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Dynamic programming application to optimize spare parts inventory

by

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Abstract: The cost of acquiring and storing spare parts generally lies between 5% to 7% of the total electricity generation cost. Considering the amount of funds invested in the spare parts inventory, most generation divisions in power industry try to optimize their investment.

This paper presents an application of an optimal resource allocation method with the use of Dynamic Programming to optimize spare parts inventory. The method considers power plant availability as the objective function; and inventory budget as the constraint. Thus, for a given budget, Dynamic Programming configures a spare parts inventory which attains the highest availability level.

This approach has been implemented as a decision support system which assists inventory managers and engineers to optimize their inventory policy. The results of two case studies, for a base load unit and a peaking unit, illustrate possible applications and outcomes of the decision support system.

Keywords: Optimization, dynamic programming, decision support system, power plant availability, inventory management.

1. Introduction: The state of art in spare parts inventory problem

Spare parts inventory is one of the most important aspects in fulfilling power plant availability, apart from power plant maintenance strategy and staff availability. Spare parts inventory is also a major investment and could incur a substantial part of expenses.

A conservative way to manage the inventory holding is to have as many spare parts as possible in stock to ensure a high level of power plant availability. However, such management leads to expensive inventory budgets, increasing the costs of energy production. On the other hand, limiting the spare part stock implies a risk of productivity loss. Hence, there is a need for a methodology which can allocate the inventory budget to spare part purchase in the best way; that is, maximizing plant availability with a limited inventory budget.

There have been many attempts to solve this spare parts inventory problem. They are aimed at optimizing certain types of plant items. It is very common to apply the ABC method, see Cohen & Ernst (1988), Pillar & Macleod (1982), of classification prior to the application of an inventory optimization formula, such as the Economic Order Quantity (EOQ) / Re-Ordering Point (ROP) formula. Although such classification is cost-based, a conclusion on the characteristics of the items in the specific groups may also be drawn. Class "C" items tend to be "consumable" items; and in this case, the EOQ/ROP formula may be applied to optimize the inventory of these items because their demand and failure rates are predictable. Class "A" items consist of "unique" items which are very expensive and their failure rates are unpredictable. Class "B" comprises a mixture of items from class "A" and class "C".

The EOQ/ROP system is based on some assumptions, including no back orders and instantaneous replenishment and defines the Total Inventory Cost (TIC) for a year in terms of parameters, such as demand rate, unit cost of material, order quantity and annual carrying cost. The optimal quantity can be derived by minimizing the TIC over the order quantity variable. This EOQ model is widely used in practice due to its relative simplicity. Its drawback is that it is only applicable under certain conditions, in particular, the demand of the plant item must be constant. (See Alonso & Fernandez, 1979, and Swendeman & Alonso, 1979, for reports on successful application of EOQ-ROP technique)

Methods of dealing with "unique" items also became the subject of many research projects. NYSEG Reliability developed a method to provide a cost benefit analysis for unique plant items where a boiler feed pump of Somerset Power Plant was taken as the system model Pillar & Macleod (1982).

As far as repairable or maintainable items are concerned, Nahmias (1981) reported a comprehensive review on various mathematical models that have appeared in the literature for determining stocking levels. A widely implemented technique is the Multi Echelon Technique for Recoverable Item Control (METRIC) model of stock allocation. The METRIC model was developed by a research group at the Rand Corporation and introduced by Sherbrooke, Nahmias (1981). The METRIC model is an analytic approach which inspired the development of CAD's version of Optimization des Stocks de Composants et d'Articles Reparables (OSCAR) version 21 and 22, Giraud (1983). Platzer (1983) employed a similar strategy, taking into consideration the failure rate, the repair rate and the turn around time to get the part.

A structured approach has been introduced by a team of EPRI researchers. They developed and a methodology model (UNIRAM) to aid the power plant operators to improve the availability of units or subsystems (EPRI project RP2462-01) EPRI Report (1989). Using a representative new electric generating plant, the study focused on a coal pulverizer for its maintainability analysis. The research team determined the availability of the pulverizers for failure modes in 20 spare parts and maintenance scenarios. The research team reported that the UNIRAM analysis performed in this study provided ample information to make economic decisions about maintenance strategies for the pulverizers EPRI Report (1986).

