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sources will further reduce the need for oil imports and thus lessen the impact of supply disruption and wild price fluctuations.

Conclusion: Adherence to this paper's proposed principles of energy security will ensure the cost-effectiveness, efficiency, and reliability of America's energy environment for future generations.

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**Energy Security: The Pathway to a Cost-Effective, Efficient, and Reliable Energy Future**

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MASTER OF MILITARY STUDIES

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## **Executive Summary**

**Title:** Energy Security: The Pathway to a Cost-Effective, Efficient, and Reliable Energy Future

**Author:** Major C. J. Basham, USMC

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## INTRODUCTION

Since the energy crisis of 1973, many in the United States government, special interest groups, and the general public have called for the country to move toward the concept of “energy independence.” President Nixon’s declared “war on oil” in the 1970’s, and a second energy crisis in 1979 deepened America’s determination to sever its ties to foreign oil.<sup>1</sup> President George W. Bush claimed in his 2006 State of the Union address that the United States was “addicted to oil,” which once again was a new call for action.<sup>2</sup> A vast majority of Americans believe energy independence is a goal we should achieve.<sup>3</sup> Due to several contributing factors, oil prices continued rising during the last half of the first decade of the 21<sup>st</sup> century, eventually peaking at \$147 a barrel in July 2008.<sup>4</sup> In light of these occurrences, on the surface, the energy independence argument seems logical.

Pundits of energy independence assert that the United States needs to rely solely on alternative and renewable domestic energy sources to avoid the effect of the fluctuation of crude oil prices on the national economy. Much of the energy independence rhetoric focuses on United States oil consumption through the use of gasoline. For example, the Energy Independence website, an independent publisher of news concerning energy independence, estimates that the United States consumes 20 million barrels of oil every day, 14 million of which is transportation fuel, and that over 60% of the transportation fuel is gasoline.<sup>5</sup> The website also states that the United States imports 30% of the oil it uses daily from the Organization of Petroleum Exporting Countries (OPEC).<sup>6</sup> The U.S. Energy Information Administration’s data supports these claims.<sup>7,8,9</sup> The website further claims that the technology and resources exist to replace gasoline worldwide, not in the distant or even near future, but today.<sup>10</sup>

Ideally, energy independence is an ambitious goal that would undoubtedly solve the economic issues tied to oil imports. Unfortunately for energy independence activists, the manufacture of infrastructure and technologies that could take advantage of oil replacements, such as synthetic alcohol touted by the energy independence website, would take decades to complete and consume as much, if not more, oil to produce.<sup>11</sup> Those who consider energy independence an unwanted or unattainable notion continually reference this argument. Even energy independence hardliners admit, “paradoxically, to build the energy economy that we want, we’re going to lean heavily on the energy economy that we have.”<sup>12</sup>

Doing nothing, though, would prove just as fatal. Many would also argue that maintaining the energy status quo is a sophomoric approach that would eventually cripple both the energy sector and the economy. Certainly the solution to the nation’s energy dilemma lies somewhere between these two extremes. A closer look at the principles of energy security could provide the answer.

## **ENERGY SECURITY AND ITS ROADMAP**

Definitions of energy security are as prevalent as they are different. Some liken energy security to adequate sources of oil, while others place emphasis on physical security of energy infrastructure. Many claim that energy security entails the support of developing the energy facilities to use bio-fuels and renewable resources.<sup>13</sup> While each of these definitions would promote energy security, they are incomplete. The United States must take a more extensive approach when devising its energy security policy.

In order for the United States to create a cost-effective, efficient, and reliable energy environment, energy security must be the focus of the government and the energy industry. This paper asserts that energy security is comprised of three principles. First, the United States must

continue to diversify its sources of oil, to include expanding its use of domestic reserves, to lessen its susceptibility to worldwide market supply interruptions. Second, the current energy infrastructure, or “grid,” must be modernized to guarantee reliable, efficient, and secure energy production. Finally, a move toward alternate and renewable energy sources is paramount for an economical and dependable energy platform.

