An Assessment of the Power- Generation Sector of China

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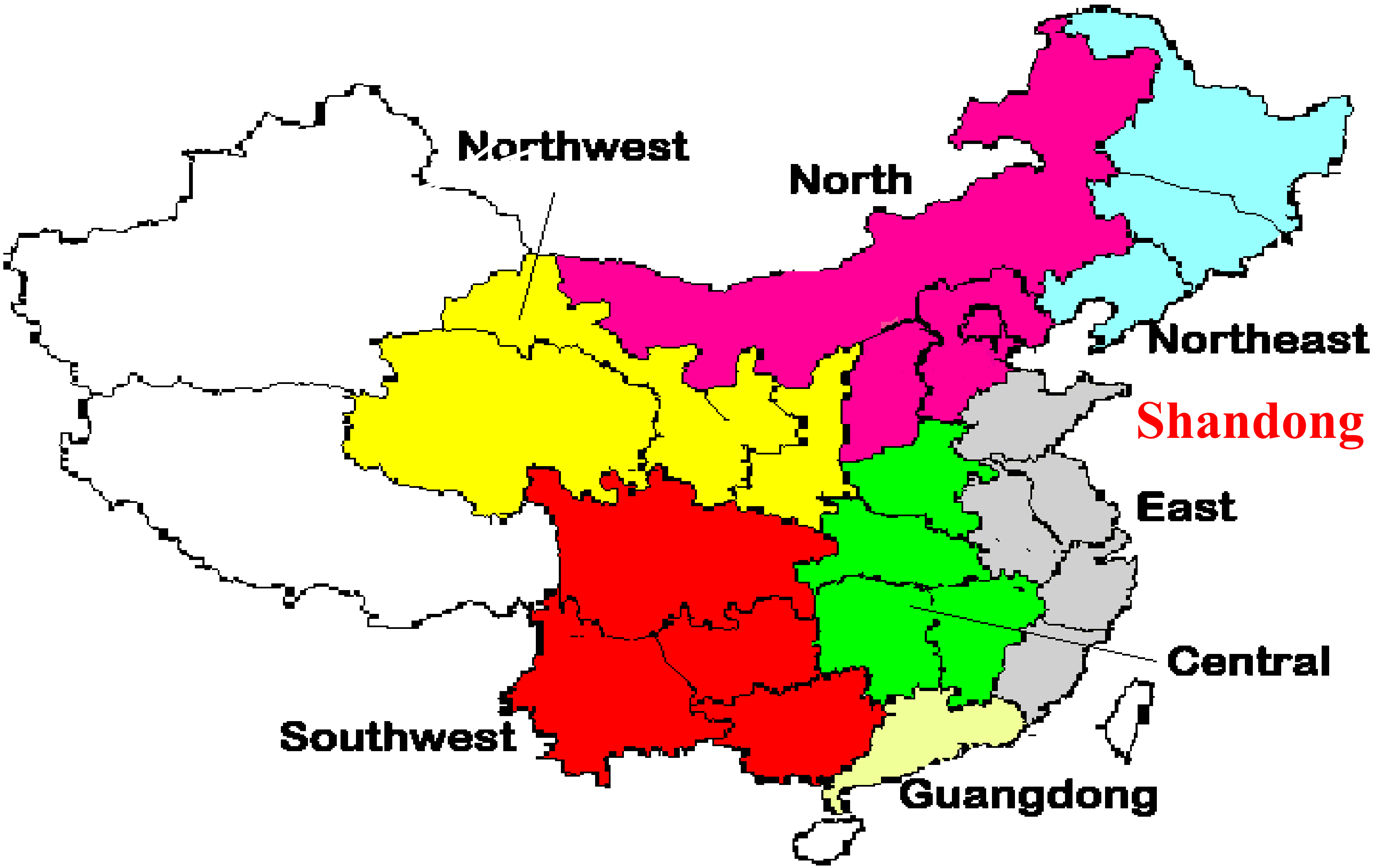
International Energy Agency (IEA/AIE) Annex IX Technical Conference Energy Models Users' Group: Global and Regional Energy Modelling.