Advances in information technology and data processing techniques allow the use of decision support systems and expert systems in inventory management. A useful description of different types of decision support systems was outlined by Bryson (1983).

In Australia, BHP engineering has developed an expert system for inventory management. The complete software package developed by BHP consists of three modules, one of which in particular is commonly used by the Australian power industry for inventory control. Spares Criticality Assessment System (SCAS) is a knowledge based expert system which asks the user a series of questions relating to a particular plant item, and in return, it determines the maximum and the minimum order quantity and the criticality of the plant item, Sugianto & Mielczarski (1993).

As can be seen from the above, the existing methods tend to deal with the inventory management problem by finding an optimal number of a particular component to be stocked so that the inventory carrying cost is minimised. However, it should be pointed out that the availability of a power station not only depends on a particular component, but also on the rest of the components used by the power plant to generate electricity.

2 The resource allocation method

Miclczarski & Sugianto (1992a) proposed a new method which is based on a global approach in optimizing inventory. The methodology attracted attention from inventory control managers and engineers, when two pilot systems were developed and installed, Sugianto & Mielczarski (1992a;b), Sugianto & Mielczarski (1993;1994). This new approach takes into account not only the aspects of individual components, but also components as elements of generation plants. The optimization aims at availability improvement in complex systems. An overall model is developed by arranging the components of a plant into series or parallel configurations (sec Fig. 1). Availability models of individual items are defined at a lower level, then aggregated to the availability model of an overall power plant.

The underlying assumption of the approach is that an optimization process which assures an appropriate level of spare part stock is analogous to a resource allocation process with the objective function formulated as the power plant availability to produce electrical energy. The process of spare part purchase and inventory is subjected to financial constraints representing the allocated inventory budget. Such a formulation leads to an application of Dynamic Programming as an optimal allocation method.

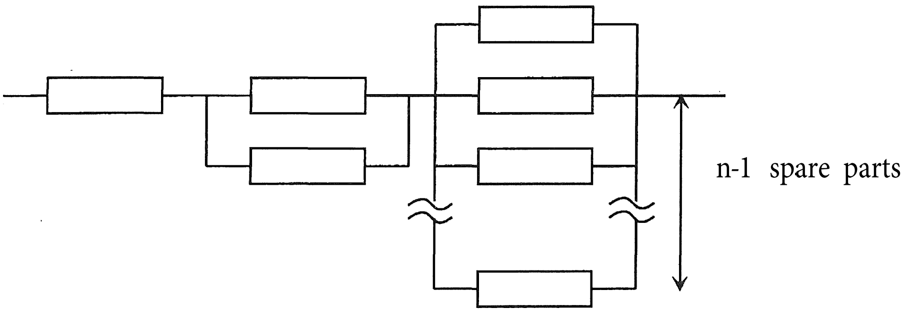

Figure 1. Modelling the interconnection of the plant items into series and parallel arrangement

Sugianto and Mielczarski formulated the objective function as the availability of a power station and modelled the power system by examining the interrelation of the electrical components in the power plant. This new approach does not have the limitation of the previous methods and it is a more generalised approach.

The Dynamic Programming application to inventory optimization has been implemented as a software package called Decision Support System (DSS). Two DSSs have been developed for two different power systems, a Boiler Feed Pump (BFP) subsystem in the Muja power station, Western Australia, Sugianto & Miolczarski (1992a;b) and a gas turbine power station in Jeeralang, Victoria, Sugianto & Mielczarski (1993;1994).

3. Availability formulation

3.1. Mathematical functions for power plant availability

Regardless of whether the power plant is a coal or gas fired, base-load, intermediate or peaking unit, the reliability, availability and maintainability (RAM) of the power plant are of economic and operational importance to the utility. Among the three performance indices, availability is the most important performance measure and it is directly influenced by the inventory holding. Availability can be defined as the probability of a system being available to function successfully in a given operating condition at time t. There are many models which describe availability mathematically, and they depend on the type of application and the operating conditions of the cases. The modelling of the availability measure can be classified into time interval based and down-time based, Rao (1992).

