WHITE PAPER

GREEN IT: MAKING THE RIGHT POLICY CHOICES

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1. EXECUTIVE SUMMARY

The cost and efficiency to operate Data Centers are dominantly influenced by three policies:

1. Degree of virtualization
2. Refresh rate of IT equipment
3. Efficiency requirements in the Procurement RFQ

However, only one of the above resides in the direct responsibility of the CIO, #1 Virtualization. Policy #2 Refresh rate is a direct result of the financial CapEx write off policy, typically in the direct responsibility of the CFO. #3 resides in the procurement department, typically under the direct responsibility of the COO.

When it comes to Green IT and Green House Gas (GHG) emissions caused by IT the most common focus is however, only on:

4. Efficiency of the physical Infrastructure

The direct responsibility of #4 is typically within the general building and facilities department, which can be either under the COO or CFO. In contrast to #1.2 and 3, which are strict policy changes, the cost effectiveness and invasiveness of #4 is dependent on when it is implemented. If done at planning and construction, it will typically be very cost effective. When done later as a renovation or improvement item it typically needs to be associated with changes in #1-3.

It is critical to enable an efficient, fact based dialogue between all functions to achieve the best cost IT and with that the lowest GHG emissions/Energy consumption possible.

This paper addresses a fundamental Industry need, a simple measure of Total Data Center Efficiency (TDCE) and a simple financial model of the Data Center Equipment. The differences in cost to deliver the same IT work load can be significant dependent on the chosen policies. To illustrate how dramatically different the total net cash demands can be, two practical choices in the virtualization and refresh policy are compared: changing CPU utilization rate from 10% to 40% through virtualization, and changing from 5 yr. refresh to 3 yr.

Due to the better utilization of the servers ability to perform useful IT work and by following Moore's law more closely an increase of approx. 424% compute ability can be achieved. Therefore 1000 Servers on a 3 yr. refresh cycle with 40% CPU utilization will be equivalent to 5242 servers on a 5 yr. cycle with 10% CPU utilization.

	5yr./low	3yr./med	Delta $
Base case	$ 780,000	$ 1,100,000	
plus 424%/yr. more servers to get to 5242 total Servers	$ 3,307,200		
plus annualized cost for new DC for 4252 more servers	$ 5,323,504		
Total annual cash layout	**$ 9,410,704**	**$ 1,100,000**	**$ 8,310,704**

The most expensive policies are the most common in the industry, 5 year CapEx write off and little to no virtualization. In the above table it is assumed that a new Data Center needs to be build, or a Co-Lo arrangement is needed to host the additional Servers in the 5 yr. low virtualization case. The annualized cost of capital plus the additional Servers under the 5 yr./low virtualization policy needed amounts to a total annual net cash outlay of $9.4m. Switching to a 3 yr. refresh/medium virtualization policy will avoid the need for a new DC and is overall significantly less expensive with $1.1m net cash outlay for equivalent performance. In total savings of $8.3m/yr. are realized. (It should be noted that the Net Cash numbers are exclusive of energy, any other OPEX)

2. INTRODUCTION

Most companies have a desire or a more formal goal to be green. Since Green is good business, there are a lot of conflicting messages around it and many definitions out there. However, most companies would probably be able to relate to this statement:

Green Enterprise => Efficient and Sustainable Enterprise

In simple words: Using the least amount of resources possible to produce high quality products, and maximize the use of renewable resources in that process. It's all about Efficiency and Sustainability, highly efficient production methods produce better balance sheets. Lately the biggest focus of Green has been on Green House Gas Emissions (GHG), which is synonymous with Energy use. There, the goal of reduced Carbon emissions or even CO2 neutrality are the most pursuit objectives. This makes good business sense too; Energy not used is cost savings.

How to accommodate IT growth is one of the most pressing issues in today's IT organizations. Complexity and every increasing amounts of Servers and Data Centers or Data Center floor space is draining valuable resources not only in the IT department, but also for the entire company. The limited availability of Capital is compounding the issue. In addition growing IT is increasing organizations GHG footprint and can be in the way of reaching CO2 neutrality.

