H.K.E. Society’s

A V PATIL ARTS SCIENCE & COMMERCE COLLEGE ALAND"

A

PROJECT REPORT ON

"Determination of Ca concentration in cement "

2021-22

Submitted By B.Sc. Students

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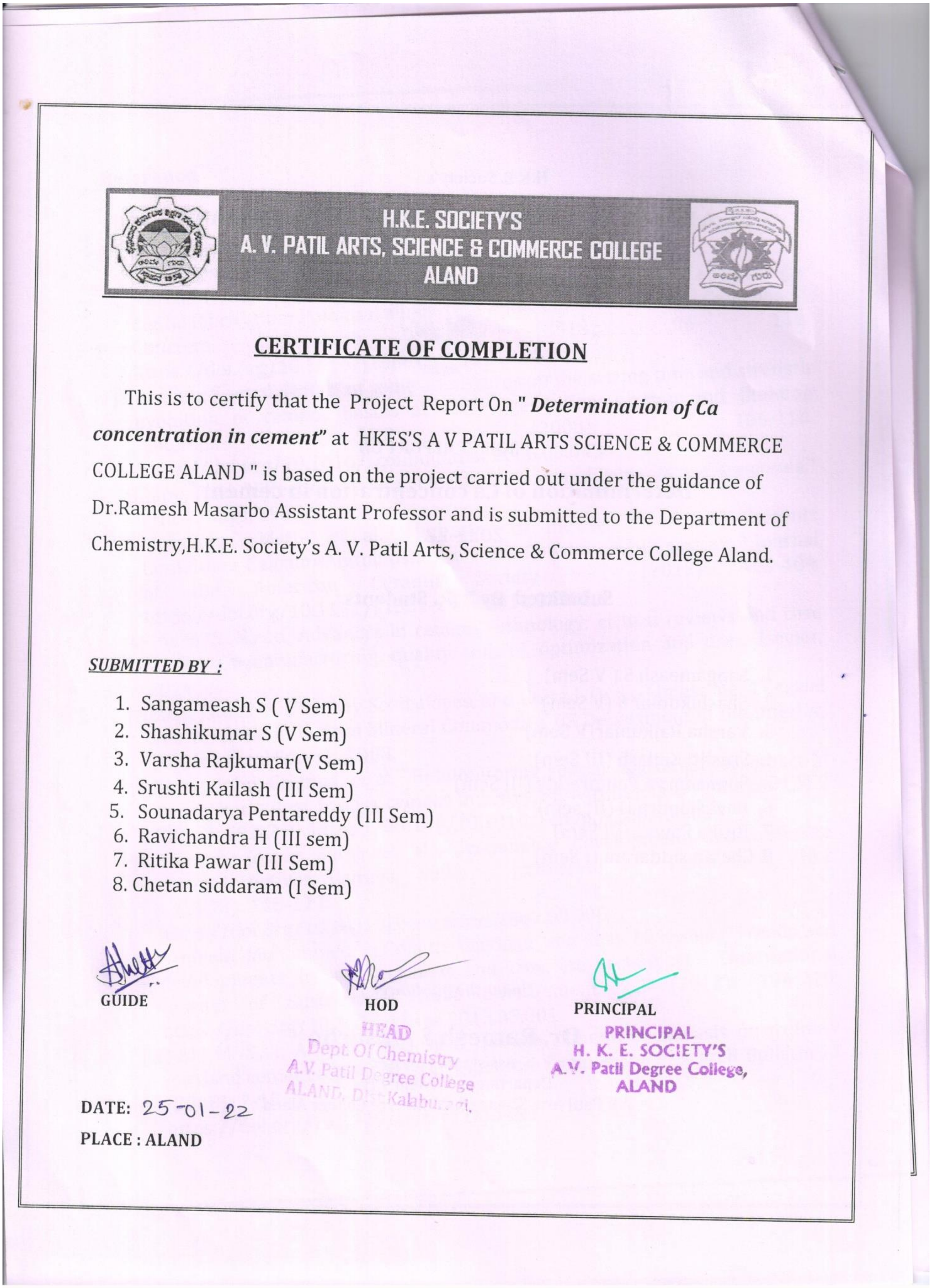

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CERTIFICATE OF COMPLETION

This is to certify that the Project Report On " ***Determination of Ca concentration in cement***" at HKES'S A V PATIL ARTS SCIENCE & COMMERCE COLLEGE ALAND " is based on the project carried out under the guidance of Dr.Ramesh Masarbo Assistant Professor and is submitted to the Department of Chemistry,H.K.E. Society's A. V. Patil Arts, Science & Commerce College Aland.

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I wish to express my sincere heartfelt gratitude to our Principal and other faculty of chemistry Dept. for the constant guidance and support in all areas. Without their guidance the outcome of this report would not have been so successful.

