Life Cycle Value for combined cycle power plants

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0. Abstract

The Siemens Energy Sector is the world's leading supplier of a complete spectrum of products, services and solutions for power generation in combined cycle power plants. Siemens combined cycle (SCC®) reference power plants (RPP) provide flexibility for easy selection of options to meet specific site and customer needs. This, together with a pre-designed balance of plant, results in short project lead times. It provides an optimum balance between capital cost, plant performance, and operational and maintenance considerations.

The financing schedule for the life time of a combined cycle power plant is essential. It has to be considered during the EPC phase, the O&M period, etc. However the cash flow will be affected by several factors during EPC (e.g. optimized planning time will reduce the construction & commissioning time & costs) and O&M (e.g. fuel, service & replacement parts) phase as well as book life of equipment, domestic taxes, tax and equipment depreciation, interest rates and discount rates etc.

In respect to the operation of a high efficiency and complex combined cycle power plant, the costs for unscheduled maintenance are crucial. These unexpected downtimes could lead to lost of revenues and/or penalties according to the Power Purchase Agreement (PPA).

Therefore a continuously remote operating diagnostic system, which needs to be supported by the OEM engineering organization, for preventive maintenance is one of the essential keystones for the optimization of operational costs for replacement parts and to avoid any unscheduled standstill of the complete combined cycle power plant. In addition the availability of necessary replacement parts for routine and preventive maintenance has to be optimized at site.

Other key elements are the longer operation intervals, resulting in a higher availability as well as the optimization of the scheduled maintenance period for each single component which will definitely reduce the outage time.
Implementation of the optimized maintenance concept via long term programs, the day-to-day operation will significantly reduce the operating risk of the combined cycle power plant as well as decreasing potential downtimes due to unscheduled and/or additional maintenance activities. Long Term Programs are managed programs for parts, parts repairs, program management and services for gas turbines, steam turbines, and generators and offering enhanced warranties to reduce further remaining risks.

1. Introduction

Cities have been the key element of human civilization for thousands of years. Whether we look at Mesopotamia, the Roman Empire, ancient Egypt or China – cities have always been the epitome of culture, trade, art, craftsmanship, and human progress. But a lot has changed since ancient times. A mere 200 years ago only three percent of the world’s population lived in urban areas. Today more than half of the world’s people – over 3.5 billion – live in cities. Around 50 percent of global economic output is now generated by the world’s 600 largest metropolitan areas. Likewise, cities account for around two thirds of worldwide energy consumption and up to 70 percent of greenhouse gas emissions, despite covering a mere two percent of the earth’s surface.

That’s why we must first look at our cities as we begin to look for solutions to the most pressing problems of our time, including, most particularly, climate change and the increasing scarcity of natural resources. Given the high population density of urban areas, there is tremendous potential here for boosting efficiency in areas such as power generation, distribution, and utilization in buildings and transportation systems. In other words, the key to humanity’s future will be found exactly where civilization began: in cities.

The good news is that many urban areas are facing up to this responsibility and taking measures to reduce their environmental footprint. Leading the way are Copenhagen and Melbourne. The Danish capital is aiming to completely eliminate its net CO2 emissions by 2025, and Australia’s second-largest city is looking to reach the same target as early as 2020.

Siemens estimates that global demand for electricity will rise by around two thirds between now and 2030. Power plants with a combined generating capacity of around 7,000 gigawatts (GW) are slated for construction over that period. Over one third of these plants will use renewable, carbon-
free sources of energy such as wind, hydro, and solar. However, around 45 percent of this generating capacity will still be supplied by power plants burning fossil fuels such as coal and gas. In other words, the next 20 years could well see an increase of around 50 percent in fossil-fuel generation. This primarily applies to Asia and the U.S., as both of them are now turning to highly efficient gas-fired power plants, some of which feature technology from Siemens.

Changes in today’s energy markets are presenting power producers worldwide with new challenges and opportunities. In a competitive, market-driven economy, it is more important than ever to reduce power generation cost and to find solutions that provide a rapid return on investment without sacrificing long-term reliability and flexibility. Based on an extensive experience in building power plants, Siemens has developed innovative combined cycle reference power plants, known as Siemens Combined Cycle (SCCTM) turnkey plants. These plants help investors to meet the challenges of a dynamic market and are designed to optimize planning, implementation times and lower life cycle costs. It also shortens the planning phase and reduces the construction time. For example, all of our plants are designed with either axial or side-exhaust condensers, which do not require high-elevation foundations. As a result, installation work of main components can start earlier, and the plant can be finished faster. Plants have been completed as quickly as 20 to 24 months. It is an intelligent concept that cuts down construction times and increases customer benefits.

The proven design for:

- High efficiency
- Superior reliability and availability
- Controlled capital costs
- Rapid implementation
- Environmental compatibility
- Operational flexibility

How do you design a combined cycle power plant for today’s demanding market? The family of advanced combined cycle power plants was developed based on a common design philosophy. These reference power plants are available in single-shaft or in multi-shaft configurations in the capacity range between 150 MW and over 1000 MW for both 50 Hz and 60 Hz applications. Whether single-shaft or multi-shaft, designing with state-of-the-art 3-D modeling results in rapid, high quality power plant implementation.
The latest series of Siemens gas turbines – the H-Class – is now operating in South Korea. Siemens has already sold eight of these gas turbines in South Korea since they were launched on the market in 2011. This success is due to the fact that South Korea has very low energy reserves itself and is therefore forced to rely on expensive imported fuels such as liquid natural gas (LNG). That’s just one more reason why the power plants need to be so efficient. For example, an increase in electrical efficiency of just one percentage point in an 800 MW facility results in an additional output of 60 million kilowatt-hours per year. That’s enough to supply electricity to 30,000 more people at the same fuel cost and the same CO₂ emission level. The fuel issue is particularly important, since fuel costs account for 75 percent of a power plant operator’s total costs.

Siemens built its first-ever combined cycle plant in Bang Pakong, Thailand, in the early 1980s. The plant had an efficiency rating of around 48 percent. In just three decades Siemens has increased the efficiency of its combined cycle plants by over 12 percentage points. That corresponds to a more than a 25 percent increase in fuel conversion.

2. Problem statement

2.1. Challenges a power plant investor faces

In today’s complex power market, power plant investors are confronted with various market requirements, challenges and their interactions. Investments in Power Generation assets inevitably results in prioritizing and optimizing goal conflicts.
2.2. Power Plant Life Cycle Timeline – course of action from ITB to operation

The power producer and its implementing architect engineer and/or consultant are responsible for the project preparation phase, which can take several years to conduct feasibility studies and prepare engineering and technical designs, to name only a few of the work products required. The power producer contracts with consultants and/or other companies for goods, works and services, if necessary, not only during this phase but also later in the project's implementation phase. Beneficiaries and stakeholders are also consulted to obtain their feedback and enlist their support for the project. Due to the amount of time, effort and resources involved, the full commitment of the power producer to the project is essential.

