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Direct Energy - Optimizing the Flow and Analysis of Plant Operating Data
A Strategic Information Architecture for Effective Asset Management

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Abstract -

The major investment in power producing assets made by Direct Energy in the U.S. power market is measured in hundreds of millions of dollars on both a first cost and life cycle cost basis. To achieve an acceptable return on investment and strengthen financial performance, Direct Energy's operational goals and objectives requires a focus on maximizing power production across their operating fleet while managing and mitigating technical risks. To achieve these critical to quality objectives, Direct Energy has executed a strategic information architecture that transforms "real time" plant operating data, across their full operating fleet, into rapid actionable information and knowledge. Management, at all levels of the business and across various departments, use this strategic business information to ensure "best in class" availability and reliability performance relative to corporate pro forma and market expectations, measure operational readiness, reduce reactionary and costly downtime and maximize parts life and repair capability for capital inventory.

This paper will describe how Direct Energy, in cooperation with Strategic Power Systems, Inc. (SPS), has deployed a strategic information architecture using the ORAP® system to integrate their combined cycle operating fleet for effective asset management. Features and capabilities of the information infrastructure will be fully described, including; plant "real time" data capture, transformation and reporting; parts life tracking and planned maintenance projections; and plant and corporate management reporting over the Internet. The value and corporate benefits will be discussed.

Background –

As an integral part of the Centrica group, a UK based company, Direct Energy supplies gas, electricity, and related services to more than five million business and residential customers throughout North America. Direct Energy's vision is to create value by being the leading integrated supplier of energy and related services in the various North American markets served (see figure 1). With market conditions in North America changing dramatically due to volatile commodity prices and fierce competition, as well as an evolving and constraining regulatory climate, Direct Energy's growth strategy is driven by how cost effectively they can build an asset base with optimized performance and maximum return on investment. Typical of today's merchant energy market, Direct Energy plants cycle daily. The average life cycle cost for a baseload plant is $140 MM. Consequently, the potential impact of cycling duty to Direct Energy is an expected life cycle cost of approximately $280 MM. Effective management of these life cycle costs is essential to Direct Energy with the key performance indicators being parts life, operational readiness, availability, inventory management, and benchmarking against industry

performance. Benchmarking for Direct Energy is valuable in identifying what is required to be best in class.

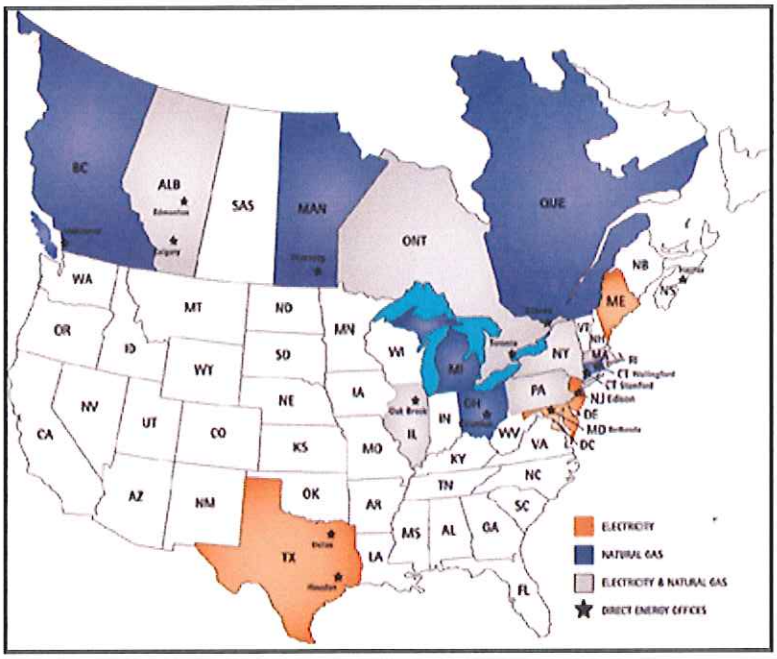

Figure 1 – Direct Energy Operations

A major aspect of Direct Energy's strategy is to produce a significant percentage of both the gas and electricity intended to meet their customer load. As an example, in Alberta, Canada Direct Energy's natural gas production assets provide 17 percent of customer demand (100 million cubic feet of gas every day), while, their three operating combined cycle power stations in Texas, as shown in table 1, provide 31 percent of peak customer demand (over 1,200 megawatts of power). These three combined cycle plants include both GE 7FA and 7EA technologies, steam turbines from Toshiba, ALSTOM, and GE, as well as three pressure level HRSG's.