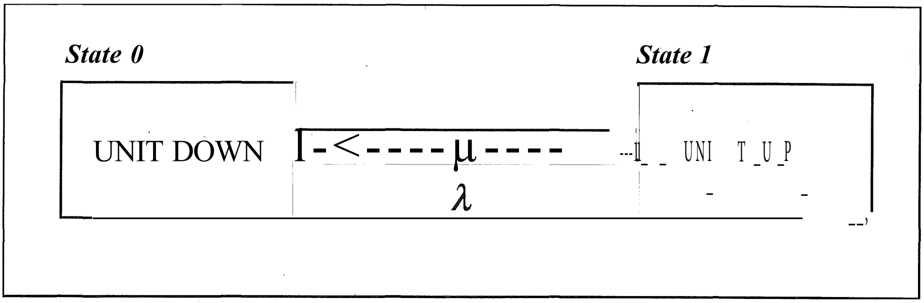

Figure 2. The two state availability model

3.2. Availability formulations for a base load unit and a peaking unit

Depending on the time period considered, the generating capacity of a power plant can be classified into static and operating capacity requirements, for long term evaluation and short term evaluation respectively. The proposed approach outlined in this paper is concerned with the static requirement of the power plant generating capacity.

The static requirement of a generating unit is concerned with the installed capacity of the plant unit and must be determined in advance. The static reserve must take into account the capacity requirement during overhaul and cover the demands during outages that are not planned or scheduled.

3.2.1. Plant item availability of a base load unit

A case study, which is outlined in a later section, focused on a base load power station located in Muja, Western Australia. The Stage D power plant in Muja comprises two identical selfcontained 200 MW generating units: Unit 7 and Unit 8. In the DSS pilot project, it was decided to model a subsystem and to choose spare parts belonging to both units. Aiming at optimizing "unique" items, twenty eight plant items were selected. The model also incorporated the fact that there are three Boiler Feed Pumps in each unit, two working units and one standby unit.

A base load power station operates in two modes, either the unit is "up" when it is called to service or the unit is "down" when it fails to operate. Fig. 2 shows a two state model, which is applicable for base load units. Basing on this model, the availability of a single plant item in a base load unit is defined as

$$A = \frac{MTTF}{MTTF + MDT} \qquad (1)$$

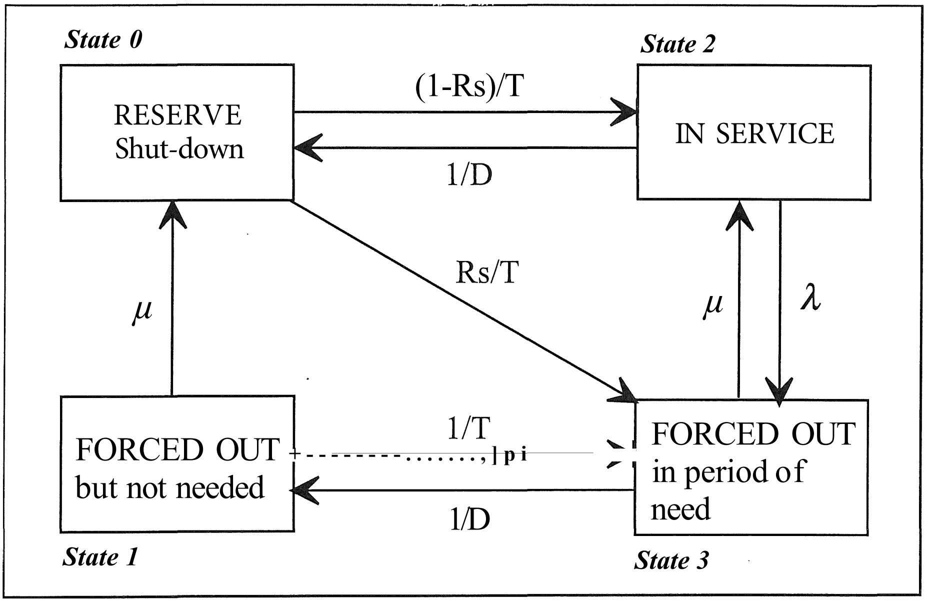

Figure 3. The four state availability model

where $MDT \{ \begin{array}{ll} MTTR, & \text{if the faulty component is repaired} \\ LT, & \text{if a new spare part has to be purchased} \end{array}$

where
MTTF Mean Time To Failure
MDT Mean Down Time
MTTR Mean Time To Repair
LT Lead (or delivery) time.

