Research Article

Gain-function of two non-identical warm standby system with failure due to non-availability of wind and failure due to no tides producing no tidal energy

Ashok Kumar Saini

Associate Professor, Department of Mathematics, B. L. J. S. College, Tosham, Bhiwani, Haryana, INDIA.
Email: drashokksaini2009@gmail.com

Abstract

Introduction: The worldwide installed capacity of **wind power** reached 283 GW by the end of 2012. China (75,564 MW), US (60,007 MW), Germany (31,332 MW) and Spain (22,796 MW) are ahead of India in fifth position. The short gestation periods for installing **wind turbines**, and the increasing reliability and performance of wind energy machines has made wind power a favored choice for capacity addition in India. **Tidal power**, also called **tidal energy**, is a form of hydropower that converts the energy of tides into useful forms of power, mainly electricity. Although not yet widely used, tidal power has potential for future generation. In **Wind turbines,** the wind plays an important and vital role. Similarly **tides** producing tidal energy plays pivotal role. The non-conventional renewable **wind** and **tidal energy** are cheap and readily available for use to produce electricity for institutions, hospitals, industries and upliftment of water to higher places for agriculture. **Wind** is the prime source from where wind energy can be generated and similarly **tide** for producing tidal energy. But when wind is not blowing strongly the wind turbines are unable to receive wind causing failure of the system. Similarly when there is no tides produce no tidal energy causing failure of the system. In the present paper we have taken two non-identical warm standby system with failure due to non- availability of wind and failure due to no tides producing no tidal energy. When there is non-availability of wind or tide the working of unit stops automatically. The failure time distribution is taken as exponential and repair time distribution as general. Using Semi Markov regenerative point technique we have calculated different reliability characteristics such as MTSF, reliability of the system, availability analysis in steady state, busy period analysis of the system under repair, expected number of visits by the repairman in the long run and profit-function. Special case by taking repair as exponential has been derived and graphs are drawn.

Keyword: warm standby, non-availability of wind, no tide producing no tidal energy, MTSF, Availability, busy period, Gain-function.

***Address for Correspondence:**
Dr. Ashok Kumar Saini, Associate Professor, Department of Mathematics, BLJS College, Tosham, Bhiwani, Haryana, INDIA.
Email: drashokksaini2009@gmail.com

Received Date: 19/09/2014 Accepted Date: 29/09/2014

Access this article online	
Quick Response Code:	Website: www.statperson.com
	DOI: 30 September 2014

How to site this article: Ashok Kumar Saini. Gain-function of two non-identical warm standby system with failure due to non- availability of wind and failure due to no tides producing no tidal energy. *International Journal of Statistika and Mathemtika* Aug-Oct 2014; 11(3): 183-189. http://www.statperson.com (accessed 01 October 2014)

INTRODUCTION

The development of **wind power in India** began in the 1990s, and has significantly increased in the last few years. Although a relative newcomer to the wind industry compared with Denmark or the United States, India has the fifth largest installed wind power capacity in the world. In 2009-10 India's growth rate was highest among the other top four countries. As of 31 March 2014 the installed capacity of wind power in India was 21136.3 MW. Wind power accounts for 8.5% of India's total installed power capacity, and it generates 1.6% of the country's power. To generate **Wind –energy** or **tidal energy** the wind or tide plays the pivotal and vital role. The non-conventional renewable **wind energy or tidal energy** which is cheap and easily available for use produce wind or tidal energy which turn the large wind panes of wind-turbines or tidal power generator to produce electricity for institutions, hospitals, industries, and upliftment of water for drinking and irrigation for cities and agriculture. **Wind or tide** is the primary source from where wind energy or tidal energy can be generated. When wind turbines becomes ineffective due to non-availability of wind or no tides producing no tidal energy resulting failure of the system.

Assumptions

1. The failure time distribution is exponential whereas the repair time distribution is arbitrary of two non-identical units.
2. The repairs are perfect and starts immediately upon failure of units with repair discipline are FCFS.
3. The operation of the unit stops as soon as there is non-availability of wind.
4. The failure of a unit is detected immediately and perfectly.
5. The switches are instantaneous and perfect.
6. All random variables are mutually independent.

