T. Boone Pickens Energy Plan: A Feasibility Analysis

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Abstract—**A major problem that the United States is facing in the 21st century is meeting energy needs. With an ever-increasing population, a question arises: can we generate and deliver enough energy in order to meet the ever-increasing demand? Each day more and more people are using automobiles to go from place to place, but there is a single point of failure in automotive design: petroleum based fuels. Travel is dependent on this mostly foreign fuel source, and as more require it, the price goes up while supply diminishes. On July 7, 2008, T. Boone Pickens introduced the "Pickens Plan," an energy proposal to reduce America's dependence on foreign oil by one-third over the next ten years. By harnessing wind power to generate electricity, and using natural gas to power automobiles, he believes that it can revitalize a dying industry and stimulate the economy.**

The objective of this paper is to describe an analysis of the T. Boone Pickens energy plan. These analysis explores the feasibility of generating 20% of the nation's electricity from wind, and reducing gasoline and diesel consumption by 20% in 10 years through examining its technological requirements, economic viability, and the policy and planning issues of implementing such plan in the United States.

The preliminary feasibility evaluation uses a parametric to conduct an economic payback analysis and life cycle assessment of wind turbines. Our study focuses mainly on the Midwestern area of the U.S. This region will have wind farms which will support large wind turbines to generate 20% of our electricity. A Monte Carlo integration of a probability density function was conducted to determine natural gas vehicle manufacturing and turnover time from petroleum based fuel powered automobile to natural gas powered automobiles.

INTRODUCTION

The United States of America spends approximately $700 billion on foreign oil each year. During 2007 the U.S. consumed roughly 57,650,000 gallons of motor gasoline *per day* [1]. T. Boone Pickens is proposing an energy plan with a goal of producing 20% of our nation's energy with wind, and reducing our foreign oil dependence by 20% within 10 years. In order to reduce our nation's foreign oil dependency, electrical energy produced by wind will replace electrical energy produced by natural gas, which would in turn be used to replace the gasoline used to provide energy to motor vehicles.

Currently, around 23% of the nation's electricity is generated using natural gas [2]. T. Boone Pickens proposes shifting the consumption of natural gas from electricity producing turbines to motor vehicles. As of 2006, according to the interest group Natural Gas Vehicles for America, there were approximately 120,000 natural gas vehicles (NGVs) on the road in the United States [3]. According to the Bureau of Transportation Statistics, in 2006 there were 135,399,945 registered passenger cars in the United States [4]. There are millions more buses, trucks, and other commercial vehicles. Thus, NGVs represent approximately 0.08% of the U.S. passenger car fleet. Reducing foreign oil consumption by 20% will require the conversion or new production of 46.1 million of vehicles from gasoline to natural gas, and will require producing millions more natural gas vehicles.

During 2007, according to the Energy Information Administration, wind energy represented approximately 0.35% of the nation's electricity [5]. Since so little energy is currently generated by wind turbines, meeting the goal of producing 20% of the nation's electricity via wind turbines will require a massive increase in the number of turbines manufactured and installed. As these turbines are machines, and machines break, such a large number of turbines will require a substantial cadre of personnel trained to operate and service them. Generating the power domestically, and paying American citizens to operate and maintain the turbines, will aid in achieving the goal of reducing the amount of money America sends outside her borders. This goal will be aided even further if the turbines are manufactured domestically rather than overseas.

Powering vehicles with natural gas, and transmitting electrical energy generated from disparate locations, will require the construction of additional infrastructure in the United States. Gas service stations will need to be modified with tanks and dispensers in order to refuel natural gas vehicles. Natural gas distribution systems will need additional pipeline and delivery trucks to keep service stations supplied with compressed natural gas. Thousands of miles of power transmission cable will need to be manufactured and installed to connect wind turbines to the national energy grid. Existing power and gas distribution

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systems will need to be upgraded to handle the increased demand.

More importantly, achieving the goals set forth by T. Boone Pickens will require willingness by the American people to change how they consume energy, and to recognize the concept that the total cost of electrical power is not solely how much it costs to generate electricity, but the additional costs to the environment and health of the nation.

