# Global Energy Interconnection

## Action Plan to Promote the 2030 Agenda for Sustainable Development

**Global Energy Interconnection Development and Cooperation Organization**

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## Foreword

Sustainable development is the most urgent task of the highest priority in the international community. On September 25, 2015, the UN General Assembly adopted Resolution 70/1 titled *Transforming our World: the 2030 Agenda for Sustainable Development* (hereafter "*the 2030 Agenda"*), which clarified 169 targets under 17 sustainable development goals(SDG) covering economy, society and environment. It is a far-reaching historic decision, which points out the direction for sustainable development of all countries in the next 15 years. The implementation of *the 2030 Agenda* is the shared responsibility and commitment of all countries in the world.

Energy concerns the overall situation of sustainable development. To address serious challenges confronting the world energy development, Chinese President Xi Jinping, for the first time in the world, proposed establishing Global Energy Interconnection, or GEI, to meet the global electricity demand with clean and green alternatives at the UN Sustainable Development Summit on September 26, 2015. The concept of GEI highly resonates with the objectives of *the 2030 Agenda*, and has received wide recognition and support from international community. UN Secretary-General Mr. Antonio Guterres has called for incorporating GEI into the implementation of *the 2030 Agenda* and encouraging the participation of different countries. Since its establishment in March 2016 in China, Global Energy Interconnection Development and Cooperation Organization (GEIDCO) has made all-round efforts in GEI concept promotion, strategy and planning studies, technology innovation and standardization, facilitating the transition of GEI from a concept into tangible actions.

To speed up the development of GEI and promote the implementation of *the 2030 Agenda*, GEIDCO has formulated Global Energy Interconnection Action Plan to Promote *the 2030 Agenda* for Sustainable Development (hereafter *GEI Action Plan*). The *GEI Action Plan* gives a thorough analysis on the role and value of GEI for implementing *the 2030 Agenda*, and puts forwards the goals, plan and roadmap of GEI development. Altogether, Ten Actions and Five Cooperation Mechanisms are proposed

based on the status quo of the economic, social, energy and power development in different continents. The Ten Actions include concept promotion, clean development, universal access to electricity, power grid interconnection, electricity replacement, smart grid, energy efficiency enhancement, innovation driven, capacity building and policy support. The Five Cooperation Mechanisms include global power grid planning, transnational project construction, global electricity trade, interconnected power grid coordination, and collaboration in technical standards.

Implementation of the *GEI Action Plan* is of great significance for the realization of *the 2030 Agenda*. It can help boost green and low-carbon energy transition to provide sustainable energy for all. It can help significantly reduce global greenhouse gas emission, and achieve mitigation targets set in the Paris Agreement. It also sheds lights on how to solve ecological environmental problems such as air and water pollution to render our earth a brighter sky and greener lands. Furthermore, it can effectively guide energy infrastructure construction, promote integration of energy, information and transportation networks, and provide new engine for transition and sustainable development of world economy; and ultimately, it will help reduce poverty and regional gaps for a world of peace and harmony.

GEI is a systematic undertaking with a far-reaching bearing on the implementation of *the 2030 Agenda*. It calls for the concerted efforts from governments, enterprises, organizations and individuals. To that end, GEIDCO hopes to appeal to the international community, to join in the grand cause of GEI so that we could collectively contribute to the realization of *the 2030 Agenda* for a better future with all the wisdom and strengths around the world.

# Content

# 1. Energy and Sustainable Human Development

## 1.1The Fundamental and Overarching role of Energy on Sustainable Development

Energy is the material basis of modern society. The transition in energy use from firewood to coal, oil, natural gas and other fossil fuels, and to water, wind, solar and other clean energy, has coincided with huge leaps forward in productivity and significant progress in human civilization.

Sustainable development is the theme of the contemporary world, and the fundamental requirement of development and progress for the human civilization. We need safe and sufficient food, clean air and water, sustainable energy and productive resources; we want to have a healthy life, a beautiful environment, and quality and fair education; we want eradication of poverty, discrimination, inequality and violence. None of the elements for sustainable development is separable from energy; they all need safe and reliable, clean and efficient energy for guarantee. Energy is the foundation of sustainable development and its impacts are global. Sustainable development is closely associated with energy in mainly the following areas.

**(1) Ensuring Sustainable Modern Energy for All**

Promote modern energy services and significantly increase the proportion of renewable energy in the global energy mix, to enhance global energy efficiency. Promote technological innovation and infrastructure construction, to provide modern energy services to all people with affordable prices.

**(2) Responding to Global Climate Change**

Energy is the core issue of climate change. Vigorously developing clean energy and reducing greenhouse gas emissions is the key to addressing climate change.

**(3) Embracing Sustainable Consumption and Production Patterns**

Controlling the total consumption of energy resources, improving the efficiency of energy use and significantly reducing pollutant emissions are important measures for achieving sustainable consumption and production of energy.

**(4) Building Cities with Sustainable Development Capacity**

Building a clean and safe urban energy supply system is the main way to reduce urban air and waste pollution, as well as the prerequisite for improving urban planning management and achieving sustainable development.

**(5) Promoting Infrastructure Construction and Sustainable Industrialization**

Energy network is the most important infrastructure of the world, with an important role in guaranteeing industrial production, enhancing industrial production efficiency and product quality, and promoting sustainable industrialization.

**(6) Promoting Sustainable Economic Growth and Ensuring Employment**

Safe and reliable supply of energy is a prerequisite for sustainable economic development. Meanwhile, energy investment will drive the development of the entire industry chain, thus stimulating sustainable economic growth and creating jobs.

**(7) Eradicating Poverty**

Energy poverty is an important aspect of poverty. Ensuring basic energy services is an important task for eradicating poverty, while turning the advantageous energy resources of underdeveloped areas into economic advantages is also an effective means to get rid of poverty.

**(8) Eliminating Inequality and Regional Disparities**

Unreasonable energy production and consumption is a major reason for the emergence of inequality. Therefore, fundamentally changing the patterns of energy production and consumption is the primary approach for eliminating inequality and

changing the international pattern of power.

### (9) Promoting World Peace and Social Inclusiveness

Currently the competition for oil and other limited fossil fuels has been a major reason for frequent regional conflicts. Replacing fossil fuels with clean energy will promote the shift of mankind from energy competition to energy cooperation, thus reducing conflicts and promoting social inclusiveness and world peace.

### (10) Forging Partnerships to Promote Global Cooperation

Energy is the basic area of global cooperation. Involving North-South, South-South and other international cooperation, it will promote the establishment of solid partnership between all parties.

**In short, energy will play a key role in achieving sustainable development of humans, and its sustainable development should be prioritized.**

## 1.2 Four Challenges for Sustainable Development of Energy

Since the Industrial Revolution, there has been unduly heavy reliance of socio-economic development upon fossil fuels, which have incurred severe challenges such as resource constraints, environmental pollution, climate change and large population without access to electricity. Those have in turn become a conundrum that impede the goals of *the 2030 Agenda* and thus should be tackled and solved as soon as possible.

### 1.2.1 Resources Constraints

Given the current development intensity, global proved reserves of coals, oil and natural gas will be exhausted in 153 years, 51 years and 53 years respectively[1]. In some countries and regions, shortage of fossil fuels has been increasingly prominent. Competition for fossil fuels will be fiercer, the original conflicts intensified and new

1. BP：World Energy Statistics 2017

disputes incurred, if no action is to taken for energy transition.

### 1.2.2 Environmental Pollution

Production, transport and utilization of fossil fuels have caused severe pollution and damages to air, water and soil and acid rain, air pollution, water pollution and strata changes, which are detrimental to human health. Around 6.5 million premature deaths each year are caused by air pollution[2]. Nitrogen oxides, sulfur oxides, particulate matter and other pollutants from energy consumption have been one of the main culprits.

### 1.2.3 Climate Change

Climate change remains a menace to the existence and development of mankind, regardless of countries, nationalities and wealth. The global energy-related carbon dioxide emission totaled 32.2 billion tons in 2014[3]. More strict measures should be taken to control global emissions of GHGs (greenhouse gases) to less than 40 billion tons, so as to fulfill the pledges of the Paris Agreement.

### 1.2.4 Population without Access to Electricity

Over the past 30 years, steady progress has been made in popularizing access to electricity. However, by 2014, a total of 1.06 billion people across the world still had no access to electricity[4], job opportunities, education and business opportunities, making it impossible for them to get rid of poverty. Among them, over 90% lived in the developing countries in sub-Saharan Africa, Asia and Latin America, including India, Bangladesh, Burma, and Haiti. Besides, around 3 billion people were still using firewood, coal, charcoal and animal dung for cooking and heating, causing severe damage to their health.

2. IEA：World Energy Outlook 2016 Special Report- Energy and Air Pollution
3. IEA：World Energy Outlook 2016
4. Sustainable Energy For All：Global Tracking Framework: Progress towards Sustainable Energy 2017.

**To address the four major challenges, we must take immediate actions to accelerate energy system transition. We must establish a stable and reliable, clean and low-carbon, economical and efficient modern energy system to promote the sustainable development of all countries.**

# 2. Global Energy Interconnection is critical for energy transition and *the 2030 Agenda*

## 2.1 GEI Development Strategy

GEI is an infrastructure platform for large-scale development, transmission and consumption of clean energy worldwide. Its strategic direction, fundamental requirements and basic constituents are as follows:

### 2.1.1 Strategic Direction

(1) **Two Replacements.** Replacement of fossil energy with hydropower, solar power, wind energy and other clean alternatives in energy production; replacement of coal, gas and oil with clean electricity from afar in energy consumption.

(2) **One Increase.** Increase electrification and the proportion of electricity in energy consumption mix, and reduction of energy consumption while effectively meeting the demands.

(3) **One Restoration.** Restore fossil fuels to their basic role as an industrial raw material to create even greater value in socio-economic development. According to statistics, 70% of the crude oil in the world has been used for fuel, while only 30% as raw materials. However, the economic value of the latter is 1.6 times that of the former.

### 2.1.2 Fundamental Requirements

(1) **Clean energy as the domination.** The energy system must be transformed and become green, low-carbon and sustainable, so that clean energy replaces fossil fuels as the dominant energy.

(2) **Electricity as the center.** With the gradual recession of fossil fuel network, the future energy system will feature electrical power system, which will transform

primary energies into power and efficiently transmit it to end users.

(3) **Interconnection.** Given their uneven distribution across the world, energy resources must be developed mainly through major energy bases, supplemented with distributed development, for the purpose of optimal allocation on a large scale. Ultra High Voltage (UHV) and smart grid technologies should be brought into full play for building interconnected power grids, to form a general pattern of global interconnection of power grids across regions, countries and continents for the globalization of energy production, allocation and trade.

(4) **Co-construction and Sharing.** GEI is an undertaking that benefits the whole mankind and a magnificent systematic project. Aimed at providing sustainable energy for all and extending the fruits of sustainable development to all, it necessitates joint efforts and wisdom, unreserved cooperation, and co-construction.

