BEFORE THE
FLORIDA PUBLIC SERVICE COMMISSION

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PROCEEDINGS: WORKSHOP

CONDUCTED BY: VICTOR CORDIANO
Division of Policy Analysis
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DATE: Tuesday, January 30, 2001

PLACE: Betty Easley Conference Center
4075 Esplanade Way
Tallahassee, Florida

TRANSCRIBED BY: KORETTA E. STANFORD, RPR
Official Commission Reporter

PROCEEDINGS

MR. CORDIANO: Good morning, and thank you for attending this workshop. As you know, we have scheduled this workshop to allow interested persons to make presentations concerning recent developments in the area of distributed resources.

For the first half of this workshop, we have a few guest speakers that are going to share information with us related to alternative ways of providing clean, efficient, safe, reliable and cost-competitive electric power to end-user customers and address issues, such as equipment and cost, insurance, net metering, interconnection, and environmental concerns.

During the second half of this workshop, we will have an open question and answer session and share comments in regard to these issues. It is our pleasure to have you all here today. And with that, I'd like to first have each staff member on his project introduce yourself, and then I'd like for each industry representative to identify yourself by name and company and state whether or not you will be making a presentation.

Note that we are audiotaping this workshop, so if you would, please use the microphones up front when you're speaking. I'll begin. My name is Victor Cordiano, and I'm with the Division of Policy Analysis and

Intergovernmental Liaison, and I'm an engineer on Staff.

MR. DICKENS: Good morning. My name is Bill Dickens. I'm on PSC Staff.

MR. CORDIANO: Roberta, are you back there or --

MS. BASS: Roberta Bass with the PSC Staff.

MR. CORDIANO: And now the industry representatives.

MR. LAUX: Mark Laux, Tampa Electric Company.

MR. CORDIANO: Okay.

MR. VALDEZ: Bob Valdez, Florida Power & Light Company.

SPEAKER: (Inaudible), FPL.

MR. CORDIANO: Okay, great.

MR. COOK: Bill Cook, Gulf Power.

MR. BATTERS: Russell Batters, Gulf Power Company.

MR. CORDIANO: Okay. Jerry Ventre is going to start off with his presentation, and he's with the Florida Solar Energy Center. And then, I thought we'd go with Dr. Clovis Linkous, who is also with the Florida Solar Energy Center. And with that, Jerry?

DR. VENTRE: I've got a handout here that -- there's only about 25 copies, so if you can share one with people. (Inaudible) talk about photovoltaic as one of the distributed resources. A little later in the program, Clovis Linkous, Dr. Clovis Linkous, from our center will be showing up here to talk to you about another area, hydrogen area, in particular about fuel cells, but what I will do is talk about the status and prospects for small photovoltaic systems.

I think, most of you are familiar with the technology, but let me just mention a few things here. In terms of fuel, we're talking about using the sun as the energy source. We've got some kind of photovoltaic device, typically, some sort of silicon module or an array of modules that converts the sunlight into direct from electricity. From there it goes through a power conditioning process converted to AC, may have storage, more and more of the systems that we're seeing for grid-tied applications do have storage, and then, it goes to the customer service panel and to the load. In addition to that, we're tied into the utility. If the utility goes down, obviously, there are protection issues that need to be addressed.

As far as our involvement with this technology, we were established by the Florida legislature back in '74. We got a mandate by the legislature to test, to rate, to certify all solar equipment manufactured or sold in the state of Florida. So, we're involved in this whether we want to or not. We don't sell anything. We're part of the state university system, and administratively we report to the University of Central Florida, which is the closest of the state universities.

In addition to our state function, since 1982, we have operated for the U.S. Department of Energy the photovoltaic southeast, used to be called residential experiment station. Now, it's called regional experiment station. It was called residential back in the early '80s, because that was the application that was of most interest, grid-tied residential applications. There was no market for that application. We got more involved with other types of applications, and now that interest has been rekindled, and we're working a lot with grid-tied systems.

In terms of utility interactive or grid-tied systems, we tested for about 15 years five systems, and in addition to that, have a lot of experience on-site testing, on-site tests and evaluations of photovoltaic systems. In addition to that, we've performed a number of field evaluations of these types of systems, probably in the order of 75. And by the end of this year, we will have monitored, and we'll be continuously collecting data on about 25 grid-tied systems.

Now, back in the early '80s, we formed with practically every major utility in the southeastern United

States a utility research group. I don't know if any of the people here were involved with that, but one of the reasons for doing that was to look at issues specifically of importance to utilities, things like islanding of photovoltaic system, one of the (inaudible) utility, power quality issues, reliability of service issues, all those types of things were looked at in a fair amount of detail back in the mid -- early to mid '80s.

In terms of the -- where this technology is at -- in fact, if you look at the last bullet there, that says a lot, in the sense that in terms of photovoltaic manufacturing, this industry is growing at about 25% per year. So, it's a very, very rapidly-growing area. About 70% of the shipments of U.S. product is going overseas. For many years, most of this was going to developing countries where there wasn't any kind of established grid infrastructure. More recently, a lot of this product is going to Germany and to Japan.

As far as the applications, solar home systems, when we talk about those, we're talking about something different in grid-tied systems. We're talking about hundreds of thousands of very, very small systems that are used to power lights and communications, typically sometimes health clinics, but there are hundreds of thousands of very small systems on the order of 50 to

70-watt systems.

Communications has been sort of the mainstay of the stand-alone photovoltaic market for years; water pumping, lighting, health care, navigation, a whole menu of applications, primarily in the stand-alone area. More recently, there's been tremendous upsurge and interest in grid-tied systems. Manufacturing costs are dropping, new products are coming onboard and, like I said, the industry is growing at about 25% a year.

As far as the area that, I think, most of you are interested in, grid-tied systems, there's probably several thousands. A couple of years ago, we were saying there was probably about 1,000 grid-tied systems in the U.S. Now, with initiatives that started in the late '90s, there's a significant number of more, but still, we're talking in the thousands.

The Sacramento Municipal Utilities District is probably the most experienced U.S. utility with rooftop PV. They've actively promoted that technology and those applications. Initially, they started out as utility-owned systems. More recently, they've shifted to customer-owned systems.

And then, in June of 1997, the U.S. announced this million solar roofs initiative. I'm sure some of you have heard of it, but the whole idea there is to get a million rooftop systems by the year 2010; not all PVs, it can be PV or solar thermal systems, primarily, in response to what the Japanese and the Europeans and other Europeans, it was the Germans that were moving this whole thing.

Now, the reason why there's relatively a small number of these systems out there is price. The price of these systems are too high. And if you wanted a number to hang your hat on, go with the simplest type of system, grid-tied system, with no battery back-up, we're talking $10 a watt, $10 an installed watt is the price you would pay. We've got them down below $7.00 a watt with some of the systems that we're dealing with, with other utilities, but we've seen them all the way up to $25 a watt in some of the other states. All of these things are (inaudible), but they have to be taken care of.