INDEX

Introduction

Portland cement is the most widely used around the world in the construction industry as a basic ingredient of concrete, mortar, stucco, and non-specialty grout [1]. Portland cement is a complex product obtained mainly from four main constituents; silicon (SiO_2), oxides of calcium (CaO), iron (Fe_2O_3), aluminum (Al_2O_3), and other ingredients (magnesium oxide (MgO) and sodium oxide (Na_2O)). Also, the common materials used to manufacture cement are limestone, shells,and chalk or marl combined with shale, clay. Calcium and magnesium oxides are importantconstituents controlling the physical performance of portland cements their accurate estimation is very important to assess the quality of cement. Calcium chloride's role is to increase the heat of the cement. However, the part of the total heat developed by the tricalcium aluminate was decreased. It is used as an accelerator in the hydration process of cement, leading to a quick set of concrete and to get high initial strength concrete [2]. Calcium chloride ($CaCl_2$) dissolves easily in water and offers many advantages such as an increase in early strengths and it speeds the rate of the set by improves the workability and improves the strength of air-entrained concrete. Therefore, it is widely used as a concrete accelerator. Concrete acceleration with calcium chloride combines to produce better quality concrete which greatly facilitates completing jobs as quickly and economically as possible [3].

Aluminum chloride, calcium formate, sodium chloride, potassium carbonate, and calcium chloride are used as accelerators for concrete but the calcium chloride was the most widely used. An accelerator leads to increases in the rate of development of certain characteristic properties of cement and concrete. In cement, the strength contributed by two compound tricalcium aluminate and calcium chloride which are decreased the time of set and increased the strength of the resulting concrete. Besides, the physical properties of cement were affected by the addition of calcium chloride. However, the optimum amount to be added are different for each types of cement and at various curing temperatures

Chemical composition of ordinary portland cement

S.No.	**Constituents**	**Range**%
1	Silica (SiO_2)	17-25
2	Calcium (CaO)	60-67
3	Alumina (Al_2O_3)	03-08
4	Iron (Fe_2O_3)	0.5-06
5	Magnesia (MgO)	0.5-4.0
6	Oxides of alkalis (Na_2O & K_2O)	0.3-1.2
7	Sulphuric Anhydride (SO_3)	2.0 -3.5

Cements Classification

Natural Cement

This type of cement is produced by calcining and grinding of the rocks, this naturally occurring to give up to 25% clayey (argillaceous) material of limestone which is also known as Roman Cement [34]. The calcining temperature for sintering and little tricalcium silicate C_3S produced is about (600 to 1220 ^oC). Therefore, strength development is slow [35]. However, the dicalcium silicate C_2S is considerable, the initial set and hardening are rapid in comparison with portland cement [36]. Natural cement is showed properties between that of Portland cement and hydraulic lime without any additional constituents are added to the production process.

Pozzolana Cement

Pozzolana cement is a materials which form hydraulic cementing materials by mixing with lime without the use of heat. These are made by simply mixing and grinding natural pozzolana (deposits of volcanic ash) and slaked lime used for making the construction walls and domes [37,38].

Slag Cement

Slag cement is made from blast furnace slag and hydrated lime which is containing up to 65 percent slag of mixture between portland cement and granulated slag. This cement set more slowly than portland cement used to a limited extent for making concrete in bulk construction where strength is relatively unimportant [39].

Portland Cement

Portland can be defined as an extremely finely ground product obtained by calcining together argillaceous (clay, containing) and calcareous (lime, containing) raw materials at about 1500 ^oC used for construction works [40]

1. Determination of Calcium by $KMnO_4$

In a small beaker 0.2 g of cement and 20 mL of HCl (1.1). The solution was heated over asbestos for 30 min, till cement is decomposed [Ca^{+2}] and converted into calcium chloride [$CaCl_2$], then 2–3 drops of methyl red indicator (color of the solution is red in acidic medium)was added. After that, 15 mL of ammonium oxalate solution and 10% NH_4OH were added slowly to the mixture till the color disappeared and calcium oxalate precipitated. The precipitate was filtered, washed by distilled water and, dissolved in 2 mL

H_2SO_4. The total volume is made up to 250 mL with distilled water in a flask. By pipette out, 2 mL of Ca^{+2} solution of cement sample into a conical flask and 10 mL of standard $MgSO_4$ solution then add 50 mL of distilled water and add 3 mL of buffer solution pH-10 (Table 3). The solution was heated to 40 °C. The indicatorwas added and titrate against EDTA till the color changes from red to blue.

Principle

The determination of calcium is carried out by converting it into oxalate, which is estimated by titrating against standard $KMnO_4$ solution, $KMnO_4$ solution is standardized by using a standard oxalic acid solution. In an acidic medium $KMnO_4$ oxalate ion into CO_2 gets reduced to Mn (II) ion. The rate of the reaction is increased as shown on heating (60-70°C) the oxidation is qualitative.

Standardization of $KMnO_4$

The solution of oxalic acid and $KMnO_4$ was prepared, $KMnO_4$ solution is standardized by titrating against the standard oxalic solution. In a flask, oxalic acid solution 25 mL and 20 mL of dil. H_2SO_2 (about 4N) then the solution was diluted.