Building a new Data Center is expensive. Prof. Koomey has published with the Uptime Institute a comprehensive analysis of modern Data Center cost components ("A Simple Model for Determining True Total Cost of Ownership for Data Centers[1], Version 2, October 24, 2007" by Jonathan Koomey, Ph.D.). The annualized cost of just the infrastructure (no OPEX, no Energy cost, no IT gear included) of a high density modern Data Center can be $1,252 per used U per year (see Appendix). For organizations struggling to accommodate ever increasing IT demands, there are alternatives to building a new Data Centers. For illustration purposes a 1000 Server Data Center is used to compare the impact of two policies, Virtualization and Refresh. The most common policies in the industry are 5 year or longer refresh with no or little virtualization.

Today the most common measure to classify the effectiveness of a Data Center is DCiE as defined by The Green Grid: "The Green Grid Metrics: Data Center Infrastructure Efficiency (DCIE) Detailed Analysis, Author: Gary Verdun, DELL[2]. It measures the "Power train" efficiencies of the physical Infrastructure. However, DCiE has no element of overall productivity; it does not measure if the IT equipment is idle, or heavily used. Underutilized Servers and IT equipment is overly inefficient and a much greater source of energy improvements than physical infrastructure by itself (The Energy Smart Data Center, John Pflueger, DELL[3]) Typically in an industrial setting, production and resources used would be put in relation and measured as utilization. DCiE in that setting would only measure the efficiency of the power distribution in the factory without counting the amount of products being produced.

[1] http://uptimeinstitute.org/index.php?option=com_docman&task=doc_download&gid=24
[2] http://www.thegreengrid.org/~/media/WhitePapers/White_Paper_14_-_DCiE_Detailed_Analysis_072208.ashx?lang=en
[3] http://i.dell.com/sites/content/business/solutions/power/en/Documents/ps1q08-20080179-CoverStory.pdf

To address this issue Dell has proposed a framework of IT Productivity in the Compute More, Consume Less[4] methodology. It is anchored around IT utilization and useful IT work. The Productivity definition is based on converting electricity into IT work, but it is a very challenging task to universally define Useful IT work. To get to actionable results a lot of data and measuring systems have to be utilized and the definition of Useful IT work is still in process.

The Green Grid has proposed a similar measure called Data Center Energy Productivity (DCeP), "A Framework for Data Center Energy Productivity" [5].

There is the overwhelming need for a more simplistic way to classify the overall effectiveness of a Data Center. And the results should be actionable and show the associated financial benefits. Typically, the highest business impact is achieved by smartly changing policies, and it is at the same time typically the most cost effective path. High impact policies in the Data Center are around things like this:

- Efficiency of the physical infrastructure
- Refresh rate of IT equipment (CapEx write off schedule)
- Utilization of IT equipment, e.g. degree of use of virtualization
- RFQ policies, e.g. perf/watt; Specify efficiencies (e.g. 95% Power Supplies)

However, up to today there hasn't been a framework effectively describing this. The proposed Total Data Center Efficiency (TDCE) is addressing all of these issues. It focuses on the efficiencies of all IT elements in the IT production chain, however, avoids the need for an IT work load definition. For illustration, this is similar to the definition of an electric motor, its ability to convert Electric Power, measured in Volts and Amps in to Mechanical Power, measured Torque and RPM's. If a motor is more or less efficient, it doesn't effect the work done on the mechanical side, as long as the same Torque and RPM 's get produced. But it will take more electricity with an inefficient or inefficiently used motor. When comparing efficiencies, it is a relative measure and does not need a definition of the absolute IT work done.

Efficiency is unitless and in a power chain the total efficiency is the product of all efficiency elements in serious.

To enable financially sound decision making the financial benefits are tide to the areas of efficiency improvements, total net cash needed to run the IT operation is easily derived.