### 2.1.3 Basic Constituents

In essence, GEI is **"Smart Grid + UHV Grid + Clean Energy"**. Smart grid is the foundation, UHV grid is the key, and clean energy is the priority.

(1) **Smart Grids.** The smart grids have incorporated advanced modern smart technologies in transmission, intelligent control, new energy integration and storage. They are capable of centralized and distributed integration and consumption of clean energy. Therefore, smart electrical equipment and interactive services could be connected to them, thus obtaining the coordinated development of power generation, transmission, distribution and storage in a coordinated and efficient manner.

(2) **UHV Power Grids.** The UHV power grids are comprised of 1000 kV and above AC and ±800kV DC and above systems, with prominent edges like long transmission distance, large capacity, high efficiency, low line loss, less land occupation, and greater safety. They are capable of transmitting power in Giga-watts across thousands of kilometers and transnational and transcontinental power interconnection.

(3) **Clean Energy.** With the progress of hydropower, wind power and solar power generation technologies, and the rapid decline of generation costs, the clean energy will replace fossil fuels at a faster rate to become the dominant energy in the future energy system.

## 2.2 GEI Facilitates Energy Transition

GEI will be a great impetus for energy transition in its development, allocation and consumption. It will further advance the upgrade of the world energy system.

### (1) Transition of Primary Energy Resources from High Carbon to Low Carbon

De-carbonization has been a trend in the global energy system. Historically, firewood was replaced by coal in the late 19th century as the primary energy and coal by oil and gas in the 1960s, showing a steady decrease of carbon content. The present-day world is witnessing an accelerated transformation from fossil fuels to clean energy. The installed capacity of solar power and wind energy power increased by 483 times and 25 times respectively from 2000 to 2016[5]. Since 2014, the increased energy demand has been mainly satisfied by clean energy. In 2016, 86% of the newly installed capacities in European Union are from clean energy. 26 European Union countries have pledged not to build any coal-fired power plants after 2020. On June 7th this year, 60% of Germany's power consumption was furnished by wind and solar power. In mid-June this year, Qinghai Province of China saw 100% of its power supply from clean energy resources for seven successive days. It can be foreseen that GEI will drive large-scale development and utilization of clean energy; that clean energy will replace fossil fuels and become the dominant energy, and that fossil fuels will be phased out eventually.

### (2) Transition of Energy Consumption from Fossil Fuel Domination to Electricity Domination

5. BP：Statistical Review of World Energy 2017

The invention and use of electricity have changed the world, greatly improving production mode and lifestyles. It has pushed human beings into the electrification era, with far-reaching impacts on the energy consumption structure. All the primary energies can be transformed into and replaced with electricity, which is the most economical option. The unit economic value produced by electricity is 17.3 times and 3.2 times of that produced by equivalent coal and oil respectively. The proportion of electricity in the final energy consumption mix had grown from 8.8% in 1971 to 18.5%[6] in 2015, exceeding that of coals, heat and natural gas successively. The proportion will continue to increase further. Germany and French have proposed to manufacture electric vehicles only from2030 and 2040 onwards respectively. Predictably, with the progress in GEI, coals, oil and natural gas will gradually be replaced by electricity in civil, industrial, commercial and architectural use. The consumption structure dominated by fossil fuels will be transformed into one dominated by electricity.

**(3) Transition of Energy Allocation from Local Balance to Global Allocation**

In history, energy infrastructure such as coal transportation network, oil and gas pipelines and power transmission systems have undergone the evolution from point-to-point supply to regional, transnational and global allocation. At present, coal is transported via railways, water ways and motorways, with about 20% allocated across nations and continents. The world's oil and gas pipelines total around 2.06 million kilometers in length, allocating 70% of the oil and 30% of the gas across nations and continents[7]. The oil and gas from the Middle East, Africa and South America are consumed in China, Japan and EU. Transnational interconnected power grids have taken shape in North America, the European Continent and Gulf Region, transmitting hundreds of millions kilowatts of power every day. The scenarios can be imagined of Chinese consumers using at night electricity generated by premium solar energy from the Sahara, and Europe using clean and stable hydropower from Africa.

6. IEA：World Energy Balance 2016
7. BP：Statistical Review of World Energy 2016

The interconnected power grids will make it possible for instant transmission and allocation of clean energy across the world. The global electricity trade will be the primary form of energy trade.

**All in all, GEI represents the direction and trend of world energy transition. It will advance the transformation of energy development, allocation and consumption, promote the energy supply system characterized by clean energy as the domination, electricity as the center, global interconnection, co-construction and sharing.**

## 2.3 Implementing the Goals of *the 2030 Agenda* with Global Energy Interconnection

Earth and its ecosystems are our common homestead. *The 2030 Agenda* presents 17 goals of sustainable development, covering economy, society, environment and other aspects. **Construction of GEI will accelerate energy revolution, allow the planet to heal and be protected, and keep the world on a sustainable and resilient path. It will eradicate poverty and hunger, eliminate inequality between and within nations, create fairer and inclusive societies and help permanent protection of the planet and its natural resources, for achieving sustainable, inclusive and lasting economic growth. It will create a safe, vibrant and sustainable world that is livable for the human race and that provides affordable, reliable and sustainable energy to all. It will promote coordinated development relationship between people, between human beings and nature, and between man and society. It will help promote a community of shared interests, destiny and responsibility featuring mutual political trust, economic integration and cultural inclusiveness. In this way, the development goals of human, earth, prosperity, and equality put forth in *the 2030 Agenda* will be achieved.**

**In short, the development of GEI is the shared vision for sustainable development in the world. It will play a global role in promoting sustainable**

**human development and the full realization of the goals in *the 2030 Agenda*.**

### 2.3.1 Sustainable Energy for All

In 2014, the world population without access to electricity was around 1.06 billion and the electrification rate was 85.3%; in 2015, clean energy accounted for 18.5 % of the primary energy consumption, with energy consumption per 1000 USD (fixed dollar value for 2010) GDP at 0.18 ton of oil equivalent[8]. GEI will accelerate the development of clean energy worldwide, as well as the capacity, efficiency and cost-effectiveness of clean power generation. The installed capacity of global clean energy is expected to reach 2.5 times that of 2014 or about 5.3 TW in 2030. The population without electricity will be reduced to less than 500 million and electricity popularization rate increased to 94%, up by nearly 9 percent against 2014. The goal of providing affordable and reliable modern energy services will be realized. The proportion of clean energy in primary energy consumption can be raised to 35%, up by 16 percent over 2015, and 10 percent higher than the Business as Usual(BAU) scenario. Unit output energy consumption index will be reduced to 0.14 ton of oil equivalent oil per $1000 GDP (2010 dollar constant price). The global energy efficiency will be doubled, reaching the goals in *the 2030 Agenda*. Construction and upgrading of national, transnational and interstate power grid infrastructure, and in particular, construction of distribution networks in rural areas, will be accelerated, offering strong smart grid support to ensuring sustainable energy to all.

### 2.3.2 Reducing Greenhouse Gas Emissions

In accordance with INDC (Intended Nationally Determined Contributions), greenhouse gas emission will reach 55 billion tons in 2030, far more than the 40-billion-ton goal set in the Paris Agreement. With GEI, carbon dioxide emission will reach the peak before 2030, when the energy-related CO2 emissions will be 26.7 billion tons, down by 17% than that of 2014. The total greenhouse emissions

8. IEA：World Energy Balance 2017

(including Nitric oxide, freon, methane and etc.) will then be below 40 billion tons, fulfilling the pledges of Paris Agreement, and lay the foundation for achieving zero emission of global greenhouse gases and control of global average surface temperature rise within 2℃ in the second half of the century.

### 2.3.3 Achieving Sustainable Production and Consumption

Construction of GEI will revolutionize the patterns of energy production and consumption, promote global in-depth exchanges in green energy and other areas and help popularize the green, low-carbon and sustainable development philosophy. We must vigorously develop clean energy, enhance the efficiency of energy production, distribution and use and control the total amount of energy to disconnect economic growth from environmental degradation, so as to achieve the coordinated development of mankind and nature. By 2030, clean energy can replace fossil energy equivalent to 5.6 billion tons of oil equivalent per year, or half of the fossil energy consumption in 2014.The proportion of electricity in terminal energy consumption will be increased to 33%, while residues, emissions and other pollution from fossil energy consumption will be significantly reduced, alleviating the impact of energy consumption growth on the environment. We will continue to promote the competitive edge of clean energy, encourage governments to gradually abolish subsidies for inefficient fossil energy and establish carbon trading and other mechanisms to guide fossil energy consumption, so as to achieve sustainable management and efficient use of natural resources. GEI construction will effectively enhance transnational cooperation in technological innovation, promote the development of energy and power technologies in developing countries, and help establish more sustainable production and consumption patterns.

### 2.3.4 Establishing Clean, Low-Carbon and Smart Cities

GEI construction will change urban energy use. First, it will speed up clean replacement. Local power generated with fossil energy will be replaced with electricity produced with clean energy and transmitted over long distances.

Meanwhile, it will also promote the development of urban distributed clean energy and help achieve diversification of clean energy supply. Second, it will speed up power alternative. By using clean electricity in industries, urban transport and other fields, consumption of fossil energy via direct combustion will be reduced, thus effectively curbing urban air, waste and water pollution. Take China for example, by 2025, electricity will be replace 480 million tons of coal in the central and eastern region, the hub of major cities, reducing carbon dioxide emission and sulfur dioxide emission by 950 million tons and 1.64 million tons respectively, and lowering total emission of PM2.5 by 20%. Construction of GEI will also accelerate the construction of urban smart grids for complementary and comprehensive energy consumption, and promote the formation of smart cities.

### 2.3.5 Promoting Infrastructure Construction, Industrialization and Technical Innovation

GEI focuses on large-scale clean energy development and globally interconnected modern power grids, so as to contribute to industrialization and technological innovation. GEI could promote countries on updating and reforming of existing electrical power infrastructure to make systems more flexible and smarter, to enhance power grid all sections' efficiency from generation, transmission, distribution to utilization. In 2030, the length of global transmission lines of 220kV and above will be twice that of 2015, reaching 5.3 million kilometers. Among those, the length of transnational transmission lines will exceed 400,000 kilometers, to enhance capability of resisting disasters, system reliability and operating efficiency for global power grids. The electric industry will drive the accelerated development of upstream and downstream industries and thus promote industrialization. In 2030, the electric industry will account for 2.4% of the global GDP, far more than the 0.9% in 2014. In the meantime, GEI will push technical progress in the fields of electricity, information and control.

