A Forrester Total Economic Impact™
Study Commissioned By IBM
July 2019

The Total Economic Impact Of IBM® Power Systems™ For SAP HANA®

Cost Savings And Business Benefits Enabled By IBM Power Systems For SAP HANA

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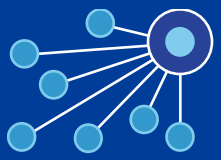
Benefits And Costs

Reduced cost of alternate server architecture:
$1,472,727



Reduced cost of downtime:
$1,074,320

Reduced cost of managing infrastructure (including power and cooling):
$441,794

Cost for IBM Power Systems:
$1.3 million

Executive Summary

As businesses adopt SAP HANA to run their core applications, the server environment needs to scale on demand with high reliability. IBM Power Systems scale large HANA environments with flexibility to easily accommodate changes in business needs while increasing application availability and systems admin productivity. Customers told Forrester that moving to IBM Power Systems reduced the cost to purchase, manage, and maintain systems to deploy SAP HANA.

IBM commissioned Forrester Consulting to conduct a Total Economic Impact™ (TEI) study and examine the potential return on investment (ROI) enterprises may realize by deploying Power Systems for SAP HANA.

The purpose of this study is to provide readers with a framework to evaluate the potential financial impact of the IBM Power Systems for SAP HANA on their organizations. To better understand the benefits, costs, and risks associated with this investment, Forrester interviewed several customers with experience using IBM Power Systems for SAP HANA.

Prior to using IBM Power Systems, the customers all used a complex array of systems to manage application environments such as SAP ERP Central Component (ECC) and SAP Business Warehouse (BW). When migrating to SAP HANA, the organizations worried about the system capacity to handle large HANA databases, often in excess of 10TBs.

One interviewee indicated: “With requirements for systems that included production, disaster recovery, development, and testing, we had about 50 physical computers. On top of that, we couldn’t layer virtualization on top of our previous environment. That’s when we acknowledged that we could rebuild this environment on IBM Power Systems and build out the environment on just four physical computers.”

Key Findings

Quantified benefits. The following risk-adjusted present value (PV) quantified benefits are representative of those experienced by the companies interviewed:

- **Avoided cost of alternate server architecture saving $1,472,727.** In lieu of an IBM Power Systems solution, the organization would have required an alternate server architecture. While the exact technical architecture could vary, Forrester’s model assumes a total server cost of $1,800,000.
- **Avoided cost of system downtime valued at $1,074,320.** Customers reported that the IBM Power Systems provided increased reliability compared to their previous server architectures. The average reduction in planned and unplanned downtime averaged 4 hours per month or 48 hours per year. The interviewed companies experienced a wide range in the average cost per hour of downtime; Forrester used a midpoint value of $10,000 per hour.
- **Reduced cost of managing and maintaining infrastructure of $323,415.** The consolidated architecture also required less effort to manage and maintain. Among the customers interviewed, the savings averaged about 60% for system admins. Organization could focus these individuals on higher-value activities.

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ROI
137%

Benefits PV
$3 million

NPV
$1.7 million

Payback
7 months

› **Reduced cost of power and cooling worth $118,379.** The cost of power and cooling is increasingly important for infrastructure purchases. While the IBM servers do consume a higher rate of power, the system architecture allowed customers to dramatically reduce the number of servers and thus the kWhs required.

Unquantified benefits. The interviewed organizations experienced the following benefits, which are not quantified for this study:

› **Using built-in virtualization to enable faster SAP HANA provisioning.** Integrated virtualization capabilities allowed customers to more easily do things such as provision new SAP HANA instances more rapidly. Customers used the phrase “at the push of a button” when describing the value of built-in virtualization.