## **DIVERSIFICATION OF OIL RESOURCES**

*“Safety and certainty in oil lie in variety and variety alone”<sup>14</sup>*

*-Winston Churchill*

### **WHERE DOES IT COME FROM?**

In 2008, the United States was the world’s third largest oil producer, but imported almost 57% of the oil it consumed daily.<sup>15</sup> Almost 50% of U.S. crude oil imports originate from the western hemisphere (Venezuela: 10.5%), while 20% arrives from the Middle East.<sup>16</sup> The U.S. Energy Information Administration estimates that the United States will cut oil imports by almost 20% in the next 20 years.<sup>17</sup> While campaigning, future President Barack Obama stressed the need for U.S. oil diversification as well as significantly decreasing dependence on oil imports from unstable or despotic regimes. The Obama-Biden comprehensive New Energy for America Plan aims to save more oil than currently imported from the Middle East and Venezuela combined within ten years.<sup>18</sup> In order to meet the President’s goals, the United States must focus on two areas. First, alternate and renewable sources of energy must be further implemented and developed (discussed in detail in a later section), and existing oil reserves which, until recently, were difficult or impossible to explore and unearth using cost-effective means, must be processed using new, innovative excavation techniques. Before that discussion, though, a brief explanation of why unstable regimes hinder the stability of the oil market is required.

## A GLANCE AT INSTABILITY

Obviously, supply and demand, or the perception of supply and demand, are main factors in the price of oil. Other recalcitrant and frequently unforeseen factors, like natural disasters (i.e. Hurricane Katrina) can significantly agitate the price for an undetermined period of time. Despotic or otherwise unstable governments that would use their position as leading oil suppliers can also potentially cause major shock waves throughout the oil trade. For example, Venezuelan President Hugo Chavez's attempt to consolidate his control over the state-owned oil company in early 2003 caused riots.<sup>19</sup> A reliable oil exporter since World War II, oil production was shut down as a result.<sup>20</sup> As of 2006, Venezuela's oil production remained 500,000 barrels a day below prestrike levels, which was estimated to be a greater impact on oil supplies than the war in Iraq.<sup>21</sup> Speaking of a despotic regime, Saddam Hussein-controlled Iraq produced 2.8 million barrels a day.<sup>22</sup> In 2008, Iraqi oil fields produced 2.4 million barrels a day.<sup>23</sup>

As of January 2009, Iran was the fourth largest exporter of oil in the world, sending 2.4 million barrels a day to countries primarily in the Middle East and Europe.<sup>24</sup> Iran has an estimated 10% of the world's total proven oil reserves.<sup>25</sup> As recently witnessed, threatening rhetoric from Tehran has promised supply disruptions due to imposed economic sanctions and the United States' stance on the construction of Iranian nuclear facilities. While disrupting supplies would arguably harm Iran's economy as much as its customers, it has not been reticent in its threats. A disruption in supply from Iran could cause serious shortages overseas and oil price fluctuations worldwide.

Russia's ability to process and export its abundant oil supply has been burdened by a variety of factors, including lack of productivity and instability within the government. Russia's oil fields have contributed nearly 40% of worldwide production increase since 2000, but internal

problems, including tenuous government policies and regulatory obstacles have slowed its production substantially.<sup>26</sup>

Lamentably, the world's most sought-after commodity lies directly beneath some of the most tyrannical and unstable regimes on the planet. Threats of supply disruption from any of these regimes could trigger significant oil price fluctuations. The United States must endeavor to diversify its sources among oil-rich regions with stable administrations and continue to expand its use of proven reserves.

### **WHERE AND HOW WILL “NEW OIL” BE RECOVERED?**

Recent technological updates in methods to discover and extract oil have incited a cautious optimism with regard to future oil supplies. The Arctic National Wildlife Refuge (ANWR) in Alaska, and the Bakken Shale in Montana and North Dakota possibly possess over 11.7 billion barrels of recoverable oil.<sup>27</sup> The Canadian tar sands are estimated to contain 173 billion barrels.<sup>28</sup> Further oil fields exist in the western hemisphere, including the Santos Basin, off the coast of Brazil (an estimated 15 billion barrels of recoverable oil).<sup>29</sup> Most recently, British Petroleum has discovered a new field in the Gulf of Mexico that might contain as many as 4 billion barrels.<sup>30</sup> (Note: Data is based on unproven estimates)

