Presentation at Hydrogen Technical Advisory Committee

Toward the Commercialization of Clean-tech and

The Crucial Option of the Water Cycle,

"Hydrogen and Fuel Cells"

to save the Earth

July 22, 2008

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(1. Introduction)

Good morning. Honorable Mr. Chair, Dr. Alan Lloyd, Dr. Byron McCormick and distinguished members of HTAC, ladies and gentlemen.

It is my tremendous honor to be here to speak in front of many eminent VIPs of the Committee about Japan's fundamental philosophy and policy on Hydrogen and Fuel Cells during 2003-2007 when I had a substantially full mandate for the policy in Japan. Indeed, it is an unprecedented honor, because a foreign official from the Far East is invited after a one-year blank in his previous position. Considering my poor English, or "Japlish mixed with Spaglish," prudent hesitation passed my mind, however, Dr. Byron McCormick and Mr. George Hansen of General Motors very kindly encouraged me to come here and talk about the common target to struggle together for the sake of the entire world. I would like to express my unending gratitude to these two gentlemen first.

Anyway, encouraged and uplifted, I will do my best. It shall be my "On-gaeshi," that is, reward to a warm favor received.

Today, I have no intention merely to introduce Japanese details which would be boring to you all, rather I will disclose the entire strategy I kept at and pushed during 2003-2007, adding some further progress in my just previous position as Director of the Recycling Promotion Division, in its real meaning Director for Eco-design and less material/energy supply-chain which the state-of-the-art industrial structure consists of toward new era.

First of all, my mission is very simple. It is to encourage people to find real breakthroughs for Hydrogen and Fuel Cell technologies which are not only very critical technologies for the future, but also important options for us human beings to save the Earth. To do so, it is important to create and cultivate technology options, to let potential, promising options compete with each other severely and to brush them up toward completing their goals, leading to real products and entire systems.

You may see many tech-options and a synergy of networks on the table paper 1.

(Hydrogen Economy)

Jeremy Rifkin, an advisor to the former-President of the European Commission, Romano Prodi, and the architect of the strategic White Paper of the Commission, argues in his international bestseller in 2002, "*The Hydrogen Economy,"* that the harnessing of the technology of hydrogen and fuel cells will spawn a new economic revolution in the 21st century and that this new energy regime has the potential to be sustainable, non-polluting, and to provide a decentralized and democratic source of power. However, it still remains a dream.

Precisely, it was not Rifkin who had the dream first among human-beings.

— L'eau, répondit Cyrus Smith. Oui, mes amis, je crois que l'eau sera un jour employée comme combustible, que l'hydrogène et l'oxygène fourniront une source de chaleur et de lumière.

"Water," replied Cyrus Smith…Yes, my friends, I believe that water will one day be employed as a fuel, that hydrogen and oxygen will furnish an inexhaustible source of heat and light and with an intensity that coal cannot provide. Then there will be nothing to fear. As long as this earth is inhabited, it will provide for the needs of its inhabitants. I believe that when the coalmines have been exhausted, they will heat and be heated with water. Water is the coal of the future."

It is not Cyrus Smith, but Jules Verne who wrote "The Mysterious Island", or "*L'Île mystérieuse*" and "Around the World in Eighty Days" ("*Le tour du monde en quatre-vingts jours*").

Now we are very close to Verne's dream. However, we have to struggle more, and with passion and patience. (In fact, I liked to use these two topics for a Japanese audience to encourage them saying "Dreams come true soon just at our hands" and remind then of the importance of their profound mission and the fortune and happiness to be able to earn money for bread and butter fighting on behalf of humanity.)

(Global warming and alternatives)

Recently global warming has become an issue of the highest priority. So, what's the nature of this challenge? The radius of the Earth is 6,400 km or 4,000 miles and the height of the troposphere which contains almost 80% of our air is only 11 km or 7 miles. The layer where we live and convection occurs is like a thin film, but human beings after the Industrial Revolution have increasingly disposed of a huge amount of heat or "entropy" and naturally convection shall be animated in order to transmit the enormous entropy out of the Earth, I mean, to space, so that consequently hurricanes and typhoons shall became ever bigger and fiercer. Of course, GHG prevent entropy emission to space and accelerate global warming. In this sense, nuclear energy can't be resurrected and become a new hero or silver bullet as it emits 70% of its residual heat directly into the sea or air.

(Lessons from Photovoltaic commercialization)

To fight against global warming, of course, renewable energy sources are very important, however further R&D is necessary. The sun provides the Earth with tremendous energy (slide). New man-made technologies can convert such huge unused energy into useful energy for humanity. In this sense in my policy I focused on third generation PV (slide). This spring I managed to establish a new international research center specializing in quantum dot PV and organic dye solar cells in Tokyo University, which is the No.1 University in Japan, gathering talent from inside and outside the country. It might be inordinate to pick up a young world-class assistant professor of Tsukuba University, who has the current world record, to the new national PV Research Center in Tokyo University. Why inordinate? Because in Japan each famous university has its own "feudal territory" or "invisible jurisdiction" and independent "castle" and "grand wall" so that an appointment moving to other universities is a very rare case in these isolated islands in the Far East.

Adding this, taking into account commercialization and industrialization, I myself persuaded Mr. Takashi Tomita, the former CTO of Sharp Corporation- who had kept the world PV championship for 7 years, to join and help this promising national project. The theoretical efficiency of quantum dots reaches 63%, while other silicon-based PV performance is less than 20% and theoretically is limited to less than 32% by the famous Shockley-Queisser Limit.

Finally, as I mentioned before this spring, the new national PV Research Center has worked on promising but difficult, invisible and unknown challenges, new concept PVs. (In June, the annual budget was fixed in 1.2 billion yen, about US $ 12 million for this fiscal year.)

Certainly I fully recognize that this theme is very promising as well as very difficult. Generally in the scientific layer, the probability of success is relatively low, and ordinary Japanese companies don't want to tackle such themes that present poor chances of profitably in the short run. That's why it is worthwhile for the government to encourage high-risk/high-return challenges. It is just in the public domain, I believe. However, generally speaking, pure scientific research tends to become research in of itself and tends to diversify into useless or trivial areas. That's why a bridge to communication with real industry is needed and very important, so that I invited Mr. Tomita, arranging to give him an honorable title such as Visiting Professor.

In addition, personally and secretly I let private equity financing professionals involved with in order to prepare to establish new rocket-start-ups from very basic science in the future (the "near" future, I hope!).

This cutting-edge research center will contribute in another aspect, education and the creation of talented human capital with a passion for very new "clean-tech." I would explain more later.

Recognizing that cutting-edge science based on advanced quantum mechanics theory has such a low

chance of success, I set and started another very industrial approach. As you all know, sound and visible competition is a crucial driver for innovation. To establish a well equipped international stadium for competition is a role for the public sector.

In this sense I prepared a "PV Wimbledon" for international players including newly established venture companies such as Q-Cells (Germany), Suntech (China), among other giants such as Sharp, Kyocera, and Sanyo. Hokuto City is located in a region that receives the most sunlight in the country and now 26 modules of ten different types from nine countries are competing under the same conditions.

This site which has started this March consists of three phases and the winner will get a wider area in the next phase. It shall be visible and apparent who will have won in the international championship for PV and this may cause strong competition among players if this system can be adequately operated and data disclosed fairly.

(Importance of "Samurai" Scientists/Engineers)

By the way, who do you think drives technologies? And who dares to advance to hard commercialization? Companies? Universities? Governments? No! I believe…, I believe that the individual scientist or engineer and his/her team substantially make the breakthroughs. And empowerment and commitment is very crucial for real and significant innovation.

One example is PV itself. Very frankly speaking, PV has been stuck in the pre-industry phase for such a long time that many people had thought of it as a low profit marginal field for commercial products. In Japan in the 90's many companies had given up seeking commercial markets for PV as they finally estimated and evaluated PV's poor future. Only two or three exceptional, enthusiastic, or rather fanatic top individual executives in Sanyo, Kyocera, and Sharp kept seeking their own dream, "Abundant Sunlight to Clean Energy," without giving up as others did.

Very recently, after 2004 when the amendment of "Erneuerbare Energien Gesetz" oder "EEG" (the German Renewable Energy Sources Act) which enabled anyone to sell electricity generated by PV at a 3x or 4x higher price which is around 80 cents had passed in "Deutscher Bundestag" (the German Federal Diet), "la scena nova del Atto Secondo dell'Opera di Sole," a very new scene has kicked off vigorously and the outlook has totally changed. The estimated market size reached $10 billion in 2006. For a long time PV had been regarded and treated as a marginal, abandoned, low profit or even infertile negative cash flow field using the waste of other industries, in other words, by-product silicon from the celebrated semiconductor industry, and was also made with inferior and simpler technology than that used in semiconductors, so that there have been very, very few "samurai" in this field.

At this point I would like to define my definition of the idea of "samurai" or "innovation samurai" here. "Samurai" is originally a term for the military nobility of pre-industrial Japan. Samurai were generally recognized as ancient noble warriors, but the ***"innovation samurai" today is defined here as a term for prepared, decided, devoted, high-minded scientists or engineers who tackle difficult breakthrough targets with bravery, deepest spirits, an appropriate combination of calm and passion and robust personal commitment under the power of self-empowerment.***

The samurai scientist/engineer may play a superb role in a very difficult area to achieve a breakthrough. Generally, tackling a great breakthrough at the cutting-edge can be a very ambivalent thing. A great prize, a huge reward, and tremendous applause is waiting you, however, there is no certain, assured way to reach the goal. You have to confront an unknown world, uneasily navigate your way in complete darkness with many hidden traps and false avenues. The last inch can become the longest inch. Even though the real goal is very close, only an inch away, perhaps, many challengers give up and abandon their dream, being exhausted and their hearts broken, maybe even making excuses for themselves or blaming others or attributing their lack of success to the will of God. As I mentioned in PV trials in Japan, there were heaps of dropouts in the 90's during the counter oil-shock period.

The process of innovation is full of dark uncertainty as "nova" originally equals "unknown," however, there is only one certain thing. It ends when giving up.

