







Finally, unlike the other analytic approximation techniques, the HAM provides a simple way to ensure the convergence of the solution series.

The homotopy analysis method is also able to combine with other techniques employed in nonlinear differential equations such as spectral methods and Pade approximants. It may further be combined with computational methods, such as the boundary element method to allow the linear method to solve nonlinear systems. Different from the numerical technique of homotopy continuation, the homotopy analysis method is an analytic approximation method as opposed to discrete computational method. Further, the HAM uses the homotopy parameter only on a theoretical level to demonstrate that a nonlinear system may be split into an infinite set of linear systems which are solved analytically, while the continuation methods require solving a discrete linear system as the homotopy parameter is varied to solve the nonlinear system.

Solving nonlinear problems is inherently difficult, and the stronger the nonlinearity, the more intractable solutions become. Analytic approximations often break down as nonlinearity becomes strong, and even perturbation approximations are valid only for problems with weak nonlinearity. This introduces a powerful new analytic method for nonlinear problems homotopy analysis that remains valid even with strong nonlinearity.

In 2000, Chen et al [7] made a study on fault analysis in power system and protection of circuits. The main advantages were its efficient energy usage. Protection improved circuit performance and makes it reliable. There observed a demerit and that was, fault is unintentional and undesirable. The study resulted in the performance depends on faultless circuits. Analysis must be done and circuits must be protected.

A fault in an electrical power system is the unintentional and undesirable creation of a conducting path (a short circuit) or a blockage of current (an open circuit). The short-circuit fault is typically the most common and is usually implied when most people use the term fault. We restrict our comments to the short-circuit fault. The causes of faults include lightning, wind damage, trees falling across lines, vehicles colliding with towers or poles, birds shorting out lines, aircraft colliding with lines, vandalism, small animals entering switchgear, and line breaks due to excessive ice loading. Power system faults may be categorized as one of four types: single Line-to-ground, line-to-line, double line-to-ground and balanced three-phase. The first three types constitute severe unbalanced operating conditions. It is important to determine the values of system voltages and currents during faulted conditions so that protective devices may be set to detect and minimize their harmful effects.

The time constants of the associated transients are such that sinusoidal steady-state methods may still be used. The method of symmetrical components is particularly suited to fault analysis. Computation of fault currents in power systems is best done by computer. The major steps are summarized below:

- Collect, read in, and store machine, transformer, and line data in per-unit on common bases.
- Formulate the sequence impedance matrices.
- Define the faulted bus and  $Z_f$ . Specify type of fault to be analyzed.
- Compute the sequence voltages.
- Compute the sequence currents.
- Correct for wye-delta connections.
- Transform to phase currents and voltages.

Thus fault analysis is performed and corrections are made. As prevention is better than cure, the system must be protected so that the fault can be reduced to a great extent. Protective equipment-relays-is designed to respond to system abnormalities (faults) such as short circuits. When faults occur, the relays must signal the appropriate circuit breakers to trip and isolate the faulted equipment. The protection systems not only protect the faulty equipment from more serious damage, they also protect the power system from the consequences of having faults remain on the system for too long. In modern high-voltage systems, the potential for damage to the power system-rather than to the individual equipment- is often far more serious and power system security considerations dictate the design of the protective system.

In 2007, Hadley et al [8] introduced the concept of plug in hybrid vehicles. The main advantages are optimize engine and battery operations for efficient operation and were the best methods to improve gasoline mileage, by using a combination of a gasoline engine and batteries to provide vehicle power. It too had few disadvantages like Local distribution grids will see a change in their utilization pattern, and some lines or substations may become overloaded sooner than expected. The conclusions of the research were: These areas can be explored further for more energy utilization. The impact of alternative vehicle operation schemes, Transmission and distribution impacts from PHEV, \*Options for utilities to modify customer behavior and \*PHEV manufacturers could improve the vehicle.

In order to conserve energy a method was implemented in 2007. Plug-in hybrid vehicles (PHEVs) are being developed around the world; much work is going on to optimize engine and battery operations for efficient operation, both during discharge and when grid electricity is available for recharging. However, there has generally been the expectation that the grid will not be greatly affected by the use of the vehicles, because the recharging would only occur during off peak hours, or the number of vehicles will grow slowly enough that capacity planning will respond adequately. But this expectation does not incorporate that end users will have control of the time of recharging and the inclination for people will be to plug in when convenient for them, rather than when utilities would prefer.

