International Journal of Advanced Studies in Humanities and Social Science (IJASHSS)
Available online at http://www.ijashss.com
Volume 3, Issue 4 (2014) pp. 260-269

Original Article

Technical and Economic Analysis of Solar Wind Hybrid Renewable Energy System with Rainwater Collection Feature

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Received: 24 August 2014, Revised: 30 September 2014, Accepted: 20 October 2014

ABSTRACT

In this paper, the technical and economic feasibility of innovative renewable energy systems, solar wind hybrid power generation capability is provided for collecting rainwater. Part of the energy required for tall buildings where the system is installed it provides. The system is compact and can be built on top of tall buildings and the construction of renewable energy required in the space provided. PAGV shape and appearance of the surrounding wind turbines can be combined with the architecture of the building and no negative impact on demand. (Part of the building). This design improves the starting behavior of wind turbines. Also for the people around safer and reduces noise pollution. Technical and economic analysis was conducted using life cycle cost. (LCC) LCC method, taking into account the full range of costs and cash flow of time makes the cost equation. Evaluations show that for a PAVG (with a diameter of 30 m and height 14 m) and wind turbine rotor vertical H- axis (diameter 17 mm and a height of 9 m) mounted on top of the building with 60 meters high, the estimated energy savings annual 195.2mwh/year.

Keywords: Solar cells, Wind turbines, Rainwater, PAGV.

Introduction

Common drawbacks of wind power and solar power to their unpredictable nature, they rely on climate change. However, complement the relationship between daily and seasonal wind and solar energy there. In addition, stable output power capability of hybrid power systems are expected through. Thus, the problem can be partly integrated into the appropriate combination of two or more sources into a hybrid system using a source prevailed strengths to overcome the weaknesses of others will disappear. For specific locations, solar wind hybrid power generation system with storage bank is very reliable electric power sources suitable for loads that require higher reliability offer. In order to combine and optimize the energy, economic and various techniques to achieve reliable numbers for hybrid renewable energy system is used. Currently Power electro isolation is produced by the power, and the transition to the urban areas is. However, in many cases in developing countries, the development of networks due to the sparse population, rugged terrain or at any Devon impractical. The system is compact and can be in high rise buildings or buildings to provide site power supply national electricity grid lines to be constructed. In this paper, the technical and economic characteristics of the recorded solar wind hybrid systems are investigated. Economic analysis using the method of life cycle cost (LCC) calculation done. The total life cycle costs, such as net present value and return for both capital and operating costs over the life of the system. LCC challenges include poor availability of data, erratic economic changes, uncertainty about discount rates, asset life, and estimated future operating and maintenance costs for the production of clean energy will certainly help to reduce emissions greenhouse gases that cause global climate change effects are noteworthy. Invisible costs related to the environmental impacts, including greenhouse gas emissions in this article have been removed, although very important.

Configure the wind and solar energy systems

In addition, hybrid power systems, solar wind, and other alternative sources for a hybrid system combined with a variety of settings, such as diesel, solar, wind, diesel, diesel, fuel cell, solar, water, wind, solar and diesel are available. Like all alternative energy sources, wind energy and solar energy are expensive in terms of initial capital costs, but operating costs are relatively inexpensive. The main engineering work on the solar wind stand-alone system to obtain the desired size and configuration for a resource optimization system volume PV / Wind hybrid energy conversion and storage of the battery under load conditions in Turkey was carried out. A new method of optimizing the size of the solar wind hybrid system with battery banks of developed and integrated economic situation under analysis. Moreover, the economic comparison between two independent systems, solar winds hybrid power of the network connection. The results show that the hybrid energy system installed at a distance of over 4671 meters more economical than the wiring of the electrical grid. Optimal design of hybrid wind- solar systems employing battery banks studied. Most of their analysis suggested settings in different weather conditions. In addition, the proposed hybrid renewable energy system to reduce cost and risk by combining a third energy source (such as auxiliary power mains) rather than increasing the size of the given hardware . Bakos and Tsagas a technical and economic feasibility study on a proposed grid connected solar power systems. Based on the method used, the technical characteristics of the system are defined. Then, based on meteorological data of solar radiation, the energy extracted was calculated. Finally, the cost and time of return from energy production systems and different financial scenarios compared to the price of conventional electricity grid was calculated. For all the economic opportunities in the solar system, to implement this project on a commercial scale, expensive initial investment and long payback was determined. Except for some isolated areas (e.g. Islands) where energy costs are high powers or network connection, or