It was same in FCs as well as PVs in that there were heaps of corpses for PAFCs and MCFCs in Japan. Still some ghosts or zombies are wandering around.

For unprecedented innovation and great breakthroughs, a never give-up mindset is indispensable through all ages and cultures so that the samurai spirit or *l'esprit de chevalier* is very important. Don Quixote is the second bestseller in the world. Don Quixote never gave up fighting for his dream with all his heart and soul, "del Corazon," even though he was mocked. It is same for innovators.

Are there any such modern samurai? There are very few, but surely they exist. If not, we have to look for and create candidates among the young generation. Here I do not say "young" meaning physically young, but spiritually and mentally young. And their empowerment is very crucial both in a national project and in a private project. There are many good examples in the world; William Shockley, Gordon Moore, Bill Gates, Steven Jobs, etc. You may trace your own history back to Thomas Edison, Henry For…oh! Sorry this may be controversial in this Committee.

Last month Gates said at his farewell event about founding Microsoft: "Microsoft is one of the few companies you can say it just started with a dream. A dream that software would be important. A dream that there would be a computer that was affordable on a personal level. That's a dream that Paul Allen and I had,

which at the time seemed very crazy." PCs are very common today, but was it very crazy? How about Personal Generators using components of water in the future?

In Japan also there is a genealogy of innovators such those created the Blue-ray laser, the plasma display, carbon fiber, carbon nanotubes, and the HEMT (High Electron Mobility Transistor, which helped and urged revolution in Eastern Europe). One example is Dr. Tsutae Shinoda, who surmounted many obstacles and difficulties. He had been transferred from a research position to an irrelevant position in production line management having only a small annual budget of US$ 15,000. But he kept seeking his own dream, of developing the color plasma display. For my part, I am now in a human self-recycling position but still keep my strong ambition, eagerness and enthusiasm for hydrogen and fuel cells and clean-tech.

However, when I was nominated to become a responsible director moving from Director for Economic-Fiscal Management of the Cabinet Office in 2003, the budget was like a sumo wrestler who appears to be obese. In reality compared to their outward appearance, sumo wrestlers are actually very muscular. However, the budget seemed like some sort of inefficient public works project or anti-unemployment measures and was filled with useless R&D activities. I was deeply shocked and it was really awful for me that there was no policy, no philosophy, no strategy nor no consistency underlining the efforts. Since then my challenge has started. My first mission was to transform the budget into a more efficient structure, like improving the fuel economy in a car, squeezing more results from the same amount of tax funding in another words, slimming the sumo wrestlers to create muscular athletes.

For that, it was important to find responsible samurai with passion who seemed able to create something new and totally different, and also to be able to trust them. Of course, "salarimen" - by which I really mean "belongers" to large institutions, or "yes men" who lack or suppress spontaneous creativity, persons who are skilled at preparing immediate excuses before facing challenges- or even, if you want to be really harsh about them, useless budget eaters, are necessary for playing second fiddle, supporting roles. But they shouldn't be major protagonists because if they take control of a project, they are likely to fritter away precious tax funding without achieving significant innovation.

To select dedicated samurai and trust them is one of the most important things in innovation management, I believe.

If there is nobody, it is highly recommended to find and create young candidates. When I talk about being young, I mean not physically but spiritually or mentally, as I mentioned before. Surely there are mature but very younger-minded persons who have a lot of experience. On the contrary, I use "old" salary men, not physically but mentally old persons, but people who always make excuses and are confined by limit which they themselves constructed consciously or unconsciously.

And, there is another important function for national labs; education and creation of human capital. If unfortunately and unexpectedly newly established labs can't establish sufficient results in a certain fixed period, it can be said that we could get enough return with new promising scientists and engineers, hopefully samurai or samurai candidates.

I do believe government's role is not to provide money for the investigation of promising challenges but to for those projects that have a higher chance of success by finding responsible and dedicated key persons with passion and trusting them, ceaselessly encouraging them during the severe innovation process, showing robust, consistent and unshaken official support both in physically and psychologically, placing real trust in them while exerting pressure on them at the same time.

To implement the above mentioned "samurai project leader" principle, there are two more things to be careful of.

First, samurai leaders are not always inherently brave people as the original samurai in ancient Japan. Confronting war and possible death, mentors such as Buddhist monks played great role for samurai to fortify their courage from their profound spirit and to maintain their confidence and to help them become brave hearted. It is almost the same today. Even though scientists and engineers may not loose their lives, they all have to confront severe difficulties against expected breakthroughs and almost inevitably they need new types of mentor today. In this sense, a neutral government official or public servant could take a certain role as a mentor encouraging them by saying "Yes, you can!", "Why not try?", "Come on!" and so on via the Internet and on a face-to-face basis.

Second, every samurai can't always achieve excellent results. There is a well known common rule of thumb called "The Pareto principle" named after Italian economist Vilfredo Pareto who observed that 80% of the income in Italy went to 20% of the population. Business management thinkers suggest the law of the vital few and the principle of factor scarcity that, for many events, 80% of the effects come from 20% of the causes; e.g., "80% of sales come from 20% of the clients." Furthermore, any group can be divided into a top 20% high performance group, a middle 60% and band of 20% of low performers. From my few experiences it may be true among samurai innovators. Even worse, sometimes pretend samurai reveal their greedy and ugly nature that they want only public R&D money not ultimate results toward reaching a breakthrough. I personally and secretly call them "Kure-kure-seijin" that means something like little green men from Mars constantly pestering for more money "gimme-gimme the money!" They are almost scamming us, committing no sacrifice for the nation's sake but for their own sake. To improve the probability of success of national projects, it is important to prudently exclude such Kure-kure-seijin and for this reason it is also important to carefully and quietly certify the project leader candidates' nature and personality as follows; is he/she not motivated by money, have enough passion, seriousness and unique vision? Passion and vision are the most crucial criteria. I sought to make sure that every national

project had substantially responsible leader indifferent to be young, old, male or female (very difficult in a country with traditional customs and a strict hierarchy) and empower them, encouraging them and reminding them of their responsibility using tax funding.

*I may have to skip the next theme such as next-gen batteries, Plug-ins Hybrids, Biofuel and other promising clean-tech, not having more time, while I would leave my speech draft later.

(Next-gen Battery and Plug-in Hybrid Vehicles)

PV and wind are surely very promising, but have several difficulties, such as high costs, fluctuation, time and weather dependency, the necessity for large spaces and so on. In this sense a robust grid and power storage by next-gen batteries shall be of great importance for dissemination and penetration in the market.

Such a robust grid and next-gen batteries will also help the dissemination of EVs, PHVs and also FCVs. In this sense, especially R&D for next-gen batteries shall be focused and urged. As batteries can have both modular and integral architectures, I believe that Japanese companies, engineers and scientists can contribute to advance the crucial and strategic technology needed, while venture start-ups may also bring very new concepts for this cutting-edge technology. In this sense I think challenges by Fisker Automotive and A123 supported by some huge giants seem very promising and very clever ways to foster this hopeful technology option.

EVs and PHVs, which could reduce CO2 emissions up to 30%, are without doubt a very crucial technology. However consistency to physical and social infrastructure is indispensable. Without adequate coordination, EVs and PHVs have to be equipped with 10 different plugs as there are 10 public utility companies in Japan and this would prevent adoption. I was a little surprised that automobile giants didn't have enough connection with giant electric utility companies so that I myself coordinated meetings between them.

At first, a major electric utility was slightly skeptical about PHV technology as it was inclined to and has made rather straight effort to EV, while they had only a small purchase plan up to 3,000 units for their own business activities. So I tried to persuade my old friend, now near to being a top executive at an electric utility giant, talking to him about the advantage of the PHV option. "Instead of your own investment, automobile companies and their users spontaneously invest to build electricity demand and pool during the night which helps to improve your lopsided load curve and consequently business efficiency. Adding this, having an electricity pool near a huge demand area automatically provides robust supply measures for contingencies or emergencies. A pumped storage power plant is inevitably energy inefficient, having 30% energy losses. PHVs will help to avoid such inefficient facilities and improve your business efficiency without any additional cost. Furthermore, dissemination of PHVs means significant improvement in the performance of high power batteries and naturally substitutes the current costly and inefficient Natrium-Sulfur batteries that had shown very slow improvements and made you and your

colleagues irritated.

Then, my old friend realized that new and renewable energy is his enemy no more but that they are friendly new forces and armament. Once this was understood, movement was rapid. An informal inter-industrial consortium among non-conflicting and complementary industries was formed to collaborate and started its activities from scratch based on mutual reliance and friendship.

It is my understanding that PHVs could be completed on the line of improvement or "kaizen" of which Japanese manufacturers have an advantage. However, R&D and competition for new batteries including components of Lithium-Ion batteries and Nickel-Hydride batteries and Capacitors is necessary. As for other options for cleaner vehicles such as bio fuel and clean diesel, smart intelligent transportation systems are important, but have each have problems and limitations. No single technology will be able to solve the entire problem. (slide)

Apart from next-gen. vehicles, there are many promising candidates and tech options for new renewable technology. Concentrated solar thermal power, micro hydropower, Dr. Kalina's cycle (ammonia cycle) generation at lower temperatures, bio-gas, next-gen. bio-ethanol, superconductors and new motors, artificial muscle and marine applications, auto-exhaust generation, dysprosium-free high performance magnets and so on are very important options, I think.

(Hydrogen & Fuel Cells)

Why Hydrogen? After taking a bird's-eye view over other new renewable energy options that are each confronted with their own difficulties, I feel hydrogen technology shines out as a very strong option to replace the carbon cycle. Coal, the ancient protagonist, was the engine for the Industrial Revolution but was hard to use and heavy so that in-situ consumption was the main usage. Then the fluid revolution took place. Petroleum is easy to use and transport and expanded its applications. At the same time electricity also expanded its application as it is easier to use and a very neutral energy media while its transmission is limited by a grid. Compared with such powerful protagonists which made human history, how about hydrogen? Hydrogen is clean to use returning to mere water after usage and is potentially free from time, location and original source constraints. Hydrogen will expand our freedom and its applications.

