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FACULTY OF INFORMATICS

DEPARTMENT OF CARTOGRAPHY AND GEOINFORMATICS

# Web GIS for Iraqi Electrical Grid System

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# *DEDICATION*

***To all my beloved family***

# Table of Contents

# Chapter 1

## 1.1 Introduction

### 1.1.1 Objectives

Today, electric power is considered as the artery of life and it represents measurement of development for countries and cultures because these days all the infrastructure and services provided to humans depend entirely on electricity and this area of energy needs constant development in the preparation plans and programs to treatment the current problems for filling the current shortfall in the power supply (in Iraq) and to meet the growing demand for the coming years, all of these plans and programs are depend on the information and data that comes from geospatial data which in turn depend heavily on how Geographic Information Systems (GIS) works in providing technical and spatial information about the electrical grid system and study the expansion of cities and population growth.

For the fact that the Iraqi Ministry of Electricity (MOE) and especially the Office of Planning and Studies and relevant general directorates they work to represent all components of the Iraqi grid system on GIS and to all Iraqi governorates except the governorates of Kurdistan due to the difficult circumstances that Iraq has been living in the last years, the number of specialists working on GIS applications are limited and working on these applications needs skills and expertise to deals with spatial data. All these circumstances contributed to the difficulty of dealing with the geospatial data of the electricity grid in Iraq.

Because of all that is mentioned and to take advantages of the development of web GIS applications programming the idea came to create and developing a user-friendly Web GIS client depending on open source and reliable software applications (HTML and OpenLayers) in order to simplify and facilitate the use of GIS data for technicians working on the electrical grid system as well as support decision makers in the study and analysis of suggestions and plans for the treatment problems of the electrical grid system and improve the performance of its work for the coming years.

As long as the Web GIS works as a facilitator to the actions and activities that need to be completed on the grid by Utility. Where the high cost of license for any proprietary system or software hold sharing of the framework at all levels and teams work, Web GIS does not need installation of any system or software on the instruments, It needs just internet with suitable bandwidth, GIS on-the-activity (secure data) can be accessed by anyone (authorized) at anywhere and Mobile GIS is a supplement of Web GIS. While the characteristics of Web GIS in Utilities are having property invested in the estate on the grid field, and maintaining & monitoring of estate is the main activity (Geospatial World, 2011).

Because that it is important to know what does Web GIS facilitate? The best answers are planning of grid field process at the zonal level, reduce and minimize the operational costs and guarantee better and faster achievement of development. On the other hand also enable use Web GIS for planning network development, new areas of buildings requiring connections with grid can be marked on the GIS, Based on data available, the locations of new substations/ transformers and poles can be studied and resolved, Better line and feeder routes can be planned by using the GIS by at zonal grid office, Route grid maps can be downloaded onto Web GIS to support the field groups and field group can study the case of maintenance works and then they prepare with them the required devices and tools (Geospatial World, 2011).

### 1.1.2 Introduction

The first Chapter will discuss several aspects; the most important are objectives from this work, general information about Iraq, the history of electricity in Iraq, and the structure and voltage levels for Iraqi electrical grid system, invested budgets in Iraqi Electricity Sectors, power generation and comparison of capacities in last ten years, renewable energy projects, will discuss also the structure and voltage levels for Hungarian power system and How it different from Iraqi grid system and the potential of wind energy system in Hungary.

The second chapter will discuss the Web GIS and what are the origins for both GIS and Web GIS, Web GIS concepts and its definition, what are its characteristics, what the important difference between Web GIS and Internet GIS and at end of this chapter will review the best 10 Open Source Web mapping tool in last year.

The third chapter will discuss the OpenLayers, why we need to use OpenLayers, what is OpenLayer, and the structure of a web-mapping application, what the linking with Google, Bing Maps, and other mapping APIs, what the layers in OpenLayers, why we need to understanding and using the vector layer and what the difference between raster and vector layer.

The fourth and last chapter will review the whole application for "Iraqi Electrical Grid System" and what the type of data used, what the source of this data, what kind of layers it used, how the user can use this application and at the end the conclusion of this work.

## 1.2 General information (IRAQ)

The Republic of Iraq is the official name for Iraq as a country in Western Asia; Turkey bordered this country from the north, from the east with Iran, from the south with Kuwait and Saudi Arabia and from the West with Jordan and Syria (See Image 1-1). The largest city and the capital is Baghdad. Arabic and Kurdish are the official languages of Iraq; also include Turkmen, Assyrians, and Yazidis. More than 95% of Iraqi people are Muslims and also present with Christianity, and Yezidism. Historically, the region between the Euphrates and Tigris rivers known as (Mesopotamia) is often indicated to as the cradle of civilization. It was here that humanity first began to read, create laws, write, and live in cities under a highly organized government— sophisticated Uruk, from which "Iraq" is derived. The area has been home to successive civilizations since the 6th millennium BC. Iraq was the center of the Akkadian, Assyrian, Sumerian and Babylonian empires.

Iraq located between latitudes 29° and 38° N, and longitudes 39° and 49° E. The area is 437,072 km2 (168,754 sq. mi). In the world, it is the 58th-largest country. It is similar in size to the US state of California and comparatively larger than Paraguay. Desert is the widely consists of Iraq, but near the two major rivers (Tigris and Euphrates) are productive alluvium plains, as the rivers carry around 60,000,000 m3 of grainy annually to the delta. The north of Iraq mostly consists of mountains; the highest point being at 3,611 m (11,847 ft.) point, nameless on the map, but known locally as Cheekah-Dar. Iraq has a small coastline measuring 58 km along the Arabian Gulf. Near to the coast and over the Shatt al-Arab. Most of the country has a hot desert climate with subtropical effectiveness. The average of temperatures in the summer is above 45 °C (113 °F) for most of the country, the temperatures in winter infrequently exceed 21 °C (69.8 °F) with maximum nearly 10 to 15 °C (50 to 59 °F) and night-time lows 2 to 5 °C (35.6 to 41.0 °F). Precipitation typically is low; almost places receive lower than 250 mm (9.8 in) annually, with maximum rainfall active during the winter months. (Wikimedia , 2018)

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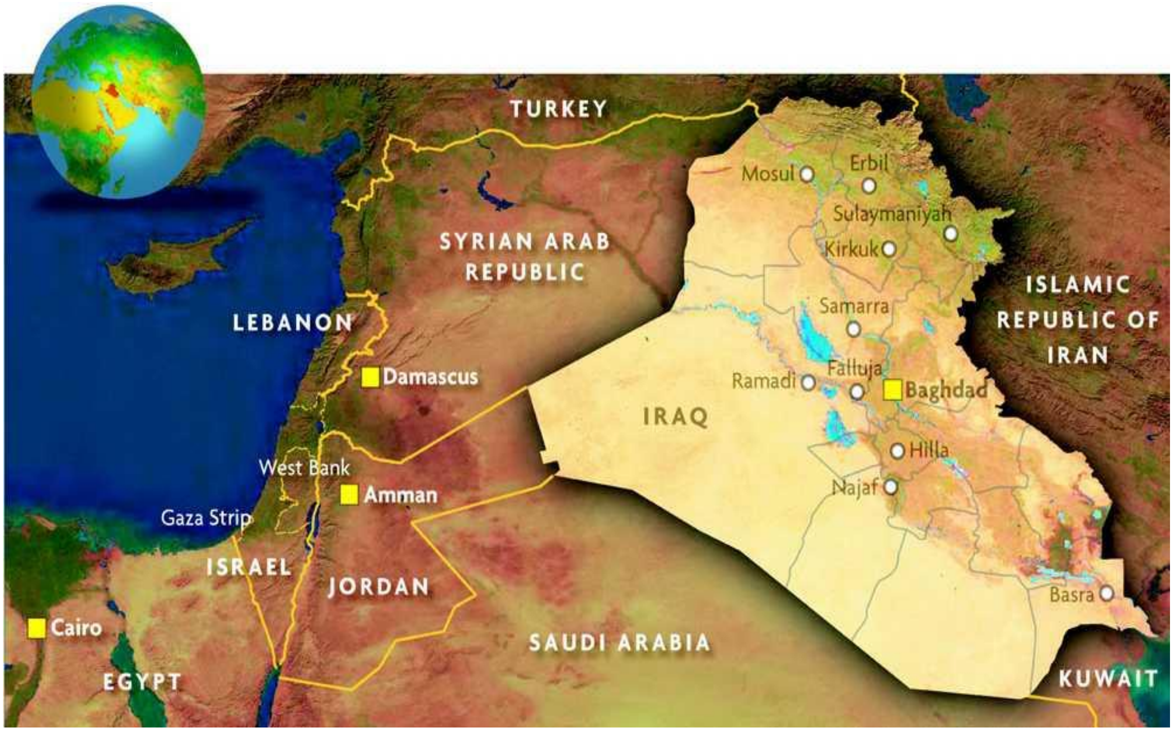



Image 1-1: Location of Iraq (GICJ, 2013)

## 1.3 Iraqi Electrical Grid System

### 1.3.1 Background of Electricity in Iraq

Electricity was first generated in Iraq in 1917 by small Diesel D.C Generators (See Image 1-2), In the Thirties first steam power plants were constructed in Al-Sarafiya with 2MW; At 1955 Daura 4x159MW steam turbine power plant was constructed. At 1976 Nassiriya 4x210MW steam turbine power plant was constructed in the Seventies 400kV grid network first constructed. In Eighties numbers of hydroelectric power plants were built: (Mosul dam 4x187+2x110+4x15MW, Haditha dam 6x110MW) and in Eighties numbers of big scale steam turbine power plants were built: (Musayeb 4x300 MW, Baiji 6x220MW). (Adel, 2015)

Image 1-2: Electricity in Baghdad. 1917 (Algardenia, 2014)

### 1.3.2 Iraqi Electricity Grid Structure and Voltage Levels

Iraqi electricity grid system differs greatly from existing systems in Europe as will be discussed (Hungarian Power System) later in this chapter as a sample of that, It is consists of three main Sectors:

1- Generation Sector (All kinds of Turbines and Power Plants).
2- Transmission Sector (Stations and Lines 400KV, 132KV).
3- Distribution Sector (Substations and Feeders 33KV, 11KV).

(See Figure 1-1)

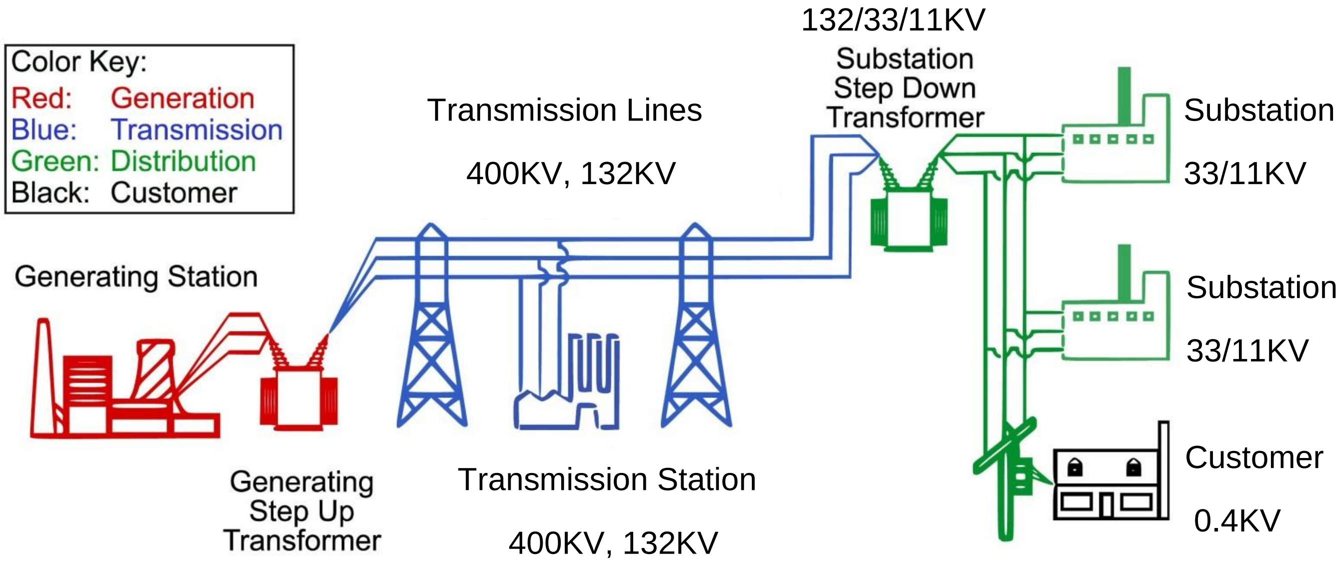



Figure 1-1: Iraqi Electricity Grid Structure and Voltage Levels

**Note:** The source of original Figure is (Energy, 2004.)

### 1.3.3 Invested Budgets in Iraqi Electricity Sectors

The ongoing unstable security situation has negative effects on the execution of new projects generation, transmission and distribution sectors, in addition to the delay in maintenance and upgrading works, result in great damages of the electricity system in the inflicted governorates. MOE (Ministry of Electricity) has already put an emergency repair plan requesting an emergency budget out of the allocated ones in order to overcome the situation within the required time frame.