Once all project details are negotiated and accepted by the government for the power supply, the project team - the power producer itself or contracted to an architect engineer cooperation / consultant company - prepares the detailed project specification (terms and conditions / technical requirements), along with other financial and legal documents, for submission to international market for consideration and bidding.

Detailed knowledge of turbine and generator technology is a necessary prerequisite for turning potential projects into economically successful ones. Plant size is important in the cost of the plant. The larger plant sizes benefit from economies of scale (lower initial cost per kilowatt) and
improved efficiency. The combined cycle design should incorporate highly efficient components and systems, which could result in low NOx, CO and VOC emissions. Enhanced Dry Low NOx (DLN) and Ultra Low NOx (ULN) combustors could provide flexible, stable, clean and economical operation. Further provisions are available in the form of catalysts in the heat-recovery steam generators to reduce stack emissions to meet the most stringent requirements. The power producer has to define the plant configuration, e.g. a single shaft combined cycle plant (comprises a gas turbine and a steam turbine driving a common generator) or a multi-shaft combined cycle plant (each gas turbine and each steam turbine has its own generator). Each configuration has its own charm and benefits based on customer needs in combination with local requirements and regulations.

While efficiency is very important in achieving low life cycle costs, high availability and reliability also are critical. Using proven, time-tested components and modules, for system redundancies backed by RAM (Reliability, Availability and Maintenance) analyses to optimize overall life cycle costs. To further improve availability and provide a high level of automation one of the world’s leading instrumentation and control systems needs to be applied. This comprehensive approach should integrate all details into a total power plant control concept.

A carefully planned and integrated maintenance strategy, along with extended major maintenance intervals, should achieve high availability without compromising reliability. By leveraging comprehensive expertise, scheduled maintenance program should plan in advance to ensure that the manpower, equipment and spare parts are exactly where they need to be when the maintenance is performed.

Generating reliable output in the shortest possible time after financial closing and Notice To Proceed (NTP) is key to realizing an early return on your investments.
3. Phases and crucial factors over the power plant life cycle

3.1. Before contract / construction start

3.1.1. Challenging Market

The Asian market is one of the strongest and fastest growing markets worldwide. According the Asia Development Bank Asia’s GDP contribution to the global GDP will double to 52% in 2050. This tremendous increase has major impact for the entire power generation business.

The strive for efficient use of primary energy in combination with a worldwide increasing demand for eco-friendly power generation are some of the requirements to accomplish with environmental regulations and increase the business case of the power plants. It is important to understand the impact of the eco-friendly power generation with long-term CO₂ reduction targets today and in the future. The integration of more renewable resources in the energy mix on the one hand-side and the increase of efficiency and or fuel utilization to further reduce CO₂ emissions on the other hand-side are decisive measures to achieve these targets. Both have major impact on the development path of a combined cycle power plant.

Considering the ASEAN region a continuous increase of power demand of approx. 6% per annum is anticipated over the upcoming years. Accordingly, new generating capacities will have to be built to cover this demand. Inversely to Europe, renewable energy power generation in the ASEAN region is still limited and plays a secondarily role within today’s energy mix. Nevertheless, it is clearly expected that in the future the renewable power generation share will increase. Driven by tremendous changes of the residual load (difference between electricity demand and renewable feed-in) an extremely fluctuating load profile is the consequence and has to be covered by the power plant (Figure 2).
Figure 2 Fluctuating load profile Singapore

The power plant has to cope also with changing operation regimes over the lifetime as a clear shift from Baseload to Intermediate to Peakload is predicted in the upcoming years.

Another effect based on the tremendous development of the Asian market is the challenge for sustainable and reliable energy production. In combination with extremely high gas prices the need of high fuel utilization factors is indispensable. Combined heat and power (CHP) is one step towards sustainable electricity production as concurrent generation of heat and electricity leads to fuel efficiencies beyond 75%. The operational boundaries for CHP applications are mainly divergent from regular electricity production as the power plant has to be optimized for this operational mode. Full flexibility between heat and electricity production at very high efficiency and heat production levels are required.

The consideration of all these boundary conditions is mandatory for the entire development process of a power plant. Siemens combined cycle reference power plants (RPP) are developed to comply with all these diverse operational requirements and focus on customer needs by tailor made solutions at highest quality.
3.1.2. Financing

Project Financing and the choice of the suitable financial instruments play a key role in developing bankable and viable projects. Depending on the planned business model and capital structure, various financing options may be available to promoters and all of these need to be analyzed carefully to find the best fit. Large Utilities may enjoy sufficient balance sheet strength to attract debt financing, whilst under a project finance scheme the future revenue stream and its likelihood becomes the major deciding factor whether or not a project is bankable. In addition, the involvement of strong and reputable sponsors, a market-optimized operating scheme and experienced contractors for the construction and operation of a plant are further key elements determining ultimate financing success.

The availability of long term off-take agreements from creditworthy counterparties may support a greater leverage and therefore result in attracting a higher percentage of senior debt, whilst pure market risk or “merchant” projects may require significantly higher at risk capital in the form of equity. Projects with substantial market risk may even not be able to attract senior debt at all.

Performance risk of the EPC contractor as well as “country risks” (the political framework, legal and tax environment) the project is subjected to are additional elements in the risk assessment when banks perform their due diligence on projects.

When developing a project, it is important to have a close interaction with the key contracting parties to reach fair and balanced risk mitigation. Contractors can also offer support in the process of optimizing project financing. EPCs and OEMs like Siemens offer alternative sourcing scenarios which would help tailor a financing package involving Export Credit Agency support thereby achieving longer tenors and lower cost of capital compared to projects not benefiting from such involvement.

Siemens Financial Services is the financing division of Siemens worldwide. It offers a variety of financial products and services that include treasury services, equity finance, debt finance, leasing, asset securitization and insurance as well as Project and Structured Finance (“PSF”) advisory.

The PSF group acts as a financial advisor to Siemens’ operating divisions including the Energy Sector and structures, arranges and implements financing packages for projects worldwide. PSF
maintains excellent working relationships with numerous international partners involved in the financing of infrastructure projects. As a result, Siemens can demonstrate an impressive track record in the area of project and export finance and enjoys an excellent reputation within the international financial community. PSF can utilize this standing and seamlessly interact with the financing institutions supporting the funding in order to develop a tailor-made financing package that meets the specific requirements of the project.

While maybe not as obvious, but the bankability of a project is also dependent on the level of impact it may have on the environment and the local population. Noise, water and air pollution need to be assessed just as social risks that may include relocation measures. More and more banks adhere to the Equator Principles – a risk management framework that aims at reaching minimum standards in the due diligence aiming at more responsible decision making standards. Currently 79 international banks financing almost 75% of global debt in project finance transactions in emerging markets have made the Equator Principles part of their approval process. Multilateral development banks as well as export credit agencies (defined through OECD common approaches) are making such minimum standards a prerequisite for their involvement.