	Direct Energy Bastrop Energy Center	Direct Energy Frontera Energy Center	Direct Energy Paris Energy Center
Plant Configuration	Combined Cycle Multi-Shaft 2x2x1	Combined Cycle Multi-Shaft 2x2x1	Combined Cycle Multi-Shaft 2x2x1
No. of GT's & Technology	(2) MS7001FA	(2) MS7001FA	(2) MS7001EA
No. of ST's & Technology	(1) Toshiba	(1) ABB Alstom	(1) GE
Plant Rating (gross)	553 MW	500 MW	250 MW
HRSG Pressure Levels	3	3	3
Emissions Control	Dry Low NOx (DLN)	Dry Low NOx (DLN)	Steam Injection

Table 1 – Direct Energy Combined Cycle Plants

To reliably and cost effectively meet the gas and electrical supply needs of their customers, Direct Energy is focused on achieving and delivering measurable "Best in Class" performance across their operating fleet. Additionally, Direct Energy's expansion of its operating portfolio requires the extension of a corporate culture that expects and rewards strong performance. This means value driven execution, based on; monitoring, measuring, and managing performance to well defined corporate benchmarks and expectations. This is Direct Energy's business rational for developing information architecture for effective asset management, and executing it across their operating fleet for timely and uniform feedback for plant managers, executive management (including parent company management), and other business units. An important benefit for Direct Energy is the ability to fulfill the specific requirements of various external stakeholders like insurance companies, project developers, and business assurance auditors. These stakeholders, both internal and external, now have access to single source performance data.

Establishing the Information Infrastructure – ORAP Link™

The foundation for the flow of information from these three plants to the operating management team is the unit level control and DCS (Distributed Control System). The process begins with the collection of once per second control data into three major production related measures; time, capacity (or energy), and events. The data collection and transformation process is based on logic developed by SPS; captured and initiated at the plants through a product called ORAP Link™, as seen in figure 2.

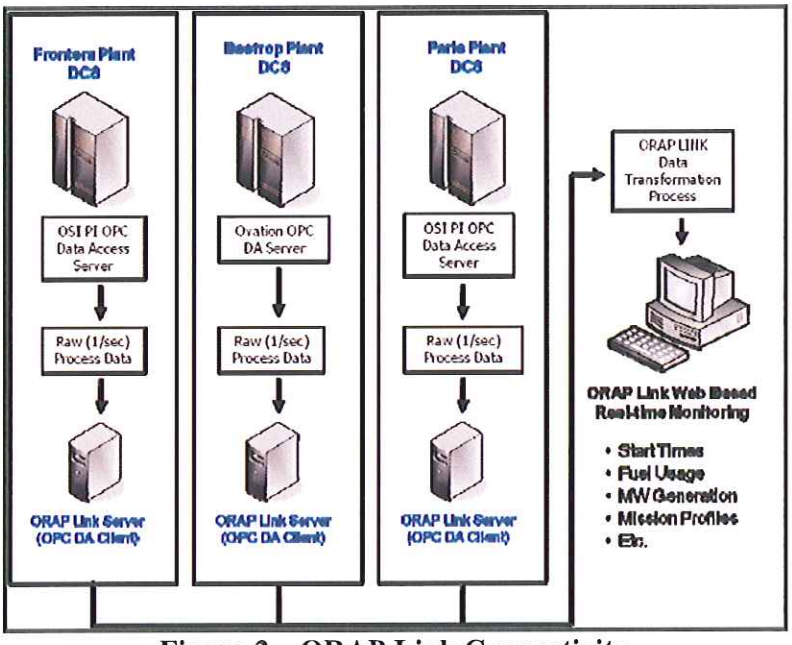

Figure 2 – ORAP Link Connectivity

ORAP Link is collecting and time stamping real time data, taking process points from the OSI PI OPC data access server or through an OPC connection to the DCS. Selected data points are used to develop the specific mission profile for each operating unit, from start-up to shutdown. ***The objective is to develop a complete operating mission for each unit, each plant, and the total fleet, with higher data fidelity, improved accuracy and quality, while eliminating the human effort and potential error in manipulating and managing this key performance data.***

The ORAP Link transformation logic develops the actual start-up times; starting reliability; running reliability (based on recording trips at load and ambient conditions); fuel use and instantaneous heat rate; operating hours and megawatt hours generated. It is the basis for calculating equivalent availability and reliability (adjusting for seasonal plant MW rating) and capacity and output factors as well as calculating lifetime measures based on the OEMs current guidelines. As revisions and modifications are made to OEM guidelines, for example GER 3620, the SPS transformation logic is updated to be fully compliant with any future revisions. Many other operating parameters that impact all scheduled maintenance (combustion inspections, hot gas path inspections, and major overhauls) are also captured by ORAP Link and developed during the data transformation process.