Aging of previously installed equipment in the electricity system due to the non-standard operation, execution of rehabilitation and maintenance works in addition to the lack of spare parts during the years 1993-2003 of sanctions and sequent wars.

MOE has already invested about 27.6189$ Billion US Dollar for the period (2006 – 2015) (See Table 1-1) and (Figure 1-2).

1- 15.3375 Billion For the new power plants installations with a total capacity equal 18500 MW.
2- 3.16 Billion For the exits power plants rehabilitations.
3- 4.3143 Billion For the transmission sector, installation of new 400KV & 132 KV stations, rehabilitation and upgrading of old ones.
4- 3.3341 Billion For the distribution sector covering the installation of new33/11 KV substations, rehabilitation, and upgrading of old ones.
5- 1.473 Billion For other supporting sectors such as Control & Operation, Inspection & Workshops and Training & Capacity Building.

Table 1-1: Invested Budgets in Iraqi Electricity Sectors (2006- 2015)

| No. | Sectors | Budgets (BUSD)$ |
|---|---|---|
| 1- | Power generation projects | 15.3375 |
| 2- | Power generation rehabilitation | 3.16 |
| 3- | Power transmission projects | 4.3143 |
| 4- | Power distribution projects | 3.3341 |
| 5- | Others | 1.473 |
| 6- | Total | 27.6189 |

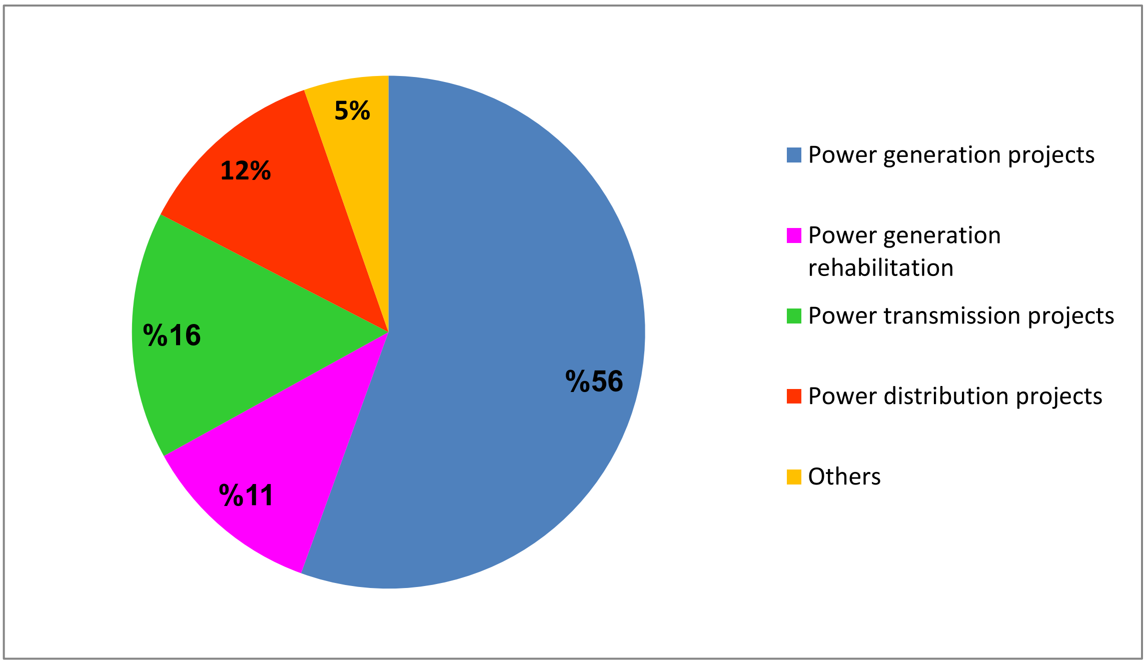



Figure 1-2 : Invested Budgets in Iraqi Electricity Sectors (2006- 2015) (%)

In those past ten years, most of the budgets were invested in the power generation sector due to the lack of generation capacities. This led to the transmission and distribution networks being unable to cope with the new power generation capacities added to the power system, and the crescent demand for electricity as they were underinvested (Adel, 2015).

Why the invest?

1- Ministry of electricity is responsible for planning & constructing new power generation projects to cover the power demand and provide 24/7 service.
2- According to the sudden change of consumer behavior after 2003, the demand for electricity jumps drastically.
3- The ministry of electricity couldn't cover the demand of electricity on its own, depending on the ministry investment budget especially after the collapse in oil prices.
4- Investment in power generation sector will accelerate covering the demand for electricity. (Ministry of Electricity- Iraq, 2015)

## 1.3.4 Power Generation

### 1.3.4.1 Present Peak Power Generation

(See Table 1-2) ( (Ministry of Electricity- Iraq, 2015)

Table 1-2: Present Peak Power Generation (MW)

| **Type of Power Plants** | **Generated Power (MW)** | |
|---|---|---|
| | **2003** | **2015** |
| Steam Turbine | 1840 | 4541 |
| Gas Turbine | 960 | 6000 |
| Diesel | --- | 528 |
| Hydro | 600 | 380 |
| Total Generation | 3400 | 11449 |
| Imports + Investment | --- | 1951 |
| Total Peak Load Achieved | 3400 | 13400 |

#### 1.3.4.2 Comparison of Capacities (2015)

(See Table 1-3)

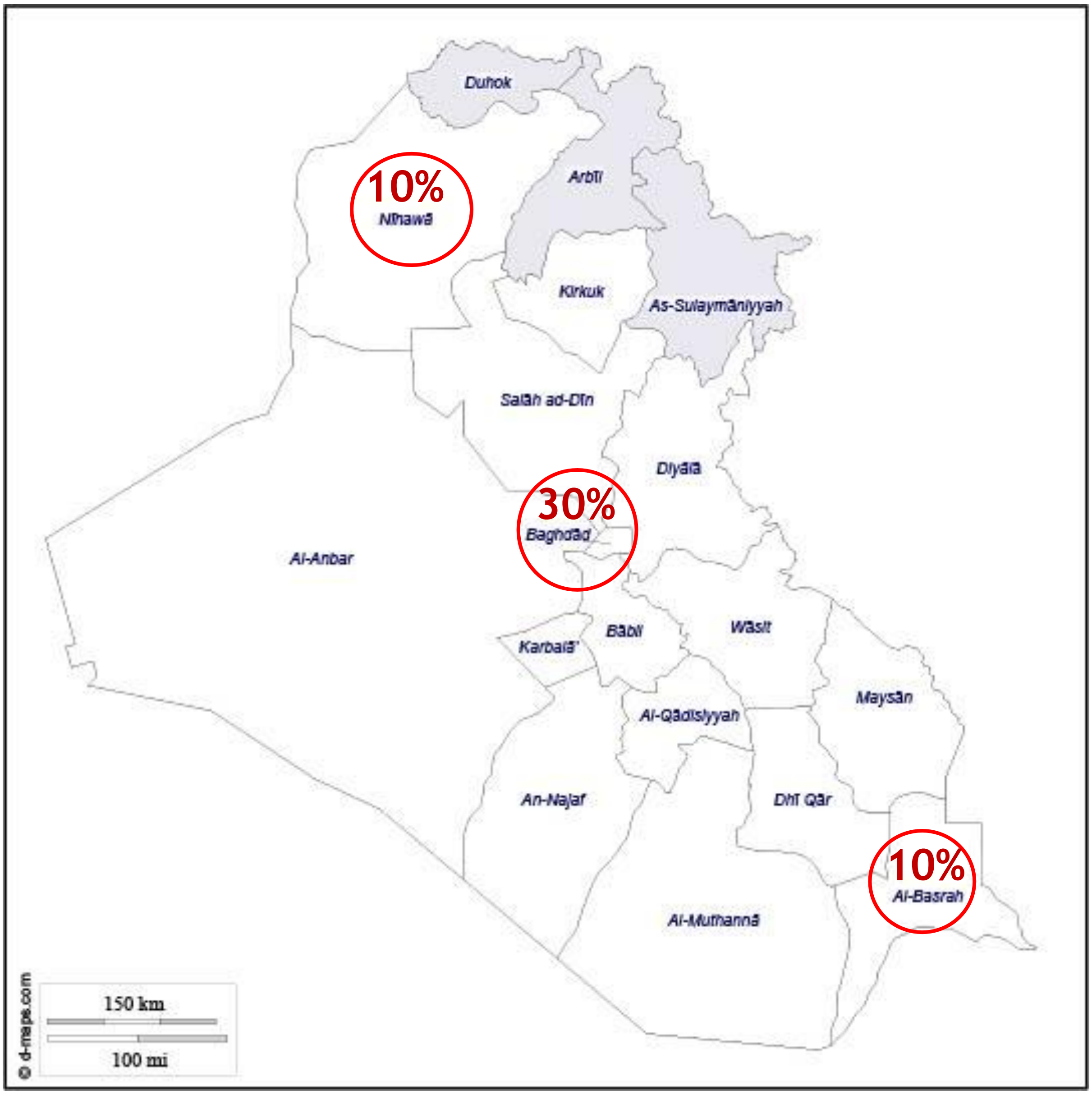
Table 1-3: Comparison of Capacities (2015)(Ministry of Electricity- Iraq, 2015)

| Type of Power Plants | Installed Capacities (MW) | Available Capacities (MW) | Peak Load Capacities Achieved (MW) |
|---|---|---|---|
| Steam Turbine | 7305 | 4790 | 4541 |
| Gas Turbine | 14968 | 10850 | 6000 |
| Diesel | 2033 | 675 | 528 |
| Hydro | 1844 | 590 | 380 |
| Imports + Investment | 2350 | 2205 | 1451 |
| Total | 28500 | 19110 | 13400 |

**Note:** Difference between installed, available and peak generating capacities is a result of the aging of power units, quantity, and type of fuel supplied from the ministry of oil, water discharges for hydro plants and transmission lines. In addition to losing about (4876 MW) due to the security situation. (Ministry of Electricity- Iraq, 2015)

### 1.3.5 Major Load Centers

(See Map 1-1) (Adel, 2015) (d-maps, 2009)

