Strategic Energy Alternatives For Coordinated Development and Environment in China by Working Group on Energy Strategies and Technologies

1993-05-05

0. Goals, Strategies and Policies

A goal is an objective to be attained or a destination to be reached; a strategy is a broad plan to achieve the goal(s) or a path to reach the destination; and a policy is a specific course of action to implement a strategy.

Goals provide a focus for a strategy. A strategy coordinates and integrates policies and help avoid inconsistencies. Without a strategy, policies have no coherence, and without goals, a strategy has no focus.

1. Objective

THE Objective of the future energy system for China is to deliver the required energy services of continued socio-economic development in an environmentally acceptable and reliable manner.

Energy was one of the areas of intensive debate at the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro, in June 1992. In Agenda 21, chapter 9, it was agreed that energy is currently produced and consumed in ways that cannot be sustained, and that one of the objectives in promoting sustainable development is to reduce adverse effects on the atmosphere from the energy sector. Two directions for the energy system to evolve were identified: (a) more efficient use of energy, in production, conversion, transmission and distribution, and end-use, and (b) growing reliance on environmentally sound energy systems, particularly new and renewable sources of energy.

2. The Challenges

A great challenge facing China is to find a balanced approach to the twin issues of development and environment. Like other developing countries, China can not but give priority to the development of its economy. It is an urgent need to identify a strategy to integrate development and environment issues, and policies for implementation.

Economic Growth. Economic growth in China has averaged 7.9% in the period 1988-1992. Energy consumption has also grown rapidly, however, at a considerably lower rate due to structural changes in the economy towards less energy-intensive industries and the utilization of more energy-efficient technologies. Population growth and continued socio-economic growth will require more energy services. The corresponding demand for primary energy must be analyzed, taking into account the efficiency of energy conversion and end-use processes. What would be the demands on capital and other resources in limited supply?

The energy supply system must be built in such a way that a sufficient level of availability and reliability is maintained, considering seasonal and climatic variations, and the growth in and distribution of energy demand.

Environment. The extraction, conversion and use of energy lead to local, regional, and global problems, including urban air pollution, acid rain, and climate change. What is the situation with respect to these problems, and what level of change from the present, and a projected business-as-usual-future, are called for? Such evaluation would provide targets for the environmental efforts.
Rural Development and Urban Growth. The problems of socio-economic development of rural areas in China requires a special analysis in light of the fact that a large fraction of the population of China is rural. The energy needs of small and dispersed communities must be addressed. Will development of such communities require the development of decentralized energy systems in addition to centralized systems? What measures should be taken to stimulate rational use of biomass and waste in rural areas?

The growth of urban areas requires special attention to provide an infrastructure of working and residential areas, that can be supplied with energy services efficiently, and that are planned for an efficient transportation situation.

3. Approach

A practical way of addressing the environment-development dilemma and of minimizing environmental degradation whilst emphasizing development is to adopt a gradual, step-by-step approach to environmental problems: first, urban pollution problems, then acid raid rain and finally global atmospheric accumulation of greenhouse gases. This changing emphasis from local to regional/national to global problems will emphasize that environmental concerns are in the country's self-interest and not at the expense of development. Proper environmental policies will be helpful to development objectives, because environmental degradation could become a constraint on development. One ambition would be to identify the measures that are attractive from both development and environment perspectives.

Energy services are, for instance, cooking, comfortable indoor climate, refrigerated storage, illumination, transportation, or, when the service is a product, steel or automobiles, for example,

The energy chain to deliver these services begins with the collection or extraction of the primary energy, which in one or several steps is converted into energy carriers suitable for the end-use. The energy sector has generally restricted itself to these supply-side activities.

The energy carriers are used in energy end-use equipment to provide energy services. Thus, the energy system extends beyond what is conventionally considered the energy sector.