Direct Energy's primary objective is to establish a reliable and repetitive information process that improves data quality, minimizes human effort, and ensures uniformity and continuity across each operating plant. ORAP Link provides this foundation, with the data transformations meeting Direct Energy's scheduled weekly and monthly production reporting requirements. Once the weekly production data is developed, the time; capacity; and event data is automatically placed into the ORAP Data Entry (DE) Web™ tool for additional input as required. The only additional data requirement is to add relevant outage detail available through knowledgeable plant operations and maintenance staff. This additional data is based on outage activities (either maintenance or forced outages), including the reason for the event, the actions taken, the symptom, corrective action, and root cause. These inputs are only available through human knowledge and must be entered into the ORAP DE Web tool to complete each operating period. This required and essential input completes the data requirements necessary for developing and calculating the operational availability, reliability, and maintainability of each Direct Energy plant. Figure 3 shows the addition and the interface with the ORAP DE Web product to Direct Energy's information architecture. Since this process is fully automated, operating staff need only review the transformations for accuracy and acceptance.

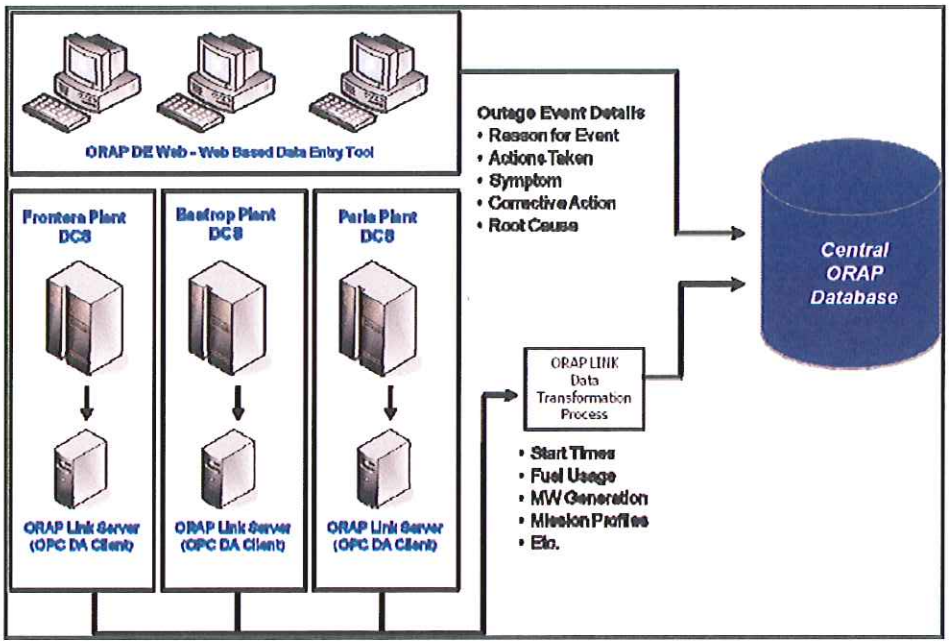

Figure 3 – ORAP Link to ORAP Central Database

As an example, data is developed through ORAP Link to be fully compliant with Direct Energy's weekly production reporting requirements (Saturday through Friday). All process data begins at 00:00 on Saturday and ends at 24:00 midnight on the following Friday. This ensures that a 168 hour week is captured (i.e. 168 period hours). A similar process is followed to develop the actual monthly period hours for each unit and each plant. Each start sequence, either successful or unsuccessful is captured during this transformation process. Any failure to start and each trip at load at some ambient condition and power level are captured to develop static references for both starting failures and trips. If no trips or failures to start occur, and the operating mission is fully successful with a safe shutdown sequence, the operating or service hours, the megawatts generated (gross and net), fuel used, load swings, and other operating metrics are derived from the process data. No additional input from operating and maintenance staff is required for these process transformations. Any and all outages, regardless of duration or impact, require operating and maintenance staff to add all related details into ORAP DE Web to complete the weekly reporting period, as described previously. Consequently each economic mission is completely captured. This process repeats itself for each operating mission and for each of the fifty-two (52) weekly reporting periods, and each twelve (12) month period. Since each economic mission is captured in this transformation process, Direct Energy's management has an accurate understanding of the probability that each mission will be completed successfully and profitably. This provides an effective operational planning and risk management tool, with Direct Energy management able to determine the actual performance of each unit and plant rapidly. All information is made directly available for viewing and sharing by each plant management team and executive management. All reporting is delivered through an internet based interface and a fully secure Website. And it should be noted that all historical data is easily retrievable for reference and comparison.

