Forecasting the Economic Impact of Fuel Cells

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Abstract— Fuel cells are promising energy carrier whose adoption would signify a radical change in which energy is produced, distributed and consumed. Growing attention is being devoted to this energy cycle in order to explore the possibilities offered to alleviate the susceptibilities and weaknesses of the present schemes. Hydrogen does not normally exist naturally in the world, but it can be used as an energy course to extract or store energy from relic fuels or intermittent renewable energy sources (RES) and then change it into electrical power and heat using fuel cells or combustion engines. It is therefore expected to play a key role in integrating future energy systems, bridging the transition from a largely fossil-based to a more RES-based European energy economy - with the advantages of diversified sources and sustainability. Used in conjunction with fuel cells for stationary, mobile, small portable or micro-power applications, hydrogen opens the real prospect of a paradigm shift in the provision of heat and power to the transport, residential and commercial sectors.

Index Terms— Social impact, economic analysis, solid oxide fuel cell, clean energy.

I. INTRODUCTION

A paradigm shift of that kind requires an in-depth analysis of the major technical, social and economic impacts that it will bring about. It is necessary to establish to what extent, and at what cost, moving to a hydrogen energy economy is achievable and realistic [1-3]. A political frame will have to be developed which embraces the planning, incentives and investment needed for moving towards a hydrogen-based energy economy. This study is an attempt to come up with some answers to these crucial questions. Natural gas and natural gas-related technologies are likely to dominate the scene for the next 10-20 years, but there are important uncertainties about gas prices as well as the vulnerability of an energy sector dominated by a carrier whose 60% of the world resources belong to a single exporter (Russia). These facts make it advisable to take the necessary steps to facilitate the transition towards a renewable/hydrogen system, i.e. the “hydrogen economy”. This system will require high financial resources, being, ultimately, almost purely capital-intensive. Here a clear divergence between scenarios arises. The analysis indicates that, apart from the necessary RTD effort targeting this long-term objective, appropriate financial mechanisms have to be put in place to facilitate the energy transition towards a fossil-fuel-free system [4-7].

Between all the potential application areas for fuel cells – portable, stationary and transport - the greatest investment will be in the change-over to a new generation of private cars. Their cost will be far higher than the cost of the new infrastructure. The use of hydrogen fueled transport will thus depend on consumer purchase of the fuel cell vehicles themselves as well as public and private investment in a widespread refueling infrastructure conforming to internationally-agreed standards of compatibility. Before that, fleet vehicle fueling stations for niche markets such as light-duty vehicles and buses and water- or rail-based applications would be introduced, particularly in environmentally sensitive areas. Forms of transport systems will also evolve over the same long-term period, with the introduction of clean urban transport such as neighborhood vehicles, scooters and three-wheelers, for which hydrogen-powered fuel cells may be ideally suited. The European Commission is currently drafting a Regulation21 relating to the type-approval of hydrogen powered motor vehicles, to allow their free circulation on public roads within the EU. The experience currently being gained on the development and mass-production of hybrid electric vehicle drivetrains can be fed forward to lower the costs of the equivalent components required for fuel cell vehicles. A detailed value analysis22 has provided projections for costs for volume production indicating lower overall vehicle cost because of the trade-offs on parts counts and systems simplification, and these now need to be proven. A breakthrough in battery technology could open a way to fuel cell/electric hybrid vehicles enabling downsizing of the fuel cell and allowing it to operate at a more constant load, thereby increasing its lifetime [11-19].

II. LITERATURE REVIEW

At the current rate of usage, the earth will be completely depleted of its oil reserves in the near future. As a result, alternative energy producing technologies must be researched and made available for public use. The transportation industry consumes a large portion of the world's oil reserves and contributes significantly to the emission of greenhouse gases [20-30]. It is for this reason that our company will research and develop a fuel cell energy source for use in the transportation industry. There are several positive impacts of fuel cell technology on society as it will fulfill the need to preserve the earth’s natural resources, reduce health impacts due to pollution and dramatically reduce the output of greenhouse gases [31-40]. However, the adoption of the fuel cell will negatively impact existing jobs and the cost involved with changing public attitude to accept the fuel cell unit is significant. This paper will discuss the positive and negative impacts on society relating to the adoption of fuel cells by the transportation industry. Our company will produce a fuel cell that uses natural gas as its fuel to create hydrogen gas. The reason for the use of natural gas is that it makes for lower emissions than other sources, such as methanol. The energy produced from the electrochemical process of ionizing hydrogen gas by injection of oxygen atoms will be harnessed as the output of the fuel cell unit [41-52]. This will reduce greenhouse gas emissions by 70% over the commonly used internal combustion engin. Natural gas fuel will be available at local refueling stations where one will also be able to expunge the remaining water from the fuel cell unit. The electrochemical reaction in which hydrogen gas is ionized

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will create enough energy to power a small vehicle. The fuel cell unit itself will be quite small, producing approximately 1 Volt, and therefore larger vehicles will require several fuel cells. This will allow our company to develop only one fuel cell model while being able to reach a large portion of the transportation industry market.