The key energy issues to be addressed by our Working Group are strategic and long-term, aiming at the identification of integrated energy systems compatible with sustainable development. An integrated energy system is the most cost effective mix of efficiency improvements (on the supply and the demand side), decentralized renewable sources of energy and “clean” centralized sources of energy. Costs must include both conventional and internalized environmental costs. The primary emphasis must be on cost-effective development.

Strategic considerations include to identify a proper balance between efficiency improvements and supply side expansion of different alternatives, both in the short and the long term. Long-term generally refers to the time period after which most of the present capital has been replaced or renovated, that is usually 10-20 years and beyond.

In addition to providing a basis for how the present energy system can develop, the policies that would implement the strategy must be identified.

A key methodological approach is to use scenario analysis. Scenarios may be used to explore the combined impact of various assumptions. This would require analysis of input parameters, including technological demand and supply side options, with respect to costs, performance, and environmental impact. Scenarios help provide an integrated understanding of how strategies can relate to the objectives.

For example, what would the energy system of China look like in, say, year 2020, if the utilization of coal and clean coal technology were emphasized for new energy supply investments, or likewise, if half of the hydropower potential was used, or likewise, if natural gas reserves could be economically utilized at ten times the present rate. What would the impact be on electricity supply, if present hydropower stations would be retrofitted to minimize water and other losses, if present electricity generation using coal would be retrofitted with flue-gas desulphurization and other cleaning processes. What would the impact be of such measures at different total energy demand levels, resulting from different levels of ambitions with respect to end-use efficiency improvements.

In evaluating such scenarios, it may be useful to define two baseline for the environmental impacts of coal use. One would be based on the environmental characteristics of the presently used coal technologies, the other on the best available technologies, from an environmental point of view. Of course, the economic costs of these technologies would differ substantially.

A basic methodological issue will be cost evaluations, including the identification of the marginal costs of new investments in the energy

http://www.cciced.net/encciced/policyr/Taskforces/phase1/wgest9296/2008020202_145225.htm
sector, as well as the costs of capital. Approaches that are helpful for both national and local implementation that will be explored include least-cost planning and life-cycle analysis. There are crucial to help identify the most attractive energy options. Likewise, procedures and elements of risk evaluation associated with different energy supply activities are important. However, present costing and risk assessment methodologies, both in China and in the rest of the world are incomplete. These issues deserve more thinking.

In many countries, including China, energy prices are not reflecting costs, nor, in the case of internationally traded energy carriers, world market prices. Prices distortions should be avoided. However, the removal of subsidies will lead to significant social difficulties, unless carefully compensated for with adequate policies.

4. Demand Side Alternatives

The energy use in a society may be judged by comparing it to the level of economic activity as measured with the Gross Domestic Product (GDP). Figure 1 shows the historical development of the Energy/GDP ratio in some industrialized countries, and the developing countries as a group. The decrease of this ratio, after the passage through a maximum, has been about 1% per year in the countries shown. The maximum of the Energy/GDP is lower for the countries that industrialized later than for those that reached the maximum earlier in time. This reflects the fact that, as time goes on, more energy-efficient technologies become available. However developing countries, with a curve which is still rising, have an Energy/GDP ratio that is already larger than the maximum ever reached by France, Japan, or Italy. (A note of caution is in order here, because of the difficulties of comparing different currencies.) This suggests that they do not have access to state-of-the-art-technologies, and rely on inefficient ways of using energy corresponding to those prevailing at the beginning of the century in Europe.

These curves also reflect the shift with economic growth away from materials-intensive, and towards more knowledge-intensive, consumptions and production patterns, and the utilization of increasingly energy efficient conversion and end-use technologies. The increase in Energy/GDP ratios in developing counties is also due to the building up of infrastructures, which require substantial amounts of energy and materials, and to supply for the first time material-intensive durable goods, in rich countries these demands are saturated, except for replacements, and the consumption can shift towards more knowledge-intensive goods and services.

