Renewable Generation Expansion Planning Based on Power Purchasing Agreement

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***Abstract*— An incentive based program presents in this paper in order to motive the resource expansion planner in a restructured power system. Power Purchasing Agreements (PPAs) are the recent contracts between Generation Companies (GENCOs) and Independent System Operator (ISO) which is right-of way of this paper. After restructuring in power system, lack of motivations for Independent Power Producers (IPPs) to partnership in power generation and long term maintaining energy have affect the long horizon expansion planning. In this area, long term contracts can help the market entities to hedging their risks in satisfying the future demands and ensuring the return of their investment cost. From an IPP point of view, clarifying the rate of return of investment has an important role in his financial decision making. In competitive power market, each GENCO would offer in the market and some of them could exercise market power in power market. One of the proposed ways to controlling the market power is PPA. The aforementioned PPAs are also guarantied the renewable resource planning which need high capital investment. In this paper, the framework of this PPA is proposed and some technical aspects of renewable PPAS are also presented.**

***Keywords*—** Renewable Generation Expansion Planning, Power Purchasing Agreement and Independent System Operator

I. INTRODUCTION

Generation Expansion Planning (GEP) is one of the most important issues in long-term power system planning. In from past, investigators noticed to GEP and supply of energy. In power system planning, generation expansion planning is performed for 5-years planning horizon or more. There are two main objective functions in GEP. First is the minimization of investment cost and another one is the maximization of reliability. GEP use future likeable engineering economics function, in order to drive certain indicator. Supply of fuel problem is one of the most important of effective factors for result. For this reason, sometimes GEP and fuel supply center go hand-in-hand [1]. Energy, Environment, Economy (EEE) is among of basic challenges in electricity industry for the 21st century. Supplying of energy with the minimum levels of possible environment contaminations, costs and the maximum levels of reliability, is an important problem in the industrialized societies. Generation companies (GENCo) has tendency to utilize more efficiency, economy, secure units with the minimum level of pollutant gasses by electricity industry restructuring, privatization and separation between Generation, Transmission, Distribution parts and to have more competition in these parts [2]. Renewable resources planning are also interested in last two decades. In this area, along with the in renewable technological developing, but the investment risk of renewable expansion is very high because of their expense capital. PPA is one of the solutions in order to hedging the risk of these expenses.

Power Purchase Agreements are contracts between two parties, one who generates electricity for the purpose of sale (the seller) and one who is looking to purchase electricity (the buyer). There are various forms of Power Purchase Agreements; these are differentiated by the source of energy harnessed (solar, wind, etc.). Financing for the project is delineated in the contract, which also specifies relevant dates of the project coming into effect, when the project will begin commercial operation, and a termination date for which the contract may be renewed or abandoned. All sales of electricity are metered to provide both seller and buyer with the most accurate information about the amount of electricity generated and bought. Rates for electricity are agreed upon in the contract between both parties to provide an economic incentive to being a Power Purchase Agreement [3].

A Power Purchase Agreement is a legal contract between an electricity generator (provider) and a power purchaser (buyer). Contractual terms may last anywhere between 15 and 20 years, and during this time the power purchaser buys energy, and sometimes also capacity and/or ancillary services, from the electricity generator. Such agreements play a key role in the financing of independently owned (i.e. not owned by a utility) electricity generating assets. The seller under the PPA is typically an Independent Power Producer (IPP). Energy sales by regulated utilities are typically highly regulated by local or state government, so that no PPA is required or appropriate. Commercial PPA providers can enable businesses, schools, governments, and utilities to benefit from predictable, renewable energy [4].

Under a PPA, the seller is often the developer and owner

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of the technology that generates electricity. The seller may also be someone who buys electricity from another supplier for resale. Under these circumstances, another PPA may be established but will usually contain similar contractual agreements as already proclaimed in the original PPA, with the exception of some pricing mechanisms that would be redefined [5].

