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Bidirectional load sharing incorpating thermal and solar power

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Abstract —This paper examines the value of concentrating solar power (CSP) and thermal energy storage(TE) in a numberof regions in India.It pivots on executions of optimal power flow (OPF) problem incorporating thermal and solar power.It discuss about the automatic power balance between the renewable and the non-renewable resources which reduces the usage of non renewable sources(thermal) and promotes the renewable resources(solar) . TE can increase the value of CSP by allowing more thermal energy from a CSP plant's solar field to be used, allowing a CSP plant to accommodate a larger solar field, and by allowing CSP generation to be shifted to hours with higher energy prices. We analyze the sensitivity of this value to a number of factors, including the optimization period, price and solar forecasting, ancillary service sales, and dry cooling of the CS plant, and also estimate the capacity value of a CS plant with TES.

IndexTerms—solarpower(SP) generation, thermal energy storage (TES).

Parameters: Number of time periods. Charging power capacity of TES (MW-t). Discharging power capacity of TES (MW-t). Hours of storage. Hourly TES heat losses (%). Round-trip TES efficiency losses (%). HTF pump parastic function. Rated electric capacity of powerblock (MW-e). Rated thermal capacity of powerblock (MW-t). Minimum and maximum operating capacity of powerblock, respectively (% of capacity). Powerblock startup energy (% of capacity). Powerblock minimum up time. Powerblock heat rate function.Powerblock parasitic function. Variable generation cost ($/MWh-e). Market-clearing price of energy in hour ($/MWh-e). Energy from solar field in hour (MWh-t).

I .INTRODUCTION:

Recent and ongoing improvement thermal solar generation technologies coupled with the need for more renewable sources of energy have increased interest in concentrating solar thermal power (CSP). Disparate solar photovoltaic (PV) generation, CSP uses the thermal energy of sunlight to generateelectricity.1 Two common designs of CSP plants parabolic trough sand power towers—concentrate the sunlight onto a heat-transfer fluid (HTF), which is used to drive a steam turbine. An advantage of CSP over many renewables is that it can also be built with thermal energy storage(TES),which can make the CSP plants dispatchable.2 The TES can allow generation to be shifted to periods without solar resource and to provide backup energy during periods with reduced sunlight that can be caused by cloud cover.3 The storage medium is typically a molten salt, which have extremely high storage efficiencies in demonstration systems. Adding TES provides several additional sources of value to a CSP plant. First, the plant can shift electricity production to periods of highest prices compared to a plant that must sell electricity whenever solar energy is available. Second, TESSee [1] for a more detailed discussion of CSP technologies and ongoing research efforts. See [2]–[4] for surveys of TES technologies and capabilities. The HTF in a CSP plant will also have some thermal inertia that can help the CSP plant "ride out" a brief reduction in sunlight from an isolated cloud.