3.3. Plant item availability of a peaking unit

Another case study was carried out and applied the approach to a peaking power station at Jeeralang Gas Turbine Station. The power station comprises seven generating plants: four power plants in Stage A and three plants in Stage B. Based on the age of the power plant and data available, station B1 was chosen as the unit model for the DSS. There arc 368 plant items included in the database of the DSS.

Jecralang Gas Turbine station operates as a peaking unit. It is on standby mode most of the time and only operates upon call. Fig. 3 shows a four-state model which has been developed by the IEEE Task Group (1972) to define the power plant availability for a peaking unit. State 3 and State 2 in Fig. 3 correspond respectively to State O and State 1 in Fig. 2. However, since the demand cycle of peaking units is relatively short, the model includes a reserve period (State 0) and an event of unavailability during the period not needed (State 1), Billinton, Ringlee & Wood (1973), IEEE Task Group (1972).

Equation (2) shows the mathematical formulation of power plant unavailability developed by the IEEE Task Group.

$$A' = \frac{f(P1+3)}{P2 + f(P1+3)} - \frac{F(FOT)}{ST + f(FOT)} \qquad (2)$$

where

$$f = \frac{P_3}{P_1 + P_3} = \frac{(\mu +)}{\left(\frac{1}{D} + \mu + \frac{1}{T}\right)} = \frac{\left(\frac{1}{r} + \frac{1}{T}\right)}{\left(\frac{1}{D} + \frac{1}{r} + \frac{1}{T}\right)} \qquad (3)$$

where
FOT Forced Outage Time
ST Service Time
T Average reserve shut down time between periods of need
D Average in service time per occasion of demand
μ repair rate (per year)
r repair time

3.4. Availability formulation for the complete plant

The Forced Outage Time (FOT) is the down-time period due to any component failure in the power plant. The remedy for such failure depends on the replacement policy of that particular plant item:

- Case 1: If a spare part is available, down time = restore time
- Case 2: If there are no spare parts in stock and the replacement policy is to repair the component (given that the component is repairable),
  down time $= MTTR + MTTRestore$ (4)
- Case 3: If the policy is to purchase a new component,
  down time = Lead time $+ MTTRestore$ (5)

Fig. 1 represents the provision of spare parts inventory in an electrical circuit diagram. Having spare parts in stock is analogous to connecting redundant components in parallel so that the current may flow through alternative paths. Given that there are n components available (one component is in use and n - 1 spare parts are in stock), n - 1 components would have a very short period of down time (as in Case 1). If a breakdown occurs, the time of nonproductivity is only during the installation of a spare part (= restore time). The last component, however, would have a period of down time as in Case 2 or Case 3.

Therefore, the unavailability of item x becomes

$$A'(x) = A(x) \prod_{i=1}^{n-1} A_i(x) \qquad (6)$$

where

A (x) unavailability of component i
A (x) unavailability of component n

Further, the model of the overall system depends on the component assembly in the peaking unit. The plant has been modelled in a series arrangement because there is hardly any redundancy identified in the system. Thus, for an n plant item unit, the availability is defined as

$$A_{total} = \prod_{i=1}^{n} A(i) \tag{7}$$

4. Dynamic programming optimization

Dynamic programming is a multistage allocation process which searches for an optimum solution by partitioning the overall case into a series of stages. In a dynamic type problem, the division is performed based on the time factor, whereas in a static type problem, the allocation process is time independent. In this application, the formulation of the inventory problem falls into the static type.

Given that there are N stages, the resource for stage i is x_i while the return function for that stage is $g_i(x_i)$. The return of each stage is directly determined by the resource allocated for that particular stage. However, allocating more resources for a particular stage implies fewer resources available for the remaining stages.

