UE-051106

Subject: Testimony of Parker Holden concerning electrical interconnection standards.
Workshop on Dec2, 2005 WUTC Offices Olympia

Background of testifier:

I have been semi-retired since 2000 but continue to operate a small alternative energy business from my home in Olympia and from a branch in Dar es Salaam, Tanzania.

My work experience includes 15 years as a Westinghouse field engineer and 20 years in various paper mill electrical positions. For all of these 20 years I was responsible for electric production in the facilities where I was employed. These production facilities were between 10 and 28 megawatts and were hydroelectric or thermal cogeneration.

I continue to do some consulting work and am presently working with two clients who have electrical system issues, White Pass Co. Inc and Holden Village in Washington State. I am also doing preliminary study work for three mission complexes in Tanzania. All three involve rehabilitation of old abandoned hydro facilities. Two are grid connected and one is off grid .

I have several comments, mainly from the Interconnector's prespective.

The subject areas I would like to address are:

1. The general philosophy of the relationship between the utility and small grid connected producers.
2. Issues around powerfactor.
3. Issues around harmonic content.
4. Issues involving time of day pricing (or the role of the small producer in managing demand.)
5. Issues around UL label.

1. THE GENERAL PHILOSOPHY BETWEEN THE SMALL GRID CONNECTED PRODUCER AND THE UTILITY.

There needs to be philosophical alignment between these two elements of the system. If either side takes a very partisan position, and there is not a powerful reconciling process and force, we won't make much progress, as a nation or as a state.

The small producer must acknowledge that the utility has certain legitimate needs in terms of the interconnect details and that that there is a legitimate cost to the utility in providing capacity and quality power as well as providing kilowatts.

The utility must acknowledge that the small producer should be compensated fairly when his production provides power at peak periods, of high or leading power factor, and is free of or low in harmonic content. This is in addition to compensation for kilowatts.

It is also very helpful if EVERYONE acknowledges that the electric supply paradigm is shifting. The basic shift is from large, centralized production facilities, to a mix of large central facilities and MANY small facilities.

In the Pacific Northwest we can expect large scale hydro production to stay about the same. We can expect a very small amount of small hydro additions (almost negligible)

The days of increased electrical generation capacity being made available to the general public due to pricing aluminum reduction facilities out of the area is about over...they are almost all gone. This cow has been milked dry.

We can expect a significant increase in wind energy production. The ROI (return on investment) on large scale wind has improved dramatically, to the point where it is competitive with central thermal plant power.

Small scale wind (battery based systems and/or inverter connected to the grid) will grow slowly....pretty much following the rate of increase of electric rates. There is one area of wind generation that is completely undeveloped at this time. That area is one of using big scale technology (rectify/invert at sub synchronous speeds and bypassing the inverter at speeds above synchronous.) on small wind units, probably 10 to 50 KW.

Solar production will follow a pattern similar to small scale wind unless there is a major breakthrough in dollar per watt cost of solar panels. At this time the capital cost per watt of solar and small scale wind is 3:1 in favor of wind.

Nuclear power may or may not make a comeback. This is a very politically charged area. Utilities that resist cooperation with small producers are likely to be advocates of rejuvenation of the nuclear approach.

Intermittent energy sources....wind and solar....must be married to a partner. Hydro is the best partner and steam turbine thermal is the worst partner. For this reason the outlook for intermittent sources is very attractive in this hydro based region. There are major regional differences, what's right for Washington is not the best for Ohio.

In the case of thermally generated production, the overall thermal efficiency of the system will become more important as fuel prices and air pollution impacts are

considered. For these reasons we can expect to see more growth in cogen and little or no growth of central plant generation.