It should also be noted that all performance metrics and measures that are provided through both the weekly and monthly reports are fully compliant with industry standards; both ISO 3977 and IEEE 762. This ensures that Direct Energy management is able to benchmark their operating performance against internal goals and objectives, as well as through relevant fleet comparisons made available through either NERC GADS, or the SPS Base ORAP system. ORAP provides a more specific and timely benchmark reference for Direct Energy through a broader access to various and more similar operating duty cycles, technologies, and combined cycle plants.

Managing Maintenance and Parts Life Requirements -

There is no doubt that in today's competitive market, the ability to effectively track and manage both the lifetime and the flow of turbine and other capital spares is an essential operating requirement. Today, the replacement cost and repair costs for hot section parts, especially for rotating blades and stationary vanes, are extremely high. Therefore, the maximum return on investment must be achieved by optimizing the operating life and reparability of this hardware. The rotation of this capital hardware through an operating fleet adds another operating constraint, associated with varying fuel conditions and operating temperatures from unit to unit that may negatively impact the price performance of the hardware. Additionally, managing the interval between required maintenance periods, based on the operating profile of each unit, is an important parameter that must be used to effectively control the life time of the parts while minimizing fall-out rates. If a hot gas path inspection is performed prematurely then available parts life will be sacrificed and could result in additional dollars of life cycle cost. Conversely, in the merchant energy market millions of dollars is placed at risk if the required maintenance is not performed in time (per the required OEM maintenance schedule) and a failure results. Consequently, tracking parts life is another major requirement of the Direct Energy asset management process.

To achieve this objective and to make effective use of the information infrastructure developed on behalf of Direct Energy, SPS' ORAP Parts Tracking™ tool was integrated into the information flow, as seen in figure 4. To ensure that this approach is implemented in an effective manner, each unit's current configuration must be known. This means that for each hardware element to be tracked at a part level (e.g. combustor, transition piece, each stage of rotating blade and stationary vane) the serialized part numbers must be entered into the ORAP Parts Tracking tool. Additionally, any serialized part that is either in stores or at a refurbishment shop can also be tracked in a similar manner. This initializing process is the basis that provides Direct Energy the ability to manage their fleet down to a serialized part level. Tracking and managing serialized parts from that point forward can be performed by part or set. Additionally, the condition-based maintenance of parts that have a high capital cost, like boiler feed pumps, can be tracked using the same process.

