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How to increase energy efficiency of the datacenter by 15-40%

(and save between $615-$1640M/USD annually year in energy costs)

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The common function for all data centers is to provide an environment whereby computers can execute computing functions. Whatever “measurable output” is used. Whether it be a metric of web pages/minute, calculations completed over a period of time or Email processing capacity…etc all of these processes relate to the desired end result where the “raw input” material is electricity / energy measured in KWH. The purpose of this paper is to review how this process is implemented today, and propose another method whereby the exact same measurable end results are achieved, while power efficiency to the datacenter is increased from current 50-75%* to over 90% without changes to the current datacenter infrastructure.

What is a power supply?

A power supply is an electronic device which is capable of receiving DC or AC voltage and converting this voltage to a DC or AC output(s). In a datacenter the largest power supply is the UPS system , and/or high power rectifiers for telecom systems. Inside the racks the power supplies are the “metal boxes” which convert the processed AC input to a DC voltage, and all the DC/DC “bricks” type, or POL (Point of load) supplies that are situated on the server PCB as close as possible to the functional load.

The power supply adds nothing to the functionality of the computers in the data center, not a singe bit more or less will be transmitted or processed any faster as a result of power supply attributes. The entire function of these electronic devices is to ensure that a reliable power source is provided at all times to the active (working) elements of the computers/ servers at the exact voltages and currents needed for their correct operation. Achieving the end result of operation of the functional loads is what consumes between 25-50% of all of the power supplied to the datacenter.

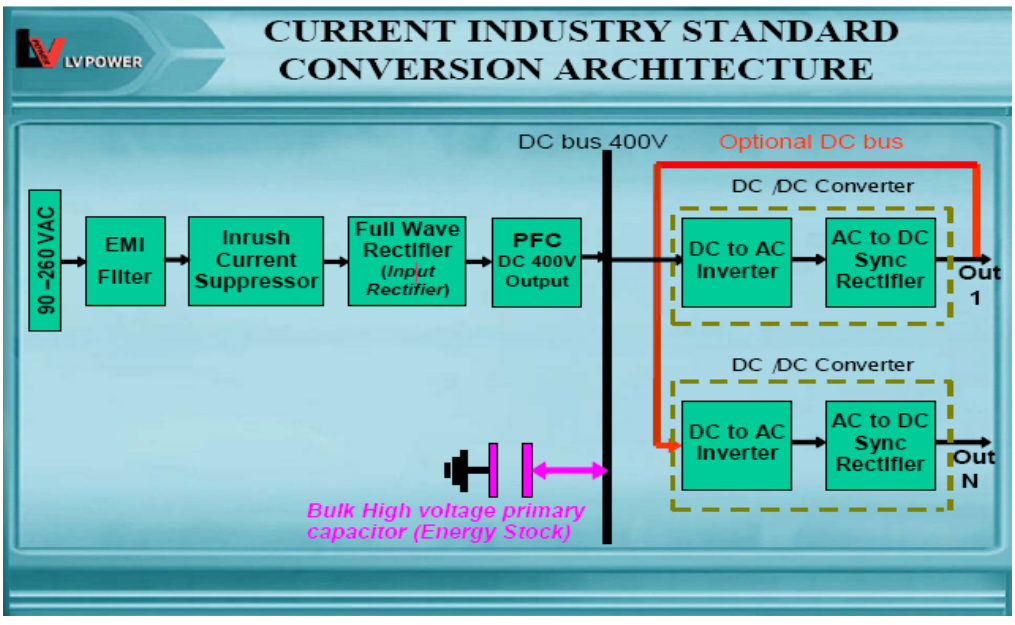
We know that this process can be carried out much more efficiently then common practices in use today. The goal of this paper is to explain one method of how this is accomplished.