Clearly, the oil is there. Several new extraction techniques have been developed within the past five years to secure it. These advances hold the promise of lowering the cost of harvesting oil.<sup>31</sup> For example, ChevronTexaco has developed a faster, more efficient, and cost-effective way to discover oil.<sup>32</sup> 3D visualization labs allow ChevronTexaco geologists to explore vast swaths of suspected oil fields using cutting-edge computer imaging and screens similar to those used by IMAX systems.<sup>33</sup> This system nearly guarantees that ChevronTexaco will not have to “explore by drilling,” which could cost the company as much as \$40 million. This money

would not only be wasted on the worthless expedition, but also could not be invested on new digs.<sup>34</sup>

New techniques have produced positive results on the Alaskan North Slope as well. The latest breakthrough, dubbed through-tubing rotary drilled (TTRD) wells, involves drilling a new well through the production tubing of an older well.<sup>35</sup> By going through the old well, TTRD can save up to \$1 million per new well.<sup>36</sup> The technique of horizontal drilling runs long sections of tubing horizontally through thin layers of oil, and drain said oil through perforations at regular intervals along the pipe.<sup>37</sup> The majority of wells drilled on the North Slope are horizontal, and horizontal drilling is the preferred technique when penetrating oil-bearing, or tar sands.<sup>38</sup> Horizontal drilling is most beneficial for reservoirs that are shallow and spread out; horizontal drilling can drain large areas, which means fewer wells and less infrastructure are needed.<sup>39</sup> Coiled tubing units have alleviated the need to use drilling rigs in certain instances, and multilateral wells involve a new well drilled off of another; at its completion, both wells operate simultaneously.<sup>40</sup> Designer wells are drilled with a high degree of precision to target small pockets of oil.<sup>41</sup> Furthermore, advancements allowing tight turns while drilling have made designer wells even more accurate.<sup>42</sup> Each of these developments has aided oil producers in developing new reserves for \$2.50 a barrel.<sup>43</sup>

Exciting new advancements are on the horizon. According to Barton Smith, an economics professor at Rice University, giant off shore oil rigs will soon be a thing of the past. He claims that oil companies are moving toward robotics aided by submarine operations that will do all of the work on the ocean floor.<sup>44</sup> This will negate the disastrous effects of hurricanes and allow drilling in the deepest parts of the ocean.<sup>45</sup> These technologies will make oil fields in the Gulf of Mexico as well as the Atlantic Ocean more accessible.

The United States must be committed to not only diversifying its oil imports throughout stable regimes, but also to maximizing the potential of its own oil fields while continuing to explore for others. While diversification won't relieve the United States from dealing with price fluctuations, minimizing imports from volatile administrations will negate the specter of supply disruptions. The discovery and recovery techniques mentioned would aid in locating new reserves as well as accessing reserves previously believed to be inaccessible. Furthermore, the resultant cost-effectiveness of oil production will translate to the consumer, yielding lower prices. As cutting edge, cost-effective search and removal techniques are fielded, domestic oil reserves will increase and ease the burden of volatile import requirements.

## **THE SMART GRID**

*"We have a very antiquated (electric grid) system in our country. The current system is outdated, it's dilapidated."<sup>46</sup> The Smart Grid is something that has a transformational impact on how energy is delivered."<sup>47</sup>*

*-Carol Browner, assistant to the President for energy and climate change*

## **THE CURRENT ENERGY GRID**

The United States' energy generation and supply system is so massive it is difficult to comprehend. "The century-old power grid is the largest interconnected machine on earth, so massively complex and inextricably linked to human involvement and endeavor that it has alternately (and appropriately) been called an ecosystem."<sup>48</sup> Other engineering achievements developed during the 20<sup>th</sup> century, including the Internet and the federal highway system, pale in comparison.<sup>49</sup> It has been dubbed "the most significant engineering achievement of the 20<sup>th</sup> century."<sup>50</sup>

The system that has provided millions of megawatts of dependable generating capacity for nearly a century has become overburdened.<sup>51</sup> While still 99.97% reliable, power interruptions and outages cost an estimated \$150 billion each year.<sup>52</sup> Furthermore, transmission growth has lagged behind peak demand for electricity by 25% for over a quarter century.<sup>53</sup> Grid components are so interdependent that a failure of any one element could cause a cascading series of failures that could cripple any of our nation's vital infrastructure sectors.<sup>54</sup> The blackout that occurred in the northeastern United States in August 2003 is a prime example.

