COMPUTER MODELING OF THE AVAILABILITY OF WASTE-TO-ENERGY PLANTS

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ABSTRACT

This paper describes the methodology and logic employed in a program for a personal computer that is capable of determining the expected availability/reliability of a waste-to-energy plant. The model is capable of optimizing scheduled outages and determining both scheduled outage rates and forced outages rates. The model can accommodate multiple plant configurations including plants with combinations of single and multiple equipment components, multiple parallel components, and varying levels of redundancy in different parts of the plant. The program is also capable of optimizing plant design by identifying critical areas where additional redundancy is required and discovering areas of over-design.

BACKGROUND

As part of the contract to supply a waste-to-energy plant, the contractor generally agrees to guarantee a level of electrical generation and a refuse burning availability. To insure that the plant is designed to be able to satisfy this criterion, detailed availability analyses using probabilistic techniques and data on the historical reliability of the individual equipment components to estimate the availability of the facility as a whole system should be performed during the engineering design stage.

The availability analysis technique employed here has the added advantage of permitting the impact of changes in scheduled outages of major equipment to be evaluated and hence permit optimization of the scheduled maintenance regimen.

DESCRIPTION OF PLANT

The major components that comprise the generic plant employed for this paper are incorporated into the availability model. The plant consists of three boilers each nominally rated at 110,000 lb/hr at steam conditions of 750°F/650 psig. The three boilers feed a common steam header that supplies steam to a single turbine with a gross output of 36 MW. The three boilers are fed refuse by two 100% capacity grapple cranes, i.e., one crane can supply all three boilers—the second crane is a 100% back-up. The cranes are designed so that either crane can supply all three boilers.

The feedwater system is common from the condenser to the boiler feed pumps., There are three electric driven one-third capacity boiler feed pumps, one for each boiler, as well as a stand-by steam driven 100% capacity back-up boiler feed pump capable of supplying feedwater to all three boilers.

The turbine generator exhausts into a split shell condenser, so it is possible to take one-half of the condenser out of service for inspection and maintenance without taking the turbine off-line. In addition, the plant is equipped with a dump condenser so that the boilers can burn refuse even if the turbine generator is out-of-service. There is single common circulating water system, but the system is provided with three one-third capacity circulating water pumps.

The exhaust gas from each boiler enters its own dry scrubber spray vessel. Each dry scrubber is equipped with a spare rotary atomizer that can be quickly installed without taking the unit off-line in the event of atomizer failure. The flue gas exiting the three spray dryers then enters a baghouse that is split into three individual trains (one for each flue gas scrubber) and is designed with spare bag compartments and crossover capability to insure adequate flue gas cleaning even when a portion of the baghouse is out of service.

The FGD lime slurry system supplies all three scrubbers with lime slurry reagent. The system consists of a single lime storage tank feeding a day silo which in turn feeds two parallel 100% capacity lime slakers which feed lime slurry through two parallel lines to a central lime slurry storage tank. From this point, there are two parallel 100% capacity lime slurry recirculation loops, each of which can feed the lime slurry to the three scrubber systems. Each scrubber has its own recirculation tank.

The vast majority of the fly ash is collected in the baghouse. There are two 50% capacity screw conveyors beneath each baghouse train which brings the ash to a central drag chain conveyor that runs beneath the dry scrubbers collecting the ash from the scrubbers along with receiving the ash from the baghouse conveyors. The bottom ash system consists of two 100% capacity conveyors per boiler, and it's availability is included with that of the boilers.

BASES FOR DEVELOPING THE MODEL

Because of the complexity of the overall plant design with different numbers and sizes of equipment at various points in the cycle and the varying levels of redundancy that exist throughout the plant, a simple series type of availability calculation would not have produced an acceptable answer. Also, there were multiple availability criteria that had to be satisfied—not all of which were affected equally by the failure of the various components. For example, even though electrical availability is the most critical to plant economics, there were also requirements for the plant availability as a refuse burner and as a transfer station.

By developing the computer model, it was possible to calculate these various availabilities by simply eliminating or modifying the affected equipment involved, rather than performing entirely new calculations.

DEVELOPMENT OF COMPUTER MODEL LOGIC

In order to develop a logic system that accurately simulates the actual interrelationships that exist among the major components of the plant a program that evaluates plant electrical generation and refuse burning capability as a function of the availability of all the major equipment components such as the boilers, turbine, condenser, flue gas desulfurization systems, baghouses, etc. had to be created.