3.1.3. Scope and Technology

Based on decades of experience, Siemens product portfolio addresses all customer expectations in terms of efficiency, environmental protection, operational flexibility and economical value. The H-class technology is the high end product to complete the wide range of the Siemens product portfolio for 50 and 60Hz market applications (Figure 3).
The H-class Technology is the advanced product solution merging the best design features of former Westinghouse Power Generation and Siemens Technology enhanced with latest innovations.

- The H-class Technology uses the well-established SGT5-4000F rotor design with high stiffness, uniform thermal expansion and stable running behavior.
- The compressor has four variable guide vanes for highest part load efficiencies.
- For full flexibility and highest load ramps the can annular combustion system is fully air cooled and currently unique in this efficiency class.
- The H-class turbine section uses directionally solidified material and enhanced TBC systems in order to avoid highly complex steam cooling and single crystal application.
- The hydraulic clearance optimization is the high end feature to compensate degradation during operation and to squeeze additional power of the gas turbine during transient operation.

Siemens provides a broad range of combined cycle power plant solutions based on single- and multi-shaft arrangements to address all customer expectations and market needs.

The single shaft design is also optimized for CHP applications. Despite the compact design with the floor mounted turbine generator train, it is possible to provide up to a three stage steam
extraction for heating purposes or process steam. A full variety of steam and heat parameters can be realized for the single shaft application (Figure 4).

Maximizing the amount of heat is a typical request for Korean CHP applications. This request can be accomplished by our decoupled LP turbine concept which guarantees heat extractions beyond 350MWth for 50Hz and 250MWth for 60Hz market applications. This guarantees full compliance of the heating grid in combination with very fast response time and full flexibility between heat and electricity production. Siemens has an impressive track record of more than 200 CHP plants worldwide based on Siemens components.

In addition to that, Siemens is unique in offering a flexible scope of supply varying between entire power plant (Turnkey) over Power Block, Power Island down to Extended Power Train. The three models with reduced Siemens scope (Power Block, Power Island and Extended Power Train) may either be sold directly to a customer, or the non-Siemens scope may be contributed by a strategic partner in a consortium setup. Which model may be applied to a specific project depends on the target region and the end customer’s capabilities. This flexible approach is a win win situation for both, Siemens and the customer as for example IPPs typically need a full scope supplier for bankability reasons and the availability and capabilities of potentially necessary partners whereas Siemens can add local partners and further optimize the project setup via local knowledge.
3.1.4. Conclude power purchase agreement and secure gas supply

A Power Purchase Agreement (PPA) is a contract between two parties, one who generates electricity for the purpose (the seller - private power company) and one who is looking to purchase electricity (the purchaser - government or public distributor of power). The PPA defines all of the commercial terms for the sale of electricity between the two parties, including commercial operation date, schedule for delivery of electricity, penalties for under delivery, payment terms, and termination. Electricity rates are agreed upon as the basis for a PPA. Prices may be flat, escalate over time, or be negotiated in any other way as long as both parties agree to the negotiation. In a regulated environment, electricity regulator will/can regulate the price. A PPA often specifies how much energy the supplier is expected to produce each year and any excess energy produced will have an impact on the sales rate of electricity that the purchaser will be purchasing. The PPA will also describe how invoices are prepared and the time period of response to those invoices. This also includes how to handle late payments and how to deal with invoices that became final after periods of inactivity regarding challenging the invoice. The buyer also has the authority to audit those records produced by the supplier in any circumstance. A PPA is the principal agreement that defines the revenue and credit quality of a generating project and is thus a key instrument of project finance. Contractual terms may last anywhere between 5 and
20 years, during which time the power purchaser buys energy and sometimes also capacity and/or ancillary services from the electricity generator.

This usually takes the place of a Build-Own Transfer (BOT) or concession agreement: in addition to obligations relating to the sale and purchase of the power generated, the PPA will also set out the output and operation and maintenance specifications for the power plant. The charges for the available capacity and the electrical output are generally a pass through arrangement between the seller and the purchaser. The price charged for the power consists of a charge (availability charge) to cover the project company's fixed costs (including a return on equity for the project company) plus a variable charge to cover the project company's variable costs. The availability charge relates to the availability of the power plant and the variable charge is calculated according to the quantity of power supplied. The purchaser will want a guaranteed long-term output from the project. Before the seller can sell electricity to the purchaser, the project must be fully tested and commissioned to ensure reliability and comply with established commercial practices. The commercial operation date is defined as the date after which all testing and commissioning has been completed and is the initiation date to which the seller can start producing electricity for sale (i.e. when the project has been substantially completed). The commercial operation date also specifies the period of operation, including an end date that is contractually agreed upon. The PPA may provide sanctions or require the power producer to pay liquidated damages if the power producer fails to deliver power as promised; in particular, if the construction of the project is not finished within the time for completion or does not perform as required when completed. Lenders will be concerned to ensure that liquidated damages do not have too damaging an impact on debt coverage ratios. Normally the power producer is usually not required to pay damages for delays resulting from events beyond its control. However the PPA will distinguish where the sale of electricity takes place in relation to the location of the purchaser and seller.

PPAs typically include scheduled outages and maintenance outages, operation and maintenance, emergencies and keeping of accounts and records. Maintenance and operation of a power generation project is the responsibility of the seller. This includes regular inspection and repair, if necessary, to ensure prudent practices. Liquidated damages will be applied if the seller fails to meet these circumstances.
PPA should address impact on tariff in event of a change in applicable law and the mechanism for tariff adjustment. Lenders will be anxious to ensure that the cash flows of the project required for debt service are protected against changes in law. The PPA will need to provide for what happens on termination (whether at the end of the term of the agreement or early termination for default etc), including obligations of the power producer on hand-over of assets, calculation of buyout price for IPP (if this is contemplated), what happens to employees of power producer if IPP transferred to purchaser on termination.

The PPA is often regarded as the central document in the development of independent electricity generating assets (power plants). Because it defines the revenue terms for the project and credit quality, it is one key to obtain non-recourse project financing. One of the key benefits of the PPA is that by clearly defining the output of the generating assets and the credit of its associated revenue streams, a PPA can be used by the PPA provider to raise non-recourse financing from a bank or other financing counterparty.

Combined cycle power generation using natural gas is currently the cleanest available source of power using hydrocarbon fuels, and this technology is widely and increasingly used as natural gas can be obtained at increasingly reasonable costs. Locally produced electricity and heat using natural gas powered Combined Heat and Power plant (CHP or Cogeneration plant) is considered energy efficient and a rapid way to cut carbon emissions.

The basis on which natural gas is sold and priced varies dramatically between global markets. As natural gas becomes an increasingly important source of energy, understanding of gas pricing concepts is crucial for energy producers, consumers, and regulators.