Table 3. Amount of calcium present in different brands of cement

S.No.	**Samples**	**Weight g/250 mL**
1.	DUNCAN	0.132
2.	RAASI	0.012

2 Determination of Calcium by Substitution Method

Principle

Calcium ions are titrated with EDTA a relatively stable calcium complexes is formed

$$Ca^{+2} + H_2Y^{2-} \longrightarrow CaY^{2-} + 2H^+$$

The Ca^{+2} ion are alone no sharp endpoint can be obtained with eriochromeblak–T and thetransition from red to blue.

The magnesium indicator complexes are much more stable than the calcium indicator complexbut less stable than the EDTA complex. Consequently during titration of the solution in the presence of eriochromebalck–T, the EDTA reacts first with free Ca^{+2} ion then with free Mg^{+2} ions, and finally the complex wine-red color of solution changes from wine-red to blue at the endpoint.

Preparation of standard $MgSO_4$

1.54 g of $MgSO_4$ in a 250 mL standard flask was dissolved in distilled water and makeupsolution up to the mark.

Standardization of EDTA

Place instantaneously titration should be done slowly at the endpoint. Calculate the pipette out 20 ml of $MgSO_4$ solution into a 100 mL conical flask and add 5 mL of buffer solution of pH-10 then heat the solution to 40 degrees. Add 10 mL of E.B.T. indicator. After that, The prepared solution titrated with the EDTA till the blue color. However, the reddish color should be disappeared at the endpoint and the blue color appeared.

Table 4. Amount of calcium present in different brands of cement

S.No.	Samples	Weight g/250 mL
1.	DUNCAN	0.122
2.	RAASI	0.014
3.	VISHU	0.022
4.	MAHAGOL	0.025

Results and Discussion

Calcium was determined by titrating with complexing agents such as ethylenediamine tetraaceticacid (EDTA) using visual and photometric techniques. They showed that all the selected cement were contained the calcium oxide (CaO) content within the standard value. Among the four selected cement samples, Duncan cement was found to contain the highest percent content of CaO while Raasi and Vishu cement showed the least percent content of calcium oxide (CaO) in both methods.

The major factor and main component of cement quality is calcium oxide (CaO). As shown in Table 5, the calcium content present in the four selected cement which determined by two methods. It is determined by severe analytical techniques. Complexometric titration with EDTA is one of the analytical techniques to determine calcium oxide and it is used usually to find the total magnesium and calcium content of milk, seawater, and various solid materials. This technique may apply to find out the total hardness of freshwater provided to the solution. EDTA was used in this method which forms a complex with calcium and magnesium ions and the indicator was a blue dye Eriochrome Black T (EBT), which is in charge of changing colour to pink during the titration. The EDTA–metal ion complex showed high stability than the dye-metal ion complex. Therefore, the solution containing the calcium ion reacts with an excess of EDTA to form a complex with the EDTA. The indicator was responsible for the colour changes from red toblue.

$$Ca^{2+} + EDTA^{4-} \rightarrow [Ca\text{-}EDTA]^{2-}$$

The interferences are mainly caused by cations of the calcium, aluminum, manganese, and iron, with EDTA to form the complex. Apart from these, the metals also react irreversibly with indicators. The secations also give rise to color change in the indicator, making it difficult to detect the endpoint. However, the calcium oxide determined in a different types of cement and compared between them (Table 5).

Amount of calcium present in $KMnO_4$ and substitution method for the same brand

Samples	**$KMnO_4$**	**Substitution**
DUNCAN	0.132g	0.122 g
RAASI	0.02g	0.014 g
VISHU	0.023g	0.022 g
MAHAGOLD	0.028g	0.021 g

The amount of calcium present is different for the same sample that’s lead to prove the estimation by $KMnO_4$ is more accurate than another method (Table 3). Therefore, the quality of cement is one of the important factors which is depending on the amount of calcium to produce, the strength, and the durability of structural concrete.

Conclusion

The level of calcium oxide (CaO) in the selected cement samples gave a positive result, especially DUNCAN cement demonstrated the highest percentage of calcium content among others. However, the determination of calcium by $KmnO_4$ method was more accurate than the substitution method.