April 4-7, 2005, Taipei, Taiwan

Paul Scherrer Institut, Switzerland



CHINA and SHANDONG

Three Attributes Define our Scenarios

- **Technology:**
  Present-day Coal and Advanced Technologies:
  - **Coal (Supercritical, IGCC, PFB)**
  - **Gas CC**
  - **Nuclear**
  - **Renewable Energy (Hydro, Wind, Solar PV)**

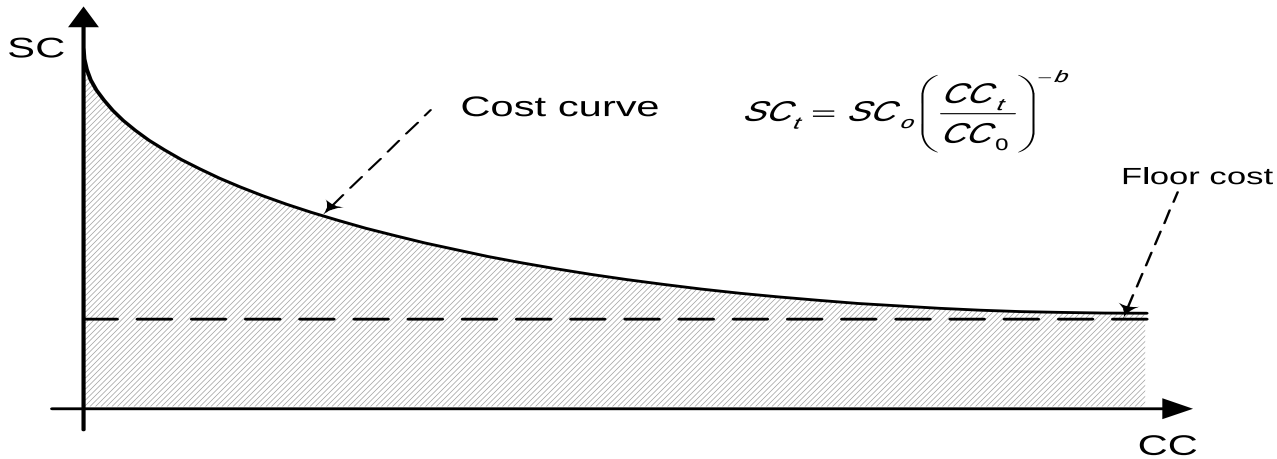
- **Economy:**
  - **- Fuel Prices (Nominal-High, N/H);**
  - **- Demand (Low-Medium-High, L/M/H);**
  - **- Discount Rate (Low-Medium-High, L/M/H);**

- **Environment (caps or taxes):**
  - **- Sulphur Constraints (Caps or Taxes, S);**
  - **- Carbon Constraints (Caps or Taxes, C);**
  - **- EMI = C + S (Caps or Taxes on S and C).**

and two methodological variants:

- **Learning by doing and**
- **Partial equilibrium**

Graphical illustration of learning curves



Partial equilibrium:

Qt is the demand for power generation; p_t is the price of electricity; GDP represents income; α and ε are the income and price elasticity respectively