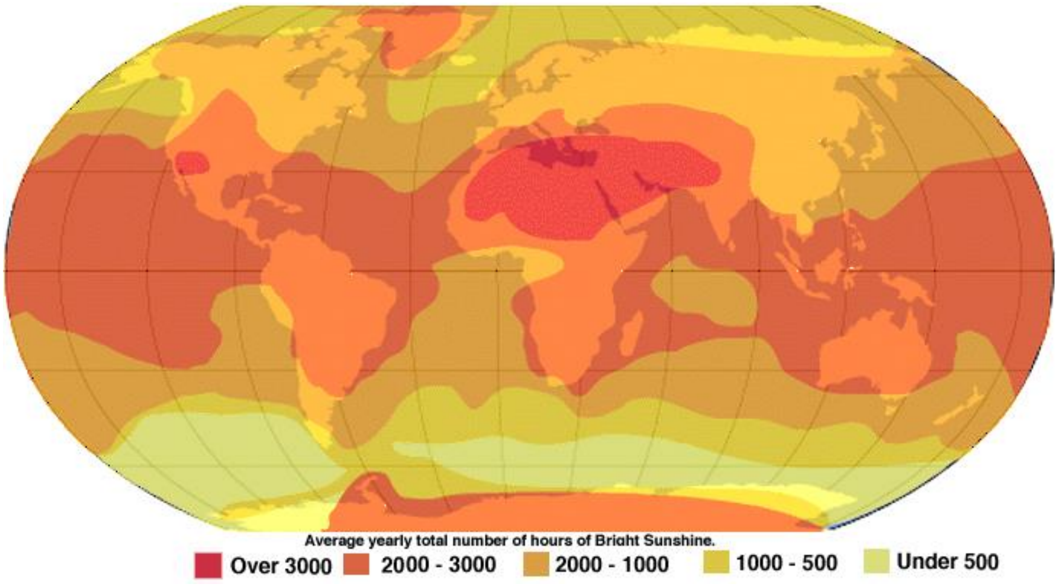



Map 1-1: Major Load Centres

### 1.3.6 Renewable Energy Projects

Solar potential in Iraq:

- 1900 kWh/ $m^2$/annum
- Sunshine periods 2800-3300 hrs./annum (See Map 1-2)




Map 1-2: World sunshine map (Earth.Rice.Edu, 2010)

Investment projects in renewable energy:

1- On-grid photovoltaic (PV) plant with 50 MW capacities in Muthanna governorate. This power plant will be synchronized with the national grid through 33 kV side of sawa 132 kV station.
2- Off-grid hybrid power plant (PV + Diesel) 10 MW, located in Muthanna governorate, Al.Salman , to reduce Diesel consumption.
3- On-grid 1 MW photovoltaic (PV) plant located in the ministry of electricity headquarters synchronized with the national grid through Ministry 11 kV feeder.
4- Install & operate Household PV panels with 12 kW connected to the grid through 0.4 kV level. (One site entered service recently).
5- Preparing other sites middle & south of Iraq to build large scale investment projects to enhance the national gird during peak time. (Ministry of Electricity-Iraq, 2015)

## 1.4 Hungarian Power System and Voltage levels

### 1.4.1 Structure of Electric Power Sector

In the last ten years, Hungary made essential improvement in restructuring its electricity power system and making a market oriented, fully European Union appropriating regulatory construction. Today, the power system industry is restructured and at most privatized. (Magyar Villamos Művek) MVM Hungarian Electricity Ltd. (http://mvm.hu/?lang=en) is a competitive strategic assets company and nationally owned corporate group. MVM Group is an incorporated player in the regional gas and electricity market, and it is also active in the electricity and gas industry in the area. The assets company led by MVM Ltd. has been working as a “Recognized Corporate Group” as of 1 June 2007. The group achieved an EBITDA (Earnings before Interest, Taxes, Depreciation, and Amortization) of HUF 110 billion and revenue after tax of HUF 48 billion in opposition to sales of HUF 1 034 billion in 2016. (IAEA, 2017)

Presently, the group Administrates one of the most significant sectors of the Hungarian national economy, the national electricity system supply. The activities cover electricity generation power plants, electricity transmission system operation and electricity trade. The key holding/companies of MVM include Paks nuclear power plant (2000 MW installed capacity) (See Figure 1-3), open cycle gas turbines (526 MW installed capacity), CHPs (114 MW installed capacity), renewable generation units (23 MW wind, 10 MW solar), MAVIR (Hungarian Transmission Operator), Hungarian Gas Storage Ltd. (4.43 bcm storage capacity) and the electricity and gas wholesalers (Hungarian Gas Trade Ltd. and MVM Partner Ltd). Orderly to provide the planned new units, MVM founded its new project company, MVM Paks II. Nuclear Power Plant Development Ltd. (MVM Paks II. Ltd.) in 2012. Due to modification of ownership in November 2014 (with the aim of decreasing the decision making routine), the project company MVM Paks II. Ltd. does not belong to the MVM Group anymore. It derives under direct state supervision beginning when the Prime Minister's Office obtained the owner's rights and until 2026. The installed capacity of local power plants on 31 December 2016 was 8 339 MWe. Parallel to the value of 31 December 2015 (8 453), it reduced partially by 114 MWe. The peak load of the Hungarian electricity power system was 6 749 MW in 2016, that means the growing of 292 MW compared to 2015 (6 457 MW). Although the growing in energy efficiency may help decrease the rate of growing of primary energy consuming, it is still predictable that the electricity demand will grow after overcoming the world crisis. The peak demands will grow between 700 and 1 300 MW until 2031. Proceeds into calculation the needed shutdown of the old fossil power plants, new generation capacity of around 4 500 to 5 100 MW is necessary until 2031. (IAEA, 2017)

The generation combine of the Hungarian electricity power system is currently fully stable, with about 17% gas, 52% nuclear, 19% coal and a growing ratio of renewables. The electricity production from renewable energy sources is increasing in conformity with the (EU) instructions on green power electricity. In 2015, renewable established electricity production made up a part of 7.3% of overall electricity production. The Hungarian energy feeding is about 60% importation dependent; then its safety is a critical, priority of the Hungarian National Energy Strategy. The secure, effective and productive operation of the country owned Paks NPP highly participate to satisfy this challenge. The mandatory stockpiling of nuclear fuel for two years is also a primary element in secures the constancy of feeding in a situation of any troubles in imports. There are 13 companies operating power plants equal to or greater than 50 MW capacities and there are more than 200 companies, operating around 300 power plants less than 50 MW capacity. (IAEA, 2017)

Hungary has electricity high-voltage transmission lines of 750 kV, 400 kV, and 220 kV; these lines measure around 268, 2,978 and 1,393 kilometers in overall length, respectively (MVM, 2016). There is also a 120 kV grid (199 kilometers) which is directly supplied by many of Hungary's power plants (See Map 1-3). The main power transmission line linking Hungary to the east is a 750 kV line from Ukraine (Fossil Energy, 2003). This transmission line network, which is held and managed by the Hungarian Transmission lines System Operator, MAVIR Ltd. This organization is, at the same time, a member of the MVM Group. The Transmission lines System Operator runs based on the (Independent Transmission Operator) ITO model: it works independently of the other economic driver that uses the transmission lines network, and its separation is specific by legislation. In conformity with the relevant legal regulations, MAVIR Ltd., as a community independent of other participants in the electricity grid system, is responsible for guaranteeing a safe electricity supply. (IAEA, 2017)

There are also 6 locally distribution companies responsible for electricity distribution of networks with a voltage of 120 kV and (35, 20 and 10 kV), as well as supply for the customers.

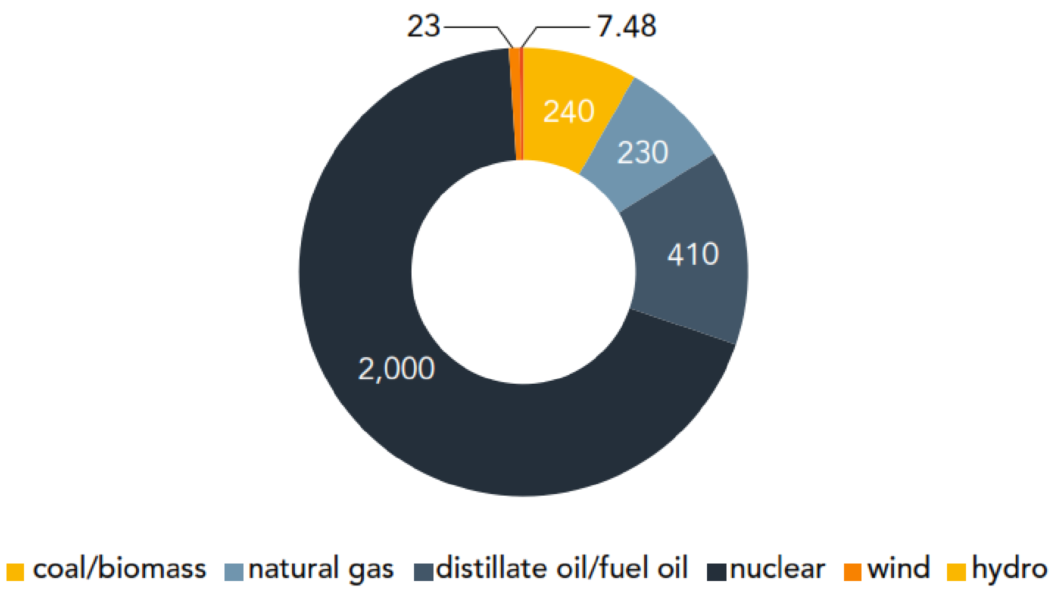
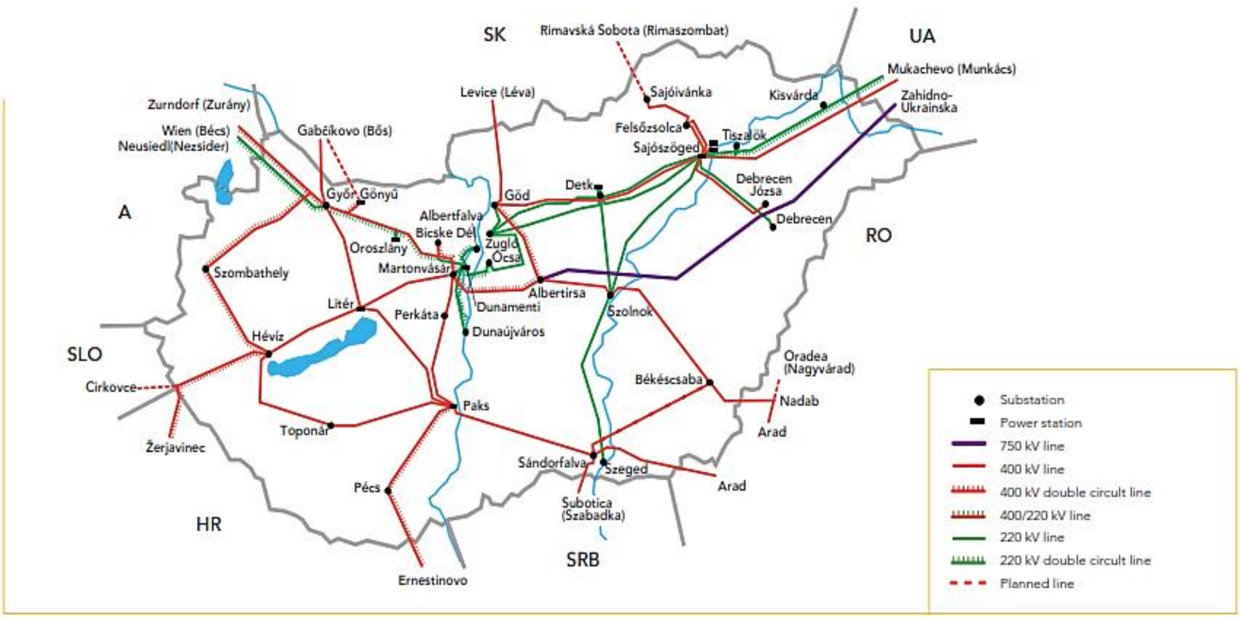