### 2.3.6 Stimulating New Momentum for Economic Growth

GEI will bring about large-scale investments with tremendous commercial values. With GEI, the cumulative investment in the electricity industry from 2015 to 2030 will reach 24 trillion US dollars, with an average annual growth rate of 10%, promoting GDP growth by 0.1% to 0.2% (assume the average global economic growth rate per year is around 3%) and creating approximately 50 million jobs. Meanwhile, GEI will accelerate the development of upstream and downstream industries like materials, information and electric vehicles, and create greater economic benefits to become the new engine for world economic recovery. GEI will reduce energy supply costs, break down bottlenecks of energy resources to economic development, promote globalization of investment, finance, production, technologies, information, goods, services and human capital, and promote the transformation and upgrading of world economic development.

### 2.3.7 Reducing Global Poverty

GEI will help achieving the goal of sustainable energy for all, and ensure that the poor have access to education, work and business operation to rid themselves of poverty. By providing access to electricity, ensure that they are resilient to certain natural disasters. For instance, assist them in using electric cooling and heating devices to fend for themselves in extreme weathers. The developing countries in Asia, Africa and South America can sell their clean energy such as hydropower, wind power and solar power to developed countries, thus transforming resource advantages into economic advantages, increasing income of underdeveloped countries, and narrowing the regional gaps. The global electricity trade volume is estimated to reach 8 trillion kilowatt hours by 2030, and 70% of the electricity export will be from developing countries.

### 2.3.8 Reducing Unbalanced National and Regional Development

GEI will accelerate energy investment in the least developed countries (LDCs) that are rich in renewable energy resources, facilitate their energy interconnection with their developed neighbors, encourage energy-related assistance by developed countries,

and allow greater development opportunities for them. It can help developing countries tap their resource advantages, participate in global energy governance in a fairer and more effective manner, obtain more opportunities to participate in and dominate the development of global energy industry, and enhance their voice. GEI allows flexible access by various distributed power sources. By encouraging the development of distributed energy and business models, and implementation of precision poverty alleviation policies and other preferential measures, it enables more channels for the poorest in remote areas to increase their income faster, thus narrowing domestic gaps. Take China for example, construction of GEI can be expected to lower by one percentage point the per capita GDP Gini Coefficient reflective of disparity between the relatively backward western and northern regions and the relatively developed central and eastern regions by 2025. Construction of GEI will make it possible for countries around the world to draw on their resource or market advantages to participate in global energy governance in a fairer and more effective manner.

### 2.3.9 Promoting World Peace and Harmony

The clean energy is abundant in the world. Theoretically its power generation potential is around 100,000 TW. If 0.05% of it is tapped, the total human needs will be met. Its annual volume in aggregate equal 38 times that of the proved fossil fuels. GEI will promote the transition of the human society from competition for fossil fuels to sharing and cooperation in clean energy. An energy community featuring consultation, joint construction and mutual benefit will be built; the political, military, diplomatic contradictions and conflicting risks arising from competition for fossil energy resources will be effectively curbed, and energy security will be shifted from individual security to collective security, thus maximally guaranteeing the energy security for countries around the world. Trust between countries and between peoples will be greatly enhanced, and international disputes and regional conflicts effectively mitigated. The world will progress toward greater peace and inclusiveness, and the entire human race will become a community of common destiny, thus

ensuring the sustainable survival of mankind and achieving common development.

### 2.3.10 Consolidating Global Partnership

GEI will propel the establishment of global coordination mechanism, promote close cooperation among countries, enterprises and international organizations, and ensure the integration of policies, strategies and plans of each nation. It will advance solid partnership among various shareholders with respect to investment, financing, technology, trade and operation. For example, promoting the coordination of governmental policies on science and technology and intellectual property; promoting research cooperation among enterprises, research institutions and universities and the formation of a global cooperation system for technological innovation; establishing new rules, new orders and new platforms for international power trade under the relevant framework of the United Nations and WTO.

### 2.3.11 Promoting Agricultural Development and Ensuring Food Security

GEI will drive large-scale construction of power infrastructure, especially the construction and upgrading of power grids in rural areas, thus providing sufficient and reliable energy and power supply for agricultural production, and enhancing agricultural production capacity and ensuring food security. In addition, GEI will solve the problem of global climate change once and for all, reduce catastrophic weather events and have a positive impact on agricultural production.

### 2.3.12 Ensuring Health Care Services and Reducing Diseases and Deaths

GEI will bring sufficient green energy, drive productivity development, drastically reduce air, water and soil pollution caused by the use of fossil fuels and reduce their impact on human health, as well as relevant diseases and deaths, thus enabling human access to cleaner air, water and food, more reliable social security, better health care, better living conditions and more beautiful natural environment.

### 2.3.13 Promoting Equal and Inclusive quality Education

The development of GEI will help provide access to modern power civilization for all human beings, thus facilitating equal education with better material foundation and educational sources; it will also help ensure more people acquire the knowledge and skills needed to promote sustainable energy development, so as to live a sustainable way of life and foster a sense of global citizenship.

### 2.3.14 Promoting Gender Equality

The root cause of gender discrimination is the difference in physical features and strength. GEI is highly knowledge and technology intensive, and can be expected to drive the innovative development of many industries. Most of the jobs created will no longer pose physical and strength requirements for the trainees. Women will be entitled to the same job opportunities and career space as men, thus their employment will be ensured. At the same time, employment will increase their income, significantly enhance their status in the family and society, and promote greater freedom and equality in gender equality.

### 2.3.15 Ensuring Clean Drinking Water and Environment

GEI will significantly reduce power supply costs. With the support of sufficient and affordable power, large quantities of collected rain, sewage discharged and salty sea water can be converted into clean and affordable fresh water, for addressing the problem of water shortage in arid and desert areas. It will significantly reduce the population suffering from water shortage, achieve universal and equitable access to safe and affordable drinking water, improve the healthy environment and promote food production. Meanwhile, it will greatly reduce the water, air and soil pollution caused by fossil energy combustion, protect and restore the ecosystem, and promote the construction of ecological civilization.

### 2.3.16 Conserving and Promoting Sustainable Use of the Seas and Marine Resources

Thermal effluent discharged from fossil fuel and nuclear power plants deployed in coastal areas will cause thermal pollution of the seas, upsetting ecological balance and reducing dissolved oxygen in water. The cooling water discharged from a thermal power plant with an installed capacity of 1 GW ranges from 30 to 50 cubic meters / second. That from a nuclear power plant with the same installed capacity is increased by about 50%. With the dramatic increase of anthropogenic carbon dioxide in the atmosphere, more carbon dioxide enters the ocean. Since the industrial revolution, the pH value of seawater has dropped by 0.1; in other words, the acidity of seawater has increased by 30%. The heightened acidity will change the chemical balance of seawater and seriously threatening coral reefs, marine creatures and even the ecosystem. GEI entails large-scale development of clean energy and gradual closedown of existing coastal thermal power plants and nuclear power plants, thus reducing the thermal pollution of oceans by the energy industry, and tackle the problem of ocean acidification from root.

### 2.3.17 Protecting Terrestrial Ecosystems and Preventing Land Degradation

The development of GEI will reduce fossil fuel exploitation and prevent land and water deterioration; it will make full use of clean energy resources in desert and Gobi area, and scale down firewood supply to ensure better environment; large clean energy projects can help with wind prevention and sand fixation, allowing for better vegetation recovery and ecological protection.

To sum up, GEI is the key to achieving sustainable human development. It could be relied upon for fully implementing *the 2030 Agenda*. Its materialization will promote the transformation of world energy into a new stage featuring domination by clean energy, electricity as the center and global allocation for meeting global power needs in a clean and green manner. It will help tackle environmental pollution and climate change from the root, make the sky bluer, water clearer and mountains greener, usher in a new chapter of ecological civilization for the human society, and help achieve sustainable human development. It will foster greater productivity, promote global

technological and industrial upgrading, turn green low-carbon, energy-saving and environmentally friendly emerging industries into powerful engines for sustainable economic growth, and steadily promote world prosperity. It will promote balanced development for all countries, enhance mutual trust, and evolve into a link for maintaining world peace, a cornerstone for ensuring social stability and a platform for integrating the common interests of the human race.

**In short, GEI will profoundly change all aspects of the global energy, economy, politics, society and environment, enable more sufficient energy supply, comfortable lifestyle, livable environment and harmonious society, and thus usher in a bright future of sustainable global development.**

# 3. The Roadmap of Global Energy Interconnection

## 3.1 Favorable Conditions for Building Global Energy Interconnection

### 3.1.1 Technically Feasible

**(1) The UHV power transmission technology is advanced and mature**

The transmission distances of UHV 1000 kV AC, ±800 kV and ±1100 kV DC can reach 1500 kilometers, 2500 kilometers and 6000 kilometers respectively, with transmission capacity reaching 5 million kilowatts, 10 million kilowatts and 15 million kilowatts respectively. Therefore, energy bases and load centers of the same continent and among different continents are within the transmission range of UHV, and the critical problems are solved for large-scale development and long distance transmission of all kinds of energy resources. The experience on large-scale construction and operation of China UHV lines has tested and verified the safety, economic performance and environmental friendliness of the UHV technology.

**(2) The clean energy technology has made constant progress**

Currently, the conversion efficiency of photo-voltaic cells has exceeded 20%, and keeps increasing at an annual rate of 1 to 1.5 percent. There have been enormous breakthroughs in large-capacity wind power generation technologies. 8 MW wind turbine has been put into commercial operation and 9.5 MW wind turbine has been successfully developed. As the precision of wind power forecast is enhanced, the predictability and controllability of renewable power generation is being improved constantly.

**(3) The Smart Grid technology has been widely applied**

The constant advancement and wide application of technologies in flexible AC/DC transmission systems, smart control, information network and large-scale energy storage have made power grids safer, more economical and flexible to large-scale

integration of intermittent power sources like wind power and solar power, as well as access of various smart electrical equipment and appliances.

### 3.1.2 Economically Competitive

#### (1) Clean energy

The costs of wind and photo-voltaic power generation worldwide have declined by 30% and 75% respectively in the past 5 years. The international bid-winning price of the photo-voltaic projects in the United Arab Emirates (go into operation in 2019) and in Chile (go into operation in 2021) has dropped to 2.4 US cents per kilowatt-hour and 2.9 US cents per kilowatt-hour, respectively, while that of onshore wind farm (go into operation in 2020) in Morocco has decreased to 3 US cents per kilowatt-hour. In North Sea of Europe, the first unsubsidized offshore wind power worldwide will be built for full engagement in free market competition. It is estimated that by 2025, the electricity from clean energy will become more competitive than fossil fuels.

#### (2) Power grid interconnection

GEI can make full use of resource difference, time zone difference, season difference, and power price difference between countries and continents to promote global power trade, reduce energy cost, and enhance the efficiency and stability of power systems.

For instance, the electricity transmits from power bases in the West and North China, to east-central area via UHV technology. Its "arrival" price could be cheaper 0.7 to 1.2US cents per kilowatt-hour than the local feed-in tariff of thermal power generation; The cost of electricity of hydropower from the Central Africa and solar power from North Africa, once transmitted in bulk to Europe via UHV technology, can be reduced to 7 to 9 US cents per kilowatt-hour, 7 US cents lower than electricity of the wind power in the North Sea and the photo-voltaic power in European Continent, with prominent economic benefits.

