建设智能电网 保障能源安全

Construction of smart grid, protect the energy security

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20世纪末至本世纪初，伴随全球气候变化加剧和传统能源日渐枯竭，一场新的能源革命悄然兴起。

新能源革命的主要目标

中国因汽车而产生能源危机绝不是危言耸听。2013年我国汽车产销规模双双突破2000万辆大关，汽车保有量已经达到1.37亿辆，保有量急剧增加车用石油占比也陡然增高，汽车用汽柴油消费占全国汽柴油消费的比例已经达到55%左右，每年新增石油消费量的70%以上被新增汽车所消耗。2012年，我国原油进口依赖度已经高达57.8%，按每年新增2000万辆车的速度，原油进口依赖度将超过70%，汽车产销规模及保有量的急剧膨胀已经威胁了到国家能源安全。

我们要与时间赛跑，以可再生能源逐步替代化石能源，降低汽车的燃油消耗量变得非常紧迫。实现可再生能源和核能等清洁能源在一次能源生产和消费中占更大份额，建立可持续发展的能源系统是这一新能源革命的主要目标。

建设智能电网的基本任务

电网的重要性在新能源革命中日益突出，我国即将进入电网可持续化、智能化发展阶段。

按不同发展阶段的主要技术经济特征，电网可分为三代。未来电网是第三代电网，是一代电网、二代电网在新能源革命条件下的传承和发展，支持大规模新能源电力，大幅降低大电网的安全风险并广泛融合信息通信技术，是电网的可持续化、智能化发展阶段。从现在起到2050年将是我国电网由第二代向第三代转型的过渡期。

与电源的转型相配合，智能电网发展的总体任务将是国家骨干输电网与地方输配电网、微网相结合的发展模式。

智能电网将成为大规模新能源电力输送和分配网络；与分布式电源、储能装置、能源综合高效利用系统有机融合，成为灵活、高效的智能能源网络；具有极高的供电可靠性，基本排除大面积停电风险；与信息通信系统广泛结合，智能电网将建成能源、电力、信息综合服务体系。

保障电动汽车的电力需求

当前新能源革命在交通领域的任务是扬弃燃油汽车、

At the end of the 20th century to the beginning of the 21st century, along with global climate change and the exhaustion of the traditional energy, a new energy revolution sadly had arisen.

The main goal of the new energy revolution

China's energy crisis is not an alarmist due to car. In 2013 car production and sales both had hit the 20 million mark in our country, the car ownership has reached 137 million, ownership increased dramatically while the automotive oil ratio also increased suddenly, petrol and diesel oil consumption accounts for the proportion of gasoline and diesel consumption has reached around 55%, an annual increase of more than 70% of the oil consumption which had been used by new cars. In 2012, China's crude oil import dependence has reached 57.8%, according to an annual increase of 20 million vehicles, the speed of the crude oil import dependence will be more than 70%, car production and sales scale and ownership of swelling has threaten to the national energy security.

We want to race against the clock to renewable energy to gradually replace fossil energy, to reduce fuel consumption of the vehicle which has become very urgent. Implementation of renewable energy and nuclear energy and other clean energy in an energy accounts for a larger share in the production and consumption,

establish the sustainable development of energy system is one of the main targets of the new energy revolution.

The basic task of the construction of smart grid

The importance of the power grid is increasingly prominent in the new energy revolution, our country is about to enter the grid sustainable and intelligent development stage.

According to the main technical and economic characteristics of different stages of development, the grid can be divided into three generations. Future grid is the third generation of power grid, a grid generation, second generation power grid in the new energy revolution under the condition of heritage and development, support large-scale new energy power, greatly reduce the security risks of power grid and extensive information and communication technologies, which is the sustainable and intelligent power grid development stage. From now on until 2050 it will be the transformation of China's power grid by the second generation to the third generation.

