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A SUSTAINABLE ENERGY STRATEGY FOR CHINA BASED ON ADVANCED TECHNOLOGIES

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INTRODUCTION

CHINA IS SUCH A BIG PART OF THE WORLD THAT IT CANNOT BE TREATED LIKE MOST OTHER COUNTRIES. FOR INSTANCE, THE WORLD MARKET PRICE OF OIL CANNOT BE CONSIDERED AN EXOGENEOUS VARIABLE, SINCE IT WILL BE GREATLY INFLUENCED BY THE SIZE OF CHINA'S DEMAND FOR OIL

IN ADDITION, CHINA HAS ENERGY CHARACTERISTICS THAT ARE DIFFERENT FROM THOSE OF MOST OTHER COUNTRIES : FOR INSTANCE THE GREAT ABUNDANCE OF COAL –
IT HAS A PERSISTENT, UNPARALLELED LEVEL OF ECONOMIC GROWTH
AND IT IS DEVELOPING AN ORIGINAL ECONOMIC SYSTEM
(THE "SOCIALIST MARKET" APPROACH)

THE "CHINA COUNCIL"

The China Council for International Co-operation on Environment and Development (**CCICED**), launched in 1993, is a high-level consultative body that reports annually to the leadership of the Chinese Government with policy recommendations relating to sustainable development. The Council is made up of 16 Vice Ministers in the Chinese Government, 10 senior Chinese academicians and 21 international members of similar stature. The Council has been chaired by Wen Jiabao, when he was Vice Premier.

Until 2002, the Council has carried out most of its detailed work through semi-permanent Working Groups, made up of both Chinese and international members, among which the Working Group on Energy Strategies and Technologies. Since 2002, the place of the Working Groups has been taken by temporary Task Forces, appointed to analyse selected issues of particular interest to the Council

The Task Force on Energy Strategies and Technologies (TFEST)

CCICED has commissioned the Task Force on Energy Strategies and Technologies – co-chaired by Prof. **Ni Weidou** (Tsinghua University) and Prof. **Thomas Johansson** (University of Lund, Sweden) to prepare a report on coal gasification-based energy strategies, including policy recommendations as an input of the 2003 CCICED report to the Chinese Government.

In the process of preparing this report, the Task Force convened a **Workshop on coal gasification technologies and strategies** (August 2003), widely attended by Chinese and international specialists and stakeholders

Modelling Work

The study carried out by TFEST was amply based on modelling work carried out by means of MARKAL mainly by **Pat DeLaquil** in co-operation with **Tsinghua** University; the analysys of the technological options for gasification derives mostly from work carried out at Princeton Environmental Institute by **Robert Williams** and **Eric Larson**

The work of the Energy Research Institute of the National Development and Reform Commission, also based on Markal modelling, has equally been of great help to the TFEST

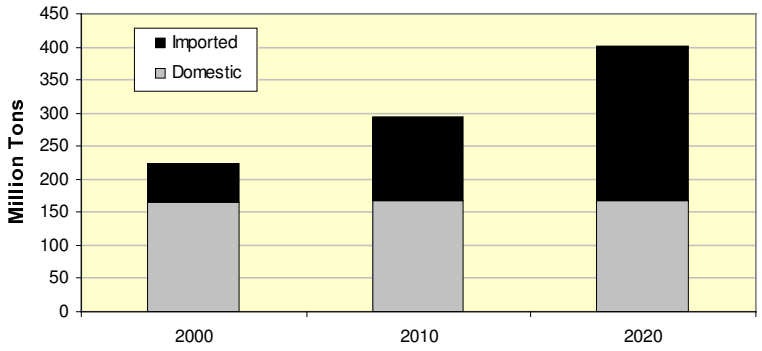
The following is a short presentation of the conclusions reached by TFEST and endorsed by the discussion held at the August workshop.