The component and manufacturing costs have to be reduced. And that deals with a couple major compounds. The module cost of manufacturing is coming down. There is -- or there are new materials that are being used. Most of the industry representatives think that we'll be able to reach price goals or cost goals of less than $1.00 a watt. This is just for the module cost, module manufacturing cost. So, whether or not that's (inaudible) remains to be seen, but most of the industry feels that

that will happen.

In addition to that, you've got inverter cost, and if you're using batteries, you've got battery costs, but all of the component manufacturing costs have to come down to meet the tolls that I'm going to show you in a second.

The system engineering, design cost, marketing and distribution cost, installation cost, all of the things associated with transaction are way too high. That's why you see this variation from somewhere in the $6.00 range up to $25 a range. So, of all the barriers facing this technology, the biggest economic barrier, obviously, is installed system price.

Of the noneconomic issues, interconnection, which is what we're going to talk about today, is probably the biggest issue. Can you -- even if you want to pay that price, can you get interconnected? So, we'll talk about that in a little bit.

Other issues have to do with the fact that the average home owner stays at home somewhere around six years. And certainly, if you look at the life cycle cost and the payback associated with these systems, generally, they're way in excess of that number, even with some of the new prices that we're going to see. It's going to take a while to get any kind of investment back.

The last issue on there has to do with, essentially, the concern of end users, whether it be utility end user to home owner to commercial building owners, is that system going to produce what it's advertised to produce from performance? And then, two, is the reliability of that system going to be acceptable? So, the performance and reliability issues are other barriers.

We can map this whole market scenario with this particular chart here. What we're looking at is if you -- we're just looking at value. We're looking at value on this scale here, and we're looking at market. Right now we're talking about a small market.

In fact, if there weren't subsidies, probably there wouldn't be hardly any market, okay? Most of this market is due to the fact that these systems were being subsidized. So, we've got a small market, and from the average potential end user, they're not valued very highly, so this is the present situation.

Obviously, if you're representing the industry or the community in general, you'd like to see that happen. And you will hear a number of people say all we really need to do is educate the public and they'll buy this thing. Well, that's not going to happen. Education by itself is not going to make that big a difference until you remove some of the barriers and the value increases.

Even if you could reduce the prices, there are -- there is the potential for other barriers prohibiting somebody from choosing to use this technology. And the most notable one would be the interconnection issue.

Even if you are willing to pay $7, $10, $15 a watt, right now it's very difficult in most of the United States to get connected to the grid. They just don't want to put up with the hassle, due to the costs associated with the interconnection or the time or the documentation or whatever.

And that's because most of the rules that are associated with interconnection are based on things that go back many years ago and have to do with large strip generation. So, you can have a high-perceived value by a good segment of the public population and still a very small market. And essentially, what we're looking at is we've got to come up with more creative solutions in order to establish any type of sustainable market.

Now, I mentioned that, because the perspective that we have as primarily a research development testing agency is kind of neutral, in the sense that we don't make any money on selling property. So, we're viewing this, I think, from a fairly objective perspective when we say there's a very small market, if any.

And our position is what can we do now that may result in a fairly substantial market in, say, 10 years? So, we're looking at pretty much a 10-year horizon in our investigation of the Florida area. So, we're not looking at it right now.

So, with that in mind, let me just give you some goals and targets for the -- both the industry as well as the Department of Energy and the national laboratories. The U.S. goal, as I mentioned, is a million solar thermal and PV roofs by year 2020. That will be met. There's no doubt that that will be met, because it will be met with solar thermal systems. We've got solar thermal dealers that are putting in 250 systems a month. So, there's no doubt that that's going to be met.

This one here, the $3.00 per AC watt installed system price is a major goal for the whole photovoltaic community. And once again, we're talking about a reduction by a factor of three from the typical price, a little more than three from the typical price.

If that goal is achieved, things start to happen. That becomes a fairly attractive market to various segments of the population. For Florida, we mentioned this million solar roofs initiative, there is a Florida partnership. A number of the utilities here and throughout the state are involved in that, but the goal is

140,000 solar thermal systems, 20,000 PV systems, total cumulative; this is not per year, by 2010.

To give you an idea of what this means, right now the yearly installation of solar thermal systems in Florida is probably in the ballpark of 12 to 15,000 a year. So, we're talking about a cumulative goal that's consistent with what we need to do now. So, it's fairly small.

In terms of megawatts of installed systems, the average size of these PV systems are going to end up, and soon they're going to be on rooftops, they're probably going to be on the order, looking at it from AC perspective, probably about two kilowatts, relatively small systems, 2,000 watts.

So, the cumulative installed capacity just on an -- just based on AC output rating of the system is going to be, what is that, 49 watts? What's the total installed capacity of -- in Florida? About, what is it, 30,000? Close to 40? Okay. So, you can see you're talking about something in the ballpark of 1%, 1/2 of 1% or less. Now -- and that's not what we're going to have 10 years from now. Anyway, those are some goals. And once again, goals are good, but a lot of things can happen to shape the direction that we're going.

In terms of photovoltaic production, we're talking about the heart of the system, the energy conversion part of the system, photovoltaic modules that are on -- you know, on the roof or on whatever. The total world production right now is just a couple hundred megawatts, very small compared to the number that you people are used to talking about. The goal for 2020, 20 years now, is 6 gigawatts by 2020, that's U.S. So, we're comparing two different things, world and U.S. here over a 20-year time frame.

The PV manufacturing industry thinks that those goals are attainable, and most of the production that you'll see with a lot of these companies is fairly small, maybe 10 megawatts. Some are bigger than that, but there's a number of companies now that are going from that size production capability up to 100 megawatts per year, so we'll see what happens.

In terms of cost reduction, the present situation, dollars per watt installed varies all over the place. $10 is as good as you'll find as an average number, $10 a watt. That's for a straight grid-tied system, an array inverter, all electrical and mechanical (inaudible) system, but no battery back-up. Start throwing batteries in there, it gets a little more complicated, but that's $10 a watt.

The goals are to get this installed price down to $3.00 by the year 2010 and to $1.50 a watt AC, by 2020.

Another goal that's been put forward by the manufacturing industry, and when we're talking about manufacturing industry, we're talking about the Siemens, the BP, the Shell, you know, these are major corporations that are involved in manufacturing, which is a different type of industry than the type of people that you'd normally associate with putting something on the roof. So, these are some of the numbers that they're throwing out.

New electric generation, the goal is 15% of all the generation by 2020. Once again, anybody's guess as to what's going to happen. Most people in the researching end don't believe that will be attainable nor the $1.50 a watt will be attainable, but we don't know. We really don't know. We do know that the whole picture is changing almost weekly, and it's going to be interesting to see how things develop.