connect to a centralized network of consumers who wish to purchase a solar system for energy production to claim.
In a further study, Bakos and Tsagas have been working on a solar- wind hybrid system using a similar method and evaluate it. Systems have been developed in parallel with the national grid and to supply the location a used were. According to an economic analysis, it was found that the time to reach a turnover of systems from a single system of solar energy is much less positive. Therefore, the use of an auxiliary energy source built into this system, independent of the system is competitive compared. However, some government subsidies to help reduce the negative cash flow and repayment period to encourage private investors to move towards greater investment in the renewable energy systems.

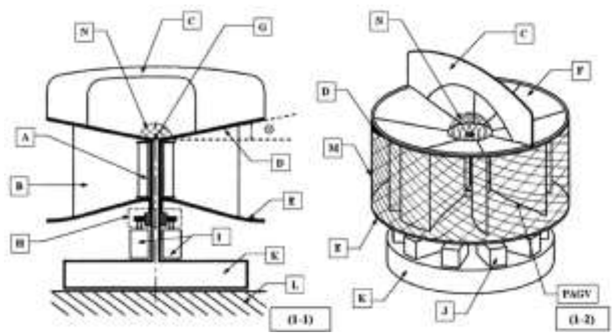

Figure 1. Interior view of small wind turbines

A review of current research on renewable systems, the most notable shortcomings evaluation of a hybrid solar wind energy system that survey shows is as follows: One. Lot of research has been done on a small scale wind energy systems for buildings. Not enough attention to large-scale wind power systems for use in urban areas yet. Two. The main problem in many areas of potential high wind speed for wind energy system application. Increase the performance of a wind turbine can help reduce this problem. The building consists of two towers of 20 - storey sail shaped office, the Cone horizontal axis wind turbine with a height of 60 meters and three meters in diameter, 29, and 225 kw. However, having such a large turbine occupy space and increasing concerns about noise and vibration there.

Fringe description designing

The first modern concepts for the integration of wind energy into the building in the 1930s and 1940s in Germany were introduced. Hermann Honnef, a German engineer, some enthusiasts will stimulate the debate on wind power proposal to build a giant tower multi- rotor wind power production to provide power level of 60,000 kw. Chung and colleagues have designed a hybrid solar wind power system integration in high- rise buildings, with more emphasis on visual impact , safety , noise and pollution and improve the start behavior of the wind turbine is considered . This patented design overcomes the inferior aspect of the low-speed wind driven (to get a better angle of the wind turbine blades) and increased wind speed at high altitude through PAGV. The general arrangement of the system is shown in Figure 1-1 and 1-2. System can cylindrical shape or form, depending on the characteristics of architectural buildings, including the oval shape, and so is the design. In the middle of a wind turbine system, [A] is located and surrounded by PAGV.

Blade design flaw is the main concern of the public. Figures 2 and 3 concept art from the solar wind hybrid system with a rain collection system in high-rise buildings are equipped explains. People have realized that building a wind turbine because the system is placed on top of the building are not well scintillation light wind turbine problem. The system seems to be in urban areas compared to conventional wind turbines (without casing) is fitted to adapt to the building permit is not a problem. PAGV of the upper duct wall [D] down the duct wall [E] and the blade guide [B] is. PAGV to prove or deviation from the course with a rudder , [C] and pressure sensors and servo motors , the current wind progressive design . PAGV wind radial flow from a larger area collects and speed up the work of Venter before entering the wind turbine makes. Turbine can be oriented vertically or horizontally in any form or their combination is designed PAGV joint axis generator. Center of the drive shaft of the VAWT generator, [I] through the cell shaft power transmission and mechanical drive system; [H] is like a gear system. PAGV includes blades with variable sizes or forms with fixed or variable thickness, which are positioned around the turbine. Walls of the upper and lower duct inclination angle, θ are the horizontal surface. Outer surface of the upper wall of the base PAGV to put solar panels , [F] or concentrated solar system provides water through , [G] in the middle of the stream flows through the system and stored in a water storage container , [K] , thus reducing the required electrical power to pump water to the upper levels of the building . A network of rain water, or filtered, [N] prevents foreign objects inside the passageway through which can cause obstruction will be. Mesh, [M] installed at the input side PAGV to prevent entry of foreign objects to strike the VAWT, like hitting a bird. The power generated from wind turbines and solar panels is stored in a battery bank, [J], or power-line network feeds. Insulating layer, [L] to prevent heat transfer to the interior of the building at the bottom of the system is built.