In 2003, a member of the Prime Minister's Council on Economic and Fiscal Policy strongly supported hydrogen and as Secretariat of the Cabinet Office I tried to incorporate hydrogen station plans in the National Structural Reform Policy Paper. But in vain. Suddenly, I was appointed Director for Hydrogen and Fuel Cells in 2003. As I mentioned, the budget (more than $300 million then) was almost blistered. Reforming the budget was my first priority and key words were tech options, synergy, confidence, collaboration, encouragement and so on.

However consistency and sustaining fire and passion necessary to keep going, a bit like keeping the flame alive as with the Olympic Torch Relay was the most important factor.

(Tech option management)

On the other hand, adequate management of tech options among tech clusters is also indispensable. Then my assistant director sent a bold suggestion to cut the entire budget and suspend official support for MCFCs. I immediately supported him. There is no innovation and chances to win where is no competition. At that time only one remaining company continued a slender R&D effort as all other rivals had given up. Of course, there were some repercussions and some zombies still remain. But several scientists and engineers might independently continue their efforts without official support. Sometimes someone might convert such a negative disgrace into a positive engine or further motivation for innovation. That was the case of Dr. Shuji Nakamura who invented the Blue-ray laser. The larger absolute value of willingness, the larger power fighting against the grand wall which prevents breakthrough. The caring option is funny and easy while the clearing option requests very might decision like Sophie's Choice.

(Each prescription)

Like there are several routes to climb a mountain, in an innovation process there are several routes to seek; tech options. Carefully examined, each route requires a different prescription or recipe to be tackled. It is important to recognize where we are climbing or going in; the scientific seed phase, or the pre-industrial phase, or the commercialization phase- and prescription and solution recipe differs as well as the balance between competition and cooperation, which differs in each phase.

(Five major FC options and seven major policies)

In my understanding there are five major options in fuel cell development and these are: home stationary, FCV or fundamental science, micro fuel cell, niche products as wheel chairs, and ventures. And in the hydrogen-related area there are two more challenges; materials and storage. Naturally, seven major policy fields come up and each concrete different prescription is derived in a different way according to different needs, just as there are totally different coaching methods for each, as for example in baseball, football and basketball for professionals, college-level, high and junior high school levels, children and street play lovers…and so on. It is important to carefully assess levels and stages in order to find adequate prescriptions. So now let us see closely each of the seven fields and my prescriptions and recipe toward achieving breakthroughs and synergy, keeping our passion for this crucial de-carbonization weapon; fuel cells and hydrogen.

(1. Home stationary fuel cells: toward the creation of the first real market)

As for stationary applications, you may have felt it was odd for Japan only to concentrate on very small 1 kW home stationary fuel cell systems. The reason is not because Japanese houses are like rabbit hutches but because of the necessity of innovation management. If my budget was three or four times bigger, I would have distributed money to larger stationary projects including poor old MCFCs even though the money is precious life blood of the nation.

Why 1 kW only? There was natural competition among the five or six major players and a sound competition field or "Stadium" was needed in order to accelerate such competition toward the first real products and the first real market. At the same time I found a strong necessity to focus on one clear product avoiding more unnecessary R&D parameters for various larger generators (which might cause fear of competition for other rival industries which have counter measures to prevent dissemination by restricting third party access) and to visualize and assure a clear common goal and fair comparison among prototypes for sound competition. Furthermore, as the system is under modular architecture at the product level, a 1 kW system could be easily expanded to a larger system. And to obtain more field data for further development, a 1 kW system could save total budget and tax, and be capable of a huge number of field test sites at huge numbers of residences all around the country, which could also be used at the same time as an excellent grassroots publicity tool, which might provoke consumer interest in state-of-the-art tech products in the home.

Frankly speaking, the situation and motivation were a bit twisted. Originally gas and oil companies, which compete severely with other energy industries, thought that automobile companies, which have a very strong innovation capacity, would invent very low price FC generators and gas and oil companies could apply the technology to cogeneration systems to compete against other industries. However, it was revealed that automobile company R&D seemed stacked and they felt that they had to make their own R&D activities by themselves. My executive friend and leading samurai- maybe almost Shogun, one day confessed that, "We suddenly realized that we are front runners, only thinking to follow automobile companies. Then, there is no way except that we have to do our best by ourselves." It was when the FCV boom seemed to have passed and calmed down and many obstacles for FCV commercialization were realized for outsiders. So I tried to focus on this option (1 kW home appliances) pouring most resources into this area to keep up the passion and confidence we needed.

Very fortunately there were many major players competing and it seemed for me that the Japanese favorite success equation for manufacturing, the kaizen method was applicable. Because the cost target was around 1/20 (one twentieth) and mass production could make a one digit reduction and the rest was only half. It might be very difficult to cut 50% of the cost but there seemed possible measures as reduce the number of

precious cell stacks by improving the inverter efficiency. Japan's manufacturing industry is known for its strong cost reduction capability but it is only applicable after the first real product goes on the market. The kaizen improvement method could help cost reduction in the long run. There are many examples and experiences such as with automobiles, photovoltaic cells, electric ovens, air conditioners, televisions and so on. Toyota, Panasonic, Toshiba, Sharp, Kyocera and Sanyo, among others, are well known high quality cost cutters. Professor Michael Porter of Harvard Business School mocked Japan in his book in 2000, "Can Japan Compete?" but he recognized that Japan's operational capability for high quality and low cost production is formidable. I intended to set this favorite and accustomed way for Japanese players as fast track Route One. However, a unique condition to make sense of this success equation is to put products in the market as fast as possible.

It was not easy then as the estimated cost was more than US$ 100,000 and the target was US$5,000. Many players shared a sense of crisis as they could reach

only US$20,000, which was never a viable figure in the real market, and they felt that they would repeat the same failure as with PAFCs, for which they couldn't finally reduce the cost to a competitive level compared with other equipment such as high performance gas cogeneration. They shared a lost battle experience and assembled to find a way out.

I myself called for an informal limited strategic study group among samurai and other players of three energy companies and five manufacturing companies. At that time even the tough samurai I gathered seemed like worriers, not brave warriors.

But! It was the beginning of hellish meetings. In order to maintain strictly private information secret, there was no way except for me myself taking the role of chair or master of ceremonies despite the fact that it is very normal to ask neutral and experienced academia to chair a study group.

When I called the first meeting, suddenly I was embarrassed. Please imagine you take the center chair and another eight Japanese members sit in front of you and say nothing, but just smile knowingly in mysterious oriental way. Maybe you could share my embarrassment. After the accomplishment of the final report one member personally confessed me that he himself felt he should take four minutes to speak each word as he was afraid that he could disclose his company's secrets even though he was clearly allowed to speak about peripherals.

After a rough investigation, the group shared three major challenges; how to cut costs on peripheral devices, a further investigation of degradation factors and an examination on the preparation for mass production. And three sub-working groups were established for further investigation. Two were for peripheral devices cost cutting projects and the rest for the investigation of degradation factors.

(Cutting costs of peripherals!)

Cost cutting looked probable for new components as stacks and reformers through further innovation of traditional peripherals as pumps, blowers, valves and sensors because these peripherals have a near-100 year history and experience of cost cutting almost every possible measure for cost cutting have been already taken. However the cost allocation for peripherals amounted to half the amount! Even though we recognized the fundamental problem, tackling the issue was not easy.

First, I called for only five manufactures and restricted the number of members because keeping each company's intellectual property and secret information is a given condition for inter-corporate cooperation, especially in competitive and critical fields. To allow us to discuss in detail, I called for experts while I asked their bosses to empower them and made their mandates and boundaries very clear in advance. Their mandate or terms of discussion were strictly limited to peripherals and no discussion on stacks and reformer-related matters were allowed as these two formed the area of core competition. In other words, the critical module was black boxed. It was necessary to build and assure mutual confidence for inter-corporate cooperation. And it is my understanding that such clear mandate and boundary could help the Ebara=Ballard and Toshiba=UTCFC groups to join, with security and no anxiety, so this was a very unique and exquisite peripheral cost-cutting national project.

As well as the strategic study group, the management of the sub working groups was very difficult. However, a brave samurai chair provided very strong leadership and dared propose the sharing of secret information on peripherals as he had the lost battle experience of PAFC and had undergone a strong sense of crisis. He explained me later that the main reason for the failure with PAFCs was the "divide and rule and enclosure" style of R&D with major component suppliers which prevented significant cost reductions from becoming possible. To keep legal compliance, only government officials like my young colleague and I gathered information on the peripherals used in each company. The data analysis was very complicated and dizzying and was a very heavy task for us.

The analyzed data was really eloquent and very shocking and awakened all the members. For example, there were a few but extremely expensive devices which every member was having trouble cutting the cost of. And it was revealed that a very small supplier which seemed trivial but in reality was very competitive had a monopoly of supply over all five members and charged different prices to each, the highest prices being 3 to 5 times higher than the lowest (slide).

They realized that tough rivals had the almost the same problems. Then, former rivals totally changed into the same camp to fight together for commercialization of the home stationary fuel cell system. Once mutual reliance was established, the unusual inter-corporate cooperation advanced smoothly and almost automatically.

Urged by the open minded samurai chair, tacitly members gradually opened their minds and mouths and real cooperation began. Each started to speak of their own very interesting trials and secret information as they

were allowed and empowered to talk about every peripherals to jointly seek every possibility to cut costs. Without any anxiety and hesitation, now they could share information as the partitions were very clear. For example, they started to talk about how to save money on the expensive sensor. While they had same difficulties for high endurance roll-bearing up to 40,000 hours, one member quietly disclosed that a secret supplier which made "air bearing" blower that was totally free from the endurance problem.

