Для упрощения анализа результатов расчетов средней абсолютной погрешности в таблице 1 приведены значения максимальной абсолютной погрешности из 10 точек комплексного сопротивления и средней абсолютной погрешности.

Таблица 1. Погрешности расчетов асинхронного режима

№ Опыта расчета	$\sigma_{\mathrm{i\,max}}$, Ом	σ_{cp}, Ом
1	12,2	4,8
2	10,6	5,7
3	13,1	5,5

ЗАКЛЮЧЕНИЕ

Количественно величину абсолютной погрешности расчета имеет смысл оценивать только относительно радиуса зоны срабатывания органа сопротивления устройства АЛАР, в данном примере величина абсолютной погрешности расчета не превышает 10% от диаметра зоны срабатывания органа сопротивления. Если принимать во внимание, что уставки срабатывания органов сопротивления устройств АЛАР выбираются с существенным запасом, погрешности данного метода расчета асинхронных режимов достаточно для выбора уставок срабатывания устройств АЛАР.

Данная методика расчетов параметров асинхронного режима позволяет снизить трудозатраты на производство таких расчетов, а в случае применения автоматизированного алгоритма время расчетов снижается до минимального.

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EFFICIENT APPLICATIONS OF NANOTECHNOLOGIES IN THE ENERGY SECTOR

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Nanotechnology is an interdisciplinary field of basic and applied science and technology, which deals with the accumulation of theoretical basis and practical methods of investigation, analysis and synthesis, as well as methods of manufacture and use of products with a given atomic structure by controlled manipulation of individual atoms and molecules.

Nanotechnologies are worldwide regarded as key technologies for innovations and technological progress in almost all branches of economy. Nanotechnologies refer to the target-oriented technical utilization of objects and structures in a size in the range of 1 and 100 nm. They are less seen as basic technologies in the classical sense with a clear and distinct definition, since they describe interdisciplinary and cross-sector research approaches, for example in electronics, optics, biotechnology or new materials, using effects and phenomena which are only found in the nano-cosmos. [1]

Nanotechnologies provide the potential to enhance energy efficiency across all branches of industry and to economically leverage renewable energy production through new technological solutions and optimized production technologies. In the long run, essential contributions to sustainable energy supply and the global climate protection policy will be achieved. Here, nanotechnological innovations are brought to bear on each part of the value-added chain in the energy sector.

Low-Loss Power Supply through Nanomaterials.

Considerable progress was made in the development of high-temperature superconductors in the last years through the production of yttrium-barium copper oxide (YBCO) on metallic carriers (so-called Coated Conductors, CC), which significantly extended the processability and applicability of this material class. Cable lengths of over 600 m could already be realized. Superconductors will play a growing role in energy technology for low-loss wired power supply, in coil windings and bearings of electric engines as well as in residual current circuit breakers in high-voltage grids. The most important challenge is the production of all deposited layers (superconducting and buffer protection layers) by chemical means from low-cost precursor to decrease costs to an economically attractive value. Nanotechnologies provide toeholds for the control of the microstructure in layer formation, for example through specific insertion of nanoparticles in the form of particle inclusions in the lattice structure. Currently, superconductive nanostructured systems from sol-gel precursors are being developed in a project supported by the German Federal Ministry of Education and Research (BMBF). In the long run, cables of carbon nanotube composites as high-efficient conductors could be an alternative for a low-loss power supply line in high-voltage grids. This, however, would require further significant progresses with regard to more efficient production methods and technologies for the production of long CNT-fibers with uniform structure. [1]

Nanostructured Insulation Materials for High-Voltage Power Lines.

Efficiency of power transfer in high-voltage power lines increases with increasing amperage. In Europe, current is usually conducted at approx. 400 kV, while in extensive countries like China and India high-voltage grids with up to 1500 kV are aspired. Due to increased voltages and the required current compaction as a result of the feeding of decentralized power generators and the supply of huge metropolitan areas, the electrical and mechanical strains on high-voltage power lines are growing. Hence, a central task of high-voltage technology is the further development of electric insulation systems, for example through the application of nanomaterials. The material design on the nanoscale enables the optimization of electric insulation properties like breakdown voltage, for example, through the application of nanostructured metal oxide powder in varistors as protection elements against overvoltages in power lines. Multifunctional, non-linear and auto-adaptive insulation systems are in development, the mechanical and electrical properties of which change with field strength, temperature or mechanical stress and adjust optimally to the power demand.

Nanotechnologies within Smart Grids.

The worldwide increasing liberalization of the electricity market will significantly increase the future demand on the flexibility of the power grids. Trans-European power trading requires efficient energy distribution even over long distances, a flexible adjustment to temporarily strongly fluctuating demands and a quick controllability of the power flow to limit the extent of grid failures and the risk of extensive blackouts. The existing power distribution grid encounters limits even regarding the growing decentral power supply from fluctuating renewable sources. The future power distribution requires grids which enable a dynamic load and failure management as well as a demand-driven energy supply with flexible price mechanisms. [2] Nanotechnologies could contribute essentially to the realization of this vision, for example through nanosensoric and power electronic components, which could cope with the extremely complex control and monitoring of such grids. Here, miniaturized magnetoresistive sensors on the basis of magnetic nanolayers provide potentials to enable an area wide online-metering of current and voltage parameters in the grid.

Efficient Application of Wireless Nanocrystals.

Use of wireless technologies refers to the perspective trends characterizing the modern stage of the scientific and technological development. In particularly, the tendency is rapidly evolving in the energy sector involving energy distribution and transmission, and nanotechnologies provide solutions to a variety of urgent problems in this area.