Hawts of the VAWT are integrated into the World Trade Center in Bahrain have used this system to the noise and vibration generated due to concerns that have been encountered. VAWT is much lower than the level of noise and vibration compared to HAWT produces. Blades snap and pull it because it is less likely to apply. In addition, the VAWT is surrounded by PAGV, noise was minimal. Larger wind turbines may be able to produce a higher amount of power, but when the wind speed is low, the turbines, much lower than the rated power works. The system PAGV smaller VAWT (within PAGV) to rotate close to its rated power helps, even if the wind speed is low. On top of the wind turbine, the size of which is enclosed in PAGV noise and less vibration. Besides all the features mentioned above, the system is taking steps in the installation and maintenance has been developed. PAGV VAWT components and operation of transport (it's easy to remove and assemble) and can be easily transported to the top of tall buildings noted. For maintenance purposes, the system is accessible from the interior of the building. VAWT to prevent movement during maintenance, a locking device can be installed. VAWT is the current operating and maintenance costs are expected. , This system utilizes the advantages of climate, Ramsar , the average exposure to the sun and too much rain in a year for energy store new and used out of water free of charge .rain, from 2005 to 2007 are . Data from a weather station located in Ramsar solar radiation and wind data obtained are measured in Ramsar , Fig. 4 . The data for the analysis of change in the mean wind speed, solar radiation and rainfall amounts were used. Force or energy derived from these parameters can be predicted.

Solar System

Solar system is here considered to consist of an array of modules PV, hybrid charge controller and the firmware is shared more with wind turbines). PV modules are placed in the top PAGV. (Based on solar radiation data and analysis of weather station located in Ramsar (Lat: 2°44N and Long: 101°42E) E (solar power generation is Esolar) estimated by the following equation:

(1) $E_{solar}=G_s.A_s.\eta_{ps}.K$

Where Gs mean daily global radiation (kwhm-2/day) is, as an active array area (m2), psη efficiency PV modules for solar energy conversion and K loss. Meteorological data from this site for four years are shown in Tables 1 and 2. This indicates that the monthly global radiation in the range of 120-140 kwh m, with daily solar radiation is 4.5 to 5.5 kwh m. Therefore, a stable output power from this source there. Monocrystalline silicon solar cells to convert solar radiation into electricity businesses selected. Specification and estimation of its daily electricity generation are listed in Table 1. By selecting monocrystalline silicon PV module efficiency of 16.4 % , solar energy production of about 108 megawatt hours / year or 295.9 kwh / day.

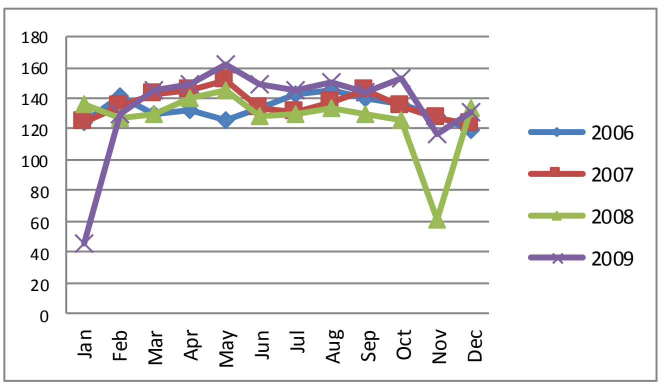

Table 1. Annual emissions from 2009 to 2006

Wind Energy Systems

Wind data obtained from the weather station in the city of Ramsar in northern Iran. Meteorological data recorded at the site from 2006 until the end of 2009. The height of the wind sensor above ground level , 46.2 meters (the height of the wind sensor above mean sea level : 60.8 m, as shown in Figure 6, the mean wind speed monthly calculation (the hourly average wind speed data) and as shown in Fig . , this diagram shows that the main part of the wind speed range of 1.5-2m / s is . Than data analysis of weather station Ramsar , wind speed is less than m / s 4 and over increase in height is considered . According to the following equation:

(1) $V(z)=V_r(z/z_r)^\alpha$

Where V (Z) wind speed at height Z, VR wind speed at the reference height above the surface, ZR, and α is a coefficient that depends on the wind rippling Earth's atmosphere is stable. So, for example, an urban area such as Ramsar, value = 0.4α. In this case, tall buildings with a height of 220 meters as a reference was considered , and wind speed based on the height by equation (2) , was calculated for the seven wind speed measured at about 1.8 times greater than the wind speed at height reference 46.2 meters . Comparative study has shown that vawts compared hawts aspects are useful in general, vawts benefits such as ease of installation and maintenance (due to the generator in the turbine is located) , wind OMNI to extract power and no yawing mechanism is required. The comparison between H - Turbine rotor and Darrieus, H - it looks much more useful rotor Darrieus. Probably a simple structure and lower levels of strength H - is the turbine rotor. Changes in wind speed can be found by the Weibull probability distribution function (h) with two parameters; the scale parameter (c) and shape parameter (K) are indicated. More likely wind speed (V) in the interval is obtained as follows

(2) $H(V)=(k/c).(V/c)^{K-1}.e^{-(V/c)k}$

Wind power is proportional to the cube of the speed, and the energy collected over the years an integral h.V3. DV is. Thus, the root mean cube (RMC) rate is defined in a similar manner. Estimate the energy of the sun on the root mean square (rms) value of the alternating current (AC) electrical circuits. Equivalent RMC of digital data log is as follows:

(3) $V_{rms}=\sqrt[3]{\frac{1}{n}\sum_{i=1}^{n} Vi^3}$

Where n is the number of digital data. RMC speed is useful in quickly estimating the annual energy potential of the site. Using Vrmc, the average power density is given by:

(4) $P_{rmc}=\frac{1}{2n}\sum_{i=1}^{n} \rho.Cp.\eta tr.\eta g.\eta PAVG.A.Vrmc^3$

The annual output value of the potential energy Prmc by multiplying the total number of operating hours per year are obtained from the site. Rotor H - due to the advantages of blade profile is selected, noise, position and behavior of the generator to start. Technical characteristics of commercial VAWT is shown in Table 2. Operating wind turbines in the range of 3-25 m / s wind speed is about 1.7 times after crossing PAGV has increased the efficiency of the system is estimated. Upon weather data for the years 2008 and 2009, the frequency of wind direction is obtained and is shown in Figure 8. So, PAGV wind deflects their path.

Rainwater Collection System

Every source of energy consumption in high-rise buildings, pumping water level of a building. Collecting data on rainfall for eight years (2002-2009), it was found that a considerable amount of annual rainfall in the site evaluation, the Ramsar will, therefore, be reasonable to invest in rainwater harvesting is shown in Table 3. Annual rainfall in the Ramsar (2002-2009) in 1 M2. Volume of collected rainwater catchment area Vrain 700 (M2) is estimated using Eq.

(5) Vrain= Ac.I.Cr

AC basin where rain (M2), I rainfall intensity (mm / month) and Cr runoff coefficient (assumed as 0.75) is. For calculating the energy efficiency of buildings by collecting rain in equation (7) is used

(6) $E_{rain}=\eta.V_{rain}.g.h.(2.778\times10^{-4})$

Where ρ is the density of water, g is the gravity and h is the height of the building, and (2.778×10^{-4}) conversion factor for watt-hours to Joules. Precipitation data for the years 2002 to 2009 the average monthly precipitation analysis and results for the volume and energy savings in Table

3 are the data analysis in Ramsar, estimated monthly rainwater collected in the area of the roof 700m2 to 143m3 is. Therefore, the energy used to pump the water to the top of a building 220 m altitude of about 1025 kwh / year be.