The objective function of the availability calculation is given by (8) while Equation (9) shows the constraint function or limitation.

$$F_N(x) = g_1(x_1) \times g_2(x_2) \times \ldots \times g_N(x_N) \tag{8}$$

$$\sum_{i=1}^{N} x_i \leq X_{total}, \text{ where } x_i = C_i \times n_i \tag{9}$$

where

x_i resources for stage i

X_{total} total resources

C_i cost of spare part i

n_i number of spare parts purchased

$g_i(x_i)$ return function using x_i as resources for stage i (the availability of a single item)

$F_N(x)$ total return function; the product of return functions from all stages (the availability of the complete system)

The availability of a single item i is given by $g_i(x_i)$. As explained in section 3.3, the availability of an item depends on the availability of the spare parts held in stock. It is clear that the availability level of the plant item increases with the inventory of the spare parts. Keeping some spare parts in stock is analogous to a redundancy in an electrical circuit, that is, having a parallel connection to provide an alternative path for the current to flow through the circuit (see Fig. 1).

The availability of the complete system is given by $F_N(x)$. The operation of the complete system requires all N components to work successfully (or to be available for operation). In an electrical circuit, this is analogous to a series arrangement of the N components. Therefore, the availability of the complete system is given by the product of the availability of each component.

The optimization procedure at each stage is given by the following:

- For stage 1

$$f_1(x) = \max_x [g_1(x)] \tag{10}$$

- For stage 2

$$f_2(x) = \max_x [f_1(x_1) \times g_2(x - x_1)] \tag{11}$$

- For stage N

$$f_N(x) = \max_x [f_{N-1}(x_{N-1}) \times g_N(x - x_{N-1})] \tag{12}$$

where

$f_i(x)$ optimized return function for stage i.

When the optimization process has completely allocated the whole resources, the next step in the procedure is to execute a backward iteration. This calculates the resources used at each stages and the optimized number of spare parts for each components.

The backward iteration process starts from (12). Knowing that $x - x_{N-1}$ is the resources allocated for stage N, x_{N-1} is the resources allocated to optimize stage N - 1. In the same way, substituting N with N - 1 to (12), the resources allocated for stage $N - 1$ can be found. Thus, the remaining resources are to be distributed for component 1 to component $N - 2$. This iteration is repeated until the optimized numbers of spare parts for all N components are found.

5. The architecture of the decision support system

Fig. 4 shows a general architecture of the Decision Support System (DSS) which implements the approach proposed by the present authors. The DSS also functions as a simulator to analyse the effect of the stocking of spare parts on the power plant availability. There are several modules in the DSS:

- The database
- The filter program
- The optimal inventory simulation
- The review of utility proposal
- The cost evaluation program
- The program interface.

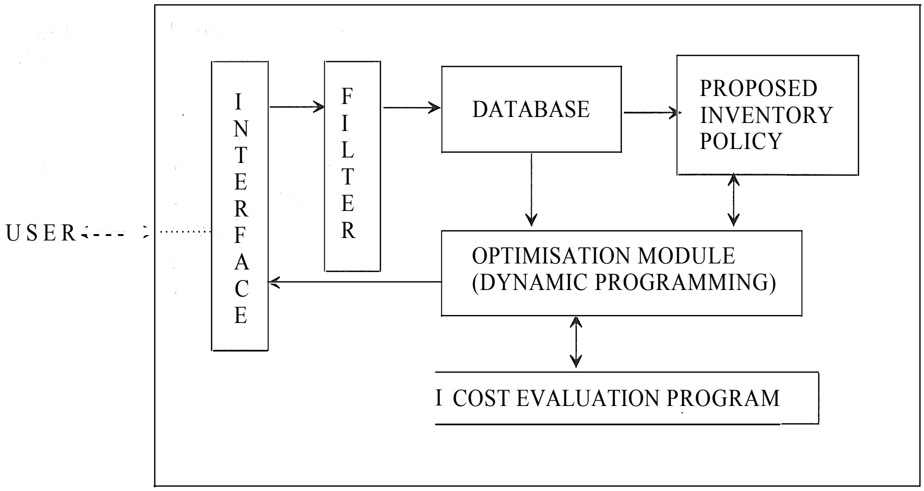

Figure 4. General architecture of the decision support system

5.1. The database

The database was organised in the form of a multilayer spreadsheet to allow expansion in a later stage of development. It has a pull down menu with six sections: multilayer spreadsheet display, shadow set display, report printing, data entry window, report generator and exit. Twenty three parameters were included in the database, fourteen of which are crucial and used directly in the optimization procedure: *80H, cost, q?J,antity v,sed per unit plant, rwmber of sets used per uni:t plant, repafr time, restore* ti:me, *lead time* or *delivery time, demand rnte, criticality factor, item number, available time, working time* or *opernti:ng time, rmmber of starts* and *nv.mber of outages.*