I. Problem Statement

There is a constant growth in the demand for more efficient forms of energy. The U.S currently represents 4 percent of the world's population but consumes 25 percent of the world's oil. Due to the increasing energy demand, we must promote every possible domestic energy resources to solve this crisis. Recently T. Boone Pickens proposed an energy plan with a goal of producing 20% of our nation's energy with wind, and reducing our foreign oil dependence by 20% within 10 years. A feasibility analysis is required to determine if the plan can be completed within the given timeframe and if it is a desirable and feasible investment.

III. DESIGN ALTERNATIVES

There are several key factors which must be analyzed before possible solutions become feasible. First, the number of wind turbines needed must be taken into consideration. This was the determining factor in whether or not it is possible to meet the goal of supplying 20% of the nation's electricity via wind power in the design alternatives selected: 10, 15, or 20 years. These design alternatives were chosen due to the fact that the T. Boone Pickens plan is an ambitious project that seems unreachable within the 10 year span originally given. By extending the time lines, we wanted to see if it would increase the feasibility.

In 2007, wind energy represented approximately 0.35% of the nation's electricity according to the Energy Information Administration. Since so little energy is currently generated by wind turbines, meeting the goal of producing 20% of the nation's electricity via wind turbines will require a massive increase in the number of turbines manufactured and installed. Second, the fraction of the U.S. motor vehicle fleet which needs to be powered by natural gas in order to reduce gasoline and diesel consumption by 20%. This fraction, when taken in context of the average fleet turnover times for commercial and passenger vehicles, was used to determine if a 20% reduction can be achieved in 10, 15, or 20 years. This scenario also would require significant changes in transmission system to deliver wind power through the electricity grid. It would require building more than 100,000 wind turbines, connecting them to large cities with at least 40000 miles of transmission lines and converting tens of millions of cars to natural gas fuelled vehicles. Such plan is expensive and time consuming and in order to accomplish this within a decade would be phenomenal effort that simply may not be achievable in 10 years. Therefore to find the economic viability and the return on this massive investment we have changed our alternatives to 15 years and 20 years. The following were the preliminary decisions of our project:

- Alternatives:
  - 10 years
  - 15 years
  - 20 years

IV. Description of wind model

Modeling the installation of wind turbines performed using parametric analysis. Two models were used: one representing wind turbines being manufactured solely by General Electric, and the second having no restrictions on manufacturer. The reason for having one model restricting wind turbine manufacturing to General Electric comes from T. Boone Pickens. During his address before the Congress of the United States of America, T. Boone Pickens advocated manufacturing as many of the wind turbines in the United States as possible. Of the three major manufacturers of wind turbines, General Electric, Vestas, and Siemens, only General Electric (G.E.) is an American company.

A base number, representing the manufacturing capacity, in megawatts, of current manufacturers was established for 1,000 trials. This base number followed a normal distribution with a mean of 2,342 megawatts for the G.E.-only model and 5,329 megawatts for the all-inclusive model. These means come from the installed generating capacity, in megawatts, of wind turbines from 2007 according to the Department of Energy. A standard deviation of 5% of the mean is used in the model. To perform parametric analysis a different growth rate, ranging from 20-70% and incremented by 10%, was utilized for each trial. The growth rate represents the percentage increase of installed capacity for each year. For example, a 20% growth rate for 20 years would mean the generating capacity installed increased by 20% each year for 20 years. Once the model is populated, the installed capacities for each year are averaged. These averages are the expected values for each year and will be used to evaluate whether the United State can produce 20% of its electrical needs from wind power.