To match the power transformation, the development of the smart

创新电动汽车．这必将极大地提高对电力的需求．为了保障电动汽车的电力及满足人民生活提高对电力需求，按我国电力的分布图，未来相当长时间内就必须要大容量远距离输电。

对我国未来（2020～2050年）电力发展和输电需求的初步估算结果表明，按未来达到中等发达国家人均年用电8000千瓦时的水平计算，全国年用电量12万亿千瓦时，按满负荷下年运行5000小时计，全国发电等价装机容量为24亿千瓦。若考虑其中煤电占10亿千瓦（装机比例为41.6%），四分之一容量西电东送，再加上西部水电、风电和光电，西电东送的整体规模依然很大。

从现在到2030年我国输电骨干网仍将基本保持超/特高压交直流输电网模式，但在基础研究和前沿高科技研发的支持带动下，将有可能出现新的输电方式突破。从2030年到2050年的远期阶段，技术发展的积累和突破有可能对输电网模式产生革命性的影响。根据技术突破程度的不同可能有两种模式：即超/特高压交直流输电网模式（延续目前发展模式）、多端高压直流输电网和超/特高压交流输电网的混合模式，后者更依赖于相关先进技术的重大突破、必要性和技术经济的优越性。

支撑智能电网的六大技术

未来智能电网发展，需要六大关键技术支撑．六大关键领域的重大问题和关键技术如下：

其一、电网发展模式与电力系统。未来20～30年我国输电骨干网仍将基本保持超/特高压交直流输电网模式，为适应未来接纳大规模可再生能源电力和各种电源大范围电能传输、互补的需求，多端直流输电和直流输电网技术将会得到发展。基于我国大容量远距离输电的需求和上述电网技术发展趋势的判断，电网发展模式与电力系统领域近期必须开展重大关键技术研究：包括适应我国能源发展的

grid task will be the country backbone transmission network and local distribution power grid, the combination of micro network mode. The smart grid will become a large-scale new energy electricity transmission and distribution network; With distributed power supply, energy storage devices, organic fusion energy comprehensive utilization system, a flexible and efficient smart energy network; Has a very high power supply reliability, the basic rule out large area blackout risk; Combined with information communication system widely, the smart grid will be the comprehensive information service system of energy, electric power,.

Ensure the electric car's electricity demand

The new energy revolution in the field of transportation task is discarded fuel cars, new electric vehicles. It will greatly increase the demand of electricity. In order to ensure the power of the electric vehicle and meet people's demand for improving living standards of the electricity power according to the distribution of power in our country, the future will have to high-capacity long-distance transmission in quite a long time.

The future of our country (2020 ~ 2050 years) the demand of electric power development and transmission preliminary estimation results show that the 8000 kilowatt-hours of electricity per person in middle-income levels in the future is 12 trillion KWH, the national power at full load next year running 5000 hours, the national power equivalent of installed capacity of 2.4 billion kilowatts. If considering the coal accounts for 1 billion kw to 41.6% (installed), to send a quarter of China's capacity plus the western hydropower, wind power and photovoltaic, it is still a large scale as a whole from the China.

Between now and 2030 transmission backbone network in China will still keep the ultra/uhv ac/dc grid pattern, but in basic research and high-tech research and development support, will likely new way of transmission. From 2030 to 2050 forward phase, the accumulation of technology development and breakthrough possible revolutionary influence on the grid pattern. Depending on the degree of technological breakthroughs may have two modes: the super/uhv ac/dc grid pattern (continuation of the current development mode), multiterminal HVDC transmission grid and super/uhv ac grid hybrid mode, the latter is more dependent on relevant advanced technology breakthrough, the necessity and technical and economic superiority.

电网发展模式、特征及电网构建的基础理论与关键技术；超大规模交直流电网结构优化的数学方法和关键技术；大规模新能源与可再生能源接入电网的规划与运行控制技术；大规模交直流混联电力系统的保护与控制技术；基于实时广域信息的交直流混联电力系统安全稳定控制技术；交直流混联电力系统多尺度精细化建模和先进仿真技术；电网的模式演化及未来直流电网的构造；直流电网的安全稳定控制；直流电网协调调度与优化运行，以及数学和系统科学、最优化理论与控制科学、信息与计算科学在电力系统的应用。着重解决新型电压源型直流输电系统、新型直流断路器和高压直流套管、直流电缆等相关重要基础科学问题.