[4] http://www.dell.com/downloads/global/power/ps1q09-20090176-Esser.pdf
[5] http://www.thegreengrid.org/~/media/WhitePapers/WhitePaper13FrameworkforDataCenterEnergyProductivity5908.ashx?lang=en

3. TOTAL DATA CENTER EFFICIENCY (TDCE)

Total Data Center Efficiency (TDCE) describes the efficiency of converting electricity into IT work. It is an approximation, but allows to identify quickly specific areas of improvements and can be used to assess the relative level of CO2 efficiency, or Greenness of a Data Center.

There are four basic elements determining the ability of a typical Data Center to convert electricity into IT work:

1. Physical Infrastructure Efficiency (DCiE)
2. Efficiency related to age mix of IT gear (ITAME) approximating the effect of Moore's law in the Data Center
3. IT gear Utilization Efficiency (ITUE)
4. IT gear Efficiency (ITE)

Since all these elements are efficiencies, the product of all four is the overall Total Data Center Efficiency:

TDCE = DCiE * ITAME * ITUE * ITE

DCiE is defined through The Green Grid. TDCE, ITAME, ITUE and ITE are new definitions, and described in this article

TDCE describes the efficiency of converting Electricity into IT work. It is an approximation, however, can be used to assess the relative level of CO2 emissions or Greenness of a Data Center.

The below table illustrates the concept. It assumes the very same IT work gets done in all cases.

	TDCE	DCiE	ITAME	ITUE	ITE	**GHG emissions**
Policies		**Physical Infrastructure**	**CapEx write off schedule**	**Virtualization**	**OEM/Vendor qualification**	**Energy Cost to operate**
typical	**4.2%**	50.0%	56.0%	15%	100%	**100.0%**
improved	**10.9%**	60.0%	63.8%	29%	100%	**38.5%**
better	**26.6%**	70.0%	73.4%	52%	100%	**15.8%**
very good	**45.3%**	75.0%	85.4%	71%	100%	**9.3%**
excellent	**63.2%**	80.0%	100.0%	79%	100%	**6.6%**

It is apparent that typical Data Centers have a lot of room for improvement, and could be more than 10x less carbon intensive. The difference in the Energy cost is directly proportional to the GHG improvements.

3. A. PHYSICAL INFRASTRUCTURE EFFICIENCY (DCIE)

The Green Grid Definition of Data Center Infrastructure Efficiency is as follows (: "The Green Grid Metrics: Data Center Infrastructure Efficiency (DCIE) Detailed Analysis", Author: Gary Verdun, DELL[2])

$$DCiE = \frac{IT\_Equipment\_Power}{Total\_Facility\_Power}$$

"DCiE is defined as the ratio of IT Equipment Power and Total Facilities Power as shown in [the] Equation (…) above. The Total Facility Power is defined as the power measured at the utility meter — the power dedicated solely to the datacenter (this distinction is important in mixed-use buildings that house data centers as one of a number of functions). The IT Equipment Power is defined as the power consumed by equipment that is used to manage, process, store or route data within the compute space."

DCiE is the inverse of Power Utilization Effectiveness (PUE), as described in the same paper. It should be noted, DCiE is the most common metric in the industry to measure the efficiency of a data center.

[2] http://www.thegreengrid.org/~/media/WhitePapers/White_Paper_14_-_DCiE_Detailed_Analysis_072208.ashx?lang=en

3. B. IT EFFICIENCY RELATED TO AGE MIX OF IT GEAR (ITAME)

Moore's Law[6] conservatively describes that the compute ability will double every 2 years. Conversely 2 year old equipment is only 50% capable compared to new equipment. Mathematically this can be described as exponential decay with a half live of two years:

$$N(t) = N_0 e^{-t/\tau}, \qquad \tau = \frac{t_{1/2}}{\ln(2)}, \qquad t_{1/2} = 2yr.$$

Since we are only interested in relative improvements over the past, we can assume the current state of Moore's law is the best implementation and use this as a base for relative improvements to past performance. Therefore: $N_0 = 1$

It should be noted that most equipment in a Data Center follows Moore's law, including network equipment and speeds. In a typical Data Center Servers are the most predominant IT gear and therefore the following analyses focuses on such.

For example: IT gear is purchased annually and servers are retired as they reach 5 years. It is assumed that every year the same amount of new servers is purchased (20% of total sever population) and the new servers replace the same amount of 5 year old servers.