Finally, the dispatchability of a CSP plant with TES allows for the provision of high-value ancillary services (AS), such as spinning reserves. Building a CSP plant with TES introduces several decisions in terms of sizing the plant, since the plant essentially consists of three independent but interrelated components that can be sized differently the power block, the solar field, and the thermal storage tank. The size of the power block is the rated power capacity of the steam turbine, and is typically measured in either the rated input of the power block in megawatts of thermal energy (MW-t) or the rated output of the power block in megawatts of electric energy (MW-e). The size of the solar field, in conjunction with solar irradiance, determines the amount of therma l energythatwillbe available to the power block. The sizing of the solar field is an important decision, since the relative size of the solar field and powerblockwill determinethe capacity factorof the CSPplant and the extent to which thermal energy and the powerblock will be wasted. Undersizing the solar field will result in the power block being underused and a low capacity factor for the CSP plant, due to the lack of thermal energy during all but hours with the highest solar resource.4 An oversized solar field, on the other hand, will tend to result in thermal energy being wasted since the power block will not have sufficient capacity to use the thermal energy from the solar field in many hours. The size of the solar field can either be measured in the actual area of the field or by using the solar multiple (SM)—which normalizes the size of the solar field in terms of the power block size. A solar field with an SM of one is sized to provide sufficient energy to operate the power block at its rated capacity under reference conditions. The areas of solar fields with a higher or lower SM will be scaled based on the solar field with a multiple of one (i.e., a field with an SM of two will cover twice the area of a field with an SM of one). The size of storage determines both the thermal power capacity of the heat exchangers between the storage tank and the HTF, measured in MW-t, and the total energy capacity of the storage tank. While the energy capacity of the storage tank can be measured in MWh-t, it is often more convenient to measure it in terms of the number of hours of storage. We define the storage capacity as the number of hours that the storage tank can be charged at maximum capacity, which is very similar to the number of hours of discharge capacity since the round-trip efficiency of TES is about 98.5%. It is worth noting that another benefit of building a CSP plant with TES is that storage can allow the plant to be built with a larger solar field, since excess thermal energy can be placed into storage for use later. For a merchant CSP developer, the decision to build and the choice of the size of a CSP plant will be governed not only by the amount of solar energy available, but also by the pattern (coincidence) of solar resource and electricity prices. Clearly, high electricity prices and an abundance of solar resource are necessary for CSP to be economic, but a lack of correlation before CSP plants can be designed with a fossil-fueled backup system. With such a design, natural gas or another fuel can be used to supplement solar thermal energy. Because our interest is in renewable resources, we focus on a pure CSP plant.

II. CSP MODEL:

We model the capabilities and costs of CSP plants using a mixed-integer program (MIP), which is based on the Solar Ad- visor Model (SAM) developed by the National Renewable Energy Laboratory (NREL). SAM is a software package that can model in detail the hourly energy production of PV, concentrating PV, and CSP plants,with different configurations and in different locations. This production data can be coupled with cost data to compute different economic benchmarks for solar systems, such as the levelized cost of energy. SAM also has some capabilities to optimize the dispatch of a CSP plant withTES,by using theuristic"time-of-day"type rules,and these the uristics can be used to compare the cost of energy from a CSP plant to other conventional generators. Unlike SAM, our MIP is formulated to fully optimize the dispatch of a CSP plant to maximize net revenues from energy sales, as opposed to using heuristic rules.5 The model assumes that the CSP plant is a price-taking generator that treats prices as being fixed. Since we are modeling only a single CSP plant ,this price-taking assumption is reasonable, as the operation of the CSP plantwould have atmost a margin impact on thedispatch.For purposes of comparison, the default heuristic dispatch rule in SAM is able to capture between 87% and 94% of the operating profits that our MIP model earns with a CSP plant with an SM of 2.0 and six hours of TES.

The available thermal energy is determined by ambient sunlight as well as solar field size and the efficiencies of the component such as concentrators,collectors,and the HTF used in the solar field. We use this hourly available solar data as an input to our model. We model CSP plants in four different locations, which are summarized in Table I. The plantsare all simulated using energy price and solar data from 2005. The solar data are obtained from

NREL's Renewable Planning Model.67 . SAM models efficiency losses from using TES by multiplying the gross output of the powerblock by a term that is a nonlinear function of the fraction of thermal energy delivered to the powerblock that comes from TES. In order to maintain linearity of our MIP model, we instead assume that 1.5% of energy taken through the storage cycle will be lost—which roughly approximates the nonlinear term in SAM. We further assume that the powerblock must be run at a minimum load of 40% of its design point (i.e., gross generation of at least 44 MW-e) whenever the powerblock is operating. We further require that the powerblock be online for a minimum of two consecutive hours whenever it is started up and assume that 58.3 MWh-t of thermal energy is required to startup the powerblock,8 which takes one hour. The output given by the heat rate curve is gross electricity production, and does not account for the parasitics of various components in the CSP plant. These parasitics include energy expended for operating the HTF pumps in the TES system,the cooling tower, and balance of plant .As with the heat-rate curve, these parasitics are represented as third-order polynomials in SAM ,and we approximatetheseasfour-segmentpiece- wise-linear functions in our MIP model.