### 3.1.3 International Consensus

**(1) Global consensus to combat climate change**

With huge support from the United Nations, the Paris Agreement was signed and entered into force on 4 November 2016. It has become a global consensus and common action of all nations for combating climate change, promoting energy transformation and pursuing sustainable development, thus creating a favorable political environment for GEI.

**(2) Keen interests in clean development around the world**

Over 140 countries in the world has put forward stimulus policies for clean energy development, and made active practices on promoting low-carbon development, strengthening power grid interconnection, and enhancing electrification level. 26 EU countries have promised not to build additional coal-fired power stations after 2020. Britain has decided to achieve zero coal-fired generation by 2025. Denmark has proposed to get rid of fossil fuels by 2050. Germany has planned to increase the share of clean energy in its power generation to 80%. Norway, India, UK and France have set up their milestone of forbidding the sale of traditional gas car in 2025, in 2030 and in 2040 respectively.

## 3.2 Driving Force and Prospects of Global Energy Interconnection

**(1) Continued fast increase in global electricity demand**

With the steady industrialization and urbanization of developing countries and the emerging market economies, along with a higher level of electricity replacement in the developed countries, the global demand for electricity is bound to grow fast and continuously. The global demand for electricity is projected to rise from 24 trillion kilowatt-hours in 2016 to 73 trillion kilowatt-hours in 2050, at an annual growth rate of 3.1%, which is 1.9% higher than that of primary energy demand.

### (2) Abundant but unevenly distributed clean energy resources

The world is abundant in clean energy. According to estimates, the potentials of hydropower, wind power and solar power theoretically would exceed 10 billion, 1 trillion and 100 trillion kilowatts respectively. In Asia, Europe and Africa, 85% of the hydropower, wind power and solar power are mainly distributed in the energy belt from North Africa to Central Asia and Far East of Russia at an angle of 45 degrees to the equator. Meanwhile, the major loads are concentrated in East Asia, South Asia, Europe and Southern Africa. Most areas with abundant clean energy have a vast territory and sparse population. However, they are often far away from load centers. This situation requires a global energy allocation platform, namely GEI, for promoting large-scale development, allocation and use of clean energy resources across the globe.

### (3) The overall picture of Global Energy Interconnection

**Figure 1** has shown the overall picture of global energy interconnection. From the continental perspective, the backbone grids of each country and domestic power grid connection are to be intensified, transnational and trans-regional grid interconnection strengthened and the transmission capacity and wide-area allocation capability enhanced, for the optimized development and utilization of clean energy resources in each continent. The energy interconnection in Asia, Europe, Africa and America will take shape. From the intercontinental perspective, the surface and cross-ocean power transmission channels connecting different continents are to be built. The first step is to realize the interconnection of Asia, Europe and Africa, while accelerating the Asia-America, Asia-Oceania and Europe-America interconnection to form a global power system featuring extensive power integration within each continent, efficient power interconnection among continents, and clean and green energy as the dominant energy sources. The GEI will serve as a robust, smart and open allocation platform for electric power worldwide. It is capable of taking advantage of seasonal, temporal and regional differences, to incur huge comprehensive benefits.


Figure 1: Overall Layout of Global Energy Interconnection

## 3.3 The Milestones of Global Energy Interconnection

GEI construction can be achieved by 2050, in three stages, namely domestic, intra-continental and inter-continental interconnection.

**By 2020:** Breakthroughs are expected in the key technologies of clean power generation, submarine cable and large-capacity energy storage. Efforts will be made to complete the planning of transnational and transcontinental power grid interconnection; to develop a number of premium clean energy bases near the load areas, accelerating the development of the distributed photo-voltaic power generation, and reducing the population without access to electricity to 970 million; to strengthen the construction of domestic interconnection and smart power grids of each country so as to improve the reliability and intelligence of power grids.

**By 2030:** Efforts will be made to develop large clean energy bases in each continent; complete the domestic interconnection within each country, promote cross-border

interconnection for major countries within each continent, and construct the key intercontinental power transmission channels of Asia-Africa-Europe and South America-North America, for achieving the regional energy interconnection. In addition, the share of clean energy in the primary energy consumption will be increased to 35%, and energy-related carbon dioxide emission reduced to 26.7 billion tons, 17% less than that of 2014; population without access to electricity to will be reduced to less than 500 million; the process of electricity replacement will be accelerated and the comprehensive commercial application of all the key technologies realized.

**By 2050 :** Efforts will be made to complete the major intercontinental interconnection channels, and realize interconnection among different continents to form a globally interconnected power system linking all countries and regions with coordinated power grid development at all levels. By then, clean energy will account for around 75% of global primary energy consumption and the energy-related carbon dioxide emission will be reduced to 11.5 billion tons, or half of that of 1990; Over 30% of electricity will come from transnational and transcontinental trade.

**Figure 2** shows the tendency of key indices of Global Energy Interconnection from 2014 to 2050, including the share of clean energy in the primary energy consumption, the share of clean energy generation in the total power generation, the share of electricity in the final energy consumption, and the share of for transnational electricity trade volume in overall electricity consumption, as well as the energy-related carbon dioxide emission and the population without access to electricity.

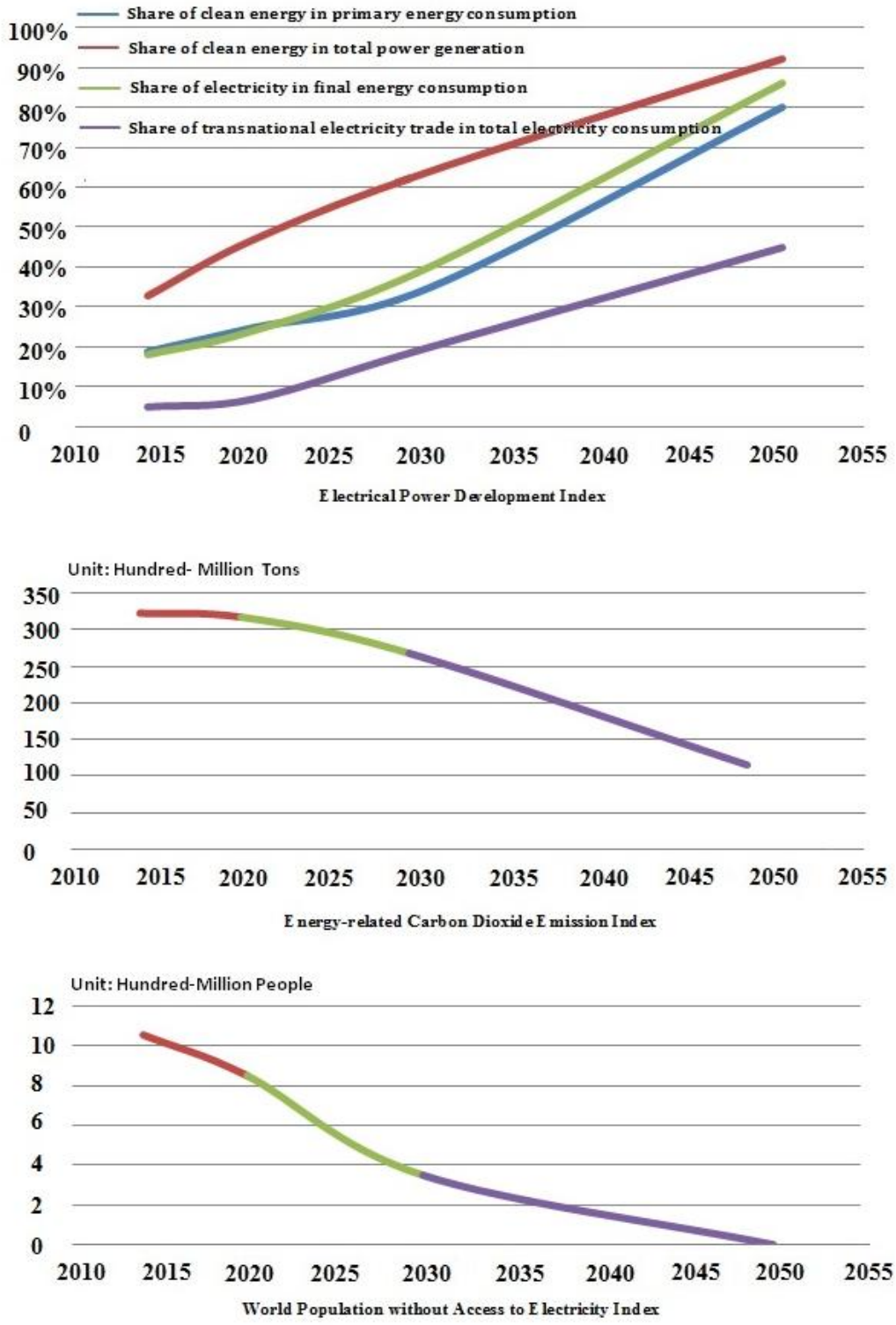


Figure 2: Tendency of Key Indices of Global Energy Interconnection

# 4. Global Energy Interconnection Action Plan to Promote the 2030 Agenda for Sustainable Development

## 4.1 The Reality and Challenges of Energy Development in Each Continent

### (1) Asia

①Asia has huge demands for energy, with primary energy consumption accounting for half of entire world.

②The energy mix is imbalanced with fossil fuels taking up 90% of energy mix. China, Northeast Asia, Southeast Asia and South Asia countries in particular, are confronted with severe environmental problems and tremendous pressure of carbon emission reduction.

③The energy resources and the power demands are unevenly distributed. The clean energy resources are mainly located in the west of China, Far East and Siberia of Russia, Mongolia, Central Asia and West Asia, while load centers are concentrated on East Asia, South Asia and Southeast Asia.

④Gaps in electrical infrastructure. The developing countries in South Asia and Southeast Asia are beset with power reliability problems, and have very few cross-border power grid interconnection and electricity trade.

⑤The population without access to electricity in Asia exceeds 400 million, which takes up 10% of total Asian population and is mainly distributed in the developing countries like India, Bangladesh, Burma and Yemen.

### (2) Africa

①Africa has abundant clean energy resources that remain to be developed. Only 10% of hydropower potential in Africa has been tapped.

②Electric power development is relatively low, with per capita installed capacity less than 0.2 kilowatt and annual per capita household electricity consumption of only 530 kilowatt-hour.

③The population without access to electricity exceeds 600 million.

④The power systems have low reliability, with frequent power outages from all kinds of reasons. There are very few cross-border power interconnections, and the power networks of five major regions of Africa are not interconnected.

**(3) Europe**

①Europe is not rich in fossil energy resources. 50% of its energy consumption relies on foreign imports.

②The energy quality of local wind power and solar power are not high, with relatively low annual utilization hours.

③There are potential gap in power supply. The EU and governments in Europe all attach great importance to the transformation of energy, as coal-fired power generation and nuclear power generation gradually phase out, there will be challenges ahead to provide sufficient electricity supply.