2020 goals, let me just summarize, 6 gigawatts per year PV shipments, 3.2 for domestic applications. Remember the earlier slide, I said 70% was international? Okay, the goal is to get over half of that U.S. production for U.S. applications. That includes both stand-alone systems; in other words, nongrid-tied as well as grid-tied and stand-alone distributed generation, 1.6 for distributed generation. 15% of new electric generation is $1.50 per watt installed.

Now, let's talk about issues that, I think, are important to everybody here, and that has to do with the interconnection issues. We'd like to break this down into these different areas. On the technical side, there are four things that we're concerned about; one is safety, two is equipment protection; three, power quality; four, reliability of service to give customers.

On the nontechnical side of things, we've got the insurance issue, we've got metering and billing, and we've got the process, education and compliance process, what does it actually take to do it? And then, another point that's been made over and over to us from just working with utilities is the whole issue of what this means in terms of precedence and research. These are things that we're going to talk about.

Now, in terms of interconnection for the small PV systems, many of you are familiar with the Institute of Electrical Electronic Engineer Standard 929. This was approved by the standards board just about a year ago, almost a year ago to the day and is in flux. This is an interconnection standard for photovoltaic systems, primarily associated with small systems, 10 kW or less, although there are variations that are allowed in one of the clauses associated with that, so it can be used for (inaudible) systems.

UL, Underwriters Laboratories, Standard 1741 is the standard for testing inverters or the standard that inverters must meet. This has just been revised, and this is of last month. There is a new amendment that's in performance as far as distributed generation is concerned.

The 1999 National Electrical Code had significant changes in it from the 1996 version. The National Electrical Code, as you know, is updated every three years, as part of the National Power Projection Agency. And there are a number of items that address issues specific to grid-tied photovoltaic systems that are in that new code. So, in our recommendation, we always try to get whatever the code enforcement jurisdiction is to require the 1999 term.

Okay. Inverter testing and system testing activity is proceeding, and there has been quite a bit of advances made in islanding research, primarily if you work down at (inaudible) National Laboratory.

Okay. As far as the standard is concerned, it deals with interconnection, provides guidance regarding equipment functions necessary to insure all these things, compatible operation of PV systems, personnel safety, equipment protection, power quality, utility system operation. I'm sure -- I know a bunch of you in here are familiar with that. What does it really impact? Primarily, the inverter, power conditioning equipment.

Now, several of you in here attended a workshop that we had back a couple of years ago, October of '98, called Interconnecting Small Photovoltaic Systems to Florida's Utility Grid. The Public Service Commission was involved in that. It was specifically for a utility representative. The whole idea was let's look at each one of the issues associated with, you know, technical requirements for interconnections and see what -- you know, what kind of agreement we can get, what kind of understanding and consensus could we get.

We did take a survey of three different groups at that meeting. It was designed for utilities but obviously, you need other kinds of utilities people to show up. So, we had utility representatives, we had nonutility representatives, and then we had the whole group.

These are just kind of summary of results for that, and these results were distributed to everybody that attended the meeting, but you can see the types of issues. One question was asked, does this standard, this was Draft 7, does that standard adequately address all of the technical issues associated with interconnection? We got

13-Y, 1-N, and 1-no response to that question.

To be fair, let me just mention that some utility representatives didn't participate in the survey, and the reason why was because it was such a big issue that it (inaudible) even though we didn't take anybody's name or address or anything like that. They didn't feel like they wanted to put anything down without first consulting some of the people in management. But anyway, for those that did, these are the results.

There are various ranges of voltage, operating voltage, and for each one of those operating ranges there are various trip times and cycles. And the question is, if you get out of -- if you go from this voltage, into that voltage, you know, how many cycles must the system trip off? Second one was frequency, they looked at direct (inaudible) injection. That's .5 of 1%.

You see here all of these things are 13-1-1, 15-0, 15-0. Harmonic distortion limits are specified. They're also specified in the new 1547 Standard that will be discussed today and no problem with that. Power factor range, it was specified as 15-yes, 0-no; reconnect time, if things go down, how long, how many minutes? I think, it was five minutes time before reconnect. Nonislanding operation limits, 13-1-2; grounding requirements, 14-1.

Here's one that always comes up. It has to do with this issue of a manual, lockable, external disconnect switch. Some utilities are requiring it, some utilities are not requiring it. But it was interesting, of the utility representatives, this one here was one of the most negatives. Okay, six of the utilities said -- or six of the utility representatives said yes, we want that capability, we want that extra switch out there; 9 said that they'd rather not have it, and it primarily had do with liability concerns.

In terms of other disconnects, they had strategically located, visible, and then, utility access to the protective relays and the protection devices that are built into the inverters, the sensors, the contactors, reloaders, whatever. And a lot of them said, no, they didn't need access to that or simply, we're not going to have that access, for whatever it's worth. I don't mean to oversell the results of this survey, because it had to do with Draft 7.

That particular standard, went through, I think, four or more drafts, although those things weren't changed very much. They're pretty much the same as what we surveyed, but nevertheless, that's how people were thinking about two years ago about that. In terms of our position on --

SPEAKER: Can I ask you a question --

DR. VENTRE: Sure.

SPEAKER: -- real quick, just to make sure I'm not forgetting this later. On this survey, that means -- I was reading it wrong. I was reading that maybe the system did not allow access, so 11 were against it and 4 were for it, but I'm reading it -- I read it --

DR. VENTRE: No, I didn't have enough space to write the whole statement out, but it basically asks -- the question that was asked, should an external, visible lockable, manual disconnect switch that can be locked in the open position; for example, if the (inaudible) was working, you know, nearby, should that be required? That's the way it was written.

Our position on this whole interconnection issue, and probably could have written it a little bit better, but the main concern is safety, absolute number one priority. The interconnected photovoltaic system should pose no serious safety or reliability problems to either the utility or the utility customer, including the system owned and operated. That's the number one priority.

Two, three and four kind of go together, the process of interconnecting a small system should be routine. It shouldn't be -- it shouldn't be a custom type situation where every requested installation requires a great deal of effort. It should be fair to be expeditious and in a process should be such that it allows the customer that's willing to pay the higher prices, it should allow that customer that option without undue burden. So, once again, number one issue is safety and reliability, but by the same token, assuming that we can address those issues, we think that the process should be -- should not discourage somebody from choosing.

Now, the four areas that we mentioned were -- the technical areas primarily have to do with the standards and codes. And then, we talked about the terms, (inaudible) and the whole process.

In the technical area, these are what we recommend. From our perspective, once again -- it's not just us, it's for work that we've done for the National Laboratories in almost a 20-year time frame, this is what we recommend.

