

8.Stuttard. D., Pinto. M. (2007). *The Web Application Hacker's Handbook: Finding and Exploiting Security Flaws.*

9.The Honeynet Project. (2004). *Know Your Enemy: Learning About Security Threats.*

10.Zeltserman, D., Skapinetz, K., Lippmann, R. (2017). *Honeypots and Routers Collecting Internet Attacks.*

11.Xiang, Y. (2018). *Honeypot Frameworks and Their Applications: A New Framework.*

12. Winder, D. (2014). *How to use the cloud as a honeypot.* CloudPro. Retrieved from: CloudPro: https://www.itpro.com/cloud/362460/how-to-use-the-cloud-as-a-honeypot