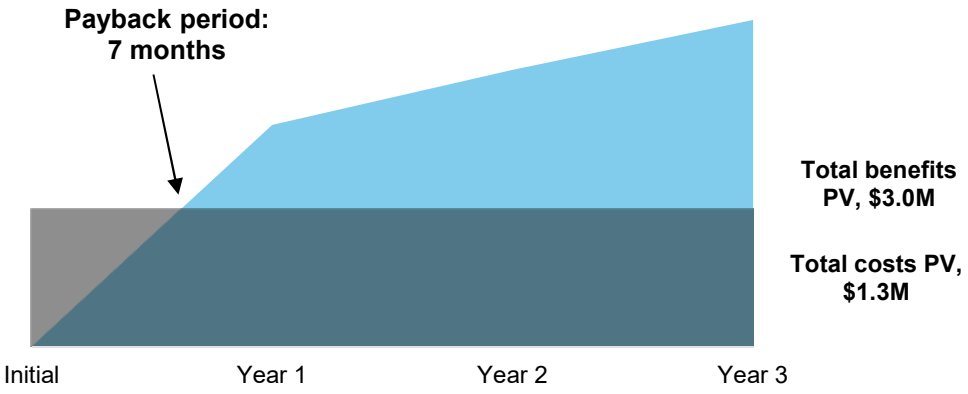
› **Leveraging IBM’s Live Partition Mobility (LPM).** Customers reported that IBM’s LPM capabilities allowed them to move a live database from one computer to another, which significantly reduced the need for downtime for critical databases during planned maintenance activities.

Costs. The interviewed organizations experienced the following risk-adjusted PV costs:

› **Cost of IBM Power Systems devices of $1,260,000.** This is the list price for three E950 servers that includes a three-year warranty along with SUSE Linux for SAP and PowerVM (hypervisor) licenses.

Forrester’s interviews with three existing customers and subsequent financial analysis found that an organization based on these interviewed organizations experienced benefits of $3 million over three years versus costs of $1.3 million, adding up to a net present value (NPV) of $1.7 and an ROI of 137%.

Financial Summary



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TEI Framework And Methodology

From the information provided in the interviews, Forrester has constructed a Total Economic Impact™ (TEI) framework for those organizations considering implementing IBM Power Systems for SAP HANA.

The objective of the framework is to identify the cost, benefit, and risk factors that affect the investment decision. Forrester took a multistep approach to evaluate the impact that IBM Power Systems can have on an organization deploying HANA environments:

The TEI methodology helps companies demonstrate, justify, and realize the tangible value of IT initiatives to both senior management and other key business stakeholders.

DUE DILIGENCE
Interviewed IBM stakeholders and Forrester analysts to gather data relative to Power Systems.

CUSTOMER INTERVIEWS
Interviewed three organizations using Power Systems for SAP HANA to obtain data with respect to costs, benefits, and risks.

COMPOSITE ORGANIZATION
Designed a composite organization based on characteristics of the interviewed organizations.

FINANCIAL MODEL FRAMEWORK
Constructed a financial model representative of the interviews using the TEI methodology and risk-adjusted the financial model based on issues and concerns of the interviewed organizations.

CASE STUDY
Employed four fundamental elements of TEI in modeling IBM Power Systems' impact: benefits, costs, and risks. Given the increasing sophistication that enterprises have regarding ROI analyses related to IT investments, Forrester's TEI methodology serves to provide a complete picture of the total economic impact of purchase decisions. Please see Appendix A for additional information on the TEI methodology.

DISCLOSURES

Readers should be aware of the following:

This study is commissioned by IBM and delivered by Forrester Consulting. It is not meant to be used as a competitive analysis.

Forrester makes no assumptions as to the potential ROI that other organizations will receive. Forrester strongly advises that readers use their own estimates within the framework provided in the report to determine the appropriateness of an investment in IBM Power Systems for SAP HANA.

IBM reviewed and provided feedback to Forrester, but Forrester maintains editorial control over the study and its findings and does not accept changes to the study that contradict Forrester's findings or obscure the meaning of the study.

IBM provided the customer names for the interviews but did not participate in the interviews.