I was surprised again that much interesting information had been gathered to be shared. Many samurai engineers worth their pride talked and talked with former rivals. These activities naturally inclined toward real joint R&D. The sub working group was enlarged with more experts and discussed many things. Next "we", I may call "we" as a camp even though a METI official was substantially involved in R&D details, started to discuss solutions inviting the above mentioned monopolist small supplier and other suppliers including members' affiliated companies. We were really overwhelmed as even very small suppliers profoundly understood their technology and further possibilities of cost reductions emerged. One supplier suggested harmonizing or unifying the specification of the size of pipes and jointing position. Another, the small monopolist, made the following amazing suggestion; "In our device, frankly speaking, the heatproof harness is very expensive and heavy. However, five giants order from us, each with a different specification they and haven't wanted to hear our voice. If you all unify the length of the harness, we could easily reduce the cost. Furthermore, if you all fit the harness by yourselves, we would produce new cheaper and simpler devices for all five of you."

After hearing from the suppliers, I had another surprise. All five friendly giants managed to almost unify their peripheral specifications and made it open and upped the "wanted list" on the METI website. Of course, it was really unprecedented for independent Japanese giants to collaborate and put up such a common wanted list of components of state-of-the-art systems as fuel cells. Open competition and new entry is generally an excellent engine for cost reduction so that not only the official website but also broad publicity was needed. For this purpose, seeking the entry of new powerful suppliers, we toured the entire country, including Hiroshima, Mie, Nagano, Mito, Akita, Tachikawa, Sagamihara, Kita and so on with top engineers of the five companies. This was a really funny experience for me to talk with samurai about the promising future and our dream for a "Family Generator in my house." Of course, among them mutual reliance and admiration and friendship become much closer and higher through such local traveling. It really functioned as a kind of Confidence-Building Measure (CBMS) among the top five competitors toward further cooperation.

At the same time the top five started a joint peripheral R&D project which I supported. The top five selected more than 20 powerful suppliers and started each R&D program sharing the burdens to be managed by five subgroups. My other surprise was here. Sanyo managed a sub group including Panasonic's and Ebara's affiliated parts maker and Fuji also managed another group including Toshiba's and Ebara's affiliated companies.

It was an unbelievable scene for me. It is normal that any secret information of a filial company shall be under strict control to rivals, but, here affiliated company's samurai engineers were able discuss issues with their former enemies. And the diversity of participating suppliers was also interesting as there was very small but glittering company with only 20 employees among the giant suppliers. Along with the open policy, we urged powerful new entries to join saying that "This peripheral national project is like the Kodokan Dojo, the central battle place for Judo and anyone who relies on their own skills will be welcomed to the national project." To disseminate this invitation, we asked the Small and Medium Enterprise Agency to call for its business coordinators around the country to help us and also took advantage of the world largest FCEXPO in Tokyo and its Seminar in Osaka where the largest supporting industry clusters or accumulations consisted of varieties of SMEs.

The results was superb in that a 75% cost cut was accomplished in three years of efforts and new potentials for further challenges were discovered. However, the most important thing of this "peripheral project" was that it established an excellent and ideal model for "competition and cooperation" and provided a sure, concrete and visibly successful experience both for overcoming the difficult issue of cost reduction while forging useful alliances. The success revived and created a self confidence between the members and encouraged samurai to fight against further uncertain difficulties.

By the way, state-of-the-art networking theory and the Internet both support the notion of "six degrees of separation" or the small world problem. How about seeking new strong peripheral suppliers? But, the real world is too complicated to recognize.

During all this process, I was afraid to discourage the samurais' efforts and spirit talking about imported innovation management theory. Some of you may have realized this is an architectural theory or more directly the "Power of modularity." Consistent integration between specifications is regarded as highly effective for cost reduction. This is comparable to the strategy of taking advantage of the "power of modularity" in the development of the computers and PCs. As described in "Design Rules" written by the Dean and ex-Associate Dean of Harvard Business School, in the field of the computers and PCs, the development and commercialization of low cost, high performance products was made possible by an efficient modular architecture in which consistently-coordinated specifications enabled the clear interfaces of various modules from different parties. This new architecture has led to severe and creative competition among "modular clusters" with an enormous number of independent venture-backed companies, which has promoted the dynamic "evolution" of performance and a drastic reduction in the cost of PC components. In the field of the fuel cells, the current FC system itself may not be subjected to a simple modular architecture because it belongs to the domain of strongly integrated manufacturing with huge number of known and unknown interdependencies among sub-components. However, auxiliary devices for the balance of plant such as the pumps, blowers, sensors and electromagnetic valves can be

made interchangeable and compatible based on open and clear interface specifications. This will offer merits for both system integrators and component suppliers. In addition, it will also assist the introduction of the principle of open competition and also open innovation and the possible appearance of new comers with strong competences. It will also contribute to further cost reductions and lead ultimately to create a real new market for stationary fuel cells with favorable effects for the consumer.

Watching a good result emerge from this semi-modular joint national program, recently Toyota/Aishin joined the collaborative group, opening their secret information to the old camp members. It is interesting for me that a normally secretive automobile company opened up. Also a SOFC maker approached and now shares part of some peripherals.

(Large-scale demonstration project)

Let us move on to the next theme, the large-scale demonstration project. This national project is in the area of individual competition to establish each supply chain including maintenance all around the country, to validate a learning curve toward mass production to make prototype systems perfect as selling products thorough the well known kaizen improvement method using abundant field error data. In other words, this field belongs to one of strongest achievement areas of industry in Japan, the world of "fabrication," or engineering with the advantageous kaizen method. To make sure of these points to prepare for commercialization in 2009, I had set a policy for creating the world's first real stationary fuel cell market as the kaizen method is valid after the first product put in market. This project contains another aspect to show the commitment of the Government of Japan, which is determined to support the achievement of mass-production toward commercialization of home stationary fuel cell systems. Showing a clear official message backed by action could encourage players and provide them with confidence. Consistent support by METI may be referred to as a persuasive tool for a company to continue its R&D efforts. This type of visible semi-mass production training project supported by the government would strengthen the strong points of Japanese industry, which are based on various data obtained through the processes of increased production and field test sites.

In 2002 the first phase of the demonstration project had started with only 12 units and in 2005 I started this enlarged project with 525 units and the upper limit of subsidy was ¥6 million. Now in 2008, the number of units installed is 3,352 and the limit is ¥2.2 million, so the number 6 times bigger and the limit almost one third large, which resembles the hidden cost reduction for three years.

At the beginning of this section I mentioned this project was for sound competition. As I have repeatedly mentioned, competition is the primary engine for innovation. In this sense I had to confess that I made too much of this. As one of the purposes of this project was to visualize current competition, I made the top 10

ranking open with visual data. The repercussions were more enormous than I expected. Panasonic was shocked as it weren't No. 1, something they had strongly believed they were. The R&D group was blamed and a senior executive of the partner company immediately took a flight to Osaka to help him calm down. Nobody reported me the details nor blamed me, maybe because they did not want to bother me. Several months later I heard very indirectly and regretted what I had done, recognizing that too much disclosure might harm the samurai spirit and damage their reputation and lead to a further wrong direction for innovation. I thought I had made a mistake. Why? Because we intended to reduce the cost by validating the learning curve; however if some players were shown to be inferior to the competitors, such players would put priority on improving their performance, which always counteracts cost reduction and looses time in the race to complete commercialization. Absorbing this hard lesson, I decided not to open the full result data to the public, but I did, however, keep it open among all players after 2006.

Today, I could confess that the disgrace felt actually became a powerful motivator. Panasonic advanced a lot of innovation and their PEFC efficiency increased unbelievably. That is another testimony to the fact that a negative impact could be converted into a strong positive engine.

The large scale demonstration is proceeding well and is accumulating learning experience based on confidence created by the peripheral project. As I mention later, another demonstration project JHFC is mounting has a totally different character.

(Competition from outside: SOFC demonstration project)

Last month the Pittsburgh Business Times reported that Siemens is looking to sell its solid oxide (high-temperature) fuel cell business. On the contrary, Japanese companies are continuing with struggle and battle in this area believing in the future of this technology. The development of SOFC, which is expected to offer high power generation efficiency, is expected to be advanced quickly. This is because they can be implemented alongside ceramic technology, which is a strong technology in Japan with a very long history of more than 1,000 years. In this field there are superb samurai whom I trust and I have continued to send out calls for voluntary support, encouraging him who was overwhelmed during a severe period at the beginning of this decade. I always encouraged him only mentally and personally without any subsidy then, but saying "Whenever you think is the best timing, you can come to me to ask for a field test project or other support. I will do my best with pleasure." The samurai responded without saying much but finally SOFC grew to the demonstration phase and a new demonstration project has started this year. Very small 1 kW SOFCs have strong competitiveness without using precious metals and with their high generation efficiency. SOFC technology is potentially a strong rival for PEFCs home stationary systems. It is normally considered that SOFCs have difficulties to precisely follow precisely load

fluctuations compared to PEFCs, however this is not true. Recently they have shown very high fidelity to load following. Originally the cost reduction potential was large and durability was an important challenge and a demonstration project could help to improve these points by the kaizen method using abundant field data. I believe severe competition among PEFCs and SOFCs in the 1 kW power range could urge further development of each promising technology option. I sincerely expect a large scale demonstration project of small SOFCs will take place soon.

On the contrary, I severely cut the budget for a large SOFC project because it lacked seriousness and passion. The group made a silly careless mistake at the World EXPO 2005 in Aichi, Japan. I really hate such slack "salarimen" who easily fritter the nation's money away. And also from the viewpoint of technology architecture, SOFC technology is also fundamentally modular and if shown successful in the 1 kW range, then it is possible or easy to expand to larger size generators. It was the reason of the failure of PAFC development seeking both parameters as performance and size at the same time. We have to study from the past lessons. I don't comment on Siemens's decision.

(Degradation factor analysis project)

We pushed another informal national project to assure the expanding of the lifetime and fidelity of the system. Generally, commercialization necessitates the overcoming of the problem of degradation. It is desirable that the service life is at least 40,000 hours, and about 60,000-70,000 hours if possible. In other words, every product should withstand use for about 10 years.