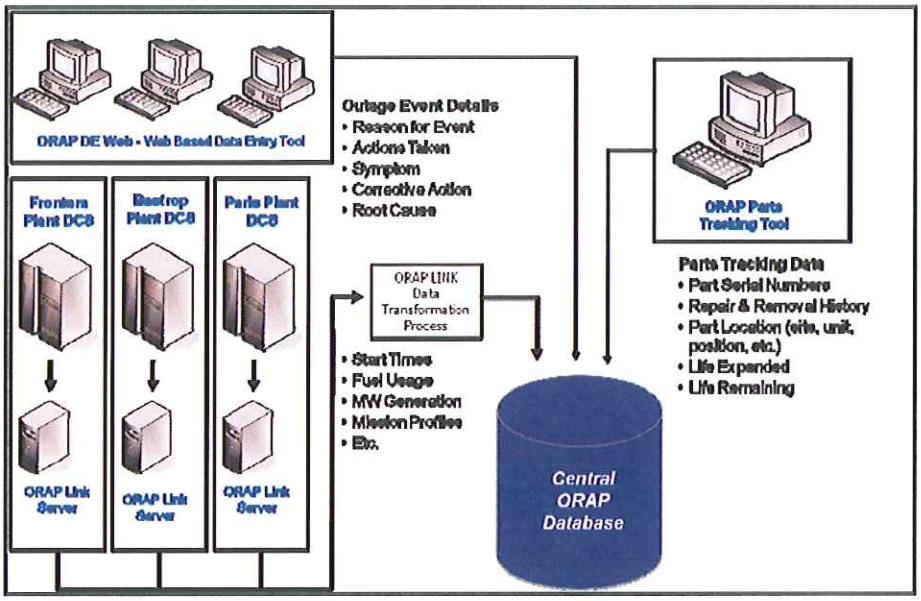

Figure 4 – ORAP Link and Parts Tracking™

The key controlling variables associated with parts condition and life such as ambient and operating temperatures and load swings that are captured by ORAP Link are the basis for calculating factored hours and starts for each unit. As described previously, in Direct Energy's case these lifetime measures are developed by implementing GE's GER 3620J methodology within ORAP Link. ORAP Link's calculation of factored hours and factored starts are applied to each part that is currently defined as being in the current configuration of each operating unit. Once a part is removed from an operating unit and is sent to a shop for repair and/or restoration or is scrapped, the service time (factored hours and starts) stops being applied to that serialized part. That is why it is important to understand which parts by serial number are currently in an operating unit. Only these parts continue to expend life. Therefore, only at the time that a serialized part is installed in an operating unit (any unit of the same model in the fleet) does operating time get recorded against it. In essence, this process provides Direct Energy with the opportunity to manage their capital inventory requirements, maximize the use and repair of these parts, and maintain optimized stores for full depreciation value.

Further, based on the operating profile of each unit, Direct Energy is able to effectively project and plan for combustion, hot gas path, and major overhauls more effectively. Since ORAP Link is monitoring each operating mission for each unit in the Direct Energy fleet on a plant basis, required scheduled maintenance activities can be projected per the OEM recommended schedule. ORAP Link provides a yearly projection for combustion, hot gas path, and major overhauls that can be used as a planning and scheduling tool (seen in figure 5). By combining the parts tracking and maintenance planning capability through ORAP Link and Parts Tracking, Direct Energy has an effective asset management capability that is the basis for asset optimization.

ORAP Link Yearly Projections for Major Maintenance										
Year	Inspection Type	Inspection Date	Operating Hours	GE CI Factored Hours	GE HGPI/MOH Factored Hours	GE Rotor Factored Hours	Actual Starts	GE CI Factored Starts	GE HGPI/MOH Factored Starts	GE Rotor Factored Starts
2008	Hot Gas Path Inspection	07/21/2008 08:43	13,465	13,584	14,638	27,254	918	963	971	993
2009	Combustion Inspection	01/04/2009 15:59	14,942	15,074	16,361	31,431	1,036	1,085	1,094	1,121
2012	Hot Gas Path Inspection	04/19/2012 03:36	25,566	25,792	28,761	61,469	1,884	1,965	1,981	2,042
2013	Combustion Inspection	12/24/2013 20:50	31,002	31,276	35,104	76,836	2,318	2,415	2,435	2,513
2014	Major Overhaul	10/18/2014 05:02	33,634	33,931	38,176	84,278	2,528	2,633	2,655	2,742
2016	Combustion Inspection	06/23/2016 17:00	39,070	39,415	44,520	99,646	2,962	3,083	3,108	3,213
2018	Combustion Inspection	02/28/2018 05:56	44,505	44,898	50,864	115,013	3,396	3,533	3,562	3,684
2018	Hot Gas Path Inspection	07/17/2018 06:01	45,736	46,140	52,300	118,492	3,495	3,634	3,664	3,791
2020	Combustion Inspection	03/22/2020 11:53	51,171	51,623	58,643	133,860	3,929	4,084	4,117	4,263
2021	Rotor Maintenance	05/02/2021 10:07	54,757	55,241	62,829	144,000	4,215	4,381	4,417	4,574
2021	Combustion Inspection	11/27/2021 06:55	56,606	57,106	64,987	149,228	4,363	4,534	4,571	4,734
2022	Hot Gas Path Inspection	04/15/2022 07:01	57,837	58,348	66,423	152,706	4,461	4,636	4,674	4,841
2023	Combustion Inspection	12/20/2023 07:28	63,272	63,831	72,767	168,074	4,895	5,086	5,128	5,312
2024	Major Overhaul	10/13/2024 10:31	65,905	66,487	75,839	175,516	5,105	5,304	5,347	5,540
2026	Combustion Inspection	06/19/2026 16:07	71,340	71,970	82,182	190,884	5,539	5,754	5,858	6,012

