World Culture and Sports Festival 2000
The Convocation of World Leaders
Seoul, Korea, February 10-14, 2000

EXECUTIVE SUMMARY

"CLEAN, AFFORDABLE, AND SELF-SUSTAINING ENERGY: A CRITICAL COMPONENT FOR A CULTURE OF PEACE IN THE 21st CENTURY"

Co-sponsored by the Federation for World Peace
and the Summit Council for World Peace

Chair: Dr. Yuri A. Ossipyan
Panel Participants: Dr. Marvin Warshay, Dr. Terry R. Galloway, Mr. Dean Price
Rapporteur: Dr. Marvin Warshay

Introduction

Three related papers made up the session, chaired by Dr. Yuri A. Ossipyan, director of the Disarmament Agency of the Russian Federation. The first paper entitled "THE EFFECTIVE UTILIZATION OF RENEWABLE SOLAR POWER SYSTEMS WITH REGENERATIVE FUEL CELL ENERGY STORGE, FOR COMMERCIAL APPLICATIONS" was presented by Dr. Marvin Warshay, a Director of Equitech International, Inc. (EII). It traced how the space age technology Regenerative Fuel Cell Energy (RFC) Storage System is being transferred to commercial applications. It discussed a number of useful variations of the Solar RFC Power System. However, Warshay concluded that the greatest benefits would arise from integration of the Solar RFC System with other systems, where effective integration of the Solar RFC with one or more systems will produce significant advantages over operating the systems independently. He went on to indicate that an important candidate is the Solid/Complex Waste Steam Reforming System.

In the second paper, Dr. Terry R. Galloway, President of the INTELLERGY Corporation and a Director of Equitech, discussed various Waste Steam Reforming Systems. The title of Dr. Galloway's paper is " CLEAN RENEWABLE ENERGY & TRANSPORTATION WITHOUT GREENHOUSE GASES". In part of that paper, Galloway discussed three different scenarios involving waste mitigation that would also produce useful products. These were "Steam-Reforming of Waste to Produce Syngas", "Future Waste Streams Available for Co-Feeding (with coal)", and "Future Energy Self Sufficient Community". This last topic was the particular interest of the third speaker, Mr. Leslie Dean Price, Chairman of Equitech International, Inc. (EII).

The title of the third paper was "EQUITECH INTERNATIONAL, INC.". As explained by Mr. Dean Price, EII was incorporated to develop the Integrated Solar RFC Power/Waste Removal System and further integrate it with advanced industrialized building/dwelling construction and telecommunications. In his paper, he described EII's E-Microsystem 100kW sustainable energy concept, as well as its much larger E-MacroSystem concept. EII has organized a consortium of

high technology companies to commercialize the Advanced Integrated Solar RFC Power/Waste Removal System. Price described the worldwide market for these systems and gave a brief look at one country to help the audience understand the market potential.

I. THE EFFECTIVE UTILIZATION OF RENEWABLE SOLAR POWER SYSTEMS WITH REGENERATIVE FUEL CELL ENERGY STORAGE, FOR COMMERCIAL APPLICATIONS- by Dr. Marvin Warshay, Equitech International, Inc. (EEI) Director, Cleveland, Ohio.

Introduction - NASA had long recognized the unique advantages of the Regenerative Fuel Cell (RFC) System to provide energy storage for Solar Power Systems in Space. The RFC System was uniquely qualified to provide the necessary energy storage for solar surface power systems on The Moon or on Mars, to use during their long periods of darkness, i.e. during the 14-day Lunar night or the 12-hour Martian night.

However, in the course of implementing the NASA RFC Program (initially to provide energy storage for a planned 25kW Solar Surface Power System for the Moon) the NASA team in charge of the RFC Program at NASA Lewis Research Center (LeRC) recognized the vast number of applications for the RFC System outside of space, i.e. for government, industry, commercial, and even university applications. An efficient, environmentally benign, highly reliable, renewable energy power system is very attractive for many types of applications on the Earth as well.

To carry out the multi-application RFC Program, in the late 1980's, a unique international coalition of government industry, and university participants was organized and led by NASA LeRC. The pioneering, multimillion dollar RFC pre-prototype system development effort by NASA led to the development of a 25kW Solar RFC Test Bed that was available to support the system development efforts of all members of the government/industry/university coalition. One of the coalition drivers was United States Public Law 104-271 which authorized 50 million dollars for the "Integration of Fuel Cells with Hydrogen Production Systems", specifically, to prove the feasibility of integrating fuel cells with (1) Photovoltaic systems for hydrogen production or (2) Systems for hydrogen production for solid waste via gasification or steam reforming.

