Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First St., NE
Washington, DC 20426
Re: Docket No. RM10-11-000

Comments of Edward G. Cazalet, PhD[1]

These comments are in response to the Commission's Notice of Inquiry on the Integration of Variable Energy Resources(VERS). The comments of Dr. Cazalet are provided as a professional with decades of electric industry experience in electricity policy, regulation, market design, market operation and investment and do not necessarily reflect the positions of any organization.

Dr. Edward Cazalet is currently CEO of The Cazalet Group, a consulting firm, and Vice President of MegaWatt Storage Farms, Inc., a grid-scale storage developer. He is a former Governor of the California Independent System Operator (2004 to 2007). He was a founder in 1996 and the former CEO of Automated Power Exchange, Inc., the first FERC jurisdictional private power exchange. Dr. Cazalet has been a consultant to many electric utilities and government agencies on energy policy, electric market design, and investments in transmission, generation and storage. He is an expert in grid modeling for planning and analysis. He is currently helping develop smart grid standards and serves as co-chair of the Energy Market Information Exchange Technical Committee of the Organization for the Advancement of

[1] The author thanks his colleague Robert Berry for his insightful suggestions, comments, and inputs to this document. Mr. Berry is the former director of regulatory affairs for Automated Power Exchange, Inc. and a former commissioner's energy advisor at the California Public Utilities Commission.

Structured Information Standards (OASIS[2]). He has a PhD in Engineering-Economic Systems from Stanford University. Dr. Cazalet's website is www.cazalet.com and he can be contacted at ed@cazalet.com.

I. A Vision of the Future Smart Grid

In response to the Inquiry, the authors begin with a sketch of a vision of the future smart electric grid. This vision is consistent with current public policies to promote VERS, the smart grid, electric markets, customer choice and responsibility, reliability and efficiency. This future grid would be:

1. A grid where most control is at the edges of the grid, with automated, smart management of stationary loads, mobile electric vehicle load, and central and distributed generation and storage.
2. A grid composed of many microgrids and microgrids within microgrids where each microgrid with local intelligence can manage itself independently and engage in transactions with other microgrids.
3. A grid with widespread interval metering and two-way communication for all significant loads, generation and storage.

[2] The Organization for the Advancement of Structured Information Standards (OASIS) is supporting smart grid standards development coordinated by the National Institute of Standards and Technology (NIST). This OASIS organization should not be confused with the Open Access Same Time Information System (OASIS).

4. A grid employing dynamic forward energy prices and transactions on shorter intervals of time as delivery approaches.
5. A grid coordinated by billions of small asynchronous transactions, rather than a few centralized auctions with large transactions.
6. A grid where innovation in automation and markets and rapid development of new transaction software occurs naturally.

This sketch of the future smart grid is openly discussed among an increasing number of forward thinking electric industry leaders and the innovators now working to build the technology for the smart grid. This is not the forum to address how this future can be achieved as that forum is the many standards workshops and other smart grid initiatives of the Commission and others. The focus of these comments is on the implications of this smart grid vision on the questions raised by the Commission in this Inquiry.

Obviously, it is highly desirable that the Commission's initiatives to integrate VERS be compatible with the inherent flexibility being developed in the smart grid, in large part under the oversight and direction of the Commission.

As paragraph 9 of the NOI states: "the Commission seeks to take a fresh look at existing policies and practices". These comments directly address the Commission's desire for a fresh look.

II. Necessary Reforms of the Scheduling and Market Processes

Despite advances in information technology, the complexity of electricity markets continues to escalate[3]. Unless we find a different approach, VERS and the changes required to accommodate in current scheduling and market processes will only increase complexity.

Neither VERs, storage, or dynamic loads are well served by the current wholesale scheduling and market processes that have evolved from systems for the central dispatch of fossil fuel generators to serve load at flat retail prices. As more VERS are introduced into a local grid, load must begin to follow generation rather than generation following load under the traditional market design.

The existing markets and tariffs are therefore highly discriminatory against VERs, price-responsive loads, fast storage and distributed energy resources that do not fit with the centralized dispatch paradigm of current electricity wholesale and retail tariffs, markets and scheduling processes. Attempts to shoehorn these technologies into large, centralized markets and scheduling processes designed for large fossil generators only increase complexity while reducing reliability and efficiency.