Symbols for states of the System

Superscripts: O, WS, SO, FNAW, FTTE

Operative, Warm Standby, Stops the operation, Failure due to non-availability of wind, Failure due to no tides producing no tidal energy respectively

Subscripts: nasl, asl, ntte,tte, ur, wr, uR

Non-availability of wind, availability of wind, no tides producing no tidal energy, tides producing tidal energy, under repair, waiting for repair, under repair continued respectively

Up states: 0, 1, 2, 9;

Down states: 3, 4, 5, 6, 7, 8, 10, 11

Regeneration point: 0, 1, 2, 4, 7, 10

States of the System

0(O_{asl}, WS_{nasl})

The first unit is operative due to availability of wind and the second unit is warm standby with non-availability of wind.

1(SO_{nasl}, O_{asl})

The operation of the first unit stops automatically due to non-availability of wind and warm standby units starts operating due to availability of wind.

2($FNASL_{ur}$, O_{asl})

The first unit fails due to non-availability of wind undergoes repair and the second unit continues to be operative due to availability of wind.

3($FNASL_{uR}$, SO_{nasl})

The repair of the first unit is continued from state 2 and in the other unit the operation of the unit stops automatically due to non-availability of wind.

4($FNASL_{ur}$, SO_{nasl})

The one unit fails due to non-availability of wind and undergoes repair and the other unit also stops automatically due to non-availability of wind.

5($FNASL_{uR}$, $FNASL_{wr}$)

The repair of the first unit is continued from state 4

and the other unit is failed due to non-availability of wind in it and is waiting for repair.

6 **(O_{asl}, $FNASL_{ur}$)**

The first unit is operative due to availability of wind and the second unit failed due to non-availability of wind is under repair.

7(SO_{nasl}, $FTTE_{ur}$)

The operation of the first unit stops automatically due to non-availability of wind and the second unit fails due to no tides is producing no tidal energy and undergoes repair.

8($FNASL_{wr}$, $FTTE_{uR}$)

The repair of failed unit due to no tides producing no tidal energy is continued from state 7 and the first unit is failed due to non-availability of wind is waiting for repair.

9(O_{asl}, SO_{nasl})

The first unit is operative due to availability of wind and the operation of warm standby second unit is stopped due to non-availability of wind.

10(SO_{nasl}, $FTTE_{ur}$)

The operation of the first unit stops automatically due to non-availability of wind and in the second unit fails due to no tides producing no tidal energy and undergoes repair.

11($FNASL_{wr}$, $FTTE_{uR}$)

The repair of the second unit fails due to no tides producing no tidal energy is continued from state 10 and the first unit is failed due to non-availability of wind is waiting for repair.

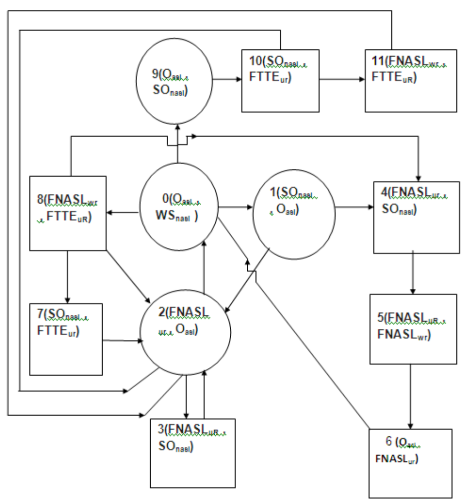

Figure 1: The State Transition Diagram

○ Up State □ Down State

TRANSITION PROBABILITIES

Simple probabilistic considerations yield the following expressions:

$p_{01} = \frac{\lambda 1}{\lambda 1 + \lambda 2 + \lambda 3}$, $P_{07} = \frac{\lambda 2}{\lambda 1 + \lambda 2 + \lambda 3}$

$p_{09} = \frac{\lambda 2}{\lambda 1 + \lambda 2 + \lambda 3}$, $p_{12} = \frac{\lambda 1}{\lambda 1 + \lambda 3}$, $p_{14} = \frac{\lambda 3}{\lambda 1 + \lambda 3}$

$P_{20} = G_1^*(\lambda_1)$, $P_{22}^{(3)} = G_1^*(\lambda_1) = p_{23}$, $P_{72} = G_2^*(\lambda_4)$,