The IBM Power Systems For SAP HANA Customer Journey

BEFORE AND AFTER THE IBM POWER SYSTEMS INVESTMENT

Interviewed Organizations

For this study, Forrester conducted three interviews with IBM Power Systems customers with SAP HANA deployed. Interviewed customers include the following:

INDUSTRY	REGION	INTERVIEWEE	BACKGROUND
Manufacturing and logistics	Global operations headquartered in Europe	Manager, SAP Basis	Migrated to IBM Power Systems to support the company's migration to SAP HANA. The company realized increased reliability and improved scalability for HANA's in-memory database requirements.
Pharmaceutical	Global operations headquartered in North America	Head of ERP architecture	Deployed an enterprisewide SAP HANA solution based on IBM Power Systems. The company stores everything from recipes to manufacturing drugs to enterprise financial data on a 10TB database.
International IT services provider	Headquartered in North America with operations in Europe	Global SAP architect	Created services offering for small- and medium-sized customers. Using IBM Power Systems allowed the company to increase reliability and the ability to deploy offerings to its customers more rapidly.

Key Challenges

The interviewees shared key challenges or problems that drove their need for an alternate solution. Those issues included:

- **Relying on systems to run every aspect of business.** The pharmaceutical exec indicated: "Reliability is paramount when deploying a 10TB database. If the system is down, our business is crippled. We can't even produce product because our drug recipes are in the system."
- **Recovering from disasters.** The same executive continued: "Obviously, disaster recovery is also critical to our business. We amended a very aggressive recovery scenario with a recovery point objective (RPO) of less than 1 minute and a recovery time objective (RTO) of less than 4 hours."
- **Managing an unwieldy number of devices, each requiring patches and updates.** The manager from the manufacturing and logistics company mentioned: "We had a total of 16 servers, eight per data center, and we needed two weeks to take care of all the patches, upgrades, and security patches on the servers. We basically ran from server to server."
- **Running an SAP HANA database 24x7.** The manager continued: "We are a global company and need our database to be available around the clock. While it's daytime on one side of the world and people are actively working, the nighttime running of reports on the opposite side of the world must run concurrently."

"We are a global company and need our database to be available around the clock. While it's daytime on one side of the world and people are actively working, the nighttime running of reports on the opposite side of the world must run concurrently."

Manager, SAP Basis, manufacturing and logistics

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Key Results

The interviews revealed that key results from the Power Systems for SAP HANA investment include:

- **Reduced downtime for planned and unplanned outages.** The head of ERP architecture told Forrester during the interview: "We run our company on a 10 terabyte (TB) SAP HANA database. It runs everything from manufacturing to financial systems. On the rare occasion that the system goes down, it stops the company, and it can take hours to recover because the database is so large." The executive continued describing how system downtime on IBM Power Systems has literally been zero hours for 18 months.
- **Increased productivity of system admins.** Interviewees indicated that the reduced number of physical servers also impacted the productivity of system admins. One interviewee specifically mentioned: "We have still the same administrators, but they can do additional work, more important work, and more sophisticated work rather than merely updating systems."
- **Providing capacity on demand.** The pharmaceutical executive said: "We use the capacity on demand model. It allows us to scale a virtual computer to be bigger and bigger on the fly because each frame has 32TBs of addressable memory." Another interviewee explained: "With IBM Power Systems and PowerVM virtualization, we can provision resources much more efficiently. If we needed to provide new large SAP HANA production systems in the past, we would have to buy, install, and configure new physical appliances. Today, we can simply set up new logical partitions as and when needed, making the process of provisioning new large SAP HANA systems up to 20 times faster — a huge improvement. Being able to make resources available more quickly in this way enables us to react faster to changing customer requirements and business demands."