PHEV penetration of the vehicle market will create a substantial change on the electric grid. By evaluating these issues early, DOE will be able to help utilities, manufacturers, and regulators to understand the issues involved and suggest ideas that will better optimize the combined system. Using ORNL staff that have expertise in

transportation technologies, battery operation, and electric systems, new ideas and options can be explored that better prepare for a PHEV world. These areas can be explored further for more energy utilization:- The impact of alternative vehicle operation schemes (longer distance batteries, partial charging, employer-provided daytime charging, vehicle to grid generation).

- Expansion of the analysis to areas besides the VACAR region
- Transmission and distribution impacts from PHEV
- Options for utilities to modify customer behavior
- Options for utilities and PHEV manufacturers to improve the vehicle/grid system
- Options for utilities to take advantage of PHEV characteristics to improve grid reliability

In 2009, Mohammad Abdullah et al [9] presented highlights the importance of Electronic Design Automation tools and system level design methodology e.g., Model-Based Design (MBD) for the Cyber-Physical Energy Systems (CPES) to tackle the heterogeneous design complexity coming from multiple domains including power-flow dynamics, market conditions, weather, infrastructure, control, communication, consumer demand responses, etc. In addition to discussing the importance of EDA tools and its associated research challenges, this paper also showcases an exemplary EDA tool developed by the author and his group that may perform a cyber-physical co-simulation of a residential micro grid as well as potentially expedite the design of various control algorithms efficiently and interactively. Furthermore, this paper proposes a novel way of abstracting a CPES model by means of a functional abstraction level that is coded through a Functional Basis language. Finally, a discussion on how high level synthesis algorithms and EDA tools may be developed to generate high fidelity simulation models quickly and efficiently is presented.

The state electricity profile of U S in 2010 [10] was also analyzed. The State Electricity Profiles 2010 presents a summary of State statistics. This report was prepared by the U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy. By law, EIA's data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views in this report therefore should not be construed as representing those of the U.S. Department of Energy or other Federal agencies. The objective of the publication is to provide industry decision makers, government policymakers, analysts, and the general public with historical data that may be used in understanding U.S. electricity markets. The State Electricity Profiles is prepared by the Electric Power Systems and Reliability Team; Office of Electricity, Renewable, and Uranium Statistics; U.S. Energy Information Administration (EIA); U.S. Department of Energy. Data in this report can be used in analytic studies to evaluate new legislation and are used by analysts, researchers, statisticians, and other professionals with regulatory, policy, and program responsibilities for Federal, State, and local governments.

The State Electricity Profiles presents a summary of key State statistics for 2000, and 2004 through 2010. Data

published in the State Electricity Profiles are compiled from five forms filed annually by electric utilities and other electric power producers. With the survey of electricity profile of U.S, 2010 analytic studies to evaluate new legislation could be made possible. It clearly shows energy and its efficient utilization.

Electrification in the early 20th century dramatically improved productivity and increased the well-being of the industrialized world. No longer has a luxury now necessity electricity powered the machinery, the computers, the health-care systems, and the entertainment of modern society. Given its benefits, electricity is inexpensive, and its price continues to slowly decline. Electric power distribution is the portion of the power delivery infrastructure that takes the electricity from the highly meshed, high-voltage transmission circuits and delivers it to customers. Primary distribution lines are "medium-voltage" circuits, normally thought of as 600 V to 35 kV.

At a distribution substation, a substation transformer takes the incoming transmission-level voltage (35 to 230 kV) and steps it down to several distribution primary circuits, which fan out from the substation. Close to each end user, a distribution transformer takes the primary-distribution voltage and steps it down to a low-voltage secondary circuit. From the distribution transformer, the secondary distribution circuits connect to the end user where the connection is made at the service entrance functionally, distribution circuits are those that feed customers. The distribution infrastructure is extensive; after all, electricity has to be delivered to customers concentrated in cities, customers in the suburbs, and customers in very remote regions; few places in the industrialized world do not have electricity from a distribution system readily available. Distribution circuits are found along most secondary roads and streets. Urban construction is mainly underground; rural construction is mainly overhead. Suburban structures are a mix, with a good deal of new construction going underground.