Under a PPA, the buyer is often a utility company that purchases the electricity generated from the seller. In some circumstances, a company may be trying to meet renewable-energy portfolio standards and would be considered a retail purchaser. Under this condition, the retail purchaser may resell the electricity to another entity under a new PPA. Typically, a PPA is established between the primary seller and a utility company who is regulated to buy the electricity [5].

This paper as follows. Theoretical consideration of renewable PPAs and investment policies of these units are addressed in section II and III, respectively. Power purchasing agreement policy making is presented in section IV. Section V addresses the simulation results of incorporating a typical renewable generation unit. Conclusion of this paper is conducted in last section.

II. RENEWABLE POWER PURCHASING AGREEMENTS

From past to now, many studies with different approaches is presented about solving of GEP's problem. Commonly, one multi-objective problem of GEP with different approaches such as minimizing investment cost, environmental issues, reliability, fuel and transmission loss allocation, security and recently investment in generation network expansion by using DG units is presented in [6].

In this paper, coordination of main infrastructures for supplying of thermal energy is considered. For example, about hydroelectric units, the necessary and sufficient condition is coordination between these units and Down-Stream (DS) units, Up-Stream (US) units and Pumped-Storage (PS) ones.

In the case of decision on construction of a hydroelectric unit, studies of electrical energy generation are not the first priority and in importance ranking, it indicated after supplying of drinking and agriculture water and flood control in some cases. Nevertheless, existing of enough water resources is necessary for dam construction. About construction and coordination of pumped-storage units, conditions are different and somewhat similar to the scenario that considered in this article.

Actually, initial infrastructure (water resources for down-stream dam) should be available and accessible to construction of pumped-storage powerhouse. Whatever, the penstock of water transmission will be longer from dam to reservoir; operation and construction will be more expensive. In this case, objective function of problem is minimizing total costs. Technical constraints should be considered this goal.

The construction problem of new thermal powerhouse is very similar to the problem mentioned above and the major difference is that, because of special conditions of problem, should be coordination between natural gas expansion planning and GEP. In this case, the conditions are not established similar to above problem and expansion of each of those cannot independent of another [1-2, 6].

There are regulatory concerns associated with the implementation of renewable technologies and the agreement on contracts for producing and purchasing power. The Federal Energy Regulatory Commission (FERC) determines which facilities are considered to be exempt wholesale generators or qualifying facilities and are applicable for PPAs under the Energy Policy Act of 2005 [7].

There are different types of PPAs according to the type of renewable technology utilized in the electricity generation process. The two most prolific PPAs utilized today are solar PPAs and wind PPAs. Other PPAs will be made commercially available once the technology utilized is established.

In the United States, the Solar Power Purchase Agreement (SPPA) depends heavily on the existence of the solar investment tax credit, which was extended for eight years under the Emergency Economic Stabilization Act of 2008. The SPPA relies on financing partners with a "tax appetite," profits that are subject to taxation, who can benefit from the federal tax credit. Typically, the investor and the solar services provider create a special purpose entity that owns the solar equipment. The solar services provider finances, designs, installs, monitors, and maintains the project [8]. As a result, solar installations are easier for customers to afford because they do not have to pay upfront costs for equipment and installation. Instead, customers pay only for the electricity the system generates [8]. With the passage of the American Recovery and Reinvestment Act of 2009 the solar investment tax credit can be combined with tax exempt financing, significantly reducing the capital required to develop a solar project. Wind Power Purchase Agreements (WPPAs) are not found quite as prolifically as their solar counterparts, but they do exist [5].

Wasatch Wind in Wyoming entered into a twenty year WPPA with PacifiCorp in July 2010; Wasatch Wind will produce wind power in its newly developed Pioneer Wind Park, and PacifiCorp will purchase it [9].