The first step was to differentiate between the two principal types of equipment outage that affect the facility's ability to operate. These are scheduled or planned outages and forced or unanticipated outages. The computer program logic developed separates these two types of equipment outages and treats them in a totally separate but interdependent manner.

SCHEDULED OUTAGES

Scheduled or planned outages, by their very nature, can to a degree be controlled. For example, if a boiler is expected to require four weeks of planned outage every year to perform preventive maintenance, inspections, etc., the timing of these outages can be scheduled so as to minimize the impact on plant operation subject to various constraints such as manpower availability, periods of higher electricity value, etc. Therefore, through careful planning, it is possible to minimize downtime resulting from scheduled outages by combining equipment outages whenever possible.

In determining those items whose planned maintenance can be performed coincidently, the model considers the following:

(a) The number of installed operating units of each major piece of equipment and the degree of redundancy provided.

(b) The degree of back-up provided by spare units.

(c) The existence of interconnections, crossovers, and quick change components included in the design.

(d) The constraint that no more than one boiler can be down on scheduled maintenance at any one time to maximize refuse processing capability.

(e) A scheduled maintenance regimen that complies fully with the terms of the energy (power sales) contract with the utility.

(*f*) The amount of generation lost when each piece of equipment is taken off-line.

(*g*) The air permit that allows the plant to operate at overload conditions (125,000 lb/hr steam from each boiler) for 200 hr per year.

By applying these constraints, the computer model develops a scheduled outage regimen that minimizes plant electrical generation losses and lost refuse burning capability due to scheduled outages.

A description of the logic process involved in developing the scheduled outage regimen is given below. The input data that corresponds to this example is shown in Table 1.

First, the model searches for those systems whose outage would result in complete plant shutdown from an electrical generation perspective or from a refuse burning standpoint, depending on the type of availability calculation desired. The computer does this by searching the input data for the longest scheduled maintenance downtime in each year and selects the longest outage time as the controlling parameter.

The model then searches to determine if other scheduled maintenance work can be performed coincidently so as to reduce total downtime. The model is also programmed to handle the scheduled boiler outage in two equal increments (two outages per year) and provide sufficient time between scheduled outages of the three boilers to burn the refuse accumulated during each boiler's outage. The model then performs a similar analysis for the other two boilers.

Finally, the model determines, by difference, the remaining hours in the year that the entire plant is available at full load and at overload conditions due to the absence of scheduled outages.

The model then combines the number of hours that the plant is available in each mode with its power production capability in each mode to determine the actual net annual electrical output of the facility. This electrical production capability is then subtracted from the annual theoretical electrical production capability of the plant and then divided by the plant's annual theoretical electrical production to determine the planned outage rate.

Once all of the above individual annual calculations have been performed, the model calculates the plant's scheduled outage hours over a 5-year period of time and then calculates the scheduled outage hours and rate for a composite year (shown in Table 2) which is used as input for the combined scheduled and forced outage rate calculation. This composite analysis is necessary to account for the different scheduled outages for various equipment components on a year-to-year basis.

FORCED OUTAGES

The regimen of coincident scheduled equipment outages for the composite year developed in the first part of the program and shown in Table 2 is then employed as the basis for determining the total impact of equipment scheduled and forced outages on electrical and refuse burning availability.

This portion of the model that determines the impact on electrical generation and refuse burning of equipment forced outages was developed employing the following conservative constraints:

(*a*) A forced outage of an equipment component can not occur during a scheduled outage of that component.

(*b*) All forced outages are considered noncoincident, i.e., the outage hours are additive.

(*c*) All forced outages for single equipment components in a given system train that have the effect of shutting down the entire train are considered to be additive.

(*d*) Part load forced outage data have been equated to equivalent full load outage hours.

(*e*) Only those forced outage conditions that have an impact on plant electrical or refuse burning availability are considered.

(*f*) Presence of stand-by equipment increases the availability of the main on-line components.

(*g*) Since forced outages generally occur randomly, the probability of occurrence of equipment forced outages is uniformly distributed among all of the scheduled operating modes exclusive of those combinations which are physically impossible.