④The peak shifting with high penetration of renewable energy will pose challenges for power systems.

**(4) America**

①It has a rather imbalanced regional development, with the aggregate GDP of America, Canada, Brazil and Argentina taking up over 80% of the entire continent in 2015.

②The hydropower, wind and solar power are abundant but are often far away from load centers, showing a tendency of inverse distribution. The Amazon River, La Plata -

Parana River and Sao Francisco River have a potential for hydropower generation around 595 GW[9], but only 25% of that potential is developed. And load centers are concentrated in the southeastern coast of South America.

③In Latin America and the Caribbean, there is quite large number of population without access to electricity, mainly distributed in Bolivia, Peru, Haiti and Honduras.

**(5) Oceania**

①It is heavily dependent on fossil fuels with the share in the primary energy consumption reaching near 90%[10].

②The Australia has abundant solar energy resources that remain to be developed.

③There are apparent gaps in electric power development among different countries in the Oceania. Apart from Australia and New Zealand, most are small island countries under development. Some of the population still does not have access to electricity. In 2015, the annual electricity consumption per capita in Papua New Guinea was only 380 kilowatts, less than one eighth of the average level of the world, with the 80% of population without access to electricity[11].

④The countries are distant from each other and divided by vast ocean, posing great difficult and challenges to transnational power grid interconnection.

## 4.2 The 2030 Goals for Energy Development in Each Continent

**(1) Asia**

①The share of clean energy accounts for over 31% in primary energy consumption mix.

9. OLADE: OLADE-Energy Statistics 2016
10. IEA：World Energy Statistics 2016
11. World Bank Database：data.worldbank.org

②Increase the electricity access rate to 97%, and reduce the population without access to electricity down to 150 million.

③Increase the share of electricity in the final energy consumption to 32%.

④From 2015 to 2030, the average annual decline rate of energy intensity in East Asia and the Gulf region will exceed 1.5%, and in Southeast Asia, South Asia and Central Asia the rate exceeds 1%.

**(2) Africa**

①The share of clean energy accounts for 50% in the primary energy consumption mix.

②Increase the electricity access rate to about 79%, and reduce the population without access to electricity to below 350 million.

③Increase the share of electricity in the final energy consumption to 20%, with above 75% population using electricity for cooking and heating.

④From 2015 to 2030, the average annual decline rate of energy intensity exceeds 1.0%.

⑤Transnational electricity trade reaches 10% of the total electricity demand.

**(3) Europe**

①The share of clean energy accounts for over 42% in the primary energy consumption mix.

②Increase the share of electricity in the final energy consumption to 40%.

③From 2015 to 2030, the average annual decline rate of energy intensity exceeds 2.5%.

④Capacity of transnational transmission lines exceeds 15% of the total installed

capacity in all countries.

**(4) America**

①The shares of clean energy in the primary energy consumption mix for North America and Latin America account for 35% and 40%, respectively.

②Increase the electricity access rate to 100%.

③Increase the share of electricity in the final energy consumption for North America and Latin America to 37% and 25%, respectively.

④From 2015 to 2030, the average annual decline rate of energy intensity exceeds 2.0% and 1.0% for the developed countries and developing countries in America, respectively.

**(5) Oceania**

①The share of clean energy in the primary energy consumption mix accounts for 25%.

②Increase the electricity access rate to 100%.

③Increase the share of electricity in the final energy consumption to above 35%.

④From 2015 to 2030, the average annual decline rate of energy intensity exceeds 2.0%.

## 4.3 Ten Actions of Global Energy Interconnection

Given the challenges confronting the energy development in each continent and the goals of GEI, Ten Actions of GEI in support of *the 2030 Agenda* are proposed, including concept promotion, clean development, universal access to electricity, power grid interconnection, electricity replacement, smart grid, energy efficiency enhancement, innovation driven, capacity building and policy support.

### 4.3.1 Concept Promotion

Concept is the lead of the action. Only when we consolidate the common development consensus, can we form the synergy for it.

The focus of GEI concept promotion is to give full play to the role of all parties of the whole society. Based on GEI's positive implications on green and low-carbon energy transition, climate change combat action, the implementation of Paris Agreement, the sustainable development of human beings and realization of *the 2030 Agenda*, efforts should be made to spread the idea of GEI with all-dimensional multi-layered publicity mechanism so that it would be widely acknowledged around the world.

①Promote GEI concept among UN member states, in particular its importance for human beings' sustainable development to achieve global consensuses so that it would be integrated into relevant nations and organizations' guiding documents to implement *the 2030 Agenda*.

②Promote GEI concept among governments, intergovernmental organizations, experts and scholars, in particular its role in reducing carbon emissions and mitigating climate change, in order to gain governmental support to incorporate it into relevant nations and organizations' energy development plans.

③Promote GEI concept among energy companies, especially fossil fuel companies, by highlighting the essential role of GEI for energy transformation, and encouraging them to initiate transition with innovation, and to participate in international cooperation and major projects of GEI.

④Promote GEI concept among universities, think tanks and research institutions by identifying its leading role to innovate ideas, theories and technologies, and encouraging them to carry out the study of GEI strategy, planning and technology, and to release research findings..

⑤Promote GEI concept by planning a series of events, including but not limited to

setting up GEI theme day/week around the world, and hosting annual GEI conferences, forum and seminars.

⑥Encourage discussions on GEI at influential international conferences such as UN Climate Change Conference, G20 Summit, and BRICS Summit to achieve extensive consensus.

⑦Improve public awareness of GEI by popularizing its basic knowledge and important values. It is conducive for the whole society to understand the great changes that GEI brings to people's lives and promote broader consensuses.

### 4.3.2 Clean Development

Clean energy development is the prerequisite for achieving clean replacement and ensuring sustainable supply of energy. The key is to prioritize the development of large energy bases with supplementary support of distributed generation, coordinate the development of clean energy worldwide, optimize the layout of power grids, and increase the share of clean energy in total energy mix. By 2030, global clean energy will account for 35% of the total primary energy consumption and the scale of power transmission of clean energy bases in the Arctic and equatorial area will reach 1000TWh per year.

#### (1) Asia

①Develop the hydro power potentials in the Far East of Russia, Siberia, Southeast Asia, and Southwest China. Large hydro power stations will be built in Irrawaddy River, Salween River, and Mekong River of Indochina Peninsula and Yalu Tsangpo River of Tibet, China, etc., with a total installed hydropower capacity of Indochina Peninsula expected to reach 40,000 MW by 2030.

②Develop wind power bases in West Asia, Central Asia, Mongolia, and "Three Northern Areas" of China (northwest, northeast and north), Bering Strait and Sakhalin, and West India, etc.; A total of ten to fifteen 10 GW and above wind power bases will

be developed in Xinjiang of China, East coast of Caspian Sea and North of Kazakhstan, Turkmenistan, and The Arctic region within Russia, with a total installed capacity expected to exceed 200 GW by 2030.

③Develop the solar power bases in West Asia, Central Asia, Mongolia, Northwest China and West India. Over ten large solar power bases will be developed in Southwest Saudi Arabia, United Arab Emirates, Oman, Central and South Iran, and Jordan, etc., with a total installed capacity expected to exceed 100 GW by 2030.

**(2) Africa**

①Develop hydropower in the basins of the Nile River, Congo River, Niger River and Zambezi River. With Central and East Africa serving as the future hydropower dispatch center of Africa, the Grand Inga Dam in Congo (King) will be developed to reach 10 GW by 2030, and the Grand Ethiopian Renaissance Dam and other hydropower projects will be further developed to reach 12 GW by 2030.

②Develop wind power bases in the north, west, east and south of Africa. A total of 8 to 10 large wind power bases will be developed along the Mediterranean coast of Egypt, Libya, and Algeria, west coast of Mauritania and Senegal, East Ethiopia, and south coast of South Africa, with a total installed capacity expected to reach 50 GW by 2030.

③Develop solar power bases in the north of Sahara Desert and south of Africa. Over 15 large PV and solar thermal power stations will be developed in north African countries like Egypt, Libya, Algeria, Morocco, Tunisia, and Sudan in East Africa, and south African countries like Namibia and South Africa, with a total installed solar power capacity expected to reach 200GW by 2030, more than 30% of the total power generation mix of Africa.

**(3) Europe**

①Develop hydropower in Scandinavian Peninsula, the Alps, and the Pyrenean region. Large hydro power stations will be further developed in Norway, Sweden, Switzerland,

and Spain, etc., with a total installed hydro power capacity expected to reach 260 GW by 2030.

②Accelerate wind power development in the North Sea. A total of 10 to 20 large wind farms will be built in the North Sea area of countries like Germany, Belgium, the Netherlands, UK, Ireland, Denmark, Norway, and Sweden, with a total installed capacity expected to reach 40 GW by 2030.

③Develop solar power bases in south Europe. A total of 5 to 10 solar power bases will be built in regions with favorable radiation conditions such as Spain and Italy, with a total installed capacity expected to reach 50 GW by 2030.

**(4) America**

①Develop the hydropower in Amazon River, La Plata - Parana River; Around 5 large hydro power stations will be built in countries like Brazil, Argentina and Peru, with a total installed hydro power capacity expected to reach 270 GW in South America.

②Develop solar power resources in the Atacama Desert and east cost of South America. A total of 5 to 8 solar power bases in North Chili, East and North Brazil, with a total installed capacity expected to reach 50 GW by 2030.

③Develop wind power bases in the south, southeast, and east of South America. A total of 5 to 8 large wind power bases will be developed in the southernmost point of Argentina and Chili, and the east of Brazil, with a total installed capacity expected to reach 60 GW by 2030.

④Develop wind and solar power bases in the central and southwest of the U.S. and develop the wind power and solar power bases in North Mexico.

**(5) Oceania**

①Develop wind power bases in the southern coasts of Australia, with a total installed wind power capacity expected to reach 12.5 GW by 2030.

②Develop solar power bases in central, northern and western areas of Australia, with a total installed solar power capacity expected to reach 15 GW by 2030.

### 4.3.3 Universal Access to Electricity

Universal access to electricity is an important target of *the 2030 Agenda* and also a major objective of GEI. In 2014, around 1.06 billion people in the world live without access to electricity, mainly concentrated in Sub-Sahara Africa, Asia and Latin America. The key is to take active measures to solve the problem, such as via governmental subsidies, commercial development, financial assistance, and technological innovation. The goal is to make the global rate of access to electricity reach 94% by 2030, and reduce the population without electricity to less than 500 million. Some common actions could be carried out for all relevant countries and stakeholders:

①Encourage governments to draft and lay down related planning, policies, regulations and action plans to clarify and actively implement their targets and roadmaps for reducing population without access to electricity.

②Take advantage of GEIDCO as an international platform with its over 50 global branches (including several representative offices), to closely connect governments, organizations, enterprises and financial institutions in order to form a global network with the common target to reduce the population without access to electricity. By offering technology, financing, consulting and aid projects for the countries or regions with large population without electricity, together we can promote better local power access, grid connection and clean energy development, relieve energy poverty and improve electrification level.

