Session 3 - Innovation for a Sustainable Hydrogen Economy

Introduction by

Dr. Woodrow W. Clark II, Former Deputy Director/Senior Advisor to California Governor

Chairman

Dr. Woodrow W. Clark II Ph.D. received three separate Masters degrees, one in Political Science, Administration/Education, and in Anthropology/Economics. He received his PhD. in Anthropology/Education in 1977 at the University of California, Berkley. Clark is a "qualitative economist" with a depth of advanced degrees and business experience in entrepreneurship, corporate governance, public policy and international SMEs.

Between 1980 and 1990, Dr. Clark founded and was CEO and Executive Producer of Clark Communications LLC and Woody Clark Productions LLP. Clark was Managing Director and a Board Member of the Centre for New Venture Alliance, Business/Economics School, California State University, Hayward from 1990 to 1993. From 1994 to 1999, he was Manager of Strategic Planning for the Energy Directorate, Lawrence Livermore National Laboratory at the US Department of Energy. Then, from 1999 to 2002, he was Visiting Professor at Aalborg University, Denmark.

However, in December 2000 Dr. Clark, left Denmark to join Governor Gray Davis to help in the California energy crisis. Dr. Clark became Senior Policy Advisor on Energy Reliability in the Office of Planning and Research (OPR). In August 2002, he was appointed Deputy Director of OPR until the recall of Governor Davis in November 2003. Currently, Clark is finishing a book with Professor Ted Bradshaw (University of California, Davis) titled 'Agile Energy Systems: global lessons learned from the California energy crisis (to be published in June 2004), and is both consulting on renewable energy and hydrogen topics, as well as serving as a visiting professor and lecturer in Europe, Asia and the USA. He is also finishing a book with Professor Michael Fast (Aalborg University), 'Toward a Science of Economics' to be published in 2005.

INNOVATION: Local actions and activities

Innovation comes from many perspectives and should not be limited to the laboratory or research organisation. One of the key elements, however, is collaboration and partnering between groups. Given some mechanisms at the local and regional level, like incubators, financial incentives, labour training and educational institutions, innovation can be nurtured and developed. What allows innovation to then flourish is the local professional and personal support from the family, community and other business products and services.

In Silicon Valley (Northern California) concepts such as "pre-competitive" conferences, forums, consortia, panels and associations provide a "milieu" unique to the region, but sought after worldwide. Such meetings formed the Joint Venture Silicon Valley in the early 1990s which mobilised the region to address and solve the economic recession in 1990-92. Numerous technology-based consortia were formed including "Silicon Chips" and "Flat Panel Displays" which set world market standards. Professor Anna Lee Saxenian captured that regional uniqueness in her book, 'Regional Competitive Advantage' which compares Silicon Valley to Route 128 around Boston. One key factor was the positive role of state and national government in promoting and leveraging finances for new technology commercialisation.

For example, it is much easier and more efficient for hydrogen to be developed and implemented in a community with the support of the local government and businesses as well as academic institutions. Rather than be a hindrance in implementing a hydrogen highway, the local community offers a number of support mechanisms, including planning, public involvement, education/training and especially procurement or purchases. State and national public policies help. Partnerships rather than advocacial roles are the core ingredient to the implementation of innovation.

PUBLIC POLICY: state and regional levels

Government public policy is needed to create the vision and set the objectives for innovation in general, and the applied processes in particular. In order for innovation to become a reality, there needs to be demonstrated leadership from the very top of the political spectrum. Otherwise, the innovation will not be taken seriously and fail to become a reality. Innovation demands public leadership through a variety of processes.

One is the declaration that the innovation is to be done, as Iceland did when its government and Prime Minister in the spring of 2001 declared it would be the world's first hydrogen economy. A "paradigm change" has been made through public policy action. That executive decision lead to attracting companies to the country and more significantly provided a sense of community and purpose to the entire nation (see below Social Constructionism).

However, governments can do other things besides providing funds, tax incentives and other resources. Governments can give "mandates" that lead to the formation of standards and codes with protocols set for the innovation.

This is being done now in the area of hydrogen throughout the world. From this, benchmarks and markers can be derived for measurement of performance and evaluative purposes.