Successful cogen requires getting the waste heat close to the point of utilization. These utilization points are generally small in size and disperse in location.
COGEN IS EXTREMELY UNDER UTILIZED IN THE U.S. AND IS THE NEXT RIPE FRUIT TO BE PLUCKED OFF OF THE ELECTRIC PRODUCTION TREE. This is why these regulations are so important. Because of the economics associated with capital equipment sizing, the smallest cogen we are likely to see is 100 KW. The average is likely to be in the 500 to 1000 KW range. There will be a few large ones in the 10 to 20 Megawatt range. The latter are associated with a location with a large demand for the waste heat. Some examples are paper mills, university campuses and steam or hot water utilities in central metropolitan cores like Seattle Steam Corporation.

Micro cogen packages using combustion turbines have some potential in very small sizes but cogen, other than combustion turbines fueled with #2 oil or natural gas are too big and complex for small installations.

ISSUES AROUND POWER FACTOR

It is important to understand the basics as applied to grid connected generation. If the electric energy source is fed into the grid via an inverter the interconnector has no control over powerfactor and in all likely hood will be generating lagging KVARH.

However, if the interconnector is generating electromagnetically, he has great control over powerfactor if he is using synchronous generation and minimal control if he is using induction generation.

The following does not apply to inverter systems and induction generators. However, induction generators should be discouraged in favor of synchronous machines. If inverters or induction machines have a negative impact on power factor (generate lagging KVARH) then the cost of this should fall on the interconnector. Conversely, if leading KVARH are generated (within reason...there needs to be some limits) the interconnector should be compensated for this.

It should be made financially attractive for the interconnector to install and operate synchronous generation even though the capital cost is more.

Prior to WW II , when we had a lot of local generation, power factor was controlled this way. Even in the early days of BPA it was controlled this way except with synchronous condensers instead of synchronous generators. Then capacitators took over. They were cheaper and had less losses but created problems of their own in the form of LC networks that sometimes became resonant. These problems became worse with the advent of electronic power conversion equipment in the late 1900's. Horror stories abound.

As we move back to more small scale synchronous generation scattered throughout the system, we have a rare opportunity to get back to controlling power factor by twinking synchronous generator excitation levels, particularly in light of the fact that electronic power conversion usage continues to grow rapidly, as it should. This equipment has made huge energy savings possible, mainly in wide use of variable speed motor controls.

For this to happen, and for the interconnector to opt for synchronous instead of induction generation, the rate structure should include this incentive. WUTC should demand this. Dozens of rate schemes can be envisioned . One simple, understandable one is as follows:

To calculate how much the utility pays the interconnector, subtract the lagging KVARH from the KW H generated. To this number add the leading KVARH generated. The resulting number is the KWH for which the interconnector gets paid.

Interconnects via inverter are usually small and KVAR metering costs may exceed the benefit though theoretically a penalty should be assessed for low powerfactor.

However, there is one major exception area and that is where inverters are used with large wind turbines that use a rectification/inverter process when operating at sub synchronous speeds and switch to synchronous operation at higher wind velocities.

Some studies I have seen indicate that as much as 1/3 to ½ of the annual generation is at these sub synchronous speeds. These are larger machines and because of the size and the synchronous operating mode, VAR hour metering is necessary as is the penalty/bonus associated with VAR hours.

Almost all interconnect generation projects are subject to an intensive ROI analysis. If the utility benefits, such as improved power factor, reduced LC resonant problems, etc, The benefit MUST be translated to dollars that appear in the generators revenue projections. Only in this way will the proper decisions be made. Not only on the go or no go for the project but on the equipment selected (for example induction vs. synchronous machines).

Careful management of power factor is generally viewed by the utility as benefiting system capacity. This is certainly true but there are also energy savings in terms of reduced I2R losses. Good powerfactor management is the GREEN thing to do, not just with big industrials but with everyone.

ISSUES AROUND HARMONIC CONTENT

The Harmonic content of the power has become an increasingly bigger issue as time goes on. Switching mode power supplies and variable speed drives have been responsible for

this. Power generated as DC and then inverted to feed into the grid also causes harmonics.