Figure 1. Energy Intensity (E/GNP ratio) in Some Countries and Groups of Countries Historical Trends (Kilograms of oil equivalent per 1000US 1975dollars)

Figure 2 shows the development of the Energy/GDP ratio for China. It shows a remarkable difference with respect to the agglomerate of developing countries, with the ratio peaking in 1997 and a steady decline thereafter. The need for material-intensive infrastructure investments suggests that the rapid decline may not continue at this pace.

Specific energy use is energy use per unit of an energy service, for instance, in the case of refrigeration, kwh per liter of refrigerated volume per year. Lower specific energy use for an energy service, can be obtained through the use of more energy efficient technology.

Fig. 2. Energy Intensity of GDP (Kilograms of oil equivalent/100 US at 1985 prices)

Efficiency improvement can be achieved at each step in the energy chain. From the point of view of basic thermodynamics, the limits to continued efficiency improvements are far away.

In formulating energy strategies, actions to improve energy efficiency can be classified thus:

(1) more efficaced primary energy extraction and conversion, for instance in power plants and refineries;

(2) more efficient transmission and distribution of energy carriers;

(3) more efficient end-use of energy in existing installations through improved operation and maintenance, and replacement of some components; and

(4) more efficient end-use of energy in new installations, equipment, etc., through systematic deployment of more energy-efficient systems and technology. These systems and technologies may be introduced at the rate of capital turnover and expansion, for instance at the rate of replacement and addition.

The energy performance of new equipment varies considerably, and it is crucial to pay close attention to the specific energy use offered by
different pieces of equipment for the same energy service.

Energy efficiency improvements are possible everywhere energy is used. This means that information about and analysis of all major energy-using sectors are required. This analysis should, to the extent possible, illustrate the present levels of energy use, the specific energy use, and the prospective, cost-effective reductions. The use of supply curves, showing the potential energy use reductions as a function of cost per unit reduction is an illustrative way of presenting the information.

The transportation sector is an important energy-using sector, and the limitations of available transport services provide constraint on development. There is a need for an integrated approach, where the composition of different transportation modes is optimized: road (including bicycles, buses, automobiles, and trucks), sea, rail, and air transport, as well as the introduction of more energy efficient technologies wherever available.

An important concept in the analysis of future energy efficient technologies is technological leapfrogging, in the meaning leaping forward. It implies the use of the most advanced technology possible for every investment that is made, thereby speeding up the gradual building up of an energy-efficient infrastructure and capital stock. This concept may be focused in an approach to introducing more energy-efficient technologies. This should be a key element in any socio-economic development strategy. Leapfrogging implies that new investments are made in technologies with performance that correspond to the best available, or that is being developed for the conditions at hand. There is a close link between modernization and leapfrogging. There are several reasons for pursuing the leapfrogging potion. Most of the technologies brought to commercial readiness in the industrialized countries are developed for the conditions prevailing there, such as the requirements of capital-intensive and labour-saving character. However, these characteristics are not well suited to conditions in most of the developing countries. Additionally, many developing countries have access to low-cost hydropower and biomass resources. Furthermore, energy needs are different from those industrialized countries, because satisfaction of basic human needs and infrastructure-building must be given paramount attention in the developing countries.

Leapfrogging should not be seen for specific technologies alone but also at the level of systems and infrastructures. For instance, in considering transportation it may be more important to shift from one mode to another (for example from road to rail or waterways), or to improve traffic conditions by extensive use of informatics, that to improve specific vehicles.

5. Supply side alternatives

On the supply side, (following Agenda 21) renewable sources of energy are import ant also because of the technological advances and corresponding cost reductions seen in the 1980's. The first example here for China is the expanded use of hydropower in a socially and environmentally acceptable manner.

Natural gas is the least problematic of the fossil fuels, from an environmental point of view. Natural gas could become an important fuel in all sectors, including the transportation sector, first in internal combustion engines and later in fuel cell powered vehicles. Using modern combined cycle technologies, power can be generated with an efficiency over 50%. Additionally, natural gas may have an important role in a renewables-intensive energy system, because it is well suited to help accommodate the intermittent power generation of solar and wind technologies.