The model then tabulates all possible operating modes of the plant, considering both the number of hours the plant will operate in that mode and the corresponding electrical output of the plant as shown in Table 3.

The model then sums the total net electrical output of the plant under all of these operating modes and subtracts this value from the theoretical electrical production of the facility for the entire year. This yields the total lost electrical production and total outage rate due to both scheduled and forced outages as shown in Table 3. Then, by subtracting out the electrical production lost due to scheduled outages computed in the first part of the program, the electrical production lost to forced outages only can be determined. By dividing the lost electrical production due to forced outages by the guarantee electrical production, the forced outage rate for electricity production is then calculated. A similar approach yields the plant's refuse burning capability and availability.

TABLE 1

INPUTS	planned outage hours				FO hrs
	yr 1&3	yr 2&4	yr 5	comp	
Crane 1	24	24	24	24	20
Crane 2	24	24	24	24	20
Boiler 1	672	672	672	672	200
Boiler 2	672	672	672	672	200
Boiler 3	672	672	672	672	200
BFW pump 1	48	48	48	48	50
BFW pump 2	48	48	48	48	50
BFW pump 3	48	48	48	48	50
BFW pump 4 (100%)	96	96	96	96	75
Turbine generator	0	0	336	121.6	75
Condenser A (half)	0	0	336	121.6	5
Condenser B (half)	0	0	336	121.6	5
Circ water pump 1	48	48	48	48	40
Circ water pump 2	48	48	48	48	40
Circ water pump 3	48	48	48	48	40
FGD 1	336	336	336	336	60
FGD 2	336	336	336	336	60
FGD 3	336	336	336	336	60
FGD Lime slurry sys	24	24	24	24	25
Baghouse 1	336	336	336	336	50
Baghouse 2	336	336	336	336	50
Baghouse 3	336	336	336	336	50
FGD sludge conveyor 1	48	48	48	48	25
FGD sludge conveyor 2	48	48	48	48	25
FGD sludge conveyor 3	48	48	48	48	25
Common BH/FGD conveyor	68	68	68	68	68

Indv boiler output	110000	lb/hr	
@ overload	125000	lb/hr	
TG output w/3 boilers	30192	kw	
@ overload	34886	kw	200 hrs/year
@ guarantee	30005	kw	
with 2 circ pumps	29927	kw	
with 1 circ pumps	28569	kw	
TG output w/two boilers	19568	kw	
with 1/2 cond & 2 pmps	18874	kw	
with 2 circ pumps	19043	kw	
with 1 circ pumps	18416	kw	
TG output w/one boiler			
with 2 circ pumps	7471	kw	
with 1 circ pumps	7533	kw	

CALCULATIONS

plannned outage rate (from separate calc)	8.10
total outage rate (planned and forced)	14.08
forced outage rate (by difference)	5.98
plant electrical availability	85.92

TABLE 2

SCHEDULED OUTAGE DOWNTIME

	indv total	COMPOSITE YEAR I	II a	II b	III a	III b	IV a	IV b	V	no outage	no outage @ overload
Crane 1	24		24								
Crane 2	24					24					
Boiler 1	672	121.6	48	502.4							
Boiler 2	672				48	624					
Boiler 3	672						48	624			
BFW pump 1	48		48								
BFW pump 2	48					48					
BFW pump 3	48							48			
BFW pump 4 (100%)	96								96		
Turbine generator	121.6	121.6									
Condenser A (half)	121.6	121.6									
Condenser B (half)	121.6	121.6									
Circ water pump 1	48		48								
Circ water pump 2	48				48						
Circ water pump 3	48						48				
FGD 1	336	121.6		214.4							
FGD 2	336					336					
FGD 3	336							336			
FGD Lime slurry sys	24	24									
Baghouse 1	336	121.6		214.4							
Baghouse 2	336					336					
Baghouse 3	336							336			
FGD sludge conveyor 1	48			48							
FGD sludge conveyor 2	48					48					
FGD sludge conveyor 3	48							48			
Common BH/FGD conveyor	68	68									
Hours		121.6	48	502.4	48	624	48	624	96	6448	200
Steam Rate [lb/hr]		0	220000	220000	220000	220000	220000	220000	330000	330000	375000
Steam produced [MM lb]		0	10.56	110.53	10.56	137.28	10.56	137.28	31.68	2127.84	75.00
Electricity Rate [kw]		0	19043	19568	19043	19568	19043	19568	30192	30192	34886
Electricity produced [MM kwh]		0	0.91	9.83	0.91	12.21	0.91	12.21	2.90	194.68	6.98