The strengths of cement are affected by calcium chloride percentage, especially when the cement composition within the range is encountered in commercial portland cement. The various types of cement are different in the amounts present of CaO, MgO, $Ca(OH)_2$, and $Mg(OH)_2$. Chemical compositions, among other factors are the most performance of producing a high quality of cement. This study aimed to determine the presence of calcium quantity in four different types of cement and study the calcium effect on its chemical constituents

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PROJECT REPORT ON

" Hydrogen fuel cell technology & progress "

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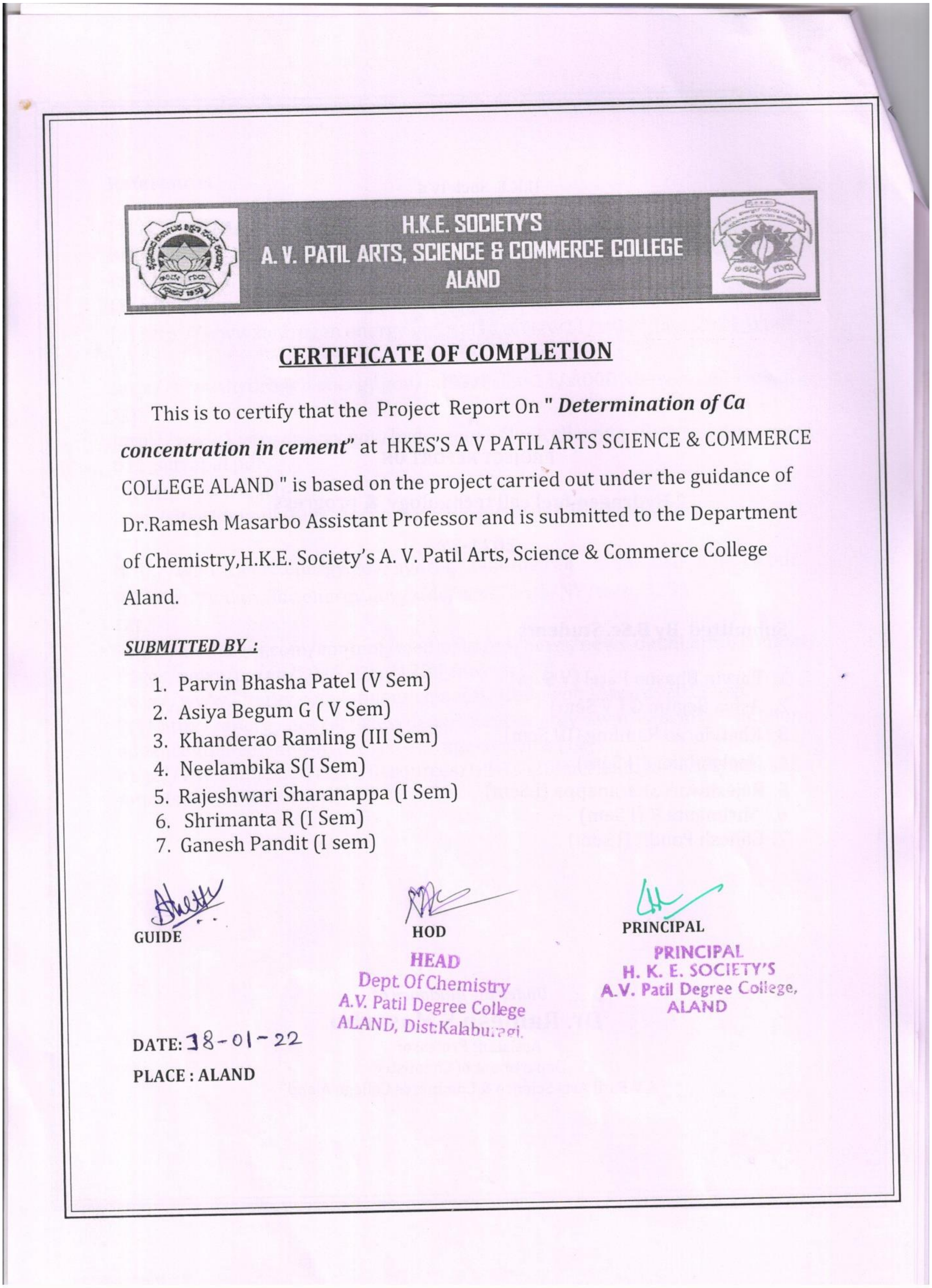

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Introduction

The Department of Energy’s (DOE) hydrogen and fuel cell activities are presented, focussing on key targets and progress. Recent results on the cost, durability, and performance of fuel cells are discussed, along with the status of hydrogen-related technologies and cross-cutting activities. DOE has deployed fuel cells in key early markets, including backup power and forklifts. Recent analyses show that fuel cell electric vehicles (FCEVs) are among the most promising options to reduce greenhouse gas emissions and petroleum use. Preliminary analysis also indicates that the total cost of ownership of FCEVs will be comparable to other advanced vehicle and fuel options.

The Department of Energy’s Office of Energy Efficiency and Renewable Energy invests in clean energy technologies to improve the economy, protect the environment, and reduce dependence on foreign oil. A single approach cannot solve the energy challenges facing the nation, so DOE supports research and development of a portfolio of clean energy technologies. Hydrogen and fuel cells are an integral part of the clean energy portfolio. Hydrogen can be produced from a number of diverse domestic resources, and fuel cells can generate electricity efficiently from a number of fuels, including biogas, natural gas, propane, methanol, diesel, and hydrogen.