The proposed regulations state that the utility MAY not permit the interconnector to share a transformer with other customers of the utility. This clause should be restated to... Power supplied to the grid via an inverter SHALL have its own, transformer. This should apply to all situations including net metering under 25KW.

There are two reasons for making this more definitive.

1. When there are grey areas or ambiguities in the regulations it makes it harder to scope, estimate, and calculate the ROI of a project. The person contemplating the interconnect project needs clear guidelines.....not maybe, possibly, I'll think about it etc.

2. Inverters generate a synthesized waveform. We KNOW that there are harmonics generated. What is much less clear, and no doubt varies widely from case to case, is the effect of these harmonics on the system and on others nearby.

   AT THE PRESENT STAGE OF ALTERNATIVE ENERGY DEVELOPMENT WE CAN NOT TOLERATE INVERTER POWER GETTING A BAD REPUTATION, REGARDLESS OF WHETHER THE ACCUSATIONS AGAINST INVERTER POWER ARE WELL FOUNDED OR NOT.

   The way to significantly reduce this risk is to NOT ALLOW others to share the same side of a transformer that is serving an inverter. The inverters owner can share it but no one else.

   I know that this is overkill in some cases and it does add some expense to the project But in terms of overall impact on the alternative energy cause it is the right thing to do at this time.

ISSUES AROUND DEMAND AND TIME OF DAY PRICING

It is well understood that every customer of a utility pays, through his electric bill, a fee to cover the cost of meeting peak demand. This is not a line item (except for those on demand meters) but it is a real and legitament cost. Power that is generated at peak periods has more value than power generated any old time.

In looking at the small interconnecting producer, there may be ways he can be selective (time wise) when he generates or at what rate (KW) he generates. IT IS IMPORTANT THAT THE RATE STRUCTURE THAT DETERMINES THE RATE PAID THE

SMALL PRODUCER REFLECT TIME OF DAY(ALSO WEEK AND MONTH) PRICING.

In some cases this premium rate plus the ability for the producer to target his production to peak demand times will make the difference of the project going forward or not.

Battery based systems and reservoir hydro are obviously well situated to capitalize on this. Some cogens can also capitalize on this. An example is a lumber mill that can curtail kiln activity on weekends and save its biomass fuel for weekdays.

Another example is an office building gas turbine cogen that uses an absorption chiller that takes maximum steam in hot weather periods, the same hot weather periods that result in peak loads for some utilities.

For most of the Northwest, peaks occur around early morning and evening of a cold winter weekdays. The morning period matches nicely with cogen where the waste heat is used for building heating. The evening hours do not match so well but would if the waste heat from generation during the evening peak were stored (thermal storage tanks or heat sinks) and used overnight, a time when electric demand is much lower.

Diverse small scale producers can do a lot to help meet the peak demand requirements but to do so the rate structure MUST REFLECT THE ACTUAL VALUE OF THE POWER PRODUCED AT THE TIME IT IS PRODUCED AND THE QUALITY OF THE POWER PRODUCED (POWER FACTOR AND HARMONIC CONTENT)

It is no longer acceptable to buy and sell power based on KWH only with all the other elements of cost buried in this KWH rate.

I do not mean to imply that rate structures have not made gains in breaking down the costs. They have. We have base rate to cover cost of service etc. It is just that they have not gone far enough. Time of day pricing, and power quality pricing must be expanded. For very small consumers, this is not important as they won't do anything differently anyway. But for the small producer, and the larger consumer, the economic viability of his project may well be determined by an accurate rate structure that reflects actual value of what he produces or consumes.

Large industrials, both consumers and cogeners, have managed this much better, with demand charges, powerfactor penalties, etc. This needs to be extended to smaller consumers and above all to ALL interconnected producers, regardless of size.

It is well to note that the mechanics of measuring all these variables and calculating the actual dollars paid (or due) has been greatly enhanced by advances in microprocessers and electronic metering and measuring techniques. What was once costly and cumbersome is now simple and relatively cheap.