In terms of the interconnection itself, we suggest requiring compliance with IEEE 929-2000. In addition to that IEEE standard, we suggest requiring -- and this was not in the original draft of the Public Service Commission rulemaking for small (inaudible), but we think it should be, and that is compliance with IEEE 1262-1995. There's a couple international electric technical commission standards that are equivalent standards. This one here, 61215, deals with, essentially, thick-film conventional crystalline cells. This one deals with some of the newer product with thin-film devices, but these are -- all three of these standards have to do, not just with safety, but have to do with performance under stress conditions.

And our concern is that if you have high-mechanical stresses due to wind load, vibration, hail, whatever it might be or high-electrical stressing, (inaudible) or high-thermal stresses that would (inaudible) we'd like to see these systems, you know, be able to perform under those extremes under which they are tested.

And so, this is more restrictive than what's been proposed by the Florida Public Service Commission to date, and we suggest if it meets the National Electrical Code, the components have to be UL approved, but we suggest specific reference to two UL standards. One has to do with electrical shock and fire propagation hazards associated with these devices, especially from rooftopping.

And in addition to that, and this is key, 1741, a safety protective version charging controllers for use in photovoltaic systems. So, you've got two IEEE standards, two UL standards, and then the 1999 National

Electrical Code. And even though the local jurisdictions may not require it, we think that from a rulemaking perspective for the interconnection rules in Florida, we'd like to see that included, if it's legally possible to do that, mainly because the prior versions don't adequately address certain issues.

Now, there is another standard that is going to be discussed today, which is the IEEE 1547 Standard, and that has to do with interconnection of distributed resources. And what we're saying is that -- and (inaudible) National Laboratories, who we work closely with, agrees with this -- don't confuse the situation -- just stick with IEEE 929 for small PV systems. There's some different concerns that come up when you start dealing with rotating machinery and other distributed resources. So, just to allow this process to proceed in an orderly fashion, we'd like to see IEEE 929 be the interconnection standard that applies to small PV systems. The larger systems, then, 1547 (inaudible).

As far as nontechnical issues, here is the position of our standard, and we're talking about here primarily rooftop systems: Liability insurance, standard home owner's policy $100,000 limit of liability and only home owner named insured. Metering and billing, our position is we support net metering at the Florida Solar

Energy Center. And our position is or what we're talking about over the next 10 years, it's cheaper and easier for you to go to net metering (inaudible) than it is with a dual-metering system. But we do encourage flexibility, if you want to go with some kind of dual meter, then you can. Once again, this is our position and we, obviously, respect other views on this.

And in terms of the application and compliance process should be, like, interconnecting any home with a grid. Once we've got the problem solved, I think, they are, I think, we've been working on this long enough, that this whole process shouldn't take very long. We suggest 10 business days, but that's up to you. And the documentation associated with that whole process should be something that doesn't, once again, unduly slow down the whole process.

Okay, let's shift gears a little bit, make some connections, if we can. There's a new standard that's been kind of pursued at a faster pace than IEEE 929, and that's IEEE P, meaning it hasn't been adopted yet, 1547, draft standard for distributed resources interconnected with electric power systems.

What this does, establishes criterion requirements for distributed resources when connected with electric power systems. So, they have a uniform standard.

Here's all the different things we looked at: Performance operation, testing, safety, maintenance, at the point of common coupling when we distributed the device and the electric power system. And it goes beyond static inverters to include synchronous generators and induction generators and so forth. Just as a (inaudible) emphasis, the standard does provide the test requirements that are suggested for compliance.

Now, this particular standard, right now, is going out for ballot, and the suggestion is or the assumption is that by going to ballot at this early date, that they'll get considerable feedback that will help modify the code. The actual (inaudible) for the ballot is not going to be approved, okay, (inaudible). It's not going to be approved with this ballot, but there should be sufficient input that allows for some improvements in that standard.

So, the best guess for approval of the 1547 Standard is December of this year. Whether or not that happens remains to be seen. That working group is headed up by Dick DeBlasio at the National (inaudible) Lab. That original working group was about 15 or 20 people when they came forward with the first draft of that. I think, and I'm sure a number of people are here on that group, I think, there's well over 200 people on that working group now or at least participating in the standard development.

Okay. In terms of some recent events, they met November in D.C., they met in December in Chicago, they finished Draft 6, it was transmitted for the working group right before Christmas and, as I mentioned the first ballot is in the purpose of being distributed.

Once again, the fellow's name at the bottom here, Dick DeBlasio, if anybody needs to get information on him, he's the guy whose chaired that, and we've been in contact with (inaudible) and Dick DeBlasio regularly on this whole process.

I don't know if you can see this very well; you've got it in your handout, but if you look at this work, it's actually being done by the Standards Coordinating Committee 21, deals with fuel cells, (inaudible) generation and energy storage.

We talked about distributed resource, some interface and the electric power system. Of those distributed resources primary fuel cells, combustion turbine generator sets, microturbine generator sets, internal combustion generator sets, (inaudible), solar thermal electric, wind energy source and other distributed resources.

And in terms of the interface, we're talking about static inverter, (inaudible) PV, and we've got induction of synchronous generators, and then questions where is the interface status, as far as utility is concerned. In addition to the criterion and technical specifications, the testing specifications are also presented in that standard.

What I'd like to do is just talk about some things that are associated with what we think's going to happen with Florida that you need to be concerned about. One of the things that we've been trying to do in working with utility companies is to approach it from a perspective of learning. What can we do now that will allow us to respond to what may develop? We don't know if there's going to be a market for this technology or not, but assuming that there may be, how do you best prepare for that?

And so, we're trying to address now by our programs and monitor systems, mention that we'll have up to 25 systems with resource-level monitoring. We'll have probably anywhere from 70 systems with at least a metering on the output of the inverter, and a number of these systems in which to look at time of day, power production.

But we want to find out, you know, what effect do a number of these things operate on the grid (inaudible), in particular, multiple systems on a given distribution generator. What's the time value of production and sufficient information for planning? And we're talking about primarily utility planning. If you wanted to get involved in this as one of your programs, what kind of information would you need in order to do that type of activity?

Another area that goes beyond price and making decisions about this technology has to do with people that are very, very much concerned about energy problems as well as environmental problems and are looking at a whole variety of different options in terms of energy efficiency, defusing energy consumption, and using renewables. Here is a system that we have been monitoring for some time. This is over in the Lakeland electric service area. This 4 kW array and also over in Lakeland (inaudible) and solar water-heating system.

That particular house has every conceivable energy-saving device you could possibly imagine on it and survey not intended to be cost-effective. It was just basically trying to address what's the best you can do in terms of looking down the road, in terms of energy efficiency, (inaudible) power production and interfacing with the grid.

