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SEASONAL LINKAGES OF ELECTRIC ENERGY WATER NEXUS IN ELECTRICITY INDUSTRY – AN EMPIRICAL ANALYSIS

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ABSTRACT

The fast growing demand for fresh water-coupled with the need to protect the environment has made many areas of India and the rest of the World vulnerable to water shortages for various uses of the economy. As they interact with Electricity Industry, water availability is critical to power generation. Without access to adequate amounts of water for steam generation and cooling, power plants that rely on heat energy to generate electricity cannot operate. Seasonal anomalies in water systems and electricity production are inextricably linked. A change in one of these systems induces a change in the other. Therefore, there is an imperative need to better understand the interrelationship of Electric Energy- water for effective management of serious water related power generation issues. This paper gauges the effects of the some of overlaps and gaps between seasonal anomalies in water availability and growth of power generation in rainy, summer, winter and post monsoon season for power plants of different energy types (Both non-renewable and renewable sources).

INTRODUCTION

The fast growing demand for fresh water-coupled with the need to protect the environment has made many areas of India and the rest of the World vulnerable to water shortages for various uses of the economy. As they interact with Electricity Industry, water availability is critical to power generation. Without access to adequate amounts of water for steam generation and cooling, power plants that rely on heat energy to generate electricity cannot operate. Seasonal anomalies in water systems and Electricity production are inextricably linked. A change in one of these systems induces a change in the other. Therefore, there is an imperative need to better understand the interrelationship of Electric Energy- Water nexus for effective management of serious water related power generation issues. This book gauges the effects of the few of overlaps and gaps between seasonal anomalies in water availability and growth of power generation in rainy, summer, winter and post monsoon season for power plants of different energy types (Both non-renewable and renewable sources). The purpose of this book is to examine water use estimation in hydel and thermal electric power plants in selected regions i.e. Coastal, Rayalaseema and Telangana regions of Andhra Pradesh. The study primarily focuses on the realistic fundamental premise that thermal electric and hydro electric energy generation is responsible for the largest monthly volume of water withdrawals in four seasons (i.e. summer, rainy, winter and post monsoon season) of a year. These enormous water withdrawals by these hydel and thermal power plants can have significant influence on local surface water resources. However there are very few studies of determinants of water use in hydel and thermal electric generation.

From the existed comprehensive literature, the research study tries to highlight two major problems faced by Electric-Energy Sector. One is physical and the other one is economic.

- Whether or not the possible seasonal variations in a 12 month period of a year adversely affect the amount of fresh water available for power generation.
- To determine the most cost effective way to find out fresh water for power generation, regardless of what the physical effects turn out to be.

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It is a well known fact that water is only one of the basic factors of production and accurate modelling of the derived demand relationships for water requires due consideration of full range of relevant factor substitutions in production activities. For electricity generation, it is probably sufficient to consider three factors namely capital, water and fuel. Generally shortage of capital and primary energy inputs are considered responsible for amount of electricity generated. But keeping in view of resource crunch, particularly 'Water- as a factor for Electric-Energy crisis' the hypothesis established from existed literature in the area of research is

Hypothesis

- The amount of electricity generated by fuel type thermal (non-renewable) and renewable energy (Hydro and biomass) depends on availability of fresh water in a 12 month period.
- The water availability due to varied climate change (seasonal fluctuations) affects electric energy production and its effectiveness in terms of Plant Load Factor.

Research Objectives

- To identify major water consuming power plants (Thermal, Combined Gas cycle, Hydro and other renewable sources)
- To determine typical water consumption per unit of generation for each power plant by fuel type.
- To estimate present and future aggregate water availability and loss of generation requirements associated with power plant type.
- To highlight and document water sustainable management techniques in Electricity Industry for meeting present and future Electricity Generation needs.

Hypothesis to Be Tested

The seasonal impact of fresh water availability on Electric Energy production and its Plant load factor

Reference Period: 2000-2001 to 2008- 2009.