A wireless nanodevice that functions like a fluorescent light — but potentially far more efficiently — has been developed in a joint project between the National Nuclear Security Administration's Los Alamos and Sandia national laboratories. The experimental success efficiently causes nanocrystals to emit light when placed on top of a nearby energy source, eliminating the need to put wires directly on the nanocrystals. [3]

The energy source is a so-called quantum well that emits energy at wavelengths most easily absorbable by the nanocrystals. The efficiency of the energy transfer from the quantum well to the nanocrystals was approximately 55 percent — although in theory nearly 100 percent transfer of the energy is possible and might be achieved with further tweaking. The work is another step in creating more efficient white-light-emitting diodes — semiconductor-based structures more efficient and endurable than the common tungsten light bulb.

Reduction of lighting costs is of wide interest because on a world scale, lighting uses more electrical energy per year than any other human invention. Nanocrystals pumped by quantum wells generate light in a process similar to the light generation in a fluorescent light bulb. [3]

There, a captive gas permeated by electricity emits ultraviolet light that strikes the phosphor-coated surface of the bulb, causing the coat to emit its familiar, overly white fluorescent light. The current work shows that the nanocrystals can be pumped very efficiently by a peculiar kind of energy transfer that does not require radiation in the usual sense. The process is so efficient because unlike the fluorescent bulb, which must radiate its ultraviolet energy to the phosphor, the quantum well delivers its ultraviolet energy to the nanocrystal very rapidly before radiation occurs.

Because the emissions of nanocrystals (a.k.a. quantum dots) can be varied merely by controlling the size of the dot rather than by the standard, cumbersome process of varying the mix of materials, no known theoretical or practical barriers exist to pumping different-sized quantum dots that could individually emit blue, green, or red light, or be combined to generate white light.

The quantum well, about three nanometers thick, is composed of a dozen atomic layers. It coats a wafer two inches in diameter and is composed of indium gallium nitride. The film is not fabricated but rather grown as crystal, with an energy gap between its different layers that emits energy in the ultraviolet range at approximately 400 nm.

In this proof-of-principle work, the energy in the quantum well was delivered with a laser. Although the difficulties of inserting energy into the quantum well using an electrical connection rather than laser light are significant, it is considered to be feasible.

As a conclusion we can say, that in view of a globally increasing energy demand, threatening climatic changes due to continuously increasing carbon dioxide emissions, as well as the foreseeable scarcity of fossil fuels, the development and provision of sustainable methods for power generation belong to the most urgent challenges of mankind. Massive effort at political and economical level is required to basically modernize the existing energy system. Growing efficiency and new methods through nanotechnological know-how may play a key role for the required innovation in the energy sector.

Nanotechnological components provide potentials for the more efficient utilization of energy reserves and the more economical development of renewables. Nanostructured insulation materials are to be implemented in smart grids and, as a result, they will contribute to the dynamic load and failure management as well as a demand-driven energy supply with flexible price mechanisms. Introduction of wireless nanocrystals is seen as a productive step in creating more efficient white-light-emitting diodes that will allow to reduce lighting costs.

To sum up, the design of a future energy system requires new long-term investments in research activities based on realistic potential assessments and careful adaptation of the individual supply chain components based on cutting-edge nanotechnologies.

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УПРОЩЕННАЯ МОДЕЛЬ БЕСЩЕТОЧНОЙ СИСТЕМЫ ВОЗБУЖДЕНИЯ С ОГРАНИЧИТЕЛЯМИ РЕЖИМНЫХ ПАРАМЕТРОВ И РАССМОТРЕНИЕ ПРИНЯТЫХ ДОПУЩЕНИЙ

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Введение

Для синхронных генераторов применяются бесщеточные системы возбуждения (БСВ), которые являются наиболее современными и перспективными электромашинными системами возбуждения. В БСВ ток возбуждения подается в обмотку возбуждения генератора без применения контактных колец и щеток, что повышает надежность и эксплуатационные качества всей системы возбуждения.

Бесщеточный возбудитель состоит из обращенного синхронного генератора и вращающегося неуправляемого выпрямителя, жестко соединенных с ротором главного синхронного генератора. У обращенного генератора обмотки переменного тока помещаются на роторе, а обмотка возбуждения – на статоре [1].

Обмотка возбуждения обращенной машины вносит запаздывание в сигнал управления АРВ, что увеличивает инерционность системы управления. Такое запаздывание ухудшает динамические характеристики возбудителя и может приводить к самораскачиванию генераторов при приближении их загрузки к номинальной. Для улучшения характеристик вводится жесткая отрицательная обратная связь по напряжению возбуждения главного генератора (ЖОС), повышаются потолочные значения напряжения возбуждения обращенного генератора, а так же возможно последовательное включение добавочного сопротивления в обмотку возбуждения обращенного генератора [2].

Постановка задачи

В ОАО «НТЦ ЕЭС» выполняется целый спектр работ по анализу колебательной и динамической устойчивости энергосистем. Для этого необходимо обладать корректными для данных задач моделями элементов энергосистем, в том числе и цифровой моделью БСВ для проведения расчетов в программно-вычислительных комплексах (ПВК).

Изначально использовалась схема замещения БСВ в виде одного апериодического звена, реализованная, например, в ПВК Мустанг. Потребности в более точных расчетах статической и динамической устойчивости вызвали потребность в создании более сложных и подробных моделей БСВ. Так, была разработана модель, в которой учитываются процессы в