In 2013, Mohammad Abdullah Al Faruque et al [11] designed on EDA, system-level design methodology and CPES model and came to certain conclusions that it could tackle the heterogeneous design complexity coming from multiple domains. It has more reliability, flexibility, efficiency and cost effectiveness and offers security of the future electric grid. The semiconductor industry has been driven by Moore's law for more than 40 years. These dramatic improvements came as a direct result of large amounts of R&D investments by the government agencies, e.g. NSF, DoD, DOE, etc. and key industry players such as Intel, IBM, TSMC and many others. Electronic System Level (ESL) design methodology and various Electronic Design Automation (EDA) tools (including high level synthesis, logic synthesis, etc.) have been successfully used to revolutionize the semiconductor industry thanks in part to their combined ability to tackle both the increasing complexity that comes with smaller and more efficient semiconductor designs, as well as to meet the short deadlines that exist due to the quick time-to-market pressure.

EDA tools and algorithms are based on rigorous analysis and optimization algorithms that are the results of many decades of work, and they are well-trusted by the industry due to them being frequently compared to existing published benchmarks. However, with the rise of new technologies and issues ranging across different fields the development and design-work of energy grid systems will require more optimization work with data cross disciplinary fields as well as more participation by the consumers.

A smart grid is a modernized electrical grid that uses analogue or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity. A smarter grid applies technologies, tools and techniques available now to make the grid work far more efficiently. The main advantages are: it ensures its reliability to degrees never before possible. It maintains its affordability. It also helps in fully accommodating renewable and traditional energy Sources, potentially reducing our carbon footprint, introducing advancements and efficiencies yet to be envisioned.

As technology evolved so did the energy measurement system. A modern energy management system is characterized with:

- The dispatch operation has been replaced with the fully digital Automatic Generation Control (AGC). The AGC integrates the dispatch function with the load frequency control, power interchange control problem, and varying degree of power system optimization functions.
- System security functions (monitoring and control) have been integrated in a hierarchical control scheme.
- Advanced economy scheduling functions are an integral part of the system, including access to the power markets, if available.

In 2013, an R&D program was organized by SERC [12] and it explained about smart energy distribution system. The Science and Engineering Research Council (SERC) of the Agency for Science, Technology and Research announce a call for research proposals in the area of Smart Energy Distribution Systems. Electricity transmission and distribution systems are among the most important technologies serving the world today, bringing clean and useful energy to meet the demand of end users in many parts of the world. However, in the light of concerns on energy security and access, environmental impacts of energy use (especially the threat of climate change) and depletion and rising costs of non-renewable energy resources, these existing energy distribution systems (built primarily around large, centralized power generation plants) have begun to show signs of age, inflexibility, vulnerability, high costs and inefficiencies. Much has to be done to address these challenges facing centralized and large scale power transmission and distribution.

At the same time, distributed energy resources (including renewable energy systems, distributed power generation, and integrated energy systems) are becoming increasingly

widespread and important, and entail the development and use of new and innovative approaches and technologies in energy supply and distribution. Distributed energy resources are smaller in capacity and output (and therefore much greater in numbers) compared to existing centralized power and energy conversion systems. They are based on a variety of different alternative and renewable energy resources with different technical and economic characteristics (including intermittency in output in the case of many forms of renewable energy resources). The design, control, management and optimization of these new distributed energy resources and technologies, and their integration into existing energy transmission and distribution networks, pose significant technological challenges to ensure their reliability and safety, and to improve and maximize their efficiency and cost competitiveness.

Micro grids and other smaller scale power networks can make important contributions to the wider application of distributed energy resources. They enable distributed energy technologies to be safely and reliably integrated with centralized networks (where they exist), or to operate on their own (in islanded mode) in remote locations not served by centralized power grids. They offer opportunities to improve energy efficiency and can ease the strain on, and cost of developing centralized power grid infrastructure. By embedding the necessary “intelligence” into energy distribution systems and optimize diverse energy resources, and provide reliable, cost competitive, and environmentally sustainable energy and power to residential, commercial, industrial, and transportation needs.