2651.29	[MM lbs]	Total Steam
241.55	[MM kwh]	Total Electricity
262.84	[MM kwh]	Guarantee Electric
8.10 %		Scheduled Outage Rate

TABLE 3

Combinations of coincident operating modes
(Units down of units operating)

boilers	total hrs	CWP	total hrs	prorated hrs	kW	kWh	
0 of 2	1699.24	0 of 2	139.617	28.3091	19043	539091.	
		1 of 2	1.31839	0.26731	18416	4922.96	
		0 of 3	8124.48	1647.33	19568	3E+07	
		1 of 3	115.077	23.3334	19043	444338.	
		2 of 3	0.00085	0.00017	18416	3.19301	
			8380.49	1699.24			
1 of 2	150.942	0 of 2	139.617	2.51467	7471	18787.1	
		1 of 2	1.31839	0.02374	7533	178.876	
		0 of 3	8124.48	146.331	7471	1093242	(rate w/ 2 circ pumps)
		1 of 3	115.077	2.07268	7471	15485.0	
		2 of 3	0.00085	0.00001	7533	0.11601	
			8380.49	150.942			
0 of 3	5620.22	0 of 2	139.617	93.6320	29927	2802125	
		1 of 2	1.31839	0.88415	28569	25259.4	
		0 of 3	8124.48	5448.53	30192	2E+08	
		1 of 3	115.077	77.1747	29927	2309608	
		2 of 3	0.00085	0.00057	28569	16.3831	
			8380.49	5620.22			
1 of 3	748.858	0 of 2	139.617	12.4758	19043	237577.	
		1 of 2	1.31839	0.11780	18416	2169.55	
		0 of 3	8124.48	725.982	19568	1E+07	
		1 of 3	115.077	10.2830	19043	195819.	
		2 of 3	0.00085	0.00007	18416	1.40715	
			8380.49	748.858			
2 of 3	33.2601	0 of 2	139.617	0.55410	7471	4139.74	
		1 of 2	1.31839	0.00523	7533	39.4155	
		0 of 3	8124.48	32.2441	7471	240895.	(rate w/ 2 circ pumps)
		1 of 3	115.077	0.45671	7471	3412.12	
		2 of 3	0.00085	0.00000	7533	0.02556	
			8380.49	33.2601			
2 of 2	3.35201				0	0	
3 of 3	0.49241				0	0	
Overload operation	200			200	34886	6977200	
No electric generation							
Forced outages	182.0			182.016	0	0	
Planned outage-TG				121.6	0	0	
Planned outage-Conveyor				68	0	0	
Maximum	121.6						
	------					--------	
	8760					225.827	total actual MM kWh all modes
						262.843	total theor. MM kWh @ guar.
						85.92	plant availability

Availability Data Base

The data base for this analysis is a composite from several sources: *(a)* information supplied by the vendors for such equipment as the turbine, conveyors, boilers, etc., and *(b)* 10-year average data from North American Electric Reliability Council (NERC) sources.

However, much of the NERC data for plants of comparable size and general characteristics of the generic waste-to-energy facility are for plants that have an average unit age of 35 years, low load factors, and are not equipped with pollution control systems. In order to perform a realistic analysis, it was necessary to adjust these data to be more representative of the operating conditions that would be experienced by the waste-to-energy facility.

For this reason, time and utilization regression analyses were performed to adjust the data base to reflect a plant during its first 5–10 years of operating life (following the initial break-in period) operating at a high load factor and with pollution control equipment.

Other correction factors were also applied. The NERC data base employed contains the characteristics of electric utility plants which are often operated as load following plants subject to economic dispatch criteria and where fuel is considered an expense. The operating criteria for the generic waste-to-energy plant are totally different. The generic plant will be operated as a base load unit running as much as possible because the utility will purchase all the power that the project can generate, and the fuel (refuse) is an income source due to the tipping fee. Since the criteria for operating an electric utility plant are not the same as for the generic waste-to-energy facility, the generic plant can and will be operated under conditions that would be uneconomic and unattractive for a utility plant.