Since very high costs are required for degradation countermeasures, it was necessary to clarify the causes of degradation and then prioritize them. Considering that it was too inefficient if individual companies stick to their own confidential R&D, I had supported and asked a samurai PhD of Osaka Gas to lead a short-term intensive project in the fall of 2004 with the participation of top companies who share a sense of crisis failing to achieve significant results within 3 years. This was a special public funded project based on a NDA (nondisclosure agreement) which is rare for similar projects in Japan and defined a very strict obligation in protecting privileged information because it would treat information in the competitive area. Several energy companies and samurai scientists of a national lab and universities also joined and supported this promising project. The project was expected to serve to determine the causes of degradation and prioritize them rationally in order to enable both cost reduction and the durability of the system. In along with the open policy, I sounded out Ebara=Ballard even though international alliance, however, they refrained from joining this sensitive project, maybe having certain concerns. For me, it was reasonable and understandable so that we started with only 3 makers and 3 energy companies. It was hard to share in critical area, however on behalf of the samurai's great effort information sharing

advanced much. And participants could have a common image of the main degradation factors and used them to improve their prototype. A superb samurai gave me his secret idea for further investigation and his hypothesis for new challenge with regard to the erosion of supporting carbon in the catalyst, however lamentably he died suddenly, but his colleagues are keeping his samurai spirit to fight against enormous challenges.

(Installation in PM's new residence)

I would add a last topic on home appliances. In 2005 it was announced that "with regards to the commercialization of stationary fuel cells, the world's first fuel cell systems in the marketplace were installed in the Prime Minister's new residence. Tokyo Gas provided two 1 kW-type systems from Panasonic and Ebara-Ballard. The latter product was developed through an international alliance between Canada and Japan."

It might seem a trivial and ridiculous event for real professionals in the world, but I dare comment on two hidden meanings.

First, I took advantage of a principal form of behavior of samurai. Do you know what Hara-kiri originally meant? It was not mere suicide or execution as a punishment. It was performed to maintain a samurai's reputation. And for him to demonstrate his purity and loyalty, the samurai opens his abdomen and disembowels himself to prove he has no evil intention. I am afraid that I explained too much, however, it is all to maintain his own reputation the and samurai is prepared to die for his name, in another words, ancient Japanese culture can be said to be a "culture of shame" as both are two sides of the same coin.

The installation in the PM's residence generated plenty of publicity, but at the same time it created very strong pressure on the equipment not to break down. Once in three days one system didn't start. I think the machine itself maybe was under strong tension like me today for this tremendous honor. Of course, officials of the PM's office blamed the maker and consequently the team struggled very hard to repair and improve the equipment strongly motivated by shame to recover their own reputation. Another day there was trouble and the cause was mere careless mistake with the brace fault. The project leader immediately made strict instructions for a thorough inspection among the production team. And such a severe and unusual experience and the counter measures to prevent future failure were from then on to be automatically built in their systems so that the system was further improved. Like these two cases PM's residence was a de facto special training ground for thorough kaizen improvement.

Second, I insisted that we install "two" systems, not one. Of course, the PM's Office opposed this. But it was necessary to install two systems: both were products of pure Japanese manufacturing and international collaboration in order to show my purity and loyalty to our open policy. For Ebara=Ballard, the project was an ideal example of international collaboration, I believe. Very fortunately PM Koizumi supported the idea and two

fuel cells were installed while my summer vacation disappeared in the struggle. Even though there was a secret double-cross, finally the delivery ceremony for the first commercial residential fuel cell took place quietly with Prime Minister Koizumi and other ministers in attendance.

(Poor Results without Samurai Leadership)

One day some groups visited and proposed to me a new project: a parallel vertical collaboration R&D project. The idea is very simple in that two teams, each consisting of a membrane maker, a system maker and an energy maker would compete with each other to test robust high temperature membranes supported by many famous academia. As soon as I heard this, I had my doubts as to who should lead the two parallel projects. However, there were many dynamics and politics, not policy! And finally, I conceded. What was the result? Please don't ask me… ummm. It was sure that the budget was executed and divided subsidies were surely delivered to each participant even though there were ugly quarrels. The lesson was that a project without dedicated samurai sometimes comes apart while flying.

(For further synergy aspect)

I am confident that when the various issues described above have been solved by concerted efforts under open policies and open collaborations, we could succeed to create the world's first real market of stationary fuel cells. And I do believe the first real market shall become a big step and a strong engine for further R&D and provide positive synergy effects and pathways to other important applications such as transportation which shall protect the Earth.

Recent Japanese collaborative activities might seem very strange and unusual. Especially, it might be a rare case that a government official was deeply involved in R&D activities in many aspects. However, this might be a good example for inter-corporate collaboration toward commercialization. The key words were passion, confidence, friendship, neutrality, and an adequate partition of secret information.

(2. Scientific Breakthrough)

Let us move on to the next important topic of FC vehicles. The Japanese Demonstration project called JHFC started in 2002. Very frankly for me JHFC is not a collaborative R&D activity but merely spectacular street show containing sincere efforts to publicise the technology aimed at the younger generation. So why do I rate it so lowly? Because the players don't want to collaborate sincerely, they not sharing real data and they are not tacking problems together. I thought this project was wasting tax money and before the second phase I put very strong pressure on the players to improve the project so that it would work toward real collaboration. I pretended I was

furious, saying "I will suspend the next phase" (come finto furioso). But in vain, finally I couldn't find any samurai among the representatives of the honourable industry. There were only powerless people with even less spirit than salarimen. My opinion about this demonstration project is that such kinds of projects are only valid when technologies are close to commercialization. If mass production and the establishment of supply chains is are not yet in sight, such demonstration projects are a waste of public money.

However in the public relation groups there are several admirable samurai. One suddenly showed his intention of resigning just when his old friend was going to resign for his family reasons. I personally asked him and persuaded him to remain and continue his dedicated effort to transmit the superb potential of hydrogen and fuel cell technology to the younger generation for the nation's sake. He still teaches students and children and their mothers among others the excellence of hydrogen and fuel cells with passion and enthusiasm. I believe among the countless students moved by his devoted passion some genius will come to fight for further innovation toward the Hydrogen Economy. Another female samurai is making her devoted efforts in a demonstration at the Toyako G8 Summit and is collaborating with a professional soccer team, and so on. I really admire their dedicated efforts, even though players do not seem to like to support saying they spend too much time on public relations. Player representatives don't seem to realize the real meaning of JHFC.

(Back to the Basics)

For fuel cell vehicles, as opposed to stationary applications, the cost target is to reduce the costs to about 1/100th of the current cost. When Dr. Ferdinand Panik boldly declared in 1997 that Daimler would produce more than 100,000 units of FCVs in 2004, panic took place inside Japanese industry and companies hastily produced their prototypes and let the PM drive the Japanese FCV even though the cell stuck was imported from Canada. They were very confident for their capability and experience to reduce costs rapidly. However, it was revealed they were confronting very severe unprecedented hurdles to overcome if they were to reach 1/100th cost reduction without sufficient knowledge to enable them to build a vehicle totally different from any produced before.

In the hot summer of 2003, a top executive came to the Office of the Vice Minister of METI, a top bureaucrat, to request two things; one was to help with international research cooperation and the other was to establish new national laboratories to support our weak research bases. Two weeks later, the designated responsible persons came to the DG's office to explain more details; however I was slightly turned off by his irresponsible and indifferent flat presentation, which I felt lacked passion. He didn't show any real eagerness to find a breakthrough. Following the top meeting, I had several continuous meetings but no concrete proposal was submitted, which I thought very strange. However, I decided to keep quiet and keep waiting. That winter a representative referred to IMEC (Interuniversity Microelectronics Center), a very successful international

semiconductor industry R&D consortium with a mission to perform microelectronics and nanotechnology and design methods and technologies for ICT systems R&D 3-10 years ahead of industrial needs, but there still remained no proposal. I thought this bizarre, but I myself studied the institutional design of IMEC and made a draft proposal by myself in spring in 2004. By the way, IMEC in Europe and SEMATEC (SEmiconductor MAnufacturing TECHnology) in the U.S. were both established after a very successful Japanese research consortium for VLSI (very large scale integrated circuit) was established in 1976 and led Japan to leadership in semiconductors. Participants of the consortium were strictly limited to the top 5 excluding free riders and developed through friendly but severe competition inside the publicly established consortium and finally accomplished very successful results as mentioned above.

As for IMEC, its institutional structure and incentive mechanisms were very carefully designed and it very successfully leads world-class cutting-edge research projects. The key words are strict control on secret information, adequate information sharing among international project members, restriction of membership to CBMS (confidence building measures), exclusion of free riders, and fair distribution of results, together with and assurance of the neutrality of the Secretariat.

Studying and investigating by myself such details of IMEC's success without any additional information from the requesting company, I made a neutral proposal to establish a collaborative consortium restricted to ten members and a rather expensive entrance fee of US $2 million to ensure the commitment of members. For neutrality, I called for a possible executive candidate who would join and manage the consortium after resigning from his/her own company. But all this was in vain. Other players only sat down at the table with a glacial look saying nothing. The requesting company itself seemed only interested in paying but sending nobody and providing no confidential information.

Then, I decided to abandon such a poor way even though it was a mission ordered directly by the Vice Minister. Normally a rather clever bureaucrat might have established such a fake consortium and use it to accrue merit to himself/herself for the achievement. But I rejected this as creating a consortium without ideas is a waste of precious tax funding; it's like taking good money and just throwing it in a garbage can.

At that time I realized that the first request itself was fake. Then I thought it through and investigated carefully what was really necessary. The responsible person seemed to have made up a kind of lie or excuse to top management.

(FC-cubic; Creation of an encapsulated scientific hangout)

My understanding was as follows;

It can be said the Japanese automobile manufacturers are well known for their manufacturing efficiency

fabrications. The famous TPS (Toyota Production System) originated in Japan and is now one of the benchmarks of manufacturers worldwide and methods such as automation, JIT, "just-in-time", and "*kaizen* (improvements)" provide a very strong input for systems integration and contribute to the manufacture of high-quality products through mutual collaboration with suppliers. The thorough and strict management of crucial information and know how, which are the basis of competitiveness, is also enabled.