The IT Age Mix Efficiency (ITAME) is calculated per age group:

$$ITAME = N(t) * (\% population)$$

For 5 years, it would result in:

Moore's Law	age group	% population	efficency
1.00	new	20%	20.0%
0.71	1 year	20%	14.1%
0.50	2 years	20%	9.9%
0.35	3 years	20%	7.0%
0.25	4 years	20%	5.0%
		ITAME 5	**56.0%**

With the previous discussed assumptions, the ability to convert electricity into IT work of the above population is only 56% compared to what it would be if all Servers were new. ITAME5 represents the relative efficiency of this 5 year write off policy.

[6] http://www.intel.com/museum/archives/history_docs/mooreslaw.htm

In case IT gear would be purchased annually and the server population of a Data Center is retired as it reaches 3 years, it would result in:

Moore's Law	age group	% population	efficency
1.00	new	33%	33.3%
0.71	1 year	33%	23.6%
0.50	2 years	33%	16.5%
0.35	3 years	0%	0.0%
0.25	4 years	0%	0.0%
		ITAME 3	**73.4%**

Here is a table for the first 5 ITAME's:

ITAME 1	100.0%
ITAME 2	85.4%
ITAME 3	73.4%
ITAME 4	63.8%
ITAME 5	56.0%

Financial Analyses:

Assuming the same IT work, the number of servers needed will change with a change in write off schedule. For illustration a three year and five year scenario will be compared.

$$\#Servers_{3yeears} = \frac{ITAME5}{ITAME3} * \#Servers_{5years}$$

$$\#Servers_{3yeears} = 76.3\% * \#Servers_{5years}$$

Or conversely if the number of Servers are held constant, more useful IT work can be achieved. The examples are generalized and showing maximum differentiation. Your organization might have different limitations and more granular calculations are needed.

As a base case, a Data Center with the capacity of 1,000 Servers is assumed. It is operated on a 5 year refresh cycle, so every year 200 Servers are retired and replaced. The net cash outlay per year amounts to $780k (s. Appendix). The organization faces an every increasing IT demand and has to upgrade its IT capabilities. Different scenarios are possible

- Changing refresh rate from 5 yrs. to 3, still little to no virtualization:

Due to following Moore's law more closely an increase of approx. 31% compute ability can be achieved. Therefore 1000 Servers on a 3 yr. refresh cycle will be equivalent to 1310 servers on a 5 yr. cycle.

	5yr./low	3 yr./low	Delta $
Base case	$ 780,000	$ 1,100,000	
plus 31%/yr. more servers to get to 1310 total Servers	$ 242,280		
plus annualized cost for new DC for 310 more servers	$ 388,891		
Total annual cash layout	**$ 1,411,172**	**$ 1,100,000**	**$ 311,172**

It is assumed that a new Data Center needs to be build, or a Co-Lo arrangement is needed to host the additional Servers in the 5 yr. refresh case. The annualized cost of capital plus the additional Servers under the 5 yrs policy needed amounts to a total annual net cash outlay of $1.4m. Switching to a 3 yr. refresh will avoid the need for a new DC and is overall significant less expensive with $1.1m net cash outlay for equivalent performance. In total savings of $311k/yr. are realized.

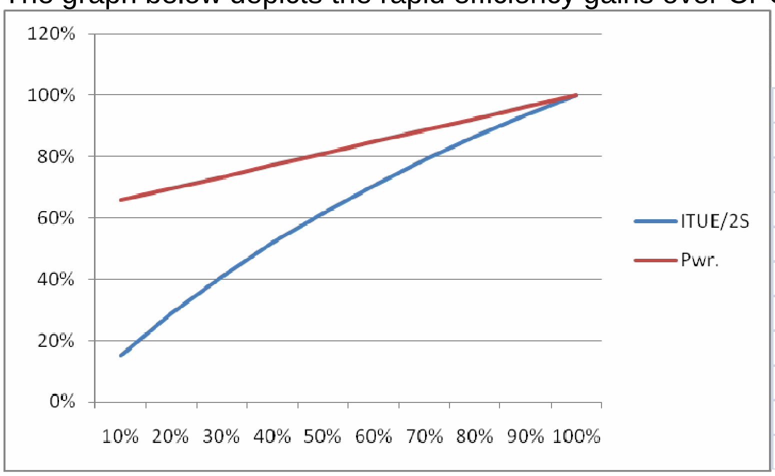
3. C. IT GEAR UTILIZATION EFFICIENCY (ITUE)