As an example, an electric utility would often take a unit down or reduce its load because another unit in their system with a better heat rate has come on-line. All of these factors which are imbedded in the NERC data base are irrelevant to the generic plant, and adjustments were made to delete those characteristics which are not relevant or applicable to the generic waste-to-energy facility from the data base.

Results of Analysis

The analysis indicates an average long-term (5-year) annual electrical availability of 85.92%. This corresponds to an annual net electrical production figure of 225.83 million kWh based on the design wet bulb temperature of 70°F. If the average annual wet bulb temperature of 56.5°F is employed, the annual electrical net output of the plant is actually 6.29 million kWh higher for a total annual production of 232.12 million kWh.

The next section of this paper repeats the process described above on a step-by-step basis showing all of the intermediate calculations and results in the exact manner that the computer model actually performs the analysis.

DETAILED EXAMPLE ILLUSTRATING COMPUTER METHODOLOGY

The following example illustrates on a step-by-step basis the calculations performed by the model to determine plant electrical availability. The first step in the logic process is calculation of the plant's scheduled outage downtime on an annual basis over the five year period of evaluation and then development of a 5-year composite average for use in the combined forced and scheduled outage calculation. An example of a typical year's scheduled outage calculation is shown in Table 4. As can be seen from the table, the year is divided into seven discrete performance levels with two of the levels further segregated into two subcases.

The first column shows the individual equipment with its yearly scheduled maintenance hours. The first performance level, Column I, represents the mode where the entire plant is shut down from an electrical generation perspective, i.e., scheduled outages due to the common BH/FGD conveyor, FGD lime slurry system, or turbine. The model scans the individual equipment totals and looks for the longest one. Since the case being shown is year 5, the turbine outage is the longest and the model schedules all three outages (conveyor, lime slurry system, and turbine) together. In addition, the model also takes down one boiler train (boiler, FGD system and baghouse) during this period to perform scheduled maintenance on these items simultaneously. Once the turbine outage is over, the turbine and boiler go back on line because all of the other scheduled maintenance has been completed.

The second performance level, Column II, represents the condition when the boiler taken down during Period I comes down the second time during the year for scheduled maintenance while the two remaining boilers remain on-line. During this period, the unit is down for 336 hr but in two distinct Modes—Mode A

TABLE 4

SCHEDULED OUTAGE DOWNTIME

YEAR 5

	indv total	I	II a	II b	III a	III b	IV a	IV b	V	no outage	no outage @ overload
Crane 1	24		24								
Crane 2	24					24					
Boiler 1	672	336	48	288							
Boiler 2	672				48	624					
Boiler 3	672						48	624			
BFW pump 1	48		48								
BFW pump 2	48					48					
BFW pump 3	48							48			
BFW pump 4 (100%)	96								96		
Turbine generator	336	336									
Condenser A (half)	336	336									
Condenser B (half)	336	336									
Circ water pump 1	48		48								
Circ water pump 2	48				48						
Circ water pump 3	48						48				
FGD 1	336	336		0							
FGD 2	336					336					
FGD 3	336							336			
FGD Lime slurry sys	24	24									
Baghouse 1	336	336		0							
Baghouse 2	336					336					
Baghouse 3	336							336			
FGD sludge conveyor 1	48			48							
FGD sludge conveyor 2	48					48					
FGD sludge conveyor 3	48							48			
Common BH/FGD conveyor	68	68									
Hours		336	48	288	48	624	48	624	96	6448	200
Steam Rate [lb/hr]		0	220000	220000	220000	220000	220000	220000	330000	330000	375000
Steam produced [MM lb]		0	10.56	63.36	10.56	137.28	10.56	137.28	31.68	2127.84	75.00
Electricity Rate [kw]		0	19043	19568	19043	19568	19043	19568	30192	30192	34886
Electricity produced [MM kwh]		0	0.91	5.64	0.91	12.21	0.91	12.21	2.90	194.68	6.98

2604.12	[MM lbs]	Total Steam
237.35	[MM kwh]	Total Electricity
262.84	[MM kwh]	Guarantee Electric
9.70	%	Scheduled Outage Rate