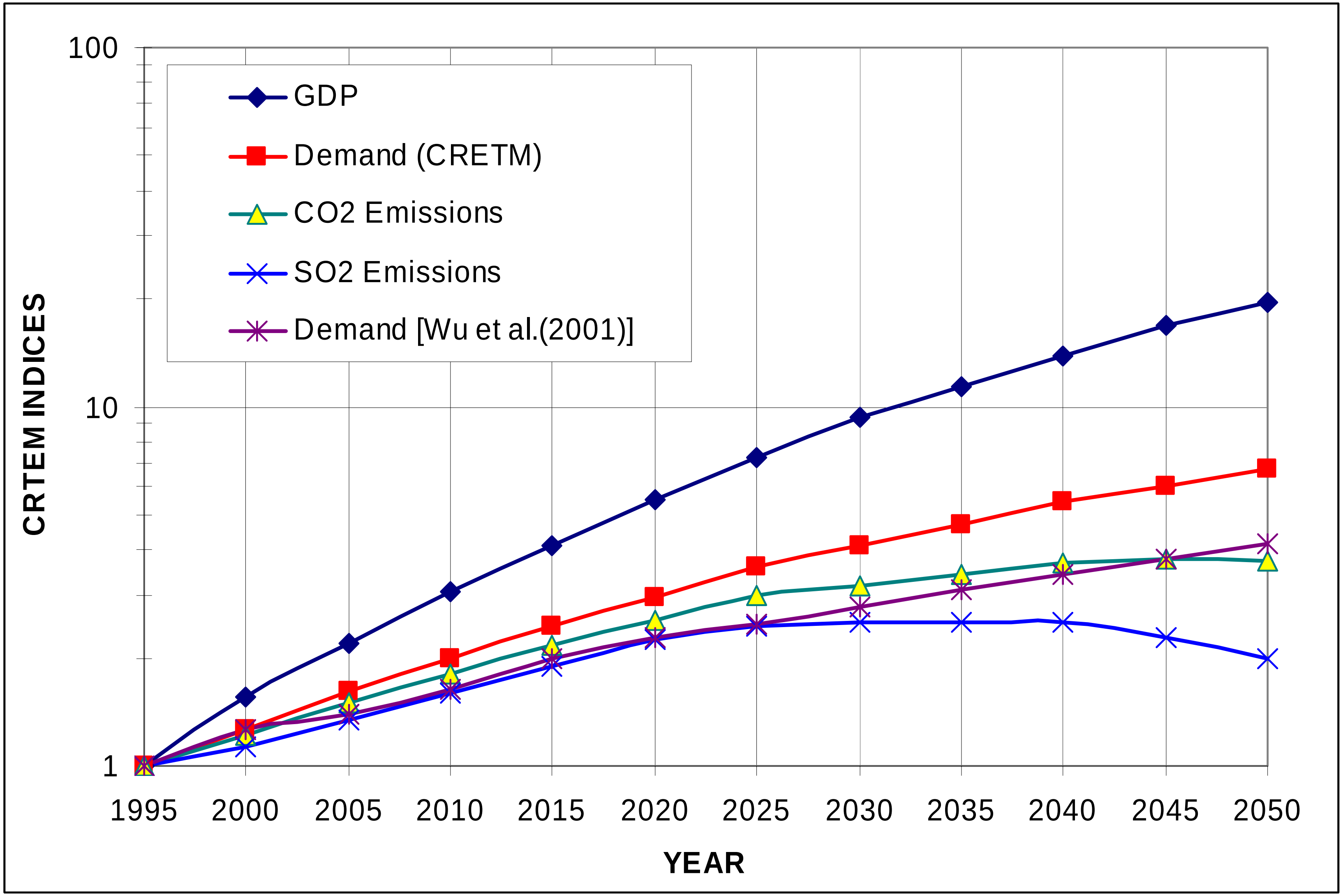
$$\frac{Q_t}{Q_0} = \left(\frac{p_t}{p_0} \right)^{-\varepsilon} \cdot \left(\frac{GDP_t}{GDP_0} \right)^{a}$$

Countrywide and Regionalized SO2, NOX, and PM10 Emission Rates and per-tonne External Costs for the Seven CRETM Regions