Oil is sold by volume or weight, typically barrels or tons. By contrast, natural gas is sold by unit of energy. Common energy units include British Thermal Units (Btu) and Joules (J). Natural gas, when produced from the reservoir, contains majority methane plus various other hydrocarbons and, undesirably, some impurities. Natural gas liquids (NGLs), a term that includes ethane, propane, butane, and condensates, are composed of longer chains of carbon molecules than methane, and thus, per unit volume, they burn hotter than methane.

The volume of gas available for sale by the oil and gas company is a function of the volume of gas produced and the fiscal terms in place. Cost of production, taxes, government controls, or
market forces set by local or regional supply and demand often determine the price of gas sold. The pipeline gas sales agreement (GSA) is also known as a gas purchase agreement (GPA) or a gas sales and purchase agreement (GSPA). These agreements between a producing company (seller) and a consuming company (purchaser) usually cover a number of provisions. There are several contract possibilities, e.g. the producing company dedicates the entire production from a particular field to a purchase; or like a supply contract, the seller commit to supply a fixed volume of gas to the purchaser for fixed term, up to 25 years. Pricing may be fixed, fixed with escalators, or floating. A fixed price with an escalator is a fixed price that changes by a certain percentage every year or otherwise specified time frame to reflect an inflator or an index of a known variable. A floating price varies according to prices reported by unbiased sources, such as newspapers quotations. Prices, both fixed and floating, may also be limited to a maximum ceiling price or a minimum floor price for the term of the contract. The terms of delivery may be firm or flexible. Today, prices are often tied to market gas prices, especially in North America and Europe. LNG exporters are forced to accept fluctuating prices linked to market gas prices in the buying country, with or without floor and ceiling prices. The delivery point is the physical location where gas is delivered to the buyer. It could be at the gate of the power plant, an interconnection of two pipeline systems, the site of a compressor, international border, or the fence of an LNG plant. The contract clearly states the quality of gas, including its maximum and minimum heating values (in Btu/MMcf units). If the seller delivers off-specification gas, purchasers may be able to demand a discount, a reduction in contract obligations for the period, or other remedies as specified in the contract.

3.1.5. Customer evaluation model – CAPEX, OPEX, LCC and soft factors

Before taking the decision to invest in a power plant, which means making a substantial, long-term investment in a market with many risks and uncertainties, investors have to find answers to pivotal questions, for example like:

- Which power generation technology is most suitable for my investment purpose and the target market? Is a coal plant or a combined-cycle power plant the better approach?
- Which power plant supplier offers the most economical solution?
What is the impact of power output, efficiency, availability and other factors on the competitiveness of a concept?

Service: Are there tradeoffs between new unit investment price and O&M cost during the operating life time? Lower availability vs. higher efficiency, what is better?

Most investors tend to favor those answers and to select those solutions, which promise to deliver the highest customer value and the best investment profitability. They use economic evaluation models to identify the highest value solutions and offers.

As a logical consequence power plant manufacturers and other players in the power generation market also use these evaluation models in an effort to understand the customer’s investment decisions and to anticipate customer moves based on the existing own product portfolio as well as competitor offers. Economical evaluation models help the manufacturers to improve their offers in terms of customer value, to optimize their target pricing and to better understand their customers’ needs based on value proposition. On a more medium and long-term perspective economic evaluation models can help to predict future customer behavior or even the development of entire markets. Evaluation results contribute to improving power plant solutions and technologies and provide decision guidance when formulating product portfolios and product development roadmaps as well as shaping the strategic positioning in a global market.

The goal of all enterprises is to maximize their value by transforming monetary wealth into assets by making investments. These assets are expected to generate value and profit over their life time, which will spawn the monetary resources necessary for future investments. In order to quantify value generation, the metric of cash flow is used. The cash flow represents the sum of all in- and outgoing payments in one period and thus reflects the change in the asset’s value. This metric is the basis of the life cycle cost (LCC) evaluations to determine customer value generation over the life time of a product or project.

One of the fundamental investment principles is the fact, that money loses value over time and that the value of future money is related to the risk of its investment. This is easily understood, when you compare the rather limited expected earnings of a low-risk savings account with those of a more risky investment in shares, where the expected earnings may be higher, but where you could also face the complete loss of your investment. This principle is considered in LCC evaluations by using present value to determine today’s value of a future or past monetary value. The nominal value of any cash flow is discounted at the discount rate, which is an external
A parameter that reflects an interest rate that can be earned through reinvestment (e.g. an average rate of return of an investor’s investments or the weighted average cost of capital).

\[
\text{Present Value (period } n) = \frac{\text{Cash Flow}}{(1+\text{Interest})^n} = \frac{15}{(1+8\%)^5} = 10.2
\]

Figure 6 Key valuation factor: “Net Present Value” Cash Flow and Present Value

The accumulated sum of the present values of the cash flows generated by the investment over its life time is called net present value (NPV). If NPV is > 0, the investor has earned the money to repay the equity investment plus interest, paid all operating costs of the asset and has received the additional absolute today value of the NPV.

Figure 7 Key valuation factor: “Net Present Value”
The NPV shows the absolute value of an investment generated over its life time based on today’s monetary value. In order to determine the relative profitability of an investment, the key valuation factor internal rate of return (IRR) is used. The IRR is defined to be that discount rate, which has to be set to achieve an NPV of exactly 0 at the end of the life time. The IRR can be viewed as the maximum interest rate which could be paid on borrowed capital and still break even.

Another key valuation factor to compare different investment projects, competitor offers or technology options is levelized electricity cost (LEC). It is the constant unit cost (per kWh or MWh) of a payment stream that has the same present value as the total cost of building and operating a generating plant over its life and considers equity investment, debt service, operating expenses (e.g. fuel cost, personnel etc.) and taxes.

A cash flow and NPV evaluation of a typical combined-cycle power plant over its life time of 20 years may look like the example depicted below. It is visible how positive and negative cash flows develop over time and how they affect profitability and value generation in a project.

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![Figure 8 Example Cash Flow Chart](image)

The competitiveness and profitability and thus the ability of a power plant to generate value for its owner are influenced by a range of key factors, which can be divided into the areas of capital investment, technical characteristics/performance and operating cost. These factors and their
development over time are represented by the positive (earnings) and negative (cost) cash flows evaluated in a LCC analysis. Some of these factors can be precisely determined, some of them are volatile (e.g. gas and electricity prices) and can only be vaguely mapped and especially the prediction of their future performance may be associated with a relatively high degree of uncertainty. This uncertainty also affects the validity and sensitivity of the evaluation metrics at changing economic boundary conditions. An overview of the most important cost and earnings factors is shown below.

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<th>Operating Costs</th>
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<th>Financials</th>
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<td>Power Output</td>
<td>Investment Volume</td>
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<td>Maintenance</td>
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**Figure 9 Key Factors for Competitiveness**

Different power generation market structures and changing economic boundary conditions worldwide lead customers to employing different metrics and evaluation approaches for the valuation of a power plant project. The figure below shows the regional distribution of evaluation models.
The cash flow based present value analysis (also called “Cost of Purchase” CoP analysis), which we have discussed before, is used by about 20% of the power plant investors worldwide, especially in liberalized power generation markets, where investment profitability is the strongest driver. Another large group with about 30% share are those customers, who base their investment decisions on power generation cost (LEC), mainly in those countries that still have state-regulated electricity markets, where power producers have to meet an electricity tariff set by the regulating authorities.