1. Global view of fuel cells and clean energy technologies

1.1. Need for clean energy technologies

The Department of Energy's Office of Energy Efficiency and Renewable Energy invests in clean energy technologies to improve the economy, protect the environment, and reduce dependence on foreign oil. A single approach cannot solve the energy challenges facing the nation, so DOE supports research and development of a portfolio of clean energy technologies. Hydrogen and fuel cells are an integral part of the clean energy portfolio. Hydrogen can be produced from a number of diverse domestic resources, and fuel cells can generate electricity efficiently from a number of fuels, including biogas, natural gas, propane, methanol, diesel, and hydrogen.

DOE's Fuel Cell Technologies (FCT) Program supports a balanced portfolio of activities that address various near-, mid-, and longer-term applications for fuel cells. The fuel cell subprogram supports R&D efforts to reduce cost and increase durability of fuel cells used in transportation, stationary, and portable applications. The hydrogen fuel subprogram supports efforts to generate hydrogen from renewable resources, and reduce the cost to store and deliver hydrogen. This paper will describe the R&D efforts as well as cross-cutting activities in the Fuel Cell Technologies Program.

1.2. Fuel cell markets

Various analyses project that the global market for fuel cells could mature in the next 10–20 years, with revenues in the billions of dollars per year for stationary, portable, and transportation applications. Increased market penetration could lead to almost 200,000 jobs in the US by 2020 and almost 700,000 jobs by 2035 [1]. In the near term, all applications of fuel cells need federal support. Applications of hydrogen and fuel cells in which a value proposition can be found, such as emergency backup power and forklifts, need less federal support and can be commercialized sooner. The technology for other applications, such as portable power, is not as mature and will need continued federal support. In the near term, all applications of hydrogen and fuel cells need federal research and development (R&D) support.

Interest in clean energy technologies, such as fuel cells, solar, wind, hybrid electric, biofuels, hydrogen, and geothermal, has been growing in recent years [2]. A measure of the level of interest of private industry is the number of patents issued for innovative concepts. The number of US patents for clean energy technologies in 2011 was at an all-time high of 2,331, i.e. 24% higher than in 2010. The most clean energy patents were for fuel cell technologies, with twice as many as the second-place holder, solar, which had just ~360 patents in 2010 and ~540 in 2011. In the marketplace, there has been a 36% increase in MW shipped globally, and a 50% increase in MW shipped in the US from 2009 to 2010.

2. The DOE Hydrogen and Fuel Cells Program

2.1. Hydrogen production and delivery

The Fuel Cell Technologies Program is pursuing a number of pathways to generate hydrogen for fuel cells. These pathways include both distributed production in the near term and central production in the long term. The Program's hydrogen threshold cost is \$2–4/kg, to be competitive with advanced hybrid vehicles. Electrolysis, bio-derived liquids, and natural gas reforming can generate hydrogen in the near term. The projected high volume cost of hydrogen produced by these pathways is seen in Fig. 1. The cost includes compression, storage, and dispensing for distributed technologies, and the cost of delivery is included for central production. The ranges correspond to variability in the price of the feedstock. The pathways envisioned for central production include electrolysis and biomass gasification. The costs of producing hydrogen from those pathways need to come down significantly to reach the threshold cost and be competitive with the cost of other fuels. One of the biggest issues preventing the wide adoption of hydrogen-powered fuel cell vehicles is the lack of infrastructure. Several options for early hydrogen infrastructure have been proposed. In the first option, hydrogen is produced at a central location and then delivered to the point of use. In this case, hydrogen would be delivered by a tube trailer to a station at which a low volume of hydrogen, ~200–300 kg/day, is sold; would cost less than \$1 million; and provide hydrogen for around \$7/kg. In the long term, the volume would increase to 400–500 kg/day and the hydrogen would cost \$5/kg. The second main option would be distributed production, in which hydrogen is produced at the point of use and generated by steam methane reforming or electrolysis. Other options include trigeneration, in which hydrogen is co-produced along with heat and power from natural gas or biogas feedstock.

2.2. Hydrogen storage

The Program is looking at several options to store adequate amounts of hydrogen onboard fuel cell vehicles. In the near term, compressed gas storage is the cheapest option; however, the cost of the tank still needs to be reduced. A cost analysis of Type IV tanks produced at high volume shows that more than 75% of the cost of the tank is due to the carbon fiber layers, and of that, 50% of the cost is from the precursor [3]. Efforts are being made to reduce the cost of the precursor and find ways to reduce the amount of carbon fiber needed without sacrificing safety. Currently there are hydrogen-powered fuel cell vehicles that have a range more than 250 miles; one vehicle from Honda traveled more than 430 miles on one fill. In the long term, hydrogen will be stored using materials such as chemical hydrides, metal hydrides, or sorbents. The Program has evaluated more than 400 material approaches in the laboratory. Fig. 2 shows the current status of gravimetric and volumetric capacity of 5.6 kg hydrogen storage systems including chemical hydrides, metal hydrides, sorbent and physical storage [4]. While some targets have been met, not all the storage targets have been met by a single technology simultaneously.