What we did within 100 yards or so of this house or (inaudible) this house, we got an identical house that was conventional, meets the Florida energy code.

Everything about the house is identical. And we're doing side-by-side comparisons between this energy efficient with PV and this control home if there's not enough PV.

DR. LINKOUS: -- typically, that limits a power plant, a combustion-based plant to 30 or 40, sometimes if you do a little cogeneration, a little more than 45% efficiency. For fuel cell, the electric chemistry though, you can deliver the full free energy of reaction as the open circuit voltage in that cell. So, as a result, people are predicting fuel efficiencies of 45 to as high as 60% when you include the high temperature fuel cells from which you can also do some cogeneration.

Okay. Where does hydrogen come from? Well, hydrogen exists mostly on earth in the form of fossil fuels, biomass, and water. And to get hydrogen from fossil fuels, it doesn't take all that much energy. The amount -- it takes roughly 10 kilocalories per mold to get hydrogen from natural gas and, of course, you get 60 when you burn it. So, the payoff is easy; it's relative pay, and it's not a problem.

For water, of course, you're essentially, reversing the combustion reaction, so you're having to identify what the heat of combustion is from another source. So, you can get hydrogen from steam performing in natural gas, gasification of coal, splitting this, in more technical terms, pyrolysis, biomass and hydrocarbon (inaudible), get it from water, just conventional water electrolysis. We've also devised some thermal chemical cycles. And then, finally, there's photoelectric chemical to photobiological where we're actually -- you're actually either using a type of a photovoltaic cell as an electrode in an increased environment. Or -- and this is also a new application of genetic engineering, we're developed strings of algae that can be induced to do photosynthesis, as all green plants, do but they involve hydrogen instead of build plant tissue.

As you might expect, hydrogen's cheaper to obtain from high-energy compounds as from low-energy compounds. So, everything's -- we tried to write this down so everything scales. If you can get natural gas at $3.00 a million BTU, then the hydrogen you would get from that natural gas would run about $9.00 a million BTU.

If you've got electrolysis, if you've got reasonably cheap electricity, let's say, 5 cents a kilowatt hour, you can probably deal with electrolysis to make hydrogen at about $25.00 per million BTU. So, in situations though, even today, most cases (inaudible) turn favorable, there are few places where electricity is cheap and the natural gas is expensive and the use or the environment for the hydrogen is small. It actually makes more sense to do it electric, to make hydrogen from electrolysis.

It is high-temperature electrolysis -- I'll get into that later on. Just to go the vast of what the total renewal (inaudible) or where we are today, (inaudible) in the winter, the desert southwest, and the (inaudible) and try to make an economic go of it, right now we're estimating it costs $78 to make the hydrogen.

So, we've got a drop in electrolysis technology and PV technology, we've got to come down probably (inaudible) magnitude before we can sell hydrogen as cheap as the natural gas broker in Texas, for example. We've got some future -- I'll leave the future classifications for a later time.

(Inaudible), they talked about the hydrogen storage as liquid and gas. I guess, that's largely correct, two very active, very (inaudible) is essentially it stores hydrogen in solid form. And by that, I don't mean we're freezing down the hydrogen to where it's a granular or salt. I mean, that's 16 degrees (inaudible). You can actually absorb hydrogen on to certain carbonaceous materials or you can react hydrogen with certain metal alloys and actually store the hydrogen in solid form. And some of these (inaudible) actually have rather large hydrogen content.

The typical gas cylinder that you see in the lab, that's only like 1, 1 1/2% hydrogen by weight. The rest of the balance is the weight of the (inaudible) itself. So, that's one of the, perhaps, hydrogen's biggest problem is that it's a gas. Because it's a gas, you have to contain it. So, for vehicular applications, then you have to include the weight of the container as part of the consideration of whether you can feasibly make a vehicle out of it. For stationary, that's not a problem.

And so, you can look at systems like this where you can store as much as 5 to 8%. And for this now, as much as 8 to 10% hydrogen by weight in this solid form. So, you don't have to pay -- I mean, liquefaction's nice. NASA likes liquefaction, but frankly, right now they have to pay the energy cost with liquefaction is like 30 to 40% in the heating value of the hydrogen itself.

So, you know, NASA, they do it, because for them (inaudible) is everything. I'm not sure for some guy operating in his backyard, some guy who just has a big (inaudible) of liquid hydrogen in his backyard (inaudible), because energy cost of producing the liquid is a significant portion of the heating value that he would ultimately derive from it.

See, NASA burns 385,000 gallons of liquid hydrogen in eight minutes. And so, you've got that surface-to-volume factor working for you, you don't have to worry about it. But if you're a smaller user and you're only using maybe 100 liters a day, then, at that point then, the cryogen storage aspect of it becomes a factor.

The other aspect which I've tried to emphasize here, though, is the consideration of how to store hydrogen and also how to deliver hydrogen becomes a factor of -- it's the same consideration, I guess, as within the other utility. It's how much you're going to use, how much is being used in a given locale and how many users there are.

And essentially, the protocol is, I think, it basically parallels the natural gas industry. If you're a smaller user, a small isolated user, the most economic way is to purchase a (inaudible) of pressurized gas (inaudible).

Now, if the need goes up, let's say you're a NASA-sized hydrogen user, the liquid hydrogen tanker -- everytime NASA has a launch, you can see them coming down I-95, there's a fleet of about 40 Praxair tankers delivering liquid nitrogen to their facilities so they can launch.

Ultimately, once you get up into the 10 million standard cubic feet per day range, at that point you start to look at on-site production. And, of course, some day near in the future, if we have -- if hydrogen becomes a domestic energy source and you have many users consuming it just as if they're consuming natural gas, at that point then the most economic way would be an (inaudible) pipeline delivery.

Okay. Hydrogen benefits here. I think, this -- let's turn this into a safety slide and talk about safety a minute. The first bullet there kind of emphasizes that it's -- well, it almost implies that it's not as flammable as gasoline, and that's really a little misleading. It's the high end, it's the rich end is what makes people concerned about hydrogen.

It's true that most hydrocarbons, as well as hydrogen, the lower flammability limit; in other words, the least amount of gas that it takes in an air atmosphere to sustain a flame is down in the handful percent. The big difference is the hydrogen, you can ignite a hydrogen flame as rich as 75% hydrogen; whereas, most hydrocarbons, conventional fuels, would give out in the teens to 20% range.

So, that's the thing you have to be careful about, requires extra attention, is that nobody ever tries this at home. The old joke you can throw a match in a gas tank and nothing will happen, because the gas vapor pressure is so high it won't ignite. Well, you would never want to do that with a hydrogen tank, because the rich mixtures are also susceptible to combustion.