Current law restricts most of the Federal government of the United States from entering into a contract longer than ten years. PPA contracts, particularly for larger systems, need at least a 20 year term [10]. In 2009, the United States Senate Committee on Energy and Natural Resources passed S. 1462, which among other things would have allowed federal agencies to enter into power purchase agreements for renewable energy for up to 30 years. However, the United States Department of Defense has a separate authority to enter into energy contracts for as long as 30 years. Using this authority, the United States Navy recently signed a renewable energy project for Marine Corps Air Station Miramar. All agencies of the US Government are exploring methods to achieve the renewable energy requirements set forth by law [11]. Nellis Air Force Base demonstrates the long term consequences of such an agreement. Completed in 2007, the Nellis Solar Power Plant generates 30 million kilowatt-hours of electricity per year—equivalent to a quarter of the total power used at the 12,000-person base. This arrangement allows Nellis to annually avoid 22,000 tons of carbon dioxide emissions while at the same time save the Air Force over $1 million dollars in electricity costs a year.

Other PPAs will become commercially available once the technology has been established and the market exists for such contractual agreements to be effective. Geothermal PPAs are being explored; their difference from wind and solar PPAs is that the actual gathering of energy would require much more active monitoring and servicing [12].

The PPA is often regarded as the central document in the development of independent electricity generating assets (power plants), and is a key to obtaining project financing for the project. Under the PPA model, the PPA provider would secure funding for the project, maintain and monitor the energy production, and sell the electricity to the host at a contractual price for the term of the contract. The term of a PPA generally lasts between 5 and 25 years. In some renewable energy contracts, the host has the option to purchase the generating equipment from the PPA provider at the end of the term, may renew the contract with different terms, or can request that the equipment be removed.

One of the key benefits of the PPA is that by clearly defining the output of the generating assets (such as a solar electric system) 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 [1] or other financing counterparty. Figure 1 shows the financial and power flows among the consumer, system owner, and the utility [14].

Because a Power Purchase Agreement or Energy Service Agreement is at the "heart" and underlying foundation of recent projects, it can help the business with the selection and oversight of PPA's and ESA's. The projects range in size from as small as 1-2 MW to well over 100 MW. It means that the project development process may include:

- Engineering (including engineering & economic feasibility studies, project
- Design, air quality and site permitting requirements, etc.)
- Procurement
- Construction and Project Management
- Project Commissioning
- Project Funding/Financing
- Power Purchase Agreements
- Long-Term Service Agreements

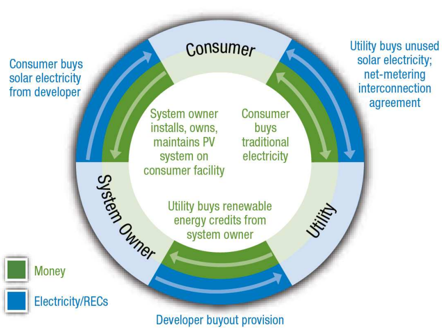

Fig. 1. Contracts and Cash Flow in Third-Party Ownership/PPA Model [13]

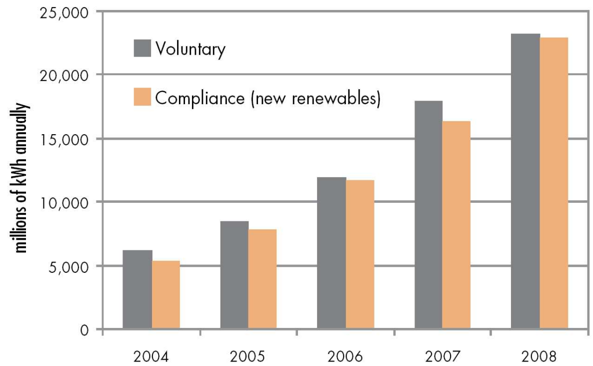

Fig. 2. Comparison of voluntary and compliance markets for renewable energy, 2004–2008 [15]

In conjunction with strategic partners, the committee is able to receive bonding for projects exceeding $100 million in value. In such cases the committee is able to secure funding for power projects that exceed 100 MW.

A Power Purchase Agreement is also "behind" almost every power plant. A PPA is a contract involving the generation and sales of electricity – which is normally developed between the owner of a power plant generating the electricity, and the buyer of the electricity. PPA's can be quite lengthy agreements that may exceed 100 pages in length and take several months to even years to finalize.