Undeniably, the nation's energy supply system that has served the country so well for many years is struggling to keep up with demand. It is vulnerable to massive blackouts that, due to its interconnectedness, wreak havoc far from the source. The economic impact from just a short interruption or outage is substantial. Massive blackouts comparable to those in the early part of this century can cripple entire regions of the country. As the United States' thirst for energy continues to escalate, our current system will continue to suffer failures.

Auspiciously, a modernized infrastructure that will revolutionize the concepts of energy production and consumption looms on the horizon. A move from a centralized, producer-controlled network to a decentralized, consumer-interactive network is imminent.<sup>55</sup>

## **WHAT IS THE SMART GRID?**

There are two concepts at the core of the Smart Grid: Advanced Metering Infrastructure (AMI) and Visualization Technology. AMI provides efficient electricity to the consumer and an early problem detection capability to the producer.<sup>56</sup> For example, real-time energy costs are relayed to "smart" home devices, such as thermostats, washers and dryers, or refrigerators. The devices then "power" based on the consumer's learned wishes. Because these systems work when the consumer wants with minimal human intervention, they are incredibly cost-efficient.<sup>57</sup>

While energy-producing systems are monitored closely on-site, currently there is little capability to integrate this information. The result is limited situational awareness.<sup>58</sup> Next-generation visualization technology will provide wide-area grid awareness, and other vital information such as weather conditions.<sup>59</sup> This technology will monitor the state of the power grid at the national level and be able to switch to the local level within seconds, as well as screen the grid for information on blackouts and power quality, all the while providing this information to utility providers at all levels.<sup>60</sup>

Electricity must be consumed the moment it's generated. The current system must estimate when the need for electricity will be at its highest, or peak, and place "peaker" plants online to meet the demand. Obviously, this process can be grossly wasteful. Compounding this fact, peaker plants sit idle for most of the year but still must be paid for.<sup>61</sup> The Smart Grid will give the operator greater situational awareness into the system, enabling operators to make informed, calculated decisions about peak, which will drive down costs and possibly eliminate the need for peaker plants altogether.<sup>62</sup>

In summary, the Smart Grid will provide reliable, cost-efficient, consumer-based electricity to users at all levels. Embedded in these concepts are stability and security, which will be vital as the need for on-demand affordable energy grows.

### **OK ...BUT WHAT'S REALLY IN IT FOR US?**

How exactly will the Smart Grid provide stable and secure electricity for generations to come? The grid system will provide five key features, including intelligence, accommodation, efficiency, end-user simplicity, and affordability; taken together, these attributes will bring a robust, secure, and effective energy system offering vast improvement to the current grid.

Many of the outages experienced on the current grid are not discovered until the user contacts the local provider. Delayed notification creates a ripple affect that ultimately costs both the consumer and producer time and money. The Smart Grid will be capable of sensing system overloads and outages, allowing it to minimize the length of, or altogether prevent a power outage.<sup>63</sup> Furthermore, the Smart Grid will work autonomously to detect, diagnose, and solve problems that will satisfy consumers, producers, and regulators.<sup>64</sup>

One of the many reasons that make the Smart Grid so attractive is its ability to accept energy from virtually any source.<sup>65</sup> These sources include oil, coal, and natural gas, which will dominate our energy supply in the near future. Wind, solar, and other sources of energy can also be accepted with transparency.<sup>66</sup> Moreover, since the Smart Grid is an open-ended system, emerging technologies, such as energy storage, can be easily integrated once market-proven and thoroughly developed.<sup>67</sup> The capability for growth and expansion will allow the seamless transition to other alternate and renewable energy resources as they are fielded, creating a truly adaptable and flexible system.