---

[3] The new California ISO and ERCOT markets each took nearly a decade and hundreds of millions of dollars to develop. The markets are so complex that modern computers struggle with the volume of calculations and a few participants understand them completely. These and other ISOs and RTOs are constantly changing. Changes in ISO/RTO protocols and software to accommodate VERS, storage, price responsive load are very difficult and take a long time. This slows adaptation of markets to these new resources. Many areas have chosen not to adopt the ISO/RTO model.

We suggest that the necessary elements for reform of scheduling and electricity markets to accommodate the future smart grid and VERS include

1. Near continuous forward scheduling for all loads and generation on shorter intervals as delivery approaches,
2. Self commitment and dispatch by generators, loads, and storage,
3. Single part bids into markets for all generation, loads and storage,
4. Energy-only markets, and
5. Retail dynamic prices following wholesale prices and price-responsive, retail automated load management.

We recognize that these fundamental reforms will take time and the Commission in this Inquiry is also asking for comments on what rule changes can be implemented in the near term to reduce discrimination among all resources. However the Commission has set forth its own policy objectives for the smart grid including "*Coordinating operation of the bulk power system with new and emerging technologies for renewable resources, demand resources, electricity storage and electric transportation systems*". If the smart grid is to assume this role, then clearly this smart grid goal must be a focus for this Inquiry and this goal should guide VERS integration related policy decisions.

III. Questions Raised in the Inquiry

A. Data and Forecasting

The Inquiry notes the impact of the variability in weather on both wind and solar VERS output and also notes the uncertainty in weather forecasting. Together these two factors cause deviations from VERS schedules in both the day-ahead and hour-ahead framework. Through its questions, the Inquiry implies that there are two broad policy improvements, which an ISO can implement to address this situation. First, improve the forecasting of VERS output. Second, improve the forecasting and add intra-hour energy schedules and auctions to reduce the impact of inevitable forecast errors.

The Commission poses many interesting questions about forecasting VERS output. Some of those questions seem to imply that FERC (or another party like an ISO) could identify a "state of the art" dominant method to forecast weather and power delivery from VERS. Forecasting thermodynamic processes like the weather is quite difficult given the inherent complexity of these processes and it requires considerable expertise and judgment to simplify these processes given the limited available data. Compared to modeling the grid, modeling the weather is more difficult because the physics of the weather is more complex and less data is available. Applied statistics often consists of a search across methods and requires informed judgment in selecting and estimating for a specific application. As the horizon of the weather forecast shortens from the next day to the next hour, the forecast task becomes somewhat simpler because the weather systems have matured and the forecaster can rely more on secondary models and restrict geographic scope of inputs. Indeed, forecasting wind speed or cloud cover within the next hour can be much simpler because often the forecaster can use time series models to track trends although even in this area, there are a broad range of methods.

Recent literature on forecasting for wind farms indicates substantial model development has occurred during the last decade. As the Inquiry implies, FERC should encourage cooperation among the interested parties in collection and distribution of data and in discussion of model development in order to improve and disseminate available forecast knowledge. This cooperation will hopefully reveal how forecasters successfully rely on the use of judgment in model specification, parameter adjustment and forecast revision. FERC should encourage the continued development of forecasting methods and encourage parties to create a forum to exchange modeling information.

In the vision of the future smart grid with many microgrids, access and dissemination of wind and solar forecasting will help each microgrid to forecast its own VERS supply and the supply and price of VERS from other microgrids. Additionally we note that loads are dependent on weather, so the joint forecasting of loads and VERS is essential for reliability and efficiency. We therefore recommend that the Commission support both local and wide area forecasting of VERS and dissemination of data and forecasts to support both centralized and decentralized combined VERS and load forecasting.

At this point, it seems that the greatest increase in the value in forecast accuracy will come from use of more frequent forecasts with a shorter horizon. However, forecasts with a shorter horizon will create more value only with implementation of more frequent scheduling and market processes, which we discuss next.