I. OPERATING PROFITS OF CSP PLANTS WITH TES IN ENERGY-ONLY MARKETS:

The addition of TES to a CSP plant provides three separate sources of value: energy, capacity. Our analysis first considers the case of a CSP plant being used solely to sell energy into the wholesale market. We first consider the case of a CSP plant being operated with perfect foresight of future solar availability and energy prices. Following [4], the optimization is done one day at a time using a rolling two-day planning horizon. Thus we assume that dispatch decisions are made one day at a time; however, the nextday'senergypricesandsolaravailabilityareaccountedfor in making dispatch decisions each day. This use of a two-day planning horizon ensures that energy in TES at the end of the day has carryover value without this use of a two-day optimization horizon, energy would never be kept in TES at the end of a day, since it would have no value. For instance, in the morning (hours 8–10), the powerblock is operated with energy from TES, which was carried over from the previous day to catch the high early-morning prices. The powerblock is shut down in hours 15 and 16, when energy prices are relatively low, and the solar field energy is put into TES. The plant then provides energy in the evening peak, using both energy from the solar field and from storage.

IV.VALUE OF CONCENTRATING SOLAR POWER AND THERMAL ENERGY :

In the summer, energy prices tend to have a peak midday or in the afternoon (due to cooling loads), and peak more in the morning and evening (due to heating and lighting loads) in the winter. Solar availability follows predictable patterns as well, withsolar tendingtopeakinmiddayorinthe afternoon(during the summer when cooling loads are driving the load peak, the peak in energy prices tends to lag the solar peak by an hour or two). Thus, price and solar data from the previous day will tend to capture the correct diurnal pattern of the following day. Moreover, while energy prices and solar availability can differ on longer term bases, for instance due to seasonal or even annual differences,the use of data from the previous 24 hours will tend to capture these effects. Finally, it is important to note that the backcasting technique we examine here does not incorporate any solar or price forecasting in operational decision making. Since weather and pricest end to be somewhat predictable , especially on a short-term day-ahead basis, the value capture.

A.Impact of Capacity Credit CSP plants, especially those with TES:

It will generally pro- vide capacity to the system, which is valuable in that it reduces the need for other capacity to be built or procured by the utility, load-serving entity, or system operator (SO). Properly valuing this capacity can pose some difficulties in electricity markets, however, as capacity is not necessarily priced in the market or market distortions can suppress these prices. Inpractice,however, prices andotherregulatory interventions in the market tend to suppress energy prices, and as such capacity may not be properly priced in the market. Indeed, even in the ERCOT market, which has a much higher price cap than the CAISOargues that the threat of regulatory intervention has served to suppress energy prices below levelsthatprofit-maximizing behaviour wouldsupport. Since capacity is not properly valued in the energy prices used in our analysis, we use the capital cost of a new gas combustion turbine (CT) to compute a proxy for the value of ca- pacity.

B. Impact of Powerblock Dry Cooling:

Our analysis thus far has assumed that the CSP plants will use a wet-cooled powerblock. Due to the arid climates, an important consideration is what effect dry cooling would have on the profitability of the CSP plants and the value of TES. Dry cooling the powerblock will tend to increase cooling tower energy losses, with the efficiency reduction depending upon the ambient temperature. This decrease in efficiency will tend to increase the value of TES,since high ambient temperatures (which give greater efficiency losses with dry cooling) will tend to be correlated with the availability of solar energy. Without TES, the solar energy must be put into the powerblock, which will produce less energy due to cooling losses. With TES, however, energy from the solar field can be stored and generation shifted to hours later in the day when ambient temperatures are reduced. SAM accounts for drycooling energy losses by multiplying gross powerblock output by a term which is a fourth-order polynomial function of the ambient temperature. We model dry-cooling energy losses in the same manner, and use the correction factors from SAM as an input to our dispatch model.