> "We run our company on a 10 terabyte (TB) SAP HANA database. It runs everything from manufacturing to financial systems. On the rare occasion that the system goes down, it stops the company, and it can take hours to recover because the database is so large."
>
> *Head of ERP architecture, pharmaceutical*

> "We have still the same administrators, but they can do additional work, more important work, and more sophisticated work rather than merely updating systems."
>
> *Global SAP architect, international IT services provider*

Composite Organization

Based on the interviews, Forrester constructed a TEI framework, a composite company, and an associated ROI analysis that illustrates the areas financially affected. The composite organization is representative of the three companies that Forrester interviewed and is used to present the aggregate financial analysis in the next section. The composite organization that Forrester synthesized from the customer interviews has the following characteristics:

- Managed an 8TB database in production running on SAP HANA with four SAP HANA instances of 2TB each.
- Averaged planned and unplanned downtime of 4 hours per month.
- Valued downtime at a cost of $10,000 per hour.
- Maintained an environment consisting of 20 servers across production, disaster recovery, development, and testing.
- Employed three system admins to manage and maintain the systems at both primary and disaster recovery locations.

Previous architecture: 20 systems

IBM Power Systems architecture: 3 systems

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Analysis Of Benefits

QUANTIFIED BENEFIT DATA AS APPLIED TO THE COMPOSITE

Total Benefits

Ref.	Benefit	Year 1	Year 2	Year 3	Total	Present Value
Atr	Avoided cost of alternate server architecture	$1,620,000	$0	$0	$1,620,000	$1,472,727
Btr	Avoided cost of system downtime	$432,000	$432,000	$432,000	$1,296,000	$1,074,320
Ctr	Reduced cost of managing and maintaining infrastructure	$130,050	$130,050	$130,050	$390,150	$323,415
Dtr	Reduced cost of power and cooling	$47,602	$47,602	$47,602	$142,806	$118,379
	Total benefits (risk-adjusted)	$2,229,652	$609,652	$609,652	$3,448,956	$2,988,841

The table above shows the total of all benefits across the areas listed below, as well as present values (PVs) discounted at 10%. Over three years, the composite organization expects risk-adjusted total benefits to be a PV of more than $3 million.

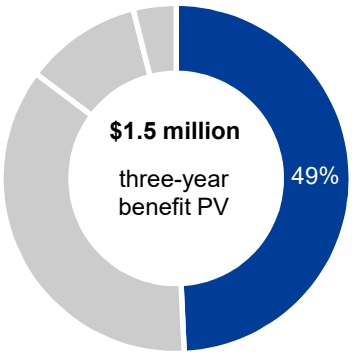
Avoided Cost Of Alternate Server Architecture

Deploying a scale-up architecture with virtualization reduced the number of servers and complexity of the environment. Customers using IBM Power Systems significantly reduced the number of systems (and related rack units) required. The three E950 systems in this study compared to the previous architecture of:

- Four production systems.
- Four systems for disaster recovery.
- Four preproduction systems.
- Four development systems
- Four systems for testing and QA.

While Forrester assumes a 20-server alternate architecture; in practice, other architectures could take a number of forms. For example, the development and QA environments might be managed with fewer servers. Similarly, companies can sometimes satisfy their DR requirements without duplicating the exact production environment.

To account for these variations, Forrester based the pricing of the alternate environment using aggressively priced, commodity, rack systems and used the lowest of possible pricing alternatives. When considering alternate costs, remember that Forrester's model is based on a company with an 8TB SAP HANA database in production with four HANA instances of 2TB each. Forrester risk-adjusted this benefit downward by 10%, yielding a three-year risk-adjusted total PV of $1,472,727.