Figure 1-3: Installed electrical capacity (MWe) (MVM, 2016)

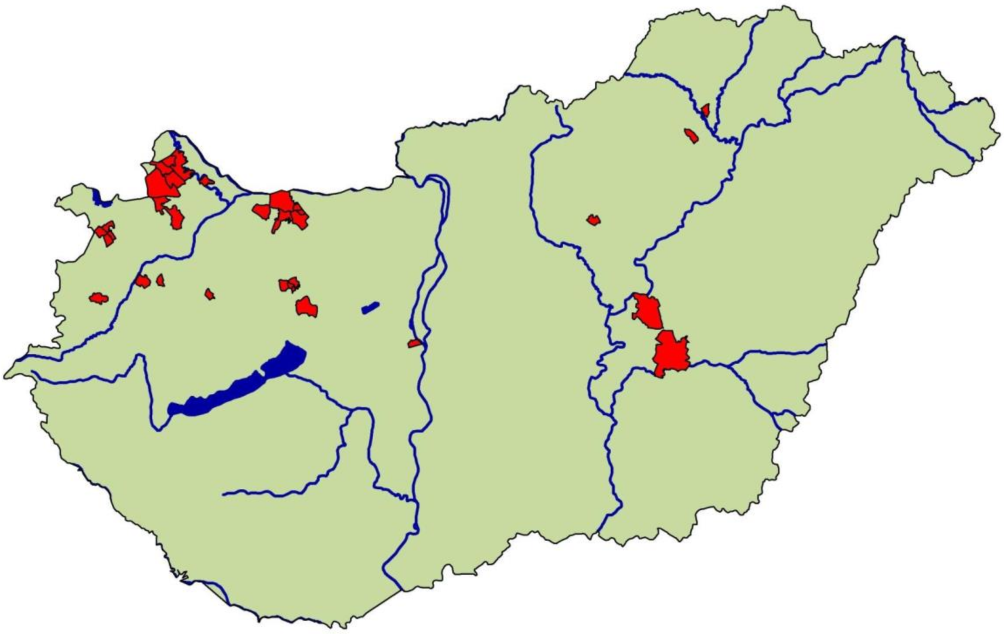



Map 1-3: Hungarian transmission network (2015) (MVM, 2016)

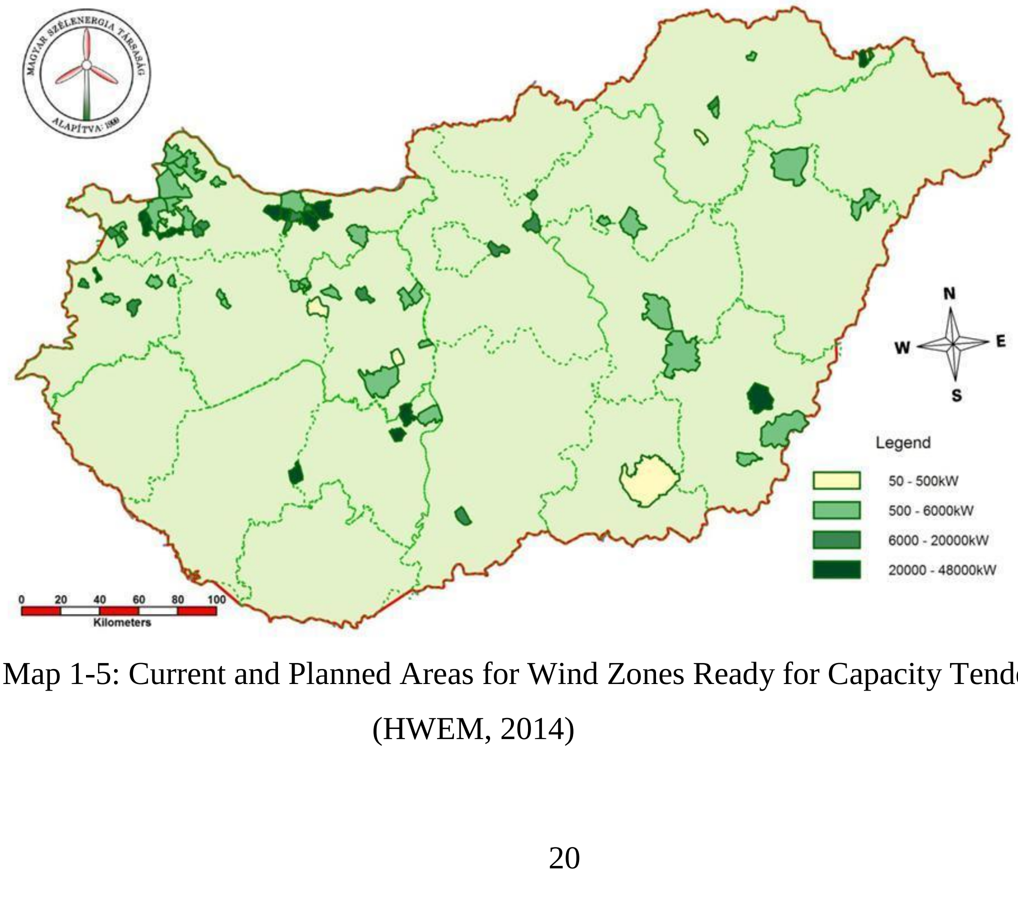
### 1.4.2 Potential of wind energy system in Hungary

The weather in Hungary is moist European, and the ruling winds at the most blow up from the border of the basin across the central areas. The mostly favorable zones for the utilization of wind energy turbines can mostly be found in the North-West, North, and some areas at South-East country's zones (See Map 1-4). The first connection of wind energy turbines to the Hungarian electricity system started in 2006, while the Hungarian Energy office released a 329 MW capacity share for wind energy turbines. This quantity has not been increased since that means today, a wind energy turbines without a share is not capable to combine the feed-in (price) tariff system, but is authorized to market the generated clean electricity on the grid market (HIP GREEN INDUSTRY, 2018).

Today there are 172 wind energy turbines in Hungary, with increasing wind energy produced electricity as a direction. In so far as wind energy is involved, the Hungarian National Renewable Action goal expects nearly 750 MW consolidated capacity and 1545 GWh Annual electricity production at 2020 (See Map ).



Map 1-4: Geographical Distribution of Current Wind Turbines (HWEM, 2014)




Map 1-5: Current and Planned Areas for Wind Zones Ready for Capacity Tender (HWEM, 2014)

# Chapter 2

# WEB GIS

## 2.1 Origins of GIS and Web GIS

### 2.1.1 Origins of GIS

Everything that happens, happens somewhere. To know "where" is "what," and "why" it is there, can be Important to the utmost level for making decisions in an organization also in personal life. GIS is the science and the technology for dealing with the "where" kind of questions and for providing best decisions based on location and space.

*"GIS is a system of hardware, software, and procedures that capture, store, edit, manipulate, manage, analyze, share, and display georeferenced data."* (Salazar, 2017)

GIS technology has been started before the Internet and the Web. The first applied step of GIS was developed in 1962 by Roger Tomlinson for Canada's Federal Department of Forestry and Rural Development. Called the Canada Geographic Information System (CGIS), it was used in Canada for planning and land inventory. He was born in England, he settled in Canada after soldierly service and university, where his work in geomorphology produced to applying computerized process for dealings map information. Dr. Roger Tomlinson has become known as the "father of GIS" for his great work by developing Canadian GIS and supporting GIS methodology (Salazar, 2017).

GIS can create over and above just attractive atlases and maps, while GIS is usually used to create a lot of maps by means of changed scales, subjects, and signs. Further significantly, GIS has great analytical utilities that opportunity data into valuable data. GIS can communicate otherwise different information on the origin of collective geography, illuminating unseen connections, configurations, and styles that are not cheerfully seeming in databases or numerical packages, and generate new data that can support knowledgeable decision creating. The actual world can be absent-minded into a number of spatial data layers, containing land usage, elevation, pictures, parcels, roads, and corporate clients (See Figure 2-1). These layers can definitely be used to produce combined maps, but they can also be used to create a multiplicity of valuable data over and done with GIS analysis (Tomlinson, 2013).

A rich set of data managing, positive thinking, and analysis abilities has been established by GIS specialists later 1962, building GIS an important tool for land-use planning, services managing, environments modeling, criminality investigation, marketplace analysis, income tax valuation, and a lot of other applications. GIS skills go more than mapping. GIS suggestions a rich set of methodical utilities that can make known unseen connections, patterns, and styles that are not freely seeming, supporting persons to think spatially to resolve difficulties and create best decisions. GIS is the supportive science and tools for GeoDesign, which is an efficient methodology for geographic planning and decision construction. The GeoDesign applications of GIS can assist persons to recognize and evaluate the world's difficulties and plan another possibility that can lead the world to an enhanced future.

For decades, GIS specialists have used GIS tools to integrate, evaluate, and visualize geographic data and understanding, leading to ample GIS applications advancing a lot of fields. On the other hand, GIS still has important potential that has not been fully understood. Right to use GIS has been limited to a comparatively small number of GIS specialists. The development of Web GIS is releasing the power of GIS to a widespread audience. The Web has made GIS not only additional accessible to persons in their organizations, homes, and on the go, but also more flexible over Web-based APIs. A software developer uses an API (application programming interface) to simplify seamless combination with additional information systems (Salazar, 2017).

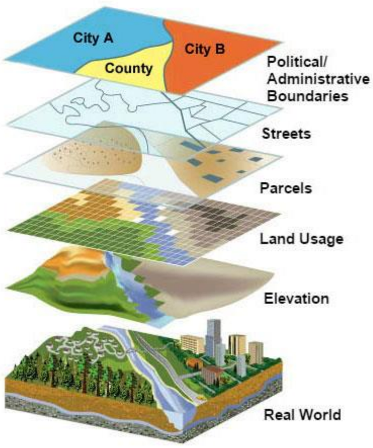



Figure 2-1: GIS layers (AbaPEIsa, 2014)

### 2.2.2 Origins of Web GIS

The combination of the Internet and the Web and conventional disciplines has produced several new ones, and Web GIS is one of these disciplines. Web GIS has developed quickly later 1993, principally in the so-called "Web 2.0" era. Web GIS has considerably improved the way geospatial information is developed, transferred, published, shared, and visualized. It characterizes an important milestone in the history of GIS.

In 1993, the Xerox Company (PARC) established a Web-based map browser, marks the origin of Web GIS. The Xerox Palo Alto Research Center (PARC) Map browser was a trial in accessing retrieval of shared data on the Web, instead of supplying access to accurately fixed files (Putz, 1994). The Web site providing simple map zoom abilities, layer choice, and map projection transformation utilities. Users can use the map browser in a Web browser and get on a link to a function. The Web browser would at that time send an HTTP request to the Web server. The Web server would take the request, execute mapping processes, and create a new map and reversion it to the Web browser that requested it. The Web browser would then take and display the map image (See Figure 2-2). This founded the methodology of running GIS internally a Web browser, representing that users anywhere on the Web possibly will use GIS without having it locally installed, an improvement that old desktop GIS does not have.