However, under such an attitude, which is a kind of pure-bloodedness or independency inside a company or an affiliated group, the knowledge tends to be in a sense, very closed. This might become a weak point in the development of unknown cutting-edge technology as fuel cells, which is a field that still requires much research into the basic scientific concepts of many fields including, in particular, the development of membranes, catalysts and hydrogen storage. While the costs need to be reduced to about 1/100th of the current cost, the mass-production effect is expected to enable only a one-digit reduction. This means that the fabrication methods should be radically reviewed by means of scientific breakthroughs. But Japanese businesses, particularly those in the fields of "fabrication," such experienced knowledge is regarded as requiring a relatively few scientists with the relevant higher degrees such as PhDs. In addition, under such a relatively closed mind-set, they are not strong in forming equal partnership alliances with other business fields and are not familiar with joint activities with venture-backed small enterprises as well as academia in basic sciences as quantum mechanics, surface physics high-energy physics and so on. They invite many PhDs but enclose them inside and restrict severely the exchange of information with the outside and almost prohibit the publishing academic articles, both which are indispensable for scientific evolution.

(Why is science needed?)

Why science is needed for FCVs compared with home stationary fuel cells? I don't want to get into complicated theory so I will briefly summarize as follows: technology has three layers- an implementation limit, an equipment limit and a physical limit. If the fundamental reason for difficulties in R&D depends on the first two limits, coordination of parameters and improvement of equipment shall be good solutions, while if the reason depends on a physical limit, such measures that Japanese makers have advantages in would be invalid so that a new system, a new concept and new materials based on science are needed. That is the critical difference between FCVs and home stationary fuel cell systems or the cost reduction to 1/100th or $1/20^{th}$, between scientific breakthroughs and experiential incrementalism (kaizen). The latter needs mainly traditional ways of fabrication, and does not deeply necessitate science. Conscientious engineers at auto makers realized this point and started to insist the necessity of "Back to science."

The characteristics described above are hindering Japan's automobile manufacturers. They are like a

double-edged sword, with advantages and disadvantages. How to overcome the disadvantageous points will be the key to successful fuel cell automobile development in Japan.

Under such circumstances, there will be various difficulties for open innovation or R&D collaborations beyond the boundary of a single company and a relational group, while inter-sectoral research cooperation is needed both nationally and internationally. To avoid such problems, it is necessary to divide up a clear border between competitive areas such as fabrication and pre-competitive or non-competitive areas such as basic scientific knowledge where open collaboration is very effective and indispensable.

Based on the above analysis, I had changed my direction and established a new national lab as an encapsulated (modularized) bridgehead for scientific breakthrough. Finally FC-Cubic[i] (the Polymer Electrolyte Fuel Cell Cutting-Edge Research Center) was established in the building of AIST (the National Institute of Advanced Industrial Science and Technology) at Tokyo Waterfront in 2005. The center invited a top scientist from Toyota to be the Chief Research Officer to keep strong ties to industry and young talented PhDs of various research fields from inside and outside Japan in order to accumulate the basic scientific knowledge of fuel cell technology toward real breakthroughs which would support commercialization by the industry. It was also intended to be an enthusiastic "hangout" for younger bright scientists, where they may freely conduct basic scientific research at the same time as meeting the specific issues and needs of industry as well as fusing the knowledge of the various scientific fields required by fuel cell technology.

After three years, the reputation of the center seems rather split. There was some confusion over its own mission and some internal conflict in the management. Administration was initially very weak, and researchers including the CRO couldn't immerse themselves in deep research. I had a strange event. I always trust every research management to each CRO. However, secrecy seems profoundly stained inside FC-Cubic as I was requested to provide bio-certification to enter. I immediately refused this as officials are legally bound to keep secrets and I have no experience to enter inside. The difficulties experienced by the center seem to reflect some of the institutional weakness of Japanese entities. However, the final result in the remaining two years will testify as to the center's usefulness. We have to be patient and wait for good tidings.

(Competition with newcomers)

In 2007 I intentionally decided to create another rival; a new national laboratory in Yamanashi and the "HiPer-FC Project" (High Performance Fuel Cell) was established in 2008. The CRO is Dr. Watanabe, who holds many patents and is ranked No.1 and received the 2007 Technical Achievement Award. HiPer-FC is designed to gather first class researchers inside and outside the country. A top scientist of Panasonic decided to join, resigning from Panasonic. Many powerful researchers are gathering from Hitachi, Tokyo Gas and the U.S. As for bridging

with industry, there are no worries about Dr. Watanabe and members keeping strong ties with industry. The governor of Yamanashi and the President of the University of Yamanashi among others are showing their full support. I have stressed only two points. One is the empowerment and reinforcement of an independent and dedicated administration to support research activities. The other is to aim at a major international research laboratory and to host international research conferences as a Fuel Cell "Davos" meeting comparable to the Davos annual meeting for top executives. The purpose of such a conference is to find clues to breakthroughs in international and free-ranging research discussions by first class scientists in a relaxed atmosphere at with a comfortable hot spring near Mt. Fuji. Yamanashi is conveniently near to Tokyo and there is also the PV Wimbledon.

The new laboratory will be strong competitor for the FC-cubic and it is important to accelerate research activities by providing quiet pressure or even provoking a sense of crisis. At the opening event held in spring, I myself participated in celebrating the promising endeavor, taking a vacation and going there as part of a private trip, bringing a large bottle of champagne, Henriot Magnum, not Romane Conti, as I believe encouragement is a very important to keep motivation high to fight against many difficulties when aiming at making breakthrough.

(Inter-corporate alliances and the Technology Roadmap Strategy)

As I realized cutting edge science is indispensable in the fight to achieve 1/100th cost reduction, I dared to visit Los Alamos National Laboratory, the top tier lab in the World with a delegation consisting of engineers of Toyota, Nissan and Honda among others in 2004 in order to stimulate them. The delegation was impressed by the huge enthusiasm of experienced and excellent scientists as well as the slogan written on their name cards that was "The World's Greatest Science Protecting America". I sincerely desire this may be interpreted as "Fuel Cells and Hydrogen to Protect the Earth," and believe close international cooperation is indispensable in the fierce battle toward the common goal for mankind and all animate life on the Earth, the development of a global Hydrogen Economy. After the visit, many times I introduced this episode in my speech in many places in Japan in order to encourage scientists and engineers, among others.

Through laborious and exhausting discussions to establish the first new national laboratory, a top samurai executive leader of an automobile company gradually realized the importance of science, appealing to the idea of "back to basics and back to science." I took advantage of such a subtle change to persuade or even brainwash him and his teams.

That is a new concept of innovation management for open innovation. The partial application of ITRS[ii] (International Technology Roadmap for Semiconductors) method and the partial adoption of an open innovation system which is still unknown for Japanese businessmen who are strongly accustomed to their pureblooded,

enclosure-minded innovation systems totally inside their group companies. I personally explained the important implication of ITRS which openly declares three key elements for innovation; updated targets, time limits and problems in many subsystems in the semiconductor industry. The roadmap, which is over 300 pages long, is open for every player including start-ups and academia who wish to challenge new technologies, giving them concrete guidance toward making needed breakthroughs. Venture capitalists also carefully watch the current roadmap and invest at critical points in innovation which may bring huge value creation and capital gains and support powerful and experienced challengers. Such an open innovation management system with the ITRS which started in 1998 has caused the development of a continuous innovation chain which has changed not only ITC technology but also the entire global economy and society. The original roadmap, the NTRS (National Technology Roadmap for Semiconductors) was established in 1992 by the U.S. Semiconductor Industry Association (SIA) to fight against the strongest Japanese semiconductor giants, expanding the roadmap into an international version that has involved many international players since 1998.

I thought such a new concept might be very useful for FCV R&D in which Japanese players were confronting a gigantic wall to break through and I tried to explain this to the top leader. At first in 2003 he was very skeptical or even mocking of my idea, which was easy to dismiss as a flash in the pan or a superficial armchair plan. After some time passed, looking at many new emerging difficulties and obstacles, and hearing time consuming discussions for the new national lab, and after watching what was going on in the domestic stationary FCs inter-corporate collaboration, he first opened his mind to hear the proposal in 2006. It took almost four years to persuade this very celebrated, famous, experienced and admired figure "integral" industry. When he finally added it up, he immediately directed his team to start strengthening inter-corporate collaboration. I was surprised as the movement was very rapid, much faster than I expected. However, his team and engineers of rival companies were a bit embarrassed that they were not accustomed such an open innovation system and secret information sharing among their rivals. I could imagine this and had sympathy for them. Despite this, there was a trial to share information and make a tentative technology roadmap, which could be called NTRFC, which started in FCCJ[iii] (The Fuel Cell Commercialization Conference of Japan) and samurai engineers made great efforts to share delicate information. It seems to have been successful so far. Frankly speaking, such open roadmap will help save internal R&D investment from wasting money inside their group. Hopefully I expect that they will expand their activities and make an international roadmap, a sort of "ITRFC." Well, that maybe a dream or mere wishful thinking.

I may also have to skip the next three themes: Micro FC, promising niches and venture innovation.

(Micro Fuel Cells)

My prescription and policy measures to the third option, DMFCs and other micro fuel cells, is very simple. No subsidies. No laboratories. No demonstration projects. I only helped establishing international transportation standards in the UN. So, I only joined internal discussions and sent some supporting letters to representatives of foreign governments. That's all. I thought a lot of subsidies would disturb private R&D and possibly cause some indulgence.

When I participated in internal meetings to prepare international procedures, I happened to meet an unusual scene. A very promising tech option was almost exiled from the procedure because of bullying by major players who were mainly concerned about pass the international requirement for their own products and wanted to exclude any risks caused by unnecessary discussions about "subspecies" which were totally irrelevant to their mainstream DMFCs. So I protected and guided the discussion in favor of a promising tech option, the RMFC, Reformed Methanol Fuel Cell. Why was it so promising? Apart from the level of technical achievement, RMFC technology is a very unique option which has a synergy effect on hydrogen storage because once established, such a micro reformer could act as substitute for other storage methods in FCVs. Finally RMFCs as well as DMFCs were allowed for in international transport regulations. However, recently the R&D for RMFCs was suspended while I had thought the team was a bit weak. A new challenge is strongly expected for micro reformers which could totally change the scene in the struggle for efficient hydrogen storage.