B. Scheduling Flexibility and Scheduling Incentives

1) Scheduling Flexibility

Consistent with the need and the capabilities of the future smart grid, the goal for scheduling should be near continuous., dynamic scheduling both within and outside of ISOs/RTOs. The current batch scheduling system evolved in an era with few VERS, less inter-balancing area trade, and more limited metering, computer and communications technology.

There is no practical reason not to institute a system of near continuous scheduling. Evolution in grid scheduling and market processes over the next decade will be necessary to accommodate VERS, electric vehicles, storage and price-responsive loads so *no change* is not a practical option. Continuous scheduling is much more in line with what is done in other modern industries employing e-commerce.

Near continuous scheduling could work as follows: By day-ahead, generation and load would develop balanced schedules either through bilateral trade or markets. Based on these schedules, any necessary congestion management is carried out using fast computer models of the grid network. Subsequently, at any time, two or more parties could submit small but frequent balanced changes in schedules including a limit price on what they are willing to pay for the change. Where near continuous markets are available, a single or many parties can submit a change or a bid at any time (Large changes could be submitted but they would be addressed in markets as a series of transactions where the size of each transaction is limited to support market stability and feedback.).

If the network models of the grid determine that the schedule changes can be accommodated with or without economic redispatch they would be approved and made part of the current schedule.

Within ISOs/RTOs, scheduling is similar to dispatch. Bids from generators, loads and exports and imports are cleared in a security constrained day-ahead auction. These auctions can be simplified so they can be run frequently, every few minutes, for example, after day-ahead and immediately in the case of sudden events. All schedules for all auctions are binding and can only be changed by paying or receiving market clearing prices for any changes. At any time a resource such as a VERS can submit a new schedule as a price taker and the grid will be redispatched with standing bids from other resources and loads.

The ISO/RTO auctions will be greatly simplified by adopting the smart grid vision outlined above to use only (1) single part bidding and (2) self-commitment by generators. Most ISOs/RTOs use multiple optimization runs that multiply the time needed for a solution. With the speed up in the auctions they can be run much more frequently. All transactions in each successive auction are financially binding and add or subtract from the previous schedule for each generator or load. Smaller transactions in each more frequent auction will greatly reduce the need for market power mitigation calculations which further speeds up the market auctions.

The simplifications of the ISO/RTO markets described above will not require major new software and systems. The simplifications simply mean that unit commitment and complex data entry by generators will go unused and the calculations will be faster.

2) Scheduling Incentives

The goal should be to eliminate administrative scheduling penalties for all resources and loads. Such penalties discourage the forward contracting that is necessary for reliability, resource self-commitment, forward transmission congestion management and coordination among microgrids and balancing authorities.

With near continuous scheduling and market clearing on 5-minute or shorter intervals near delivery, everyone will have full incentive to adjust schedules quickly for changes in unit availability, ramp limits, sudden load changes and forecasted VERS output. And with price-responsive automated management of some loads, reliability can be maintained by loads choosing the level of service needed at that time as a function of price. It is just as important that loads provide early information on changes as it is that VERS provide such information. Waiting to the last minutes or seconds to provide such information only increases costs. Those who wait should pay the full costs of such last minute changes which can largely be avoided with more frequent scheduling and markets.

Elimination of administrative penalties does not mean elimination of consequences for non-delivery or non-consumption of energy under forward contracts. Suppliers will still be responsible for buying from the market at volatile spot prices or incurring a charge from a balancing operator for non-delivery. Buyers who do not consume forward contracted amounts may have to sell the energy back at low and possible negative prices. Buyers and sellers will need to meet appropriate credit standards to ensure that they pay for such balancing charges.

C. Day-Ahead Market Participation and Reliability Commitments

1) Day-ahead Market Participation

With near continuous scheduling and market processes and elimination of administrative penalties for all generation and load, VERS will have less risk to participate in the day-ahead market and may have increased incentives to schedule forward to obtain higher prices.

However, when the full output of a wind farm is sold to a load serving entity on a long-term contract then the load serving energy should be the scheduling entity and should bear the risks and benefits of day-ahead market participation. For load serving entities only the deviations in the total portfolio of load, generation and VERS will be at risk to balancing markets. Large load serving entities are typically required to fully schedule in forward, day-ahead markets which means that they will have to decide how much VERS to schedule.