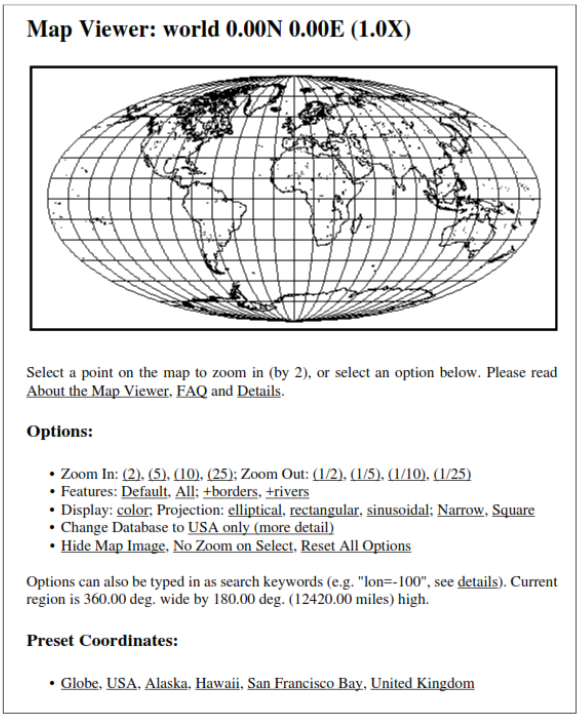



Figure 2-2: The PARC Map Viewer (Putz, 1994)

This map browser and set of the first Web GIS applications supported only partial functionality, and several couldn’t execute well when there were many synchronous users. Though, they obviously proved the advantage of using the Web as a carrier to provide GIS functions to a wide public. Those who use it don’t have to set up by the computer where the GIS application is installed. They can be anyplace, even on the other part of the world, so long as there is an Internet linking. They can visit a Web site with an easily accessible Web browser without having to pay anything. They can use the simple GIS mapping utilities supported by the map browser without requiring installing GIS system and files on a local computer. GIS corporations initiated freeing their trade Web GIS application in 1996. These commercial products are used by a set of groups, including government organizations such as USGS, Department of Housing and Urban Development (HUD), the U.S. Environmental Protection Agency (EPA), and the Bureau of Land Management (BLM), to create applications in various arenas (Putz, 1994).

## 2.3 Web GIS Concepts

### 2.3.1 Web GIS Definition

Web GIS is the kind of distributed information system. The basic model of Web GIS ought to have the least possible a server and a user client, where the server is a Web application server, and the user client is a Web explorer, a desktop application, or a mobile application. The server has a URL so that user clients can find it on the Web. The client then depends on HTTP advantages to direct requests to the server. The server executes the requested GIS process and directs a reply to the user client, once more by HTTP. The structure of the response might be the HTML that is used by the Web explorer client, but it might also be in other forms, for instance, binary image, JSON (JavaScript Object Notation), or XML (Extensible Markup Language).

Web GIS is every so often understood of as GIS executing in a Web browser, but this description directs systems with desktop user clients and mobile user clients. Web GIS application is every GIS that uses Web techniques. In a closer to a definition, Web GIS is any GIS that use Web techniques to transfer between components (Esri, 2017).

Web GIS application is additional well-defined via the following:

- HTTP, among various Web techniques, is the most important protocol used by the various elements of Web GIS application to connect with all other. If the Internet is a disconnect, several thick user clients can still work depends on caches and previously loaded data or utilities, but most user clients will stop running.
- The basic structural design of Web GIS is a two-tier system (See Figure 2-3) that consists of a server and one or more user clients. A Web GIS is not only the software package running on your computer, but extra importantly, the server is located in someplace on the Web, or "in the cloud." Occasionally, the server and the user client can work on one computer, but they are in reality two different sides.
- A lot of Web GIS architectures contain three tiers, containing a data tier. And now as the mashup methodology expands the range of Web services, Web GIS is progressively becoming more than three tiers. These tiers and elements can be speared to a different of locations via the Internet.
- Web GIS and desktop GIS are progressively intertwined. Web GIS depends on desktop GIS to author resources. Desktop GIS, further, has extended its functionality to create use of the source on the Web. Such as an ArcGIS desktop user, you can use basemaps accessible over the Web, for example, those served by USGS or Microsoft Bing Maps, without having to hold your private copy of the files on your local computer (Salazar, 2017).

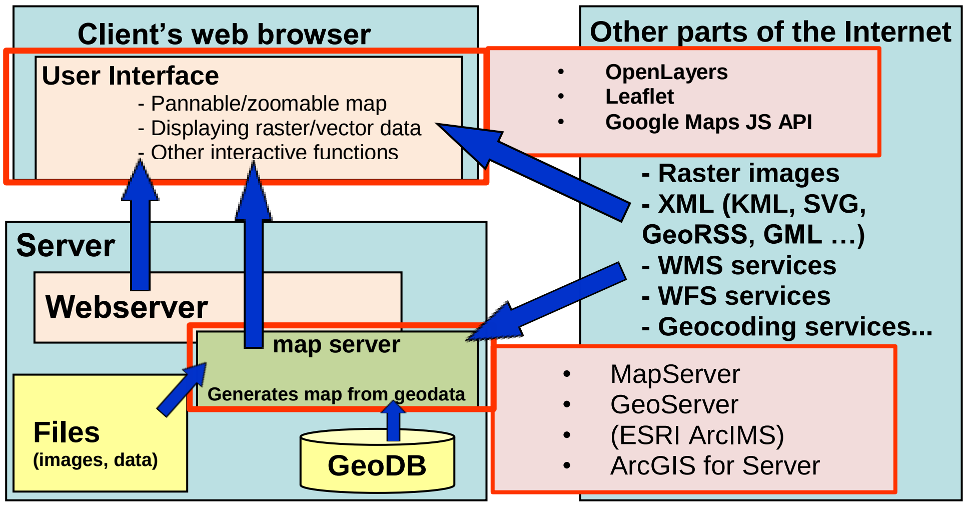



Figure 2-3: Architecture of Web GIS Applications (Mátyás, 2017)

### 2.3.2 Web GIS Characteristics

The Internet and the Web eliminated the limit of range from cyberspace, permitting direct access to data by the Web without a look at how far away the user and the server may be from each other. This feature provides Web GIS ingrained advantages over old desktop GIS, containing the following:

- **A global reach**: A software developer can offer Web GIS applications to the world, and the world can get them. A client can contact Web GIS applications from their personal computer or mobile phone. The world nature of Web GIS is transmitted from HTTP, which is widely supported. Practically all establishments open their firewalls at confident network ports to permit HTTP requests and answers to go over their local network, growing accessibility.
- **A large number of users**: Generally, an old desktop GIS is used by the only single user at a time, but a Web GIS can be used by lots of users jointly. This requires greatly efficiency and scalability for Web GIS applications than for local desktop GIS.
- **Better cross-platform capability**: The most of users of Web GIS are Web browsers. There are Web browsers, for instance, Mozilla Firefox, Internet Explorer, Apple Safari, and Google Chrome for various operating systems, as well as Linux, Microsoft Windows, and Apple Mac OS. For the reason that these Web browsers generally compatible with HTML and JavaScript principles, Web GIS that depends on HTML users usually supports various operating systems. Web GIS that depends on Java.NET and Flex users can execute on several platforms where the necessary run-time setting is set up. It is importance indicating that Web GIS for mobile users is away from being section plat- form due to the variety of operating systems for mobile and the present incompatibility between different mobile Web browsers.
- **Low cost as averaged by the number of users**: In the spirit of the Internet, the great plurality of Internet content pages are at no cost to finale clients, and this is real of Web GIS. In general, you do not a necessity to purchase software or pay to usage Web GIS. Establishments that require providing GIS abilities to lots of clients can also keep their Web GIS cost little. Rather than purchasing and installed desktop GIS for all clients, an establishment can install at least one Web GIS, and this single system can be public by lots of users—from the house, at the office, or in the field

work. The compact costs of buying and repairs support to be responsible for a high reoccurrence on investment.

- **Easy to use for end users**: Desktop GIS is designed for expert users with years of practicing and skill in GIS. Web GIS is prepared for a wide sharing, as well as audience users who might realize nothing about GIS. They believe Web GIS to be as simple as using a normal Web site. Their beliefs are even greater—"if I don't be familiar with how to use your Web page, it's your responsibility." Therefore, Web GIS is generally intended for simplicity, obviousness, and accessibility, creating it normally greatly easier for end clients than desktop GIS.
- **Unified update**: For desktop GIS to be modernized to a new version, the update requires to be set up on each PC. For Web GIS, any update runs for all users, creating updating greatly easier. If the software package and information are updated on the server, almost Web GIS users will take automatic updates. This means simplicity repairs for Web GIS and highly developed timeliness for GIS, creating Web GIS a good fit for providing immediate data.
- **Diverse applications**: Not like desktop GIS, which are exclusive to a specific number of GIS experts, Web GIS can be used by every person in an organization and by the audience at wide. This wide-ranging public has different requests, which leads to Web GIS being used in a set of applications, both official and unofficial.

These features make known both the advantages and challenges confronting Web GIS. For instance, the simplicity-to-use quality of Web GIS encourages public sharing, but it also mentions the Web GIS planner to take into accounts Internet clients and managers who have no GIS experience. The wide number of clients supports better GIS distribution, but it also needs that Web GIS be scalable that is, capable to preserve good execution as the total of users growths (Esri, 2017).

## 2.4 What is the Important Difference between Web GIS and Internet GIS?

### 2.4.1 Web GIS

As almost may recognize, Web GIS is a GIS system that uses web equipment. It often utilizes web tools to connect between different components of the system. Web GIS constructs from a combined of web technology and the GIS, which is a known technology that is generally collected of data processing tools for storage, retrieval, managing and analyses of spatial information, Web GIS is a type of distributed information system. The normal structural design of a Web GIS should have at least one user or client and one server that user is a PC application or web browser application that lets clients connect with the server, and the server is a web server application.

### 2.4.2 Internet GIS

Web GIS is a relative expression to Internet GIS. These two terms are constantly used as equivalent with each other. There is a small variance between these two synonymous. The Internet supports a lot of services with the Web being one of these services. So we can title a system as Internet GIS if it uses a lot of of services of the Internet not only Web service and if it uses the only Web we have to name it Web GIS. This description forms Internet GIS boarder than Web GIS (See Figure 2-4). In actuality Web is the more attractive service of Internet and because that Web GIS is more public than Internet GIS. The geospatial Web, or GeoWeb, is an additional expression that uses to call Web GIS, However, the description of Web GIS is not conformable to Web GIS. GeoWeb can be known by combining geospatial data with none geospatial data for instance events, pictures, articles, etc. (GIS LOUNGE, 2014)

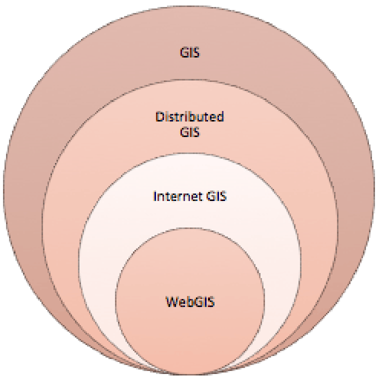



Figure 2-4: Web GIS and Internet GIS Comparision

# Chapter 3

## 3.1 Introducing OpenLayers

*"Within the past few years, the popularity of interactive web maps has exploded. In the past, creating interactive maps was reserved for large companies or experts with lots of money. But now, with the advent of free services like Google and Yahoo! Maps, online mapping is easily accessible to everyone. Today, with the right tools, anyone can easily create a web map with little or even no knowledge of geography, cartography, or programming. Web maps are expected to be fast, accurate, and easy to use. Since they are online, they are expected to be accessible from anywhere on nearly any platform. There are only a few tools that fulfill all these expectations.*

*OpenLayers is one such tool. It's free, open source, and very powerful. Providing both novice developers and seasoned GIS professionals with a robust library, OpenLayers makes it easy to create modern, fast, and interactive web-mapping applications."* (Hazzard, 2011)

Everything started with **OpenLayes 2**, that it was generated in 2005 with the supply of MetaCarta Labs. The first appearance was in 2006, and in 2007 it turned into an OSGeo project. The library is written in JavaScript; thus it uses an object-oriented process. It is a firm, closed project with fantastic capabilities. It would not undergo any alteration in its operation; therefore it can be applied as a secure basis for a web mapping application.