3.2. EPC Phase

3.2.1. EPC phase – Advantages of Energy Solutions as OEM EPC

Most trusted partner
Siemens Energy Solution is a strong partner when it comes to power plant business with worldwide references and excellent reputation. More than 24 GT’s of Siemens H-class Technology has been sold already and are currently in preparation, under construction or in
commercial operation (Figure 11). This outstanding number of H-class gas turbines is a proof for the trust of our customers in Siemens H-class Technology.

Each project has been finished on time or even completed ahead of schedule. Figure 12 shows an extract of a press release regarding the high performance of the EPC at Cape Canaveral.

**Figure 11** References Siemens H-class Technology

**Figure 12** High EPC performance of Cape Canaveral

*Press on Cape Canaveral*

'This plant uses 33 percent less fuel to generate electricity. FPL said it expects the new plant to more than pay for itself with fuel savings.'

'The new facility generates power with half the rate of carbon dioxide emissions and more than 90 percent fewer air emissions.'

'The plant is capable of producing more than 1,200 megawatts of electricity or enough to power approximately 250,000 homes and businesses roughly double the amount generated by the previous plant – without using any additional water or land.'

'Construction was completed more than a month ahead of schedule and under customer budget.'
Figure 13 shows the Provisional Acceptance Certificate of Dangjin CCPP 3 which is the first power plant in Asia to exceed 60% net efficiency. Besides this outstanding performance the single shaft arrangement will provide a world record operational flexibility that will enable cycling and frequent start and stop cycles.

**Figure 13 (Bugok 3) Commercial operation prior to contractual schedule**

![Provisional Acceptance Certificate](image)

Cutting Edge Integration

As a solution provider, predesigned modules and reference power plants build the basis for an optimal balance between capital cost, plant performance and plant operation and maintenance behavior. The Integration of the Package into the entire power plant out of one hand goes along with economical, operational, and technological benefits. Each component is designed and integrated to focus on the optimization of the entire power plant. Energy Solution is the conductor in a perfect symphony to ensure high class Technology, performance, reliability and operational behavior for optimization of customer’s value.

Following leading technologies have been tested successfully on site and are basis of our successful H-class Technology:
- First combined cycle application breaking the 60% efficiency limit currently holding world record
- Fast Cycling and rapid start up system to ramp up to half a Gigawatt in less than half an hour
- Plant fast shut down achieved in less than 30 minutes
- Fast cycling dynamic load tests with excellent capability to effectively contribute to grid stabilization and to run in a fast load following mode.
- Operational efficiency comprising highest efficiency throughout the whole load range
- Zero liquid discharge to minimize the necessary water and over exceed worldwide expectation in Environmental standards
- Siemens is owner of the famous BENSON Technology in combination with advanced water steam cycles with 600°C steam temperatures with triple pressure reheat for highest demand in efficiency, reliability and operational flexibility
- Benchmark lead times for early power production
- Optimized degradation for highest business case over the lifetime of the power plant

Siemens has a worldwide network of service with profound knowledge and understanding of local needs and markets due to a high degree of localization. A fast response time with flexible and cost effective solution is given by this organizational setup. Siemens provides a broad range of in-house capabilities with a full portfolio of services that include plant engineering, procurement, transportation, construction, Technical field assistance (TFA), commissioning and operation and maintenance (O&M). Siemens Energy Solution ensures that each unit perfectly corporate with each other for best in class power plant solutions with integrated solutions at the highest quality tailored to your needs.

### 3.3. Warranty & Service

Siemens’ fossil energy organization is committed to the entire life cycle of its customers’ power plant and aims to be a reliable and dedicated project partner. After the turnkey erection of the plant, Siemens new plant organization (Siemens Energy Solutions) grants a defects liability period of typically two years. Besides the defects liability for the delivered scope, customers need a strong service partner who has expert knowledge in maintaining power plants and from whom
the customers can obtain operational support and technical advisory. Siemens has divided its service and new plant organization in order to fully focus on their particular core competencies and to be more flexible towards customer requests. The aim of Siemens Energy Service is to continuously improve its service products in order to provide superior performance for their customers’ assets. The portfolio of Energy Service includes long term service contracts, spare parts, maintenance and repairs on case by case basis, modernizations and upgrades as well as training and consulting. The objective is to accompany the customer from a point in time before begin of commercial operation to the end of the project. Therefore, at the beginning the service activities are performed in parallel to the defects liability period of Siemens Energy Solutions, however the portfolio of services reaches until the end of the lifetime of the plant.

There are many reasons for customers to choose a LTP instead of purchasing services on a case by case basis. LTPs often have a long duration and are a commitment for the customer as well as for Siemens Energy Service, however both parties benefit of the value it creates. Figure 14 summarizes the beneficial relationship between plant owner and Energy Service under a LTP:

**Figure 14 Customer benefits**

<table>
<thead>
<tr>
<th>Customer's Needs</th>
<th>Customer's Benefits</th>
<th>Siemens' Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>High power &amp; efficiency output</td>
<td>Performance increase</td>
<td>Greater customer intimacy &amp; feedback</td>
</tr>
<tr>
<td>Operating flexibility</td>
<td>Lower and predictable costs</td>
<td>Ability to invest &amp; smart investing</td>
</tr>
<tr>
<td>High reliability &amp; availability</td>
<td>Higher dispatch rates / Higher availability</td>
<td>Optimised capacity</td>
</tr>
<tr>
<td>Low maintenance costs</td>
<td>More profit potential</td>
<td></td>
</tr>
<tr>
<td>Low emissions</td>
<td>Higher project returns</td>
<td></td>
</tr>
</tbody>
</table>

The key question for Energy Service is how can Siemens help the customers generate maximum benefit out of the experienced services Siemens delivers under long term service agreements? From customer perspective it is important to allocate the risks between himself and Siemens in a way so that each contract party can provide its best capabilities to project success. Customers aim at predictable service costs, higher performance and fulfillment of financing requirements as well as insurance requests. In order to optimize their project’s life cycle success, customers need to find their best suiting EPC scope and service program at the very project start – Siemens provides
OEM turbo machinery, EPC concepts and long term service out of one hand. The division between new plant investment and service contract investment in terms of CAPEX and OPEX as well the service driven project parameters support the LCC optimization. Figure 15 illustrates the influence of a service contract on cash flow drivers:

3.3.1. Service scope variants – LTP and O&M

Long term service agreements of Siemens Service are tailor-made to the customer’s needs. Figure 16 and Figure 17 illustrate the various scopes of service programs, whereas Long Term Programs (LTP) and Operation & Maintenance Service Agreements (O&M) are customers’ first choices.
Besides the standard scope definitions like LTP and O&M, Energy Service also offers variants, e.g. Full Scope Maintenance (FSM) with Operation Supervisor or LTP including deployment of a resident engineer at the customer’s site. In general Energy Service seeks to fulfill customers’ needs, which is why any contractual design and scope adjustment is generally thinkable.
Provided a plant owner is prepared to commit himself to a partnership with Energy Service, the customer enables optimized service, life cycle success and mutual benefit in the service partnership.