2) Reliability Commitments

Out-of-market reliability commitments by ISOs/RTOs serve to artificially suppress day-ahead prices and thereby reduce the incentives for conventional generation and VERS to self commit . In the smart grid vision, loads with interval metering, two-way communication and automated price-responsive smart devices will participate more fully in ISO/RTO markets reducing the need for out-of-market commitments to generators.

With price-responsive load it is unclear what level of forward commitment that the ISO/RTO should strive for. Currently the ISOs/RTOS use and arbitrary standard. With price-responsive load, the consequences of under-commitment can be managed for short periods of time (10s of minutes to seconds) while high prices defer some loads and quickly bring more self-commitment of generation in near continuous scheduling and market auctions. In section E and F we discuss the use of forward energy and energy option contracts that will further support self-commitment by generators in support of reliability. And with smart meters and two-way communications it is possible during an emergency to curtail some or all loads based on a reserve bid or a price in a longer term contract or service agreement. This should further reduce or eliminate the need for out-of-market reliability commitments.

Unit commitment by ISOs/RTOs today requires both a capacity payment and an energy payment to generators. Instead we recommend single part bids and payments and self-commitment by conventional generators. Generators will want to offer bid prices that cover start-up and no load costs in addition to energy costs. The bidding and self-commitment process of generators will be eased by near continuous scheduling and market processes. This will enable generators to firm up more revenues in a sequence of transactions or to sell off forward commitment should they decide not to self-commit or de-commit because of unit failures. The elimination of two-part pricing and payments for all resources including conventional generators will avoid the artificial depression of day-ahead energy prices and further incent VERS to participate in day-ahead forward markets to gain additional revenues and revenue certainty. In the smart grid vision additional payments will be available to generators for call options as described in sections E and F below.

Elimination of reliability commitments as described above simplifies the market auctions and facilitates more frequent auctions. The ISOs/RTOs should monitor self-commitment and inform all market participants of the total commitments in relation to load. As total self commitment declines in relation to load, the risks of higher balancing spot prices will increase.

These spot price increases will be anticipated by loads and intermediaries and cause them to offer to pay more in forward markets to generators to self-commit or encourage generators to commit some excess capacity in pursuit of high real-time prices.

Local reliability unit commitment also needs to be replaced by better use of market tools and smart grid price-responsive demand. First, voltage support should be a priced service that can be provided by local generation and loads. Second, in light of the import limits into local reliability areas congestion prices should be the primary driver of higher locational wholesale and retail prices in local reliability areas. Revenues from financial transmission rights can be allocated in a way that mitigate equity concerns of higher local retail energy spot prices. Third, price-responsive retail loads need to receive such real-time prices for load reductions when needed for local reliability.

D. Balancing Authority Coordination

With near continuous scheduling and market clearing by balancing authorities, balancing authorities will have new opportunities to continuously coordinate scheduling among balancing authorities. Then it will no longer be necessary for FERC to advocate excessively large balancing authorities to solve seams problems between balancing authorities and to reduce reserve requirements. In fact it is easily argued that many, smaller balancing authorities continuously coordinating with each other and making many small schedule changes will be a more robust and reliable solution. Such coordination would be done in the context of shared full network models the can properly manage the effects of transactions within and among microgrids on other microgrids and transmission congestion.

The encouragement of many balancing authorities is consistent with the smart grid vision of many microgrids each with balancing responsibility. And microgrids that contain microgrids within them can extend to ISO/RTO assisting in the coordination of many microgrids. There is no reason that smaller microgrids and balancing authorities engaged in frequent and dynamic scheduling and transactions that respect the underlying network constraints will impose higher reserve costs on the market in support of VERS.

E. <u>Reserve Products and Ancillary Services</u>

Reserve products and ancillary services in the conventional sense will become obsolete with full implementation of the smart grid vision. Customers will self select the amount of reliability using call or put options for energy in an energy-only market. Such options can be provided by both generators and loads.

In continuous, energy-only markets, higher prices quickly signal shortages and lower price quickly signal surpluses to all parties and devices on the grid. This will give all loads, generators and storage an opportunity and incentive to respond. Price caps and price floors in these markets need to be very wide to provide the necessary incentives for reliability and efficiency. Near continuous energy markets and energy options will allow all to self-manage their risks.