Figure 5 – ORAP Link Inspection - Projections

Corporate Management Reporting –

The value and importance of tracking and monitoring key performance metrics is clearly understood as a major part of Direct Energy's corporate culture. The belief is that improvements cannot be made, or acceptable and profitable performance sustained without access to valid, uniform, and meaningful metrics. If strong communication is a key aspect of any successful organization, Direct Energy's management reporting process is the foundation. To effectively manage across a growing fleet of operating assets, Direct Energy's management reports provide a strong basis for effective decision making. Some of the key performance indicators required and available in the various reports are seen in table 2.

Key Performance Indicators - Direct Energy Fleet	
Gross Generation (MWhrs)	GT Trips From Load
Net Generation (MWhrs)	Number of Trips
Duct Burner Hours	GT Factored Starts (CI)
Duct Burner Gas Fuel Consumption (MMBtu)	GT Factored Starts (HGPI/MOH)
GT Fired Hours	Gross Capacity Factor (%)
GT Peak Fired Hours	Net Capacity Factor (%)
GT Gas Fuel Consumption (MMBTU)	Service Factor (%)
Average Heat Rate (BTU/kWhrs)	Starting Reliability (%)
Service Hours	Service Hours per Start
GT Factored Hours (CI)	Equivalent Availability Factor (%)
GT Factored Hours (HGPI/MOH)	Equivalent Forced Outage Factor (%)
Reserve Shutdown Hours	Equivalent Maintenance Outage Factor (%)
Forced Outage Hours	Equivalent Planned Outage Factor (%)
Maintenance Outage Hours	Equivalent Forced Outage Rate (%)
Planned Outage Hours	Availability (%)
Successful Starts	Forced Outage Factor (%)
Test Starts/Restarts	Maintenance Outage Factor (%)
Revenue Starts	Planned Outage Factor (%)

Table 2 – Direct Energy Key Performance Indicators

Direct Energy's operating management has access to all performance data through a user interface to the web called ORAP Interactive™. This interface provides the ability to select various reporting periods (at the minimum weekly) to review the key performance indicators at any time. This process provides a uniform approach for communicating effectively and with no variability as to the meaning of acceptable performance across the operating fleet. ***Direct Energy is now able to view the performance of their entire portfolio in a single consolidated report at the same time that individual plant information is available. This once manual and error prone process is now fully automated.***

ORAP Interactive also provides access to the ORAP Parts Tracking reports and supplemental data views available through ORAP Link, providing direct access to the process data transformations. An example is shown in figure 6. Coupled with Base ORAP's benchmarking reports for fleet performance comparisons and with parts tracking for effective capital spares management, ORAP Interactive unifies the data and reporting requirements across Direct Energy's fleet for effective asset management.

Engineering review of the ORAP Link data is made on an on-going basis by both Direct Energy and SPS project engineers to validate the fidelity of the data. Supplemental data and transformed business information is also available for review and use. Included are the following major reporting features; daily production reports (hour by hour); each operating mission profile (start-up to shutdown); current factored hours and starts (cumulative); and maintenance projections (twenty (20) year projection if desired). These ORAP Link data views are also supplemented by active messaging to operating management hand held devices (PDA's) on a near real-time basis. This notification capability provides access to unit starts, load, trips, and other relevant current performance data.