The basic information contained in a Power Purchase Agreement includes the following items:

A. Definitions

- Purchase and Sale of Contracted Capacity and Energy (such as steam, hot water and/or chilled water in the case of co-generation and tri-generation plants
- Operation of the Power Plant
- Financing of the Power Plant
- Guarantees of Performance
- Penalties
- Payments
- Force Majeure
- Default and Early Termination
- Miscellaneous

PPAs allow Federal agencies to fund on-site renewable energy projects with no up-front capital costs incurred.

With a PPA, a developer installs a renewable energy system on agency property under an agreement that the agency will purchase the power generated by the system. The agency pays for the system through these power payments over the life of the contract. After installation, the developer owns, operates, and maintains the system for the life of the contract [16].

Power purchase agreements feature a variety of benefits and considerations for Federal agencies, including:

Benefits:

- No up-front capital costs
- Ability to monetize tax incentives

- Typically a known, long-term energy price
- No operations and maintenance responsibilities
- Minimal risk to the agency

Considerations:

- Federal sector experience with PPAs is still growing
- Contract term limitations
- Inherent transaction costs
- Challenges with site access contracts and concerns

III. INVESTMENT SETTING IN UTILITY AND MARKET ENVIRONMENT

In traditional utility environments there are two types of projects, utility construction and independent construction. Utility construction refers to a project in which the power plant is owned and operated by the utility. Before construction, projects must be approved by the state utility commission. The approval process includes a provision for the utility to finance the debt and equity of the project through customer rates.

Independent construction refers to projects in which a new power plant is owned and operated by an independent power producer (IPP). Before construction a power purchasing agreement (PPA) is signed between the producer and the utility; the PPA is subject to the approval of the state utility commission. There are many possible structures for the PPA, but the essence is that the utility provides a guaranteed payment to the producer in exchange for agreed-upon power production and capacity.

Along with approval for the PPA, the state utility commission provides a mechanism for cost recovery to the utility through customer rates.

The common feature of both of these mechanisms is cost recovery through regulated rates. Furthermore, the recovery mechanism is set in place over the lifetime of the project. Banks find this feature very attractive and readily provide financing for such projects.

In nontraditional markets, neither retailers nor power producers are able to demonstrate regulated cost recovery to banks. Banks are less willing to finance projects that don't have cost recovery mechanisms than projects that are backed by a cost recovery mechanism. In a nontraditional market, the only agent that can provide regulatory assurances is the ISO. This presents a bit of a quagmire for federal and local authorities wishing to develop free markets. To ensure financing for new construction, regulatory agencies must provide the ISO with the authority to enter PPAs so that cost recovery can be ensured. Absent such authorization, financing for new construction may be difficult to arrange and the state cannot ensure reliability of supply. Of course, providing such authorization restores a regulated environment, with the ISO assuming the role of the traditional utility. There is tension between the desire to develop free markets and the desire to regulate reliability. Organizing long-term planning activities is difficult in this environment [17].

A. Project Analysis for a Merchant Plant

IPPs select projects that maximize profit. They predict revenues of proposals by performing a simulated dispatch of the proposed power plant against a forecast of fuel and power prices over the time horizon of the project, 20 to 30 years.

Prices assume the role of the system lambda. The result of the simulation provides a projection of financial and physical outputs, revenues, fuel costs, fuel requirements, and power production. This information together with projections of other costs (maintenance, personnel, and capital costs) provides earnings projection. IPPs then perform a standard net present value (NPV) assessment to determine the value of a project; that is, revenue streams are discounted to a present value with a corporate discount rate.

The earnings and associated value are dependent on the power and fuel price forecasts that are used within the dispatch simulation. Each fuel has its own forecasting methodology and is not addressed; it is assumed that a forecast of prices is available. A consensus approach toward power price forecasting is given below.