$P_{72}^{(8)} = G_2^*(\lambda_4) = P_{78}$

We can easily verify that

$p_{01} + p_{07} + p_{09} = 1$, $p_{12} + p_{14} = 1$, $p_{20} + p_{23}\,(=p_{22}^{(3)}) = 1$, $p_{46}^{(6)} = 1$ $p_{60} = 1$,

$p_{72} + P_{72}^{(5)} + p_{74} = 1$, $p_{9,10} = 1$, $p_{10,2} + p_{10,2}^{(11)} = 1$ (1)

We can easily verify that

$p_{01} + p_{07} + p_{09} = 1$, $p_{12} + p_{14} = 1$, $p_{20} + p_{23}\,(=p_{22}^{(3)}) = 1$, $p_{46}^{(6)} = 1$ $p_{60} = 1$,

$p_{72} + P_{72}^{(5)} + p_{74} = 1$, $p_{9,10} = 1$, $p_{10,2} + p_{10,2}^{(11)} = 1$ (1)

And mean sojourn time are

$\mu_0 = E(T) = \int_0^\infty P[T > t]\,dt$ (2)

Mean Time to System Failure

We can regard the failed state as absorbing

$$\theta_0(t) = Q_{01}(t)[s]\theta_1(t) + Q_{09}(t)[s]\theta_9(t) + Q_{07}(t)$$

$\theta_1(t) = Q_{12}(t)[s]\theta_2(t) + Q_{14}(t), \theta_2(t) = Q_{20}(t)[s]\theta_0(t) + Q_{22}^{(3)}(t)$
$\theta_4(t) = Q_{9,10}(t)$ (3-5)
Taking Laplace-Stiltjes transform of eq. (3-5) and solving for
$Q_0^*(s) = N_1(s) / D_1(s)$ (6)
Where
$N_1(s) = Q_{01}^*(s) \{ Q_{12}^*(s) Q_{22}^{(3)*}(s) + Q_{14}^*(s) \} + Q_{09}^*(s) Q_{9,10}^*(s) + Q_{07}^*(s)$
$D_1(s) = 1 - Q_{01}^*(s) \quad Q_{12}^*(s) Q_{20}^*(s)$
Making use of relations (1) and (2) it can be shown that $\theta_0(0) = 1$, which implies that $\theta_0(t)$ is a proper distribution.
MTSF = E[T] = $d/ds\, \theta_0^*(0) \Big|_{s=0} = (D_1'(0) - N_1'(0)) / D_1(0)$

$= (\mu_0 + p_{01} \mu_1 + p_{01} p_{12} \mu_2 + p_{09} \mu_9) / (1 - p_{01} p_{12} p_{20})$
where
$\mu_0 = \mu_{01} + \mu_{07} + \mu_{09}, \mu_1 = \mu_{12} + \mu_{14}, \mu_2 = \mu_{20} + \mu_{22}^{(3)}, \mu_9 = \mu_{9,10}$