Coal presently has a dominating role in the China energy system. The resources are very large. Most of the environmental problems can be dealt with if the so-called "clean coal" technologies are successfully developed and applied. The conditions for the application of these to large and small scale coal using installations in China must be better understood.

Also the expanded use of nuclear power is an alternative to consider. Here, the complete nuclear fuel cycle should be studied.

In the analysis of renewable, the possibilities of producing biomass, either as agricultural/forestry/industrial wastes, or in dedicated plantations are important. The latter might be on degraded land, that used to carry vegetation and could be restored to do so again. Biogas already has an important role in China. In general, biomass converted to modern energy carriers such as electricity or liquid and gaseous fuels is now becoming cost-competitive with conventional sources of energy.

With respect to wind energy, the most modern technology can generated electricity from the wind in suitable areas at costs comparable to that of environmentally sound coal-based power generation. It is important to identify wind resources on a sufficiently detailed scale to allow for
investment decisions.

Solar electricity, including both solar thermal electric and photovoltaic cells, is an emerging power source that is already finding applications in niche markets. Costs are very high, but expected to decrease rapidly. Would this happen, a major expansion of solar power would be feasible.

In general, there is a complementarity between centralized and decentralized energy systems. The latter are often more reliable and less expensive, however, they have a limited capacity. A balance between the options should be sought.

6. Implementation

The development process requires large investment in all sectors of society. The challenge with respect to energy is to make these investments energy-efficient, in order to gradually introduce energy-efficient technology, and to minimize total cost for the energy services. Barriers exist at the consumer, utility, local, national, and international levels. They need to be identified and overcome.

Rationalization of energy prices. The rapid economic growth and the gradual introduction of market mechanisms in China will lead to substantial reformation of the productive sector. In order to gradually pursue an economically efficient path of energy pricing, and to avoid negative social effects, it is advisable to expand, to the extent possible, the use of cost-based prices, reflecting, where appropriate, international energy prices. The use of more energy-efficient technologies will help protect the consumers that are more sensitive to the expenditures for energy services in total, than to the unit cost of energy. Innovative financial mechanisms for this needs to be designed.

It should be noted that the rationalization of energy prices will generate significant funds, that may help finance the total activity in the sector.

Institutions and markets. Because price rationalization alone is not likely to bring about a full utilization of cost-effective energy efficiency opportunities, institutional and market barriers should be assessed.

Market oriented policies help provide an economically efficient system. With respect to the energy issues, the short-sighted aspects of the market functioning should be corrected for by creating market boundary conditions that account for the poor, the long term, the infrastructure needs, and the environment. Measures to consider include financing mechanisms, performance standards, and regulations about, for example, least-cost planning and demand side management.

Time horizons. The issue of allocating financial resources between the short and the long term should also be considered. For example, the largest short-term environmental improvement per yuan spent may be in incremental improvements of the coal using equipment. On the other hand, investing too much in this way may make it more difficult to change the structure of the energy system in the long term.

Information, Training and Motivation. Information, training and motivation of the professionals and the general public should be an element of implementation.

International cooperation. The Working Group should consider the pros and cons of international cooperation, as well as the modalities thereof, in, inter alia, the fields of natural gas resource development, reduction options in leapfrogging, and the implementation of carbon emissions reduction options in general. The use of both private and public capital should be considered.

A significant opportunity for China with respect to technological leapfrogging may be export of energy-efficient technologies. Already, the cost of compact fluorescent light bulbs in China are one fifth of that of the world market, using current exchange rates. There are reasons to believe that energy-efficient appliances in general, and other equipment, could become similarly competitive.

In situations where cost-effective national developmental projects damage the global environment, international assistance of the type offered through the Global Environment Facility may help the country to adopt for itself less cost-effective but globally more beneficial technologies.

With respect to the work under the auspices of the China Council, these issues are coming back in several contexts. It may be advisable to have a generic approach to the problems, without losing sight of the specifics of each situation.