Price forecasts rely on two components: an energy component and a capacity component. The energy component is the marginal cost of production, system lambda, from a simulated dispatch. The marginal cost of production is insufficient to cover capital costs of new construction. An assumption that is adopted by the forecasting community is that IPPs will be able to recover the full capital costs, both debt and equity, required to build sufficient resources for ensuring reliability. The capacity price component is the difference between full capital costs and energy payments received by selling electricity at the energy price. All units receive both an energy payment and a capacity payment.

Summarizing the approach, once price curves are established, a given project may be assessed by performing an economic dispatch of the proposed project using the forecasted energy and fuel prices over the time horizon of the project. This provides a cash flow from energy revenues. On top of the energy revenues, capacity revenues are added to the cash flow. The cash flow is then discounted back to a present value with an appropriate discount rate.

IV. POWER PURCHASING AGREEMENTS POLICIES

Federal Energy Management Programs (FEMP) FEMP developed an introductory guide to PPAs for Federal on-site renewable projects. FEMP outlines the power purchase agreement process in its Alternative Finance Options (AFO). An on-demand recording of the training is available. Dates and times of upcoming training sessions are posted to the FEMP events calendar. An updated version of the PPA portion of this presentation is available, featuring typical PPA processes, benefits, challenges, and several case studies. Several PPA sample documents are available. Available resources include sample requests for proposal, contracts, land use agreements, case studies, and more [16].

A. High-Level Project Plan for Solar PV with PPA Financing

Implementing power purchase agreements involves many facets of an organization: decision maker, energy manager, facilities manager, contracting officer, attorney, budget official, real estate manager, environmental and safety experts, and potentially others [18]. While it is understood that some employees may hold several of these roles, it is important that all skill sets are engaged early in the process. Execution of a PPA requires the following project coordination efforts, although some may be concurrent.

Step 1: Identify Potential Locations

Identify approximate area available for PV installation including any potential shading. The areas may be either on rooftops or on the ground. A general guideline for solar installations is 5–10 watts (W) per square foot of usable rooftop or other space. In the planning stages, it is useful to create a list that contains site plans and to use Google Earth software to capture photos of the proposed sites [19]. In addition, it is helpful to identify current electricity costs. Estimating System Size (this page) discusses the online tools used to evaluate system performance for U.S. buildings.

Step 2: Issue a Request for Proposal (RFP) to Competitively Select a Developer

If the aggregated sites are 500 kW or more in electricity demand, then the request for proposal (RFP) process will likely be the best way to proceed. If the aggregate demand is significantly less, then it may not receive sufficient response rates from developers or it may receive responses with expensive electricity pricing. For smaller sites, government entities should either:

1). Seek to aggregate multiple sites into a single RFP

or

2). Contact developers directly to receive bids without a formal RFP process (if legally permissible within the jurisdiction).

Links to sample RFP documents (and other useful documents) can be found at the end of this fact sheet. The materials generated in Step 1 should be included in the RFP along with any language or requirements for the contract. In addition, the logistical information that bidders may require creating their proposals (described later) should be included. It is also worthwhile to create a process for site visits. Renewable industry associations can help identify Web sites that accept RFPs. Each bidder will respond with an initial proposal including a term sheet specifying estimated output, pricing terms, ownership of environmental attributes (i.e., RECs) and any perceived engineering issues.

Step 3: Contract Development

After a winning bid is selected, the contracts must be negotiated. This is a time-sensitive process. In addition to the PPA between the government agency and the system owner, there will be a lease or easement specifying terms for access to the property (both for construction and maintenance). REC sales may be included in the PPA or as an annex to it (see Page 6 for details on RECs).

Step 4: Permitting and Rebate Processing

The system owner (developer) will usually be responsible for filing permits and rebates in a timely manner. However, the government agency should note filing deadlines for state-level incentives because there may be limited windows or auction processes.