The Smart Grid must improve upon glaring inefficiencies within the current system. In order to completely implement the Smart Grid, an investment of an estimated \$1.5 trillion over the next 20 years into new infrastructure must be made.<sup>68</sup> While an investment of \$1.5 trillion in any endeavor is substantial, this commitment will produce a system that not only takes advantage of existing infrastructure, but also will pay for itself with its efficiency.<sup>69</sup> Smart Grid enhancements are estimated to increase the amount of energy through existing corridors by as little as 50% and as much as 300%.<sup>70</sup> Furthermore, allowing consumers to automatically reduce demand through emerging technologies and real-time pricing heightens the system's efficiency.<sup>71</sup>

A critical factor in determining the Smart Grid's ultimate success is its simplicity. Consumers are willing to engage with the Grid on their end if it doesn't interfere with their daily lives and leads to a smaller electric bill.<sup>72</sup> With its "set-it-and-forget-it" technology, consumers will spend an estimated two hours each year setting their energy preferences, allowing the Smart Grid to work on their behalf, all the while saving money.<sup>73</sup> Additionally, consumers will be able to see the price of energy before they buy, enabling them to make cost-effective energy choices in line with their daily lives.<sup>74</sup>

Intelligence, accommodation, efficiency, and end-user simplicity lead to affordability. As explained, instantaneous recognition of supply problems, plug-and-play capability with various energy sources, exploitation of current energy infrastructure, and "set-it-and-forget-it" technology will allow consumers to enjoy cost-effective energy with minimal input to the system. Producers benefit through the Smart Grid's minor additional infrastructure requirements and its much-improved efficiency. The advantages of implementing the Smart Grid should certainly outweigh the cost of implementing it.

## **THE SMART GRID IN ACTION**

Several communities have implemented portions of Smart Grid technology and seen immediate and remarkable benefits. For example, a Department of Energy (DOE) project on Washington's Olympic Peninsula allows consumers to set preferences in their user profile. Meanwhile, energy was transparently managed for the consumer to save money and reduce the impact on the grid.<sup>75</sup>

The results were remarkable. Consumers saved approximately 10% on their bills, while peak load was reduced by 15%, which created another three to five years of peak load growth.<sup>76</sup> Furthermore, this expansion allows the installation of more efficient supply technologies.<sup>77</sup>

In West Virginia, Allegheny Energy's super circuit project "demonstrates an advanced distribution circuit with improved reliability and security through integration of distributed resources and advanced monitoring, control, and protection technologies."<sup>78</sup> The super circuit will take advantage of biodiesel generation and energy storage integrated with a Wi-Fi capability in order to anticipate faults and quickly restore power with minimal impact on its customers. The resultant capability to ensure that only miniscule portion of the circuit's customers are effected during an outage will greatly improve reliability and affordability.<sup>79</sup>

The city of Fort Collins, Colorado, is establishing a Zero Energy District, which will demonstrate a system of mixed distributed resources to increase the use of renewables, such as solar, wind, fuel cells, and photovoltaics with the aim of increasing efficiency, reliability, and affordability.<sup>80</sup>

## **COMMITMENT**

As seen, many of the technologies that constitute the Smart Grid have been either implemented or demonstrated. In each case, results were achieved that promised efficiency, reliability, affordability, and expandability. Nevertheless, a nationwide commitment is required to see the Smart Grid to fruition.

President Obama made an aggressive stance on the improvement of our nation's energy infrastructure during his election campaign. This stance included an assertive push for Smart Grid technology.<sup>81</sup> In October 2009, the President announced an investment of \$3.4 billion of stimulus funds to modernize the electric grid.<sup>82</sup> Over 100 companies will receive grants to "help build a nationwide smart energy grid that will cut costs for consumers and make the nation's electrical system more reliable."<sup>83</sup> Furthermore, another \$4.7 billion has been invested by private donors to match the grant awards.<sup>84</sup> Additionally, in November 2009, the DOE announced it

would award \$620 million to 32 projects that demonstrate energy storage, smart meters, and a host of other “smart” innovations.<sup>85</sup>

The Obama administration’s campaign rhetoric has been followed by action. Myriad leaders at all levels of government understand the requirement for a new energy system. Not only will the Smart Grid necessitate a substantial investment of time and resources, it will also require a new way of thinking for the beneficiaries of the new system. As potential consumers of the Smart Grid become educated about its advantages, a more serious commitment will be made by an entire nation that will reap the rewards that the Smart Grid promises.

