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<http://www.cigre.org>

**CIGRE US National Committee
2012 Grid of the Future Symposium**

Using Demand Response as a Virtual Power Plant

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SUMMARY

Tennessee Valley Authority (TVA) developed an Integrated Resource Plan in 2011, which recommends a strategic direction that focuses on a diverse, balanced mix of energy sources. A key element of this plan was to initiate an Energy Efficiency and Demand Response program capable of providing up to 2,600 megawatts (MW) of peak demand reductions through Demand Side Management. The Demand Response (DR) component can be used to alleviate financial constraints associated with serving the load or for maintaining reliability and provide ancillary services in the Balancing Authority Area. Utilities normally call upon their DR programs on an hours-ahead or day-ahead basis due to forecasted system load or market conditions. Since small temperature errors or unexpected thunderstorm activity can dramatically impact the system load and necessity of calling upon the DR resource, TVA has focused on reducing the notification period so that these important decisions can be made close to the time DR is needed to maximize value.

TVA exercises its DR programs for both economic and reliability curtailments via an internally-developed Demand Response Management System (DRMS), which provides the System Operator with the necessary information and tools to effectively manage a diverse portfolio of Demand Response Resources. These products are viewed as "Virtual Power Plants", integrated into the daily resource plan, and are dispatchable by the Balancing Authority.

KEYWORDS

Demand Response, Smart Grid, peak reduction, curtailment, distributor, customer, Balancing Authority, meter, event

Demand Response as a Virtual Power Plant

TVA dispatches resources, from the least to most expensive, based upon the load requirements. This dispatchable stack is managed via an application called the Block Pricing Compendium (BPC) that provides the Balancing Authority (BA) with a quick overview of the generation resources that should be called upon to increase or decrease as the load rises and falls. Units with low operating costs, such as hydroelectric and nuclear resources, are typically at the bottom of the stack with more expensive coal-fired plants and combustion turbines (gas and oil) at the top.

In order for DR to be viewed as a virtual power plant by the BA, it needs to be viewed within the same context as other resources so that it will be utilized as load increases. This brings DR into the operational realm and optimizes its value as a true power plant and not just a day-ahead resource.

To include DR as a dispatchable resource, the costs for each product must be calculated by TVA's Energy Trading organization and coded in the DRMS.

Current TVA Demand Response Portfolio

TVA is developing a portfolio of DR products that will be offered to customers. Six of those products are currently in effect.

1. **Reserve Preservation (Reliability and Economic)**
Curtailment of large commercial and industrial customers upon 30 minute notice
2. **Instantaneous Response (Reliability Only)**
Instantaneous curtailment of customers with discrete blocks of non-conforming load (greater than 50MW), such as an arc furnace.
3. **Dispatchable Voltage Regulation (Reliability and Economic)**
Day-ahead notification to Power Distributors to reduce load via voltage reduction
4. **3rd Party Aggregation (Reliability and Economic)**
30-minute notification to demand service providers that aggregate load from medium and small commercial and industrial customers
5. **Five Minute Response (Reliability Only)**
Curtailment of large commercial and industrial customers upon 5 minute notice
6. **Sixty Minute Response (Reliability Only)**
Curtailment of large commercial and industrial customers upon 60 minute notice

Demand Response Management System (DRMS)

In 2011, TVA evaluated the various DRMS systems available on the market. It became evident that these systems were designed for day-ahead, economic-based DR programs and not for implementing DR as an operational Virtual Power Plant. In order to meet TVA's vision for DR implementation, a decision was made to develop a custom solution using TVA personnel.

The functionality implemented is:

1. Integration between the DRMS system, the Balancing Authority, and Energy Trading
2. Near-real-time view of current load by product
3. Calculation of curtailable load

4. Event history of DR participant performance
5. Integration with telephony notification system
6. Post-operative financial evaluation of DR events

Integration Between the DRMS System, the Balancing Authority, and Power Trading

DRMS automates coordination functions between the BA and Power Trading. All reliability curtailments in TVA are initiated by the BA while economic curtailments are approved by the BA but executed by the Power Trading organization. When Power Trading schedules a day-ahead economic curtailment in the DRMS, the “Request for Approval” window immediately appears on one of the BA displays. The BA has the authority to Approve, Cancel or Acknowledge the request using the DRMS. Once an event is approved by the BA, it automatically goes into “Scheduled” status and the DRMS will initiate notifications and monitor the actual load during the event.