The Solar RFC Power System- The basic Solar RFC Power System consists of the Solar Power Subsystem, the RFC Energy Storage Subsystem, and the supporting subsystems. The Solar Power Subsystem consists of photovoltaic (PV) arrays. The RFC Subsystem consists of the Electrolyzer Subsystem and the Fuel Cell Subsystem with reactant storage tanks. In addition, in order to maintain operation, Thermal Management and Electrical Power Management Subsystems are required. The basic system operates as follows: When the sun shines, the Solar PV arrays not only put out enough dc power to satisfy the daytime loads, but also to supply power to the Electrolyzer Subsystem which dissociates water and stores the resulting hydrogen and oxygen in storage tanks. During the night, when the solar arrays are inactive, the Fuel Cell Subsystem is turned on to supply the required nighttime loads. Of course the product water is stored and later separated back into its hydrogen and oxygen constituents by the solar-powered

electrolyzer during the next daylight portion of the cycle. Therefore, the basic Solar RFC Power System does not require any supply of external fuel to operate its fuel cells. The sun is the only source of external energy required.

Applications- As described, the basic Solar RFC Power System is a closed system requiring no additional supply of reactants or water. However, for commercial applications, it is often advantageous to design a variation of this basic system. On the Earth, an obvious variation is to use available air in the Fuel Cell Subsystem in place of the oxygen produced by the Electorlyzer Subsystem. The oxygen would be available for other uses such as for biological waste purification, hospital and home health uses, etc. Another variation could involve periodic export of the pure water produced in the Fuel Cell in exchange for an external supply of less pure water. One could also envisage another scenario in which the pure hydrogen generated by the electrolyzer is used to provide hydrogen fuel for fell cell powered cars or buses. In this variation, a less costly fuel than the usual pure hydrogen would have to be available to the Fuel Cell Subsystem. Finally, in the Thermal Management Subsystem, where there is both opportunity and advantage, waste heat from the Fuel Cell Subsystem could be recovered (to supply space heating, heat for hot water, etc.) rather than disposing of the system waste heat.

However, as potentially useful as are these variations of the Solar RFC Power System, the greatest benefits will arise from integration of the Solar RFC System with other systems, where effective integration of the Solar RFC with one or more systems will produce significant benefits. An important candidate is the Solid/Complex Waste Steam Reforming System. The leading proponent of integrating these two Advanced Systems is Equitech International, Inc. As an outgrowth of its membership in the Solar RFC System Coalition, EII has organized a consortium of high technology companies to commercialize these two Advanced Systems, initially for modular housing clusters which will supply power on the order of 100kW.

It is clear that the RFC is the key to the Solar RFC Power System. That being the case, the designer should understand that RFC does not require a particular type among the current five leading types of fuel cells, the Proton Exchange Membrane (PEMFC), the Alkaline (AFC), the Phosphoric Acid (PAFC), the Molten Carbonate (MCFC), and the Solid Oxide (SOFC). They all have different characteristics. And in the final analysis, a fuel cell type's ability to meet application requirements, including cost and availability will determine selection.

II. CLEAN RENEWABLE ENERGY & TRANSPORTATION WITHOUT GREENHOUSE GASES- by Dr. Terry R. Galloway, INTELLERGY Corporation, 6801 Sherwick Drive, Berkeley, CA

ABSTRACT
In his paper, he showed a series of demonstration projects, underway, that will pave the way for future communities to be supplied with clean and efficient energy, have their waste reformed into hydrogen, and co-producing useful chemicals. The demonstrations start with salvaging old coal plants and applying new technology breakthroughs, where coal can be fully utilized as an important energy and chemical resource without troublesome emissions of carbon dioxide (CO2)

and without the typical problems of NOX, sulfur, and other particulate emissions. By aggressively retrofitting only 285 of our old 1000 MWe coal plants, a l5% CO2 reduction of 200million tons of CO2 can be met by 2010 – the goal of the European Nations. Dr. Galloway calculated typical 3 year paybacks for such plants.

Next he showed how solar photovoltaic collectors can be used to drive electrolysis units to produce hydrogen and oxygen to further increase the efficiency of a steam-reforming waste-to-energy plant and where hydrogen can be used to recharge hydride modules to power clean hydrogen vehicles.

Finally, through the use of steam-reformer/gasifiers that produce hydrogen-rich syngas, the hydrogen can be extracted and stored by metal hydrides; thus, enabling hydrogen fuel vehicles that only emit steam from their tailpipes. These technologies are the first steps toward a worldwide hydrogen economy.

