Step 3: Among the dominant machines obtained in Step 2, select those machines with bigger inertias.

Step 4: Check for the practical constraints.

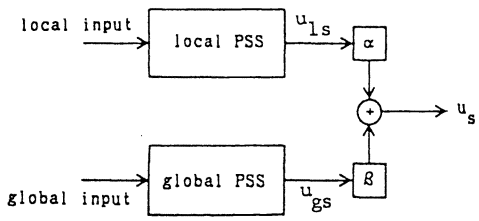

Fig. 1. Hybrid PSS.

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Voltage Optimization Using Augmented Lagrangian Functions and Quasi-Newton Techniques

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Abstract—This paper shows how the application of augmented Lagrangian functions and quasi-Newton techniques can be utilized for power system voltage optimization. The developed algorithm is attractive for three reasons: 1) it can accommodate power system constraints in a straightforward manner, 2) it is capable of reaching a solution even from infeasible starting-points and 3) it converges in a few iterations. The proposed algorithm offers substantial improvements in the computational efficiency due to: 1) a reduction in the dimensionality of the formulation by exploiting variable reduction and active-reactive decoupling in the AC-network, 2) sparse matrix techniques to selectively generate the required sensitivities and 3) an active set strategy that relaxes all inactive constraints. Computer runs have been performed and the results proves the efficiency of the algorithm.

Discussers: J. A. Momoh, G. Pan, D. Y. T. Cheng, G. Zhang, W. Hubbi, C. N. Lu, and S. Vemuri

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Analysis and Evaluation of Five Short-Term Load Forecasting Techniques

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Summary

Load forecast has been a central and an integral process in the planning and operation of electric utilities. Many techniques and approaches have been investigated to tackle this problem in the last two decades. These are often different in nature and apply different engineering considerations and economic analyses.

In this paper a comparative evaluation of five short-term load forecasting techniques is presented. These techniques are:

1. Multiple Linear Regression;
2. Stochastic Time Series;
3. General Exponential Smoothing;
4. State Space Method; and
5. Knowledge-Based Approach.

The authors have applied these algorithms to obtain hourly load forecasts (for up to 24 hours) during the winter and summer peaking seasons. Thus the five forecasting methodologies have been applied to the same database and their performances are directly compared.

The forecast error analyses are provided in Tables 1 and 2 for the winter and summer days respectively. As these results are based on forecasts of two single days, these should be used for comparative purposes only.

Some interesting observations are made about the results presented in Tables 1 and 2. For example, for the peak summer day the transfer function (TF) approach gave the best result, whereas for the peak winter day the TF approach resulted in the next to the worst accuracy. During the peak summer day the temperature profile was typical whereas during the peak winter day the profile was unseasonal. Thus one can see that because of its strong dependency on historical data, the TF approach could not take into account abrupt changes in weather as efficiently as others, like the knowledge based expert system (KBES).

Based on the observations and the authors' experience in dealing with these five forecasting techniques the following recommendations can be put forward.

1. Devise techniques for automated updating of the model parameters and coefficients.
2. Compare which model perform better under specific conditions and why.
3. Analyze if model performance can be improved by selective use of variables for different times during the day or different days.
4. Study how these techniques can be adapted for weekly instead of daily forecasts.
5. Develop detailed models for holidays and weekend using the MLR and the GES techniques.

Table 1
Forecast Percent Error for Summer Using the Five Load Forecasting Algorithms

Time	Load	MLR	STS		GES	SS	KBES
			ARIMA	TF			
1	4946.	1.79	.08	.07	1.11	.31	-.33
2	4757.	-.15	.15	.18	1.44	.77	.33
3	4600.	-1.28	-.67	-.53	1.14	.24	.02
4	4586.	-.92	-.93	-.74	1.43	.20	.25
5	4756.	1.91	-.77	-.57	1.34	-.24	-.25
6	5196.	-5.01	.20	.37	1.78	-.05	-.33
7	5809.	1.18	.67	.80	1.88	-.08	-.55
8	6261.	3.14	-.84	-.81	.06	-2.56	-1.26
9	6847.	4.34	.06	-.02	1.49	-1.34	-1.27
10	7106.	.57	-1.16	-1.36	.27	-2.78	-1.69
11	7527.	.20	.13	-.13	1.35	-2.57	-1.52
12	7693.	-1.59	.07	-.28	.77	-3.75	-1.43
13	7698.	-5.80	-1.64	-2.09	-.16	-3.26	-1.43
14	7972.	-4.02	.45	-.05	2.22	.09	-2.30
15	8082.	-.79	.93	.47	3.17	1.57	-1.49
16	8214.	1.41	1.36	.95	4.03	2.96	-2.65
17	8180.	2.46	1.04	.70	4.27	3.36	-2.40
18	7937.	1.85	-.39	-.67	2.93	1.74	-2.75
19	7559.	1.18	-.70	-.95	2.55	1.48	-1.60
20	7467.	4.55	.32	.14	3.44	1.45	-1.93
21	7284.	6.17	.06	-.11	3.53	1.34	-.16
22	6724.	10.02	.23	.10	3.56	1.49	-.11
23	5989.	4.01	.05	-.05	3.38	2.17	1.97
24	5402.	-2.34	.14	.09	3.59	1.97	1.19