## **ALTERNATE & RENEWABLE ENERGY**

*We will harness the sun and the winds and the soil to fuel our cars and run our factories.*<sup>86</sup>

*-President Barack Obama, January 20<sup>th</sup>, 2009*

### **DEFINITIONS**

As of January 2004, renewable energy provided almost 14% of the world’s energy, mainly through biomass, and, through hydropower, almost 20% of its electricity.<sup>87</sup> These numbers may surprise many people. Though most casual conversations about energy inevitably turn toward alternate and renewable energy sources, many fail to understand what comprises alternate and renewable energy, how they’re being used, and their potential for growth. While most use “alternative” and “renewable” interchangeably, a subtle difference between the two exists that needs to be reviewed.

Alternate energy is “energy, as solar, wind, or nuclear energy, that can replace or supplement traditional fossil-fuel sources, such as coal, oil, and natural gas.”<sup>88</sup> Renewable energy consists of “any naturally occurring, theoretically inexhaustible source of energy, as biomass, solar, wind, tidal, wave, and hydroelectric power, that is not derived from fossil or nuclear

fuel.”<sup>89</sup> The definitions are nearly identical, and all sources of renewable energy can be considered alternate energy. Alternate energy, including nuclear energy, is not required to be naturally occurring or theoretically inexhaustible.

Furthermore, the energy conversations that discuss alternate or renewable energy naturally progress toward “why” we need these types of energy. The phrase, “we are running out of oil” is a common answer, even though oil has virtually nothing to do with electricity generation and almost everything to do with the production of transportation fuels. Nevertheless, oil is a vital part of our daily lives. So, are we really running out of oil?

### **ARE WE RUNNING OUT OF TIME?**

The argument that we need to quickly transition to alternative or renewable energy because oil will eventually run out is seemingly logical. After all, oil is a nonrenewable resource. Pundits argue that as demand for oil continues to grow, as evidenced by the emergence onto the oil market of regional Asian powers China and India, supplies will dwindle and eventually be depleted. China’s oil demand has increased by 11% yearly, and it will soon replace the United States as the world’s leading consumer of oil.<sup>90</sup> According to *The Oil Drum*, world oil production peaked in July 2008 and will continue to decline at a rate of 3-4% despite advances in drilling technology and the continual discovery of new oil fields.<sup>91</sup> Indeed, this simple mathematic formula spells doom for the oil industry.

Others claim that when oil and gasoline prices rise, those without a thorough understanding of the oil industry predict scarcity of supplies and the depletion of oil reserves.<sup>92</sup> As a matter of fact, world oil production continued to increase at the end of the previous century, the price of oil and gas, adjusted for inflation, were lower than they have been for most of the last 150 years, and estimates of the world’s oil reserves have increased more rapidly than they

have been used.<sup>93</sup> Furthermore, the United States oil reserves have remained nearly steady for the better portion of a century despite rising demand, and the world's proven oil reserves have increased nearly twentyfold in 70 years.<sup>94</sup> This data, assuming it is reasonably valid, reinforces the fact that higher oil and gasoline prices encourage new discovery and development.<sup>95</sup>

That's good news. After all, oil and its derivatives are used in thousands of products, not just gasoline for cars and airplanes. So, which argument is more convincing? Those who say that oil is not long for this world, or those that claim that oil will be readily available for the unforeseeable future? The answer is both, for the United States must hedge its bets. The technology and infrastructure to fully implement alternate and renewable energy sources is not in place, and oil's byproducts are the base for too many daily necessities for the United States to haphazardly rush out of the oil business. On the other hand, relying solely on nonrenewable sources of energy would be akin to a 20-year-old relying exclusively on Social Security benefits to fund his retirement. Too many other attractive, advantageous options exist. The United States must aggressively research and implement alternate and renewable energy sources while slowly reducing its dependence on oil. Many of these sources are already proven, or hold great promise.

## **NUCLEAR ENERGY**

Chernobyl. Three-Mile Island. Any mention of these facilities is likely to incite talk of grisly death and destruction of biblical proportion.

Such is the plight of the nuclear energy sector, even though deaths from the Chernobyl "disaster" have yet to reach fifty.<sup>96</sup> Facts about the industry, and not nervous innuendo spurred by ignorance, need to be promulgated in order for the American public to fully grasp the benefits of nuclear energy.