Background-The Challenge: The Executive Branch of our government has a strong desire to move the U.S. energy policy toward renewable/sustainable energy sources, and they want to do it without polluting the atmosphere. As a consequence, the White House Office of Science and Technology Policy (OSTP) is very interested in the steam-reforming, solar energy, and fuel cell technology synergies for the future. The purpose of the paper was to give a brief overview of how these new technologies fit together and, at the same time, offer the simultaneous opportunity to eliminate greenhouse gas emissions from fossil plants and help move toward a hydrogen economy. Dr, Galloway illustrated an example where future solar/hydrogen communities could be built in remote areas without a utility infrastructure, such as in many developing countries.

The burning of fossil fuels in boilers to raise high temperature, high pressure steam that has been used to power turbo-electric generators produces a problem source of carbon dioxide and other greenhouse gases. This fossil fuel combustion, especially of coal, needs a technological fix to avoid the emission of carbon dioxide and other greenhouse gases with their attendant undesirable release to the Earth's atmosphere. There have been significant efforts to develop coal technologies to greatly reduce the release of acid gases, such as sulfur oxides and nitrogen oxides. But to date, none of these clean coal programs aim to eliminate carbon dioxide and other greenhouse gases.

The new concepts presented here (for which a patent has been filed) avoid the difficult path of attempting to strip and capture the carbon dioxide from stack gases and attempt to produce useful products. The new approach uses commercially available gasification technology combined with fuel cells to generate electricity at high efficiency, while being able to recover the greenhouse gases for the production of useful chemical products, thus sequestering the CO2. In this way, a combustible feed gas can be fully oxidized without being co-mingled with the final oxidation products.

New Concepts—A Future Direction: The first commercial demonstration step now underway is to upgrade a typical old coal combustion plant to a first-of-its-kind coal plant of the future, where coal can be fully utilized as an important energy and chemical resource without problem emissions of CO2, acid gases, and particulates. The plant's conceptual design includes the use

of several advanced technologies, most of which have been proven individually, but have never been integrated into a single system. A local source of coal co-mixed with industrial/municipal waste would be steam reformed to manufacture synthesis gas (syngas), consisting mostly of hydrogen and a fraction of carbon monoxide. This syngas would feed a fuel cell to make electricity and co-generate steam for a turbo-electric generator system to make more electricity.

In addition, if the geographical location is suitable for solar energy production, PV panels could be installed to generate enough electricity to drive water electrolysis units to produce oxygen and hydrogen. The hydrogen could augment plant syngas, to supply a steady source to the fuel cells during plant outages or down-cycles as well as provide hydrogen for clean transportation vehicles. The oxygen produced by the electrolysis units could be used for coal steam reforming or as part of the oxidant supply for the fuel cells. The Solar panels, the electrolyzer, and the fuel cells constitute a Solar RFC System, which Dr. Warshay spoke about in the previous paper.

The chemical co-production options are: methanol, carbon disulfide solvent, higher molecular weight middle distillates (i.e. kerosene), urea fertilizer, lubricating oil, highway asphalt-extender, inorganic concrete additives, etc. Utilizing the carbon source to produce chemicals eliminates any C02 emission and sequesters the C02 for longer periods, or forever. So we see that the fossil plant of the future can be an integrated simple chemical plant and power plant.

Fuel Cell/Turbo-Generator Electricity Generation: The fossil fuel-steam-reforming plant concept will require that the fuel cell type accept carbon monoxide and light hydrocarbons, in addition to normal hydrogen. This requirement almost guarantees that the only two types to be considered are Solid Oxide Fuel Cells or Molten Carbonate Fuel Cells. Integrating one of these high temperature fuel cells with the turbo-generator improves plant efficiency greatly.

In the case of our present combined cycle project, despite its more than double the efficiency, the upgraded coal plant is designed to deliver about the same power as the present old coal plant. However, the plant's additional output can be used to manufacture chemical products.

Waste Mitigation for Energy and Chemical Production: Galloway discussed three waste mitigation scenarios. The first involved Steam-Reforming of Waste to Produce Syngas. Carefully selected waste like petroleum coke was discussed in this scenario. To handle the large variety of community waste, Co-feeding of Waste Streams with Coal to the Demonstration Plant was the second scenario discussed. Galloway pointed out that the economics of diverting municipal waste was not favorable at this time. Environmental incentives would have to come into play. In his last scenario, he discussed the exciting possibility of combining these key technology breakthroughs to create an energy self-sufficient community, e.g. a small village in a developing country, that would handle its own sanitary waste without a centralized wastewater treatment plant, will handle crop and food waste, will provide for all needed electrical and space heating needs, and supply hydrogen in hydride modules for use in clean fuel cell vehicles.