(Niches; FC wheel chairs)

The fourth option is a unique niche. Michael Dell's business model would be applicable. Dell's business model is a modular strategy making products by mixing and matching very rapidly the newest modules from all over the world. In Dell's quickest business model, not only module production and assembly but also delivery is outsourced in order to save time. A samurai had intended make almost same thing for FC wheel chairs which is a limited but very interesting niche as FCs would have longer operational times than conventional chaires and R&D target is relatively low with easier requirements for weight, volume, durability, performance and cost. And this system safety reasons uses metal hydride as the hydrogen storage, this technology is very useful for accumulating experience and moving up learning curve for metal hydride used in a real application and such data can be used to further improve FC technology and lead to the invention of important options for hydrogen storage. Even more importantly, this niche has the advantage of a promising market with a knowable number of units and provides a desirable test bed for the accumulation of data, which is bound to have a synergy effect on other areas of the FCV field.

However two curious and sad things happened. First, I put this validation project under the umbrella of the JHFC and there was very a severe conflict between two different R&D principles; the traditional integral

approach and the new and speedy modular approach. After the samurai had been transferred to another position with a special mission ordered by a top executive, his successors were appointed and followed the negotiations with JHFC people who were accustomed to the integral approach. The primary importance of this modular system is speed and time to market, but the traditional engineers of JHFC automobile makers couldn't understand it and prevented the new project from falling under the same umbrella of JHFC. Lamentably I couldn't intervene as I was no longer responsible for this.

This samurai had almost formed an international alliance including the Department of Environmental Protection of the Commonwealth of Pennsylvania but finally his bosses couldn't accept his promising proposal and very recently he resigned from the stubborn company. Unfortunately this promising option is now suspended. The samurai is regretting that he has no time to follow this and is waiting for a powerful candidate to succeed the suspended international project from all over the world.

(Venture-based innovation)

The fifth and last option is venture-based innovation. As you may know, after the 90's when modular architectures became dominant in many industries, protagonists of superb innovation were entrepreneurs and supporting venture capitalists. Private equity financing fits the creation of new cutting edge tech options taking and controlling risks in larger portfolios. Ballard is known to ventures and it holds its own venture capital fund to find out and create promising seeds. Private equity financing has accumulated an impressive track record in the ICT and healthcare industries, and very recently also in new renewable areas as PVs, biofuel and so on. Google was founded in 1998 and IPO's in 2004 and its market capitalization was around US $30 billion, rising to US $170 billion- a rise so impressive that a famous first tier venture capitalist called this as "the greatest legal creation of wealth." Q-Cells was founded in 1999 and underwent an IPO and now became the world's No.1 PV production company defeating Sharp, the defending world champion for 7 years. First Solar was established in 1999 and with its exit in 2006 its market capitalization was around US$ 20 billion. In FCs and hydrogen also, venture-backed companies may be able to create tremendous ideas for breakthrough. Of course, there were many fake ventures however; the market capitalization remains very poor. Among other stars, Conduit Ventures in London has accomplished a sure truck record of 5 exits in 7 investments. The exit ratio is unbelievably high and Conduit supported a carve out team on high temperature membranes from Höchst and created value and finally sold it to BASF and acquired a certain amount of capital gain.

A unique problem for this venture option is the architecture. While start-ups could make their own products in micro FCs and niche FCs, major FC markets as FCVs and stationary FCs may have an integral architecture as they contain many and very complicated interdependencies among major components as

membranes, catalysts, bipolar plates and so on as main chemical reaction occurs at a 3-phase interface. It seems necessary for start-ups to coordinate with giants.

With regard to this option, the U.S. government has cultivated an excellent system called SBIR (Small Business Innovation Research) to foster and support promising ventures since 1982. NIH and NASA are known for fostering outstanding start-ups. The DOE also has an excellent track record. Fuel Cell Energy took advantage of SBIR for its key component for their competitive MCFC. I studied SBIR for ten years just after returning from Spain and finally introduced a new SBIR scheme for new renewables in Japan last year in order to find and foster outstanding and promising ideas of samurai entrepreneurs in important fields as fuel cells, hydrogen, photovoltaics, next-gen advanced batteries, next-gen biofuels and so on.

(Material Science and Applications)

Cost reduction and the safety of hydrogen stations are essential if hydrogen stations are to be built all around the world in the future. For this purpose, I believe long term R&D for hydrogen materials is the most important step we can take and such knowledge surely will have a synergy effect on FCV development.

One day I was hit by an unexpectedly grave incident at the hydrogen station at the World EXPO 2005 in Aichi, Japan. There was a hydrogen leakage and many fire trucks and police cars surrounded the station. The incident occurred 10 times earlier than the design specifications. Later it was reported with very simple reasoning and analysis that excess mechanical force had been added to the bored flexible hose. I immediately had a hint of suspicion that hydrogen embrittlement might have caused this incident and asked Dr. Murakami, Vice President of Kyushu University, to investigate the bored piece. Amazingly cutting edge analysis revealed the fundamental reason for the incident and the analysis of only a small piece very correctly recounted how many times the hose had been used. Through this incident, I affirmed the importance and necessity to establish the one and only international lab for hydrogen materials headed by the eminent samurai Professor Murakami who I admire and rely on. In 2006 the "Research Center for Hydrogen Industrial Use and Storage" (HYDROGENIUS)[iv] was established by AIST, the National research agency inside Kyushu University. It is another experiment in the country as prior to this there had been only one awkward precedent for coupling between a national lab and a university in Japan, even though it is normal in the U.S., for example LANL and other eminent U.S. national laboratories. The brightest researchers from the U.S. France, Ukraine, Israel, South Korea and China gathered under Dr. Murakami, who is well known for his talent, leadership and strong passion. For example Prof. Jean-Marc Olive of the University of Bordeaux 1 resigned his post there and joined the new project with his family. The CRO's passion may transfer to all the members. Sometimes the administration worries about Dr. Olive's health as he sometimes works through the night at the lab. When I told this episode to my counterpart French DG,

he seriously responded that "Appassionato French people do our best even if it means working through the night when needed."

The research result was amazing in that in only three months Dr. Murakami's team revealed a fundamental principle of so-called hydrogen embrittlement. New discoveries continue one and after the other. Hydrogenius revealed that the recycling duration time of around 10 minutes is a key factor and almost found new measures for the recovery of used materials. It is now seeking cheaper materials as an alternative to the well known and very expensive SUS316L. SUS316L is normally used for critical materials as it is known as to be highly resistant to hydrogen embrittlement. However, it is very expensive at twice the price of normal stainless steel and ten times the price of normal steel, while being slightly weaker so that more of it and a weight penalty are required for its use. Research in Hydrogenius will help to build hydrogen stations and produce hydrogen-related devices for FCVs at a much cheaper cost while maintaining a sufficient level of safety. In this sense also, the mass construction of hydrogen stations doesn't seem an intelligent approach when specifications have yet to be fixed. I am expecting more advances and accumulation of the necessary knowledge to enable the development of the Hydrogen Economy during 7 years that this unique international lab, Hydrogenius, is committed to work. By the way, last fall the ceremony for opening newly a constructed research facility was held with the Governor and President of University of Kyushu in attendance. I also took a vacation and attended privately, bringing another magnum bottle of Champagne, Moët et Chandon of course, to celebrate and encourage Dr. Murakami's fireball-like appassionato team even though they need no further encouragement.

I have really studied this issue and realized that gathering first class researchers in one place interactively will be the main means to create great breakthroughs. The great Austrian economist Joseph Schumpeter suggested early in last century that mixing up and fusing different knowledge is a good way for innovation. That is true, indeed. Personally I see further fertile ground or new platinum mine that knowledge that will be accumulated in HYDROGENIUS would be applicable and pricelessly useful not only for the Hydrogen Economy but also for other fields as fatigue breakdown in all kinds of machines, nuclear power plants, and advanced semiconductors and so on.

(Hydrogen Storage)

Now let move on to the final issue, hydrogen storage. This is still in the scientific research phase except for the technology of very high pressure tanks.

As for very high pressure tanks, I had insisted on and refused two things; 70 MPa station and pre-cooling at the station. Why did I refuse the requests of the industrial main players? The pressure of a natural gas vehicle is 20 MPa and the current FCV is 35 or 70 MPa. I don't want to let my family and friends and even

myself sit on the seat on top of a flask containing combustible gas at 70 MPa. Joking aside, using 70 MPa for consumer durables doesn't seem like a good idea while of course it might be possible for it be safe technically, the economics, practicality and environmental aspects of this are unknown. The upper limit has not been decided, however at 70 MPa the nature of hydrogen differs far from that of an ideal gas. Finally I made go sign to construct a 70 MPa hydrogen station as industry explained that they were looking for an optimal pressure between 35 and 70 and I thought it made sense that experiments at the uppermost pressure would be necessary.

On the other hand, I kept my refusing pre-cooling during my duty as it seemed for me to be somewhat an irresponsible attitude for a real innovator or challenger. It is not good to make a boundary wall surrounding one's own research field and blaming difficulties as the responsibility of others. It can be easily imagined that pre-cooling might cause other different difficulties and disadvantages such as durability and the safety of the hydrogen station and be the cause of significant and considerable energy losses even though the filling time and rate might be a bit improved. That why pre-cooling seems to be escaping away from the path required to lead to a real breakthrough. It might be totally opposite to the attitude of an innovator such as Alan Kay, the famous inventor of laptop computer, meant when he said, "The best way to predict the future is to invent it!"

There are other options as metal hydrides, organic and inorganic chemical hydrides, even with carbon nanotubes, but these still remain in the science phase. You might imagine that I apply the same equation: new national lab and samurai leader. Forse che si, forse che no.

Fortunately there is samurai scientist in this field in Japan and I visited Dr. Akiba's research place in AIST in Tsukuba, north of Tokyo on a day of heavy snow. My first idea was a united national lab on hydrogen materials and storage. However, he denied the idea immediately and refused to establish a new national lab. Because if he calls for scientists and engineers from all over the country, of course, they would gather to his place but their companies, universities and laboratories would be denuded of their best researchers. So he wanted to establish a virtual research network for in various candidates as metals, chemicals and carbon. I immediately agreed with this at it was virtually established then. It was very easy to focus and prioritize his project or new virtual national lab.