Does the transition to fuel cell technology would happen in near years and what is the social impact of that transition?

The DOE maintains a division dedicated to hydrogen-fuels research. Within that division, the Hydrogen Technical Advisory Panel (HTAP) conducts scenario-based planning to envision possible hydrogen-fuel developments. In a conference held in 2001, the HTAP identified two main drivers for hydrogen development and proliferation: the rate of social concern and activism and the rate of hydrogen-technology development.41 The panel developed four quadrants and story lines from these drivers to address the DOE's vision of a hydrogen-fuel-based society. Since the HTAP's work focuses primarily on DOE-related issues rather than Air Force issues, the scenario story lines developed by the panel are not particularly useful for addressing the service's concerns. But by using the HTAP's drivers and the methodology described in the Air Force's study Alternate Futures for 2025 (1996), one can derive four plausible fuel-cell worlds for the future (fig. 2).42

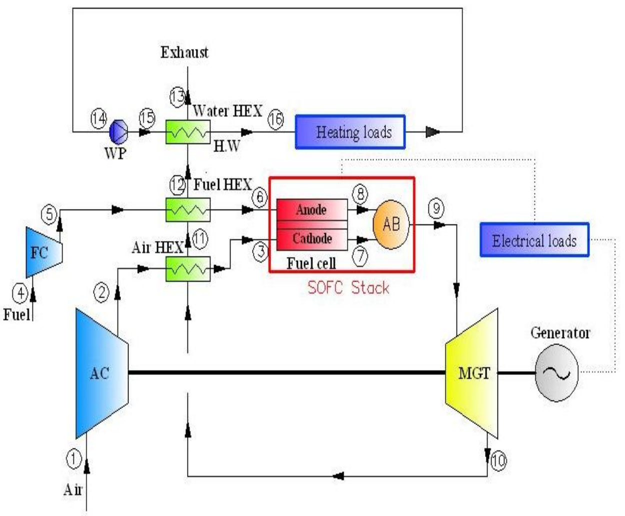

Figure 1. Fuel-cell Schematic

Greenpeace is a world characterized by increased awareness of global warming. The inhabitants of Greenpeace—situated at the axes of slow fuel-cell development and high social awareness—have taken to heart the destructive environmental effects brought on by mankind over the industrial age and early portion of the information age. Actively engaged in seeking to reduce greenhouse-gas production, Greenpeace has turned to several alternative forms of energy production to meet a still-increasing worldwide appetite for energy. In the Greenpeace world, social concerns drive energy alternatives. The success of the New Electric Car (NECAR5) initiative prompts the development of NECAR6. Publicity of the true costs of fossil fuels on the environment makes daily headlines. Although natural gas is a fossil fuel, the campaign promoting cleaner-burning fuels results in quick exploitation of vast reserves of methane hydrates on the US continental shelf in 2010. California's lead in requiring zero-emission vehicles becomes a national model in 2015. By 2020 Air Force base realignment and closure activities result in the consolidation and closing of foreign-operated facilities. Each "superbase" is powered by stationary fuel cells, maintaining autonomy from the commercial power grid. Concerns over national greenhouse-gas emissions force the closure of the last coal-fired power plant in 2025. Advances in photovoltaics, geothermal energy, and wind-recovery ensure that alternative-energy production eclipses that of conventional fossil-fuel facilities.48 Greenpeace is marked by slow fuel-cell development as a variety of energy alternatives emerge in a socially aware world.

Fuel cells exist in society and the military; however, their proliferation is but one facet of the alternate-energy equation. In 2002, capacities of 3 MW of stationary power evolved but only to the point where it was economically feasible for government-sponsored organizations to take advantage of this capability. Because the majority of fuel-cell progress occurs in transportation, fuel cells can power nearly all forms of transportation. Nevertheless, fuel cells remain a niche market in external power production as other alternatives emerge.

In a Greenpeace world, environmental concerns affect operations tempo, basing, and training. To satisfy increasing societal awareness, the Air Force will have to adopt energy alternatives. Fuel cells can provide stationary power and meet stationary requirements for deployed forces. But a slow rate of technological development means that fuel cells will continue to fill only secondary roles. The Air Force's fuel-cell investments will continue to leverage other government programs as well as commercial research and development.49 Finally, since the United States has not yet become self-reliant in terms of energy, it still expends vast sums of money protecting energy supplies.

Adversaries stand poised to take advantage of a Greenpeace world. Our historical indifference to environmental issues can be used against us in a major public-relations campaign directed at Air Force operations. As people worldwide become more socially active, we are apt to find ourselves objects of their ire. Furthermore, a global-environment movement that targets oil use holds danger for energy-producing alliance nations.