Loads desiring protection from higher prices can either purchase forward energy contracts or call options from generators, other loads, or storage either bilaterally or in markets. The options can have a range of exercise prices, and notification lead times such that buyers can decide on the level of protection they want to pay for. With interval metering and real-time dynamic pricing, loads will have full incentive to purchase such forward energy and option contracts and generator and load will want to sell such contracts for firm forward revenues.

As addressed below in Section F, long-term energy and option contracts can provide long-term risk mitigation to loads and long-term firm revenues to generation, storage and load providing such contracts.

With flexibility for the market to choose forward energy and option products, the ISOs/RTOs and the Commission will have less need to formally develop reserve and ancillary products. Current ancillary service products are designed to be provided by fossil fuel units. The Commission has initiated proceedings to facilitate ancillary service participation by loads and storage. The Commission also asks in this Inquiry whether VERS could provide ancillary services.

The challenge of using current ancillary products for storage illustrates the problem. Some batteries and flywheels have 15-minutes of storage and extremely fast responses whereas fossil generation has much slower but more sustained response capability. Every type of storage is different as to power vs. energy, cycling wear and round-trip efficiency. Standard ancillary service products cannot work for both, nor do they work well for many loads and VERS that install or could install the technology to offer ancillary services.

With interval metering, two-way communication and automated smart price-responsive devices, fast and reliable response as a function of price will be provided by loads, storage, and distributed generation resources. Today's generators on automated generation control (AGC) receive signals every 4 seconds or so. Energy transactions based on price offers and transactions are practical and if properly can enhance reliability. To see that this is practical, we only need to observe current financial markets where similar transactions in the billions are completed every day with round trip transactions times of micro seconds. Each such financial transaction has a buyer, seller, a price and a quantity, just like energy.

F. Capacity Markets

The advent of VERS, price-responsive load, and mobile electric vehicles demonstrates the futility of standard capacity products and markets for these products. No one can effectively assign a capacity value to a VERS, energy limited storage, or the capacity made available by price responsive load. And any such capacity value would be arbitrary. As with ancillary services, capacity products and markets should be replaced by long-term forward energy and energy option products and markets purchased primarily by customers. Generators need these long-term products to support investment. Some loads and load serving entities are willing to contract long-term as well. Where they are not, financial intermediaries will be incented to purchase long-term energy and option contracts from generators and sell shorter-term energy contracts to loads.

G. Real-Time Adjustments

Near continuous scheduling and markets are consistent with the smart grid vision. Such markets are driven by many small, priced transactions among willing participants and not centralized dispatch control or curtailment. With wide price caps and floors, VERS and all loads and resources will find effective ways to manage in real time.

In over-generation situations, VERS and so called "must-run generation" should be subject large negative prices. Then they will quickly develop technology and operating procedures to minimize such costs. And retail loads and storage exposed to negative real-time and forward prices will quickly find ways to consume such excess power productively.

Similarly, loads exposed to extremely high real-time prices for imbalances will quickly find ways to shift or reduce load. And generators, storage and VERS exposed to extremely high real-time prices for imbalances will be rewarded for being available to provide such services.

IV. Conclusions

The smart grid vision offers substantial guidance to the Commission on how it should address policy for integration of VERS including wind and solar. The smart grid will help enable near continuous scheduling and markets that are less complex and more responsive. The simplifications include (1) single part bidding and payments, (2) generator self commitment, and (3) energy-only markets. Ancillary services and forward capacity products can be replaced by much simpler energy and energy option contracts that will naturally adapt to market needs and new technologies. This will ensure that markets are nondiscriminatory, reliable and efficient.

As a next step we suggest that the Commission develop a program of application of the smart grid concepts outlined above. Development and implementation should be carried out in cooperation with such entities as NERC, NIST, NAESB, DOE, the ISO/RTO council and others. Near term, patch work policy fixes will be necessary, but it is only by fully embracing the smart grid vision sketched in these comments that the electricity market for all technologies and participants will be nondiscriminatory, reliable and efficient.

Respectfully submitted,

Edward G. Cazalet

The Cazalet Group