5.2. Filter

The filter is a program to define the lower limit boundary of the simulation. Since the DSS is an expandable system and the prices of the items vary enormously, the filter is necessary. A user might wish to disregard the inexpensive items and only requires the DSS to assist him or her in making inventory decisions for purchasing expensive items.

5.3. Dynamic Programming formulation

Dynamic Programming optimizes the stock holding of the spare parts by considering the budget allocation in a step by step process and "remembers" only the optimum budget allocation at each step.

5.4. User policy

The DSS enables a user to simulate an inventory proposal and analyses the resulting power plant availability. Further, it automatically provides an optimized alternative for configuring the inventory using the proposed budget, hence allowing the user to compare between the two.

5.5. Cost evaluation

The objective of the cost evaluation module is to evaluate the inventory system from the "cost effectiveness" point of view. The productivity of a power plant depends on availability and reliability factors. However, these performance indices do not provide meaningful information on the economical impact of the plant productivity. For instance, an increase in the availability level from 85% to 90% does not reflect how much additional profit would be gained. Therefore, it is proposed that this particular module would serve as an analysing tool to quantify the power plant productivity.

The total profit or loss results from the reconfiguration of the inventory and it is concerned with three elements:

- The buying and selling of spare parts - in selling spare parts, the salvage value of the item of any age is only a portion of its original value.
- The profit or loss resulting from the increase or decrease of the availability level - represented by a simple linear function
- The unspent amount of the inventory budget - due to the nature of the Dynamic Programming optimization when the interval factor is not set to the Least Common Divisor of the prices of the plant items.

5.6. System interface

It is desirable to have a support system which is user friendly and provides a graphical interaction between the computer and the user. Therefore, a screen management software, Screen Machine, was used to enhance the presentation of the DSS.

6. Case studies

A number of simulations have been carried out to verify the effectiveness of the DSS.

6.1. Case 1: Dynamic Programming optimization in the base-load unit

A substation of a base-load unit was chosen as a system model. Plant items which cost more than $4000 and have high turn around were included in the optimization simulation. There were 28 plant items satisfying the above criteria.

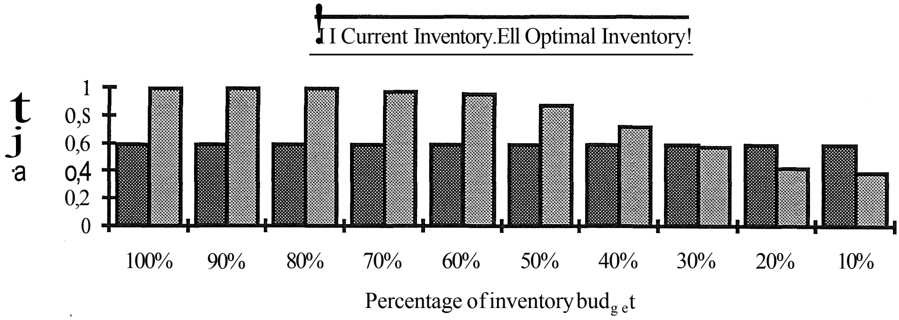

Figure 5. Availability levels of current inventory & optimal inventory (base load power station)

The program calculated the current inventory cost for these items to be \$423,000. This is the cost constraint for the optimization procedure. Table 1 shows the result of the optimization. The Dynamic Programming method managed to increase the subsystem availability level from 0.59 to 0.99. A significant increase in the availability level was obtained due to the fact that there was an excessive stock of some items, such as item 9, 10 and 12. when the failure rates of those items did not require so many spare parts to be held in stock. The optimised inventory configuration shown in Table 1 suggests that the relative demand of the twenty eight items is quite uniform, thus, an optimal way to stock spare parts for those items is by holding at least a spare part for each component.