Siemens’ long term service programs come with premium program management. The plant owner gets access to Siemens’ vast global expert knowledge, however enjoys the comfort to communicate with only one single point of contact. The program manager is involved from the very beginning of the service partnership and is dedicated to the customer’s service contract.

Figure 18 Benefit: Program Management (Onshore & Offshore)

Plant owners mostly decide to conclude a LTP in order to create a fruitful service partnership with their service supplier of choice Siemens Energy Service. LTPs typically include the scheduled maintenance on the OEM core equipment (customized to needs of customer):

- Fixed scope for all scheduled outage services
- OEM parts, repairs and turnkey outage services
- Typically covering OEM core equipment (e.g. GT, ST and Geno)
- Risk sharing through Term Warranty
- Dedicated Program Management
- Remote diagnostics

Plant owners gain advantages by concluding a LTP contract with Energy Service, because they benefit from OEM’s expertise, are enabled to calculate with predictable budget incl. fixed
payments and enjoy long term discounts – all factors supporting the project’s life cycle success. The plant owner receives Term Warranty “insurance”, enhanced performance warranties, engineering support, and access to newest upgrades/developments, fixed prices for extra purchases plus predictable lump sum service costs and volume discount on the program scope. A typical project timeline for the conclusion of a LTP contract is shown in Figure 19. As mentioned before the foundation for life cycle success is created particularly in the project phase before start of commercial operation.

Figure 19 LTP Project timeline

Operation and Maintenance service agreements (O&M) typically include operation and maintenance of the complete plant (customized to needs of customer), i.e. O&Ms represent a care free package which may ease customers’ mind:

- All scheduled outage services and routine (day-to-day) maintenance
- Plant operations
- Focusing on the total plant (incl. spares, performance and environment)
- High predictable maintenance costs
- Dedicated program management
- Full site staff
- Remote monitoring and diagnostics
- Plant management IT systems

Figure 20 illustrates the comprehensive scope of O&Ms:

<table>
<thead>
<tr>
<th>O&amp;M Management</th>
<th>Non Siemens OEM</th>
<th>Siemens OEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduled Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unscheduled Maintenance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Unscheduled outages of Siemens OEM dependent on warranty conditions

Pass Through Costs if required
Included in O&M Option Siemens OEM

Steam Generator & Balance of Plant
HRSG
Gas Turbine
Generator
Steam Turbine

Figure 20 O&M Maintenance Scope

To summarize, plant owners obtain a lot of advantages by concluding a long term service program – LTP, FSM or O&M – which support their life cycle model, by e.g.:

- Reduced technical risk, improved plant reliability
- Reduced financial risk, more predictable budget
- Enhanced risk sharing, extended Performance Warranties
- Complete outage planning & coordination by Siemens
- Optimized emergency response
- Optimal parts utilization
- Reduced logistical requirements & inventory
- One point of contact
- High quality through OEM parts, repairs and services
- Offer of latest technology advancement

Therefore the value add to the customer by a long term service agreement is eventually lower generation costs, improved revenue stream and higher project returns.
3.3.2. Service concepts – The Siemens BOX Model

The service concept of choice is the BOX model for the cutting-edge gas turbine SGT5/6–8000H, because the Box model enables the power plant operator to flexibly operate his power plant while enjoying maximum transparency in life consumption and contractual cost.

The Siemens Box model divides the turbine life consumption counting into Equivalent Base Hours (EBH) and Equivalent Starts (ES). For power plants operating with standard natural gas the EBH normally go along with actual time operating hours, since in most cases no special operation conditions and therefore no penalization applies. In general the biggest burden for combustion turbines are changes in temperature – the quicker the temperature change and the higher temperature delta, the higher the technical stress for the components of the combustion machine. The challenge lies in the measurement of this machine stress and aggregating it into one simple number – the number of Equivalent Starts (ES). The combination of EBH and ES creates the BOX model, considering the duration of operation and the technical stress of the combustion machine in terms of starts, trips, fuel quality and operation. The customer always experiences transparent information of the machines’ service requirement and can consume EBH and ES in the boxes’ boundaries. In Figure 21 the Box model is compared with a standard life consumption model, whereas the additional operation period with the BOX model under LTMP is depending on the customer’s operating regime. The Siemens BOX concept allows currently the highest flexibility in the market.
Figure 21 Inspection Schedule

Figure 22 depicts the service intervals and outage scopes of the 25BOX model of the cutting-edge gas turbine SGT5/6-8000H, which is the heart of Siemens’ state-of-the-art SCC5/6-8000H power plants.

Figure 22 Maintenance - Scheduled Outage (8000H)
A Combustor Inspection (CI) is to be conducted every 12,500 EBH, whichever occurs first. CIs can be performed within a short time frame and with deployment of a minimum number of Siemens experts. The SGT5/6-8000H rotor design is featuring rotor disks which are aligned on a tie-rod by hirth serration and enables short cool-down time of about one day, wherefore standstill times are at minimum. The short cool-down time together with limited hot recommissioning complexity is a differentiator to other OEMs’ gas turbines and a value add to the customer. The value add substantiates in a higher confidence in outage duration planning and generally shorter outage times – assuming eight or more combustor inspections in the plant’s life time, outage times constitute a decisive factor for customers life cycle cost.

The first inspection of the hot gas path is to take place after 25,000 EBH, whichever occurs first. The first Major Overhaul (MO) is planned after 50,000 EBH, whichever occurs first. For HGPIs and MOs all advantages of afore mentioned CIs apply, too. In general CIs serve to visually assess if the machine is ready to run the full cycle of 25 kEBH. At HGPIs and MOs Siemens Energy Service assesses the machine more comprehensively and exchanges particular components, if necessary. The necessity to exchange is due to time related wear effects like internal creep, mechanical loading, oxidization, vibrations and erosion, as well as cyclic related wear effects. Therefore the 25BOX model under a long term service program secures high and reliable performance and brings clarity and predictability to operator’s maintenance costs.