V. Description of natural gas Vehicle model

order to calculate the expected growth rate for natural gas vehicles, a parametric analysis approach was taken. For this, we used the normal cumulative distribution for the specific mean and standard deviation. Data for our mean and standard deviation was taken from historical natural gas vehicles from previous years. Below is the equation we used

for our models in Microsoft Excel:

NORMINV(rand(),mean,standard_deviation)

The number of gas vehicles was derived below in the model section, which states that in order to reduce the foreign oil consumption as a whole by 20%, a total amount of vehicles produced to run on natural gas would have to be approximately 46.1 million. Data was input in order to find how much of a growth would be needed to produce the amount of natural gas vehicles by the deadlines given in the design alternatives. Varying the growth rate of the normal distribution, one thousand iterations were run using random seeds in order to develop a cumulative number produced at the end of each cycle.

VI. Figures and Graphs

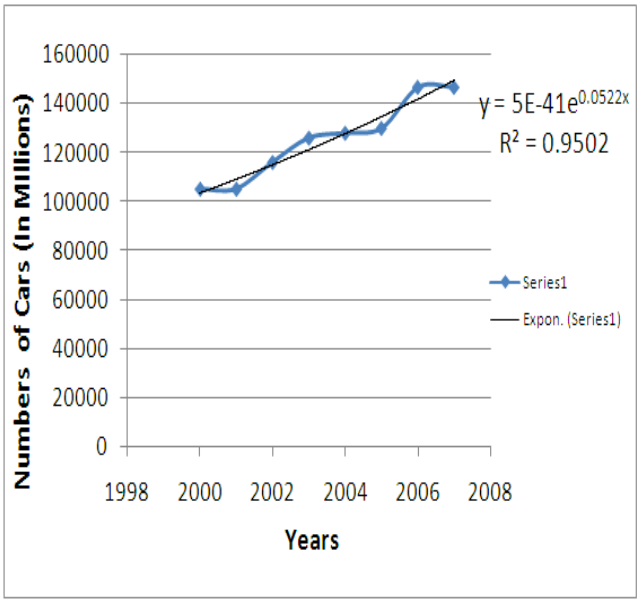

Figure 1: Current Natural Gas Vehicles Trend

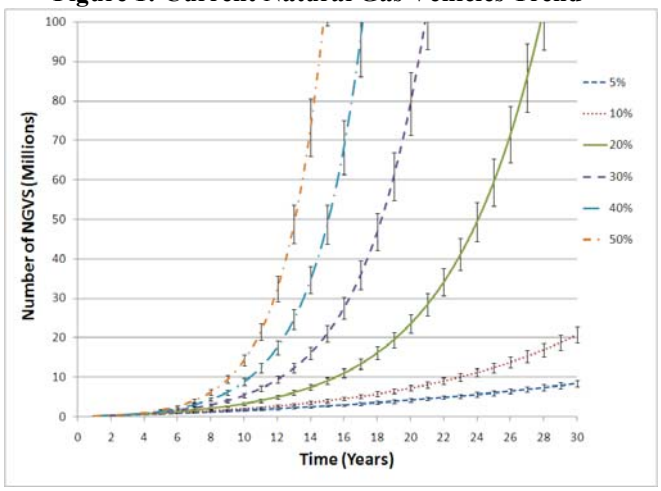

Figure 2: NGV Growth Rate Vs. Time

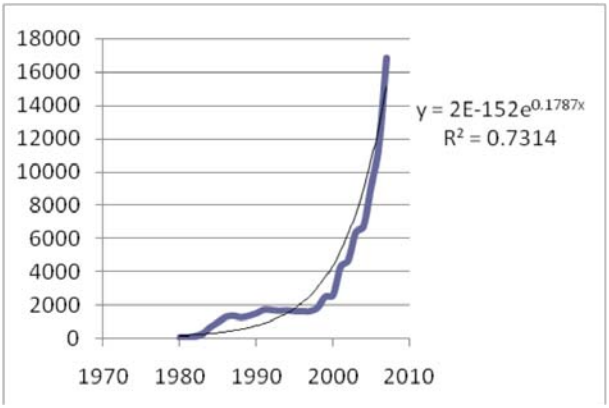

Figure 3: Current Installed Capacity Trend

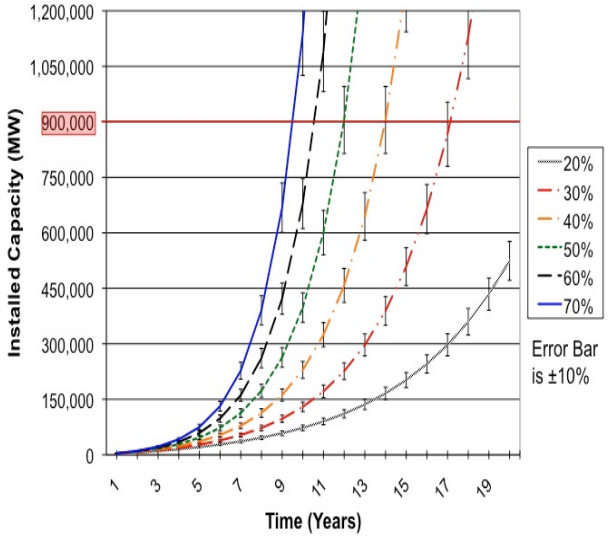

Figure 3: GE Installed Capacity Vs. Time

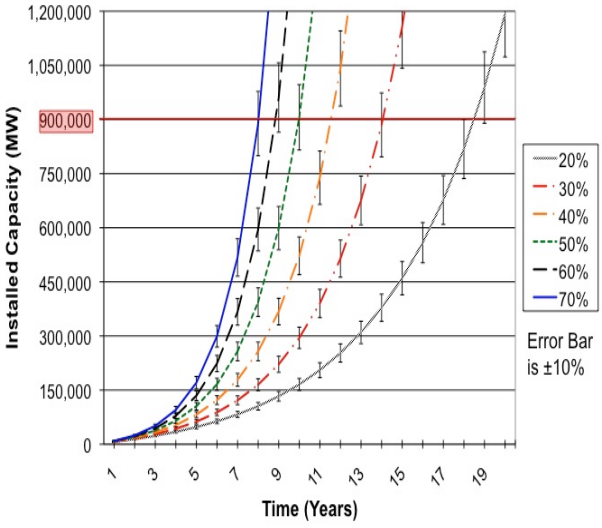

Figure 4: Cumulative Installed Capacity Vs. Time

A. Abbreviations and Acronyms

DOE: Department of Energy

FAA: Federal Aviation Administration
EIA: Energy Information Administration
NG: Natural Gas
NGV: Natural Gas Vehicle