A "PARADIGM SHIFT": The Hydrogen Economy

A significant paradigm shift is now under way as a major change in the way government policy makers and industry leaders are looking for clean fuels and renewable energy for their own Nation States. Current volatile gasoline prices, as well as national and international energy / environmental crises, conflicts and now war, are motivating this shift. Moreover, the worldwide limitations on fossil fuel supplies causes more concern not only at economic, but also now at political levels. The motivation, furthermore, is to find new clean sources of fuel to convert to hydrogen in both economical and efficient ways so that the industrial and developing worlds do not become dependent upon "foreign" fuel sources.

"Social Constructionism" of HYDROGEN

"Social Constructionism" is a European social science term that applies directly to the hydrogen economy because it is a socio-cultural revolution that takes place without any political agenda. Rather, the hydrogen economy is a movement supported by science and technology that the people want without indicating their desire in a vote or election. In California, there is a real awareness of the effects of pollution and dependency on fossil fuels, which the public has become increasingly aware of and now wants dramatic changed.

Governor Schwarzenegger supports these ideas, as did his predecessor, Governor Davis. Moreover, the USA Presidential race in 2004 has both major candidates promoting and embracing the hydrogen economy. President Prodi of the European Commission has been one of the world leaders in promoting clean energy for hydrogen production and use. Clearly his public announcements and the programmes started by the Commission have propelled hydrogen into the forefront of public policy initiatives. All of this government and policy-orientation has come without any vote or poll among the regions or nations in Europe.

REGIONAL AND STATE GOVERNMENT: The Public Sectors

Governments should be engaged in a combination of policy, procurement, and transportation plans that work in partnership with the private sector to both set standards and lower prices. The leadership, as noted above, must make public announcements about innovation and promote its implementation, even if the funds and financing mechanisms do not exist. Businesses and local regions need to know that the government leadership supports the innovations. There must be

co-operative work to create new codes that match the chemical properties of hydrogen. There is an unknown level of risk for insuring hydrogen vehicles. Rates must be set at the appropriate levels.

State support for hydrogen-powered vehicles can transform the nascent industry into a broad consumer market. Leasing of vehicles by the State and the replacing of outdated vehicles is a good way to start the purchase of hydrogen vehicles Fleet purchases are best because a central refuelling station can be used. For example, Honda has already begun leasing to Los Angeles City Government. Listed below are considerations for state or regional sponsored support for hydrogen:
Operating hydrogen-powered vehicles purchased in the State
Regulation which is monitored by an air resources committee
Implementation of public policies that are monitored by State and local Districts.

Procurement of equipment through competitive processes can be done under:

Master contracts for purchases of hydrogen vehicles
Codes and Standards
Fire Standards
Insurance.

Safety labelling for hydrogen is important for consumer confidence, given the myths in history about hydrogen. For local communities, resources for Workforce Development along with the involvement of Labour Unions for new jobs created by the hydrogen economy are important. Education (public schools, colleges and universities) also need to be created. One way to promote hydrogen in education can be done by holding a competition among architecture schools for a student design for a hydrogen refuelling station.

Innovation for a sustainable hydrogen economy by

Mr. Ivar Hexeberg, Vice President, Norsk Hydro, Norway

Speaker

Mr. Ivar Hexeberg was born on 27 August 1960 in Bergen, Norway. He holds degrees at Masters levels from both the Norwegian Institute of Technology (1984) and the Norwegian School of Economics and Business Administration (1987).

From 1987 to the present day he has held various positions within Norsk Hydro's oil and energy business. Today he is Vice President of Norsk Hydro ASA and heads the company's hydrogen related activities. He is also Chairman of the daughter company Norsk Hydro Electrolysers AS.

Hydro is a Fortune 500 energy and aluminium supplier with around 36,000 employees in more than 40 countries.

Hydro is a significant offshore producer of oil and gas with leading-edge technology and expertise in deep water field development technology. Hydro is both a producer, supplier and buyer of energy and a significant player in the European energy markets. Producing oil, natural gas and electric power – renewable sources only – as well as buying natural gas and electricity in our production units provides the company with a unique expertise.

Hydro is the third largest integrated aluminium supplier in the world with presence on every continent. Our customers include automotive, packaging and building industries.