2.3. Fuel cells

One of the key issues preventing mass commercialization of fuel cells is the high cost of the system. The Program monitors the cost of 80 kW fuel cell systems for transportation applications to assess progress in its R&D efforts. The cost is projected to 500,000 units produced per year. In 2011, the projected cost of an 80 kW fuel cell system for light-duty vehicles was $49/kW [5], higher than the target of $30/kW required to be competitive with today's vehicles. The projected cost is more than 30% lower than the estimate in 2008. Since the introduction of fuel cell vehicles will be at a volume lower than 500,000 units per year, the cost was projected at different manufacturing rates

[5]. At 1000 vehicles per year, the system cost is around $219/kW, whereas at 30,000 vehicles per year, the cost is $82/kW.

2.4. Technology validation

The Technology Validation subprogram evaluates the performance and durability of hydrogen and fuel cell systems under real-world operating conditions. Past activities in the subprogram include driving fuel cell vehicles on the road and on dynamometers, dispensing hydrogen from refueling stations, and then assessing the status and progress of each technology. Since the Learning Demonstration effort began, the fuel cell electric vehicles were driven over 3.6 million miles and they operated ~2500 hours on average. Over 151,000 kg of hydrogen were produced or dispensed at the stations, although not all of the hydrogen was used in the Learning Demonstration vehicles. The evaluation effort has since expanded to other types of fuel cell vehicles, including fuel cell buses in cooperation with the Department of Transportation and forklifts located at a Department of Defense warehouse. The Technology Validation subprogram also monitors the performance and durability of stationary fuel cells.

The National Renewable Energy Laboratory (NREL) has evaluated data from the Technology Validation Program and from the fuel cells deployed using funding from the American Recovery and Reinvestment Act of 2009. NREL partners with end-users and fuel cell developers to create data sets and composite data products of the fuel cell systems operating under real-world conditions. NREL found that the fuel cell systems in backup power operated 1100 hours on average, with a projection to 2400 hours for a 10% degradation in voltage (a metric created to monitor durability at a set current density). Fuel cell vehicles averaged ~2700 hours of operation, with a projection of 4000 hours for a 10% drop in voltage, which is approaching the DOE durability target of 5000 hours for transportation fuel cells. Fuel cell powered forklifts operated more than 4000 hours with a projected time to 10% voltage drop of almost 15,000 hours, while fuel cell systems used for prime power (1–10 kW_e residential combined heat and power and distributed generation fuel cell systems) operated ~7000 hours, with over 11,000 hours projected to 10% voltage drop. For short stacks, NREL found that the projected hours are between 3000 and 5000 hours for all applications except prime power. For the complete systems, the fuel cell systems providing prime power and backup power lasted ~6000 hours, whereas fuel cell systems in forklifts were projected to last 17,000 hours.

A very promising new activity in the Program is a combined heat, hydrogen, and power (CHHP) system, installed at the Orange County Sanitation District in Fountain Valley, California. The fuel cell system operates on hydrogen from anaerobic digestion of municipal wastewater, and is illustrated in Fig. 3. The unit generates heat, electricity, and hydrogen with 54% efficiency (hydrogen plus power) when operating in hydrogen co-production mode. With a compressor located onsite, the unit can provide 100 kg/day to refuel fuel cell vehicles. The public-access dispensing station was established by the project team of Air Products, FuelCell Energy, and the National Fuel Cell Research Center at UC Irvine.