③Explore innovative business models to attract investment of private sectors. Initiate energy poverty alleviation programs to support residents unable to afford their power bills. Fulfill NGOs' role to expand charitable aids, assistance and project funding in order to meet the power demands of the most underprivileged.

④Develop clean energy technologies with lower costs and higher reliability, such as

roof-top photovoltaic, small-scale wind turbine, small-scale hydro power and biomass power generation, to satisfy the basic needs of lighting and heating in rural areas.

**(1) Asia**

In 2014, rate of access to electricity in Asia was 90%. The population without access to electricity was around 410 million, among which 30 million in urban areas, and 380 million in rural areas, mainly distributed in South Asia, Southeast Asia, Central Asia, and Middle East. Strive to improve the rate to 97% by 2030, with 100% coverage in urban areas, and reduce the population without access to electricity to 150 million.

①For those countries with more population without access to electricity, such as India, Bangladesh, and Myanmar, to enhance electricity supply coverage by building and upgrading transmission and distribution networks in cities, towns and nearby areas. In remote rural areas, solve the problem of residential power supply by developing distributed generation systems of photovoltaic, wind power and biomass.

②For Iraq, Afghanistan and other countries torn and trapped in war in recent years, strengthen the cooperation with regional financing institutes, such as Asian Development Bank, as well as other international aid organizations, to rebuild electric power infrastructure and improve electricity access rate.

**(2) Africa**

In 2014, the rate of access to electricity in Africa was 47%. The population without access to electricity was around 590 million, among which 110 million in urban areas and 480 million in rural areas, mainly distributed in Sub-Sahara Africa.

By 2030, the aim is to increase rate of the access to electricity to 79%, while keeping the population without electricity down to 350 million. It is to adopt measures of both commercial development and charitable donations to fulfill the target.

①For countries with relatively strong economic basis and high per capita income, such as South Africa, Botswana and Angola, the priority is to develop commercial

projects. The investment from private sectors shall be encouraged through governments' policies, which includes means of interest-free and interest-low loans.

②For countries with low per capita income, such as Uganda, Ethiopia and Chad, the electric power infrastructure development will be accelerated and basic electric equipment for living can be provided to residents without electricity through national aid, charity foundation, non-reimbursable donations and strengthening cooperation with multilateral financial institutes including African Development Bank.

**(3) Latin America**

In 2014, the rate of access to electricity in Latin America was 98%. The population without access to electricity was around 20 million, mainly distributed in rural areas of the Caribbean region and South American countries.

The main challenges for the region are the less affordable electricity price for residents and acute situation of power theft. The action to eliminate non-electrified population focuses on reducing development cost and save the expenditure of residential electricity. By 2030, the rate of access to electricity in Latin America aims to reach 100%.

Haiti, the country with the most population without electricity in Latin America, faces many problems. The main reasons are the severe damage of infrastructure caused by successive natural disasters in recent years, large rural population and political instability. To gradually resolve these problems, comprehensive measures should be taken to rehabilitate infrastructures, build distributed PV systems.

### 4.3.4 Power Grid Interconnection

Advancing power grid construction is the key to achieve interconnectivity for large-scale allocation. The priority should be building power grids within each country, and propelling transnational power transmission projects for domestic, transnational and inter-continental interconnection.

**(1) Asia**

To promote the construction of intercontinental and transnational energy channels to form the interconnection layout made up of power grids of China, Northeast Asia, Central Asia, West Asia, South Asia, and Southeast Asia. It will feature synchronous power system within each region, and asynchronous interconnection of the whole continent. Central and West Asia will become the clean energy base to transmit power; Northeast Asia (Japan and Korea), South Asia and Southeast Asia will accommodate electricity coming from other regions.

①Build 500kV AC backbone grids of Southeast Asia By 2030, power grids of 7 countries of Myanmar, Laos, Thailand, Vietnam, Cambodia, West Malaysia and Singapore will basically be interconnected with the transmission capacity up to 30 GW.

②Build regional power grid interconnection of South Asian subcontinent, with AC transmission channels connecting India, Nepal, Bangladesh, and Bhutan, and DC transmission channels connecting India and Sri Lanka. By 2030, power grids of the above five countries will be formed.

③Strengthen the power grid interconnection among Gulf countries; and build transmission lines connecting Gulf countries with Europe, East Africa and South Asia, transmitting the abundant solar power. By 2030, Gulf region will become world's largest solar power base in which 400kV backbone grids and main cross-region links are developed in coordination.

④Build China-South Korea-Japan power transmission project, which transports electricity from China to Japan via South Korea. The project would be made up of two sections with the total transmission capacity of 2GW.

⑤Build Yunnan of China-Myanmar-Bangladesh power transmission project, transporting hydropower from Yunnan Province, China to Myanmar and Bangladesh to resolve their power shortage issue with transmission capacity of 5GW.

**(2) Africa**

Advance the construction of power transmission channels within the region. By 2030, Northern, Western, Central, Eastern and Southern parts of Africa will be connected with AC power transmission lines. Electricity produced in large clean energy bases will be transported to load centers in Southern Africa, Northern Africa and Europe through UHV DC transmission lines.

①**Northern Africa:** build Northern Africa-Europe power transmission lines via Mediterranean. Three lines, west, central and east ones (Morocco-Portuguese, Tunisia/Algeria-Italy, and Libya-Greek), could be constructed to transport solar and wind power from Northern Africa to Europe.

②**Western Africa:** Step up the Nigerian electricity voltage to 765kV to connect Nigeria, Cameroon, and Gabon for Niger hydropower transmission; strengthen 330kV backbone power grids in Cote d'Ivoire, Senegal, and Ghana.

③**Central Africa:** Based on Grand Inga hydropower station, build 400kV power grid interconnection with grids of D.R. Congo as the center. Construct D.R.Congo-South Africa power transmission project to transport surplus electricity from Grand Inga to load centers in South Africa.

④**Eastern Africa:** Strengthen 400kV backbone power grids to connect Ethiopia, Kenya, Tanzania, Djibouti and Sudan with AC transmission lines to improve power trade within the region. Construct Ethiopia-Sudan-Egypt power transmission project.

⑤**Southern Africa:** Build 400kV power transmission lines connecting Angola, Zambia, Botswana and other countries in the region. By 2030, Southern African power grids will be interconnected. Construct Tanzania-Zambia power transmission project to connect grids from Southern Africa and East Africa.

**(3) Europe**

With high penetration of renewable energy and increase of electricity demand, European power grid development should focus on strengthening the backbone grids

and improving the transmission capacity of trans-national and trans-regional power grid interconnection. To cope with the problems of insufficient capacity of power transmission under the current voltage level and lacking of power transmission channels, there is growing need to build UHV power transmission channels, improve operation control of AC/DC hybrid power grids and increase the power system reliability. Meanwhile, Europe can receive high-quality clean energy from Asia and Africa to bring down costs of electricity supply.

①Strengthen the backbone grid. Priority should be given to constructing power transmission channels from North Europe and the North Sea to Central Europe, and enhancing transmission channels between Spain, France, Germany, Italy and other countries

②Construct the trans-Mediterranean interconnection channels to receive North Africa clean energy.

③Construct interconnection channels to Russia, Turkey, and West Asia countries such as Saudi Arabia to receive the surplus clean energy in Asia and the Arctic regions.

**(4) America**

**North America:** The interconnected power grid between the U.S. and Canada needs to be enhanced with the development of clean energy. At the meanwhile, to build transmission channels connecting the clean energy bases in southwest and central of U.S. and north of Mexico to the load centers in east and west coasts of U.S.

**Latin America:** There are two synchronous power grids in north and south Latin America respectively. Enhance transnational interconnection within each synchronous grid. Build multiple UHV transmission and back-to-back projects between the two synchronous grids to transmit hydro power from north to south, wind power from south to north, and solar power from west to east, so as to realize complement among different types of clean energies.

①In Brazil, construct UHV DC transmission channels from the hydro power bases along the Amazon River as well as UHV AC channels from the wind and solar power bases in northeast area, to meet the needs for clean energy development and delivery. Construct UHV looped network in southeast load centers, and further extend to south to form a "ladder" ring structure, which would support receiving large-scale clean energy.

②Construct DC transmission projects from Argentina to Brazil with transmission capacity of 10 GW, so as to complement electricity supply between the two countries during rainy and dry seasons.

③Realize interconnection between Chile and Argentina by building transmission channels in north, central and south of the two countries, with total transmission capacity of 3 GW.

**(5) Oceania**

Enhance power grid in each country to meet the demand for renewable power integration and load increase before 2030, and to construct DC power transmission projects between Australia and Indonesia to transmit the rich solar and wind power in Oceania to the load centers in Southeast Asia in the long term.

### 4.3.5 Electricity Replacement

Electricity replacement is the main approach to increase the level of electrification and improve people's living standard. The focus is to adopt new technologies and new equipment to replace fossil fuel consumption with electricity in the fields of industry, transportation and residents living. The ratio of electricity in global final energy consumption aims to increase to over 30% by 2030 from 18.5% in 2015. Common actions include:

①Replace Coal with Electricity: In industrial and residential areas, centralized and dispersed coal-fired appliances with electric boiler, thermal pumps, furnace, heating

cable, electro-thermal film and carbon crystal equipment and etc.

②Replace Oil with Electricity: In transport areas, electrified-railways, electric vehicles, low-speed electric vehicles (LSEV), on-shore power system, electric port operation and electric jet bridge system shall be developed. In petroleum production areas, oil pipeline and drills can be driven by electricity. In agriculture areas, electricity can be used in irrigation and threshing.

③Replace gas with Electricity: Electricity can be utilized to replace gas stoves from restaurants, gas boilers from industries and gas cookers, gas air conditioner from residences.

**(1) Asia**

Coal and oil each accounts for 30% in final energy consumption in Asia. The key to improve the energy consumption structure and to reduce environmental pollution and carbon emission is to replace coal and oil with electricity. By 2030, the share of coal and oil in final energy consumption would be reduced to below 25% both, and electricity increased to above 30%.

①In countries with large industrial capacity in East Asia, South Asia and Southeast Asia, such as China, Japan, India and Indonesia and etc., actions should be taken to promote the use of electric boiler, electric furnace and electric-thermal pumps in replace of coal-fired and oil-burning boiler & furnace.

②In rural areas with lower level of electrification in China, South Asia, Southeast Asia, and Middle East, actions such as electric heating reform campaign, should be taken to promote the use of induction cooker, regenerative electric boiler and heater, and electric thermal film in replace of coal-fired appliances for cooking and heating.

③In oil-deprived countries in East Asia and Southeast Asia, such as China, Japan, Korea and India and etc., electric vehicles are urged to vigorously developed and promoted to replace traditional fossil-fuel vehicles. Meanwhile, electrified railways

should also be deployed to replace steam locomotives and diesel locomotives.