Our mission is to create a more viable society by developing natural resources and products in innovative and efficient ways. We are committed to working on sustainable solutions in three dimensions: for society, for the environment and for the economy. Thus, our approach to sustainability is coherent with the drivers for a change to hydrogen as an energy carrier.

The security of energy supply, the control of green house gas emissions and the availability of energy at a reasonable price for the consumers are challenged both by the availability of energy resources, and by energy consumption. Thus, oil resources and production rates are altered from OPECcountries to politically and economically more unstable regions of the world, whereas current energy use implies an increase in CO2 emissions by almost 69% from 2000 to 2030. Also, air pollution threatens public health in large cities. Hydrogen can contribute to the security of our energy supply, as it may be produced from different sources ranging from fossil fuels, to bio-fuels and renewable energy sources, and in the long term even from modified algae. When used in PEM fuel cells, there are no other emissions than water.

The governments in the three large OECD markets - USA, Japan and Europe - are supporting both the development of renewable energy solutions, and also the development of hydrogen and fuel cells. This support is essential in order to achieve commercial successes with research and product development. The main obstacles for a transition to the use of hydrogen as energy carrier are technological development, uncertainty in the research achievements versus competition, and public acceptance of hydrogen as a fuel. Given that the technology challenges are solved, a sufficient hydrogen infrastructure is required.

The alternatives for hydrogen supply are:

Large scale production on central plants – preferably with CO2 handling, and then transported to the customers either by truck or piped.
Local hydrogen production based on existing infrastructure for electricity and water for electrolysis, or on existing gas infrastructure, where available, for small scale natural gas reforming.

Hydro has a solid experience both in large scale hydrogen production based on steam reforming of natural gas, and with water electrolysis, as well as solid knowledge of small-scale hydrogen production with water electrolysis. We like to say that Hydro has hydrogen in the genes.

The outlook for hydrogen as we see it, will come in three phases: In the building market phase until 2010. Small-scale hydrogen production based on water electrolysis and steam methane reforming will go hand-in-hand with large scale production and trucked hydrogen. In the building infrastructure phase from 2010 to 2030, carbon handling and piped hydrogen will have a dominant role in addition to the current methods. In the hydrogen economy from 2030 onwards, electrolysis based on renewable energy and nuclear energy will come as a significant add-on to the existing supply options.

Hydro's priorities are at present: to complete hydrogen solutions with local hydrogen production based on water electrolysis; hydrogen in renewable energy systems; and future large scale hydrogen production from natural gas with CO2 handling.

Our main project activities at present are in accordance with our priorities.

Projects with hydrogen for transportation:

ECTOS, which is the first part of the Icelandic hydrogen vision of transferring Iceland to a hydrogen economy. Hydro has been a partner in the project since 1999. The hydrogen fuelling station supplied by Hydro opened in April 2003.

CUTE: the first major demo project for transporting hydrogen in Europe. Hydro is project partner and responsible for a quality and safety of fuelling stations. Hydro was also a supplier to the hydrogen station in Hamburg, which opened in September 2003.

Clean Energy Partnership in Berlin (CEP-Berlin): a major German project for hydrogen in everyday use with broad participation form several automotive companies, with tests of different hydrogen supply solutions. The station is planned for opening at the end of 2004.

In connection with these projects we have developed systems for more efficient hydrogen fuelling and designed a new state of the art hydrogen dispenser. We are also performing safety risk assessment with our cave technology – originally developed for a virtual reality understanding of geological structures. In addition, we are developing high performance electrolysers with a small footprint and higher efficiency with our partner in the JV company GHW. In fact, Hydro has been an early promoter of alternative fuels; we had our first hydrogen vehicle for research purposes in 1933.

Our commitment to a sustainable energy future is exemplified by our Utsira wind hydrogen project, where we are demonstrating a hydrogen future. The island of Utsira, west of Haugesund in Rogaland county, Norway, is the location for a unique demonstration project developing new technology. It is, in fact, the first ever full-scale combined wind power and hydrogen plant. Approximately 10-15 households on the wind-swept island will be linked to the autonomous electricity grid, which will provide renewable energy from the wind and hydrogen systems.