MATERIALS AND METHODS

Water Foot Printing method

The water foot print indicates the volume of water used (measured in cubic meters per year). To calculate the approximate total water consumed in electricity generation by fuel type (Thermal, Natural gas, Hydro, wind and Biomass). This chapter illustrates the data relating to volumetric water numbers on water consumed for production/extraction of raw materials, water consumed for refining of raw fuel (if necessary), water consumed for steam generation and process, ash slurry and DM make up water, for cooling purpose depending upon the type of technology adopted. The total arrived figures in power stations of three regions of Andhra Pradesh relating to total amount of water directly consumed for fuel development and in the process of producing electricity have been calculated for various types of electric energy production. These are compared with the standard norms of water usage in Indian Power Industry as well as prescribed by International Geological Survey. These water foot prints vary considerably based on the type of electric energy plant.

Application of Seasonal Variation Index for Power Plants of Andhra Pradesh

The relevance of Seasonal Variation Index or Ratio to Moving Average Method for its practical application in Electricity Generation Industry is of vital importance. Seasonal Variations occur within a period of one year or less. It is a component of time series which is defined as repetitive and predictable (seasonal changes) around the trend line in one year or less. It is detected by measuring the quantity of interest for small intervals that is days, weeks, months and quarters. By this strong seasonal movements can be predicted. But when data are expressed annually there is no seasonal variation. A measure of seasonal variation is referred as Seasonal indexes (percent). They are given as percentages of their average. Electricity Supply Industry exhibits inquisitiveness in knowing their performance w.r.t. to water withdrawals vis-à-vis power generation relative to normal seasonal variation with the aid of SVI.

- Electricity Supply Industry affected by seasonal variation (in terms of water availability due to climate variability)
- Expects an increase or decrease in power generation
- Both in prospective and lean period of a year

Econometric Approach: Estimating Water Use in Power Plant by Different Energy Type

This book will analyze the structure of Narla Tata Rao Thermal power station, Kothagudaem Thermal power Station and Rayalaseema Thermal Power Station, Nagarjuna Sagar Hydel power Station, Srisailam left and Right Canal hydel power stations, lower and upper sileru hydel power stations relating to water withdrawals by taking in to account large number of potential independent or explanatory variables. The approach followed is a multivariate model of unit water withdrawals expressed as cubic meters per kilowatt hour for a group of thermal and hydel power stations in selected regions of Andhra Pradesh. The quantity of water withdrawn in any given year depends on weather conditions in any given year depends on weather conditions. The quantity of water withdrawn in any given year depends on water withdrawals for most purposes increases during periods of hot and dry weather and decrease during periods of cool and wet weathers. This dependence of water withdrawals on weather conditions can be determined by including weather related variables in a set of explanatory variables.

The variables that can be examined as potential predictors of state level thermoelectric withdrawals include the following:

- Dependent Variable: Total water withdrawals for thermal electric use or for hydel purpose.

The independent variables can be listed as follows:

- **Electric Energy Generation by fuel type:** Thermo Electric generation by coal or hydel
- **Installed Generation Capacity :** Total generation Capacity in MW
- **Water Withdrawals:** Total Water withdrawals in various stages of Electricity Generation.

a) Water withdrawals: Total water withdrawals in various stages of Electricity Generation. (Process + Boiler Feed)
b) Water withdrawals for Ash slurry and DM Back wash
c) Water withdrawals for cooling purpose.

- Availability of Cooling towers: total number of cooling towers: number of cooling towers
- Weather Conditions: Cooling degree days, heating degree days, average annual temperature.
- State Water Nominal Cess
- Number of generating units.

However the effect of total water withdrawals for power plants that depend upon the above mentioned independent variables differ greatly among three regions of Andhra Pradesh.

Valuation of Water Resources

There are several concerns about using economists Water Valuation Techniques. These techniques mainly assess the value of water used for different power stations in three regions of Andhra Pradesh using Residual Value (Value Marginal Product) and Opportunity Cost. The major imputed water valuation techniques are Residual Value and Opportunity Cost.

Residual Value

Total Value Product = $\sum p_i q_i + p_w q_w$

$$p_w = \frac{TVP - \sum p_i q_i}{q_w}$$

Where

TVP = Total value of the commodity produced

$p_i q_i$ = the opportunity costs of non water inputs to production

P_w = value of water (its marginal product)

q_w = the cubic meters of water used in production

Non-water inputs include intermediate inputs, labor, capital cots and land.