其二、输电方式和输电技术。该领域的关键科学问题主要包括围绕输电线路、输电管道、电缆用的各种电工材料及其组合，在恒定或交变或瞬变的电气应力、机械应力、温度梯度作用下的综合性能研究以及长年的性能稳定研究。未来二三十年内，架空输电线路仍将是各种输电方式中最主要的方式。架空线路输电的制约因素主要是输电走廊、电磁环境、大气环境和可靠性。架空线路智能化监测、综合利用或提升已有走廊输电能力的技术研究。高电压大容量电缆输电、尤其是高电压大容量气体绝缘管道输电作为架空线路的补充有一定优势，值得大力研究。架空线路、电缆和管道输电的研究应主要集中在各种新型、高性能电工材料及其性能提升和长期稳定性方面。

其三、超导电力技术。该领域的关键问题主要包括：高性能超导材料的电磁特性及其与多物理场的相互作用机理与规律；交流高温超导线圈的稳定性及动态特性；低温高电压放电规律与机理；超导电力应用的新原理与新型拓扑结构；超导电力装置的动态特性及其与电网的相互作用机理；超导直流骨干网的结构及其运行特性。超导材料的突破是超导电力技术得以规模化应用的关键，应推动超导

The six major technical support smart grids

The future smart grid development, six key technologies need to support. The six key areas of major problems and key techniques are as follows:

First, power grid development mode and power system. Over the next 20 to 30 years in our country transmission backbone will still keep the ultra/uhv ac/dc grid pattern, in order to adapt to the future to accept large renewable energy electricity and all kinds of power supply a wide range of power transmission, complementary requirements, multiterminal HVDC and dc grid technology will be developed. Based on the demand of high-capacity long-distance transmission and judgment of the technology development trend of the power grid, the grid development pattern and the field of power system in the near future must develop major key technology research, including to adapt to the development of China's energy development of power grid pattern, characteristic and basic theory of the power grid construction and key technology; Very large scale mathematical methods and key technology in optimizing the structure of the ac/dc power grid; Large-scale new energy and renewable energy grid planning and operation control technology; Large-scale ac/dc hybrid power system protection and control technology; Based on wide-area real-time information of ac/dc hybrid power system security and stability control technology; Multi-scale refinement ac/dc hybrid power system advanced modeling and simulation technology; The structure of the grid pattern evolution and the future dc grid; Dc power grid security and stability control; DC power grid scheduling and optimization operation coordination, and mathematics and systems science, the theory of optimum and control science, information and computation science in the application of power system. To solve the new voltage source type dc transmission system, a new type of dc circuit breaker and high-voltage dc casing, dc cable and other related important basic scientific problems.

Secondly, The transmission mode and transmission technology. The key scientific problems in this field mainly includes around transmission lines, transmission line, cable with all kinds of electrical materials and their combinations, in constant or alternate or transient electrical stress, mechanical stress and temperature gradient under the action of the comprehensive performance of study and years of stable performance. In the next 20 or 30 years, overhead transmission lines will still be the main transmission way

材料及相关科学的研究。建议持续支持超导电力的应用基础和关键技术研究、试验和示范，积极推动有需求、有效益的实际应用。

其四、电力系统储能。该领域的关键问题主要包括：储能在电力系统中的应用耦合机制及能量管理控制理论，着重解决电力系统（含电动汽车）中急需应用的新型蓄能电池、大规模压缩空气等储能系统的集成机理与设计优化，满足长寿命、低成本、高安全及高效率要求的储能装置本体技术。电力系统储能技术的突破将带来电力系统的变革，它可提高电网接纳可再生能源发电的能力，提高现有电网设备的利用率和电网运行效率，提高供电可靠性和电能质量。多种储能方式、载体和规模在电力系统中都有应用前景。应开展电力系统中储能应用需求的系统研究，

of all the way. Overhead line transmission constraint is mainly transmission corridor, electromagnetic environment, atmospheric environment and reliability. Overhead line intelligent monitoring, comprehensive utilization technology research or improving the capacity of existing transmission corridors have been studied. High voltage large capacity of cable transmission, especially in high voltage large capacity gas insulated pipeline transmission supplement overhead line has certain advantages, which is worth to study. Overhead line, cable and pipe transmission research should be focused on all kinds of new, high-performance electrical materials and its performance and long-term stability.

Thirdly,The superconducting power technology. The key issues in the field include: high-performance superconducting material electromagnetic properties and the interaction mechanism and laws of physical fields; Communicate the stability of the HTS coil and dynamic characteristics; Low temperature high voltage discharge regularity and mechanism; Superconducting power applications of new principles and new topology structure; Dynamic characteristics of superconducting electric power device and its interaction mechanism with the grid; Superconducting dc backbone structure and its operating characteristics. Breakthrough of superconducting material is the key to the large-scale application of the superconducting power technology, superconducting materials and related scientific research should push. Advice continues to support the application of superconducting power base and the key technology research, experiment and demonstration, actively promote demand and benefit of actual application.