It's also having an arranged build with various objects representing various functionalities. The major objects can be found in any web mapping library. They are the map object, the control object, and the layer object. The library's large flexibility lies in the subclasses. There are a wide-ranging variety of layer formats, support for displaying, editing, and saving vector data with WFS, custom projection support, and several various controls.

The library utilizes DOM (Document Object Model) components to extract data to an interactive map. There are three kinds of renderer OpenLayers 2 can use Canvas, VML, and SVG. They affect the rendering mechanism of vector features. The default vector renderer is SVG (Farkas, 2015).

A basic workflow with OpenLayers 2 starts with creating one or more map object. Every map object can possess zero or more layer objects and control objects, albeit one or more is recommended. A layer can be a raster layer of some source (tile or image), or a vector layer. Vector layers can be filled with features described in the internal format. There are different format objects, which can be used to read vector data from the corresponding source format.

OpenLayers 2 APIs can be found at http://dev.openlayers.org/releases/OpenLayers-2.13.1/doc/apidocs/ and is encouraged to look up and use if something is not clear from the study's examples.

At 2014 was the date of the first release of **OpenLayers 3**. It is a fresh project with an enhanced and better-considered structure. It is under continual development, newer versions are coming out frequently. Though the library is in an early development status, therefore migrating a perfect WebGIS application takes serious considerations and a lot of custom functions to rewrite some OpenLayers 2 functionality. The main renderer in OpenLayers 3 is Canvas. The library loads all of its components on one Canvas component, enhancing rendering speed and extending functionality. A basic workflow in OpenLayers 3 also starts with creating one or more map object. Each map object needs an own view object, which defines the extent, projection, center, etc. Maps can have layers, controls, and interactions. Layers can be aggregated in layer groups. Each layer needs a source, which are specialized classes for different layer types. For example, a TopoJSON source can read a TopoJSON file, and translate its content for the library. The OpenLayers 3 API can be found at http://openlayers.org/en/latest/apidoc/ (OpenLayers 3, 2017).

## 3.2 Why we use OpenLayers?

It makes creating powerful web-mapping applications easy and fun. It is very powerful but also easy to use—the users don't even need to be a programmer to create a great map with it. It's open source, free, and has a strong community behind it. Thus if a user wants to dig into the internal code, or even improve it, you're encouraged to do so. Cross-browser compatibility is handled for users. It is not tied to any proprietary technology or company; therefore users don't have to worry so much about the application breaking (unless user breaks it). It allows users to build entire mapping applications from the ground up, with the ability to customize every aspect of user map—layers, controls, events, etc. users can use a multitude of different map server backends together, including a powerful vector layer. OpenLayers makes creating map 'mashups' extremely simple (Hazzard, 2011).

## 3.3 What is OpenLayers?

It is an open source, client-side or (user side) JavaScript library for creating interactive web maps, viewable in nearly any web browser. As it is a client-side library, it needs no special server-side software or settings—you can use it without even downloading any files! Initially developed by MetaCarta as a reaction, partially, to Google Maps, the 2.x series of the library has grown-up into a mature, prevalent framework with a lot of passionate developers and a very useful community (Gratier, 2015).

As we said OpenLayers is a client-side JavaScript library, but what does this mean? You will see answers in the following context.

### 3.3.1 Client side

The expression "client-side", is indicating to the user's computer, especially their web browser. Only one thing you need to make OpenLayers work is the OpenLayers code itself and a web browser. The user can either download it and use it on user's computer locally or download nothing and simply link to the JavaScript file served on the site that hosts the OpenLayers project (http://openlayers.org). It works on approximately all modern web browsers and can be served by any web server or user's computer. By using a modern, standards-based browser such as Google Chrome, Firefox, Opera, or Safari is recommended (Gratier, 2015).

### 3.3.2 Library

The expression "library", is mean that OpenLayers is a map engine that offers an API (Application Program Interface) that can be used to improve the user web maps. Rather than building a mapping application from scratch, the user can use OpenLayers for the mapping part, which is maintained and developed by a bunch of brilliant people.

Such as, if the user would want to write a blog, the user could either write his own blog engine or use an existing one such as WordPress or Drupal and build on top of it. Similarly, if the user would want to create a web map, the user could either write his own from scratch or use software that has been developed and tested by a group of developers with a strong community behind it.

When user choosing to use OpenLayers, user dose has to learn how to use the library, but the benefits greatly outweigh the costs. The user gets to use a rich, highly tested, and maintained code base, and all user have to do is learn how to use it. It is written in JavaScript (Hazzard, 2011).

## 3.4 Structure of a web-mapping application

Firstly, Let's take a look at the following figure:

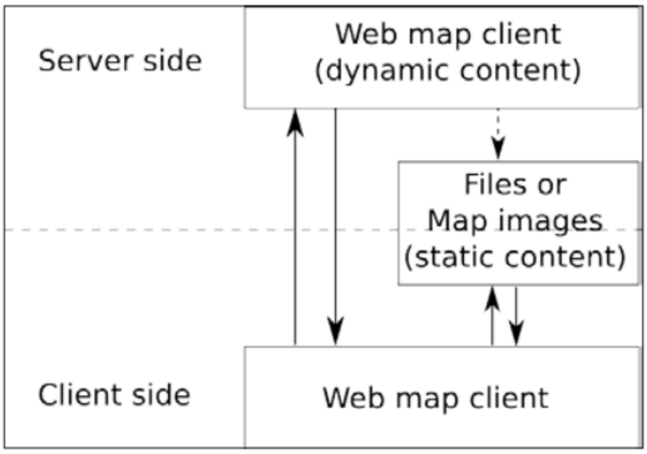



Figure 3-1: The client / server model

It's the client/server model and it is, basically, the core of how all web applications work. Concerning a web map application, several sorts of map client (for example OpenLayers) connects with some sort of web map server (for example a map server using the WMS (Web Map Service) standard, an OpenStreetMap backend, or some satellite images). We've added a bit of complexity in it because the truth is that users can also rely only on client-side for web mapping applications using static content that you have pre-created. To explain, users can use GeoJSON files. For instance, it is very useful for mobile content (Gratier, 2015).

### 3.4.1 Web map client

OpenLayers exists on the client-side. The important task the client executes is to get map images from a map server. Basically, the client asks a map server for what you want to look at. Whenever users navigate or zoom around on the map, the client has to create new requests to the server—because users are asking to explore something different.

So OpenLayers process this all for users, and it is happening by AJAX (Asynchronous JavaScript + XML) calls to a map server. For reiterating—the basic concept is that OpenLayers sends requests to a map server for map data every time user react with the map, then OpenLayers pieces together all the returned map data (which might be images or vector data) so it looks like one big, seamless map.

### 3.4.2 Web map server

The map server (or map service) offers the map itself. There is a lot of different map server backends. The instances include:

- Map servers using WMS and WFS standards (for instance the GeoServer, MapServer, and so on).
- Copyrighted backends provided, for instance, Bing Maps or Esri's ArcGIS Online, generally based on proprietary data.
- The backends based on OpenStreetMap data, for instance, the official OpenStreetMap, Stamen maps, or MapQuest maps

The main principle behind all these services is that they allow users to specify the area of the map they want to explore (by sending a request), and then the map servers send back an answer containing the map image. Using OpenLayers, users can choose to use as lots of different backends in any sort of combination as they would like. (OpenLayers isn't a web map server; it only consumes data from them. Thus, users will need access to several kinds of WMS.)

By using various web map servers, users do not have to do anything to use them—just providing a URL to them in OpenLayers is sufficient. OSGeo, OpenStreetMap, Google, Here Maps, and Bing Maps, such as, offer access to their map servers (though some commercial restrictions may apply to various services in some situations) (Gratier, 2015).

## 3.5 Linking with Google, Bing Maps, and other mapping APIs

All of Bing, Google, Yahoo!, and ESRI's Mapping APIs allow users to link with their map server backend. The APIs as well usually support a client-side interface.

Like Google APIs, for example, is properly powerful. Users have the ability to insert markers, plot paths, and use KML data (this things users can also do in OpenLayers)—but the prime drawback is that user mapping application depends completely on Google. A map server and map client are supported by a third party. It's not inherently a bad thing, and for a lot of projects, Google Maps and the others like it, are a good fit (Gratier, 2015).

But, there are quite a few drawbacks for instance:

- Users are not in control of the backend.
- Users can't really modify the map server backend, and it can change during any time.
- It might be commercial constraints or some other costs involved for consuming maps images or other services, for instance, geocoding or routing for car traffic.
- Another APIs also cannot support users with anything near the quantity of flexibility and customization that an open source mapping application framework (it is, OpenLayers) provides.

## 3.6 Layers in OpenLayers

What about the layers in OpenLayers? It allows users to have multiple different backend servers that user map can use. For accessing a web map server, the user declares a layer and adds it to user map with OpenLayers.

For example, if users needed to have a Bing Maps and an OpenStreetMap service showed on user map, the user would use OpenLayers to create a layer referencing Bing Maps and another one for OpenStreetMap, and then add them to user OpenLayers map.

Similar to layers of an onion, every layer is above and will cover up the previous one; the order that user inserts in the layers is significant. By using OpenLayers, users can arbitrarily set the overall transparency of any layer, thus users are simply able to control how many layers cover each other up, and dynamically alteration the layer order at every time.

Generality, users make a distinction between base layers and overlay layers. The Base layers are layers below the others and are used as a background on the user maps to give general setting. After the users choose one base layer, the others will not be displayed. At top of base layers, the users have overlay layers used to emphasize specific topics. The users can also choose to use only overlay layers if users are considering that they are enough to understand the map. For standard example, the users could have a Bing map as user base layer, a layer with satellite imagery that is semi-transparent, and a vector layer, all active on user map at once. The vector layer is the main layer that allows for the addition of markers and various geometric objects to users maps (Hazzard, 2011).

## 3.7 Understanding and using the Vector layer

With OpenLayers, the vector layer is used to present vector data on top of a map and allow real-time interaction with the data. Principally, it means the users can load raw geographic data from a set of sources, as well as geospatial file formats, for instance, KML, and GeoJSON, and display that data on a map, styling the data however users see fit.

### 3.7.1 Features of the vector layer

There is a sentence that says: what you see is what you get, this is what happens with a raster image. Whether users were to look at some close- up satellite imagery on user map and view a bunch of buildings clustered together, the user wouldn't certainly know any additional information about those buildings. The user may not even recognize they are buildings. Because raster layers are made up of images, it is up to the user to explain what they see. It doesn’t mean certainly a bad thing, but vector layers provide much more.

Concerning the vector layer, the users can display the realistic geometry of the building and append additional data to it—for instance its address, its square footage, who owns it, etc. It's simple to put a vector layer on top of user existing raster layers (Base layer) and make features in a specific location. You'll also see how users can acquire additional data about features just by clicking or hovering the mouse over them. The users can show any type of geometric shape with the vector layer— polygons, lines, points, squares, markers, any shape users can imagine. The users can use the vector layer to draw lines or polygons and then determine the distance between them. The users can draw shapes and then export the data using a set of formats, then import that data in other programs, for example, Google Earth (Gratier, 2015).