Such “intelligence” will enable flexible and interactive exchange of energy and power between distributed systems and centralized energy systems. They will enable price awareness and price sensitivity to be shared with energy suppliers and users across time and space dimensions, creating a sophisticated real time energy marketplace that is robust, adaptive, interconnected and interactive. A\*STAR’s initiative in Smart Energy Distribution Systems therefore targets the research and development of sensor and communication technologies, power control and distribution devices, advanced software for energy management and the integration of various energy technologies at a system and “system of systems” level.

In 2014, Sani at el [13] researched on the application of VLSI EDA on power distribution system. Energy distribution networks delivers power to homes and business for efficient products. But to the contrary significant amounts of energy are being wasted simply due to inefficiencies in this network. With the technological advancements, this domain is rapidly changing with new types of loads such as electric vehicles or the spread of new types of energy sources such as photo-voltaic and wind. A comprehensive design automation capability for energy distribution networks leading to much more flexible yet effective system is being demonstrated. The new system’s capabilities include power load distribution and transfers, equipment upgrading, geospatial-aware network optimization, outage identification, contingency planning and loss analysis/ reduction. These features are enabled by advanced simulation, analysis and optimization engines that

are adapted from those available in the traditional VLSI design automation area.

The main algorithm used is Comprehensive Design automation capability. It also includes power load distribution and transfers, load balancing, contingency planning and network optimization. It made the system more flexible and effective. It could make energy distribution market more dynamic and the usage of advanced simulation, analysis and optimization made the system more perfect. The algorithm focused on loss analysis and loss reduction. One drawback of this algorithm is that wastage of energy is still being continued after the implementation of this algorithm. Thus it can be concluded that Energy grid Optimization is an important problem that can generate significant benefits for society. Another one is addressing problems such as the reaction to outages, monitoring/adjusting power quality, and equipment management is focused. With the tight integration of geographical, societal and weather models into energy distribution system was practicable.

Currently in the power systems industry, there is a paradigm shift from the traditional, non-interactive, manually controlled, power grid to the tight integration of both cyber information and proper physical representations (the flow of electricity governed by the laws of physics continuous dynamics) at all scales and levels of the power grid network. This new grid which features this cyber and physical combination is termed as Cyber-Physical Energy Systems (CPES), and it is expected to improve the reliability, flexibility, efficiency, cost-effectiveness, and security of the future electric grid. However, the introduction of Distributed Energy Resources (DERs) which include renewable and new types of loads (specifically Electric Vehicles(EVs)) in the residential distribution grid presents the challenge of multi-

level monitoring and control for supply and demand management to an already complex and heterogeneous grid.

A consequence of the rapid addition of these DERs would be that traditional power system design methodologies become more time-consuming to perform and that the ability to preempt grid problems would be more difficult. Various research challenges have been already identified in the 2009 NSF Workshop "Research Recommendations for Future Energy Cyber-Physical Systems", of which various funding and research efforts from the past few years have been performed towards meeting these challenges. It is the author's understanding that now would be a good time to further identify research challenges of interest in the area of CPES due to the introduction of more heterogeneity in the grid, such as through the addition of DERs. Energy systems is an integral part of the overall Utility service package that is necessary for the consumer and industrial demand sector to continue thriving, and the work done towards researching and building the models and tools that drive CPES to meet the aforementioned challenges will have a positive impact towards both improving the overall system design and to meeting these important consumer end-goals.

The main advantage of power system modeling is accelerated developments and managed risk. System modelling is an essential technology for managing the interactions that occur across the CCS chain. It allows not only detailed analysis of individual components such as capture plant operation, but quantification of the interactions that occur up and down the chain and eventually across networks. The key benefit is the potential to reduce technology and commercial risk, and rapidly screen and rank options and tradeoffs, thereby accelerating deployment.

### 3. Comparative Analysis

Table 3.1: Various Energy Conservation techniques

Author	Year	Method	Merits	Demerits	Results
Sani et al	2014	1) Comprehensive 2) Design automation capability 3) power load distribution and transfers 4) load balancing 5) contingency planning 6) geospatial-aware network optimization	1) more flexible and effective systems 2) made energy distribution market more dynamic 3) advanced simulation, 4) analysis and optimization made the system more perfect 5) Loss analysis and loss reduction.	1) Wastage of energy due to inefficiencies of network	1) Energy grid Optimization can generate benefits for society. 2) There are significant research opportunities arising in this area.
Gi-Joon Nam et al	2010	1) Distribution Network System Optimization using grids.	1) efficient 2) reliability 3) affordability 4) reduces carbon footprint		Usage of grid increases the energy efficiency as traditional energy sources
Mohammad et al	2009	Electronic Design Automation (EDA)	1) widely used 2) Faster than traditional sources.		One of the best algorithms adopted for energy management.
Stanton W. Hadley	2007	1) Plug in hybrid vehicles	1) optimize engine and battery operations for efficient operation 2) Best methods to improve gasoline mileage, by using a	1) Local distribution grids will see a change in their utilization pattern	These areas can be explored further for more energy utilization.