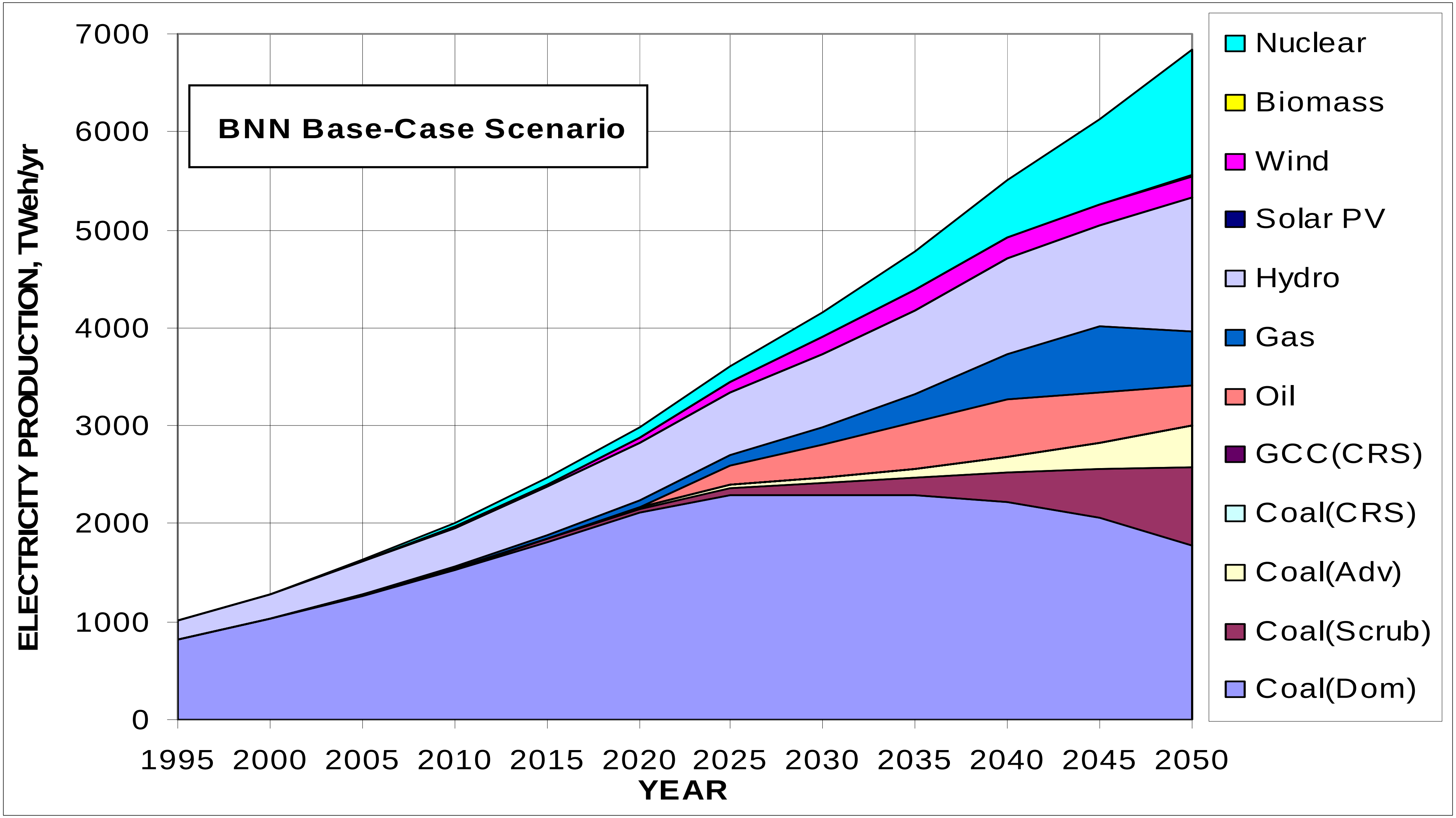
Region (Table I)	Population 1000 persons	Area 1000 km^3	Density persons/km^3	Factor relative to Shandong	External Costs, \$/tonne, Scaled with Population Density		
					NO_X	SO_2	PM
NO	139910	1572.2	89.0	0.1610	737.0	1135.9	810.0
NE	103850	757.2	172.8	0.3126	1431.3	2205.8	1572.9
EA	268180	638.5	439.9	0.7957	3643.4	5615.1	4003.9
SA[a]	80000	153.0	552.9	1.0000	4579	7057	5032
SC	333990	1007.0	331.7	0.5999	2747.0	4233.6	3018.8
SW	190630	2317.8	82.3	0.1488	681.2	1049.9	748.6
NW	86070	3140.3	27.4	0.0496	227.0	349.9	249.5
Total	1202630	9586.0	125.5				

[a] Shandong province serves as the reference (Hirschberg, 2003).

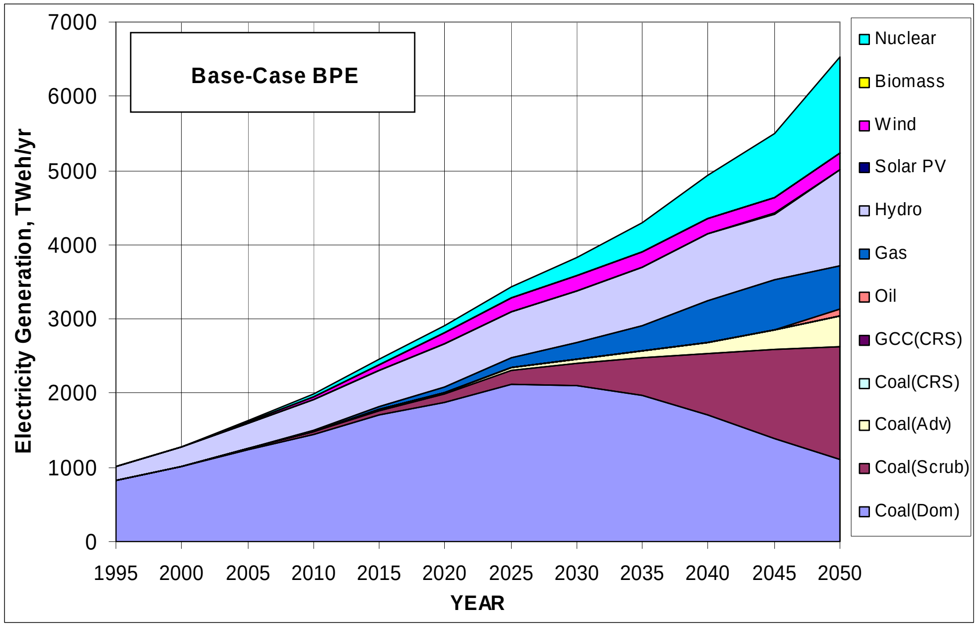
Time-dependence of GDP, electricity demand, and emission rates indexed to the base-year 1995