The main challenges

The main challenges facing the energy future of China are:

- Meet the rapidly increasing demand for energy services of an **economy** that will rise fourfold by 2020
- Meet the projected liquid fuel needs, especially for transportation, without endangering the **security** of energy supply
- Reduce the dangers and costs (7 to 13% of GDP!) of pollution, especially air pollution, in both urban and rural **environment**
- Contribute to mitigate **Greenhouse Gas** emissions "on the basis of equity and in accordance with its common but differentiated responsibilities and respective capabilities" (UNFCCC)

China's projected oil consumption
(from E.R.I. scenario 3: high efficiency, but without coal gasification)

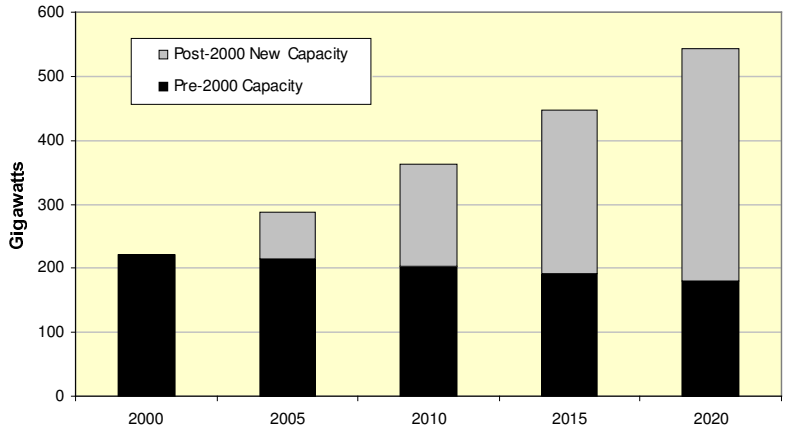


The Opportunities

- China has very large reserves of **coal**, and is already the first coal producer in the world
- China needs to build in the next few years the bulk of its **infrastructures** for the future: it has much more freedom of choice on how to shape its energy system than countries with slow economic growth and/or large existing infrastructures representing sunk capital
- China has an advanced **scientific and technological** background allowing innovative solutions to be developed or adapted locally

Projection for coal power plant capacity

Based on estimates of the Electric Power Technology Market Association of China, 2/3 of capacity in 2020 is yet to be built



Why coal gasification?

- Coal combustion is inherently dirty, while gasification allows for effective and relatively cheap **cleaning**
- Gasification allows using gas turbines and combined cycles for a greater **efficiency** in electricity generation
- Syngas from gasification is the starting point for the synthesis of high quality **liquid fuels** (methanol, DME) of and of a number of chemicals
- By using oxygen-blown gasification and membrane separation of exhaust gases one obtains a nearly clean stream of **CO_2** that could be **segregated** at low marginal costs
- Power production and fuel synthesis can be economically combined in a **polygeneration** plant with a once-through cycle

Coal gasification is not new for China

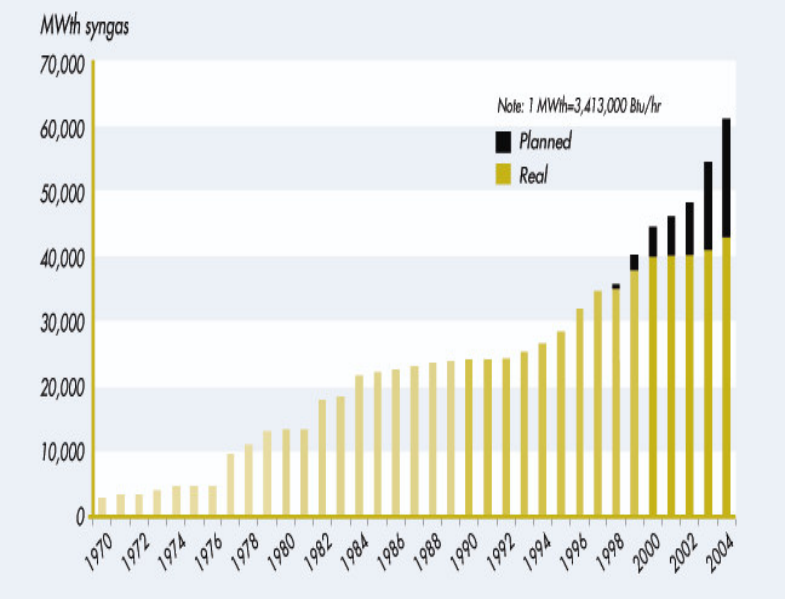
- Coal gasification is used extensively throughout the world: there are presently 60,000 MWth of installed capacity
- China is one of the countries with most experience in coal gasification, having plants for 9 GW
- However, coal gasification in China is used by the chemical industry and not by the power industry: a sector-to-sector cross-fertilisation is needed
- If the single components of a polygeneration plant based on coal gasification are all available now, their integration is relatively new and requires some development work