The objective of the project is to show how the combination of wind power and hydrogen can ensure a stable supply of electricity. One of the challenges of renewable energy sources is that the electricity supply is intermittent – solar power cannot be produced at night, and windmills stand still without sufficient wind. On Utsira, periods of optimal wind conditions will give a significant surplus of power. This will be used to produce hydrogen, which will be employed as fuel in a hydrogen generator set/fuel cell that will supply energy when the windmills stand still. The wind turbines are already installed, the hydrogen equipment will be installed in 2004, and thereafter a two-year demonstration phase will begin with household customers, who have an average electricity consumption of approx 20 000 kWh.

Hydro is leading the Utsira initiative, which will run through 2005. The German wind turbine company Enercon is a partner in the project, and the supplier of the wind turbines, grid-stabilising equipment and control system.

This could be a European energy future for communities willing to choose an alternative energy solution. Highville is a project applied for funding under EU's Concerto programme in the 6th Frame Programme.

Hydro is committed to shaping a future based on new energy solutions, thus making a progress of a different nature.

Mr. Tomas Bruce, President, Euroheat & Power, Stockholm

Speaker

Mr. Tomas Bruce was born on 8 July 1944 in Stockholm. He gained a Masters in Engineering in 1968 at the Royal Institute of Technology in Stockholm. He is the former CEO of Stockholm Energi/ Birka Energi.

Mr. Tomas Bruce was President of Euroheat and Power, of the Swedish Economic Association and Vice President of the Swedish Orienteering Federation.

He was also Chairman of Capital Cooling Europe AB and of GAIA Leadership AB.

Mr. Tomas Bruce is currently Managing Director of AB Tomas Bruce and President of Euroheat and Power.

Mr. Bruce's presentation can be found on the conference website

www.partnersforinnovation.org/programme

Contributions in Switzerland for a more sustainable individual mobility in the future

by

Mr. Philipp Dietrich. Head of Technology Transfer, Paul Scherrer Institute

Speaker

Mr Philipp Dietrich obtained a diploma at the ETH Zürich as Mechanical Engineer in 1985. Between 1986 and 1998, he worked for BMW AG München, ABB Kraftwerke AG in Baden and ETH Zürich.

Since 1999, he has worked for the Paul Scherrer Institut as Head of Technology Transfer and Projectcoordinator Fuel cell powered vehicles.

In the past, the concern about local pollutants such as CO, NOx, HC and PM has driven development towards enhanced powertrains in cars. Recently the concern about the influence of CO2 in particular, and the global warming effects on the earth have appeared on the radar of public concern. It is possible that in years to come concern about the resources of primary energy as fossil oil or natural gas become significant, too.

As mankind is demanding more mobility as income increases, the demand for individual mobility can be predicted based on the assumptions of the IPCC and UN to rise by four times between 1990 and 2050. If we want to stabilise the energy consumption for individual mobility near the actual value we have to improve the efficiency by a factor of around four.

Roadmap of technologies for the future

The different technologies are in different degrees of maturity. The first step to improve the efficiency of cars is improvements to the known gasoline and diesel internal combustion engines. With new injection systems and combustion control mechanics, the efficiency of the combustion process can be improved further. With advanced transmissions, such as the continuously variable transmissions of automated shifted geared transmission, the operating point of the engine can optimised.

A further step is the integration of an electric motor, creating a hybrid system, to improve low power efficiency of the powertrain combined with enhanced dynamics and the ability to use the braking energy of the vehicle at least partly.

One disruptive step can be the implementation of a fuel cell system into a car. The potential of a fuel cell system is in the range of the averaged use (part load for driving in urban traffic); the fuel cell has the potential to increase the efficiency by more than factor of two.

It has to be expressed clearly that the potential of the technology is vast but the degree of maturity is not as advanced as improved internal combustion engines, or hybrid powertrains, which both can be bought on the market place already at a reasonable cost.

Fuel cell activities in Switzerland

Besides the field of Polymer Electrolyte Fuel Cells (PEFC) we discussed here for automotive application, there are other fuel cell activities based on other principles for different markets.

As discussed, a transport application for several projects are ongoing.

- HY.POWER

In the Paul Scherrer Institut, new membranes are looked at and investigated to find cheaper materials and improved performance. Also, the development of new stacks in the range of 8 kW electrical power output has been investigated and integrated in a technology platform, which is based on a Volkswagen BORA car. The system consists of six stacks with each eight kW electrical output of the stack. The system can deliver up to nearly 30 kW. In the same vehicle called "HY.POWER", an electrical storage device based on double-layer capacitors module has been implemented. The 282 super-capacitor cells stored 360 Whof energy and could deliver and store a power of 60 kW for about 15 seconds. This combination enabled a good dynamic performance of the car. The car demonstrated the state of the art technology by driving over a Swiss Alps pass in January 2002.