The Greenpeace scenario depends upon a dramatic increase in social awareness. How such awareness evolves becomes the key to getting to quadrant A. Assuredly, environmental groups will tout the benefits of fuel cells while decrying the destructive effects of traditional fuel sources. What causes this message finally to take hold may come from one of several sources. First, many countries are more "green" oriented than the United States. If our position in the world diminishes in the coming decades, those external views may become more prominent. Second, as members of a younger, more environmentally conscientious generation mature, their message may begin to take hold as they move into leadership positions. Additionally, if record warm-weather patterns continue, even detractors of global-warming theories may concede that fossil fuels adversely affect the environment. Finally, local, state, and federal governments may lead the environmental cause. The mandating and subsidizing of

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environmental issues may generate increased social awareness. Fuel-cell technology may make noticeable gains, but without increased social awareness, a pathway to Greenpeace is not possible.

In Fuel cell high social concerns and a fast rate of fuel-cell technology development converge. Fuel-cell capabilities advance rapidly as nations and corporations eagerly seek alternatives to fossil fuels. As technology development overcomes storage and distribution barriers, economies of scale allow wide proliferation of fuel-cell technology.

The DOE's hydrogen program succeeds in obtaining a massive infusion of federal dollars in 2005 (fig. 4).50 Social activism brought on by the election of 2008 results in a government mandate that all federal vehicles be powered by direct-methanol fuel cells by 2010. In 2012 the demand for oil exceeds supply, raising the cost of a barrel of oil to $100 and pump prices to five dollars per gallon in 2015.51 Advances in stationary fuel-cell power result in the Fuel Cell Proclamation Act of 2020 whereby all government facilities are removed from the power grid and fed by fuel cells. Lower Heating Value efficiencies reach 95 percent in 2025.52 Fuel-cell technology permeates all four corners of the globe, resulting in a true hydrogen economy and absolute, worldwide distributed power by 2030.53

Fuel cells are adopted as the primary means of power production. Society becomes truly all-electric as fossil fuels are abandoned in favor of the rapid development of hydrogen-fuel technology. Portable fuel cells become as common as AA alkaline batteries. The internal-combustion engine goes the way of the covered wagon because vehicles powered by fuel cells meet all cost and performance requirements. Lastly, stationary fuel cells achieve remarkable efficiencies, and a movement away from centrally based power production to distributed power production becomes standard.

In Fuel cell the Air Force will likely remain at the forefront of the transition from petroleum to hydrogen-based fuels. Large-scale government investment will allow the service to field state-of-the-art fuel-cell equipment, thus decreasing the logistical footprint of deploying forces and reducing overall airlift requirements. The increased reliability associated with electrical versus mechanical equipment means the Air Force will need far fewer maintainers in active service. Effects-based strategy needs to evolve from slogan to practice. Fuel cell does not diminish the military option; it just transforms how it is powered.

The transition from oil-based to hydrogen-based societies may cause increased tensions in the Middle East. As oil revenues decrease, peacekeeping requirements will likely increase. Distributed power generation worldwide forces a fundamental reassessment of Air Force doctrine. The production of electrical energy is no longer considered a center of gravity because there are simply too many energy facilities. Instead, storage and distribution networks gain increased strategic and operational importance. Finally, in Fuel cell the increased dependence on electronics and electronic controls increases the vulnerability of Air Force equipment to electromagnetic pulses. Without electromagnetically hardened equipment, everything from transportation to information is subject to disruption.

The path to Fuel cell presents the double challenge of increased social awareness and increased technology. Besides the environmental concerns, key technological hurdles must also be cleared. First among these is the efficiency of fuel cells. In the transportation industry, if cars powered by these devices can overcome problems associated with fuel storage, safety, and supply infrastructure, fuel cells will begin to move from government-led efforts to the mainstream. Second, fuel cells cannot achieve widespread public acceptance until they become commercially and economically viable. Government investment must bridge the development costs to true commercial viability and then advertise the successes to encourage new customers and investors to continue. Without an engaged public or three to four technological leaps, establishment of a pathway to quadrant B becomes less likely.

Characterized by low social activism and high technological development, the For a Price world presents fuel-cell opportunities to those who can afford it—namely governments and government-supported industries. While most Americans remain apathetic to decreasing fossil-fuel supplies and deteriorating environmental conditions, other countries—most notably Iceland, Germany, Singapore, and Japan—make rapid advancements in fuel-cell development. The US government and its departments capitalize on these advantages, primarily in the military arena, but overall costs compared to those for fossil fuels keep fuel cells from breaking into the mainstream.