ORAP Link Data View

Daily Operating Report for : 7/15/2007

	GT1		GT2		ST	Total Plant				
Hour Ending	GT Period	Energy Generated (MWh)	GT Period	Energy Generated (MWh)	ST Period	Energy Generated (MWh)	Test Energy Generated (MWh)	Dispatched Energy Generated (MWh)	Dispatch Order (MWh)	Power Imbalance	Comments
1		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
2		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
3		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
4		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
5		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
6		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
7		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
8		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
9		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
10		0.00		0.00		0.00	0.00	0.00	0.00	0.00	
11		1.06		0.00		0.00	0.00	1.06	0.00	1.06	
12		43.43		0.00		0.00	0.00	43.43	0.00	43.43	
13		67.04		0.00		24.79	0.00	91.83	0.00	91.83	
14		74.80		0.71		31.82	0.00	107.33	0.00	107.33	
15		76.19		39.07		41.66	0.00	156.92	0.00	156.92	
16		77.44		79.42		71.92	0.00	228.78	0.00	228.78	
17		77.70		82.53		82.94	0.00	243.17	0.00	243.17	
18		77.91		82.83		74.48	0.00	235.22	0.00	235.22	
19		77.77		82.81		75.98	0.00	236.56	0.00	236.56	
20		77.27		81.67		73.64	0.00	232.58	0.00	232.58	
21		77.13		81.86		73.67	0.00	232.66	0.00	232.66	
22		76.69		81.52		73.25	0.00	231.46	0.00	231.46	
23		57.86		23.71		26.11	0.00	107.68	0.00	107.68	
24		1.12		0.39		0.00	0.00	1.51	0.00	1.51	
Totals		863.41		636.52		650.16	0.00	2,150.09	0.00	2,150.09	

Figure 6 – Daily Operating Report

The value proposition to Direct Energy for establishing shared and automated information architecture across their operating fleet is improved overall performance, shared operating values and practices, and a better understanding of what is required to achieve "best in class" performance. With a strong infrastructure established, Direct Energy executes oversight and control through timely access to their operating information over the Internet. Further, the key performance indicators of success are well defined and directly coupled with the pro forma expectations for profitable performance.

Summary and Conclusion –

As Direct Energy's operating fleet grows, covering other plant arrangements and technologies, with varying economic mission objectives, the value of executing and extending a strong and reliable information architecture that is scalable is required for success. ORAP is this scalable common platform for information sharing, from plant to plant, focusing on the key metrics of corporate importance.

Figure 7 provides a review of Direct Energy's information flow and architecture. The critical to quality features include maximum automation, minimum manual input, repeatable and timely data transformations and processing, with common and understandable performance metrics, and value tied to pro forma expectations. The ability to rapidly transpose this process to newly acquired operating assets is simply procedural. Yet, it is the cornerstone for enforcing the business strategy while indoctrinating these new assets into Direct Energy's corporate culture.

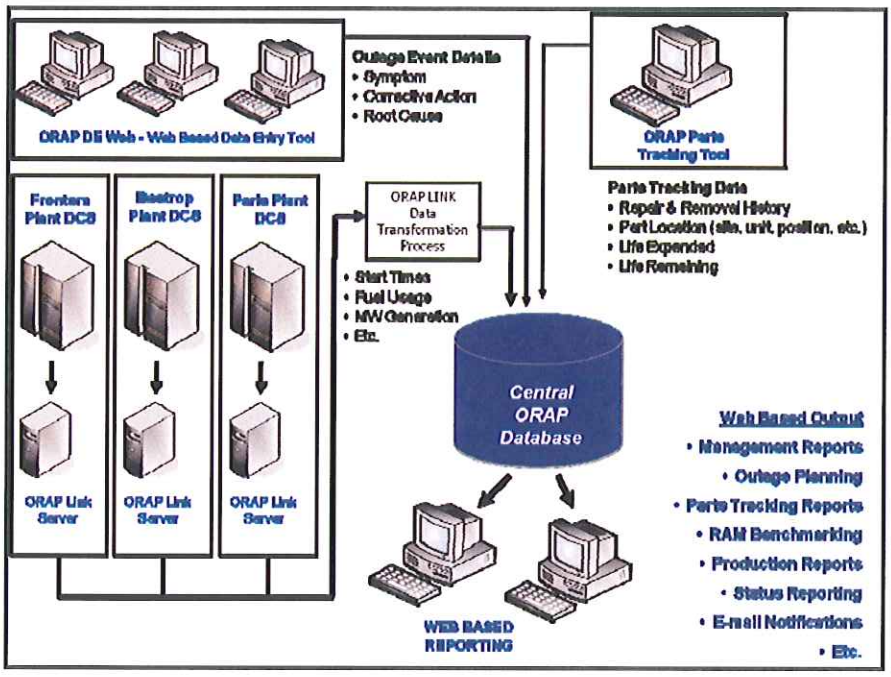

Figure 7- Direct Energy – ORAP Information Architecture

The result of Direct Energy and SPS' efforts is an infrastructure for effective asset management based on repeatable and meaningful processes, while building a platform for effective and transparent communication.