V. OBJECTIVE

The main objective of this thesis is to power optimization which means reduce the utilization of power from non renewable resources and to promote the power from renewable resources.

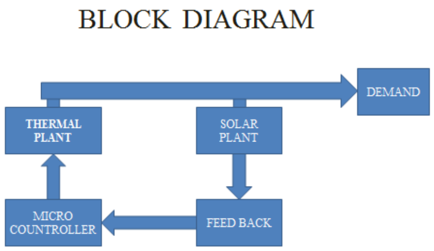
VI. EXISTING SYSTEM

It ensures integrated operation of Power System Grid and it displays only Grid Frequency(Voltage) and the other renewable sources(Wind or Solar Panel) grid frequency(Voltage) data is not updated with Non renewable resources total Power system. Hence the system provides only intimation of power from Non renewable resources only.

VII. PROPOSED SYSTEM

This system provides a Feedback from Renewable Plant to Non renewable Plant to increase or balance the total power. According to the Power demand, the generation of Power will be Controlled between Renewable and non renewable resources.

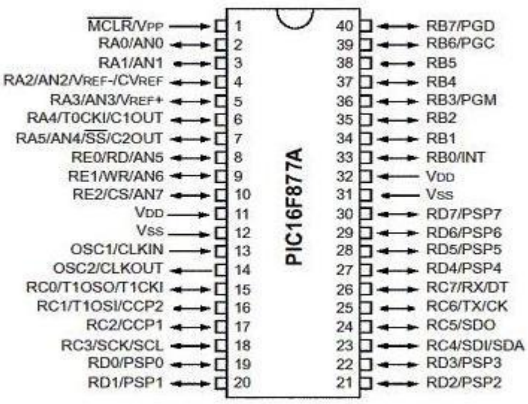
VIII.BLOCK DIAGRAM:



According to the power demand ,the solar power available during the day time is collected and given as feedback to the thermal power system and the remaining power desires to fulfill the user claim is generated by the thermal unit. Here the feedback is given using the microcontroller and insinuation is received by the thermal unit then conferring to that power generation will be started.The 100%demand will be statisfied and the renewable source will be used more than the non renewable resources.

IX. PROPOSED SYSTEM ARCHITECTURE

PIC16F877A:



PIC16F877A is a powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC architecture into an 40- or 44-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F877A features 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 8 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I²C™) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

A.FEATURES:

- 2 PWM 10-bit
- 256 Bytes of EEPROM
- Data memory LCD 25 mA
- Sink/source per I/O
- Self Programming Parallel Slave Port.

B.PARAMETERS:

- Program Memory Type: Flash
- Program Memory (KB):14
- CPU Speed (MIPS):5
- RAM Bytes:368
- Data EEPROM (bytes):256
- Digital Communication Peripherals:
- 1-UART, 1-SPI, 1-I2C1-MSSP(SPI/I2C)
- Capture/Compare/PWM Peripherals
- 2 Input Capture, 2 CCP,
- Timers: 2 x 8-bit, 1 x 16-bit
- ADC:8 ch, 10-bit
- Comparators:2
- Temperature Range (C):-40 to 125
- Operating Voltage Range (V):2 to 5.5

X. CONCLUSION:

Hence the proposed system overcome the difficulties in the existing system. It is developed in a user-friendly manner.Finally the automatic power balance between the renewable and the non-renewable resources which reduces the usage of non renewable sources (thermal) and promotes the renewable resources (solar) has been done in a well mannered

.

XI.RESULT AND DISCUSSION:

For instance if the demand is 80v the power produced by the solar is 44v(55%) ,then the remaining power of 36v(45%) will be generated by the thermal power station.Hence the demand will be fulfilled.

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