The utilization of IT gear is one of the biggest sources of efficiency in the Data Center. The power draw of IT gear is typically not directly proportional with CPU load. As descript in the Dell Hidden Data Center PowerSolutions article[7] a typical 2 Socket 2U server will draw approximately 66% of its nominal power at about 10% CPU load with an approximate linear increase to the 100% point. The ability of a server to convert electricity into IT work is best at full CPU utilization and worst at very low CPU utilizations.

ITUE describes the efficiency to convert electricity into IT work, and is defined as:

$$ITUE = \frac{CPU_{Load}}{(Power / Power_{\max})}$$

The graph below depicts the rapid efficiency gains over CPU loading.



ITUE/2S	Pwr.	CPU load
15%	66%	10%
29%	70%	20%
41%	73%	30%
52%	77%	40%
62%	81%	50%
71%	85%	60%
79%	89%	70%
87%	92%	80%
94%	96%	90%
100%	100%	100%

For example, a typically Server utilization or CPU load of 10% is common if operated without virtualization. The efficiency of the Server to convert Electricity into IT work is only 15% compared to its maximum ability of 100%. Through virtualization typically CPU loads of 40% can be achieved safely. The output of IT work has increased 4x, however, only 17% more power gets consumed. Therefore the IT utilization efficiency (ITUE) of the server has increased by about 3x!

Financial Analyses:

The effect of ITUE is compounded with the effect of ITAME (s. chapter 3. B.). For illustration a 10% CPU load and 40% CPU load scenario will be compared.

As a first analyses changing CPU utilization rate from 10% to 40% through virtualization, still 5 yr. refresh is assumed. Due to the better utilization of the servers ability to perform useful IT work a 300% compute ability increase can be achieved. Therefore 1000 Servers with 40% CPU utilization will be equivalent to 4000 servers with 10% CPU utilization.

[7] http://www.dell.com/downloads/global/power/ps1q08-20080198-Esser.pdf

	5yr./low	5yr./med	Delta $
Base case	$ 780,000	$ 780,000	
plus 300%/yr. more servers to get to 4000 total Servers	$ 2,340,000		
plus annualized cost for new DC for 3000 more servers	$ 3,756,000		
Total annual cash layout	**$ 6,876,000**	**$ 780,000**	**$ 6,096,000**

It is assumed that a new Data Center needs to be build, or a Co-Lo arrangement is needed to host the additional Servers in the 5 yr. low virtualization case. The annualized cost of capital plus the additional Servers under the low virtualization policy needed amounts to a total annual net cash outlay of $6.9m. Switching to a medium virtualization policy will avoid the need for a new DC and is overall significant less expensive with $780k net cash outlay for equivalent performance. In total savings of $6.1m/yr. are realized.

To demonstrate the compounding effect of ITAME and ITUE changing CPU utilization rate from 10% to 40% through virtualization, and changing from 5 yr. refresh to 3 yr. is assumed here. Due to the better utilization of the servers ability to perform useful IT work and by following Moore's law more closely an increase of approx. 424% compute ability can be achieved. Therefore 1000 Servers on a 3 yr. refresh cycle with 40% CPU utilization will be equivalent to 5242 servers on a 5 yr. cycle with 10% CPU utilization.

