SMART POWER GENERATION SYSTEM FOR NUCLEAR POWER PLANT

Vallimurugan.E[1], Nirmal K. N[2], Mohan Kumar.S[3], Sri Parthasarathy.S[4], Dr.S.Vimal Raj[5]
UG Scholar[1,2,3,4], Associate professor[5]
Electrical and Electronics Engineering[1,2,3,4,5]
Sri Krishna College of Technology, Coimbatore[1,2,3,4,5]
vallimurugan896@gmail.com[1], nirmalkn17@gmail.com[2], mohankumar110197@gmail.com[3], srirenga111@gmail.com[4], s.vimalraj@skct.edu.in[5]

Abstract-- In this paper, we will be introducing a new model for energy supply system in near future which produces electric with dispersed power grid with nuclear power generation units. With nuclear power generation increasing, power system peak load situation is becoming more and more serious. Recently, in nuclear field, a lot of effort has been done in nuclear major countries to develop small and medium reactor for enhancement of nuclear peaceful use as like in district heating, electric power generation, seawater desalination or hydrogen generation. Nuclear Plant is a modular pressurized water reactor and it is expected to be used for dual-purpose applications of seawater desalination and small-scale power generation. Since Nuclear Plant will be located relatively near the residential area, Nuclear Plant should have highly enhanced safety characteristics compared with current Nuclear Power Plants.

***Index Terms*--Nuclear Power Generation Units, System-integrated Modular Advance Reactor, Dispersed Generations, Power System, MATLAB Simulation**

INTRODUCTION

Based on the idea of energy storage, this paper presents a novel joint generation dispatching model with nuclear power units participating in peak load regulation. By increasing the capacity of heat storage device, the peak load regulation can be realized when nuclear power is regarded as the base load in power grid. The distributed generations (DGs) are expected to reduce energy loss during power transmission and save energy by selecting an optimum site in a power demand area. In addition, DGs are expected to have a significant role in the safeguard of the earth's environment. With the introduction of diverse distributed sources (or distributed generators) of various forms, the distribution part of a power system will consist of equipment ranging from those that supply only electric power, and heat combined equipment, which supplies electric power and heat simultaneously near the load center to new complex networks. The sources would have micro gas turbines, fuel cells, wind energy generators, and solar cells, etc., for small scale and would have combined cycle units, hydrogen energy, and small size nuclear reactor etc. for small or medium scale units. Additionally, the study on DGs whose propagation would be expected by drying up the energy source and the energy policy of country is necessary and important. In nuclear field, a lot of effort has been done in nuclear major countries to develop small and medium reactor for enhancement of nuclear peaceful use as like in district heating, electric power generation, seawater desalination or hydrogen generation. It has been developing an integral type nuclear cogeneration reactor, Nuclear Plant (System- integrated Modular Advance Reactor). Nuclear Plant is a modular pressurized water reactor and it is expected to be used for dual-purpose applications of seawater desalination and small-scale power generation. It has a capability to produce the fresh water of 40,000 tons per day and the electricity of 90 MW. The designed life of Nuclear Plant is 60 years and the target for the operating rate is 95%. Since Nuclear Plant will be located relatively near the residential area, Nuclear Plant should have highly enhanced safety characteristics compared with current Nuclear Power Plants (NPPs).

Literature Review:

[1] Design of grid-connected directly driven wave power generation system with optimal control of output power - This paper presents a directly driven wave power generation system which is connected to power grid composed of permanent magnetic linear generator (PMLG), generator side converter, grid side converter, controller and grid. Control strategies based on back to back converter structure was proposed: vector decoupling control was used to generator side converter aiming at optimize power extraction from wave energy; Grid voltage-oriented control was used to grid side converter in order to make the current sinusoidal and realize unit power factor control. Since the DC link voltage has fluctuation using traditional method, a method with power feed forward was proposed to keep the DC link voltage stable and improve the dynamic response of the system. A simulation model was built for the whole system in MATLAB/Simulink and simulation results verified that the proposed control strategy is feasible and effective. Published in: 2013 15th European Conference on Power Electronics and Applications (EPE) [2] Wind generation ramping coordinated control - This paper proposes a ramping coordinated control strategy which considers the temporal and spatial difference of wind farm group and the AGC ability of wind farms. According to certain grouping principles, wind farms in wind farm group are divided into several joint power generation units, to which the dispatching centre distributes its scheduling plan, while wind farms in each joint power generation unit coordinate to split