LNG: Liquefied Natural Gas
CNG: Compress Natural Gas
BTU: British Thermal Unit
MPG: Mile Per Gallon
mi: mile
gal: gallon
FO: Foreign Oil
GDP: Gross Domestic Products

VII. MODELS

A. NGV Model Concept

According to the U.S. Department of Energy, 30% of natural gas is currently consumed through the energy generation, while 3% of the total natural gas is being used towards transportation [2]. Shifting these resources and reallocating into the transportation sector, we find out if there is enough natural gas to reduce foreign oil consumption by 20% without additional drilling.

- Current Natural Gas => 23.6*.3 + 23.6*.03 =7.788 Quadrillion BTU
- Foreign Oil => 39.8 Quadrillion BTU
- Theoretical Percent Reduction = 1 – (39.8 – 7.788)/39.8 ~= 19.5% Reduction in foreign oil.
- Gasoline Consumption => $3.9*10^8$ gal/day or $1.4*10^{11}$ gal/yr
- A reduction of 19.5% is =
  X(gasoline) = $2.78*10^{10}$ gal/yr
  MPG(gasoline) = 22.4 (data from 2006)
  X(gasoline) * MPG(gasoline) = miles = $6.22*10^{11}$ mi/yr
  MPG(NG) = 28 (case is Honda Civic GX)
  Miles/MPG(NG) = X(NG) = $2.22*10^{10}$ gal/yr
- Given we know that
  X(NG) = $2.22*10^{10}$ gal/yr
  Average mile driven yearly per person = 13476
  MPG(NG) = 28
- We find out that the number of NGV's needed to reduce foreign oil consumption by 19.5% is (($2.22*10^{10}$ gal/yr) / 13476 mi/yr) * 28 mi / gal ~= 46.1 million NGV, assuming all things equal

B. Wind Model Concept

- Monte Carlo simulation
  - 1,000 trials per timeline.
- Initial installed capacities are random
  - Normal distribution.
  - Mean is 2007 installed capacity.
  - Standard deviation is 5% of that capacity.
- Model uses the average of the 1,000 trials.