**(2) Europe and North America**

The energy consumption in both Europe and North America has entered saturation period. The key for achieving the goal of carbon emission reduction is to replace oil and gas with electricity, which will improve final energy efficiency and regulate aggregate of energy consumption. By 2030, the share of electricity in final energy consumption would reach 40%.

①Accelerate development of electric vehicle and increase the market share to over 30%.

②Gradually phase out the internal-combustion locomotives, and improve railway electrification level to 100% by 2030.

③Build smart homes of full electrification based on intelligent technologies of rooftop photovoltaic generation and energy storage.

④Develop fully electrified home technology to build a smart home integrated with rooftop PV system, energy storage, electric cars and other smart electric appliances.

**(3) Africa**

The ratio of biomass and waste-to-energy in primary energy consumption is as high as 55% in Africa, over 80% of which is used in low efficient manners such as direct burning of firewood, straw and animal manure. The dust and harmful substance from direct burning cause annual deaths of over 2 million. The focus is to replace biomass and waste-to-energy with electricity in energy consumption. By 2030, the share of electricity in final energy consumption should reach over 20% by improving efficiency of biomass and waste-to-energy.

①Promote the utilization efficiency of biomass and waste energy. The wide use of induction cookers, microwave ovens and other electric cookers can replace direct

burning of firewood, straw and animal manure for cooking and other residential activities.

②In metallurgy and mining industries, especially for countries with favorable conditions such as South Africa, the electric furnaces and electric motors shall be encouraged to replace oil and gas fired devices.

**(4) Latin America**

Oil takes up 50% in final energy consumption in Latin America. The main measure is to replace oil with electricity, and realize 25% share of electricity in final energy consumption by 2030.

①Increase electrification level of iron, chemical and mining industry.

②Enact incentive polices to promote electric vehicles so as to relieve the dependence of transportation upon oil.

③Electric railway transportation should be constructed in cities with low coverage of city railway.

④Electric on-shore power system should be adopted in the major ports in replace of the oil-burning marine auxiliary machinery.

**(5) Oceania**

Oil and natural gas take up 70% in the final energy consumption in Oceania. By 2030, it needs to assure the share of electricity in final energy consumption reaches 30% by mainly replacing oil and gas with electricity.

①Accelerate development of electric vehicle and increase the market share to over 25%.

②Promote the use of electric boiler, electric furnace and electric motors in replace of

the traditional oil-fired and gas-fired equipment in industries of steel, metallurgy, chemicals and mining.

### 4.3.6 Smart Grid

The Smart Grid is the basis of GEI. Smart equipment and advanced techniques of monitor and control will be employed to improve the observability and controllability of power generation, transmission, distribution and consumption. It will also improve the intelligence and reliability of power system.

**(1) Smart electric power generation**

①Build a global solar and wind power forecasting system to increase the accuracy of day-ahead forecast for renewable energy to 95%.

②Promote the use of virtual synchronous machines and other new technologies to enhance the flexibility and stability inertial of wind farms and solar power plants.

**(2) Smart electric power transmission**

①Accelerate the development of large-capacity power storage technology and equipment to meet the global needs of access to clean energy; expand the industrial scale of energy storage and innovate in business models to reduce the costs of energy storage and increase the flexibility of power grids.

②Adopt high-precision simulation and other technical means in China, Japan, Europe, North America and other countries and regions with better developed power grids to improve the capacity for operational analysis of large-scale interconnected power grids and scientifically optimize grid operation.

③Upgrade dispatching automation system for the power grids and adopt more advanced smart monitoring devices to enhance the capabilities for monitoring them. By 2030, achieve 100% real-time online monitoring of transnational and intercontinental interconnection lines and major hub substations worldwide.

④Combine traditional automatic control with big data, in-depth learning and other intelligent technologies to improve the regulation of interconnected power grids. Adopt automatic prevention, isolation and recovery to deal with perturbation and enhance the self-healing ability in the event of faults.

**(3) Smart electric power distribution**

①Accelerate the development of distributed clean energy power generation and microgrids in China, Japan, Europe, North America, Oceania, the Gulf region, South America and other countries and regions with bettered developed power grids. By 2030, increase the global proportion of distributed power generation in total generating capacity to about 8%.

②Optimize the distribution network structure, enhance the capabilities of national distribution network in monitoring and smart control, construct active distribution network with adaptive and self-healing capacity to allow for flexible accommodation of distributed clean energy, microgrids, electric vehicles and various electrical devices and enhance the quality of electricity. By 2030, the voltage eligibility rate and frequency qualification rate for major developing countries around the world shall exceed 98%.

**(4) Smart electric power consumption**

①Promote extensive installation of smart meters and the construction of smart homes and smart cities, to achieve two-way interaction between the consumers and the grids. By 2030, over 60% of the countries worldwide will implement the Advanced Metering Infrastructure (AMI) Program, which covers about 70% of the world population.

②Accelerate the construction of charging piles and charging network for electric vehicles in China, Japan, Europe, North America, Oceania and other countries and regions. By 2030, the number of charging piles worldwide reaches 80-120 times than

that of 2015[12].

③Promote combination of electric vehicles, desalination industry and clean energy; innovate in business models to promote participation of electric vehicles in power grid regulation in Europe, North America, Oceania, South America and other areas with higher degrees of power marketization to increase system flexibility and power supply reliability.

### 4.3.7 Energy Efficiency Enhancement

It is the fundamental means to enhance energy efficiency for total energy usage control and carbon emission mitigation. The key is to take administrative and market-oriented measures to stipulate policies and technical standards in the stages of production, allocation and consumption of energy, and also develop energy-conserving technologies. From 2015 to 2030, the average annual decline in energy intensity shall reach 1% to 2.5%.

**(1) Energy production**

①Adopt new technologies to improve the efficiency of power generation with wind energy, solar energy and other clean energy; by 2030, the unit capacity of offshore wind turbines shall reach 10 megawatts or above and efficiency of crystalline silicon and thin film battery shall approximate or exceed 30%.

②Developing countries are implementing the policy of "sanctioning larger ones and closing down small ones" for coal power plants and replace low-parameter small units with high-parameter large units to promote intensive coal use. By 2030, they shall reduce the coal consumption for unit power generation by 5%-10%, and increase the proportion of coal for power generation from 55% in 2015 to 70% or above, while controlling the total consumption of coal, and significantly reducing the low-efficiency coal combustion.

12. IEA: Global EV Outlook 2016

③Transform the traditional biomass energy use and build more biomass and garbage power stations in Africa and other areas where firewood are directly burnt for fuel, to improve energy efficiency.

④Actively develop energy-saving technologies with cogeneration and central heating as the core in countries and regions with larger heat loads.

**(2) Energy allocation**

①Actions should be taken to promote UHV technologies worldwide to reduce the transmission loss.

②Optimize the structure and operation of distribution power grids and reduce the distribution network loss.

③By 2030, expand the total length of UHV AC and UHV DC lines to over 100 thousand kilometers, and the reduce the average loss rate of global power grids to below 6%, compared with that of 8.2% in 2015.

**(3) Energy consumption**

①In industrial sector, actions should be taken to promote using high-efficient and energy-saving electric motors and energy-saving smart terminal for wind turbine and water pump, and to optimize the production process. Promote energy efficiency management system for industrial production and strengthen energy consumption certification and energy efficiency labeling for products/equipment.

②In transportation sector, green logistics should be developed by increasing the proportion of railway and waterway transportation, and advocating eco-friendly public transportation.

③Energy-saving technologies should also be employed in buildings, and advocate energy-saving devices for lighting and air-conditioning. Around 2030, achieve “near-zero energy consumption” for all newly completed buildings; implement energy

consumption certification and energy efficiency labeling for buildings.

④Adopt a variety of clean energy technologies for residential communities, commercial parks and other end users according to local conditions, to achieve integrated and complementary use of “cold, heating, electric” energy resources and improve energy efficiency.

### 4.3.8 Innovation Driven

Innovation is the fundamental driving force to the construction of GEI and sustainable development. **Technical innovation** should be strengthened in fields of energy conversion, allocation and consumption, and focus on key technologies of smart grids, UHV, clean energy, power grids operation and control. **Financial innovation** requires innovating business models and investment programs, constructing high-efficient investment and financing system, providing financial support for GEI projects, reducing risk and improving return on investment.

**(1) Smart Grid technology**

①The security, reliability and economic of power grids will be enhanced and ensured through development of intelligent technologies for power generation, transmission, transformation, distribution, utilization and dispatching.

②The energy density of energy storage devices will be improved. New energy storage equipment will be developed of large capacity, long life cycle, low cost and high security. Electrochemical energy storage systems with the capacity of hundreds of Megawatts and hundreds of Megawatt hours are ready for commercial application by 2030.

③It is also necessary to carry out in-depth integration of electric power technologies with cloud computing, big data, internet of things and mobile internet.

④It is also necessary to develop high-power super-fast EV charging technology to

reach the goal of charging 80% of total amount within 15 minutes in 2030.

**(2) Ultra high voltage (UHV) technology**

①Actions should be taken to develop UHV DC (±1100kV and above) transmission technology and to accelerate equipment development and engineering application, and accommodate integration of large-scale clean energy bases.

②It is necessary to develop ±800 kV UHV DC cable system, and raise the overall performance to ±800 kV /6GW to solve the bottleneck of cross-sea interconnection.

③It is necessary to promote the manufacturing and application of core UHV equipment for use in extreme cold (-60℃) , extreme hot (60℃) or high altitude (4000 meters) environments,

④It is necessary to develop technologies of ±800 kV multi-terminal VSC-UHVDC, VSC-UHV and EHV DC circuit breaker, controllable series compensation, controllable shunt reactors, and other flexible AC transmission technologies.

**(3) Clean energy technology**

①Speed up the development of super-large wind turbines and technological research for their application, to popularize the use of large-scale wind turbines with an installed capacity of 10MW and above. Accelerate the study of large-scale wind power generation equipment with high efficiency and cold resistance to meet the needs for developing wind power in the Arctic Circle.

②Develop perovskite solar cell technology to improve the efficiency of photoelectric conversion to at least 45%. Achieve technological breakthroughs for design and control of ultra-large-scale light and thermal mirror fields, and build demonstration projects of photovoltaic and thermal power generation bases with installed capacity of 1GW and above.

③Develop energy supply systems for miniaturized modular ocean energy, and break through bottlenecks in efficient conversion, efficient energy storage and high reliability design, to turn out equipment and products for comprehensive utilization of marine energy with application values.

④Develop a complementary optimized operation system integrating water, wind and photovoltaic generation and build more stable and controllable clean energy bases.

**(4) Technology for power grid operation and control**

①Achieve breakthrough in the mechanism for safe and stable operation of large-scale AC-DC hybrid power grids and the corresponding characteristic analysis technologies, build a new generation of power grid simulation platform and improve the calculation efficiency and precision.

