



**Ain Shams University  
Faculty Of Engineering  
Elec. Power & M/Cs Dept.**

# **Generation Adequacy Assessment Using Analytical and Sequential Simulation Techniques**

**M.Sc. Thesis**

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Submitted in partial fulfillment of the requirements for  
the Master of Science degree in electrical engineering

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**Cairo - 2009**

## **Approval Sheet**

*For Thesis with Title*

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*Submitted in partial fulfillment for the requirement of degree in  
Master of Science in Electric Engineering*

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## **Statement**

This Thesis is submitted to Ain Shams University in partial fulfillment of the requirements of M.Sc. degree in Electrical Engineering.

The work included in this thesis is carried out by the author in the Department of Electrical Power and Machines, Faculty of Engineering, Ain Shams University.

No Part of this thesis has been submitted for a degree or a qualification at any other university or institution.

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# Acknowledgments

## Acknowledgments

*Prays Be To ALLAH*

I would like to express my sincere gratitude to my supervisor

**Prof. Dr. A. R. Abul'Wafa**, whose encouragement, support and guidance helped me all the time during my research and writing this thesis. His insights and knowledge were extremely valuable.

I also wish to express my appreciation to **Prof. Dr. M. A. Mostafa** for his guidance and assistance in providing some data for this thesis. My gratitude to the department staff for strengthening my knowledge on electrical engineering

Last and certainly not least, I would also like to thank **my family** for their ongoing encouragement and support.

**Reda Awad-Allah**  
**Cairo, 2009**

**Abstract****Generation Adequacy Assessment Using Analytical and Sequential Simulation Techniques**

Modern electric power systems have the responsibility of providing a reliable and economic supply of electrical energy to their customers. The economic and social effects of loss of electric service can have significant impacts on both the utility supplying electric energy and the end users of the service. Maintaining a reliable power supply is therefore a very important issue in power system design and operation.

This thesis focuses on adequacy assessment of power generation using an analytical technique and Monte Carlo method. Monte Carlo simulation can be considered to be more preferable than an analytical approach in situations which involve, for example: Time-dependent or chronological issues; duty cycle of peaking units, Nonexponential component state duration distributions. Simulation results produced the same expected reliability indices as those obtained analytically. Beside it provided the probability distribution associated with the various reliability indices, which, in consequence, provided additional and more informative data about the behavior of the system.

Most published analytical algorithms take assumption and approximation on the Generation Model or Load Model to reduce the calculation time or computer memory. So, the thesis worked on two parts as the following:

- 1- Development elaborated an analytical algorithm to get accurate

reliability indices. Computation results of this algorithm are used as a benchmark.

- 2- Development an algorithm to calculate reliability indices by Monte Carlo Simulation. Monte Carlo Simulation (MCS) proves to be sound in simulating generation system with exponentially distributed state residence time. It also capable of simulating operating histories for a unit with Weibull, normal or log-normal distributed state residence times. Data of IEEE RTS are modified to consider last possibility.

Both the analytical and the simulation programs were extensively used to get accurate reliability indices and to investigate the following:

- a. Effect of Derated States.
- b. Effects of Load Forecast Uncertainty
- c. Effect of Scheduled Maintenance
- d. Effect of Additional Generation (Gas Turbine).

The research in this thesis was conducted using the analytical and simulation programs to “IEEE-RTS” reliability test.

## ملخص الرسالة

الهدف الرئيسى من نظم القوى الكهربائية هو تحقيق رغبة المستهلك في الحصول على طاقة كهربائية ذات درجة عول عالية وتكلفة اقتصادية مناسبة وللوصول إلى مستوى جيد من العول فإنه يلزم حساب مؤشرات العول التى يجب توافرها لتحقيق هذا المستوى. ويتم عادة تقدير عول التوليد باستخدام الطرق التحليلية أو الطرق التمثيلية.

يقدم هذا البحث تقدير عول التوليد باستخدام الطرق التحليلية و الطرق التمثيلية إلا أنه باستخدام الطرق التمثيلية (تقنية مونت كارلو) تتحقق نفس النتائج إضافة إلى توفير نتائج أخرى إضافية لا يمكن الحصول عليها باستخدام الطرق التحليلية (التوزيع الإحتمالى لمؤشرات العول كمثال) إضافة إلى أن التقنية الأخيرة يمكن أن تقبل توزيعات إحتمالية أخرى (ويبل وجاودس ولو غارتمى وغيرها) غير التوزيع بدالة أسية لمتغيرات العول الذى تعتمد كل الطرق التحليلية.

تلاحظ أن الكثير من تقنيات حسابات عول التوليد غالبا ما تحوى تقريبات وفروض فى نمذجة التوليد والأحمال و/أو خوارزم الحساب وذلك لاختصار وقت الحساب الطويل وللتغلب على محدودية ذاكرة الحاسب. كل هذه البنود تجعل من نتائج الحساب تقريبية. بناء على هذه الأسباب فإنه لايمكن معرفة مقدار عدم دقة النتائج مع اعتماد تقريب أو أكثر مالم تتم مقارنتها مع نتائج يتم الحصول عليها من خوارزم حساب دقيق لا يحوى التقريبات المذكورة.

لذلك تم العمل في هذه الرسالة على هدفين:

أولاً : تم تطوير خوارزم حساب دقيق لعول التوليد (طريقة تحليلية) يتم عن طريقه الحصول على مجموعة من النتائج ذات مستوى دقة عال يمكن اتخاذها كمرجع تقاس عليه دقة أى من الطرق التقريبية.

ثانياً: تم تطوير البرامج اللازمة لحساب عول التوليد بطريقة التمثيل التتابعى (تقنية مونت كارلو) مع إمكانية تمثيل أزمنة حالات التشغيل بتوزيع أسى وغير أسى. اعطت هذه البرامج نفس نتائج الطرق التحليلية مع اجراء العدد المناسب من التمثيل التتابعى.

وأكتمل هذا الجهد باحتواء الخوارزم المطور (الطرق التحليلية وتقنية مونت كارلو) على إمكانية دراسة:

- أ. تأثير الخروج الجزئى لحدات التوليد.
- ب. تأثير عشوائية قيم الأحمال.
- ج. تأثير الصيانة الدورية (الخروج المخطط).
- د. تأثير إضافة التربينات الغازية.

جميع الدراسات التى تمت بالرسالة بالطرق التحليلية وتقنية مونت كارلو اجريت على منظومة IEEE-RTS لحساب عول التوليد حيث تطابقت نتائج التقنيتين.



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