### 3.7.2 The vector layer is client side

The additional important difference is that the vector layer is a client-side layer. It means that interaction with the realistic vector data occurs on the client-side. After the user show vector data, such as its visual representation is generated by OpenLayers in response to the rules user define it in the user code. Raster data looks the way it looks and a user couldn't simply change the color of roads or choose not to show buildings. While the user navigates his map, vector data is generally already available and can be displayed directly. By raster layers, every time user zoom in or out, OpenLayers has to request extra image tiles from the server and wait for them to arrive unless they are already in the browser cache (Hazzard, 2011).

### 3.7.3 Performance considerations

At most of the cases, the vector data is loaded on the client-side, submitting of and interaction with the vector layer generally happens nearly immediately. But, there are several practical restrictions. Generality vector sources create a lot more data available than can be loaded and rendered in the browser. Internet bandwidth, RAM and processor speed all have limits and, although PCs and web browsers are getting faster and extra powerful at all time, there are continuously practical restrictions to what can be done with vector data. The OpenLayers designers have worked hard to push these restrictions and many things that were impossible to consider even last years ago are now practical (Gratier, 2015).

## 3.8 The difference between raster and vector

As for computer graphics, there are basically two types of data: raster and vector. The plurality of image files—.jpeg, .gif, .png, and other bitmap image formats—are raster images. The raster image is a rectangular grid-like graph paper—of color data, and every color point in an image is called a pixel. While user looks at a raster image on his computer, it explains the color data in every pixel and maps this to physical pixels on the user's screen. When the user zooms in on a raster image, there is a point at which each pixel in the raster image can be rendered to a single physical pixel on the user's screen. It is indicated to as the resolution of the image, the most data that the image can exactly represent. When the user zoom in more, every pixel in the raster image is drawn into more than one physical pixel and the quality of the image starts to degrade—can say it is pixelated. As the user zooms out, every pixel in the raster image needs just part of a physical pixel on the screen and so some adjacent raster pixels are collective to compute a color to show in the physical pixel (Hazzard, 2011).

But with a vector, furthermore, encodes information about how to draw an actual shape. Here may be many ways of representing vector shapes—a straight line can be represented as a first point and a final point, or a first point, direction, and distance. After the user shows a vector on a computer screen, it has to be changed from its encoded format into colors for physical pixels—a process called rasterization. On the other hand, because the computer has detailed instructions on how to draw the shape, it could choose a resolution that accurately matches the physical pixels of your computer show every single time it draws it, in any case of how much a user zooms in or out. Actually, the same vector data can be drawn on any other screen at the proper resolution. Therefore, they regularly call vector data resolution independent.

In this illustration (See Figure 3-2) of how a circle represents when drawn as a vector and a raster. At the left side is rendered as a vector and at the right side is rendered as a raster. After the image is zoomed, the vector remains sharp and clear but the raster turns into blocky (Gratier, 2015).

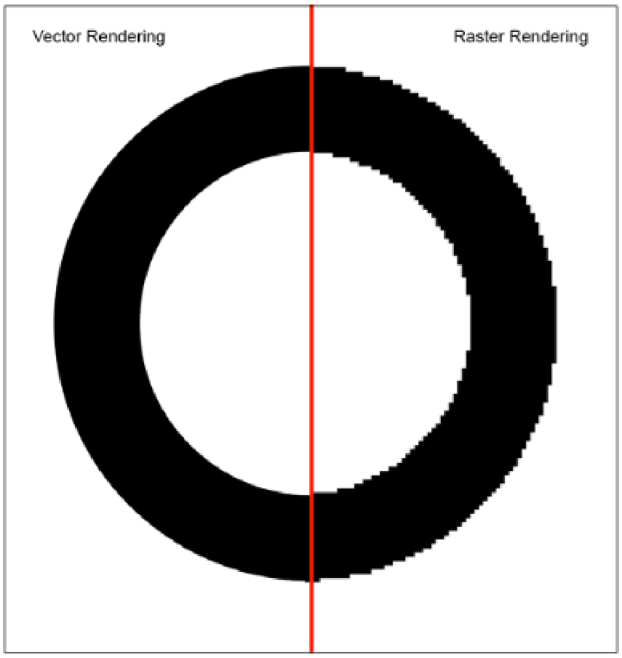



Figure 3-2: The difference between raster and vector

# Chapter 4

## 4.1 Application for Iraqi electrical grid system

### 4.1.1 The Base Layers that used in the Application

In every Web GIS application the user needs to choose and determine, what are the best Base Layers according to the objectives and the purpose of the application, by using OpenLayers to represent and display the electrical grid system for Iraq it was better to choose and using the OpenStreetMap as the first Base layer to display the streets, cities, buildings and important places to its utmost importance equipment's for dealing with electrical grids.

As the second Baselayer, and for display Aerial map it was very useful to choose and using Google maps to present the actual electrical grid with the possibility to see what the user can be shown according to the terrain in all areas or zones. It is very important to see and display the original and real site of the ground and to study the geographical barriers and problems that may be delayed the solutions for grid lines problems, like mountains, rivers, lakes, public parks, and etc.

As you will see in Figures with next sections, Google maps was the second option for the user to select another BaseLayer for this application that the user can display over it all the grid components and because it might be some internet problems between OpenLayers and Google maps servers, that was the idea and the cause to insert another Base layer for Aerial map to make the user dealing with this application with more flexibility with choosing Baselayer. Bing maps was the third Base layer to display Satellite maps because it fast to load with the grid components layers (According to the speed of internet for the user) and it's simply to insert with OpenLayers coding.

### 4.1.2 The Overlays Layers that used in the application and its Classification

In Iraqi ministry of electricity (MOE) - Planning and Studies Office they working for several years with other directorates to draw and representing all components of electrical grid for all governorates by using (Arc GIS for ESRI) to build Unified Geodatabase for the whole country, and because they use this system, this application will depend to create Overlays Layers on ESRI's shapefiles that the researcher brings its officially from (MOE).

As discussed in the first chapter, Iraqi electrical grid system is consists of three main Sectors (Generation sector, Transmission sector, and Distribution sector) and according to these sectors we will using this shapefiles as Overlays layers and we will classify each one of them according to the representing in the electrical grid. (See Figure 4-1) the user started with power plants layer that represents the Generation sector and follow it by Transmission sector layers (Stations 400 KV, Lines 400 KV, Lines 132 KV, and substation 132 KV) and at the end of the list with Distribution sector layers (Feeders 33 KV, substation 33/11 KV, Feeders 11 KV, and Transformers 11/0.4 KV) the users can see the classification for each layer according to the Legend in the same figure.

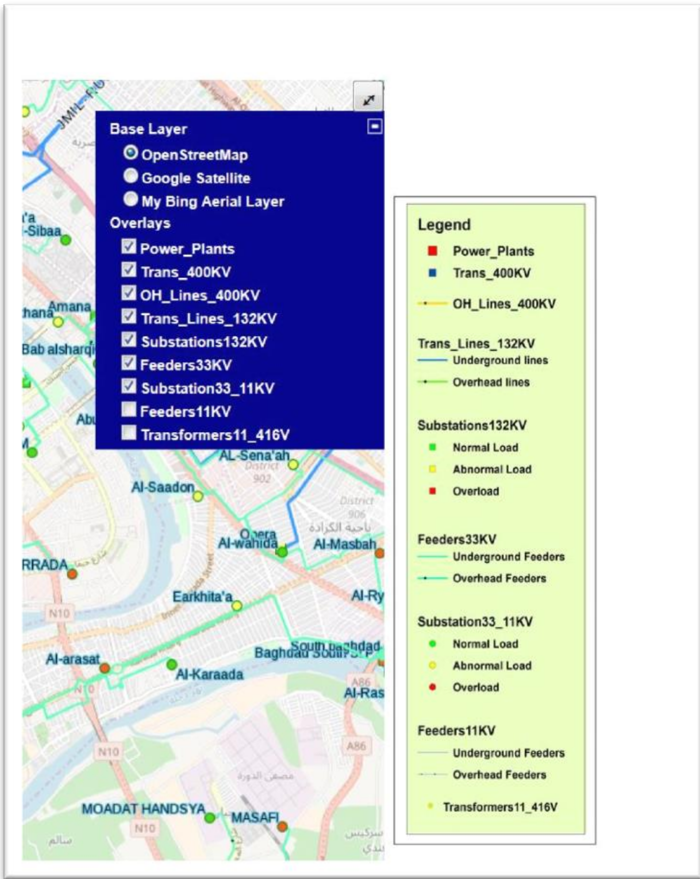



Figure 4-1: Base Layers and Overlays layers for the Application

As the users can see in Figure 4-1 especially inside the legend there is different classification for each layer according to type of the layer, for example, Lines 132 KV, Feeders 33 KV, and Feeders 11 KV, all of them classified to two sections (Underground and Overhead Lines and Feeders with different size and colors). But with substations used another method to classify these layers according to the load of substations (Substations 132 KV and Substations 33 KV) in the legend classified by using special equations with application Map file to three cases as a result to comparison between the installed capacity and the updated load for each substation to give the users more simply recognize for the status of the substation (Normal load, Abnormal load, and Overload) (See Figure 4-2).

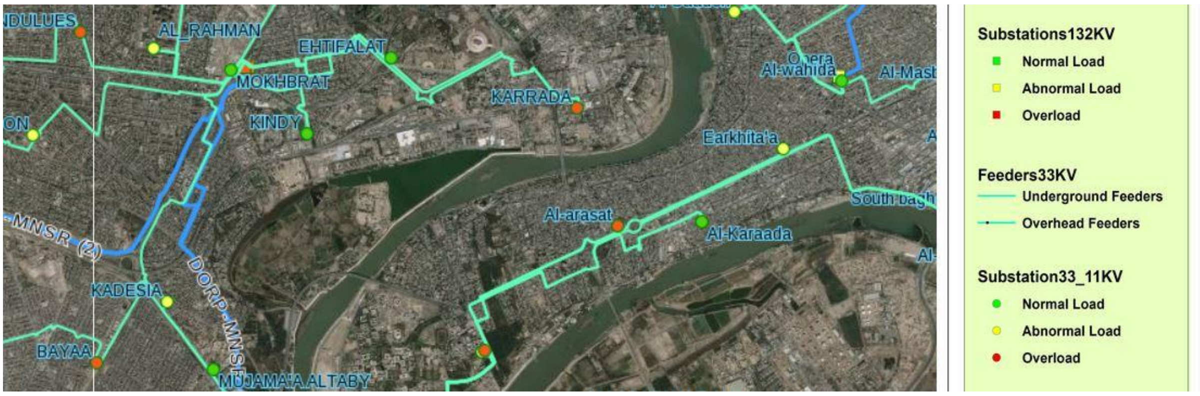



Figure 4-2: Classification of Substations according to the Load

## 4.2 How the users can use this Application

At the first every user would like to link with this application will need to know the Web address as follow http://mercator.elte.hu/~i5hod8/Iraqi_grid/iraq_electricity_grid.html and this link will be temporary because surely will be changed by (Iraqi MOE), also the users will need to know the User name and the Password for this application in order to ensure the security of data for the Iraqi electrical grid system, after that the users will be able to display all the Base Layers and Overlays layers that consists all electrical grid layers and also the users will be able to choose which layers the users need to display by check and uncheck any Overlays layer, the users will be able to explorer the information for each element of the grid, in the lower right corner the users will find the Scale text for the map, while in the upper right corner the users can find the option button to make full screen for the map (See Figure 4-3), also the users will be able to print the map by click the button (Print this page) and there is possibility to search about places.