At this point I can't help but inject a blurb about cost accounting. Some years ago I was Plant Engineer at a paper mill that was sold by an American Company to a Japanese paper company. At the level I was working at, having a Japanese boss breathing down my neck was more than I could tolerate and I left after a few months but I was there long enough to see major changes being made by the new owners. The most noticeable was their unsatiable desire to know where every outgoing penny was going. This resulted in a doubling of the number of employees in the cost accounting section. At the same time, there was no way in hell that any other department was able to replace a retiree much less add a new position. I was furious.

It was years later that I fully understood the value of knowing the cost of doing business, not by departments but by EVERY MINUTE ELEMENT.

INTERCONNECTED POWER PRODUCER NEEDS TO BE PAID BASED ON THE TRUE VALUE OF THE POWER HE PRODUCES, INCLUDING TIMING OF THE PRODUCTION IN RELATION TO THE DEMAND CURVE, AND THE QUALITY OF THE POWER PRODUCED IN TERMS OF POWERFACTOR IN RELATION TO THE GRIDS POWERFACTOR AND THE HARMONIC CONTENT IN RELATION TO THE GRIDS HARMONIC CONTENT.

If this kind of analysis is applied, The value of synchronous generation and synchronous cogeneration will be measurably higher than if analyzed using KWH produced at a postage stamp rate structure as payment for production.

UNDERWRITERS LABORATORIES

If El Quada wants to bring the US economy to its knees, all it would have to do is enforce all the rules and regulations that require the UL label on electrical equipment. (thank God, this would not be nearly as easy at it sounds)

UL is a great organization and has done a super job in insuring that electrical equipment (as well as various heat producing appliances) is safe. You are not likely to get shocked from it nor is it likely to start a fire.

They are professional in their work and to the best of my knowledge can't be bought off by unsrupulous manufactures. But.....

The process of getting approval is slow and expensive.

It is a bit like one of my clients, an off grid Church Camp that needs to add to its hydro base. We can probably put in the additional 150 KW for about $250,000. However the

permit for the project is expected to cost $2,000,000. Obviously we are looking at alternatives but all things considered, it should be another hydro station.

The grid tie inverter people, like Xantrex and Out Back, have their equipment UL approved. This is not a problem. These inverters are massed produced and are expected to have a long production run. The actual cost of the UL approval per unit of production is only a few dollars per unit.

When we are talking grid tie equipment above 11KW, it is a different story. Every system is custom designed, custom built and usually one of a kind. As time goes on, I suspect that we will see standardized equipment become available for larger systems, Particularly those up to 25KW (the net metering limit). We may see some standardization and mass production of synchronous generator controls and switch gear for sizes above 25KW, at least in the more popular size ranges. At this time we really don't know where the inverter grid tie and the non inverter grid tie line of separation will be drawn, though it may well be at the 25KW mark.

It is completely impractical and really impossible (economically) to get UL approval on a one of a kind system. Right now this includes anything above 11KW. In a few years it will likely be anything above 25 KW. Above 25KW it's all one of a kind...individually designed, custom work.

So.....The local inspector, who goes by the book, holds up the project while a battle is carried out. All kinds of schemes have been devised to resolve or avoid these conflicts. I won't give away my professional secrets but I will say that the only place you will find a UL label in a paper mill, a steel mill, or a hydro facility is on the panelboards and light fixtures....and, yes, on the coffee maker in the lunch room.

It a bit like the prohibition laws of the 1920-30 period, when getting around the law becomes a popular game it is time to change the law. People are going to drink, law or no law, just like we are going to refine oil, make paper and cement, roll steel, etc. law or no law and no one in his right mind is going to spend 24 months and $250,000 getting a UL label on a custom metering or protective relay panel costing $25,000.

Please take this into account when you draw these regulations. The difference between a politician and a statesman is that the politician focuses on being politically correct. The statesman defines what is politically correct by looking at a much bigger picture over the long term.