7. Work Plan the first year of the Working Group's activities

The work will be a gradual approach to some important areas. The WG has identified six areas where workshops will be arranged and/or
reports prepared. These will be further considered at the two meetings of the WG that are planned, one at the end of October 1993 and one in March 1994.

(1) Analytical methods. Analytical methods are crucial to the identification of opportunities and constraints. The methods of cost evaluations and comparisons for energy supply and energy efficiency improvements will be discussed at a workshop.

(2) Energy use in heavy industry. The energy use in heavy industry is very important in the iron and steel industry, with a view to the leapfrogging possibilities, that may be of significant importance considering the foreseen expansion of the steel production.

(3) Biogas. Biomass utilization in the rural areas will be analyzed in the context of maintaining the soil quality, reducing pollution, and providing energy, considering present moves to abandon biogas installations. A report will be prepared on the issues and policies.

(4) Energy efficiency. A report on the institutional, legislative, financing, and regulatory measures to introduce energy efficient technologies and energy price rationalization will be prepared.

(5) Renewable sources of energy. A report will be prepared on the increased utilization of renewable sources of energy and the role of the Government, especially in creating early markets.

(6) Natural gas utilization. A report will be prepared analyzing the opportunities and the costs for a rapid expansion of the natural gas industry. The study will also consider the most cost-effective way of distributing the energy, either as gas or converted to electricity. The efficiency of natural gas using equipment will also be considered, so that the whole chain from primary energy to energy service is studied.

8. Recommendations

The Working Group on Energy Strategies and Technologies has stated its work only recently. The first meeting was held on April 26-28, 1993 in Beijing. The major finding at this point is the approach to be taken by the WG, which is reflected above. Work along the lines indicated will have to be done before substantive recommendations are made.

The availability of energy services in all sectors is central to the development process. This requires an integrated approach, including all energy-using sectors, the energy supply sector, and the agriculture and forestry sectors to develop an energy system compatible with a sustainable development.

Because of capital and environmental constraints, the WG believes that methods of using energy much more efficiently, especially at the point of end-use, should be studied carefully, as well as environmentally sound sources of energy supply, both centralized and decentralized.

The WG intends to work hard to help provide the Council and planners with a step-by-step approach and the methodologies needed.

Working Group

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Statement to CCICED

Thomas B. Johansson

Mr. Chairman, Yours Excellencies, Ladies and Gentlemen:

It is an honour to present to you the first report of the Working Group on Energy Strategies and Technologies of the Council, on behalf my Co-chairmen and the Working Group. I am doing this at the request of my Co-chairman, professor Yang Jike, with whom I have had the privilege to work closely and to learn from his wisdom and experience.

The state of the work of the Group is presented in the report to you, and I will here only highlight some of the issues, approaches, opportunities and constraints that the Group has been discussing.

A great challenge facing China is to find a balanced approach to the twin issues of development and environment. Like other developing countries, China must give priority to the development of its economy. Proper environmental policies will be helpful to development objectives, because environmental degradation could become a constraint on development. It is an urgent need to identify a strategy to integrate development and environment issues, and policies for its implementation.

The objective of the future energy system for China is to deliver the required energy services for continued socio-economic development in an environmentally acceptable and reliable manner. This is in itself a significant challenge.

However, there are also strong linkages between the energy issues and other central contemporary issues. At the Earth Summit in Rio de Janeiro last year, energy was one of the areas of intensive debate and it was agreed that energy is currently produced and consumed in ways that cannot be sustained.

A practical way of addressing the environment-development dilemma and of minimizing environmental degradation whilst emphasizing development is to adopt a gradual, step-by-step approach to energy-related environmental problems: first, air quality problems, then acid rain and finally global atmospheric accumulation of greenhouse gases. This changing emphasis from local to regional/national to global problems will emphasize that environmental concerns are in the country's self-interest and not at the expense of development.

Energy services, the objective of the energy system, are, for instance, cooking, comfortable indoor climate, refrigerated storage, illumination, transportation, or, when the service is a product, steel or automobiles, for example.