TABLE 5

INDIVIDUAL COMPONENT AVAILABILITY

	PO hrs	FO Avl hrs	FO hrs	"A"	forced outage hours number of components lost of components on-line: 1 of 1	1 of 2	2 of 2	1 of 3	2 of 3	3 of 3
Crane 1	24	8536	20	0.99765	0.05623	19.8970	0.04672			
Crane 2	24	8536	20	0.99765	0.05623	19.8970	0.04672			
					------	------	------			
					0.11246	39.7940	0.09345			
Boiler/FGD/BH/BFP/Sldg 1	672	7888	335.443	0.95747		54.7240	2.43054	255.122	22.6623	0.50326
Boiler/FGD/BH/BFP/Sldg 2	672	7888	335.443	0.95747		54.7240	2.43054	255.122	22.6623	0.50326
Boiler/FGD/BH/BFP/Sldg 3	672	7888	335.443	0.95747		54.7240	2.43054	255.122	22.6623	0.50326
						------	------	------	------	------
						164.172	7.29162	765.368	67.9869	1.50980
BFW pump 1	48	7888	0.44305	in boiler						
BFW pump 2	48	7888	0.44305	in boiler						
BFW pump 3	48	7888	0.44305	in boiler						
BFW pump 4 (100%)	96	8464	75	in pumps						
Turbine generator	121.6	8438.4	75	0.99111	75					
Condenser A (half)	121.6	8438.4	5	0.99940	5					
Condenser B (half)	121.6	8438.4	5	0.99940	5					

					5					
Circ water pump 1	48	8512	40	0.99530		0.44900	0.00211	39.1780	0.36995	0.00087
Circ water pump 2	48	8512	40	0.99530		0.44900	0.00211	39.1780	0.36995	0.00087
Circ water pump 3	48	8512	40	0.99530		0.44900	0.00211	39.1780	0.36995	0.00087
						------	------	------	------	------
						1.34702	0.00635	117.534	1.10985	0.00262
FGD 1	336	7888	60	in boiler						
FGD 2	336	7888	60	in boiler						
FGD 3	336	7888	60	in boiler						
FGD Lime slurry sys	24	8536	25	0.99707	25					
Baghouse 1	336	7888	50	in boiler						
Baghouse 2	336	7888	50	in boiler						
Baghouse 3	336	7888	50	in boiler						
FGD sludge conveyor 1	48	7888	25	in boiler						
FGD sludge conveyor 2	48	7888	25	in boiler						
FGD sludge conveyor 3	48	7888	25	in boiler						
Common BH/FGD conveyor	68	8492	68	0.99199	68					
					------		------			------
					173.112		7.39144			1.51242

Total forced outage hours with no electric generation: 182.016

where one boiler feed pump and one circulating water pump are also down for maintenance and Mode B when these pumps are back in service. These two modes correspond to two different levels of turbine performance.

The performance modes shown in Columns III and IV are basically the same as for Column II (one boiler down at a time) with the exception that these boilers have a longer total duration for their outages than the boiler shown in Column II because none of these boilers scheduled maintenance could be performed coincident with the outage shown in Column I. This is because of refuse burning guidelines built into the model which do not permit more than one boiler to be down for scheduled maintenance at a time.

The performance mode shown in Column V represents the period when the spare 100% capacity steam driven feed pump is unavailable due to its annual scheduled outage. There is no loss of power in this mode since this pump is totally redundant, but it does represent a different plant operating configuration.

The last two modes represent the amount of time that the entire plant is not affected by scheduled outages with the overload mode being of 200-hr duration by definition. The hours shown for normal and overload operation of the plant are not consecutive hours, but total hours of operation in each mode for the entire year.

The model then sums the generation output of all seven operating modes to calculate the scheduled outage rate for the year, which is 9.70% for the fifth year. The model then develops a composite year based on similar calculations for the other years. The composite year case is shown in Table 2.

The model then employs the input data on individual unit equipment forced outage hours from Table 1 to develop the amount of time (hours per year) each individual system that comprises the plant will be available in various configurations, i.e., one of three boilers down, one of two boilers down (one boiler out for scheduled maintenance), one of two cranes down, etc. as a result of both scheduled and forced outages. The results of these computations are shown in Table 5.

The model uses these individual availability modes to develop the combination of all probable operating modes—considering both scheduled and forced outages as well as the amount of time the plant is in each operating mode and the amount of electricity generated in that mode. The model then totals the values for all of these modes into an annual average total as shown in Table 3, whose end result is the overall plant availability, which is 85.92% in this case.