			combination of gasoline engine and batteries to provide vehicle power.	2) Some lines or substations may become overloaded sooner than expected.	
Melville et al	1993	1) Artificial Parameter Homotopy Methods	1) remains valid even with strong nonlinearity	1) Solving nonlinear problems is inherently difficult	new analytic method for Nonlinear problems homotopy analysis
Bjornson et al	1986	Electric Power Distribution for Industrial Plants	1) flexibility	1) energy wastage	1) one of the energy conservation technique
Swamy et al	1980	1) Linear time invariant networks	1) more accuracy 2) does not fluctuate with time		
Chen et al	1974	1) Power system modeling 2) EMS concept	1) Accelerated developments and managed risk. 2) commercial risk		

#### 4. Conclusion

Various kinds of energy distribution systems are being compared in this paper and include details of Plug-in Hybrid Electric vehicles, Power system modeling, artificial parameter homotopy methods, LU Factorization in Network Sensitivity Computations and Power Distribution Planning. State Electricity Profiles of U.S is analyzed for the betterment and progression of our country. Thus came to a conclusion that by applying VLSI EDA to energy distribution system the energy can be conserved and could be useful for future.

There is no doubt that energy grid optimization is an important problem that can generate significant benefits for society. However, most current research appears to be focused on operational management addressing problems such as the reaction to outages, adjusting power quality, and equipment management. At the other end of spectrum, a whole new research opportunity crops up in the design planning realm. With the tight integration of geographical, societal and weather models into energy distribution system, believe that there are significant new research opportunities arising in this area.

#### References

[1] Wikipedia Online Encyclopedia  
 [2] Python official website  
 [3] Mo-Shing Chen and Dillon, W.E., "Power system modeling" in Proc of the IEEE, July, 1974  
 [4] Swamy M.N.S. and Roytman, L.M., "An alternate approach to deriving sensitivity formulas for linear time invariant networks," in proc. of the IEEE, Aug. 1980  
 [5] IEEE Recommended Practice for Electric Power Distribution for Industrial Plants, ANSI/IEEE Oct 10, 1986  
 [6] Melville ,R.C .and Trajkovic, L. and Fang, S C and Watson, L T, "Artificial parameter homotopy methods for the DC operating point problem," IEEE Transactions on Computer-Aided Design of Integrated Circuits, June 1993

[7] Analysis of Complex Power System Faults and Operating Conditions, Demetrios, Tziouvaras, Schweitzer Engineering Laboratories  
 [8] Hadley, S.W., "Evaluating the impact of Plug-in Hybrid Electric Vehicles on regional electricity supplies," iREP Symposium, Aug. 2007  
 [9] Mohammad Abdullah Al Faruque, Department of Electrical Engineering and Computer Science, University of California, Irvine  
 [10] State Electricity Profiles, U.S. Energy Information Administration, 2010  
 [11] Electronic Design Automation Past, Present, and Future, July 8-9, 2009 Robert Brayton (UC Berkeley) and Jason Cong (UCLA)  
 [12] SERC Energy Technology R&D Program Science and Engineering Research Council (SERC)  
 [13] Applying VLSI EDA to Energy Distribution System Design, Sani Nassif, Gi-Joon Nam, J. Hayes , 2014

#### Author Profile



**Rakhi B. Menon** completed her B.Tech in Electronics & Communication Engineering under Mahatma Gandhi University. Currently she is pursuing M.Tech in the specialization of VLSI and Embedded System of CUSAT



**Dr. Gnana Sheela K** received her Ph D in Electronics & Communication from Anna University, Chennai. She is working in TIST. She has published 16 international journal papers. She is life member of ISTE