	5yr./low	3yr./med	Delta $
Base case	$ 780,000	$ 1,100,000	
plus 424%/yr. more servers to get to 5242 total Servers	$ 3,307,200		
plus annualized cost for new DC for 4252 more servers	$ 5,323,504		
Total annual cash layout	**$ 9,410,704**	**$ 1,100,000**	**$ 8,310,704**

It is assumed that a new Data Center needs to be build, or a Co-Lo arrangement is needed to host the additional Servers in the 5 yr. low virtualization case. The annualized cost of capital plus the additional Servers under the 5 yr./low virtualization policy needed amounts to a total annual net cash outlay of $9.4m. Switching to a 3 yr. refresh/medium virtualization policy will avoid the need for a new DC and is overall significantly less expensive with $1.1m net cash outlay for equivalent performance. In total savings of $8.3m/yr. are realized.

3. D. IT GEAR EFFICIENCY (ITE)

Not all IT equipment has the same efficiency to convert Electricity into IT work. The difference between vendors can be significant. There is not a single value for ITE, it is dependent on Vendor, configuration and form factor. Most IT vendors have online Power tools available (www.dell.com/switch). Taking the same approach as with all other Efficiencies, ITE is a relative efficiency. In a comparison between vendors and models, the identical desired configuration should be used in the various tools. The server with the lowest power consumption at these specific configuration requirements will be ITE = 100%. As for illustration, Dell has been focusing on Energy Smart technologies[8] and has had an advantage over competition in several Server lines. Typically an up to a 20% difference between one vendor and another on efficiency can be found.

ITE and DCiE are both hardware related efficiencies, however, they are very different in the cost of change associated. Changing ITE is a procurement policy change and associated with little to no cost. These changes can be incorporating perf/watt specifications in the RFQ, including minimum efficiencies on Power Supplies, etc.

[8] HTTP://WWW.DELL.COM/DOWNLOADS/GLOBAL/POWER/PS1Q08-20080206-FENNER.PDF

4. MANAGING DATA CENTER POLICIES FOR LOWEST COST AND HIGHEST EFFICIENCY

The actions to Green the Data Center are guided by the above scoring and ease of implementation:

1. Increase Utilization: The most effective lever is ITUE. Typical IT equipment is utilized only to a fraction of its capability, the CPU often runs only 10% utilized. At this level servers are extremely inefficient to convert electricity into IT work as explained before. Assuming a 40% CPU utilization is a safe desired state, the ITUE improves to about 52%. An approximate 3.5x improvement in lower GHG/Energy can be achieved.

2. Refresh your hardware: Typically IT gear is used 5 years or longer. Assuming a successful adoption of virtualization has occurred, a reduction to 3 years of useful life will yield 1.3x improvement in GHG

3. Update your Procurement policies to improve ITE. Effective requirements can be to incorporating perf/watt specifications in the RFQ, including minimum efficiencies on Power Supplies, etc. As an example, Dell has been focusing on Energy Smart technologies and has had an advantage over competition in several Server lines. For indication purpose a difference of 20% can be assigned if the majority of the Server population is best in Class equipment. This is a very easy and cost effective change in your policies and can yield approximately 1.2x improvement for both lowering net cash and lower GHG/Energy cost

4. Improving Infrastructure efficiency DCiE from typically 50% to a better 70% by improving existing or deploying state of the art A/C and Power delivery systems will result in 1.4x improvement

Action #1, #2 and #3 are achieved most effectively through IT and procurement policy changes, Action #4 is associated with more or less intensive facility changes and construction. A survey of the as is situation is typically needed to derive a specific course of action. In almost all cases a significant improvement with little to moderate investment can be achieved.

5 CONCLUSION

Most of today's Data Centers are operated at very improvable operating points due to policies not optimized for efficiency. Conversely these data centers operated at very high cost and energy consumption not counting the sprawl of new unnecessary data centers. The analyses presented shows that reduction on GHG will reduce the overall cost of operation.

Significant savings can be achieved by changing financial and IT policies affecting the cost of IT. It is critical to enable an efficient, fact based dialogue between all functions in an Enterprise to achieve the best cost IT and with that the lowest GHG emissions/Energy consumption possible.

This paper addressed this fundamental Industry need, a simple measure of Total Data Center Efficiency (TDCE) and a simple financial model of the Data Center Equipment. The differences in cost to deliver the same IT work load can be significant dependent on the chosen policies.