3.3.3. Service friendly machine design

A combustion machine is strained by many effects which contribute to the aging of the machine’s components. Figure 23 illustrates the aging effects for the SGT-8000H gas turbine.
The aging of gas turbines have to be assessed during planed outages. During CIs the turbine’s combustion system is inspected via accessible manholes and via boroscope. Figure 24 illustrates the different areas of HGPI and MO, which are effected in an outage. In case the plant is operated for a very long period of time, possibly a rotor inspection can be conducted after 166 kEBH of operation in order to further ensure the reliable operation of the machine. In contrast to other OEMs the rotor inspection is conducted on customer’s site. By means of a rotor inspection the life time of the machine’s body and the machine’s rotor are harmonized, which is a differentiator to other OEM’s rotors, which need to be exchanged within the gas turbine’s life time. The spare rotor needs to be purchased and stored by the plant owner, which is not required for Siemens gas turbines due to the superior rotor inspection concept.
Maintainability and service friendly design are guideline principles in Siemens gas turbine development. For example the SGT-8000H is designed for turbine vane carrier roll-out and roll-in without rotor lift, i.e. capability to exchange stationary turbine hardware without rotor lift. Another example for service friendly design is the capability to exchange all rotating blades without rotor lift. This is one design factor to enable optimized outage times and high availability. Siemens invested into the development of special service tools which are the key to perform top-notch services at customer’s site. In general Siemens Energy Service undertakes its best endeavors that the majority of upgrades and mods are retrofittable to earlier machines of the same frame in order to secure plant owners investment – another factor for life cycle considerations.

3.3.4. Service guarantees

Siemens offers guarantees in the framework of its long term contracts, because LTPs and other long term service agreements enable Siemens to become acquainted with the plant owner and his project. The portfolio of Siemens service guarantees includes Availability Guarantee, Reliability Guarantee, Scheduled Outage Duration Guarantee, Term Warranty on highly strained hot gas
path parts, Heat Rate Degradation Guarantee, Power Output Guarantee and more. Therefore a long term service agreement with Siemens puts the customer into the position to pool his risks with Siemens Energy Service according to their respective capabilities.

**Reliability, Outage Duration, Availability**
Reliability, Outage Duration and Availability need also to be considered in a comprehensive life cycle model, because they have direct impact on the project success. The customer is only in the position to generate revenues when the plant is available to the dispatcher. Moreover reliable running reduces business interruptions and saves technical life consumption. In combined heat and power projects the plants reliability is even the pivotal key to the plant owner since the owner might have contractual commitments to have the plant running.

Siemens can ensure high reliability and availability numbers of its technologies because it is an integrated supplier of energy products, technologies and services - Siemens is OEM gas turbine manufacturer, EPC supplier and experienced power plant service partner.

**Performance-Degradation guarantee**
The heat rate and power output degradation guarantee enables customers to forecast the technical performance of the plant and puts the customer into the position to plan his business more accurately. Due to moderate turbine firing temperatures Siemens may offer moderate degradation. The degradation will be agreed in the contract by the service partners, while the actual degradation is tested periodically after HGPIs and MOs.

**Term Warranty**
Siemens grants a Term Warranty on hot gas path parts in the framework of long term service programs. The Term Warranty is a comprehensive approach to share OEM’s and owner’s risks according to their capabilities, whereas Siemens is the only OEM offering this comprehensive Term Warranty approach in the market.

The basic concept of Term Warranty is to harmonize the warranty duration of program parts with the customer’s operation regime respectively the exchange interval of program parts, while taking over the customer’s scrape rate risk and reducing the customer’s logistics and handling efforts. The program part’s warranty is not limited to a duration of only one year after its installation, as
it is the standard for other OEMs in the market. In contrast Siemens warrants that its installed program parts do not require repair or replacement due to defects in material or workmanship or due to normal wear and tear within one entire HGPI interval – program parts are the most strained and most expensive hot gas path parts. The concrete benefit for the customer is that in case a program part fails under Term Warranty Siemens Energy Service will replace the respective part free of charge. Moreover and also more important is the shift of the scrape rate risk from the customer towards Siemens. Siemens Energy Service grants that the program parts last the interval as mentioned above and exchanges the program parts during HGPIs and MOs on Siemens sole scrape rate risk, i.e. plant owners get ease of mind in terms of increased scrape rate and repair cost since both is covered under Term Warranty. Therefore plant owners may plan expenses and cash flow more accurate, which is important for the life cycle model commercial-wise. The program parts of the SGT-8000H are shown in Figure 25:

Figure 25 Benefit - Supply of Program Parts (8000H)

In addition to Term Warranty Siemens Energy Service may also offer an Unscheduled Outage Coverage. In cases of unscheduled outages Siemens Energy Service may participate on the customer’s financial impact, which is additional coverage for the plant owner besides his insurance coverage.
To summarize the Term Warranty concept has been designed considering customers’ needs, who wants to obtain transparency and reduce risks, which are not in the field of their expert knowledge. With Siemens’ Term Warranty the customer and Siemens pool risks according to their capability in the respective subject matters.

3.3.5. Operational Monitoring - Power Diagnostics, TDY and O&M Fleet

Siemens is a fully-integrated supplier of power generation technology and services. Besides Siemens’ vast experience in the field of new power plants, Siemens is also an experienced service supplier featuring a long track record of power plant operation under O&M contracts (see Figure 26 & Figure 27).

![Annual GWh Generated / Consumed by Organization / Country](image)

Figure 26 Siemens O&M - Global Player in Energy Production
This pool of knowledge sources supports Siemens in offering remote diagnostics services - Power Diagnostics®. Hardware failures, plant instrumentation malfunctions or I&C control logic issues may result in failed start attempts, engine trips, and power output and heat rate
degradation. The objective of Siemens remote monitoring is the maintenance of highest plant reliability through the detection of operating anomalies long before they would normally be observed by plant personnel. In general, the remote monitoring methodology is to observe and analyze long term trends in operating data – using sophisticated analytical software and a technical and engineering staff specialized and experienced in such complex analysis. In case deviation from normal operation is noticed, diagnostics and root cause analyses are initiated. The first Power Diagnostics® data acquisition system was commissioned in 1998. Today, data from more than 450 units are collected, transferred into the Siemens Power Diagnostic Centers office and are monitored daily and world wide. Power Diagnostics® can monitor Gas Turbines, Steam Turbines, Generators and combined cycle balance of plant equipment.

Many information and factors are considered before taking decisions regarding corrective actions following diagnostics findings. Some of the factors that must be considered are the plant’s dispatch requirements and dispatch schedule, hardware and labor costs and availability, contractual arrangements and safety requirements. The early detection of abnormal operating conditions provided by Siemens remote monitoring system enables the plant operator to take a more proactive approach in order to make an informed decision. This will:

- Help to reduce number of trips and failed starts by:
  - Catching intermittent or failing instrumentation before the control system responds
  - Early detection of hardware issues
- Reduce outages duration by:
  - Focused inspections;
  - Better understanding of support needed (parts, tools, personnel).
- Improve profitability through:
  - Monitoring operation key performance indicators and assessment of improvement potentials;
  - Early detection of unexpected changes in operating performance by deviation from normal operating behavior;
  - Access to the expert network within Siemens back office.