In order to observe the effect of the cost constraint upon the availability level, a series of similar simulations were run, in which the cost constraint was varied to 90% of the original budget (90% of \$423,000 = \$380,000), 80%, 70%, and so on. The results are presented in Fig. 5.

6.2. Case 2: Dynamic Programming optimization of the peaking unit

A similar optimization procedure has been performed on a peaking unit with the inclusion of plant items which cost more than \$25,000 and have criticality factor above 0.95. Fifteen plant items fulfilled the specified criteria.

Table 3 shows the result of the simulation. The program indicated that the current inventory cost for these items was \$1.4894 million and the availability level of the current inventory is 0.94. The inventory budget (\$1.4894 million) was then specified to be the constraint constant for the optimization procedure. Using Dynamic Programming method, an optimal inventory with an availability level of 0.99 was attained.

No.	Cost (k$)	Current Inventory	Optimal Inventory.
1	5	2	2
2	42	1	1
3	26.5	1	1
4	10.5	1	1
5	6	3	1
6	11	1	1
7	34	0	1
8	24	0	1
9	10	5	2
10	10	7	2
11	10	3	1
12	10	6	1
13	10	3	1
14	8	0	1
15	8.5	0	1
16	11	0	1
17	11	0	1
18	11	0	1
19	20	0	1
20	20	0	1
21	20	0	1
22	25	0	1
23	7.5	0	1
24	4.5	0	2
25	4	0	1
26	4.5	2	2
27	5.5	6	2
28	6.5	3	2
Total Cost (k$)		243	243
Availability		0.59	0.99

Table 1. Result of Dynamic Programming optimization on 28 (base load) plant items

No.	Cost (k$)	Current Inventory	Optimal Inventory
1	10.5	1	2
2	8.5	2	3
3	9.7	2	2
4	6.5	1	2
5	4.5	1	2
6	7.57	4	1
7	4.54	4	1
8	4.53	1	1
9	2.54	2	4
10	2.52	3	2
11	2.87	1	0
12	2.84	1	1
13	9.45	1	1
14	6.45	1	1
15	3.78	1	2
Total Cost (k$)		1489.4	1460.4
Availability		0.94	0.99

Table 2. Result of Dynamic Programming optimization on 15 (peaking) plant items

6.3. Case 3: Optimization of user's proposed policy

To verify a proposed policy, the DSS incorporates a module that allows an evaluation of the user's own policy in relation to an optimal policy produced by Dynamic Programming using the same cost constraint.

A case example has been conducted on thirty two plant items which cost more than $10,000 and have criticality factor above 0.85. An inventory configuration was proposed, as shown in the "proposed" column of Table 3. The proposed inventory simulated a power engineer's decision to keep an item in store. Such a policy costs $1.288 million and optimization using this inventory budget as the constraint constant produced an optimized inventory holding, as shown in the optimal column of Table 3.

In summary, the above simulation predicts that an availability level of 0.7862 would be achieved by the proposed policy. It also suggests an alternative configuration with an availability level of 0.8825 using the same amount of inventory budget.

6.4. Case 4: Comparison of several cases

Several simulations of Case 2 were performed by varying the cost constraint in each simulation. Fig. 6 shows the availability level of the current inventory in comparison with other availability levels obtained using some percentage of the inventory budget. It can be concluded that a cost reduction of up to 40% is possible in this particular case study. By reconfiguring the inventory according to the result of the simulation with cost constraint set to 60% of the inventory budget, an availability level of 0.94 can be maintained.

Table 4 shows the profit and loss resulting from the increase and decrease of availability levels. The cost evaluation program calculates the profit and loss, based on information obtained from the industry, such as the profit gained for each percentage increase in the availability level.

As can be seen in Table 4, the profit du to an increase in the availability levels, is noticeable when a large investment is involved. Accordingly, it decreases as the investment is reduced. On the other hand, the profit obtained from the buying and selling of the spare parts becomes more significant when less resources arc invested. This is because the low availability level does not require the stocking of many of the plant items.