In 2005 the Air and Space Expeditionary Force (AEF) Battlelab's early work on the Common Core Power Production spawns the first full AEF deployment of support equipment wholly powered by fuel cells (fig. 5). In 2010 solar-cell efficiencies allow the Air Force to test the first fuel-cell-powered UAV.58 The California and New York energy-deregulation experiments of 2000–05 fail miserably, resulting in enactments of government-subsidy programs. To advance additional research, industry leaders switch to a fuel-cell infrastructure for stationary-power distribution in 2015. By 2020 the North Atlantic Treaty Organization (NATO) reaps the benefits of member-nation research and adopts PEM fuel-cell standards for all ground-transportation vehicles.59 The year 2025 marks the first anniversary of Project Endure—the successful, continuous operation of a fuel-cell-powered UAV. With 176 nation-state signatories to the Kyoto protocols in 2012, fuel cells and other alternative technologies advance rapidly. However, since the Middle East and South America still supply 90 percent of the world's oil without interruption or price fluctuations, fuel-cell benefits remain limited to those customers outside the main power grid and other niche markets.61 Not until 2030 do fuel-cell costs per kW of energy produced break the $1,000 barrier.62 Fuel cells have been available over the past three decades; however, cost has prevented their introduction into mainstream commercial markets.Fuel-cell technology makes advances in portable, mobile, and stationary markets. However, American social pacifism prevents widespread concern or desire for environmentally friendly alternatives to fossil fuels. Accordingly, capabilities exist but only to those who can afford them. The US government sees utility in fuel cells and incorporates those technologies into specific

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military applications that require reliability and persistence. Adoption of common fuel standards for fuel cells allows more concentrated development, which nevertheless remains outside US influence.

The Air Force recognizes that fuel-cell development will not occur without government-led efforts. Even though rapid technological developments will not replace jet fuel in aircraft, the service still needs to capitalize on advances made by other countries in unique mission applications. Specifically, support equipment and UAVs are ripe for fuel-cell proliferation. UAVs powered by these devices allow for space like capabilities in persistence with substantially reduced costs.63 Benefits to the logistical tail run the gamut from maintenance to supply. With fuel-cell-technology applications primarily confined to governments, the Air Force stands to have a significant unilateral benefit in this scenario.

Until costs become competitive with conventional power production, fuel-cell usage is likely to remain confined to governments that can afford them. Because those governments tend to be democratic and because of increasing globalization, fuel cells offer the potential for greater national security. For our adversaries who take advantage of fuel cells in the For a Price scenario, distributed power assumes key importance. Energy infrastructure loses its desirability as a target. But if such targets are in fact attacked, the potential for collateral damage may well exceed the expected payoff or desired strategic effect. As a result, fuel cells become a means to achieve strategic ends against the United States.

To realize a For a Price world, similar technical breakthroughs to Fuel cell must occur. Those advancements are likely to come through government involvement because initial costs prevent extensive proliferation. However, the crucial issue in quadrant C remains social apathy. Diverse interests and attitudes keep Americans and the rest of the world largely uninvolved. America is often categorized as a “throwaway” society. Whether their attitude is based in fact or perception, the American public considers the country’s environmental policy largely “window dressing” rather than an effective plan. We consume most of the world’s energy, yet we comprise less than 5 percent of the planet’s population. Our reluctance to engage in environmental negotiations gives rise to world acrimony. Our affluence can make us indifferent to problems beyond our own borders. Additionally, rising nations—be they industrial or informational—spurn environmentally imposed mandates by citing the need for immediate progress rather than long-term effects. Finally, debate continues over the extent to which existing technologies affect the environment; this, in turn, delays the reaching of consensus in addressing problems on a global scale. As long as overall social apathy exists, fuel-cell developments are unlikely to transform the worldwide energy picture.

SOS is a world not too different from the one we live in today, distinguished by a low rate of social activism and low fuel-cell development. Research on alternative-energy technologies remains a minuscule portion of the federal budget. Indifference to the modest 1o C rise in global temperatures over the past three decades has only furthered global-warming debates. Fossil-fuel usage continues as the primary source of energy. Tensions over access to energy sources require continued US defense involvement around the world.

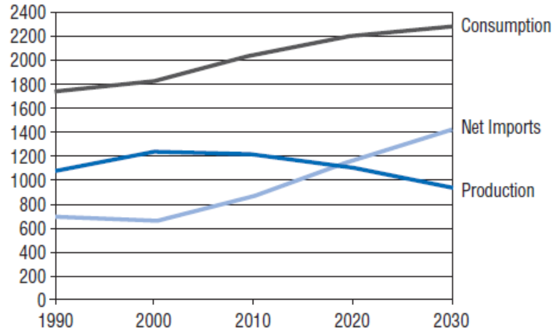

Figure. 2. European Union Total energy (in million tone)

As the federal deficit exceeds $7 trillion, a Balanced Budget Amendment passes in 2005, causing cuts throughout government. Notable among these is the cancellation of all DOE hydrogen projects.64 Oil-industry leaders, in cooperation with the Russian government, explores the vast Siberian region. An oil find estimated at 10 trillion barrels is announced in 2010. The Organization of Petroleum Exporting Countries responds by increasing production, causing gasoline prices to drop to 50 cents per gallon. In 2015 scientists in Antarctica report that the ozone hole has closed. In contrast to global-warming theories, the apparent cause is tied more to the 1980s ban on chlorofluorocarbons than on greenhouse-gas emissions. The Joint Strike Fighter achieves initial operational capability in 2020 and introduces JP-10 as the fuel standard. Not only does JP-10 meet all engine-performance requirements, but also its energy content is so high and flash point so low that it becomes the standard for auxiliary-power production. By 2025 the Army’s transformation process is complete, and a demonstration using a soda-can-sized fuel cell powers an office for one week.67 Further demonstrations lead to the building of a blimp for the modern age—the Hindenburg II—powered solely by fuel cells. However, in 2030 a freak accident reminiscent of the one that destroyed the dirigible’s namesake keeps fuel-cell technology confined to niche markets.