It is true, though, however, from a radiant effect that hydrogen flame -- I should say it's a cool flame. Let's just say when you have a hydrogen flame, it's what's above the flame is what gets hot. The radiant heat to the side, the heat that's surrounding that doesn't get hot. It's the direction of the flue of the hot gases coming off the hydrogen flame, that's where the heat is delivered. So, if anything, if there was any provision made for hydrogen safety, it might be higher ceilings or something, because the heat's going upwards as a result of that combustion.

And the other thing is dissipation. Because hydrogen is such a small molecule, the rate of effusion, the rate of leakage, essentially, for given pressure and the amount of gas is perhaps eight times that, it's the inverse square (inaudible). So, it's like eight times as much as any other gas that you might expose yourself to.

So, that's why if you remember Mike Swain's schematics there, if there's a hydrogen flame -- if there's a hydrogen leak, the rate of leakage away from that orifice is so fast that you stay below the combustible mixture. The hydrogen, very quickly, spreads throughout the room and dissipates away; whereas, the other gases which tend to be heavier than air, tend to fall and blanket the basement of the room.

So, in that sense, I'll tell you this much, you're never going to pick up the morning paper some day in the future and read about how a hydrogen pipeline in a neighbored had a leak and the whole block blew up, okay? That's never going to happen, because hydrogen doesn't behave that way. For that to happen, it would have to (inaudible) with the type of many terms, there's a natural gas leak and the gas (inaudible) along the lines of a (inaudible) meets an emission source, but for hydrogen that's not going to happen. The plume's just going to go up into the atmosphere and be lost.

Okay. So, let's talk electric industry now. I think, you've been exposed to the basic concept of where you have two electrodes separated by an ion conducting medium and electrolyte; hydrogen is fed to one side, it's oxidized, so they call it an (inaudible). You feed oxygen to the (inaudible) over into the other electrode, so it's called a cathode, the product of this electric chemical reaction, net reaction, is water. So, at this point the electric chemical conduction now is truly zero emission substance, aside from water vapor.

Because it's -- because most -- because there is a number of fuel cell technologies, most of which operate in lower -- well, not room temperature, let's say warm temperatures, not combustion temperature, not hundreds of degrees centigrade, because of that, there's no (inaudible) either.

So, that's why -- this is why California or, say, Detroit is excited about fuel cells, because it enables them -- if you insist that you're going to have zero emission vehicle, then, what it comes down to is if you're going to use fuel cells or are going to use batteries. And from performance point of view, fuel cells beats batteries.

There are, essentially, five basic fuel cell technologies that are defined by an electrolyte, that ion conducting unit that separates two electrodes, okay? And for alkaline or fem (inaudible) membrane, phosphoric acid, molten carbonate, and solid oxide. The way these are shown, hydrogen is the only thing fed to the (inaudible) oxygen's always being fed to the cathode, but that's a little misleading as I'll show you here in a minute.

Actually, I like this table better, because it doesn't inundate you with chemical equations, and we can kind of talk about it one sector at a time, okay. In a fem cell, the electrolyte separating the electrodes is typically a polymeric, an organic polymer material. The leading technology in this area is natheon. It's made by DuPont. There are Japanese-equivalent products, but that's -- I think, that's the agreement between DuPont and the Japanese company is basically, there's Japanese natheon sold in Japan and there's American natheon sold in America, but it's essentially the same stuff.

It's rather expensive stuff, because it has to be resistent to voltage, it has to be resistent to reasonable temperature, and it has to be resistent to deep (inaudible) per oxidation. It has to be -- the most important characteristic, it has to be highly conducted. Most polymeric materials all around this stuff have little or no electrical conductivity, but this stuff has a very high ionic conductivity, protonic conductivity.

As a result, its price is kind of high. It goes for -- I know more about this because I've done a lot of research in developing alternatives to natheon. Right now if you go out to buy natheon, it costs about $80 a square foot. And if you go to build, like, a 5-kilowatt fuel cell, you've got to buy -- we calculated you have to buy $1,000 worth of natheon to make a 5-kilowatt cell.

And so, clearly, the cost of that has to come down. So, that's -- don't worry, I'm not going to torture you with my specific work, but essentially the major objective of some of the work we do at Florida Solar is to try to develop a membrane that's low cost, but nevertheless, reasonable performance.

Alkaline cells are much simpler. That technology's been around 150 years. Just take the caustic to make 28% weight and off you go. It's just a caustic solution. And you can go to term with that. Phosphoric acid, also very simple. You basically just take a -- (inaudible) separating two (inaudible) electrodes and you just soak that silicone carbide with phosphoric acid and let it go.

Actually, it's the most reliable technology, at this point, for fuel cell technology. But molten carbonate and solid oxide, molten carbonate, you take sodium (inaudible) in carbonates, heat it to red heat, about 600 degrees C, and it'll actually mold into salt type electric chemistry.

And finally, salt oxide fuel cells, you take zirconia, (inaudible) it with little (inaudible) to generate some vacancies and crystalline (inaudible). And at 1,000 degree C at white heat you can actually get oxygen ions to zip across that ceramic membrane like it was saltwater. So, it's an interesting technology, but for utility applications, it's received actually a fair amount of attention, although it's still not quite ready for commercial development.

So, as you can see, they're actually conducting ion through that medium. The fem membranes tend to be acidic, alkaline membranes, of course, alkaline. Phosphoric acid, once again back to phosphoric acid, acidic. The carbonate is interesting in that the carbonate ion acts as a oxygen transporter. So, that's what enables you to get the mass balance in the cell.

And then, finally, as I said, the zirconia, it's ion transport, oxygen ion transport. The catalysis, now, as you might expect at low temperature, you need a very active metal, reactive metal to do the chemistry for you. As you go to higher temperature you can get away with less exotic, cheaper materials.

So, for the fem cell and phosphoric acid, unique platinum and noble metals are expensive. Noble metals are, at this point, a necessary part of the operation of those cells. Alkaline cells, much cheaper. You can get away with -- well, silver's $5 to $10 an ounce. So, nickel and silver, sometimes even a high-grade steel can be used as an electrode there.

Molten carbonate, you can get away with nickel. And also for solid oxide, you can use nickel or (inaudible) oxide (inaudible). And so, these are reasonably cheap materials, although the materials properties that they have to satisfy are rather demanding. Because as you see, the working temperature, this is probably the upper range. Typically, the average fem cell that they're looking at for a carb is actually 80 degrees C, I mean, if you all touch it.

Alkali, once again, you can run it that hot, but there is a corrosion problem with the electrodes when you get that hot. Phosphoric acid, United Technologies, they can run their cells flat out at 180 degrees. So, it's pretty well shown that they're going to stay consistent at that temperature. As you see, molten carbonate, pretty hot; solid oxide, really hot, but nevertheless, they work.