III. EQUITECH INTERNATIIONAL, INC. By Mr. Leslie Dean Price, Chairman, Equitech International, Inc. (EII)

The company- Equitech International, Inc. (EII) is an R&D holding company, headquartered in Washington, D.C.. It is a consortium of high technology companies. Equitech's business consists of two activities. First, it is active in R&D work that helps generate patents and, second, in work that markets and sells developed products based on those patents. EII was formed to develop and apply clean advanced power technologies integrated with industrialized building construction and telecommunication systems.

The Products- Equitech has patented the integration of two advanced technologies into a single system based on the proven technologies of solar regeneration and solid/complex waste steam reforming. This system, developed at a cost of $52 million, provides hydrogen from the sun and from waste products to produce clean power without the need of expensive infrastructure. The system is sustainable, stand alone and rapidly deployable. These energy and communication systems are built into industrialized buildings made from prefabricated carbon deposit materials with a modular factory built distribution system.

The products are:
- Solid/complex waste to total energy solar methanol fuel cell power technology (E-Micro and E-Macro systems).
- Advanced fuel cell and system component manufacturing.
- Manufacturing and deployment of Industrial facilities. Advanced photovoltaics and robotic fuel cell logistic systems. Integrated telecommunications and wireless Internet based intelligent monitoring systems, telemedicine.
- Composite material based industrialized buildings.
- Prefabricated horizontal and vertical distribution systems.
- Fuel cell powered liquid fueled transit buses.

Equitech technology, which is modular and rapidly deployable, when completed, can provide power, communications, waste disposal, and fresh water with minimal infrastructure costs and negligible environmental impact. And it can be easily integrated into an industrialized construction program.

The technologies that Equitech uses already exist, but as stand alone systems. They are commercial, but not yet commercialized. Equitech integrates these technologies into one, sustainable, system. This is called the Equitech E-Microsystem.

E-Microsystem: Mr. Dean Price stressed that we need solutions to many basic global problems. He pointed out that two and a half billion people have no electricity! Most are also without clean water, health facilities, and other amenities. EII can deliver clean water affordable housing, electric power, safe waste disposal, and modern communications to most people worldwide as well as complete "life support" elements such as oxygen and fuel for clean vehicles.

E-Microsystems will integrate existing proven technologies in ways that enhance energy efficiency so that there are manufacturing economies of scale. Its products and services are packaged, bundled, and delivered to customers in ways that are sustainable.

Customers realize multiple benefits from receiving a bundle of integrated services in one closed system. It will be especially attractive in remote locations in developing countries. Nevertheless, its market is worldwide, in high and low-density population areas.

Specifically, the E-Microsystem is a 100kW (kilowatt) sustainable, energy unit. It has all the utility technologies integrated inside it. It consists of factory-made modules that are highly integrated. This box unit contains fuel cells, a waste disposal unit, methanol storage tanks, and other utility systems.

The E-Microsystem also integrates and imbeds remote communications. This delivers modern communication services. Satellite and cellular telephoning, teleconferencing and telemonitoring act together to deliver modern communication services. Remote monitoring, through system component sensors, allows pro-active maintenance.

The E-Microsystem can serve 50 cluster houses or apartments. It can serve a 42 bed advanced technology hospital, or small commercial facilities, community centers, schools, government offices, police stations, banks, and other facilities of comparable size. It can service a complete community.

The E-Microsystem design allows easy installation during new construction. This is particularly useful where there is no access to the energy grid. It reclaims and produces potable water. It recycles water run-off from the roof and all building wastewater. It is a complete closed system. Equitech installs this unit, integrated with a solar array electric unit, on site. Installation involves connecting the entire unit, plus solar roof paneling, to a building. This closed loop system then becomes a sustainable energy building.

E-Macrosystem: The E-Macrosystem is scaled up from the E-Microsystems producing unlimited megawatts of power. The E-Macrosystem is applied both to existing and planned infrastructures. Dean Price pointed out that this technology is directly applicable to retrofitting coal burning power plants. It is clean and mitigates landfills while recovering greenhouse gases via sequestering CO2. In addition, the system produces large amounts of fresh water, medical oxygen, and methanol. With the active involvement of Dr. Galloway, design concepts have been developed for Big Sky Economic Development Authority of Billings Montana and Pittsburgh Power and Light.

The Market- As an illustration of the vast potential, Price talked, briefly, about contacts that Equitech has had with representatives of China. China's new housing plan calls for 400,000,000 square meters of urban housing and 700,000,000 square meters of rural housing by 2010. Equitech plans a demonstration with appropriate Ministries. This will prove E-Microsystem suitability for new housing in China. A successful demonstration will enable China to relieve its over-taxed energy grid. It will allow building community scale towns and villages that are energy self-sufficient. Equitech's approach also provides economic development opportunities within China. The Chinese government has also expressed an interest in participating in a demonstration project in Southern Illinois that Equitech has been invited to participate in.