Fuel cells remain novelty items for most of the population. Like the progress of conventional battery technology in the last half of the twentieth century, fuel-cell efficiencies make only modest gains. Automobile makers offer fuel-cell alternative cars, but their range and refueling requirements make them less attractive than vehicles equipped with internal-combustion engines. Stationary fuel-cell power generation remains cost prohibitive to all but the most isolated or ecologically minded. The impending oil shortage never materializes, and fuel cells, as well as other energy alternatives, remain on the sidelines.

SOS is perhaps the most recognizable yet most dangerous of all the worlds discussed here. The Air Force can be expected to maintain the status quo relative to other nations. No impetus for revolutionary change exists. The notion of transformation or effects-based targeting has the potential to become the next “quality” movement—a mere slogan for each new service chief. Our dependency on foreign oil never wanes. Danger lurks around the globe as other countries make advances in alternative-energy sources and seek alliances

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based on assured-energy access. How we choose to respond will affect our vision and strategy for decades to come.

III. Analysis

The investment cost functions are listed in Table 1 for major components in terms of their design parameters.

Table 1: Cost functions for the major components of the SOFC-MGT system

Component	Cost function ($)
Compressor (centrifugal)	$91562(P_c/445)^{0.67}$
Gas turbine (radial)	$(-98.328\ln(P_{GT}) + 1318.5)P_{GT}$
Recuperator	$111.6(m_{HE})^{0.95}$
SOFC stack	$A_{tot,stack}(2.96T_{cell} - 1907)$
Inverter	$100000(P_{cell}/500)^{0.7}$
Generator	$60(P_{GT} - P_c)^{0.95}$
Auxiliary equipment	$0.1\ A_{tot,stack}(2.96T_{cell} - 1907)$
Heat recovery exchanger	$8500 + 405A_t^{0.85}$
pump	271.54m'+1094.7
After burner	(46.08 m')(1+exp(0.018T-26.4))/ ($0.995-P_r$)

The Payback period is defined as the time period necessary for the net income received from selling the output of a system (i.e. Electricity and recovered heat) after deductions to get well the initial investment prices of the particular system [26]. Regarding the time value of money, the worth of hybrid system capital investment as well as the fuel consumption costs in the pth year of running can be estimated from the following equation:

$$C_{invest,p} = C_{capital,m}\sum_{m=0}^{p-1}(1+i)^{p-m} + 3600N\dot{C}_{fuel}\sum_{m=1}^{p}(1+i)^{p-m}$$

where i is the annual interest rate and N is the number of running hours per year.

Using SOFC systems incorporating GT imposes additional expenses for investment and operational costs in comparison with that of conventional systems. These extra expenses arise from the capital and maintenance costs of the SOFC as well as the GT. The additional costs can be considered over time with reduction in electricity efficiency of the fuel cell (in comparison with that of conventional systems). But in this research the payback period is calculated by ignoring these additional.

The capital investment cost of plant (and of the hydrogen produced) depends on fuel and size, with cost increasing from natural gas to coal. For instance, for a hydrogen production capacity of 2.8 million Nm^3/day the capital cost of the plant ranges between 100 million € for natural gas to 300 million € for coal. The production cost of hydrogen, for different plant size with a cost of fossil fuel of 2-3 €/GJ for natural gas and 1-1.5 €/GJ for coal.

At present, hydrogen production costs from renewables are in the range of 10-20 €/GJ for biomass and 20-40 €/GJ by electrolysis (with electricity cost ranging from 0, 05 and 0.08 €/ kWh). In the long term these costs may be reduced to 9-12 €/GJ for biomass and 13-25 for electrolysis (with electricity cost of 0.03 and 0.06 €/kWh, the long term cost target for wind and PV respectively).

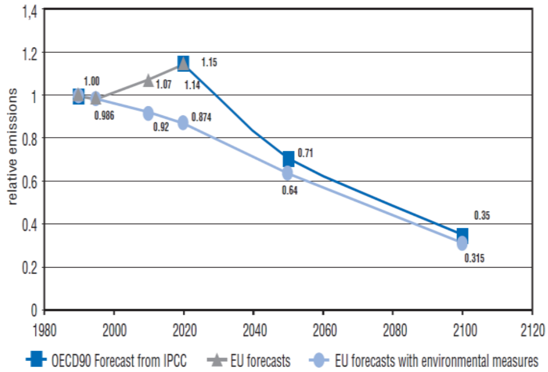

Figure. 3. Comparison between CO2 annual emission forecasts (referred to 1990)

Electricity generation in China shows a very strong dependency on coal due to their abundance in coal resources; approximately 79% of the total electricity is produced by coal-based power generation systems. U.S. and Germany also depend strongly on coal-based technologies, accounting for 44% and 49%, respectively. However in U.S. and Germany, natural gas and nuclear technologies are also widely employed in the range from 10% to 25%. Japan shows a relatively well-balanced energy mix in power generation; each quarter of the total electricity is generated from coal, natural gas, and nuclear resources, respectively. In Switzerland, two main contributors exist; 44% of the total electricity is generated by nuclear power plant, while 31% is produced by hydropower utilizing their geographical characteristics. France uses mainly nuclear technology, which accounts for 76.8% of the total electricity generation. In Norway, however, over 85% of the electricity is produced in hydro-power-plants.