②Achieve breakthrough in power grid fault diagnosis, recovery and automatic reconstruction and other technologies, to comprehensively enhance the resilience of mega power grids in the event of chain failure, extreme disastrous weather or external damages.

③Develop smart adequacy analysis, optimization and decision support system for the power system to achieve GEI online assessment of adequacy analysis and auxiliary decision-making.

④Establish the communication architecture for wide-area adaptive control, which is characterized by “distributed autonomy and centralized coordination”; develop wide-area adaptive system-protection devices for large-scale power systems.

**(5) Build a win-win business model**

①It calls for joint action of governments, energy enterprises, investment and financing institutions and other entities to promote the construction of GEI in accordance with the market rules. The associated benefits, as well as the risks, are shared by all

participants.

②The professional enterprises are to take responsibility for the construction, operation and maintenance of GEI projects according to commercial covenants.

③The electricity suppliers or users are to pay for the network access fees based on the access points and the voltages level, and fulfill the settlement and benefits sharing in electricity market under regulation.

④Give full play to pilot projects. Promote financial innovation through pilot projects and form typical investment and financing business models.

**(6) Build a multilevel investment and financing system**

Take full advantage of all sorts of financial institutions, and establish a comprehensive multilevel mechanism for investment and financing.

①Multi-financing modes: Support the GEI projects financing through bonds, equity trade, crowd funding, PPP and etc.

②Multi-stakeholder involved: Introduce more social capital into the industry of GEI with institutional advantages in funding, financial leasing, and security, and guide more social capital to invest in the GEI industry.

③Policy-based bank support: Provide financial support from institutions, such as Asia Infrastructure Investment Bank and World Bank, to those key projects in countries with weak fiscal base.

④Government policy support: For the projects with good social benefits but limited economic returns, advice the state government and policy banks in providing support via financial discount and direct loans.

**(7) Build high-efficient support mechanism for investment and financing.**

①It is necessary to design fair methods to distribute profits among various stakeholders with an interest compensation mechanism to support the interconnected countries duly receive the benefits of transmission, interconnection and environment.

②Promote international cooperation in policy negotiation to optimize the investment environment in aspects of commercial, legal, regulatory and fiscal, and to strengthen safeguard for investors as well as mitigate international investment barriers.

③Strengthen investor protection mechanisms. The host governments shall offer risk protection to investors through governmental guarantees and various types of insurance.

### 4.3.9 Capacity Building

GEI construction necessitates global efforts and puts forward higher requirements for the development capacity, scientific and technological strength and research capabilities of countries around the world.

**(1) Enhance development capacity**

①Promote the channels for developing countries to raise domestic and foreign funds by providing international support, so as to ensure that they have the investment and financing capacity for GEI projects.

② Establish GEI capacity development centers and improve the GEI capacity assistance mechanism, to enhance the technologies and managerial expertise of developing countries in clean energy development, power grid construction and operation, and improve their capacity for implement GEI projects, through personnel training, international exchange, cooperative R & D and technology transfer.

**(2) Improve scientific and technology strength**

①Action should be taken to break through key technologies: enhance the simulation and analysis capability for globally interconnected power networks by developing the

operation simulation platform of GEI; enhance capability in key technology R&D by establishing research and test bases for key technologies and equipment of GEI and conducting testing and researches on grid operation and integration in extreme weather conditions; enhance the forecast, operation control and dispatching capability of GEI by building global level numerical weather forecast center and joint power forecasting center.

②Build a sound, multilevel and cross-disciplinary talent cultivation system. The specific actions may include: set up professional courses and training projects on GEI related majors; set up the international scholarship for GEI to cultivate a large number of high-level technical professionals and project management talents.

**(3) Promote research capability**

①Action should be taken to set up professional think tanks of GEI, with GEI developing strategy as research focus, together with internationally renowned think tanks, to research on related topics, which could lead important theoretical and strategic research directions for energy transition and infrastructure interconnection, and regularly publish research reports of GEI, so as to promote continuous support capability for GEI.

②Actions should be taken to build energy research platform, to support joint researches on strategic and forward looking topics with organization, enterprises, universities, research institutions from different countries; release research achievements and share research results.

### 4.3.10 Policy support

The governments are to draw up the policies and measures of clean energy development, power grids interconnection, universal electricity access and enhancing efficiency based on respective circumstances. The intergovernmental organizations should provide guidance and coordination so as to improve the compatibility and

interoperability of policies, and promote establishing the mechanism of international technical cooperation and support.

**(1) Policy on clean energy development**

①Enact policies and regulations to support clean development, accelerate electricity replacement and improve energy efficiency with specific actions and measures.

②The energy subsidies for inefficient fossil-fuel should be gradually abolished. In those countries and regions with proper basis, the carbon tax should be imposed step by step, or conduct carbon emission permit trading.

③Establish special funds for electrification to support enterprises in launching energy alternative projects; establish special funds for energy efficiency, and adopt tax incentives and other means to support energy-efficient, low-power enterprises or industries and promote the development of technologies for enhancing energy efficiency.

**(2) Policy on power grid interconnection**

①Action should be taken to work out the policies and regulations for transnational power grid interconnection and trading, covering the entire process of project planning, preparation and preliminary stage, construction and operation.

②Strengthen the coordination and integration among different countries in the investment, financing, tariff and trade of cross-border power lines, remove the barriers and create a favorable policy environment for power grid interconnection.

**(3) Policy on universal access to electricity**

①For the countries with a large population without access to electricity like in sub-Sahara Africa, South Asia, Southeast Asia, Latin America, the detailed goals and roadmaps for promoting universal access to electricity are needed, including setting up the relevant subsidy mechanism and public investment system.

②Develop incentive policies to promote investment by enterprises and social capital in a variety of ways to reduce the population without access to electric power and alleviate the burden of residential electricity use.

# 5. International Cooperation Mechanism

For building GEI, governments, businesses and social stakeholders[13] need to establish effective cooperation mechanism to promote negotiation and concerted action of all parties in planning, construction, trade, operation and standards for the interconnected power grids.

## 5.1 Mechanism for Global Power Grid Planning

The principle of combining globally top design and nationally independent planning should be followed. The coherent power planning of global, regional and national level should be performed, considering global energy resources and demand.

①Develop generic process and methods for power planning and establish the cost-benefit analysis models for clean energy development and cross-border power projects.

②Based on full communication and data sharing, organize and perform unified global and regional planning, proposing cross-border power projects.

③Establish a revision mechanism to update the planning, according to the economic and social development as well as the implementation situation of the planning scheme.

④Promote the coordination of global and regional planning with national planning, establish a global cross-border project library, and clarify the construction plan.

## 5.2 Mechanism for Transnational Project Construction

13. The governments mainly includes the national governments, public institutions, intergovernmental international organizations and the United Nations; enterprises include power generation companies, power grid companies, equipment manufacturers, financial institutions, service companies and other private companies; social stakeholders mainly include non-governmental organizations, universities, think tanks and other research institutions.

Based on the planning scheme and the basic principles of openness, transparency, fairness, co-construction and sharing, establish the mechanism for global development of clean energy and cross-border projects.

①Establish a research and design platform for global clean energy, cross-border and other projects; organize relevant national governments, power companies and other stakeholders for project feasibility study and other preliminary work.

②In view of project characteristics, establish suitable business model, including capacity and cost allocation models, for attracting global investors. The cost and the benefits should be allocated fairly for any project.

③Financial institutions and non-governmental organizations can cooperate with the power companies, participate in project investments and financing, and promote business model innovation.

## 5.3 Mechanism for Global Electricity Trade

Follow the basic principles of free, fair and non-discriminatory electricity trade; coordinate the power system institutions and market organization forms of different countries, and establish a cross-border electric power trade mechanism based on full communication between all market participants. The mechanism should include tax, trade organization, transmission costs and dispute mediation to achieve efficient collaboration in global power exchange.

①Promote free trade of electric commodities around the world, coordinate national policies on tax and other aspects.

②Promote cross-border bilateral and multilateral long-term contract transactions, and encourage day-ahead, intra-day, real-time and auxiliary service market transactions involving two and multiple parties. Where conditions permit, further establish the regional electricity markets and regional power trading centers.

③According to the transaction forms, establish the transmission service tolling mechanism and congestion management mechanism for cross-border lines, taking into account the cost of line construction and operation, for reasonable allocation of transmission service costs and channel capacity among all parties.

④Establish the power trade mediation mechanism and clarify mediation participants and procedures for solving possible deficiencies and disputes in the global power trade mechanism.

## 5.4 Mechanism for Interconnected Power Grid Coordination

As the scope of interconnected power grids expands and interaction deepens, greater efforts shall be made to ensure grid security brought by the high-share clean energy and complicated environment. Economic issues of large-scale power allocation and operation coordination of transnational power grids also should be tackled.

①Develop the mechanism for the operation of interconnected power grids, coordinate the joint operation of the power grids of different countries and regions; in particular, study the operation rules adapted to the characteristics of clean energy, in order to optimize grid operation in a wider range, and promote access of all kinds of centralized and distributed clean energy resources.

②Establish joint operation agreements for cross-border and inter-continental power grids, regulate the operation of interconnection lines, optimize the power flow, achieving cross-border interdependence and mutual complementation.

③Establish a global information and early-warning system for global power grids, through which every national grid operators can obtain the real-time status and data of global, regional, national grids, strengthening collaboration between parties.

## 5.5 Mechanism for Collaboration in Technical Standards

Construction of GEI necessitates the coordination of technical standards and

procedures for project, transaction and operation.

①Prepare technical standards for cross-border grid construction and related equipment to reduce construction costs, improve cost-effectiveness and reliability.

②Develop models and tools for cross-border power trade to improve market transparency and reduce transaction costs.

③Improve the coordination and compatibility between technical standards and procedures for global grid regulation and operation, further enhance the efficiency and stability of system.

④The International Standardization Organization (ISO) should set up a platform for organizing and coordinating enterprises, universities and other research institutions in developing relevant standards.

## Concluding Remarks

Over the last three hundred years since industrialization, the large-scale development and use of fossil fuels have led to acute problems such as the resource depletion, environmental pollution and climate change, posing great threats to the existence and sustainable development of human beings. With energy as one of its core tasks, *the 2030 Agenda* calls for the international community to work out solutions for the coordinated development of energy, economy and environment. GEI provides a viable and practical action plan for world energy transformation and sustainable energy development. The development of GEI will play a critical role for the realization of the sustainable development goals in *the 2030 Agenda*.

GEI has pictured a bright future for mankind and brought unprecedented opportunities of development for all relevant parties. We welcome all governments, enterprises, organizations and individuals to join the collective efforts for achieving this grand goal. GEIDCO, collaborating closely with the United Nations and relevant stakeholders, will pool collective strength worldwide, promote the sound and fast development of GEI and contribute to the realization of sustainable development goals of *the 2030 Agenda*. In near future, the world will be transformed into a bright, peaceful and harmonious global village of green land and blue sky with smooth information flow, well-developed transportation and sustainable energy for all.