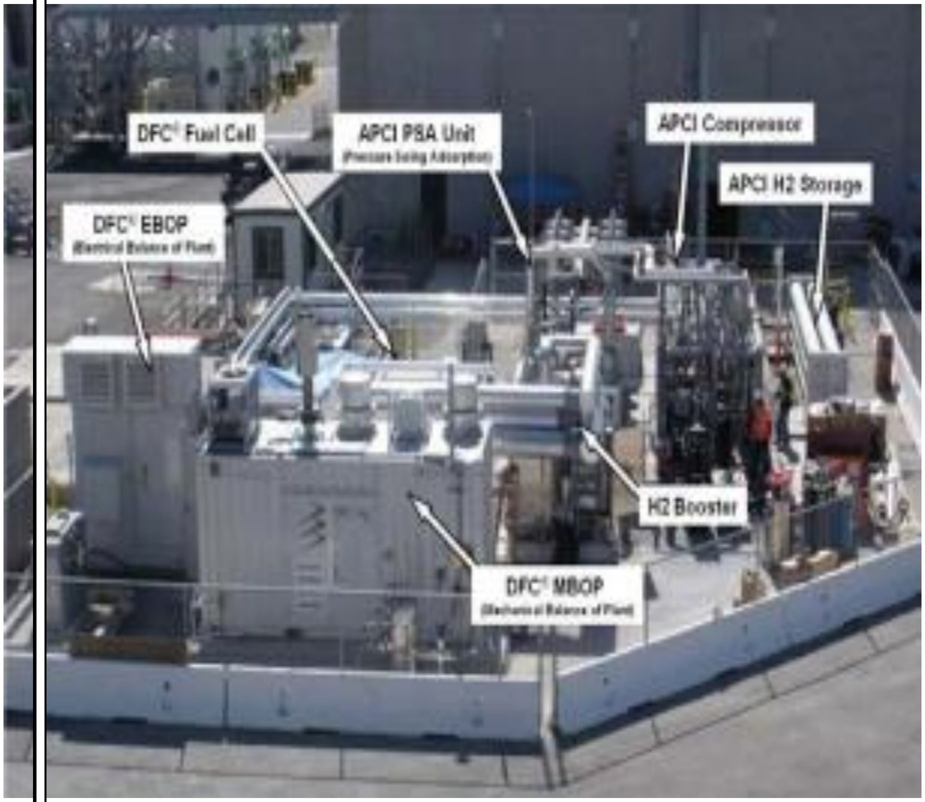

Fig. 3. Combined heat, hydrogen, and power (CHHP) system at the Orange County Sanitation District in Fountain Valley, California.

2.5. Market transformation

In 2009, the Fuel Cell Technologies Program awarded ~$42 million of funding from the 2009 American Recovery and Reinvestment Act (ARRA) to deploy fuel cell systems around the United States. The US Congress passed the ARRA to create new jobs in the US and save existing ones, spur economic activity, and invest in long-term economic growth. Including industry cost-share, the total funding for fuel cell deployment is $96 million. The fuel cells were deployed in the following early market applications: materials handling, backup power, residential and small commercial combined heat and power (CHP), portable power, and auxiliary power. More than 1000 fuel cell systems are currently operational, and the majority are used for backup power at telecommunications sites and in forklifts for materials handling. Most of the fuel cell systems are deployed in California, Pennsylvania, and Texas. As of December 2011, the forklifts had been operated for almost 1 million hours. The ARRA projects were quite successful in the case of the forklifts, as the companies which used them now plan to deploy more than 3000 additional fuel cell-powered forklifts on their own, without federal funding. Compared to conventional forklifts, the maintenance cost of fuel cell-powered forklifts is lower, the labor cost to refuel the forklift is much lower, and the net present value of the total system cost is lower. In addition, the fuel cell-powered forklifts generate less greenhouse gases than conventional internal combustion engine (ICE) and battery electric forklifts.

3. Analyses

3.1. Well-to-wheel analyses

Figure 4 shows the greenhouse gases emitted in grams per mile for a variety of vehicles and fuels. The vehicles include conventional internal combustion engine (ICE) vehicles with today's technology, and also hybrid electric vehicles (HEVs) and plug-in HEVs, battery electric vehicles (BEVs), and fuel cell electric vehicles (FCEVs) with propulsion technology assumed to be available in 2035. The fuels include gasoline, natural gas, hydrogen, and US Grid Mix electricity. Conventional IC engine vehicles fueled with ultra-low-carbon fuels from renewable resources and fuel cell vehicles running on hydrogen from biomass emit the least amount of greenhouse gases.

Additional analysis was carried out to determine the amount of petroleum energy consumed to propel a vehicle one mile, again for various types of vehicles and fuels. The results are shown in Figure 5. The most fossil fuel is used by conventional ICE vehicles fueled by gasoline. Battery electric vehicles, operating on electricity from ultra-low-carbon renewable resources and the grid mix in 2035, and fuel cell electric vehicles running on hydrogen from biomass or ultra-low-carbon renewable resources, consumed the least amount of petroleum energy. The Department of Energy supports research and development for all of these technologies.

3.2. Vehicle life cycle cost analysis

Argonne National Laboratory, NREL, and the DOE Biomass, Vehicles Technologies, and Fuel Cell Technologies Programs analyzed the life cycle cost of operating a vehicle [7]. They examined battery electric vehicles, fuel cell electric vehicles, extended-range vehicles, hybrid and plug-in hybrid electric vehicles, and internal combustion vehicles. The vehicles were fueled by hydrogen, gasoline, E85, and diesel. The cost is in dollars per mile for 2030 technology, except for a couple of ICE vehicles running on gasoline. The results are shown in Fig. 6. The cost of ownership is broken down into components such as batteries, fuel cells, tank, engine and emission controls, the glider and wheels, and fuel. The error bars reflect the range of the assumptions for a given cost; for example, a battery for a fuel cell vehicle may

BTUs of petroleum/mile

cost $600–1000/kWh, whereas for a battery electric vehicle with 200 mile range, the battery may cost $125–300/kWh. The red bars reflect the range of assumptions for the cost of the powertrain, while the green bars reflect the range in the price of fuel. The most expensive vehicles to operate are the battery electric vehicles, with a 400 mile range at a cost of around 30¢/mile to almost 65¢/mile. The high cost is the result of the large amount of batteries needed to obtain the range. The rest of the vehicles would cost around 25–30¢/mile to operate. This analysis shows that there are benefits from a portfolio of options.