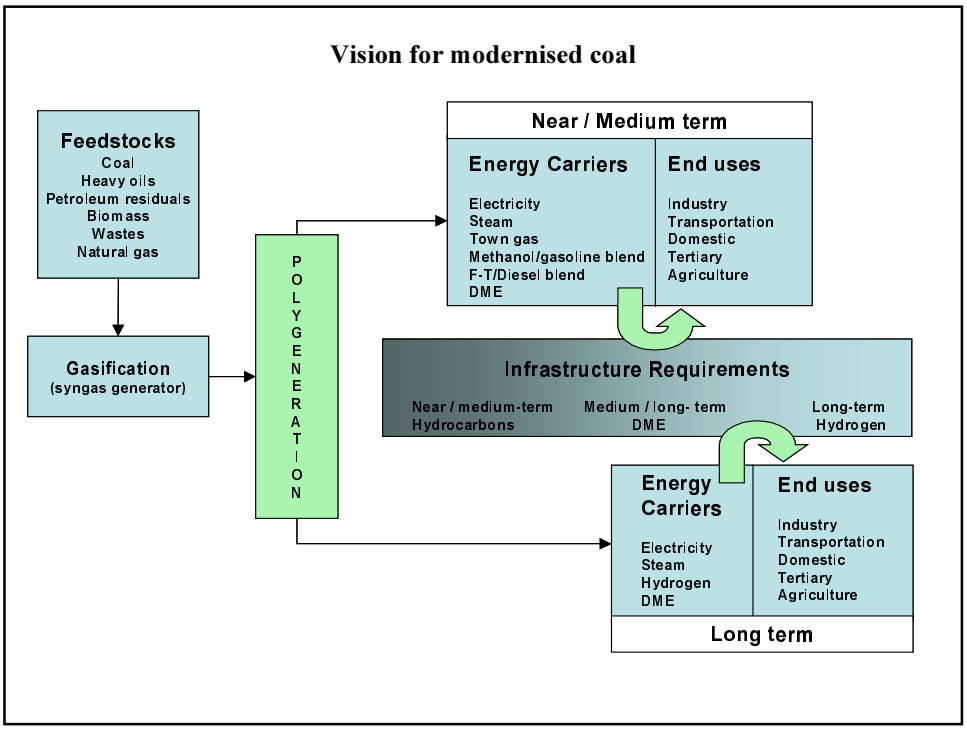
Cumulative Worldwide Gasification Capacity and Growth