Dr. Akiba wanted international collaboration with China. When he organized a Japan-China research seminar, I asked Minister Xu Tong Mao of the Chinese Embassy in Tokyo to come and make an opening speech. It was not celebrate an important seminar but I really wanted to inform Beijing that Japan is prepared to collaborate with China in such a state-of-the-art and cutting edge research field via a diplomatic route and also wanted to encourage and put the spotlight on his counterpart researchers who were working rather in obscurity in a rural Institute of China.

On the other hand Dr. Akiba intended to involve other scientific fields such as high-energy physics,

using synchrotron radiation and neutrons. And I thought at the same time international collaboration with the U.S. would be necessary in the future. The time soon came. When I accompanied Minister Nikai's visit to LANL, which was a memorable first ministerial visit after we were A-bombed in WW2, I telephoned Dr. Akiba to arrange a new collaborative research project on hydrogen storage. And just after returning back to Tokyo I tried to slide in an additional new budget request just on the final day of the limit.

In 2007 the Advanced Fundamental Research on Hydrogen Storage Materials (HYDRO☆STAR[v]) was established to study hydrogen storage materials from fundamental point of views using large scale facilities such as SPring-8 (synchrotron radiation) and J-PARC (neutrons) while inviting modeling scientists to meet experimental scientists in order to realize significantly higher performance materials for on-board hydrogen storage in collaboration with industry. And collaboration with Hydrogenius also naturally commenced.

Are there any more tech options for hydrogen storage? Yes, there are. For me, micro reformers with nano-devices are interesting and also the Ammonia Cycle might become an unexpected but promising option in the future. It is interesting that there are many possibilities so that making decisions about hydrogen station too early is not only unnecessary but also potentially rather harmful.

(Insistency of Policy)

Frankly, I was dismissed last year even though it is very unusual for a Japanese official to stay four years- usually a director works for as one year or two years. However, I am very happy as I have found a new gold mine, fertile land for Eco-design, Eco-Production, anti-metabolic strategies among the industrial structure, greener Supply chains, greener Keiretsu, "integral architecture version 2.0" and I have also found an "urban mine" from recycled products as mobile phones. I myself could not have imagined that the Recycling Policy Division could make a very new policy, but it has, with green design and production aiming to change the entire industrial structure of our country under the constraints of both scarce and restricted fossil fuel and materials, and CO2 emissions. Adding to this, recently my old friends including several samurai contacted me about the theme of recycling of fuel cell systems. It seems for me a good opportunity to prepare for our promising future. However, I had moved to yet another new position in the Cabinet Office.

(Five options and seven policies)

In brief, I put five options and two measures in a matrix. The section on Modular & Science is very suitable for international cooperation and the technology roadmap strategy as the ITRFC, which provides good guidance for venture clusters.

Also I summarized progress of the seven policies so far. As Pareto's Law suggests some may succeed,

others not and the remainder will continue thir efforts sincerely.

("Teian"; Some possible advice)

I am afraid that it might impolite to express some observations or even offer some kind of advice. However, as I really believe the in the future promise hydrogen and fuel cells, I have to call up my courage again.

- **ZEV regulation**: I really appreciate bold ZEV regulation. However, it is important to synchronize this to the proper stage of technology evolution. I don't know exactly but GM and Honda might have heavy burdens. Costly investment for several hundred or thousand FCVs could be substituted for other more efficient investments for further development.
- **Preferential Reversible Lane**: I also appreciate this measure. This fair treatment greatly helped the commercialization of Japanese hybrid cars. I admire fairness of the U.S. This is very effective measure to foster selected cleaner vehicles.
- **Demonstration project**: This makes sense only for preparing experiments for commercialization. If not, for me it seems a waste of money and it is good to cut the budget for this to make better use of the money in other fields.
- **Hydrogen stations**: it seems better to wait and see until the materials and specifications are be fixed. Even though there is some possibility for the use of ammonia.
- **Universities**: It is important to foster young talented scientists and engineers so that strengthening hydrogen fuel cell education in first-tier universities such as Stanford and MIT shall be of great importance. Japan could cooperate and contribute. How about Japan and the U.S. creating endowment chairs? (Now I have no power, indeed.)
- **Technology Roadmaps**: When a giant company informally writes a draft roadmap, the power of TR increases tremendously. That was the case of the ITRS when IBM and Intel among others wrote the draft and gathered talent from all over the world to create a continuous innovation chain that has enabled Moore's Law to continue to exist for more than 40 years. I see the possibility of and think GM and Toyota could make this approach which could save their own investment.
- **Venture investment**: SBIR is a well organized system to foster promising tech options and Silicon Valley is inclined to Clean-tech. However, new investment in hydrogen and fuel cells seems inactive and decreasing. It might be an option to put public money to a Clean-tech fund instead of wasting it on demonstration projects. For example, a GM Green-tech Fund, a U.S. Green-tech Fund or a California Green-tech Fund would have a strong impact on gathering the attention needed to making the necessary breakthroughs. However, compared with ICT and biotech, there are few experienced experts for clean-tech who have a track record. Only members of Conduit shall be possible candidates for hydrogen and fuel cells. In this policy, desirably a new Technology Roadmap for

fuel cells and Clean-tech shall be set for guidance. On the other hand, it might be an idea to manage common a SBIR for Clean-tech between Japan and the U.S. It might controversial if it involved China but a Japan=U.S.=China joint program might be very interesting.

- **Funding Opportunity Announcement**: It was announced that the DOE issued a Funding Opportunity Announcement (FOA) for up to $130 million over three years to advance the development and use of fuel cells for automotive, stationary, and portable power applications. I couldn't understand the real meaning and intention. Without any specific focuses more than seven major areas, it might only disseminate tax to various players. Otherwise, strengthening SBIR and a private equity fund might seem a better way for me.

- **World' largest FCEXPO and other events in Japan:** Taking advantage of the world's largest FCEXPO I welcome your FC and hydrogen related products and technology conquering Japan. It seems like bad joke, however fuel cell development is really borderless, I believe. I also welcome other presences. For example, a professional baseball team, Rakuten, which manages Japan's most eco-friendly stadium is inviting an FCV demonstration performance in August.

- **Miscellaneous**: I mentioned that the RMFC and FC wheel chair projects are both up in the air. It might be a good opportunity to take them over. The last item is not an invitation but only an observation.

(Conclusion)

Just a month ago, The Washington Post reported that one presidential candidate proposed a "$300 Million Prize for Electric-Car Advance" for the inventor of a better battery to power electric or hybrid vehicles, with the goal of spurring innovation to wean Americans off their gasoline habit. Is this a wise policy or not? I have no intention on commenting on the presidential election. The "Wanted" prize is a traditional way to encourage people and let them to do something. However, today innovators can obtain huge amounts of capital gain. Google was established in 1998 and IPO was in 2004. Its market capitalization was $30 billion then, not $300 million and it is around $170 billion now. As for Clean-tech, First Solar was established in 1999, IPO was in 2006 and its market capitalization is $21 billion. So a huge prize may be surmounted by a huge capital gain for founders.

Now returning back to table paper 1, please look at it and please image that the z axis, or value axis, stands strictly vertical to the sheet. If all of us here, Japanese samurai, Europeans and Chinese friends give up on the hydrogen and fuel cells, the landscape of created value shall be zero and on the sheet itself. On the contrary, I do believe in the real breakthroughs for the crucial water/hydrogen cycle in the future and I imagine Rocky Mountains or the Himalayan Range standing on the sheet indicating the scale the huge value created. Rifkin implicitly insisted on changing from the "carbon cycle" to the "water cycle." Needless to say, the water cycle option must be achieved as soon as possible.

Famous Entrepreneurs in Silicon Valley have said "Only the Paranoid Survive" or "Stay hungry, Stay foolish."

However, for the hydrogen option, it is important to "Never Give up."

Effort certainly shall be rewarded. "Persistence is Power." Mr. Shinoda, Dr. Nakamura and others never gave up. When now we are facing crisis, why can we forget the important option? Why don't we fight together? The opposite word of impossible is passion, I believe. On the other hand, 100 years ago, when Japan was still a distant, poor, small country, a great American professor, Dr. William Smith Clark, the third president of Massachusetts Agricultural College taught Japanese students, "Boys, be ambitious!" After that time, big ambition has been a key driver for challenge and innovation in Japan.

To close my poor speech, I dare to express again my undying gratitude to Mr. Chair and Dr. McCormick all the members and secretariat. And I confess that I really admire Mr. Steven Chalk. He is the best officer and public servant I have ever met, not only for his talent, experience, passion but also his braveness. He taught me priceless lessons only in a 10 minute talk, what is the brave heart. This has encouraged me for a long time.

Let me thank Mr. George Hansen. GM is generally regarded as the best car company with first class vehicles I also admire Mr. Hansen. He is an excellent bridge between the U.S. and Asia and Japan.

Finally, we have to not only share the dream but also realize it. At the cutting-edge there is complete and unknown darkness, however, as Japan will not give up, why don't we move forward together to protect the Earth.

Dr. Kiyoshi Kurokawa, Special Advisor to the Cabinet, the PM's scientific adviser always encourages us with the phrase of Horace or Quintus Horatius Flaccus;

"Carpe diem, quam minimum credula postero!"

Today, I came here to show my purity and passion for fuel cells. I don't know whether it was of a certain level success or not. However, "I have a dream that one day our sons will be able to sit down together in the driving seat of a brotherhood of freedom-car under a perfect international alliance." And Howard Hawks left a famous phrase in his script that, "In this business, there's only one law you gotta follow to keep outta trouble. Do it first, do it yourself and keep on doin' it."

Thank you very much for your kind attention and patience.

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[i] http://unit.aist.go.jp/fc3/index_e.htm
[ii] http://www.itrs.net/
[iii] http://www.fccj.jp/index_e.html
[iv] http://unit.aist.go.jp/hydrogenius/cie/index.html
[v] http://unit.aist.go.jp/energy/hydro-star/english/index.html