Currently, the nuclear power industry generates about 20% of the nation's electricity.<sup>97</sup> As a comparison, France generates about 75% of its electricity from nuclear power.<sup>98</sup> No nuclear plants have been ordered in over 30 years, and 100 have been canceled in that time. Energy produced at the 103 nuclear plants across the United States is more abundant than from oil, natural gas, and hydropower.<sup>99</sup>

Arguments against nuclear power, aside from the "nuclear armageddon" fallacy, include high production and regulatory compliance costs.<sup>100</sup> In addition, reactor security costs and spent rod storage are significant issues.<sup>101</sup> Reactors completed since the mid-1980's cost between \$2-\$6 billion, but the industry claims that new plants could be built for less than half that amount if identical plants were built in a series.<sup>102</sup> Furthermore, average operating costs have dropped considerably in the last decade, and plant downtime has been substantially reduced.<sup>103</sup>

The United States would be well served in expanding its nuclear energy program. With the cost of construction and operation dwindling, nuclear power can serve a significant amount of the nation's energy needs while further development of renewable energy resources is ongoing.

## **HYDROPOWER**

Hydroelectricity uses the mechanical conversion of the potential energy of water. In 2008, hydropower produced 6% of U.S. electricity and 67% of the electricity from renewable energy.<sup>104</sup> While an excellent source of energy, hydropower is not readily available to all consumers because of the higher elevations required to take advantage of the potential energy water provides.<sup>105</sup> Furthermore, to expand this industry, factors that must be considered include public acceptance of large dam construction projects, the displacement of local communities that the construction causes, and the possible interruption of food supply.<sup>106</sup> Nevertheless,

hydropower produces substantial amounts of electricity; both government and industry should look to expand where economically and socially feasible.

## **BIOMASS**

Biomass uses plant, animal manure, or municipal solid waste to create energy. Its sources are abundant, including forestry plantation, natural forests, agriculture residues and agro-industrial activities.<sup>107</sup> Two of the most popular sources of biomass energy are ethanol, derived from corn, and biodiesel, obtained from oilseeds. Biomass is readily abundant in most areas, and technologies currently exist to transform current and low-tech uses of biomass to energy.<sup>108</sup>

The United States has made a substantial commitment to the advancement of biomass energy through the Energy Independence and Security Act of 2007. This Act “raises standards for vehicle fuel economy and mandates that U.S. transportation fuel include 21 billion gallons of advanced biofuels by 2022 and 2 billion gallons as soon as 2012.”<sup>109</sup>

Skeptics of biomass cite a variety of issues that hamper the efficiency of the biomass industry. Take ethanol, for example. Some estimate that if the United States’ entire corn crop were used to create ethanol, less than one-sixth of the current fuel requirement would be produced.<sup>110</sup> In order for farmers to gain a foothold in the ethanol business and still sustain the food market, they’ve had to plant many more acres of corn, many times on land not suited for agriculture, “exacerbating erosion and other environmental problems.”<sup>111</sup> Furthermore, since corn is a chemically intensive commercial grain, the expansion of the industry created by the ethanol market has created problems involving water contamination.<sup>112</sup>

While problems exist in certain areas of the biomass industry, its abundance and widespread availability cannot be ignored. Future refinements in the production process will undoubtedly make the biomass industry a more viable and cost-effective energy source.

## SOLAR

Perhaps no other renewable energy source has been more readily accepted than that derived from the sun. Its potential to create energy is, in a word, astounding. The solar radiation received by the earth is many times greater than annual global energy use.<sup>113</sup> Solar energy is already used in a variety of ways, including the generation of heat, cold, steam, light, ventilation, and hydrogen.<sup>114</sup>

One way to convert solar radiation to useful energy is through photovoltaics (PV). Solar modules are the main conversion elements of solar energy systems, and currently several are in service, with efficiencies ranging from 12%-15%.<sup>115</sup> Developers believe the efficiency of these systems can be raised to as much as 30%.<sup>116</sup> Other systems, such as solar thermal electricity (STE) technologies, produce high temperature heat that produces the steam necessary to generate electricity.<sup>117</sup>

One argument, leveraged specifically against PV systems, is payback. Currently, it requires 3-9 years to gain back the energy required to manufacture a complete system.<sup>118</sup> The payback on solar-based home systems is 7-10 years.<sup>119</sup>

Nevertheless, solar energy has taken root in the United States, and will only continue to expand. The potential is enormous despite the current energy requirements of system production. For example, a building constructed using materials designed to benefit from renewable energy can receive 100% of its energy from solar power.<sup>120</sup> Through further refinement of existing solar technologies, and development of emerging technologies, solar power will become more cost-effective and efficient and provide a significant amount of electricity worldwide in the coming years.