the dispatching plan. In order to improve the control ability of wind farms, a new kind of wind generation automatic generation control strategy is proposed in which response speed is promoted. Simulation results show that the proposed strategy can improve the output characteristics of wind power. [3] Discuss of the future Power Generation Structure in China Southern Power Grid with High Penetration of PV Generation - The increased focus on environmental protection and the problem of lack of fossil energy around the world has prompted the rapid development of renewable power generation technology. As the penetration of renewable power generation such as photovoltaic (PV) power generation gradually increases, its impacts on power system planning and operation are increasingly obvious. In this paper, the generation structure in China Southern Power Grid (CSG) in 2050 with high penetration of PV generation is discussed. In addition, the impacts of high penetration of PV generation on power balance and peak-load regulation, as well as the influence of investment of PV and energy storage equipment on power generation structure have also been investigated. And some conclusions and suggestions have been presented to provide reference for the future power system planning and operation in China Southern Power Grid. Published in: 2018 International Conference on Power System Technology (POWERCON) [4] Integration of distributed generation in the networks of Latvian power system - Distributed (dispersed) generation (DG) entities are private and operated independently upon the main grid in Latvia. In the paper the impact of connected DG to the distribution network is analysed in regard to network operation modes and network operation parameters: voltage losses, power flows and overflows, energy losses per year etc. As research objects private electric power plants have been analysed: hydro, wind and co-generation plants in Western electric distribution network of the Latvian power system (WEN). The results of the research are of essential significance and not only for Latvia but in general for any analogue power system. Published in: 2005 IEEE Russia Power Tech [5] Estimation of capacity credits for wind generation plants in the South East Australian power grid - It is important to estimate the contribution of the wind generation plants in the evaluation of system generation adequacy for power generation planning. Australia has recently proposed to utilize the diversity of the wind energy resources in Southeast Australian power grid through existing inter-State interconnections. This paper aims to present a probabilistic adequacy model for the capacity credit estimation of wind generation plants in interconnected power systems. In particular, the proposed adequacy model will be applied to investigate how sharing of wind energy resource diversity can enhance the capacity credit of the wind generation plants. The impact of the inter-tie rating and varying wind penetration on the estimated capacity credit of the shared wind generation plants is also investigated. The capacity credits of the wind generation plants in each State are estimated within the purview of National Electricity Market (NEM) framework of Australia. The results obtained from simulations are presented and discussed. Published in: 2nd IET Renewable Power Generation Conference (RPG 2013)

SYSTEM MODEL DESCRIPTION

Development of Nuclear Power Generation Units

Since Nuclear Plant is an integral type reactor, it includes the major components such as steam generator, reactor coolant pump, and pressurizer in the reactor pressure vessel. The existing proven technologies are basically adopted for the Nuclear Plant design. However, Nuclear Plant also adopts various new and innovative design features and technologies that need to be proven through experiments and analyses. In order to verify the design and performance of Nuclear Plant, Nuclear Plant was developed. In a normal operation condition of Nuclear Plant, the reactor core is designed for a thermal power of 65 summarized in Table I MW, a gas pressure in the pressurizer of 14.7 MPa, steam generator primary inlet

Parameter	**Design Value**	**Calculated Value**
Reactor Power (MWt)	**950**	**950**
Primary System		
Core Mass Flow Rate (kg/sec)	**1538.48**	**1538.13**
Pressure	**14.99**	**14.99**
Inlet Temperature of SG (℃)	**309.68**	**309.78**
Outlet Temperature of SG (℃)	**269.68**	**270.00**
Temperature at IC (℃)	**83.72**	**83.58**
Secondary System		
Feedwater Flow Rate (kg/sec)	**152.70**	**152.70**
Feedwater Pressure (MPa)	**5.66**	**5.66**
Feedwater Temperature (℃)	**180.00**	**180.00**
Pressure at SG Inlet (MPa)	**5.07**	**5.08**
Temperature at SG Inlet (℃)	**180.05**	**180.05**
Pressure at SG Outlet (MPa)	**3.42**	**3.42**
Temperature at SG Outlet (℃)	**279.74**	**279.74**
Steam Pressure (MPa)	**3.30**	**3.30**

Table a): Calculations

and outlet liquid temperatures of 583 K and 548 K, respectively. As for the secondary loop, the feed water temperature is 323 K, the steam temperature and the pressure at the outlet of the steam generator are 558 K and 3.45 MPa, respective

MATLAB Diagram: Currently, in many countries, because the number of large-scale electric power system has increased rapidly with power demand and also the power distribution system has increased in number, capacity and complexity. That is continuously increased on demand means to be difficult to transmit largely the power in a distance gradually. Far-away power generation plants producing electric power are gradually introducing distributed sources to some areas because of problems of proper power division among areas as well as power transmission and distribution problems.