Table 2
Forecast Percent Error for Winter Using the Five Load Forecasting Algorithms

Time	Load	MLR	STS		GES	SS	KBES
			ARIMA	TF			
1	4229.	1.75	.77	.62	-.90	.32	-.10
2	4124.	-.31	1.86	1.64	-.24	.43	.10
3	4107.	-2.06	2.77	2.12	-.50	1.12	1.29
4	4182.	-.68	3.95	3.38	.11	2.01	1.61
5	4315.	-.58	4.85	4.49	.02	2.56	2.08
6	4738.	-18.71	4.50	4.31	-.45	2.83	1.30
7	5842.	-1.88	6.19	6.17	.81	5.40	1.22
8	6558.	8.68	6.67	6.75	.54	7.10	2.18
9	6432.	7.47	4.97	5.09	-1.33	4.27	1.58
10	6149.	-2.04	2.34	2.46	-2.99	1.05	.47
11	5879.	-2.40	.83	.47	-4.63	-.16	-2.42
12	5688.	-3.90	.35	-.44	-4.44	-.43	-1.44
13	5463.	-4.98	-.78	-1.84	-4.25	-.85	-.98
14	5303.	-3.17	-.77	-2.09	-4.43	.09	-1.03
15	5219.	-3.03	-.62	-1.75	-3.55	-.15	.09
16	5138.	-3.69	-.50	-1.49	-2.87	.83	.65
17	5364.	-.95	-.50	-1.56	-1.17	1.81	1.25
18	5889.	-3.18	-1.56	-2.78	-.59	1.60	1.74
19	6277.	-.18	-.29	-1.56	-.54	1.46	1.49
20	6156.	-3.80	-.42	-1.72	-.02	.94	.85
21	5921.	3.18	-1.11	-2.33	-1.15	-.36	1.84
22	5597.	-.19	-1.82	-3.11	-1.46	-1.16	1.67
23	5115.	-4.41	-2.16	-3.64	-2.69	-2.50	1.52
24	4628.	-9.07	-1.49	-3.00	-3.26	-1.50	2.10

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A Survey of Current Operational Problems

A report prepared for the System Operations Subcommittee by the Working Group on Current Operational Problems

W. R. Prince, *Chairman*

Summary

This paper is one of a series prepared for use in the Working Group on Current Operational Problems (COPS) forums with the goal of focusing attention of the industry on problems faced by those who are involved in actual power system operation. The questionnaire was sent to System Operation Subcommittee members and to North American Electric Reliability Council (NERC) key operating members. One hundred thirty responses were received.

The high priority topics identified as problems by the survey can be divided up into three categories of people, analysis and control, and computer system. Some of the items, for example, Dispatcher Training Simulator could be assigned to any of these new categories. We arranged them as follows:

People Problems —Dispatcher Training Simulators
- Management Problems due to Shift Work
- Evaluation of Training Programs
- Simulators to Practice System Restoration
- Job Desirability
- Dispatcher Selection
- Relations with Dispatchers

Analysis and Control Problems —
- Key Monitoring Indicators
- Load Shedding
- System Condition Assessment
- Contingency Voltage Levels
- Transmission Access and Compensation
- Generation Cycling
- Resource Scheduling

Computer System Problems —
- Alarms (present techniques need improvement)
- Alarming (Artificial Intelligence systems are needed)
- Performance Considerations (Computer systems handling inadequately during emergencies)

Conclusion

We believe that this survey is a valid expression of prioritizing problem topics from a significant portion of the industry. We also believe that care should be taken not to ignore the other problems in the survey. It would be easy to say that one problem is more important than another because of a few percentage points difference in some measurement. None of these problems can be ignored as all had a number of respondents say the problems are important. However, COPS will use the list to organize technical sessions and encourage discussion in the areas considered of sufficient priority.

When reading the comments on topics, it is a rare topic that does not have at least one response that indicates that someone believes they have solved that particular problem. A more formal approach to listing solutions to problems is recommended to the System Operations Subcommittee.

Many of the problems listed in the 1976 COPS "Current Operational Problems" [2] are still of concern to us today. This is true even though we may not spend as much time on them now and they were not mentioned in the survey.

References

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[2] R. O. Usry, et al, "Current Operational Problems," IEEE Paper A76051-3, PES Winter Meeting, January, 1976.