AVAILABILITY ANALYSIS

Let $M_i(t)$ be the probability of the system having started from state I is up at time t without making any other regenerative state belonging to E. By probabilistic arguments, we have
The value of $M_0(t)$, $M_1(t)$, $M_2(t)$, $M_4(t)$ can be found easily.
The point wise availability $A_i(t)$ have the following recursive relations
$A_0(t) = M_0(t) + q_{01}(t)[c]A_1(t) + q_{07}(t)[c]A_7(t) + q_{09}(t)[c]A_9(t)$
$A_1(t) = M_1(t) + q_{12}(t)[c]A_2(t) + q_{14}(t)[c]A_4(t)$, $A_2(t) = M_2(t) + q_{20}(t)[c]A_0(t) + q_{22}^{(3)}(t)[c]A_2(t)$
$A_4(t) = q_{46}^{(3)}(t)[c]A_6(t)$, $A_6(t) = q_{60}(t)[c]A_0(t)$
$A_7(t) = (q_{72}(t) + q_{72}^{(8)}(t))\, [c]A_2(t) + q_{74}(t)[c]A_4(t)$
$A_9(t) = M_9(t) + q_{9,10}(t)[c]A_{10}(t)$, $A_{10}(t) = q_{10,2}(t)[c]A_2(t) + q_{10,2}^{(11)}(t)[c]A_2(t)$ (7-14)
Taking Laplace Transform of eq. (7-14) and solving for $\hat{A}_0(s)$
$\hat{A}_0(s) = N_2(s) / D_2(s)$ (15)
where
$N_2(s) = (1 - \hat{q}_{22}^{(3)}(s)) \{ \widehat{M}_0(s) + \hat{q}_{01}(s) \widehat{M}_1(s) + \hat{q}_{09}(s) \widehat{M}_9(s)\} + \widehat{M}_2(s)\{ \hat{q}_{01}(s) \hat{q}_{42}(s) + \hat{q}_{07}(s)(\hat{q}_{72}(s) + \hat{q}_{73}^{(8)}(s)) + \hat{q}_{09}(s) \hat{q}_{9,10}(s)(\hat{q}_{10,2}(s) + \hat{q}_{10,2}^{(11)}(s))\}$
$D_2(s) = (1 - \hat{q}_{22}^{(3)}(s)) \{ 1 - \hat{q}_{46}^{(5)}(s) \hat{q}_{60}(s) (\hat{q}_{01}(s) \hat{q}_{44}(s) + \hat{q}_{07}(s) \hat{q}_{74}(s))$
$- \hat{q}_{20}(s)\{ \hat{q}_{01}(s) \hat{q}_{12}(s) + \hat{q}_{07}(s)(\hat{q}_{72}(s)) + \hat{q}_{72}^{(8)}(s) + \hat{q}_{09}(s) \hat{q}_{9,10}(s)$
$(\hat{q}_{10,2}(s) + \hat{q}_{10,2}^{(11)}(s))\}$
The steady state availability
$A_0 = \lim_{t\to\infty}[A_0(t)] = \lim_{s\to 0}[s\, \hat{A}_0(s)] = \lim_{s\to 0} \frac{s\, N_2(s)}{D_2(s)}$
Using L' Hospitals rule, we get
$A_0 = \lim_{s\to 0} \frac{N_2(s) + s\, N_2'(s)}{D_2'(s)} = \frac{N_2(0)}{D_2'(0)}$ (16)
Where
$N_2(0) = p_{20}(\widehat{M}_0(0) + p_{01}\widehat{M}_1(0) + p_{09} \widehat{M}_9(0)) + \widehat{M}_2(0)\, (p_{01}p_{12} + p_{07}\, (p_{72} + p_{72}^{(8)} + p_{09}))$
$D_2'(0) = p_{20}\{ \mu_0 + p_{01} \mu_1 + (p_{01} p_{14} + p_{07} p_{74}) \mu_4 + p_{07} \mu_7 + p_{07} \mu_7 + p_{09}(\mu_9 + \mu_{10}) + \mu_2 \{ 1 - ((p_{01}p_{14} + p_{07} p_{74})\}$
$\mu_4 = \mu_{46}^{(5)}, \mu_7 = \mu_{72} + \mu_{72}^{(8)} + \mu_{74}, \mu_{10} = \mu_{10,2} + \mu_{10,2}^{(11)}$
The expected up time of the system in (0, t] is
$\lambda_u(t) = \int_0^{\propto} A_0(z)dz$ So that $\widehat{\lambda_u}(s) = \frac{\hat{A}_0(s)}{s} = \frac{N_2(S)}{SD_2(S)}$ (17)

The expected down time of the system in (0, t] is

$\lambda_d(t) = t - \lambda_u(t)$ So that $\widehat{\lambda_d}(s) = \frac{1}{s^2} - \widehat{\lambda_u}(s)$ (18)

The expected busy period of the server for repairing the failed unit under non-availability of wind in (0, t]

$R_0(t) = S_0(t) + q_{01}(t)[c]R_1(t) + q_{07}(t)[c]R_7(t) + q_{09}(t)[c]R_9(t)$
$R_1(t) = S_1(t) + q_{12}(t)[c]R_2(t) + q_{14}(t)[c]R_4(t),$
$R_2(t) = q_{20}(t)[c]R_0(t) + q_{22}^{(3)}(t)[c]R_2(t)$
$R_4(t) = q_{46}^{(3)}(t)[c]R_6(t),\ R_6(t) = q_{60}(t)[c]R_0(t)$
$R_7(t) = (q_{72}(t) + q_{72}^{(8)}(t))\ [c]R_2(t) + q_{74}(t)[c]R_4(t)$
$R_9(t) = S_9(t) + q_{9,10}(t)[c]R_{10}(t),\ R_{10}(t) = q_{10,2}(t) + q_{10,2}^{(11)}(t)[c]R_2(t)$ (19-26)