The most expensive policies are the most common in the industry, 5 year CapEx write off and little to no virtualization. The better set of policies, 3 year write off and medium adoption of virtualization yields an significant improvement over the most common, enabling significant IT workload growth with virtually no impact on GHG and little impact on overall yearly net cash layout .

As shown, there is no conflict or compromise to be made, the:

Green Enterprise is **Efficient and Sustainable Enterprise**

There is the overwhelming need for a more simplistic way to classify the overall effectiveness of a Data Center. And the results should be actionable and show the associated financial benefits. Typically, the highest business impact is achieved by smartly changing policies, and it is at the same time typically the most cost effective path. High impact policies in the Data Center are around things like this:

- Efficiency of the physical infrastructure
- Refresh rate of IT equipment (CapEx write off schedule)
- Utilization of IT equipment, e.g. degree of use of virtualization
- RFQ policies, e.g. perf/watt; Specify efficiencies (e.g. 95% Power Supplies)

However, up to today there hasn't been a framework effectively describing this. The proposed Total Data Center Efficiency (TDCE) is addressing all of these issues. It focuses on the efficiencies of all IT elements in the IT production chain, however, avoids the need for an IT work load definition.

To enable financially sound decision making the financial benefits are tide to the areas of efficiency improvements, total net cash needed to run the IT operation is easily derived.

6 APPENDIX:

"A Simple Model for Determining True Total Cost of Ownership for Data Centers, Version 2, October 24, 2007" by Jonathan Koomey, Ph.D.
http://uptimeinstitute.org/index.php?option=com_docman&task=doc_download&gid=24

Data and derived data:

Racks		200
#U/Rack		42
Rack filled %		76%
Power/filled U (W)		340
Total power/Rack (kW)		10.9
PUE		2
cost of $/kwh		$0.068
total electricity cost/yr. per Rack	$	12,344.98
total electricity cost/yr. per used U		$386.75
Total Installed capital cost per Rack (excl. IT gear)	$	364,000
Total Installed capital cost per used U (excl. IT gear)	$	11,404
Discount Rate		7%
write off period in years		15
Annuallized Installed Capital/Rack/yr.	$	39,965
Annuallized Installed Capital/used U/yr.	**$**	**1,252**
For CAPEX and Electricity		
Total Annulized Cost/Rack/yr.		**$52,310.23**
Total Annulized Cost/used U/yr.		**$1,638.79**

Other additional assumptions:
Typical financials on a 1U server

New cost:	$4,500
Reclaim value after 3 yrs.	$1,200
Reclaim value after 5 yrs.	$ 600

Assuming continuous renewal of retired, the Net Cash outlay per Server is:

3 yrs. Cycle	$3,300
5 yrs. Cycle	$3,900

Bio:

Dr. Esser is founder and CEO of Econdius, LLC, a firm providing sustainable energy technology solutions and technology management services to a number of businesses and organizations. Dr. Esser is a resident of Austin, TX where he recently served as Vice President of Power and Infrastructure Solutions for Dell, Inc., where he was responsible for the company's Infrastructure Product line and its global Power and Cooling Initiative. In that role, Dr. Esser enhanced Dell's IT solutions that provide insight gained from customers to the server, storage, data center and services product leaders to maximize value across the enterprise.

Previously, Dr. Esser served as a vice president at Eaton Corporation, leading its Innovation Center; Chief Technology Officer and Vice President at Emerson Electric, overseeing global research and development of Emerson Network Power across six continents; Senior Vice President at Hilti, Liechtenstein; Global Imaging Subsystems Manager in General Electric's MRI division, and Power Controls Program Manager in General Electric's Corporate R&D Center. While at GE, Dr. Esser was awarded the company's top team award, the Dushman award.

Dr. Esser is the owner of both Master's and doctorate degrees in Electrical Engineering from the University of Aachen in Germany. He has published a book on wireless transmission of electric power and signals for robots, authored more than ten papers, received a post-doctorate scholarship from the German Research Foundation and received the Outstanding Prize Paper Award given by the IEEE and IEE Japan.