Forth, energy storage power system. The key issues in the field includes: energy storage application in power system, the coupling mechanism and energy management control theory, power system (including electric cars) to solve in application of new energy storage cell, such as large-scale compressed air energy storage system integration mechanism and design optimization, long life, low cost, high safety and high efficiency requirements of the energy storage device ontology technology. Power system, energy storage technology breakthrough will lead to the change of power system, it can improve the grid's ability to embrace renewable energy power generation, improve the utilization rate of existing grid equipment and the efficiency of the power grid, improving power supply reliability and power quality. A variety of energy storage way, carrier and scale has applied prospect in the power system. Which Should be carried out systematic study of the energy storage application requirements in power system, in view of the current and future needs to carry out the basic research and key technology research, organization of advanced equipment manufacturing, new energy power generation industry and electric power system to carry out the energy storage application technology research and experimentation.

Fifthly, new power electronic materials, devices and equipment.

针对当前及未来的突出需求开展基础研究和关键技术攻关，组织先进装备制造业、新能源发电行业和电力系统开展储能应用技术的研究和试验示范。

其五、新型电力电子材料、器件和装备。该领域的关键问题主要包括高性能碳化硅材料、器件理论，尤其是新型器件结构和制备工艺问题；高性能碳化硅功率器件产业化过程中的长期可靠性问题；基于新型功率器件的新装置及其应用系统。新型电力电子器件及其装备是支撑未来电网的关键，其中以碳化硅为代表的宽禁带半导体材料及器件可望大幅度提高未来电力电子装置的性能；以电压源型直流输电装置等为代表的新型电力电子装置在电力系统中具有广泛的应用前景。应组织材料、器件、电力电子装置、电力系统等学科开展基础研究和联合攻关，取得突破；应尽快开展从新型电力电子材料、器件到装置的全面基础性研究，突破材料和器件关键工艺和技术、创新电压源换流装置拓扑和控制技术，支撑电网技术发展。

其六、直流输电装备。该领域的关键问题主要包括：高压直流绝缘的状态表征和绝缘特性演变规律及新型绝缘材料、直流断路器的拓扑和短路电流限流机理及标准等。基于电压源直流输电（VSC-HVDC）在可再生能源电力接入电网和分布式电力系统中具有广泛的应用前景，应着重开展VSC-HVDC中主要电力设备如高压直流套管、直流电缆、直流断路器的相关基础理论研究和联合技术攻关。

为了保障国家电力能源安全，促进电动汽车发展，推动重大电工装备、电网技术和电工材料的重大专项基础研究是非常必要的.

The key issues in the field including high performance silicon carbide materials, device theory, especially the new device structure and preparation process; The long-term reliability problems in the process of industrialization of high performance silicon carbide power device; The new device and its application system based on new power devices. New power electronic devices and equipment are the key to support the future power grid, which represented by silicon carbide of wide bandgap semiconductor materials and devices are expected to greatly improve the performance of the future power electronic device; Represented by voltage source type dc power transmission device and other new type of power electronic devices in power system had broad application prospects. Of which should organize materials, devices, power electronics, power systems and other disciplines to carry out the basic research and joint research and make a breakthrough. Of which should carry out as soon as possible from the new power electronic materials and devices to the device comprehensive fundamental research, materials and device key technology and technical breakthrough, innovation, voltage source converter topology and control technology, support grid technology development.

Sixth, The dc transmission equipment. The key issues in the field including: high voltage dc insulation state and insulation properties of evolution law and new insulation materials, topology of dc circuit breaker and short-circuit current limit flow mechanism and standard, etc. Based on voltage source dc transmission (VSC - HVDC) in renewable energy power grid and has extensive application prospect in the distributed power system, should be mainly carried out mainly in the VSC - HVDC power equipment such as high voltage dc casing, dc cable, dc circuit breaker related basic theory research and joint technical research.

In order to ensure national electricity energy security, promote the development of electric vehicles, promote important electrical equipment, power grid technology and electrical material major projects of basic research are very necessary.