So, none of the fuel gas -- this is the part I wanted to point out -- these guys, fem cells, need hydrogen, clean hydrogen; the lower the temperature, the more sensitive the system is to purities. So, once again, for vehicular applications where you basically would like for it to operate under ambient heat and you don't have to use a lot of energy to either heat or cool, you do have to have a rather clean source of hydrogen to supply that cell.

On the other hand, for the high temperature fuel cells, you can use any number of fossil fuel feed stocks. And if you get some steam vapor to operate with, it will reform -- that will form a reaction that we talked about earlier for the natural gas, it will occur internally inside the cell, since these cells operate at a temperature that will form a unit it would operate at anyway. So, they're just going to feed the (inaudible) so you don't need a reformer. Just send the gases in and it will open up steam do their performing reaction and Co2 will come out with the water vapor, but you'll wind up just using it directly.

As an oxidant, might use air, if at all possible, but one problem with alkali is that it will (inaudible) Co2 out of the air. We're sitting here at 300 parts per million. That's not a whole lot of Co2, but it is a cumulative effect. And so, if you don't do something to remove the Co2 from the air, it would eventually choke your cell. You eventually just precipitate carbon result to the cell.

So, a lot of people, when they talk about fuel cells, they assume two things: They assume, one, that you're only interested in terrestrial applications, you're not interested in space. So, they say this is out. They don't even consider it, because of the Co2 problem. The other consideration is that they say it's impossible to stop it.

There are vendors out there for alkaline fuel cells, and they will argue that it is economically feasible to clean the Co2 out of the air before it hits the fuel cell. I don't really want to get into the middle of that today, but I throw it out there just for the sake of completeness. It also at least gives those guys a chance to make their case some day that yes, you can consider. This is certainly an ultra cheap way of running the fuel cell. And, what can you say? If the worst problem they have is they've got to figure out how to clean the Co2 out of the air before it goes to the cell, who knows, maybe they'll get to the bottom of that.

So, what's left? Application. Okay. Now, as I said before for the fem cells, the reason Detroit's nuts about it is because the kilowatts per kilogram seems to be maximum, because it runs at low temperature, you don't have to -- you don't have to have a lot of cooling lines, you don't have to regulate temperatures much, you don't have to heat it as much. It basically runs at its own ambient temperature. And so, that's nice. And so, they've been trying to figure out how to mount those other (inaudible) and run a carb from it.

Alkaline cells, still, there's a few proponents, but not too many believers at this point. The biggest customer for alkali cells is NASA, because they're supplying the oxygen anyway, so they can supply pure oxygen and it doesn't matter. For these guys, phosphoric acid, there have been a number of Department of Energy programs where they have made, oh, 15 to 50 kilowatt units to operate what's called small distributed -- well, midsized distributed power applications where they would fuel, perhaps, a laundry mat or 20, 25 pounds of (inaudible) area, and the fuel cell would be a central power facility.

There's a project going on right now up in Alaska where they're trying to replace a diesel generator with a -- I believe, it's one of a couple of PC 25s, I'll show a picture of that, that generates a couple hundred kilowatts of power. Most people, when they consider the molten carbonate and the solid oxide, they're looking for medium to high-end generation. They're thinking that it would get up into the megawatt range, but still technology is still in its developmental stage.

Actually, if I recall, I think, the largest cells built to date have been phosphoric acid. They've built, I think, one to two megawatt phosphoric -- they've been in the single megawatt range for generating phosphoric acid electricity.

Molten carbonate has approached one megawatt. I know they're in the hundreds of kilowatts. And I know of solid oxide, right now they're in the tens of kilowatts, and they're shooting for hundreds. So, that gives you an idea of how that technology is progressing and what the next step is for each one.

Now, just to show you pictures, I tell people that my management comes to me and let's me put together demos and stuff, and I keep telling them fuel cells ain't sexy, that it's just a box, it sits there, there's no noise, no moving parts, it just sits there, you turn the gas valve, and you run your (inaudible). There's not much more to it.

So, the fuel cell designs, the technologies, as I've described them, perform differently, but basically they all consist of a series of (inaudible) components that are stacked up to each other. Basically, you take diffuser plates, the electrodes themselves. This is diffuser plate and a membrane electrode assembly set up. It's a giant Dagwood sandwich. Typically, a fuel cell only puts out any -- a single cell only puts out, oh, from half to one volt of charge. Electric (inaudible) devices are inherently high current, low voltage. So, typically, what they'll do is they'll stack up 50, 60, 100 cells in one array in order to generate, typically, from 100 to 200 volts type DC output.

Here's a schematic update. Perhaps the most popular or the most successful commercial fuel cell at this point United Technologies. I guess, Odyssey is the subdivision of international fuel cells, which is also a subdivision of United Technologies. They make the phosphoric acid-based PC 25. It operates at the -- it delivers 200 kilowatts of power, and they have sold over 100 of these units worldwide. They really have orders to 200. What else can be said?

From the picture, it's basically an oversized garden shed, in terms of its footprint. Basically, all you have to do is supply it with some clean water, hook it up to a natural gas supply, the reformer is fit inside that contained vessel, and it will generate a steady 200 kilowatts of power. They've got performance data to prove that it's very reliable. In fact, they've made legitimate sales to hospitals and data management services as the UPS, as an uninterruptible power supply, because they can prove that their electricity is more reliable than the local utility.

You see the fuel efficiency, if -- typically, the electrical efficiency we talked about here is a flat 40%. If you throw in some cogeneration -- if you're able to use -- if you use the heat, and let's face it, it runs at 180 Cs that you can make some boiled water out of it, if you want to. If you throw that in, you can get as high as 85% energy efficiency. And you see here that they have ranged the (inaudible), and you see, basically, it's in the single digits or none at all.

Here's the schematic for the multi-carbonate fuel cell. Just to show you no matter what you use, in each case it's basically the stack of thin lamina, air diffuser, electrode, electrolyte, electrode diffuser and so on in a stack of however many cells you need. One difference perhaps would be Westinghouse and their concept of making a solid oxide fuel cell.

As you might expect, electric chemistry is not a problem. (Inaudible), you're going to get something to happen, but the difficulty are the materials requirements, keeping the various lamina from interdiffusing into one another. So, what they've done is they have a tubular fuel cell. They call it FBA cells, that's a flashlight battery cell. Essentially, you might expect -- essentially, each one of these tubes is inside its own chamber, which is then stacked up to make an array like so.

And so, for years -- well, hydrogen is, you know, it's the reactive substance, the oxygen comes from the air, let's bathe these tubes in oxygen and feed the hydrogen inside the tube, but a few years back -- well, a good many years back now, they decided to switch it around. The Westinghouse approach is to feed oxygen or air to the inside of the tube and have it come out and diffuse back out and then blanket this chamber with hydrogen. So, you've got hydrogen being fed in here flowing over the tubes, reacting on the outer surface, and then the effluent water vapor comes out through this orifice. You've got air coming through this orifice diffusing through -- going into each tube and then coming back out.