Power conversion today: A long hot bucket brigade

Perhaps as a result of the fact that many different companies focus on several different aspects of the Power Chain, and that the multiplicity of the various voltage rails has greatly increased over time, a serial power architecture has evolved. No matter what the efficiency is of each individual power supply “link” in the chain, the hard fact remains that the overall efficiency of power conversion in the datacenter remains in the 50-60% range. The reason for this is that power conversion efficiency is a multiple of the efficiencies of each link in the chain. When electrical power is being converted from Line AC to rectified DC for the UPS system, and then converted into processed Line voltage again, then converted into DC used in distributed power architecture …. Where it is then converted several more times into lower level DC outputs, *something* gets lost on each step of the way. Like a bucket brigade where every man in the line spills some water; at the end of the line the bucket is half full at best. The Distributed Power Architecture (DPA) commonly in use today with its many Rectifiers, Bricks and POL’s causes havoc with the overall system efficiency. Each power conversion of every AC/DC, DC/DC in the chain reduces the efficiency further.

To further clarify the power conversion chain sequence it is worth pointing out that a “DC/DC converter” is in reality a complete subsystem power supply which has DC as the input voltage. This DC is then converted into AC voltage, then “passed through” a transformer and rectified and filtered to the new required DC voltage level at the output. Current “real world” power supply efficiency ranges from 65-92%. A typical chain includes at least three power supplies and a UPS system. Without taking the UPS inefficiency into account with only three conversions the overall efficiency of the server power chain will be between 65-75%. Include the UPS and the power chain efficiency drops by another 5-6 percent.

The corollary of 65-75% efficiency means that 35-25% of the energy is converted into waste heat, which needs to be removed by air conditioning systems …..which in themselves consume 1.4W of power for each 1W of power supplied to the servers. This is starting to become fairly expensive isn't it?



Distributed Power Architecture (DPA): The wrong way to convert power

The commonly used (DPA) method used today to generate multiple DC outputs is simply "wrong" as it does not take into account the fact that the more "flavors" of voltages which are generated the lower the overall conversion efficiency will be. This is inherent in the serial chain methodology used in DPA architecture, and has nothing to do with the conversion efficiency of each specific power supply in the chain. Initially (DPA) was the only method of generating multiple output voltages, and this method met the needs for previous generations of computer equipment. Now with both increased power demands due to expansion of datacenters coupled with the need to increase operating efficiency a new overall view is needed on how to better convert electrical energy from one form to another.

Another method to convert power: The AC link + Parallel conversion

LV Power has developed a Bidirectional Energy Conversion System called B.E.C.S. for power conversion which maintains power factor requirements (if AC line power is used as the input source) and raises the overall system datacenter efficiency to above 90% at any combination of line load variations. The system is designed for above 90% efficiency at either full, half or light load. The method is based on a "top down" view of all of the power loads in the data center and is geared towards getting the right type of electrical power to the needed load (processor, disk drive, memory etc) with the highest total conversion efficiency possible today. This conversion method also greatly increases system reliability while maintaining the current cost structure of existing conversion methods. There are a few key features of the new conversion method, the first of which is that it is based on a high frequency AC Link. All of the system loads are drawn in parallel from this AC link, which can be likened to a large transformer. Any end voltage, be it 48V, 12V, 5V, 3.3V, or 0.8V can be drawn from this AC link in parallel without additional conversion steps. This fact is a huge contributor to the overall system efficiency. A second key feature is that energy is stored in a bulk capacitor (energy stock) which is connected to the output of the AC Link through a bidirectional inverter/converter. When excess energy is available …..for example near the top or bottom of the AC power line period, this energy is stored in the bulk capacitor. When this energy is needed for the loads…. near the zero crossing of the AC power line period, the energy is supplied back through the bidirectional inverter/converter directly to the loads. Finally; This conversion method employs no bulk capacitor on a high voltage DC bus (as done in almost all current conversion methods in use today) resulting in virtually zero inrush current upon initial turn on, increasing both reliability and efficiency as no additional inrush protection circuitry is needed…. Power supplies are like incandescent light bulbs in that they most always fail when they are initially turned on.