Avoided cost of alternate server architecture: 49% of total benefits

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Avoided Cost Of Alternate Server Architecture: Calculation Table					
Ref.	**Metric**	**Calculation**	**Year 1**	**Year 2**	**Year 3**
A1	Original CAPEX of previous architecture		$1,800,000		
At	Avoided cost of previous technology architecture	=A1	$1,800,000		$0
	Risk adjustment	↓10%			
Atr	Avoided cost of previous technology architecture (risk-adjusted)		$1,620,000	$0	$0

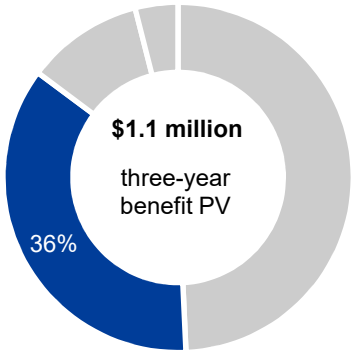
Avoided Cost Of System Downtime

The interviewed organizations experienced both planned and unplanned downtime averaging 4 hours per month using their previous systems, often for activities such as maintenance, updates, or patches. Because the SAP HANA database is a large, in-memory system, merely the task of reloading a multi-terabyte database into memory required an extended period of time.

In the financial model, Forrester calculates:

- Four hours of planned or unplanned downtime per month. Readers should adjust the value to represent the total downtime that they experience in their current environments.
- An average cost per hour of $10,000 of downtime. Interviewees expressed costs that ranged from a couple thousand dollars to hundreds of thousands of dollars per hour.

The risk inherent in Forrester's calculation is the wide range of responses in the interviews. To account for this risk, Forrester adjusted this benefit downward by 10%, yielding a three-year risk-adjusted total PV of nearly $1,074,320.



Avoided cost of system downtime: 36% of total benefits

Avoided Cost Of System Downtime: Calculation Table					
Ref.	**Metric**	**Calculation**	**Year 1**	**Year 2**	**Year 3**
B1	Avoided an average four hours of downtime per month (planned and unplanned)	From interviews	48	48	48
B2	Cost to organization per hour	From interviews	$10,000	$10,000	$10,000
Bt	Avoided cost of system downtime	B1*B2	$480,000	$480,000	$480,000
	Risk adjustment	↓10%			
Btr	Avoided cost of system downtime (risk-adjusted)		$432,000	$432,000	$432,000

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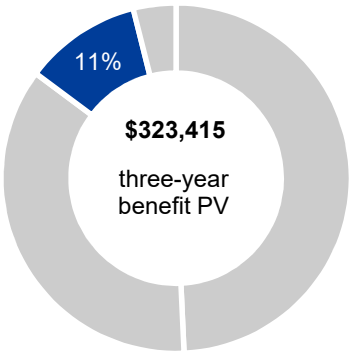
Reduced Cost Of Managing And Maintaining Infrastructure

In addition to reducing the cost of downtime, customers freed up the work of system admins to focus on other, higher-value tasks within the organization. While the number of staff managing the systems varied widely among interviewees, they consistently indicated that improved productivity of system admins was around 60% (responses ranges from 50% to 75%).

In the financial model, Forrester calculates this benefit using three system admins who realize a 60% reduction in the work required to care for IBM Power Systems compared to the previous architecture. Using an average burdened salary of $85,000, that results in an annual productivity benefit of $153,000.

As with previous benefits, readers are likely to realize a range of value for the benefit depending on the current organization of system admins, other systems in the data centers, the efficiency of their current environments, and the average salaries in a specific geography. To account for these risks, Forrester adjusted this benefit downward by 15%, yielding a three-year risk-adjusted total PV of $323,415.



Reduced cost of managing and maintaining infrastructure: 11% of total benefits

Reduced Cost Of Managing And Maintaining Infrastructure: Calculation Table

Ref.	Metric	Calculation	Year 1	Year 2	Year 3
C1	Number of system admins focused on servers before IBM	From interviews	3	3	3
C2	Improved productivity of system admins	From interviews	60%	60%	60%
C3	Average burdened salary	From interviews	$85,000	$85,000	$85,000
Ct	Reduced cost of managing and maintaining infrastructure	C1*C2*C3	$153,000	$153,000	$153,000
	Risk adjustment	↓15%			
Ctr	Reduced cost of managing and maintaining infrastructure (risk-adjusted)		$130,050	$130,050	$130,050