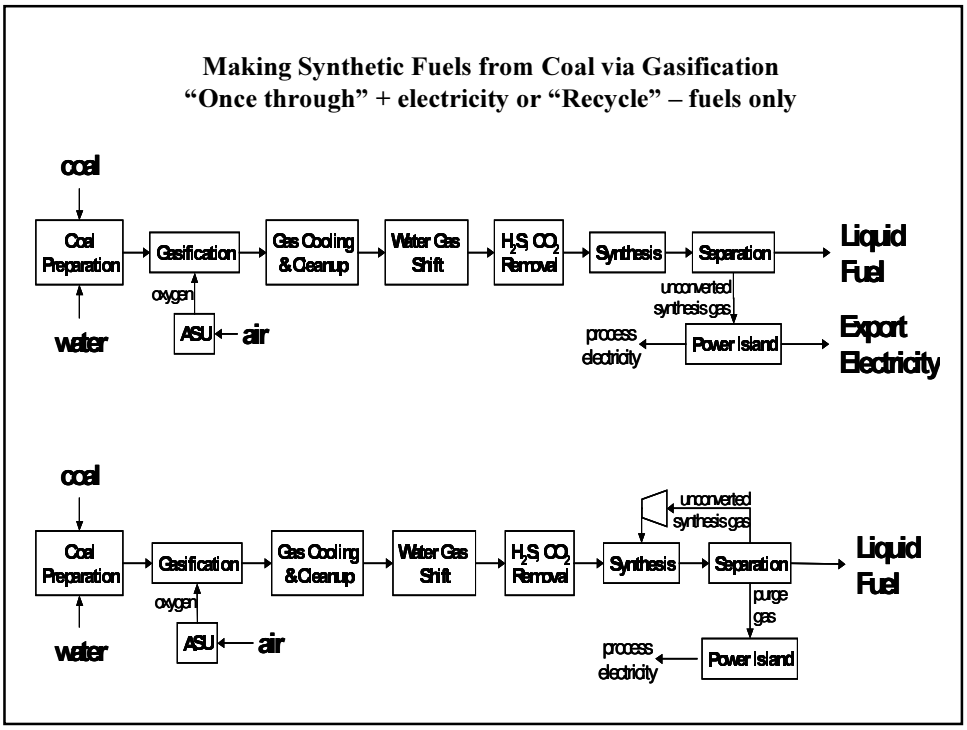
In 2004
By activity:
24 GW_{th} chemicals
23 GW_{th} power
14 GW_{th} synfuels

By region:
9 GW_{th} China
10 GW_{th} N America
19 GW_{th} W Europe
23 GW_{th} Rest of world

By feedstock:
27 GW_{th} coal
27 GW_{th} petroleum residuals
6 GW_{th} natural gas
1 GW_{th} biomass




Vision for modernised coal
Feedstocks
Coal
Heavy oils
Petroleum residuals
Biomass
Wastes
Natural gas
Gasification
(syngas generator)
POLYGENERATION
Near / Medium term
Energy Carriers
Electricity
Steam
Town gas
Methanol/gasoline blend
F-T/Diesel blend
DME
End uses
Industry
Transportation
Domestic
Tertiary
Agriculture
Infrastructure Requirements
Near / medium-term
Hydrocarbons
Medium / long- term
DME
Long-term
Hydrogen
Energy Carriers
Electricity
Steam
Hydrogen
DME
End uses
Industry
Transportation
Domestic
Tertiary
Agriculture
Long term


Making Synthetic Fuels from Coal via Gasification
"Once through" + electricity or "Recycle" – fuels only
coal
Coal Preparation
water
Gasification
oxygen
ASU
air
Gas Cooling & Cleanup
Water Gas Shift
H_2S, CO_2 Removal
Synthesis
Separation
Liquid Fuel
unconverted synthesis gas
process electricity
Power Island
Export Electricity
coal
Coal Preparation
water
Gasification
oxygen
ASU
air
Gas Cooling & Cleanup
Water Gas Shift
H_2S, CO_2 Removal
unconverted synthesis gas
Synthesis
Separation
Liquid Fuel
purge gas
process electricity
Power Island