The benefits of Power Diagnostics® Services are illustrated in Figure 29:
Main Features

- Online, real-time remote monitoring
- Features advanced diagnostics tools
- Data acquisition & Processing
- Analysis
- Diagnoses power plant operation
- Plant operation & optimisation

Outcome / Benefits:

- Early detection of abnormal operation
- Profound Root Cause analysis
- Scheduled outage instead of Forced Outage
- Timely Repair Planning

Figure 29 Benefit – Power Diagnostics® Services

4. Life cycle cost case study for an Asian combined cycle power plant

4.1. Case Study – CCPP in Korea featuring a Long Term Program

The followings illustrate a possible increase of customer benefits, considering the advantages, which Siemens offers along the whole power plant life cycle. Therefore, in a life cycle cost case study, an Asian combined cycle power plant by a standard EPC provider has been compared with a Siemens optimized power plant for the region Korea. The possible quantified improvements are listed below:

Lead Time

The development and optimization of predefined modules in combination with improved processes in terms of procurement and construction leads to benchmark lead times of Siemens power plant projects. The construction and commissioning schedule have been optimized on each other to guarantee early power production. An improvement of around 3 months is realistic in comparison to a standard EPC provider.
Optimized start-up times

The cycling capability of a power plant is getting more and more important in the energy business as increasing share of renewables amongst other requires full flexibility of the power producers.

Siemens Fast Cycling (FACY™) Technology optimizes the start-up efficiency which leads to a drastic reduction of fuel consumption. The optimization of the start-up procedure from ignition of the gas turbine to Base load power production leads to a reduction of around 40 minutes in comparison to the competition. Based on these two effects, Siemens Fast Cycling Technology guarantees optimized fuel consumption driven by highest start-up efficiencies in combination with increased power production as a Siemens Power plant delivers far earlier base load energy while the competition is still in the ramp-up procedure.

Based on a typical annual start-up regime of 145 hot starts, 45 warm starts and 5 cold starts a benefit of >1.5Mio € during the start-up procedure can be generated within one year for a typical power plant in the Asian region.

Service

Technically OEM services allow for short outage durations, early detection of technical inconsistencies via Power Diagnostics as well as early planning and implementation of technical improvements. Therefore the plant owner enjoys higher availability when conducting a long term contract with Siemens Energy Service. Furthermore the “full-fledged Siemens” plant with OEM service contract enables the customer to negotiate a reduction of his insurance costs, because insurers appreciate OEM services due to their fleet knowledge and vast experiences of the OEM.
Case Study
The result of an exemplary LCC evaluation in Figure 30 shows the significant customer benefits.

<table>
<thead>
<tr>
<th></th>
<th>Standard EPC Provider</th>
<th>Siemens optimized Power Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>IRR (over whole life cycle)</td>
<td>11,06 %</td>
<td>14,56 %</td>
</tr>
<tr>
<td>NPV (over whole life cycle)</td>
<td>25,321 EURMio</td>
<td>53,141 EURMio</td>
</tr>
<tr>
<td>Payback Period</td>
<td>17,1 years</td>
<td>14 years</td>
</tr>
<tr>
<td>ø Electricity Generation Cost (Present Value)</td>
<td>8,92 Ct/kWh</td>
<td>8,75 Ct/kWh</td>
</tr>
<tr>
<td>Debt Service Coverage Ratio (Min.)</td>
<td>1,08 in 2016</td>
<td>1,19 in 2016</td>
</tr>
</tbody>
</table>

Figure 30 Illustration of possible customer benefits with a Siemens optimized Power Plant

Over the whole power plant life cycle, the above mentioned advantages result in around 3,5% higher IRR or 28 Mio. € higher NPV. With a Siemens optimized power plant, investors could reduce their payback period by 3 years and expect a decrease of the average electricity generation cost of 0,2 Ct/kWh. Nevertheless, in this illustration the advantage of Siemens' part load efficiency hasn't been taken into consideration yet. By taking further factors, e.g. part load efficiency, for the life cycle evaluation into account, investors could even expect a higher customer benefit.

4.2. O&M Power Plant in the Philippines – Firsthand account

With a capacity of approximately 1,500 Megawatts, First Gen Corporation is running two power plants - Santa Rita and San Lorenzo - in Batangas, both built by Siemens. From the beginning, Siemens was entrusted with operating and maintaining the facilities within the scope of a full-scale O&M contract, which has been extended for another 15 years in 2010.

Jon Russell, Executive Vice President at First Gen Corporation, describes their Siemens partner as follows: “Our colleagues at Siemens are well known for their engineering prowess and take pride in the quality of their service. They did a great job on the first phase, so naturally we were keen to look at them for the second phase also. The plants in Batangas have performed very smoothly and reliably and we need to make sure that this continues.”
Ensuring smooth operations in large facilities is exactly the idea of O&M contracts and the advantage of choosing a global partner like Siemens with its OEM-EPC and service expertise. “While we do not hope for problems, we are aware that if anything comes up, Siemens has the service and technological resources to make sure that all issues are solved. Usually they apply them to avoid disturbances. But if anything arises, we know that Siemens will solve the issue”, asserts Russell.

Especially in regard to the whole life cycle, Siemens is a competent partner, who provides in addition to the comprehensive overhauls, with the continuous technological development, suggestions for enhancing upgrades and modernizations.

“The net result is in fact roughly 7 percent better than the guarantee level. Approximately 3 percent of the excess productivity in the past ten years came from good operational practices, while the other 4 percent came from equipment upgrades that lead to capacity growth and efficiency gains, First Gen estimates.

Russell’s remarks, “Like a fine wine, the Siemens plant actually improves with age.”

In the search for value for combined cycle power plants, Siemens provides solutions over the whole plant life cycle.

5. Conclusion – Planning and competent partners are the key for commercial project success

The challenges that are faced by individual energy systems vary from region to region. But one thing for sure: sustainable energy supplies are needed all over the world. Highly efficient natural gas power plants almost always hold the key to success, as several examples in Asia illustrate.

Siemens guides you through the complete process and helps you by:
- Setting the strategic direction for a future-proof combined cycle power plant solution
- Analysis-driven recommendations for planned investments to meet current and future market needs
- Workflow-oriented design methodologies and professional project management for efficient and cost-effective energy solution concepts that are on schedule and within budget
- Performance monitoring, operation and maintenance service for enhancements in the power plant operation and financial performance

To keep pace with global competition, you need a partner with international experience – one who provides the necessary expertise for all project related measures. You also need a partner who can draw on a wealth of international experience to provide you with unique, valuable knowledge right from the start. This includes knowledge of both legal regulations that vary by regions as well as local conditions for planning and integrations of culture-specific requirements.

**Siemens Energy Solutions** supports you with turn-key solution required for your future endeavor for high efficiency combined cycle power plant – focused on the needs and targets of your energy organization:

- Development and/or enhancement of **project ideas**
- **Consulting** and **financing**
- Overall **design** considering **commercial evaluation model for life-cycle**
- **Engineering, Procurement, Construction** and **Commissioning**
- **Lifetime Service Partnership**
6. Disclaimer

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