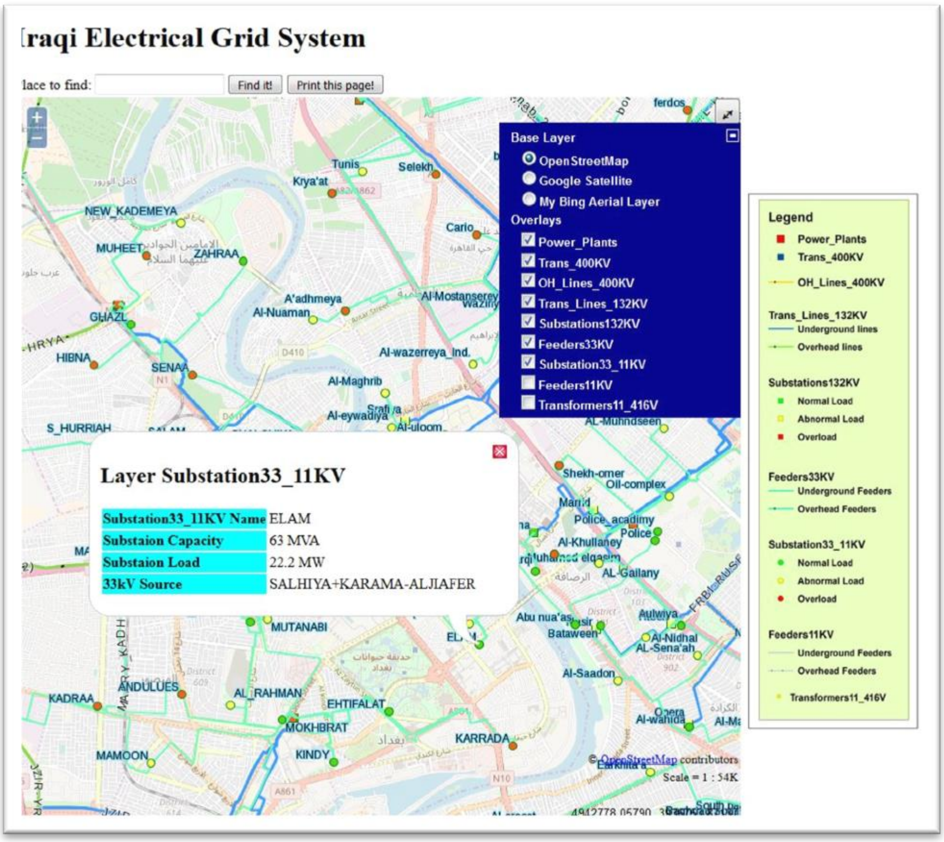



Figure 4-3: The Application for Iraqi electrical grid system

# Conclusions

If the users working with both of Electrical grids and GIS systems this application and this work will be very useful for the users to display GIS data for all kinds of users and without needs to use and setup any software to deal with geospatial information. This application will help different types of the users they are already working electrical grids especially the engineers who they work for planning and study the future planning for development and enhancement the performance of the electrical grids for next years and also they would like to solve the actual current problems with loads for substations and lines, also this application will help the decisions makers to understand the current situation for all the grid and they will be able to use this Web GIS application without needing to any training for how they can use it and they will get all the data and any information about the grid just by click on the part of the grid, such as, substations, lines, and other components and also they will be able to access this application in anywhere and at any time with any device can use the internet by using any browser.

According to the security situation in Iraq, and with a lot of accidents for electrical grid, especially in the summer with high voltage lines that its locations far away from the cities, this Web GIS application it will be very important for maintenance teams that they will need to study the nature of the location and prepare to treat those accidents.

Finally, I hope by this Web GIS Application I will help and present simple tools for all the people working with electrical grids that they will be able to use it for different areas (Decision makers, Planning for future situation and solving current problems, Maintenance works, and Monitor loads for substations and Lines or Feeders).

# Bibliography

AbaPEIsa. (2014, 05 13). *Seminar on Hydraulic Models and GIS*. Retrieved 03 07, 2018, from AbaPEIsa: http://abapeisa.com/evento/seminario-sobre-los-modelos-hidraulicos-y-el-gis/

Adel, A. (2015). *Country Report 2015.* Ministry of Electricity- Planning & studies office, Power system studies. Iraq- Baghdad: Unpublished. Retrieved 02 10, 2018, from By Email- allamimalla@gmail.com

Algardenia. (2014, 11 10). *mochtaratt*. Retrieved 03 02, 2018, from https://algardenia.com/: https://algardenia.com/mochtaratt/13481-2014-11-10-10-13-42.html

d-maps. (2009, 07 02). *Maps Iraq*. Retrieved 03 03, 2018, from d-maps.com free maps: http://d-maps.com/pays.php?num_pay=86&lang=en

Earth.Rice.Edu. (2010, 01 07). *World sunshine map*. Retrieved 03 03, 2018, from (MuTPE): http://earth.rice.edu/mtpe/geo/geosphere/hot/energyfuture/sunlight.html

Energy, U. S. ( 2004.). *Final Report on the August 14, 2003 Blackout in the United States and Canada.* Ohio: by User:J JMesserly. Retrieved 03 06, 2018, from http://www.ferc.gov/industries/electric/indus-act/reliability/blackout/ch1-3.pdf

Esri. (2017, 02 01). *About web GIS—Documentation (10.5)*. Retrieved 03 11, 2018, from ArcGIS Enterprise: https://enterprise.arcgis.com/en/server/latest/create-web-apps/windows/about-web-gis.htm

Farkas, G. (2015, 06 30). *Comparison of Web Mapping Libraries for Building WebGIS Clients.* (U. o. Gábor Farkas, Ed.) Retrieved 04 09, 2018, from https://www.academia.edu/: https://www.academia.edu/20370923/Comparison_of_Web_Mapping_Libraries_for_Building_WebGIS_Clients

Fossil Energy. (2003, 02 11). *Energy Overview of Hungary*. (R. Lynch, Editor) Retrieved 03 07, 2018, from Fossil Energy International: http://www.geni.org/globalenergy/library/national_energy_grid/hungary/EnergyOverviewofHungary.shtml

Geospatial World. (2011, 01 21). *Dimensions and Directions of Geospatial Industry*. (Y. Arora, Editor) Retrieved 03 03, 2018, from https://geospatialworldforum.org/2011/proceeding/pdf/YashitaArora.pps

GICJ. (2013, 03 15). *Geneva International Centre for Justice*. Retrieved 03 01, 2018, from GICJ: http://www.gicj.org/topics/509-gicj-and-iraq-towards-accountability-and-justice-2

GIS LOUNGE. (2014, 02 21). *What is is the Difference Between Web GIS and Internet GIS?* (M. Hojati, Editor) Retrieved 03 30, 2018, from GIS LOUNGE: https://www.gislounge.com/difference-web-gis-internet-gis/

Gratier, T. (2015). *OpenLayers 3 Beginner's Guide.* Birmingham B3 2PB, UK.: Published by Packt Publishing Ltd. Retrieved 03 21, 2018, from https://www.packtpub.com/mapt/book/web_development/9781782162360

Hazzard, E. (2011). *OpenLayers 2.10 Beginner's Guide.* Birmingham, B27 6PA, UK.: Packt Publishing Ltd. Retrieved 02 19, 2018, from https://www.geos.ed.ac.uk/~bmg/software/OpenLayers.2.10.Beginners.Guide2.pdf

HIP GREEN INDUSTRY. (2018, 01 27). *HIP GREEN INDUSTRY*. Retrieved 03 02, 2018, from HUNGARIAN INVESTMENT PROJECTS AGANCY (HIPA): https://hipa.hu/images/HIP/Green%20industry%20overview.pdf

HWEM. (2014, 05 14). *Opportunities in the Hungarian Wind Energy Market*. (L. Csók, Editor, & S. Share, Producer) Retrieved 03 02, 2018, from https://www.slideshare.net/enerjimizgunes/opportunities-in-the-hungarian-wind-energy-market

IAEA. (2017, 09 13). *Country Nuclear Power Profiles*. (G. Körmendi, Editor) Retrieved 03 07, 2018, from International Atomic Energy Agency: https://cnpp.iaea.org/countryprofiles/hungary/hungary.htm

Mátyás, G. (2017, 09 21). *Open Source Web GIS*. Retrieved 03 07, 2018, from Dr. Gede Mátyás: http://mercator.elte.hu/~saman/edu/webgis.html

Ministry of Electricity- Iraq. (2015, 09 10). *Statistical Reports*. Retrieved 03 03, 2018, from moelc: https://moelc.gov.iq/index.php?name=Pages&op=page&pid=273

Monde Geospatial. (2017, 01 23). *Best 10 Open Source Web Mapping Tools that trend for 2017*. Retrieved 03 31, 2018, from Monde-Geospatial.com: http://monde-geospatial.com/best-10-open-source-web-mapping-tools-that-trend-for-2017/

MVM. (2016, 01 02). *Annual Reports*. Retrieved 03 07, 2018, from MVM group: http://mvm.hu/download/MVM-Group-Integrated-Report-2015.pdf/?lang=en

OpenLayers 3. (2017, 10 11). *Documentation/ tutorials/ Introduction*. Retrieved 04 08, 2018, from OpenLayers 3: http://openlayers.org/en/v3.4.0/doc/tutorials/introduction.html

Putz, S. (1994). Interactive Information Services Using World-Wide Web. *first conference on World-Wide Web. 27*, pp. 273-280 . Geneva, Switzerland : Elsevier Science Publishers B. V. Amsterdam, The Netherlands, The Netherlands ©1994. Retrieved from http://map.sdsu.edu/geog583/lecture/putz.pdf

Salazar, F. P. (2017, 11 22). *WebGIS_Chapter01*. Retrieved from DOCLEGEND.COM: https://doclegend.com/download/115391webgischapter01_5a160564d64ab28f8c63c164_pdf

Tomlinson, R. (2013, 11 14). *Thinking About GIS: Geographic Information System Planning for Managers, Fifth edition*. Retrieved 03 04, 2018, from Esri Press: http://esripress.esri.com/display/index.cfm?fuseaction=display&websiteID=241&moduleID=0

UNITED NATIONS. (2017, 09 10). *World Population Prospects 2017*. Retrieved 03 01, 2018, from Department of Economic and Social Affairs: https://esa.un.org/unpd/wpp/DataQuery/

Wikimedia . (2018, 02 10). *Wikimedia Foundation, Inc.* Retrieved 03 01, 2018, from Iraq: https://en.wikipedia.org/wiki/Iraq

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# List of Figures



# List of Maps

# List of Tables



# List of Images

# Abbreviations

| | |
|---|---|
| GIS | Geographic Information System |
| MOE | the Iraqi Ministry of Electricity |
| HTML | Hypertext Markup Language |
| MW | The megawatt (MW) is equal to one million (106) watts |
| GW | The gigawatt is equal to one billion (109) watts |
| MVA | Megavolt-ampere, a unit of measure of apparent power |
| KV | Kilovolt (kV), a unit of electric potential |
| MVM | Magyar Villamos Művek |
| EBITDA | Earnings before Interest, Taxes, Depreciation, and Amortization |
| APIs | Application programming interface |
| PARC | The Xerox Palo Alto Research Center |
| HTTP | Hypertext Transfer Protocol |
| JSON | JavaScript Object Notation |
| XML | Extensible Markup Language |
| GeoWeb | The geospatial Web |
| BSD | Berkeley Software Distribution |
| LGPL | Lesser General Public License |
| SVG | Scalable Vector Graphics |
| CSS | Cascading Style Sheets |
| GPL | General Public License |
| MDX | MultiDimensional eXpressions |

| | |
|---|---|
| WFS | Web Feature |
| OGC | Open Geospatial Consortium |
| ISO | International Organization for Standardization |
| WMS | Web Map Service |

# DECLARATION

I, undersigned **FAROOQ ABBAS SALMAN AL-QURAISHI (I5HOD8)**, declare that the present master's thesis is my original intellectual product in full and that I have not submitted any part or the whole of this work to any other institution. Permissions related to the use of copyrighted sources in this work are attached.

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(Signature of the student)