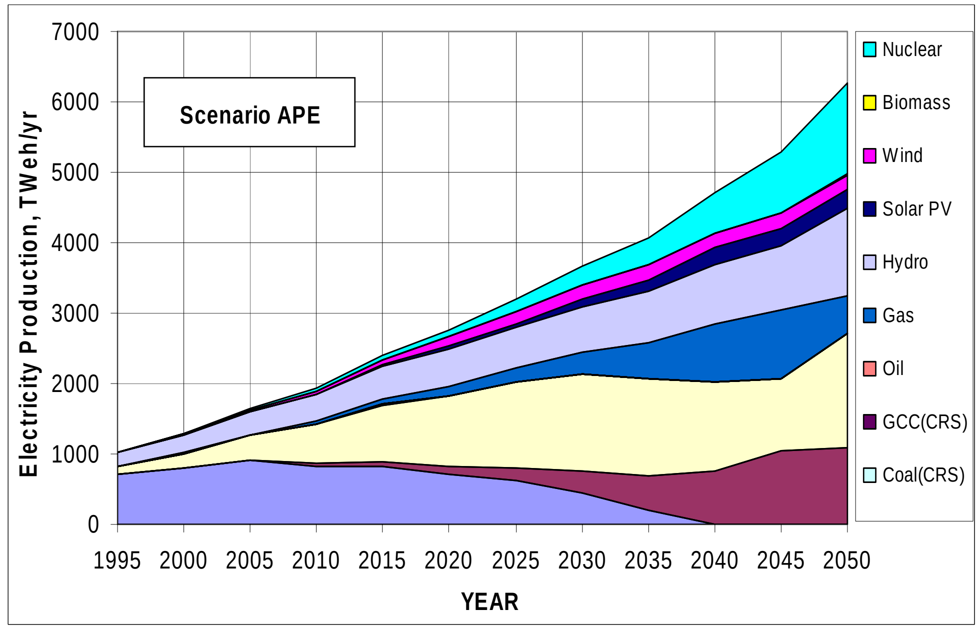


Generation by Technology BNN case; Baseline with present policy



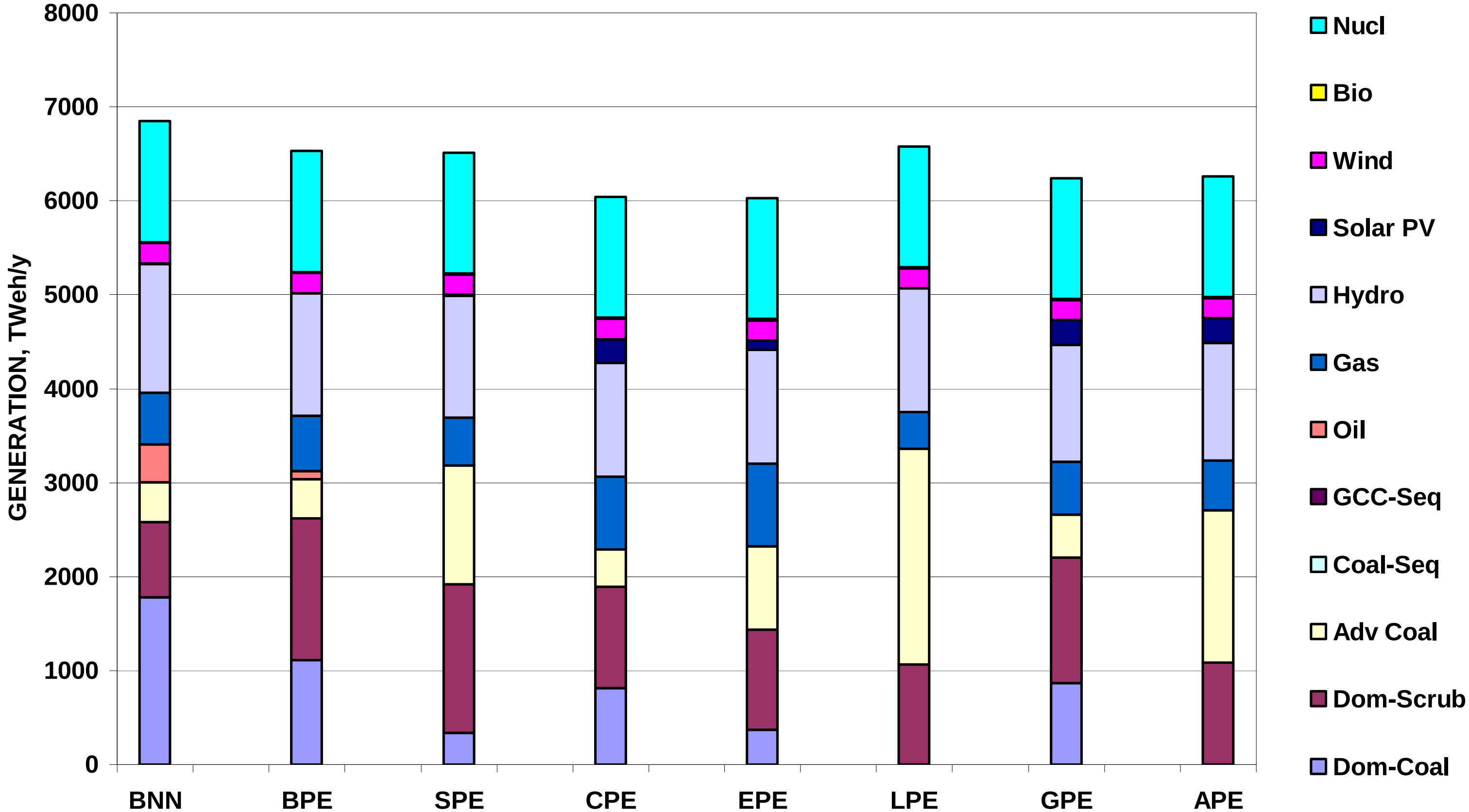
Electricity generation mix without externalities (BPE) and with all externalities charged (APE);