7. Conclusion

Determining an appropriate level of inventory whilst maintaining the availability of a power station is a complex task. Despite the abundance of inventory and reliability data from statistical calculations, historical records and factual data, one cannot possibly relate such data and information and draw a conclusion on ho to configure the inventory in the most economical way. Hence, there is a need for a support system to optimize spare parts inventory.

No.	Cost (k$)	Current	Proposed	Optimal
1	10.5	1	1	2
2	8.5	2	1	2
3	9.7	2	1	1
4	6.5	1	1	1
5	4.5	1	1	1
6	5.5	1	1	1
7	4	1	1	2
8	7.57	4	1	0
9	4.54	4	1	1
10	1.79	1	1	1
11	2.87	1	1	1
12	1.58	1	1	1
13	1.6	1	1	1
14	1.67	1	1	1
15	2.03	2	1	1
16	4.53	1	1	0
17	2.15	3	1	1
18	1.66	2	1	2
19	1.55	1	1	2
20	2.54	2	1	2
21	1.37	4	1	1
22	2.52	3	1	1
23	2.87	1	1	0
24	1.68	2	1	1
25	2.84	1	1	1
26	1.95	1	1	0
27	7	1	1	1
28	9.45	1	1	0
29	1.85	3	1	1
30	1.75	1	1	1
31	6.45	1	1	0
32	3.78	1	1	1
Cost (k$)		2083	1288	1247
Availability		0.8477	0.7862	0.8825

Table 3. Result of Dynamic Programming optimization on 32 (peaking) plant items

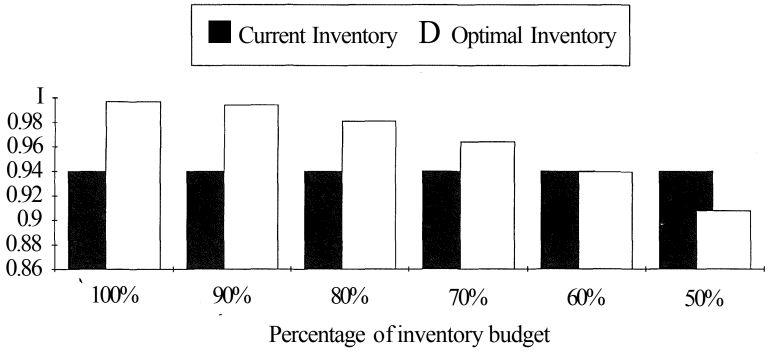

Figure 6. Availability levels of current inventory & optimal inventory (peaking power station)

Inv. Budget	Budget spend	Percentage	Avail.	Buy/sell parts	P/L from av. Level	unspent amount	Total P/L
$1489k	$1489k	100%	0.9968	($399k)	$1706k	0k.	$1307k
$1340k	$1325k	89.9%	0,9942.	($234k)	$1626k	$15k	$1407k
$1200k	$1185k	79.6%	0.9811	($22Dk)	$1232k	$15k	$1027k
$1045k	$1032k	69.3%	0.9641	($182k)	$723k	$13k	$554k
$900k	$884k	59.4%	0.9393	($75kJ	($20kJ	$16k	($79kJ
$750k	$734k	49.3%	0.9076	$75k	($971k)	$16k	($880kJ

Table 4. Result of a series of simulations on 15 (peaking) plant items

Although there are several computerised tools on the market today, most are very specific in their application. The proposed DSS attempts to fill the gap in inventory decision making viewed from economics and engineering perspectives. The approach is based on reliability engineering theory and optimization techniques, and it is applicable as a simulator tool to be used in the power industry.

As far as the application of the DSS is concerned, it would be of assistance in:

- providing inventory planning or analysis
- providing alternative policies for current stock holding
- predicting the future benefit of the inventory.

The results of the simulations up to date have indicated a cost reduction of 35% of the current budget. Moreover, the DSS is applicable to any power station with minor additional work, such as power plant modelling and supplying relevant data to the database. A DSS can be developed for any type of power station, such as: thermal, gas and hydro power stations.

8. Work in progress

The implementation of two DSSs for power stations in Western Australia and Victoria has proven the effectiveness of this new approach. However, there is difficulty in obtaining reliable data because of incomplete historical records and the low frequency of breakdown of some plant items. Therefore, the authors are currently investigating the effect of the problem of data uncertainty in the optimization process.

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