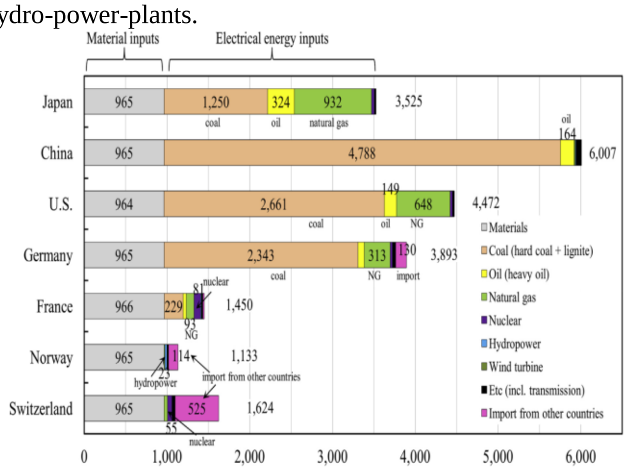

Figure. 4. Environmental impacts of system manufacturing using different energy mixes of electricity generation (seven different countries' data were selected for comparison).

IV. CONCLUSION

The transition to fuel cell technology would require a significant investment in promotion of fuel cell powered

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vehicles. It would be up to the government of Canada to put forth an incentive program for its citizens and companies to purchase fuel cell powered vehicles. Fuel cell powered vehicles will start out more expensive than internal combustion vehicles, but as demand for the former increases, the price per vehicle will decrease. It is for this reason that an incentive must be given to potential purchasers of these vehicles because otherwise they will simply buy internal combustion powered vehicles which are cheaper and more abundant. A large amount of the funds for this marketing operation would come from the currently allocated budget for Kyoto protocol compliance. The marketing campaigns would include information on how safe the fuel cell units are and how they positively affect the environment. For this marketing campaign to be effective it would need to be executed through print, radio, Internet and television media so that it meets all citizens of this country. The accelerated acceptance of fuel cell powered vehicles, or more generally, the acceptance of some alternative energy powered vehicles is absolutely necessary for Kyoto protocol compliance. The government may lose gas tax revenue and thus need to find funding for the promotion of fuel cell powered vehicles from increased taxes or cut spending in other sectors. While it would seem a reasonable idea to impose the gas taxes on natural gas, that would slow the adoption of fuel cell technology, rather than aid in accelerating it.