- TOYCO-Rider

The Supercaps are also used a source of energy in the storage device on a city bus (Tohyco-Rider) developed by the FH of central Switzerland. This concept is that they can be charged at end stations very quickly because the supercaps can be charged at high power rates. The bus is tested in regular operations in Lucerne.

- PAC-Car

With the fuel cell technology developed at PSI and the Swiss Federal Institute of Technology ETH, Zurich, the PAC-Car performed in the Shell-Eco-Marathon in France 2003 and had an equivalent gasoline fuel consumption of 1700 km/l. The fuel used was hydrogen.

- HY.CAR

Besides these research projects, another fuel cell driven car has been designed in 2003. The HY.CAR from ESORO is a small Pick-up truck on which the fuel cell system can be seen from outside. Demonstration to and education of the public is a key goal of this project. We have seen that most people's interest is high. Besides the car, a specific hydrogen filling station was developed from ESOSRO with Sauerstoffwerke Lenzburg working together. The ease of use can be demonstrated impressively with this filling station, which includes features such as direct charging on credit cards, and updating a database with the parameters of the fuel cell system from the specific car.

Hydrogen supply for the fuel cell

It is very important to keep in mind that hydrogen is only an energy carrier and not a primary energy source. Therefore, the production of hydrogen is a key in the assessment of the efficiency of the fuel cell. The total energy chain has to be compared.

Several ways are possible to switch the energy supply to renewable energy sources. The hydrogen can be produced by electrolysis based on electricity produced by wind, solar or hydro. Hydrogen can also be produced with solar chemistry meaning that the solar light can be focussed to reduce metal oxides (e.g. ZnO to Zn). In a second step the combination of steam and Zn hydrogen can be released and the ZnO can be used again in a material cycle. Also, biomass can participate with a certain share in the range of 10 % of energy to the transportation. Based on biomass, CH4 can be produced or the gasified energy can be shifted to hydrogen.

In an intermediate step, the Swiss research laboratories try to implement, together with industry, a 20 MW power plant to convert woody biomass into CH4. This gas can be supplied in the well equipped natural gas distribution net and used elsewhere. The aim is to improve the use of the Swiss forest by about 1 Mio tons of wood (biomass) per year.

Conclusions

- Several technologies show the potential to improve the efficiency of individual mobility.
- Besides its use in cars, fuel production has to be considered.
- If we want to change the energy consumption situation, efficient technologies like fuel cells and a sustainable production of fuels is key.
- Besides the will for change, we have to see clearly that this shift is not for free, but we do not know today what it will cost if we do not change.

Dr. Jan Erik Hanssen, Scientific Officer, European Commission, DG Energy and Transport

Speaker

Dr. Hanssen has an MSc in petroleum chemistry (1984) and an engineering PhD. He was a visiting scientist at the University of California at Berkeley. He has had a 16-year career in active R&D and research management, doing applied R&D, mostly upstream, for major oil companies and public bodies, as well as working in the oil-field service industry. Positions held include head of laboratory, section head, R&D manager, and chief scientist.

Dr Hanssen has written more than 50 technical publications. In 2000, he was seconded to the European Commission in Brussels, as a National Expert from Norway. His main job function is to be the Commission's technical responsible on a range of RTD and demonstration projects, mostly in the downstream energy sector. Many of these focus on fuel cell and hydrogen technologies, and Dr Hanssen is a member of the Hydrogen task force in the Directorate of New energies and demand management, and of the Commission inter-service hydrogen team.

Dr. Hanssens presentation can be found on the conference website
www.partnersforinnovation.org/programme.htm

The California Sustainable Hydrogen Highway Economy by

Dr. Woodrow W. Clark II

Basic points in presentation include:

THE "HYDROGEN FREEWAY": California has “free” i.e. no toll roads

The California Hydrogen Highway is now under construction and leads the world in the number of “H_2 refuelling stations” with six now completed and nine more in the pre-approved stage (as of January 2004).