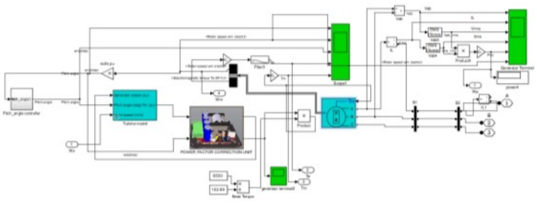

Fig a) Circuit Diagram

The transmission line voltages were 154kV and 345kV HVAC. For power system, three main generators are an aim to feed power for a large generating capacity through the transmission line and transformers. The three transformers have a Δ-Y connection for connecting to the generator, and a household load or local loads have a Y-Y connection. The circuit breakers are connected to many mid points of the transmission line for the purpose of inserting power to the next line or the transformer. The distributed generator is connected to 154kV transmission line, which has an almost at the end point of the transmission line. The transformers for raising and lowering the transmission voltage are the Y-Y type. The connection for both the endpoint transformer and the remote large generator is Y-Y.

SIMULATION

Figure 8 represents power waveforms of three main generators without small nuclear unit. Figure 9-12 show power waveforms of three main generators with small nuclear power generation units of 2MW, 5MW, 10MW, and 20MW, which the power injection has relatively small. The results of the analysis were simulated and illustrated using the MATLAB tool.

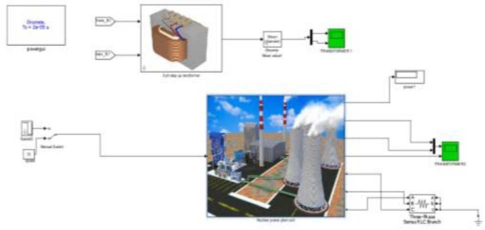

Fig b) Design Diagram

CONCLUSION:

The results of the analysis were simulated and illustrated using the MATLAB tool for the effect of inserting small nuclear power generation units. Simulation result of loss of offsite power incident with this model shows the potential risk on nuclear safety and provides input for analysis during unit commission and maintenance, which is frequently required by both engineering and operation. This paper showed the insertion effects of a 2MW, 5MW, 10MW, and 20MW nuclear units for the 154kV electric power grid.

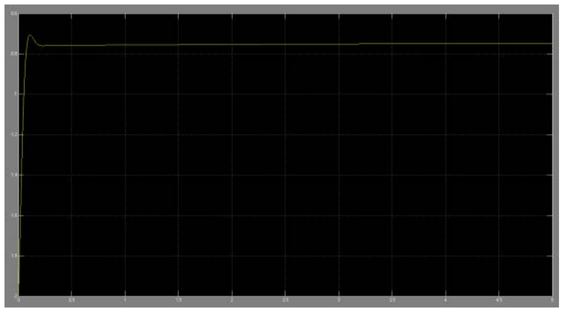

Fig c) Power Factor.

The small nuclear power generation units items are follow:

- Distributed & remote cogeneration system using small reactor, which connect and support the main power distribution grid.
- Small reactor for enhancement of nuclear peaceful use as like in district heating, seawater desalination or hydrogen generation, and electric power generation.

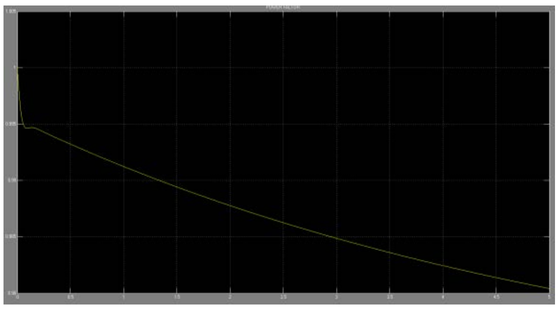

Fig d) Current Rating.

- Small nuclear unit design with 2MW to 20MW less than NUCLEAR PLANT-P capacity.

- Use of distributed power generation for the local power systems with 154kV or 22.9kV distribution line.

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