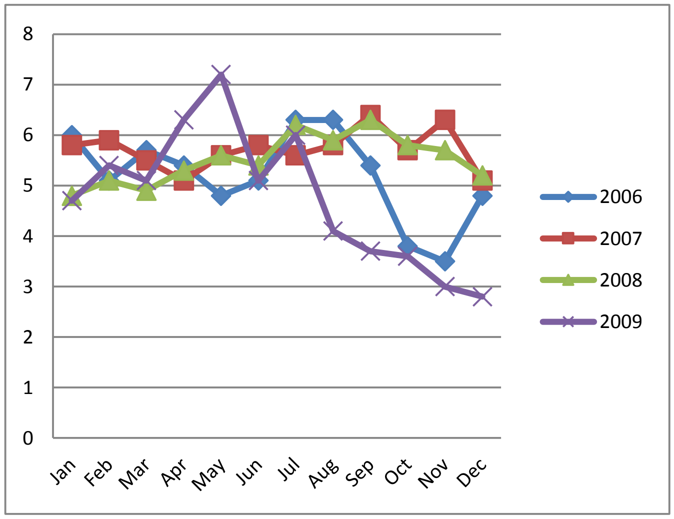

Table 2. Wind speed at 40 m height from 2009 to 2006

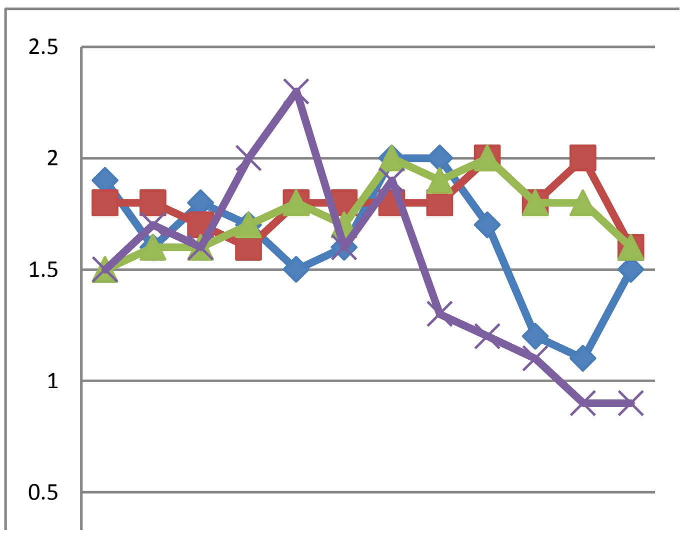

Table 3. Wind speed at 60 m height from 2009 to 2006

The electricity generated by the proposed hybrid system, wind - rain, sun city power grid feeds. (Figure 9) for an economic analysis of the proposed hybrid system, LCC method is used and the full range of costs and cash flow is equal to the time it takes. Savings solar wind, rain (WSRS) the difference between the unit cost of energy produced (CUE) and the trade tariff rates (CTR) kilowatt-hour of electricity generated by the

(1) WSRS=CTR-CUE

Mortgage payment, including principal and interest payments on loans borrowed money to install the system. To keep the system

operational conditions of the period, such as operation and maintenance costs required to be paid. Income tax savings for the system can be stated:

(2) ITS=ETR $\times (IP + PT)$

The bad factor (PWF) included in the calculation to determine the total profit of the system., If payment is repeated every year and every year i is the wind speed, PWF paid by the word about the equation are obtained

$$PWF(N,i,d) = \sum_{j=1}^{N}(1+i)^{j-1}/(1+d)^j \quad (3)$$

Where N is the economic evaluation period. Inflation and discount by i and d are shown. Then, to determine the existing value (PV) or revenue for the period number n (usually a year) in the future, the following equation is used:

$$PV = \frac{1}{(1+d)^N} \quad (4)$$

PV is used to return the value of future payments, or income in a given period to the present value. Then, the net present value (NPV) to obtain the total present value of the cash flow of a has been calculated.