So, it's a very interesting design which basically, came from the requirement of having to figure out how to put these sequential layers of (inaudible) -- let's see, what was it? (Inaudible) the cobalt cermet, a little bit of material, a nice lesson in ceramics is what it is, but nevertheless they've been able to demonstrate these things on the 100 kilowatt level. If you know how to make power plants, and so maybe some day they'll get the bugs worked out, then you'll be able to demonstrate this, probably as a base load.

The other thing when you're up to 1,000 Cs you don't want to thermally cycle these guys. You want to get it up to 1,000 and leave it. Maybe you could even think that they're thinking of using a solid oxide fuel cell the same way people think about nuclear power plants; you send it up (inaudible), they give them capacity, base load power and just let it go. And so, perhaps some day they'll get there.

Okay. Fuel cell manufacturers, actually, this list is getting larger by the day, it seems, plus it's hardly comprehensive, but I would think that the leaders for phosphoric acid technology, at least in the U.S., is United Technologies and Westinghouse, although I do (inaudible) a lot in that particular area. The proton exchange because California is really hot now, but certainly the long-time leader has been Ballard out of Vancouver, Canada.

We do have Energy Partners down in West Palm, which is our competitor in the (inaudible) fuel cell market. The proton energy systems is kind of an off-shoot from -- how should I say this? Proton exchange membrane technology came out in the '60s through GE. They sold off their technology to Hamilton Standard. Hamilton Standard has since allowed some of their employees to form their own off-shoot company called Proton Energy Systems. So, essentially, the SPE, the solid palmer electrolyte technology out of GE now exists today as Proton Energy Systems. And then, I don't know, I guess, it's funny that GE's getting back into this. GE has very much a lot of involvement in getting a plug-power guard, which is pushing domestic fuel cell manufacture.

Molten carbonate, the two players are ERC, Energy Research Corporation, in Connecticut and also MC

Power. I forget where those guys are, though. But by far, the leader of -- there are some -- Softco and Ztec are making plainer solid oxide cells, but Westinghouse, in my mind, is still by far the leader in that effort. They were making solid oxide fuel cells in the early '60s, and so I feel like they still have the most expertise in-house. If anyone's going to crack that nut, it'll be them.

MR. DICKENS: Just a quick question.

DR. LINKOUS: Yes.

MR. DICKENS: I recently read a week ago that Bill Gates had announced he was going to put $100 million into a leading fuel cell manufacturing company. I just can't remember which company it was. Would you, by chance, know from the slide here which one that might be?

DR. LINKOUS: Do you want me to guess who it is? I'm guessing Ballard.

MR. DICKENS: Ballard.

DR. LINKOUS: Yeah. They're the ones who have liked -- they're the ones who like when Chicago passed their fuel cell bus program and immediately they took several buses and converted them into (inaudible) fuel cells. I believe -- I think, they had methanol reformer in those, but nevertheless it was a fem fuel cell driven bus that was all Ballard that did that. I mean, certainly for vehicular fuel cell-driven vehicles, I think, Ballard's the leader in that area.

Now, when you think of Bill Gates, I don't know if he's spending his own money or if he's spending Microsoft money. I mean, there is a whole other application of having fuel cells as micropower sources. There is an idea, if you've got a computer that's got hundreds of PC boards in it, if you've got a central power source and it goes bad, then the whole computer goes down; whereas, the power source for each board or on the board itself, in other words, you had a micro fuel cell on each board, then you could have just one board go bad at a time, and it wouldn't be a disaster. You could still power your device by borrowing the power generated from the remaining board.

It's an approach that's especially of interest to NASA who is, of course, trying to build fail-safe electronic devices. So, I just wonder if Bill Gates was thinking about that, even though there's a company out there that's pushing hard on the micro fuel cell technology which -- he makes software. He doesn't make computers. I guess, he's probably given it to Ballard.

MR. DICKENS: Diversification.

DR. LINKOUS: Yeah. Well, let's see. Okay. Let's share some sobering thoughts about cost, though.

For the consumer market, for John Q. Public, to buy a 5 -- or let's say a 1, 3, 5, 10 kilowatt fuel cell to operate in his garage or in a shed in the backyard, it's probably going to cost, at this point, just to go out and buy one, it's probably going to cost upwards of $10,000 per kilowatt.

That's probably in the high end, but that's utterly realistic. I know he could buy one for that if the economy of scale can be built into it, like, when United Technologies sold five PC 25s to the Alaskan Postal Service, they sold those for like five and a half thousand kilowatt. That was the sale price. It was not their price. So, you know, profit margin and everything is included in on that.

So, you know, so let's drop that. Let's say for economy of scale, if you can sell a big unit or a lot of units, you can probably cut that in half, but I would say $5,000 per kilowatt is a realistic price for what you have to pay today to have fuel cell power in a domestic or small consumer or small business situation.

That pretty much covers this for me. The only other thing I would want to mention is I guess, as you're gathered, we do have -- Florida Solar does have an abiding interest in hydrogen energy and then, correspondingly in fuel cells. We are trying to develop our newly-formed hydrogen research and applications center. And I did bring some brochures which were -- seem to be stacked up rather uniquely. So, Vic has been nice enough to run off some copies. So, those of you who didn't have a look at it can.

It's essentially -- it's called a Manifesto of Hydrogen, why hydrogen is a good idea for Florida. I think, just because California is indirectly nuts about hydrogen because of their smog problems, I don't know if that's necessarily the same rationale that Florida should follow but, nevertheless, there is a rationale for hydrogen in Florida. In fact, that document resulting from two summit meetings that they've had over the last several months, I think, articulates that point pretty well. I think, that finishes the --

SPEAKER: I have a question, doctor.

DR. LINKOUS: Go ahead.

SPEAKER: Do you see any interconnected problems that fuel cells would have that we haven't talked about with the PV system?

MR. CORDIANO: Are there any other questions or comments? Well, we thank you, Dr. Linkous and also Dr. Ventre for sharing with us your presentations. And also we thank the industry representatives for being here and everybody else. That concludes our workshop.

STATE OF FLORIDA)

: CERTIFICATE OF REPORTER

COUNTY OF LEON)

I, KORETTA E. STANFORD, RPR, Official Commission Reporter, do hereby certify that the foregoing proceedings, Pages 1 through 54 were transcribed from cassette tape.

I FURTHER CERTIFY that I am not a relative, employee, attorney or counsel of any of the parties, nor am I a relative or employee of any of the parties' attorneys or counsel connected with the action, nor am I financially interested in the action.

DATED THIS 8TH DAY OF MARCH, 2001.

Koretta E. Stanford

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