Reduced Cost Of Power And Cooling

The cost to both power and cool systems is an increasingly relevant cost for system purchase due to the increased density of both compute and storage resources. In fact, the US Chamber of Commerce indicates that the average number of kWh consumed per system in a data center ranges from 15 to 25 kWh and an annual consumption of 8,760 kWh per year per RU.[1]

The impact for the composite organization was a reduction of 20 systems that averaged 2.5 kWhs for a total consumption of 438,000 per year. IBM's Power architecture average for 3 systems consumed a total of 12 kWhs. Using an average cost per kWh of $0.13 from the US Department of Energy, the savings reach $47,602 per year.[2] Readers should replace both the value for RU savings and the local cost per kWh for electricity with local data to calculate the benefit for their organizations.

To account the variation that readers will experience, Forrester adjusted this benefit downward by 5%, yielding a three-year risk-adjusted total PV of $118,379.

Implementation risk is the risk that a proposed investment may deviate from the original or expected requirements, resulting in higher costs than anticipated. The greater the uncertainty, the wider the potential range of outcomes for cost estimates.

Reduced Cost Of Power And Cooling: Calculation Table					
Ref.	**Metric**	**Calculation**	**Year 1**	**Year 2**	**Year 3**
D1	Number of kWhs consumed with alternate architecture	20 systems *2.5 kWhs	50	50	50
D3	Total kWH required per year	D1*24 hours *365 days	438,000	438,000	438,000
D4	Number of kWhs consumed by IBM Power architecture	From IBM	12	12	12
D6	Total kWHs required per year	D4*24 hours *365 days	52,560	52,560	52,560
D7	Price per kWh	US Department of Energy data	$0.13	$0.13	$0.13
Dt	Reduced cost of power and cooling	(D3-D6)*D7	$50,107	$50,107	$50,107
	Risk adjustment	↓5%			
Dtr	Reduced cost of power and cooling (risk-adjusted)		$47,602	$47,602	$47,602

Unquantified Benefits

In addition to the benefits outlined above, the interviewed executives shared other benefits that did not have specific financial implications. Specifically, the companies benefited in the following ways:

- **Using built-in virtualization to enable faster SAP HANA provisioning.** One interviewee indicated: "One thing about Power is that the virtualization is built right into it, which is a significant advantage for us. Because it's virtualized, we are able to do all the other things that come with virtualization (e.g., easily provision new HANA instances or change capacity allocation at the push of a button)." Another interviewee added: "We can flexibly scale up, if needed, by pushing a button, and within minutes. This is thanks to Capacity on Demand capabilities that enable us to activate additional processors and memory as needed. Having fewer servers reduced our physical footprint by 50%, saving us a great deal of floor space and halving energy costs."
- **Leveraging IBM's Live Partition Mobility (LPM).** An architect indicated: "IBM has functionality called Live Partition Mobility that allows us to move a live database from one computer to another without impacting the business. It allows us to do maintenance on a hardware frame because we can move the database and vacate an entire frame by moving the workload."

Impact risk is the risk that the business or technology needs of the organization may not be met by the investment, resulting in lower overall total benefits. The greater the uncertainty, the wider the potential range of outcomes for benefit estimates.

Analysis Of Costs

QUANTIFIED COST DATA AS APPLIED TO THE COMPOSITE

Total Costs

Ref.	Cost	Initial	Year 1	Year 2	Year 3	Total	Present Value
Etr	Cost of IBM Power Systems devices	$1,260,000	$0	$0	$0	$1,260,000	$1,260,000
	Total costs (risk-adjusted)	$1,260,000	$0	$0	$0	$1,260,000	$1,260,000