Near-Real-Time View of Current Load by DR Product

The BA needs a near-real-time view of load available for curtailment to operate DR as a true Virtual Power Plant. The DRMS real-time monitor uses four sources of data to obtain real-time or near-real-time information:

1. SCADA
Most large TVA customers have SCADA measurements that are sent to the TVA SCADA system every two seconds and passed into the DRMS.
2. ICCP
All customers that sign up for the Dispatchable Voltage Regulation product are required to transmit their current load (by feeder) to TVA via their ICCP connection. This information is then passed to the DRMS.
3. Meter Data Management (MDM)
DR customers that do not have SCADA or ICCP connectivity have their billing meter interrogated every 15 minutes and passed to the DRMS.
4. Load Forecast
If the SCADA, ICCP or MDM data does not come in on schedule, the DRMS uses the customers load forecast as a proxy for the actual load.

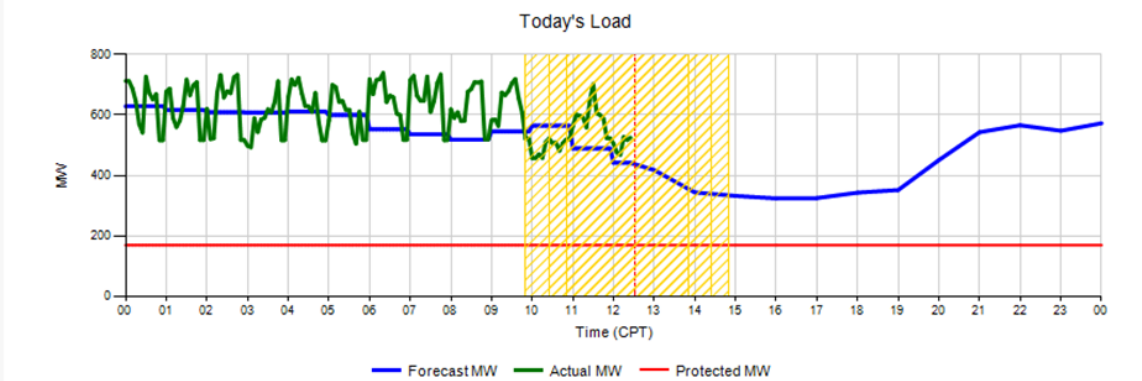
Product Type: Economic Product: Reserve Preservation

Customer Name	Actuals			F.Cast MW	Nom. MW	Prot. MW	Curtable		Remaining Minutes				
	Last Updt. CPT	Source	MW				Source	MW	Day	Week	Month	Year	
West End Electric	08/08/12 12:25	SCADA	58.000	92.934	0.000	50.000	SCADA	8.000					900
Fashion Boat Hulls	08/08/12 12:15	MDM	6.520	6.395	0.000	0.500	MDM	6.020					900
Adler Chemical, Inc.	08/08/12 12:15	MDM	13.409	5.054	0.000	2.500	MDM	10.909					4440
Itasco Mfg.	08/08/12 12:25	SCADA	95.489	90.903	0.000	39.000	SCADA	56.489					1020
Total			524.88	441.312	0	169.5		355.38					

* Forecasted MW substituted for missing Actual MW in calculating Curtable MW

Select data to view :

Forecast MW Actual MW Protected MW Curtable MW



Calculation of Curtable Load

Prior to implementing the DRMS, the BA had only a rough estimate of megawatts (MW) available to interrupt. TVA DR products are designed to meld TVA system needs with customer operational attributes which creates complex business rules for curtailment. These complex rules compounded establishing an interruptible load estimate.

Since the DRMS brings in near-real-time data, the actual number of Curtable MW for each customer at any point in time can be calculated. So for DR events, the Curtable MW would use the Actual customer's load and the appropriate contractual baseline. For future DR events, it would use the customer's load forecast.

In practice, the DRMS calculation for Curtable MW has been very accurate, based on event actuals. This accurate forecast has given TVA Power Operations and Energy Trading confidence in the DRMS forecasts for Curtable Load and makes DR credible as an actual virtual power plant.

Event History

Each DR event is displayed within an event history page. This display allows TVA to monitor all ongoing, scheduled, and historical DR events. By clicking on each event, the actual load before, during, and after the event is displayed.

Event History:

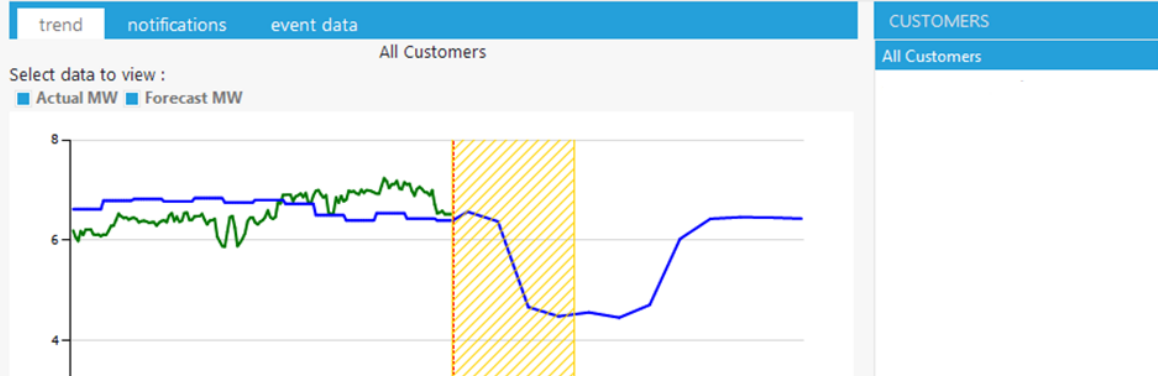
Last Refresh(CST): 08/08/12 12:32:32

Export Filter Refresh

Id	Product	Type	Start Time	Stop Time	Duration	Req. MW	Cre. By	Event Status	Approval Time	Action
53	RP	Economic	08/08/12 12:30	08/08/12 16:30	240 Min.	5.895	esridley	Cancelled	08/08/12 12:21	
52	RP	Economic	08/08/12 11:40	08/08/12 13:40	120 Min.	22.179	esridley	Cancelled	08/08/12 11:31	
51	RP	Economic	08/08/12 10:50	08/08/12 14:50	240 Min.	4.433	esridley	InProgress	08/08/12 10:41	Terminate
49	RP	Economic	08/08/12 10:25	08/08/12 14:25	240 Min.	81.01	esridley	InProgress	08/08/12 10:16	Terminate
48	RP	Economic	08/08/12 09:50	08/08/12 13:50	240 Min.	151.046	esridley	InProgress	08/08/12 09:41	Terminate
40	RP	Reliability	08/06/12 11:57	08/06/12 16:02	245 Min.	43.953	jnhicks	Terminated	08/06/12 11:53	
42	RP	Reliability	08/06/12 12:00	08/06/12 16:02	242 Min.	56.839	jnhicks	Terminated	08/06/12 11:56	
37	RP	Reliability	08/06/12 12:46	08/06/12 16:01	195 Min.	39.375	jnhicks	Terminated	08/06/12 12:42	

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Integration with Telephony Notification System

In order to manage the multiple DR products with reduced curtailment notification periods, an automated curtailment system was needed. The TVA DRMS performs telephone notification to all DR customers at the start and end of each event using an on-site 3rd party voice XML notification server. The notification system accepts voice XML as an input which is generated by the DRMS system. The actual messages are typed into the DRMS and use placeholders to fill in specific DR event information, such as product name and event start and end times. In addition to telephone notification, the DRMS will also send text messages and emails to customers.

Message Notifications

✚ Edit product notification : TVA [ProductName] Suspension Notice

Notification Method:*

Notification Types:*

Select Place Holders:

Subject:

Message:*

TVA is initiating a reliability suspension of [ProductName] power. This event will continue until further notice beginning [EventStartTime]. Please reduce to your protected load in accordance with your contract. If you have any questions, please consult your contract or your TVA Customer Resources representative.

All notifications are logged.

Customer Name	Event Start Time		Event Stop Time				
ACME Steel	08/06/12 09:50		08/06/12 13:50				
ProductEvent Notifications							
	Notification Type	Start Time	Stop Time	Attempted	Successful	Unsuccessful	
	Suspension	08/06/12 09:40:03	08/06/12 09:46:14	8	5	3	
Notification Methods							
	Notification Method			Total Attempts			
	Email			2			
	Phone			4			
Product Event Notification Details							
	Start Time	Stop Time	Attempts	Error	Reference Number	Notification Contact	Notification Target
	08/06/12 09:40:04	08/06/12 09:43:58	3		9	Mike Theman	423298
	08/06/12 09:43:58	08/06/12 09:46:14	1		10	Bob Upfrom	423432
	Text			2			
	Restoration	08/06/12 13:50:07	08/06/12 13:50:07	0	0	0	

While the current system uses the telephone as the primary means for DR event notification, a new standard called Open Automated Demand Response (OpenADR) will eventually be integrated into the DRMS. Using OpenADR, the DRMS will function as an OpenADR server communicating directly with 3rd party OpenADR clients at the customer sites.

Post-Op Financial Evaluation of DR Events

The DRMS is able to calculate the impact to TVA of each event because all economic factors (e.g. current system cost, curtailment amount, contract prices and DR credits) are fed into the

DRMS from other sources. The DRMS displays this value by event, customer and product allowing management to evaluate the benefit of each DR product to TVA. This provides immediate feedback on the effective use of DR for each event.

BIBLIOGRAPHY

[1] All references within this document are internal TVA sources.