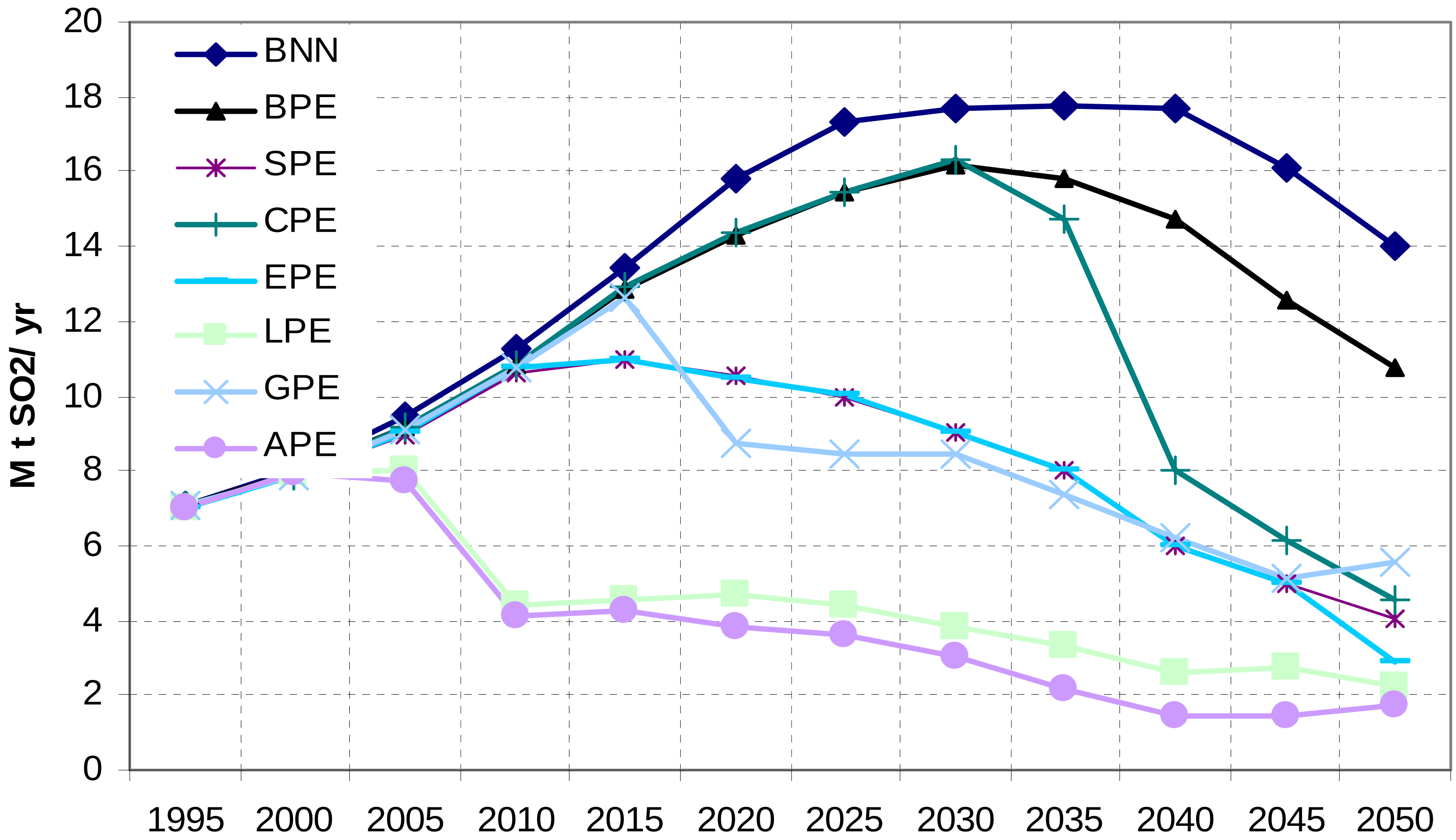
Electricity -generation becomes more diversified when externalities are internalized