Taking Laplace Transform of eq. (19-26) and solving for $\widehat{R_0}(s)$

$\widehat{R_0}(s) = N_3(s) / D_2(s)$ (27)

Where

$N_2(s) = (1 - \hat{q}_{22}^{(3)}(s))\ \{ \hat{S}_0(s) + \hat{q}_{01}(s)\hat{S}_1(s) + \hat{q}_{09}(s)\hat{S}_9(s)\}$ and $D_2(s)$ is already defined.

In the long run, $R_0 = \frac{N_3(0)}{D_2'(0)}$ (28)

where $N_3(0) = p_{20}(\hat{S}_0(0) + p_{01}\hat{S}_1(0) + p_{09}\hat{S}_9(0))$ and $D_2'(0)$ is already defined.

The expected period of the system under non-availability of wind in (0, t] is

$\lambda_{rv}(t) = \int_0^{\infty} R_0(z)dz$ So that $\widehat{\lambda_{rv}}(s) = \frac{\hat{R}_0(s)}{s}$

The expected Busy period of the server for repair of dissimilar units by the repairman in (0, t]

$B_0(t) = q_{01}(t)[c]B_1(t) + q_{07}(t)[c]B_7(t) + q_{09}(t)[c]B_9(t)$
$B_1(t) = q_{12}(t)[c]B_2(t) + q_{14}(t)[c]B_4(t),\ B_2(t) = q_{20}(t)[c]\ B_0(t) + q_{22}^{(3)}(t)[c]B_2(t)$
$B_4(t) = T_4(t) + q_{46}^{(3)}(t)[c]B_6(t),\ B_6(t) = T_6(t) + q_{60}(t)[c]B_0(t)$
$B_7(t) = (q_{72}(t) + q_{72}^{(8)}(t))\ [c]B_2(t) + q_{74}(t)[c]B_4(t)$
$B_9(t) = q_{9,10}(t)[c]B_{10}(t),\ B_{10}(t) = T_{10}(t) + (q_{10,2}(t) + q_{10,2}^{(11)}(t)[c]B_2(t)$ (29- 36)

Taking Laplace Transform of eq. (29-36) and solving for $\widehat{B_0}(s)$

$\widehat{B_0}(s) = N_4(s) / D_2(s)$ (37)

where

$N_4(s) = (1 - \hat{q}_{22}^{(3)}(s))\ \{ \hat{q}_{01}(s)\hat{q}_{14}(s)(\hat{T}_4(s) + \hat{q}_{46}^{(5)}(s)\hat{T}_6(s)) + \hat{q}_{07}^{(3)}(s)\ \hat{q}_{74}(s)(\hat{T}_4(s)$
$+ \hat{q}_{46}^{(5)}(s)\hat{T}_6(s)) + \hat{q}_{09}(s)\ \hat{q}_{09,10}(s)\ \hat{T}_{10}(s))$

And $D_2(s)$ is already defined.

In steady state, $B_0 = \frac{N_4(0)}{D_2'(0)}$ (38)

where $N_4(0) = p_{20}\ \{(p_{01}\ p_{14} + p_{07}\ p_{74})\ (\hat{T}_4(0) + \hat{T}_6(0)) + p_{09}\ \hat{T}_{10}(0)\ \}$ and $D_2'(0)$ is already defined.

The expected busy period of the server for repair in (0, t] is

$\lambda_{ru}(t) = \int_0^{\infty} B_0(z)dz$ So that $\widehat{\lambda_{ru}}(s) = \frac{\hat{B}_0(s)}{s}$ (39)

The expected Busy period of the server for repair of unit fails due to no tides producing no tidal energy in (o, t]