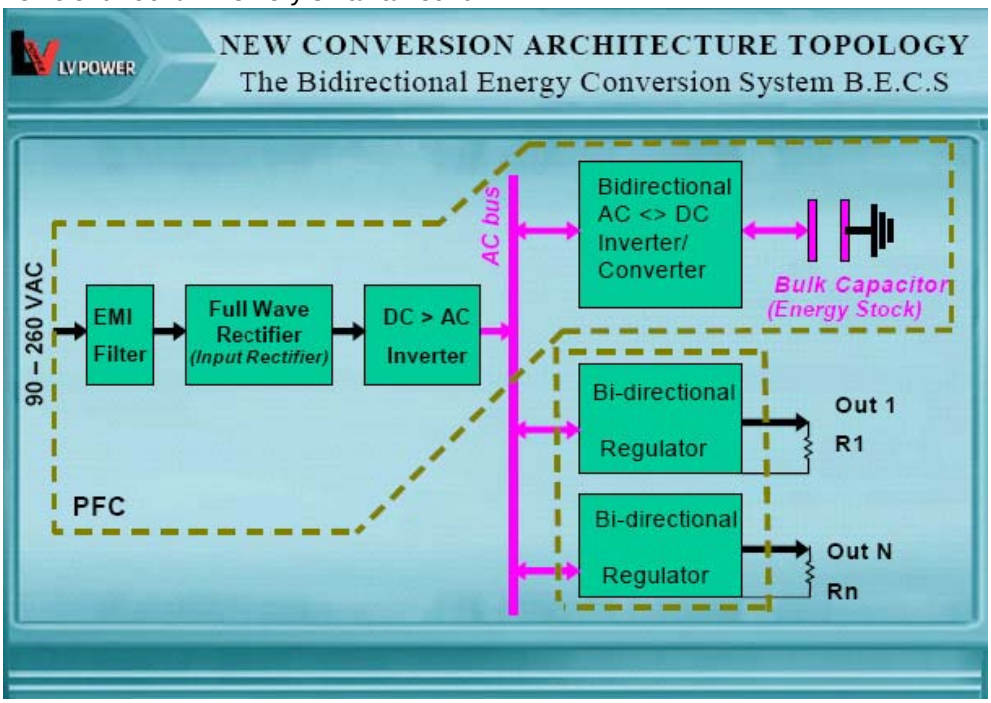
Additional features of B.E.C.S. Topology

The B.E.C.S. topology is operating on one single conversion frequency. This fact greatly simplifies RFI /EMI system requirements caused by many different AC/DC and DC/DC converters all operating on different switching frequencies. B.E.C.S. topology is highly efficient >90%. The very small amount of waste heat generated by use of the topology allows
the power supply to be physically very small.

A derivative of the B.E.C.S. topology called *Any*voltage allows for the application of a very wide input range (1- 11) to the supply as opposed to the (1-3) range in use today. Thus the input of the power supply can be 48VDC or 220VAC while maintaining supply efficiency. Thus the issue of whether the datacenter supply voltage will be 48VDC, 220VAC or 400VDC as proposed in the technical conference is resolved.
The cost of a B.E.C.S. power supply is no greater then the cost of high quality supplies used in the industry today.

In Summary

The EPA conference from February 2007 was focused on ways and methods of reducing energy consumption in the datacenter.
LV Power is of the opinion that the most straightforward method of achieving this goal is to focus on increasing power conversion efficiency in the datacenter from it's current 50-75% to 90%. The reduction in waste heat as a result of the improved efficiency has a double effect on power cost savings as Air conditioning power costs are also reduced proportionately due to the reduction in Air conditioning requirements.
LV Power has introduced in this paper our proprietary method of greatly increasing efficiency in the datacenter.



It may be only one of several methods to do so. The key point of the paper for EPA purposes is to point out the deficiencies of the current serial method of power conversion used in Distributed Power Architectures, and the need to have a single solution
to provide the required Voltages and Currents to the functional computing elements. The cumulative “waste contribution” of all the current manufactures of small bits of the power conversion processes in the Datacenter system is simply too great to ignore.

LV Power
Aaron Applebaum: General Manager
LV Power specializes in developing and manufacturing advanced power conversion topologies.
The company has dedicated the last three years to theoretical and practical applications of novel power conversion topologies which are applicable to the 100-4000W power range and have patented topologies for the B.E.C.S. and *Any*voltage conversion methods.
LV Power is an approved supplier to Fortune 500 companies in the USA and it's products have been field deployed in telecomm instillations throughout the USA. The company is based in Israel and markets its products through a combination of both direct B2B customer alliances and representative activity.

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