REFERENCES

1. Abdollahzadeh Jamalabadi, M.Y. (2015). Effects of micro and macro scale Viscous Dissipations with Heat Generation and Local Thermal Non-Equilibrium on Thermal Developing Forced Convection in saturated porous media, Journal of Porous Media, 18(9), 843-860.
2. Abdollahzadeh Jamalabadi, M.Y. (2015). Joule Heating in Low-Voltage Electroosmotic with Electrolyte containing nano-bubble mixtures through Microchannel Rectangular Orifice, Chemical Engineering Research and Design, 102, 407-415.
3. Abdollahzadeh Jamalabadi, M.Y., Ghasemi, M., & Hamedi, M.H. (2012). Two-dimensional simulation of thermal loading with horizontal heat sources, Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 226, 1302-1308.
4. Abdollahzadeh Jamalabadi, M.Y., Park, J.H., & Lee, C.Y. (2015). Optimal Design of MHD Mixed Convection Flow in a Vertical Channel with Slip Boundary Conditions and Thermal Radiation Effects by using Entropy Generation Minimization Method, entropy, 17(2), 866-881.
5. Abdollahzadeh Jamalabadi, M.Y., & Park, J.H., (2014). Effects of Brownian motion on Freezing of PCM Containing Nanoparticles, Thermal Science, OnLine-First Issue, 00 94-94.
6. Abdollahzadeh Jamalabadi, M.Y., Park, J.H., & Lee, C.Y. (2014). Thermal Radiation effects on the Onset of Unsteadiness of Fluid Flow in Vertical Microchannel Filled with Highly Absorbing Medium, Thermal Science, OnLine-First Issue 00, 124-124.
7. Abdollahzadeh Jamalabadi, M.Y., Ghasemi M., & Hamedi M.H. (2013). Numerical Investigation of Thermal Radiation Effects on Open Cavity with Discrete Heat Sources, International Journal of Numerical Methods for Heat and Fluid Flow, 23(4), 649-661.
8. Abdollahzadeh Jamalabadi, M.Y. (2013). Electrochemical and exergetic modeling of a CHP system using tubular solid oxide fuel cell and mini gas turbine , Journal of Fuel Cell Science Technology, 10(5), 051007.
9. Abdollahzadeh Jamalabadi, M.Y. (2016). Optimal Design of Cylindrical PBX by Entransy Dissipation Extremum Principle, International Journal of Energetic Materials and Chemical Propulsion, accepted for publication, 15.
10. Abdollahzadeh Jamalabadi, M.Y. (2016). Thermal Radiation Effects on Creep Behavior of the Turbine Blade, Multidiscipline Modeling in Materials and Structures, minor revision.
11. Abdollahzadeh Jamalabadi, M.Y., Park, J.H., Rashidi, M.M., & Chen J.M. (2015). Effects of Thermal Boundary Conditions on the Joule Heating of Electrolyte in a Microchannel, Journal of Hydrodynamics, Ser. B, accepted for publication.
12. Abdollahzadeh Jamalabadi, M.Y., (2015). Entropy generation in boundary layer flow of a micro polar fluid over a stretching sheet embedded in a highly absorbing medium, Frontiers in Heat and Mass Transfer, 6(1), 1-13.
13. Abdollahzadeh Jamalabadi, M.Y. (2014). The frequency response of a cavitating hydrofoil, Noise and Vibration Worldwide, 45(8), 21-27.
14. Abdollahzadeh Jamalabadi, M.Y. (2014). Analytical study of Magnetohydrodynamic propulsion stability, Journal of Marine Science and Application, 13(3), 281-290.
15. Abdollahzadeh Jamalabadi, M.Y. (2014). Experimental investigation of thermal loading of a horizontal thin plate using infrared camera, Journal of King Saud University – Engineering Sciences, 26(2), 159-167.
16. Abdollahzadeh Jamalabadi, M.Y., Park, J.H., & Lee, C.Y. (2014). Economic and environmental modeling of a micro gas turbine and solid oxide fuel cell hybrid combined heat and power system, International Journal of Applied Environmental Sciences, 9(4), 1769-1781.
17. Abdollahzadeh Jamalabadi, M.Y. (2014). Simulation of electrochemical impedance spectroscopy of a solid oxide fuel cell anodes, World Applied Sciences Journal, 32(4), 667-671.
18. Abdollahzadeh Jamalabadi, M.Y., & Park, J.H. (2014). Investigation of property variations on freezing of pcm containing nanoparticles, World Applied Sciences Journal, 32(4) 672-677.
19. Abdollahzadeh Jamalabadi, M.Y. (2014). Economic and environmental modeling of a MGT-SOFC hybrid combined heat and power system for ship applications, Middle-East Journal of Scientific Research, 22(4), 561-574.
20. Abdollahzadeh Jamalabadi, M.Y. (2015). MD simulation of Brownian motion on trapping of Buckminsterfullerene in nano-Optical tweezers, International Journal of Optics and Applications, 5(5), 161-167.
21. Abdollahzadeh Jamalabadi, M.Y. (2015). Numerical investigation of thermal radiation effects on electrochemical impedance spectroscopy of a solid oxide fuel cell anodes, Materials Performance and Characterization, DOI: 10.1520/MPC20140062.
22. Abdollahzadeh Jamalabadi, M.Y. (2015). Effect of fuel inject angle on the thermal behavior of a 2D axisymmetric non-premixed methane–air flame in vertical cylinder filled by porous media, International Journal of Energy Engineering, 5,1, 1-8.
23. Abdollahzadeh Jamalabadi, M.Y., & Park, J.H. (2014). Thermal radiation, joule heating, and viscous dissipation effects on mhd forced convection flow with uniform surface temperature, Open Journal of Fluid Dynamics, 4(2), 125-132.
24. Abdollahzadeh Jamalabadi, M.Y. (2014). Effect of fuel inject angle on non-premixed combustion of air/methane mixtures in vertical cylinder, International Journal of Multidisciplinary Research and Development, 1(5), 1-4.
25. Abdollahzadeh Jamalabadi, M.Y., & Park, J.H. (2014). Electro-Magnetic Ship Propulsion Stability under Gusts, International Journal of Sciences: Basic and Applied Research Sciences, 1, 421-427.
26. Abdollahzadeh Jamalabadi, M.Y., Hooshmand, P., Khezri, B., & Radmanesh, A. (2014). Investigation of using different fluids for using in gas turbine- Rankine cycle, Indian journal of Scientific Research, 2, 74-81.
27. Bita, S., Abdollahzadeh Jamalabadi, M.Y., & Mesbah, M. (2015). Toxicity study of silver nanoparticles synthesized using seaweed Sargassum angustifolium in common carp, Cyprinus carpio, Journal of Chemical and Pharmaceutical Research, accepted for publication.
28. Dadgostari, F., Hosseininia, M. (2012). Phasing of Traffic Lights in Urban Intersections. Graph Theory for Operations Research and Management: Applications in Industrial Engineering: Applications in Industrial Engineering, 257.
29. Dousti, S., Cao, J., Younan, A., Allaire, P., & Dimond, T., (2012). Temporal and Convective Inertia Effects in Plain Journal Bearings With Eccentricity, Velocity and Acceleration, Journal of tribology, 134(3), 031704,8.
30. Dousti, S., & Fittro, R.L. (2015). An Extended Reynolds Equation Including the Lubricant Inertia Effects: Application to Finite Length Water Lubricated Bearings, ASME Turbo Expo 2015: Turbine Technical Conference and Exposition.
31. Dousti, S., Kaplan, J.A., He, F., & Allaire, P.E., (2013).Elastomer O-Rings as Centering Spring in Squeeze Film Dampers: Application to Turbochargers, ASME Turbo Expo 2013: Turbine Technical Conference and Exposition.