$P_0(t) = q_{01}(t)[c]P_1(t) + q_{07}(t)[c]P_7(t) + q_{09}(t)[c]P_9(t)$
$P_1(t) = q_{12}(t)[c]P_2(t) + q_{14}(t)[c]P_4(t),\ P_2(t) = q_{20}(t)[c]P_0(t) + q_{22}^{(3)}(t)[c]P_2(t)$
$P_4(t) = q_{46}^{(3)}(t)[c]P_6(t),\ P_6(t) = q_{60}(t)[c]P_0(t)$
$P_7(t) = L_7(t) + (q_{72}(t) + q_{72}^{(8)}(t))\ [c]P_2(t) + q_{74}(t)[c]P_4(t)$
$P_9(t) = q_{9,10}(t)[c]P_{10}(t),\ P_{10}(t) = (q_{10,2}(t) + q_{10,2}^{(11)}(t))[c]P_2(t)$ (40-47)

Taking Laplace Transform of eq. (40-47) and solving for

$\widehat{P_0}(s) = N_5(s) / D_2(s)$ (48)

here $N_2(s) = \hat{q}_{07}(s)\ \hat{L}_7(s)\ (1 - \hat{q}_{22}^{(3)}(s))$ and $D_2(s)$ is defined earlier.

In the long run, $P_0 = \frac{N_5(0)}{D_2'(0)}$ (49)

where

$N_5(0) = p_{20}\ p_{07}\ \hat{L}_4(0)$

and $D_2'(0)$ is already defined.
The expected busy period of the server for repair of the switch in (0, t] is

$$\lambda_{rs}(t) = \int_0^{\infty} P_0(z)dz \text{ So that } \widehat{\lambda_{rs}}(s) = \frac{\widehat{P}_0(s)}{s} \quad (50)$$

The expected number of visits by the repairman for repairing the non-identical units in (0, t]

$H_0(t) = Q_{01}(t)[c]H_1(t) + Q_{07}(t)[c]H_7(t) + Q_{09}(t)[c]H_9(t)$
$H_1(t) = Q_{12}(t)[c][1+H_2(t)] + Q_{14}(t)[c][1+H_4(t)]$, $H_2(t) = Q_{20}(t)[c]H_0(t) + Q_{22}^{(3)}(t)[c]H_2(t)$
$H_4(t) = Q_{46}^{(3)}(t)[c]H_6(t)$, $H_6(t) = Q_{60}(t)[c]H_0(t)$
$H_7(t) = (Q_{72}(t)+ Q_{72}^{(8)}(t))[c]H_2(t) + Q_{74}(t)[c]H_4(t)$
$H_9(t) = Q_{9,10}(t)[c][1+H_{10}(t)]$, $H_{10}(t) = (Q_{10,2}(t)[c] + Q_{10,2}^{(11)}(t))[c]H_2(t)$ (51-58)

Taking Laplace Transform of eq. (51-58) and solving for $H_0^*(s)$

$$H_0^*(s) = N_6(s) / D_3(s) \quad (59)$$

Where

$N_6(s) = (1 - Q_{22}^{(3)*}(s))\{Q^*_{01}(s)(Q^*_{12}(s) + Q^*_{14}(s)) + Q^*_{09}(s)\, Q^*_{9,10}(s)\}$

$D_3(s) = (1 - Q_{22}^{(3)*}(s))\{1 - (Q^*_{01}(s)\, Q^*_{14}(s) + Q^*_{07}(s)\, Q^*_{74}(s))\, Q_{46}^{(5)*}(s)\, Q^*_{60}(s)\}$
$\quad - Q^*_{20}(s)\{Q^*_{01}(s)\, Q^*_{12}(s) + Q^*_{07}(s)(Q^*_{72}(s)) + Q^*_{72}{}^{(8)}(s) +$
$\quad Q^*_{09}(s)\, Q^*_{9,10}(s)\,(Q^*_{10,2}(s) + Q_{10,2}^{(11)*}(s))\}$

In the long run, $H_0 = \dfrac{N_6(0)}{D_3'(0)}$ (60)

where $N_6(0)= p_{20}(p_{01} + p_{09})$ and $D'_3(0)$ is already defined.