Step 5: Project Design, Procurement, Construction, and Commissioning

The developer will complete a detailed design based on the term sheet and more precise measurements; it will then procure, install, and commission the solar PV equipment. The commissioning step certifies interconnection with the utility and permits system startup. Once again, this needs to be done within the timing determined by the state incentives. Failure to meet the deadlines may result in forfeiture of benefits, which will likely change the electricity price to the government agency in the contract. The PPA should firmly establish realistic developer responsibilities along with a process for determining monetary damages for failure to perform [16].

V. SIMULATION RESULTS

This section provides a simulation case study to illustrate the features of long-term renewable generation expansion planning based on power purchasing agreement. In this case, annual load duration curve of test system is incorporated in order to determination of hourly dispatch of the renewable generation units.

This system has an 8736 hourly load which the maximum load is 2850 MW. Fig. 3 and 4 show the entire and peak load duration curve, respectively.

PPA is one of the most important and adopted strategy in order to hedge the investment risk of renewable generation units. The simulation results state that integral of the benefit of the candidate unit entire of the system should be greater than PPA which has been allocated for this unit.

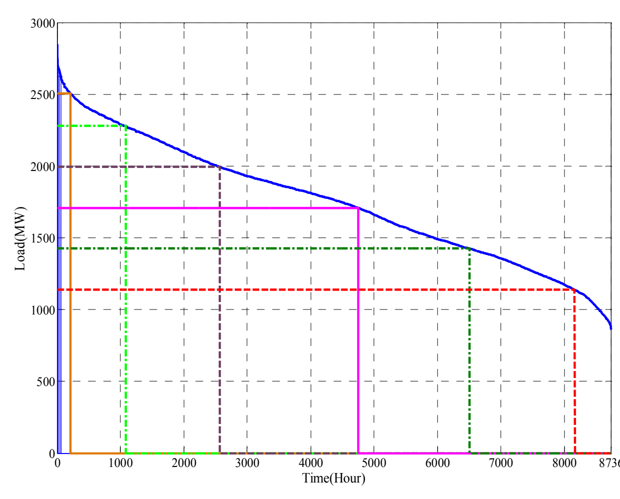

Fig. 3. Entire Load Duration Curve (LDC)