The energy chain to deliver these services begins with the collection or extraction of the primary energy, which in one or several steps is converted into energy carriers suitable for the energy end-use at the demand side. The energy sector has generally restricted itself to the supply-side activities.

The energy carriers are used in energy end-use equipment to provide energy services. Thus, the energy system extends beyond what is conventionally considered the energy sector.

The key energy issues to be addressed by our Working Group are strategic and long-term, aiming at the identification of integrated energy systems compatible with sustainable development. An integrated energy system is the most cost-effective mix of efficiency improvements (on the supply and the demand side), decentralized renewable sources of energy and "clean" centralized sources of energy. Costs must include both conventional and internalized environmental costs. The primary emphasis must be on cost-effective development.

Strategic considerations include to identify a proper balance between efficiency improvements and supply side expansion of different alternatives, both in the short and the long term. Long-term generally refers to the time period after which most of the present capital has been replaced or renovated, that is usually 10 -20 years and beyond.

In formulating energy strategies, the most important actions to improve energy efficiency are to introduce more efficient end-use of energy in new installations, equipment, etc., through systematic deployment of more energy efficient systems and technologies. These systems and
technologies may be introduced at the rate of capital turnover and expansion.

The energy performance of new equipment varies considerably, and it is crucial to pay close attention to the specific energy use offered by different pieces of equipment for the same energy service without increasing total cost. In general, using less energy means that less energy would be produced and there would be less pollution for the same service.

Additionally, there is a considerable potential for cost-effective improvements in the present capital stock.

China has focused on more efficient use of energy for more than a decade, with impressive results, as shown in the Figure attached to the Working Group Report. However, there still remains a large untapped potential for cost-effective efficiency improvements, especially when new investments in energy-using equipment are done.

An important concept in the analysis of future energy efficient technologies is technological leapfrogging, in the meaning leaping forward. It implies the use of the most advanced technology possible for every investment that is made, thereby speeding up the gradual building up of an energy-efficient infrastructure and capital stock. This concept may be focused in an approach to introducing more energy-efficient technologies. This should be a key element in any socio-economic development strategy. Leapfrogging implies that new investments are made in technologies with performance that correspond to the best available, or that is being developed for the conditions at hand. There is a close link between modernization and leapfrogging.

Leapfrogging should be considered for specific technologies, and also at the level of systems and infrastructures. For instance, in considering transportation it may be more important to shift from one mode to another (for example from road to rail or waterways), or to improve traffic conditions by extensive use of informatics, than to improve specific vehicles.

Leapfrogging is not simply transfer of technology. Simple transfer of technology does not work, because technology has to fit the socio-economic and cultural conditions of the country. Technology can be advanced and modified to fit, and that is inherent in the leapfrogging approach.

On the supply side, (following Agenda 21) renewable sources of energy are important. The first example here for China is the expanded use of hydropower in a socially and environmentally acceptable manner.

Natural gas is the least problematic of the fossil fuels, from an environmental point of view. Natural gas could become an important fuel in all sectors, including the transportation sector. Using modern combined cycle technologies, power can be generated with efficiency over 50%. Additionally, natural gas may have an important role in a renewable-intensive energy system, because it is well suited to help accommodate the intermittent power generation of solar and wind technologies.

Coal presently has a dominating role in the China energy system. The resources are very large. Most of the environmental problems can be dealt with if the so-called "clean" coal technologies are successfully developed and applied. The conditions for the application of these to large and small scale coal using installations in China must be better understood.

Also the expanded use of nuclear power is an alternative to consider. Here, the complete nuclear fuel cycle should be studied.

In the expanded use of renewable, the possibilities of using biomass, either from agricultural/forestry/industrial wastes, or from dedicated plantations are important. The latter might be on degraded land, that used to carry vegetation and could be restored to do so again. Biogas already has an important role in China. In general, biomass should be converted to modern energy carries such as electricity or liquid and gaseous fuels. These are now becoming cost-competitive with conventional sources of energy.