Opportunity Cost

Price differential for alternative (Example: replacing hydro electric power with coal fired electricity) opportunity cost, difference between production cost of hydro power and cost of next alternative, thermal/coal power.

Rent = $(C_T - C_H)QE_H$ where

C_T = Cost of production per unit of electricity for thermal power plants

C_H = Cost of production per unit of electricity for hydro power plants

QE_H = Quantity of electricity produced by hydro power plants.

Based on these formulae eight scenarios of opportunity cost in case of different power plants of Andhra Pradesh can be found out.

Sampling Design: Three regions of Andhra Pradesh viz; Coastal Andhra Pradesh, Rayalaseema and Telangana are selected. In each of these regions one power plant by fuel type (both non-renewable and renewable energy source will be selected. They can be listed as follows:

Table 1. Selected power plant in three regions of Andhra Pradesh

Power Plant by Fuel Type	Coastal Region	Rayalaseema Region	Telangana Region
Thermal	Narla Tata Rao Thermal Power Station	Rayalaseema Thermal Power Plant	Kothagudaem Thermal Power Station
Hydel	Lower and Upper Sileru Hydel Power stations	Nagarjuna Sagar Hydel Power station	Srisailam Hydel Power Station
Natural Gas	Vijjeswaram Combined Cycle Gas power plant	Nil	Nil
Biomass	Satyakala Private Power Projects Limited	Shri Rayalaseema Green Energy Limited	My Home Power Limited

Analysis of hydel and thermal electric water use data in the existing power plants clearly indicates that there is wide variability in unitary hydel and thermal electric water use within the system. The multivariate regression procedures were used to identify the significant determinants of thermal and hydel water withdrawals in various power plants i.e. five hydel and four thermal power plants. The estimated regression coefficients indicate that the best explanatory variables for the total quantity of hydel water withdrawals are storage capacity, tail water level and actual generation and thermal water withdrawals are condenser cooling and ash disposal.

The unit variability of unit water usage indicates that there is significant potential for water conservation in existing power plants. Apart from this as water is no longer available as a free good; it calculates the real value of water in selected power plants using Water Valuation Techniques such as Residual Value and Opportunity costs.

REFERENCES

APGENCO Field level Power Stations data collected in 10 power stations.

Arnaud Buchs, Fevrier, 2008. "Standards Applied to Water Use: An attempt to built up Dynamic Indicators"- A Manuscript published in "Global Changes and Water resources: Confronting the expanding and Diversifying Pressures: XIIIth World Water Congress, Montpelier: France.

Dominguez-Faus, Susan E powers *et al*. 2009. Status paper on "The water foot print of bio-fuels: A Drink or Drive Issue"

Environmental Science and Technology, Vol.43, 3005-3010.

Estimating Fresh Water Needs to meet future Thermo Electric Generation requirements", (2008), Update DOE, NETL-400/2008/1339.

Falkenmark, Malin and Lundquist (January, 1997)" Comprehensive assessment of the fresh water resources of the World", World Fresh water problems call for a new realism. Stockholm Environment Institute.

Intergovernmental panel on Climate Change, 2008. "Climate and water", IPCC, Technical Paper.

International Energy Agency Report, 2006 and World Energy Outlook 2006 Reports.

Jason Morrison, Mari Morikawa *et al* (February, 2009), "Water scarcity and Climate Change: Growing risks for Businesses and Investors", *Aceres Report*, Authored by the Pacific Institute.

Kabat P, Schulze R.E, Hellmuth M.E *et al,* Wagenningen (November, 2002)," International Dialogue on water and climate: Coping with impacts of climate variability and climate change in water management: A scoping Paper".

Kagal, J.A, Role of Total Productivity Maintenance in power plant performance" IIPE: LF 0923.

Krol, M. S. and Van. Oel P. "Integrated Assessment of water stress in Ceara, Brazil under climate change Forcing ", Water Engineering & Management, Department of Civil Engineering, University of Twente.

Water Energy Vision, 2009. "Thirsty Energy: Water and Energy in the 21st Century" World Economic Forum in partnership with Cambridge Energy Research Associates.

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