Electricity generation mix in 2050; All Cases with learning and partial equilibrium

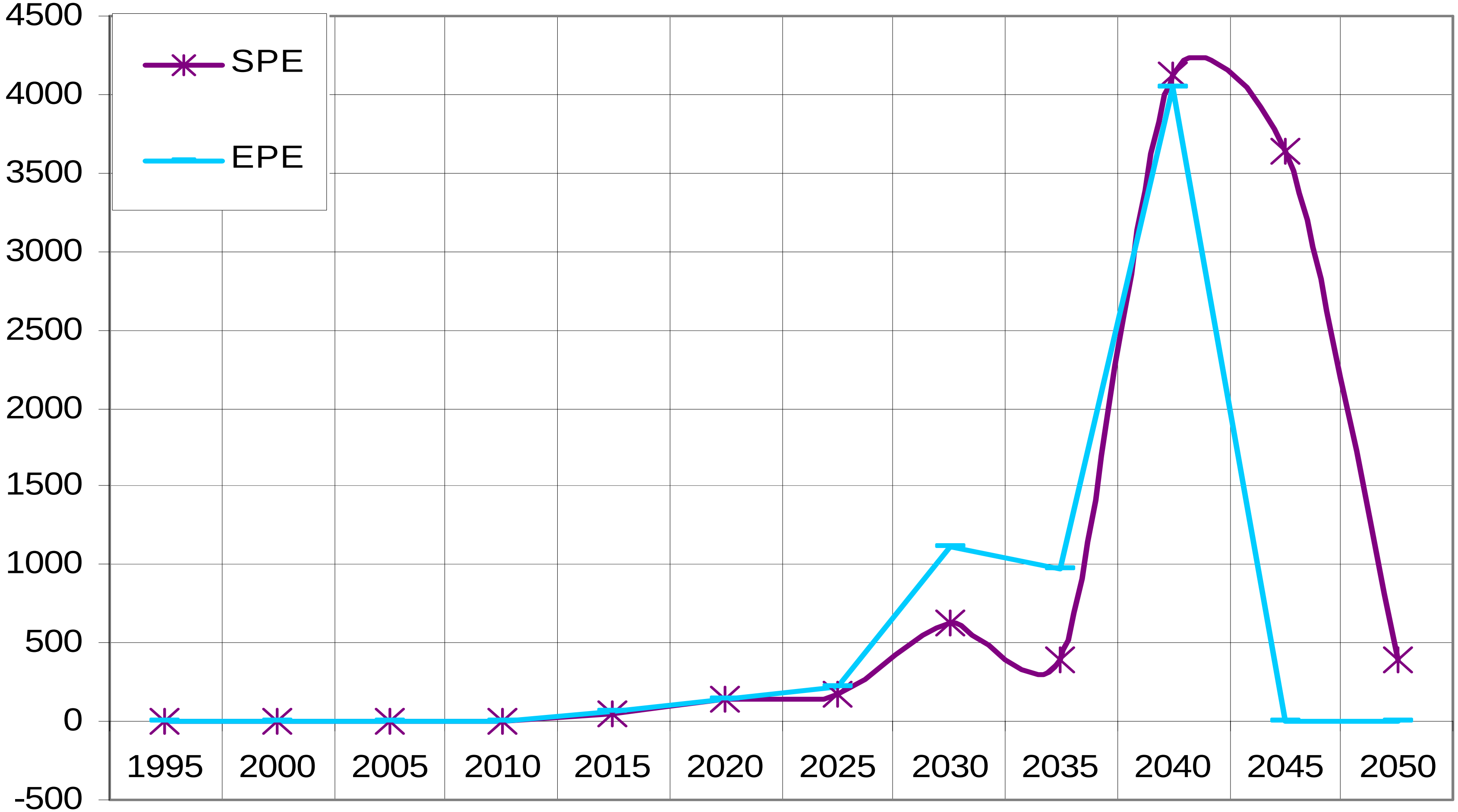