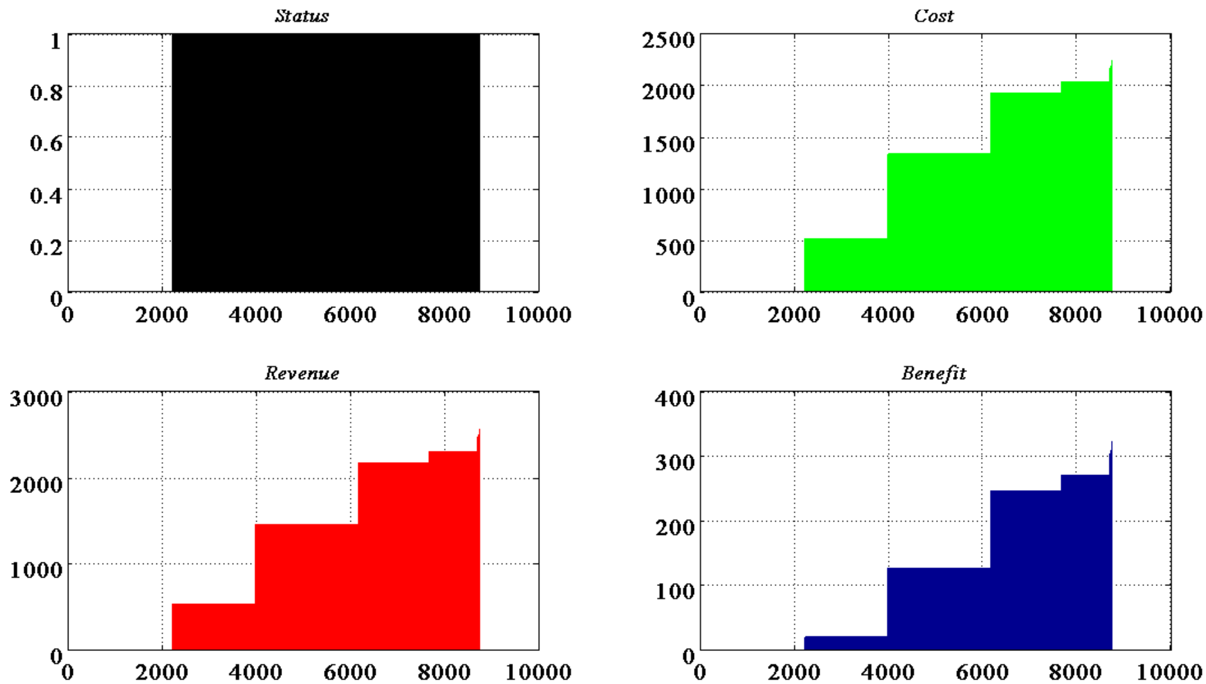

Fig. 5. Candidate renewable generation unit state, cost, revenue and benefit (simulated analysis)

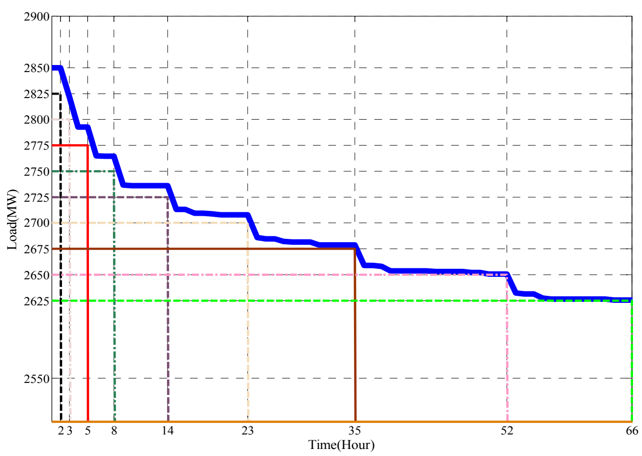

Fig. 4. Load Duration Curve (LDC) at peak hours

VI. CONCLUSION

In this paper the Power Purchasing Agreements presented. The importance of these contracts in restructured power system is illustrated. Below are several ways to structure the energy payment:

- Indexed to power price. The energy payment may be set at the settlement price of a designated market. This requires the availability of a price that is published in a forum acceptable to both the owner and the counterparty. An ISO index is an example. Another example is a daily price that is published in an industry-wide accepted publication.
- Indexed to gas price. The energy payment may be indexed to the settlement price of a designated gas market. Once again, an acceptable published price must be available. There is a contractual heat rate that converts the $/MMBTU charge of the gas index into a $/MWH charge for the energy. The owner often sets the contractual heat rate at a level that allows the owner to recover all variable energy costs and is accordingly often higher than the actual operating heat rate of the plant.
- Indexed to coal. Another possibility is for the variable component to be indexed to a different fuel such as coal with a contractual heat rate.
- Determined by guaranteed operational costs. The energy payment may be made in the form of a variable heat rate in accordance with agreed-upon operating characteristics applied to an indexed fuel price. This provides the fuel payment. In addition to the fuel payment there are additional variable operations and maintenance charges along with start-up charges.
- Lessee provides fuel and pays guaranteed operational costs. Under this arrangement the lessee independently arranges for fuel shipments to the plant and pays all of the fuel costs of the dispatch. However, the owner provides a guaranteed efficiency in the form of a variable heat rate. If the actual fuel burn exceeds the contractually guaranteed fuel burn as determined by the contractual heat rate, the owner must reimburse the lessee for the additional fuel cost. Variable operations and maintenance costs along with start-up costs are charged to the lessee at a set cost.

- Lessee provides fuel and pays actual fuel costs along with set Variable Operation and Maintenance (VOM) and start-up costs. Under this arrangement, the lessee independently arranges for fuel shipments to the plant and pays all of the fuel costs. Additionally, the owner charges variable operations and maintenance costs along with start-up costs.

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