## **WIND**

Another renewable energy source that most Americans have become familiar with is the energy derived from wind, signified by massive windmill farms scattered across the country. Obviously, a region's wind speed and frequency are the determinant factors in the amount of electricity that can be produced. Improvements in the integration between wind units and electricity infrastructure, windmill design, and the development of off shore wind farms have increased the efficiency, output, and potential of these systems.<sup>121</sup> In fact, in Germany, Spain, and Denmark, electricity production from wind turbines has increased by 30% a year for the last two years.<sup>122</sup>

Detractors of wind energy are mainly environmental, including noise emission, visual impact, its influence on bird behavior, and electromagnetic interference with radio, television, and radar signals.<sup>123</sup>

Advancements in wind technology, especially the development of offshore farms, will increase the attractiveness of wind power. Not only can offshore farms produce more electricity than most onshore systems, many of the environmental impacts can be avoided by moving wind farms to the oceans.<sup>124</sup>

## **PERCEPTION, PRICE, AND PERSISTENCE**

Alternate and renewable energy provides an enormous energy-producing potential, some of which has been highlighted in the previous discussion. To gain widespread acceptance, those in government and the alternate and renewable energy industry must convince their constituents that an aggressive push toward further researching and implementing alternate and renewable energy infrastructure is in their best interests.

Usually, that argument centers on gasoline prices, and is further bolstered when fuel prices skyrocket due to a spike in oil prices. On the other hand, those committed to the industry face dwindling interest when oil prices, and therefore gasoline prices, are low.<sup>125</sup> Furthermore, electricity generated from alternate and renewable sources tends to cost more to produce than energy from our traditional sources.<sup>126</sup> Further funding for research and development is required for improvements that will drive down the costs of using alternate and renewable energy.

Many state governments have enacted tough legislation that demands a certain portion of its energy come from alternate or renewable sources. For instance, by the end of 2010, 20% of California's energy must come from renewable resources.<sup>127</sup> Many other states have enacted similar measures. This trend must continue in order for alternate and renewable energy to gain a foothold.

## CONCLUSIONS

*“Energy will be one of the defining issues of this century, and one thing is clear: the era of easy oil is over. .... innovation, collaboration and conservation are the cornerstones on which to build this new world. But we can't do it alone. Corporations, governments and every citizen of this planet must be part of the solution as surely as they are part of the problem. And so, we ask you to join us.”<sup>128</sup>*

*-Statement from Chevron*

Colin S. Gray observes in the novel *Another Bloody Century* that “we humans are prone to use new technology in order to do more efficiently what we were doing already.”<sup>129</sup> New and abundant technology spurred both the industrial and Internet revolutions. The new technologies that comprise advanced drilling protocol, the Smart Grid, and alternate and renewable energy sources provide the source of the burgeoning Energy Revolution that the United States must embrace.

The implementation of these technologies will be challenging, comprehensive, and initially, expensive. A lack of detailed study of either the industrial or internet revolutions does

not preclude the prospect of reasonably assuming that introducing vast amounts of industrial machinery or computer processors was more expensive when first implemented than when their respective revolutions were in full swing. For instance, through continuing technological advancements, a computer that filled an entire room and was virtually cost prohibitive to the general consumer in the 1980's now fits in a pants pocket and costs only a small fraction of its ancestor. So it will be with the initial energy security technologies.

In order to succeed in this Energy Revolution, the United States must achieve and maintain energy security. Increasing oil imports from stable governments while endeavoring to increase production at home, implementing the Smart Grid, and furthering the use of alternate and renewable energy sources are the cornerstones of this policy.

Only through acceptance, innovation, research and development, and funding can the United States attain the requirements for energy security. This will not be simple or rapid process. Nothing worthwhile ever is.

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