The expected number of visits by the repairman for repairing the unit fails due to no tides producing no tidal energy in (0, t]

$V_0(t) = Q_{01}(t)[c]V_1(t) + Q_{07}(t)[c]V_7(t) + Q_{09}(t)[c]V_9(t)$
$V_1(t) = Q_{12}(t)[c]V_2(t) + Q_{14}(t)[c]V_4(t)$, $V_2(t) = Q_{20}(t)[c]V_0(t) + Q_{22}^{(3)}(t)[c]V_2(t)$
$V_4(t) = Q_{46}^{(3)}(t)[c]V_6(t)$, $V_6(t) = Q_{60}(t)[c]V_0(t)$
$V_7(t) = (Q_{72}(t)[1+V_2(t)]+ Q_{72}^{(8)}(t))[c]V_2(t) + Q_{74}(t)[c]V_4(t)$
$V_9(t) = Q_{9,10}(t)[c]V_{10}(t)$, $V_{10}(t) = (Q_{10,2}(t) + Q_{10,2}^{(11)}(t))[c]V_2(t)$ (61-68)

Taking Laplace-Stieltjes transform of eq. (61-68) and solving for $V_0{}^*(s)$

$$V_0{}^*(s) = N_7(s) / D_4(s) \quad (69)$$

where $N_7(s) = Q^*_{07}(s)\, Q^*_{72}(s)\,(1 - Q_{22}^{(3)*}(s))$ and $D_4(s)$ is the same as $D_3(s)$

In the long run, $V_0 = \dfrac{N_7(0)}{D_4'(0)}$ (70)

where $N_7(0)= p_{20}\, p_{07}\, p_{72}$ and $D'_3(0)$ is already defined.

GAIN-FUNCTION ANALYSIS

The Gain- function of the system considering mean up-time, expected busy period of the system under non-availability of wind when the units stops automatically, expected busy period of the server for repair of the units fails due to no tides producing no tidal energy and, expected number of visits by the repairman for non-identical units failure, expected number of visits by the repairman for failure due to no tides producing no tidal energy.

The expected total Gain-function incurred in (0, t] is
C (t) = Expected total revenue in (0, t]

- expected total repair cost for switch in (0, t]
- expected total repair cost for repairing the units in (0, t]
- expected busy period of the system under non-availability of wind when the units automatically stop in (0,t]
- expected number of visits by the repairman for repairing the unit fails due to no tides producing no tidal energy in (0,t]
- expected number of visits by the repairman for repairing of the non-identical units in (0,t]

The expected total cost per unit time in steady state is

$C = \lim_{t\to\infty}(C(t)/t) = \lim_{s\to 0}(s^2 C(s))$
$= K_1A_0 - K_2P_0 - K_3B_0 - K_4R_0 - K_5V_0 - K_6H_0$

Where

K_1: revenue per unit up-time,
K_2: cost per unit time for which the system is under switch repair
K_3: cost per unit time for which the system is under unit repair
K_4: when units automatically stop cost per unit time for which the system is under non-availability of wind
K_5: cost per visit by the repairman for repair the units fails due to tides producing no tidal energy,
K_6: cost per visit by the repairman for non-identical units repair.

CONCLUSION

After studying the system, we have analyzed graphically that when the failure rate due to non-availability of wind and failure rate due to failure due to no tides producing no tidal energy increases, the MTSF and steady state availability decreases and the Gain-Function also decreased as the failure increases.

REFERENCES

1. Barlow, R.E. and Proschan, F., Mathematical theory of Reliability, 1965; John Wiley, New York.
2. Gnedanke, B.V., Belyayar, Yu.K. and Soloyer, A.D., Mathematical Methods of Relability Theory, 1969 ; Academic Press, New York.
3. Dhillon, B.S. and Natesen, J, Stochastic Anaysis of outdoor Power Systems in fluctuating environment, Microelectron. Reliab.. 1983; 23, 867-881.
4. Nakagawa, T., A 2-Unit Repairable Redundant System with Switching Failure, IEEE, Trans. Reliab., 1977; R-26, 2, pp.128-130.
5. Goel, L.R., Sharma,G.C. and Gupta, Rakesh Cost Analysis of a Two-Unit standby system with different weather conditions, Microelectron. Reliab., 1985; 25, 665-659.
6. Goel, L.R., Sharma G.C. and Gupta Parveen, Stochastic Behaviour and Profit Anaysis of a redundant system with slow switching device, Microelectron Reliab., 1986; 26, 215-219.
7. Gupta, Rakesh and Goel, Rakesh, Profit Analysis of a Two-Unit Cold Standby system under Different Weather Conditions, Microelectron. Reliab., 1991;31, pp.18-27.

Source of Support: None Declared
Conflict of Interest: None Declared