VIII. COST ANALYSIS

Using a bulk cost of $3 million per turbine [6] for General Electric's 1.5 MW turbine, and an upper bound of 600,000 turbines to have 900 gigawatts of installed capacity, we arrive at an upper bound for purchasing costs of $1.8 trillion. Assuming an average installation cost of $1,710 per kilowatt [7], this amounts to an installation cost of $1.5 trillion. Assuming an average interconnection cost of $457 per kilowatt [8], this amounts to $410 billion to connect 900 gigawatts of capacity. Assuming an average cost of $120 per kilowatt [9] to add sufficient transmission capacity, this amounts to $110 billion for 900 gigawatts. Assuming an operating and maintenance cost of $30.30 per kilowatt [10], this amounts to a cost of $27 billion per year to operate and maintain 900 gigawatts of generating capacity. This leads to an estimated total of $4.1 trillion after 10 years. This is significantly lower than T. Boone Pickens' stated estimate of $10 trillion, however, our estimate does not take into account any estimated costs of control systems to regulate surge capacity and delivery, costs to upgrade existing infrastructure, and numerous other costs which we can not estimate with any level of certainty.

No analysis was performed to estimate the cost of producing enough natural gas vehicles to reduce gasoline consumption by 20% from 2008 levels. As it is not technically feasible to produce enough natural gas vehicles in 10, 15, or even 20 years, the cost is irrelevant. It is possible to convert gasoline fueled automobiles to run on natural gas, but the cost is significant. Current conversion costs range from $12,500 to $22,500 [11] depending on the type of vehicle. With such a significant cost, it is unreasonable to expect American consumers to convert their automobiles to run on compressed natural gas.

IX. METRICS

We created a utility function to measure the feasibility of the Pickens's plan by weighting time, economic security, and environmental issue. We formulated an equation to relate the Plan based on a survey conducted by us. The equation consists of Time (T) that will be predicting if it's feasible to have the project finished within 10 years. The equation also consists of Economic security (Es), while having the jobs kept inside the U.S and lastly there is Environmental Issues (Ei) which will deal with reducing greenhouse gas emissions. The metrics for these underlying values for the categories are as follows:

- Time (T) is measured by:
  - Time to Produce 20% Electricity (years)
  - Time for 20% Reduction of Foreign Oil (years)
  - Time for NGV Production/Conversion (years)
- Environmental Security (Es) is measured by:
  - Increase of Jobs in U.S. (number of employees, maximize)
  - Increase GDP in U.S. (supply vs. demand)
- Environmental Issues (Ei) is measured by:

- Reduce Greenhouse Gas Emissions (grams, minimize)

X. CONCLUSIONS

Analysis of our wind models suggests it is not feasible to produce 20% of America's electricity with wind power in less than 20 years. This result renders our utility function ineffectual as there is only one feasible alternative. While T. Boone Pickens stresses manufacturing as much of this new infrastructure as possible inside the United States, this appears to be an infeasible expectation. To successfully produce enough wind turbines in 20 years it will be necessary to utilize all wind turbine producing companies, including those based in foreign countries.

Analysis of our automotive models suggests it is not feasible to reduce America's gasoline consumption by 20% solely through the production and sale of natural gas vehicles. Given a fleet replacement time of 15 years, historical new car sales numbers, and the number of natural gas vehicles needed, this requirement can not be met in 10, 15, or even 20 years. This model does not even take into account plummeting new car sales due to recent economic turmoil. Given a cost of $12,500-$22,500 to convert gasoline fueled automobiles to natural gas fueled automobiles, it is infeasible to expect large scale voluntary conversion by American automobile owners without significant tax subsidies.

ACKNOWLEDGMENT

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