Cost Of IBM Power Systems Devices

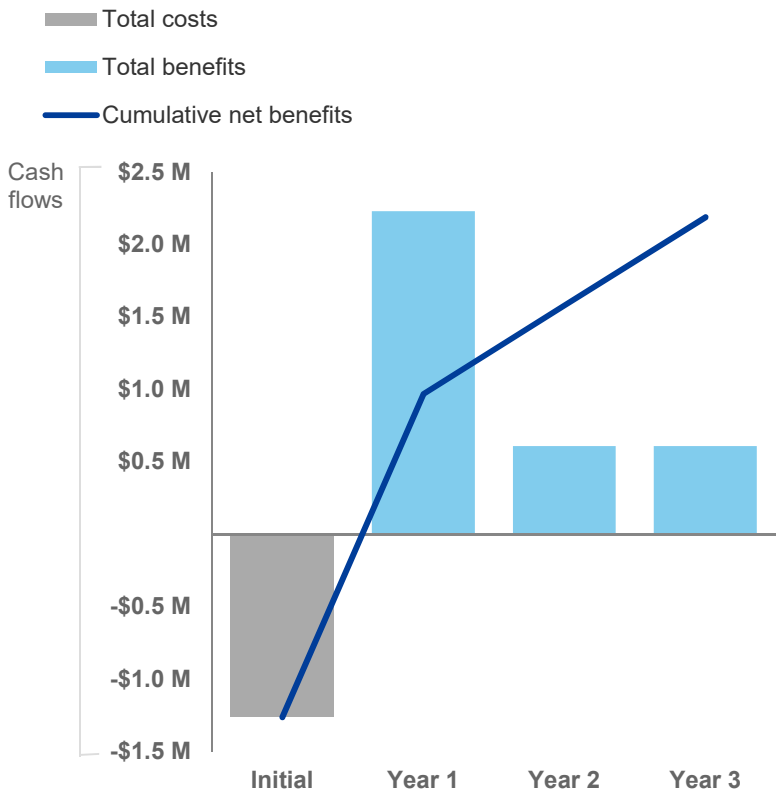
The price for three IBM E950 Power Systems totaled $1.26 million. The list price for these systems includes a three-year warranty, which eliminates the typical annual maintenance costs. It also includes SUSE Linux for SAP and PowerVM (hypervisor) license and support for three years. Because the cost is based on list price, Forrester did not risk-adjusted this cost, yielding a three-year risk-adjusted total PV of $1.26 million.

The table above shows the total of all costs across the areas listed below, as well as present values (PVs) discounted at 10%. Over three years, the composite organization expects risk-adjusted total costs to be a PV of nearly $1.3 million.

Financial Summary

CONSOLIDATED THREE-YEAR RISK-ADJUSTED METRICS

Cash Flow Chart (Risk-Adjusted)



The financial results calculated in the Benefits and Costs sections can be used to determine the ROI, NPV, and payback period for the composite organization's investment. Forrester assumes a yearly discount rate of 10% for this analysis.

These risk-adjusted ROI, NPV, and payback period values are determined by applying risk-adjustment factors to the unadjusted results in each Benefit and Cost section.

Cash Flow Analysis (risk-adjusted estimates)

	Initial	Year 1	Year 2	Year 3	Total	Present Value
Total costs	($1,260,000)	$0	$0	$0	($1,260,000)	($1,260,000)
Total benefits	$0	$2,229,652	$609,652	$609,652	$3,448,956	$2,988,841
Net benefits	($1,260,000)	$2,229,652	$609,652	$609,652	$2,188,956	$1,728,841
ROI						137%
Payback period						7.0 months

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IBM Power Systems for SAP HANA: Overview

The following information is provided by IBM. Forrester has not validated any claims and does not endorse IBM or its offerings.

Discovering and exploiting real-time insights from SAP HANA® places massive scalability, availability, and performance demands on an organization's infrastructure. Just as important, that infrastructure must meet those demands in an environment with flat to declining IT budgets. SAP HANA running on IBM® POWER® hardware helps you meet these needs.