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32. Dousti, S., Dimond, T.W., Allaire, P.E., & Wood, H.E. (2013). Time Transient Analysis of Horizontal Rigid Rotor Supported With O-Ring Sealed Squeeze Film Damper, ASME 2013 International Mechanical Engineering Congress and Exposition.
33. Dousti, S., Jalali, M.A., (2013). In-Plane and Transverse Eigenmodes of High-Speed Rotating Composite Disks, Journal of Applied Mechanics, 80(1), 011019.
34. Farahani, R.Z., Dadgostari, F., & Tirdad A. (2011). Future Trends in SCM.Supply Chain Sustainability and Raw Material Management: Concepts and Processes: Concepts and Processes, 82.
35. Farrokh, M, & Dizaji, M. S. (2015). Adaptive simulation of hysteresis using neuro-Madelung model, Journal of Intelligent Material Systems and Structures: 1045389X15604283.
36. He, F., Allaire, P.E., Dousti, & S., & Untaroiu, A. (2013). Forced response of a flexible rotor with squeeze film damper under parametric change, ASME Turbo Expo 2013: Turbine Technical Conference and Exposition, 1 (2013).
37. Hasani, R., Jafarzadeh, H., & Khoshalhan, F. (2013). A new method for supply chain coordination with credit option contract and customers' backordered demand. Uncertain Supply Chain Management, 1(4), 207-218.
38. Hassanzadeh, A., Mohseninezhad, L., & Tirdad, A., Dadgostari, F., Zolfagharinia, H. (2009). Location-routing problem. In Facility Location, 395-417. Physica-Verlag HD.
39. Hosseininia, M., & Dadgostari, F. (2013). Connectivity. In R. Farahani, & E. Miandoabchi (Eds.) Graph Theory for Operations Research and Management: Applications in Industrial Engineering, 37-47, Hershey, PA: Business Science Reference. doi:10.4018/978-1-4666-2661-4.ch004.
40. Hosseininia, M., & Dadgostari, F. (2012). Hamiltonian Paths and Cycles. In Graph Theory for Operations Research and Management: Applications in Industrial Engineering: Applications in Industrial Engineering, 96.
41. Jafarzadeh, H., Gholami, S., & Bashirzadeh, R. (2014). A new effective algorithm for on-line robot motion planning. Decision Science Letters, 3, 1, 121-130.
42. Joghataie, A., & Dizaji, M.S. (2009). Nonlinear analysis of concrete gravity dams by neural networks, In Proceedings of the World Congress on Engineering, 2.
43. Joghataie, A., & Dizaji, M.S. (2012). Designing High-Precision Fast Nonlinear Dam Neuro-Modelers and Comparison with Finite-Element Analysis, Journal of Engineering Mechanics, 139(10), 1311-1324.
44. Joghataie, A., & Dizaji, M.S. (2010). Transforming results from model to prototype of concrete gravity dams using neural networks." Journal of Engineering Mechanics.
45. Joghataie, A., & Dizaji, M.S. (2010). Reducing extent of cracks and increasing time to failure of concrete gravity dams by optimization of properties of layers of concrete." Scientia Iranica. Transaction A, Civil Engineering, 21.1 67.
46. Kaplan, J. A., Dousti, S., Allaire, P. E., & Nichols, B. R., Dimond, T. W., & Untaroiu, A. (2013). Rotor Dynamic Modeling of Gears and Geared Systems. In ASME Turbo Expo 2013: Turbine Technical Conference and Exposition.
47. Sarshari, E., Vasegh, N., Khaghani, M., & Dousti, S. (2013). Sliding Mode Control in Ziegler's Pendulum With Tracking Force: Novel Modeling Considerations, ASME 2013 International Mechanical Engineering Congress and Exposition.
48. Shahidian, A., Ghassemi, M., Khorasanizade, S., Abdollahzade, M., & Ahmadi, G. (2009). Flow Analysis of Non-Newtonian Blood in a Magnetohydrodynamic Pump, IEEE Transactions on Magnetics, 45(6), 2667-2670.
49. Shadloo, M. S., Poultangari, R., Abdollahzadeh Jamalabadi, M.Y., & Rashidi, M.M. (2015). A New and Efficient Mechanism for Spark Ignition Engines, Energy Conversion and Management, 96, 418-429. pp. 876—880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

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