With respect to wind energy, modern technology can generate electricity from the wind in suitable areas at cost comparable to that of environmentally sound coal-based power generation. It is important to identify wind resources on a sufficiently detailed scale to allow for investment decisions.

Solar electricity is an emerging power source that is already finding applications in niche markets. Costs are still high, but are expected to decrease. With that, a major expansion of solar power into grid markets is feasible.

In general, there is a complementarity between centralized and decentralized energy systems. The latter are often more reliable and less
expensive, however, they have a limited capacity. A balance between the options should be sought.

A basic methodological issue will be cost evaluations, including the identification of the marginal costs of new investments in the energy sector, as well as the costs of capital. Approaches that are helpful for both national and local implementation that will be explored include least-cost planning and life-cycle analysis. There are crucial to help identify the most attractive energy options. Likewise, procedures and elements of risk evaluation associated with different energy supply activities are important. However, present costing and risk assessment methodologies deserve more thinking in all countries, and also in China.

In many countries, including China, energy prices are not adequately reflecting cost, nor, in the case of internationally traded energy carriers, world market prices. One objective in the policy area is to minimize price distortions, through the removal of subsidies, carefully compensated with adequate policies to avoid significant social difficulties. Price rationalization is not the only policy to consider. There are many institutional, regulatory and legislative issues to study in an analysis of barriers to energy efficiency improvements. Demand-side management is one of several approaches here.

A key methodological approach to understanding the relations between goals and alternative future energy systems is to use scenario analysis. Scenarios may be used to explore the combined impact of various assumptions. This would require analysis of input parameters, including technological demand and supply side options, with respect to costs, performance, and environmental impact. Scenarios help provide an integrated understanding of how strategies can relate to the objectives.

For example, what would the energy system of China look like in, say, year 2020, if the utilization of coal and clean coal technology were emphasized for new energy supply investments, or likewise, if half of the hydropower potential was used, or likewise, if natural gas reserves could be economically utilized at ten times the present rate. What would the impact be on electricity supply, if present hydropower stations would be retrofitted to minimize water and other losses, if present electricity generation using coal would be retrofitted with flue-gas desulphurization and other cleaning processes. And, what would the impact be of such measures at different total energy demand levels, resulting from different levels of ambitions with respect to end-use efficiency improvements.

The initial work will be a gradual approach to some important areas. The Working Group has identified six areas where workshops will be arranged and/or reports prepared in the first year of working. These will be further considered at the two meetings of the Working Group that are planned, one at the end of October 1993 and one in March 1994.

1. Analytical methods are crucial to the identification of opportunities and constraints.
2. Energy use in heavy industry, especially the iron and steel industry, will be studied, with a view to the leapfrogging possibilities.
3. Biomass utilization in the rural areas will be analyzed in the context of maintaining the soil quality, reducing pollution, and providing energy.
4. Energy efficiency. A report on the institutional, legislative, financing, and regulatory measures to introduce energy efficient technologies, and energy price rationalization will be prepared.
5. Renewable sources of energy. A report will be prepared on the increased utilization of renewable sources of energy and the role of the Government, especially in creating early markets.
6. Natural gas utilization, either as gas or converted to electricity, studying the whole chain from primary energy to energy service.

Because of capital and environmental constraints, the Working Group believes that methods of using energy much more efficiently, especially at the point of end-use, should be studied carefully, as well as environmentally sound sources of energy supply, both centralized and decentralized.

The availability of energy service in all sectors is central to the development process. This requires an integrated and interdisciplinary approach, including all energy-using sectors, the energy supply sector, and the agriculture and forestry sectors to develop an energy system compatible with sustainable development.

On my part, Mr. Chairman, I would like to say that the goals of your Government in this area are crucial for sustainable development. The
gradual achievement of them will have a historical impact in the development of China, as well as for the world. Therefore, it is with great respect and commitment we have engaged in the work of this Working Group. We wish you all success in your endeavours.

Thank you for your attention.

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