Two technology scenarios

BASE TECHNOLOGIES

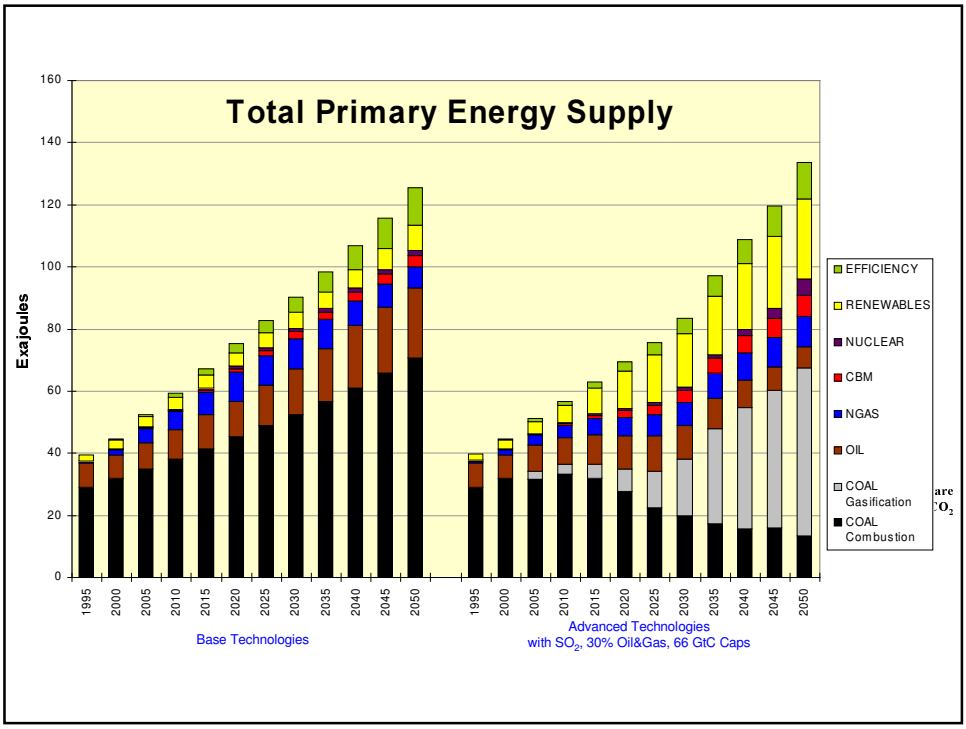
- **Coal used primarily by existing or advanced direct combustion technologies**
- **Energy end-use technologies include current best energy-efficient options**
- **Renewable energy technology limited to those currently commercial**
- **Carbon sequestration options are not available**
- **Technologies already available**

ADVANCED TECHNOLOGIES

- **Advanced polygeneration technologies based on gasification of coal and biomass**
- **Advanced high-efficiency industrial processes**
- **Advanced renewable energy technologies**
- **Urban residential demand technologies**
- **Hybrid electric and fuel-cell vehicles**
- **Carbon capture and sequestration options**
- **Available starting 2005-2015**

Constraints in the Advanced Technology Scenario

- Security of supply**: Imports of oil and gas are limited to 30% of consumption of oil and gas over the long-term**
- Environmental Protection**: SO_2 emissions are reduced from 23.7 Mt in 1996 to 16.2 Mt in 2020 and 8.8 Mt in 2050**
- Climate change: **Carbon emissions are limited to 66 Gt C (=stabilisation of atm. at 450 ppmv and a year-2000 population-based apportioning of globally allowed carbon emissions)**



Conclusions

- **Advanced technologies strategies offer the opportunity for meeting near-term environmental and energy security goals at lower costs than with a "business-as usual" approach**
- **They also provide a lower-cost path to deep reduction in CO_2 emissions**
- **Modernisation of coal based on gasification and polygeneration is a large and necessary component of such strategies needed to satisfy the "3E" for China's sustainable development: Economic Development, Energy Security and Environmental Protection**
- **Coal gasification can be used to produce synthetic gas for power, clean fuels for transportation and cooking, domestic and industrial heat to replace coal combustion and oil imports**
- **High end-use efficiency and renewable resources also play an important role**
- **These strategies are based on technologies that are mostly known and proven in China**

Further developments

The model was further applied to study the impact of:

- A 20-year delay in the introduction of coal and biomass gasification technology to produce liquid and gas fuels
- A low-efficiency, high energy growth scenario
- A 2x oil price shock

In the future, it will be interesting to:

- Observe the impact of the proposed strategy in China on the world energy scenario (world model incl. China region)
- Break down the strategy by provinces (the proposed aggregated China model); see effects on growth of West China
- Develop models at level of some cities (next priority for CCICED is sustainable urbanisation

References

- **"Transforming Coal for Sustainability: A Strategy for China", Report by the Task Force on Energy Strategies and Technologies to the China Council for International Cooperation on Environment and Development, 1 September 2003**
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- **Eric Larson, "Synthetic Fuel Production from Indirect Coal Liquefaction" ibid.**
- **Zhou Dadi "Energy Policy in China in Coming 20 years", ibid.**
- **Thomas B. Johansson, "Energy for Sustainability: a Broad Strategy for China" ibid.**
- **Robert H. Williams and Eric Larson "A Compsrison of Direct and Indirect Liquefaction Technologies for Making Fluid Fuels from Coal" ibid.**