The HANA on POWER solution runs the same SUSE or RedHat Linux distributions as x86 servers, with the flexibility, scalability, resiliency, and performance advantages of POWER servers that help you:

- Accelerate SAP HANA deployments with:
  - Flexibility of built-in virtualization that allows faster provisioning of HANA instances and allocating capacity with granularity as little as 0.01 cores and 1 GB.
- Minimize infrastructure and simplify management with:
  - Virtualization scalability of up to 24TB in scale up.
  - The ability to deploy up to 16 SAP HANA modules in a single server.
  - Shared processor pools that optimizes CPU cycles across HANA VMs in a server.
- Maximize uptime with:
  - Zero-impact planned downtime leveraging Live Partition Mobility.
  - Highest availability non-mainframe Linux platform for over a decade.[iii]

Appendix A: Total Economic Impact

Total Economic Impact is a methodology developed by Forrester Research that enhances a company's technology decision-making processes and assists vendors in communicating the value proposition of their products and services to clients. The TEI methodology helps companies demonstrate, justify, and realize the tangible value of IT initiatives to both senior management and other key business stakeholders.

Total Economic Impact Approach

Benefits represent the value delivered to the business by the product. The TEI methodology places equal weight on the measure of benefits and the measure of costs, allowing for a full examination of the effect of the technology on the entire organization.

Costs consider all expenses necessary to deliver the proposed value, or benefits, of the product. The cost category within TEI captures incremental costs over the existing environment for ongoing costs associated with the solution.

Flexibility represents the strategic value that can be obtained for some future additional investment building on top of the initial investment already made. Having the ability to capture that benefit has a PV that can be estimated.

Risks measure the uncertainty of benefit and cost estimates given: 1) the likelihood that estimates will meet original projections and 2) the likelihood that estimates will be tracked over time. TEI risk factors are based on "triangular distribution."

The initial investment column contains costs incurred at "time 0" or at the beginning of Year 1 that are not discounted. All other cash flows are discounted using the discount rate at the end of the year. PV calculations are calculated for each total cost and benefit estimate. NPV calculations in the summary tables are the sum of the initial investment and the discounted cash flows in each year. Sums and present value calculations of the Total Benefits, Total Costs, and Cash Flow tables may not exactly add up, as some rounding may occur.

Present value (PV)

The present or current value of (discounted) cost and benefit estimates given at an interest rate (the discount rate). The PV of costs and benefits feed into the total NPV of cash flows.

Net present value (NPV)

The present or current value of (discounted) future net cash flows given an interest rate (the discount rate). A positive project NPV normally indicates that the investment should be made, unless other projects have higher NPVs.

Return on investment (ROI)

A project's expected return in percentage terms. ROI is calculated by dividing net benefits (benefits less costs) by costs.

Discount rate

The interest rate used in cash flow analysis to take into account the time value of money. Organizations typically use discount rates between 8% and 16%.

Payback period

The breakeven point for an investment. This is the point in time at which net benefits (benefits minus costs) equal initial investment or cost.

Appendix B: Supplemental Material

Online Resources

Source: U.S. Chamber of Commerce, Data Centers, Jobs and Opportunities in Communities Nationwide, 2017. (https://www.uschamber.com/sites/default/files/ctec_datacenterrpt_lowres.pdf).

Source: U.S. Energy Information Administration, (https://www.eia.gov/electricity/state/).

Appendix C: Endnotes

[1] Source: "Data Centers: Jobs and Opportunities in Communities Nationwide," US Chamber of Commerce (https://www.uschamber.com/report/data-centers-jobs-opportunities-communities-nationwide).

[2] Source: "Electricity, State Electricity Profiles," US Energy Information Administration, January 8, 2019 (https://www.eia.gov/electricity/state/).

[iii] Source: ITIC 2019 Global Server Hardware, Server OS Reliability Survey (https://www.ibm.com/downloads/cas/DV0XZV6R)