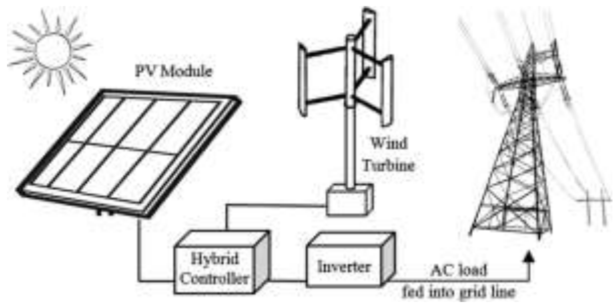

Figure 3. Schematic of wind and solar hybrid system

Pagv Effect On System Performance

The benefits of using solar and wind system integration PAGV compared with the same features with the time and energy extracted from the wind turbine system without PAGV implementation increases. Thus, the initial investment and payback time is influenced by the choice of the wind turbine system according to original specifications, the minimum wind speed of 3.0 m / s is. The mean operating time and energy to this website in 2007-2009 is shown in Table 5. The analysis is based on the wind speed in the range of 3-25m / s is performed , on average, a 57.6 % increase in the number of operating hours apply PAGV Similarly, energy production has increased by about 327 percent . Annual energy generated and stored by the solar wind hybrid system and rainwater collection 195.2mwh was estimated at Ramsar site. , The average annual electrical energy consumption per unit of domestic customers in Ramsar is about 2.86mwh. The amount of stored energy to supply 68 units of the internal customer is enough. , It is estimated that the cost of the entire system USD $ 600.240 with 10 % down payment is made. Remaining capital financing for 25 years at an interest rate 7 percent.10%. Additional 2 % tax on the initial investment. Operation and maintenance costs for PV panels and wind turbines are estimated at $ 0.001, and 0.011 dollars per kilowatt- hour. Cost is estimated that the rate of 4 % per year increase. Effective income tax rate in a life cycle of 45 % is estimated.

NPV energy system over a period of 25 - years at $ 29.528 on the market discount rate is 8 % . Financial calculations are shown in Table 8. Present value of annual total solar wind, rain system NPV, the benefits of this hybrid system. Significant portion of energy demand in high-rise buildings can be supplied by the system, the innovative hybrid. Economic analysis shows that the system for the first time after 8 years, the cash flow is positive. However, due to the replacement controller combines reverse and for some years cash flow is negative. , Then after 15 years the cash flow to always be positive, so that the effect PAGV improves the performance of the energy system combinations. The efficiency of this system, it becomes more economical system does. Annual energy generated and stored by the solar wind hybrid system and rainwater collection 195.2mwh was estimated at Ramsar site. , The average annual electrical energy consumption per unit of domestic customers in Ramsar is about 2.86mwh. The amount of stored energy to supply 68 units of the internal customer is enough. , It is estimated that the cost of the entire system USD $ 600.240 with 10 % down payment is made. Remaining capital financing for 25 years at an interest rate 7 percent.10%. Additional 2 % tax on the initial investment. Operation and maintenance costs for PV panels and wind turbines are estimated at $ 0.001, and 0.011 dollars per kilowatt- hour. Cost is estimated that the rate of 4 % per year increase. Effective income tax rate in a life cycle of 45 % is estimated.

Conclusion and Summary

In this article, technical and economic analysis about the initiative wind hybrid renewable energy systems - solar and rainwater collection feature for high application in urban areas is done. Technical capabilities of the system shows that the integration of available technologies from wind turbines , PV panels and rainwater collectors PAGV, the system can cover a significant portion of the building 's energy demands and to become independent (or partially become independent) for building grid AC power helps. Analysis shows that for a system with PAGV diameter of 30 meters and a height of 14 metro rotor - VAWT H (17 m Qtrv 9 meters high) mounted on top of a building with a height of 60 m. Ramsar 195.2mwh/year estimated annual energy savings . PAGV importance of comparing performance with other systems that are technically similar, but has no PAGV determined. When PAGV applied to energy production increased 327 % there. PAGV also improve treatment initiation and enhance the performance of wind turbines in hours. Economic analysis shows that production costs for operation and maintenance of the system over the lifetime of the system for this project, 29.528 dollars for a lifetime of 25 years. 'S design a reliable model systems for large urban areas that are configured to solve or alleviate many problems of energy systems, solar wind, such as safety , visual impact , pollution, noise and sound and response of the wind . Within the building to prevent any disturbance to the surrounding environment will be .could be in renewable energy systems. Since the place chosen for this study is the average wind speed in the area, a shorter return period wind speed for sites located more than expected.

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How to cite this article: Hesam Sanatnama, Nasrin Sabet, Technical and Economic Analysis of Solar Wind Hybrid Renewable Energy System with Rainwater Collection Feature. *International Journal of Advanced Studies in Humanities and Social Science*, 2014, 3(4), 260-269. http://www.ijashssjournal.com/article_83575.html