In Southern California, South Coast Air Quality Management District (SCAQMD), the regional air board, has aggressively taken the lead because of the extraordinary need and demand in Southern California. Linking Los Angeles and San Francisco is symbolically important to demonstrate the potential of the hydrogen economy. The California State department of transportation, called Cal Trans, has partnered with SCAQMD on this approach.

Likewise, several industrial partners appear to be partnering and collaborating to form the California H_2 Freeway.

Hydrogen Energy Stations

Until there are enough vehicles to justify the costs and to provide a private sector business market, the creation of “hydrogen energy stations” are the most economical and efficient approach to get clean hydrogen into common use, and therefore create new markets and businesses. Hydrogen can be stored on-site for homes and business, and then used during times of day when grid connection energy is expensive, or it can be stored and used for all power needs.

Hydrogen refuelling stations and the creation of a “hydrogen freeway” are essential for a hydrogen infrastructure. While these stations can be separate from hydrogen in homes and businesses, they can be modelled on current retail fuelling stations, but also supply power for the local community homes, stores, and businesses. However, in the next three to five years, hydrogen energy stations will be the prevailing model for implementing a hydrogen economy.

Government’s Vision and Leadership

The government leaders can issue an executive order that would publicise the state’s commitment to hydrogen, creating public awareness and industry confidence. The public, while sympathetic and aware of “green energy” and the need for a clean environment, is unaware that hydrogen currently exists, and does not realise its benefits. The concept of “civic-markets” (below) allows this process to occur and move ahead collaboratively with both government and businesses.

Government leaders can hold a press conference or summit with major H_2 companies to announce “strong civic market-based support for hydrogen economy”.

Legislation is needed to authorise the setting aside of public policy for financing guarantees, as well as directing ministry secretaries to be briefed for decision making. The members of parliament can hold “summits” or a series of forums on the H2 economy.

Draft a policy recommendation that connects sustainability and climate change to a hydrogen future.

Create a sustainable development overview/vision so that hydrogen can be seen as both an energy and refuelling station.

Such a vision and public policy argues for new "design" and image for sustainability. Hence this vision must incorporate traditional infrastructure such as water, waste, and education, along with energy and transportation into the hydrogen economy. Further, it provides for new linkages with infrastructures such as IT and Digital.

On the international front, need to establish an international clearinghouse on hydrogen.

Note that Hydrogen is being implemented today, not after 30 to 50 years more research. Hydrogen is a partial answer to climate change and renewable energy needs. A hydrogen economy need *not* be dependent upon natural gas and LNG for its source of H2. These are only short-term (three to five years) solutions. Longer-term and immediate investment need is for a diversified portfolio such as renewables – non-fossil.

CIVIC-MARKETS: Innovation in Finance and Investment

"Civic markets" mean business creation and jobs through partnerships between public and private sectors. Financing the construction of a new infrastructure is not a large barrier to implementing the hydrogen economy. Furthermore current large corporations (traditional oil/gas and auto makers) recognise and are investing heavily in a hydrogen economy. Entrepreneurial opportunities are abundant as technologies exist that are now expanding in demonstration sites worldwide. The time now is to move rapidly to a public-private mass consumer market.

There need not be a "chicken or egg" problem. Several speakers gave insight into possible financing schemes. Demonstration sites now exist and more are being installed. The US Department Of Energy plans on supporting a national hydrogen effort. The Southern California South Coast Air Quality Management District (SCAQMD) plans to build a total of 30 hydrogen stations over the next few years. A refuelling infrastructure needs to grow at the same rate as vehicle production.

FINANCE MECHANISMS: State Treasurer and Local Finance (Bonds)

Revenue Bond Funds such as CAEAFTA (authorised, 1994) can provide over $200 million in financing from government or non-government organisations. Local communities can issue bonds. Meanwhile the State Infrastructure Bank has over $200 million in finance authority. California Public Utility Commission (CPUC) must be involved for public policy as well as finance purposes. CPUC clearly plays an important role in encouraging business development. Finally, the California Energy Commission (CEC) has incentive programmes for businesses, but might also set goals for larger infrastructure issues. The CEC has its Integrated Resources Plan for State in late 2003 which highlights hydrogen and renewable energy as the near-term future for the State.