Fig. 6. Component cost per mile. All platforms assume technology available in 2030 except where noted.

3.3. State activities for hydrogen and fuel cells

Not only do hydrogen and fuel cell activities occur at the national level, but many of the states have initiated their own programs, specific to their geographic regions. In California, more than 450 fuel cell electric vehicles have been in operation since 1999. Fuel cell buses operate on regular service routes near San Francisco and Palm Springs. California has many hydrogen stations, but most were built for research and development or as part of the Technology Validation effort. Many hydrogen refueling stations are behind fences or not available to the public. Looking to the future, the California Air Resources Board and the California Energy Commission have invested ~$34 million in hydrogen stations, with an

additional ~$23 million in industry cost-share. In 2010, the California Fuel Cell Partnership surveyed automakers, who predicted that sales of fuel cell electric vehicles in the state of California would dramatically increase after 2014.

New York plans 100 hydrogen stations by 2020 to fuel 50,000 fuel cell vehicles, beginning with 1500 vehicles and 20 stations in 2015. Six auto companies plan to invest nearly $3 billion in vehicles, while the state plans to provide $50 million for infrastructure. New York State offers many tax credits, tax incentives and rebates for implementation of renewable resources and increased energy efficiency [8].

The state of Hawaii has some of the highest electricity and gasoline prices in the nation. To address these challenges, Hawaii signed an agreement with General Motors, utilities such as The Gas Company, and the US Department of Energy and Department of Defense (DOD) to establish hydrogen as part of the solution to Hawaii's energy issues. In one of the DOE projects, electricity from geothermal and wind sources will be used to produce hydrogen, which will then be used to fuel buses on the Big Island of Hawaii. In cooperation with several DOD agencies and the car manufacturer GM, the US Army has just launched a pilot fleet of 16 vehicles powered by hydrogen fuel cells in Hawaii. Hawaii has also planned 20–25 hydrogen stations on Oahu to fuel the fuel cell vehicles [9].

3.4. Communications and outreach

The FCT Program carries out communication and outreach activities to alert and inform its stakeholders on the continued progress in advancing hydrogen and fuel cell technologies. Webinars are held periodically on topics such as low- and zero-Pt catalysts; a database on hydrogen storage materials was launched; and blogs and news stories are released. A recent news story described the use of a fuel cell powered mobile light at the last NASA space shuttle launch; the mobile light has also been used at major Hollywood award shows such as the Grammys and Academy Awards [10]. In an announcement of fuel cell awards, Secretary of Energy Steven Chu noted that, 'These technologies are part of a broad portfolio that will create new American jobs, reduce carbon pollution, and increase our competitiveness in today's global clean energy economy' [11].

The Fuel Cell Technologies Program also funds a number of documents and key reports. The report, *The Business Case for Fuel Cells*, profiles fuel cell customers and explains how the companies are saving time, money, and emissions by using fuel cells. The *State of the States: Fuel Cells in America* report highlights each state's activity and energy policies. The *2010 Fuel Cell Technologies Market Report* provides an overview of trends in the fuel cell industry and markets, including product shipments, market development, and corporate performance in 2010. A clear trend identified was continued growth in commercial deployments, largely in the materials handling, power, CHP, and backup and APU sectors. Other Program documents include the recently released Program Plan, as well as Proceedings from the Annual Merit Review and Peer Evaluation with a Peer Evaluation Report. The Annual Progress Report provides short technical reports from each of the projects funded by the Program, highlighting the accomplishments from each project and comparing the current status of the technology to DOE's technical and cost targets.

3.5. International activities

The FCT Program participates in international activities such as the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE). The mission of IPHE is to organize and implement international research, development, demonstration, and commercial utilization activities related to

hydrogen and fuel cell technologies. IPHE provides a forum for advancing policies and establishing harmonized regulations, codes, and standards. A recent product of IPHE is a cost comparison of fuel cell systems from different countries [12]. The Program also participates in the Hydrogen Implementing Agreement and Advanced Fuel Cells Implementing Agreement of the International Energy Agency. The purpose of the Implementing Agreements is to advance the state of understanding of hydrogen and advanced fuel cells through a coordinated program of research, technology development, and system analysis. These implementing agreements support information exchange and task sharing with reports and databases as products. The FCT

Program also has bilateral agreements with Brazil, Japan, Italy, and the European Commission.

Conclusion

One of the key issues preventing mass commercialization of fuel cells is the high cost of the system. The Program monitors the cost of 80 kW fuel cell systems for transportation applications to assess progress in its R&D efforts.

Currently there are hydrogen-powered fuel cell vehicles that have a range more than 250 miles; one vehicle from Honda traveled more than 430 miles on one fill. In the long term, hydrogen will be stored using materials such as chemical hydrides, metal hydrides, or sorbents.

Because of necessary of energy sources its very essential. For our development and taking green chemistry principles in view we should use renewable energy sources like Hygrogen fuel cells.

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