Electricity -generation becomes diversified when externalities are internalized

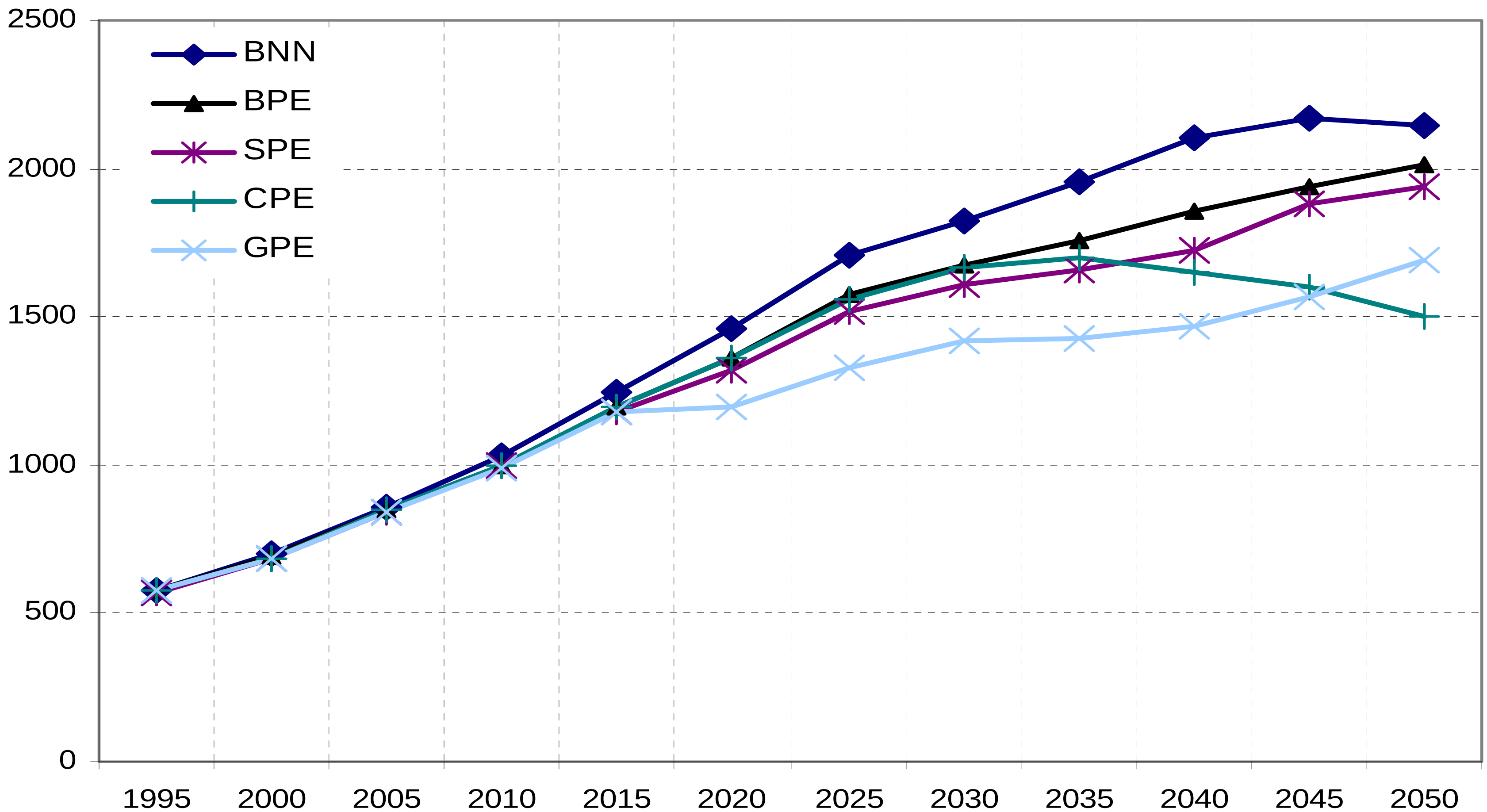
CRETM-CHINA; Sulphur Emissions (Mt SO2/yr)



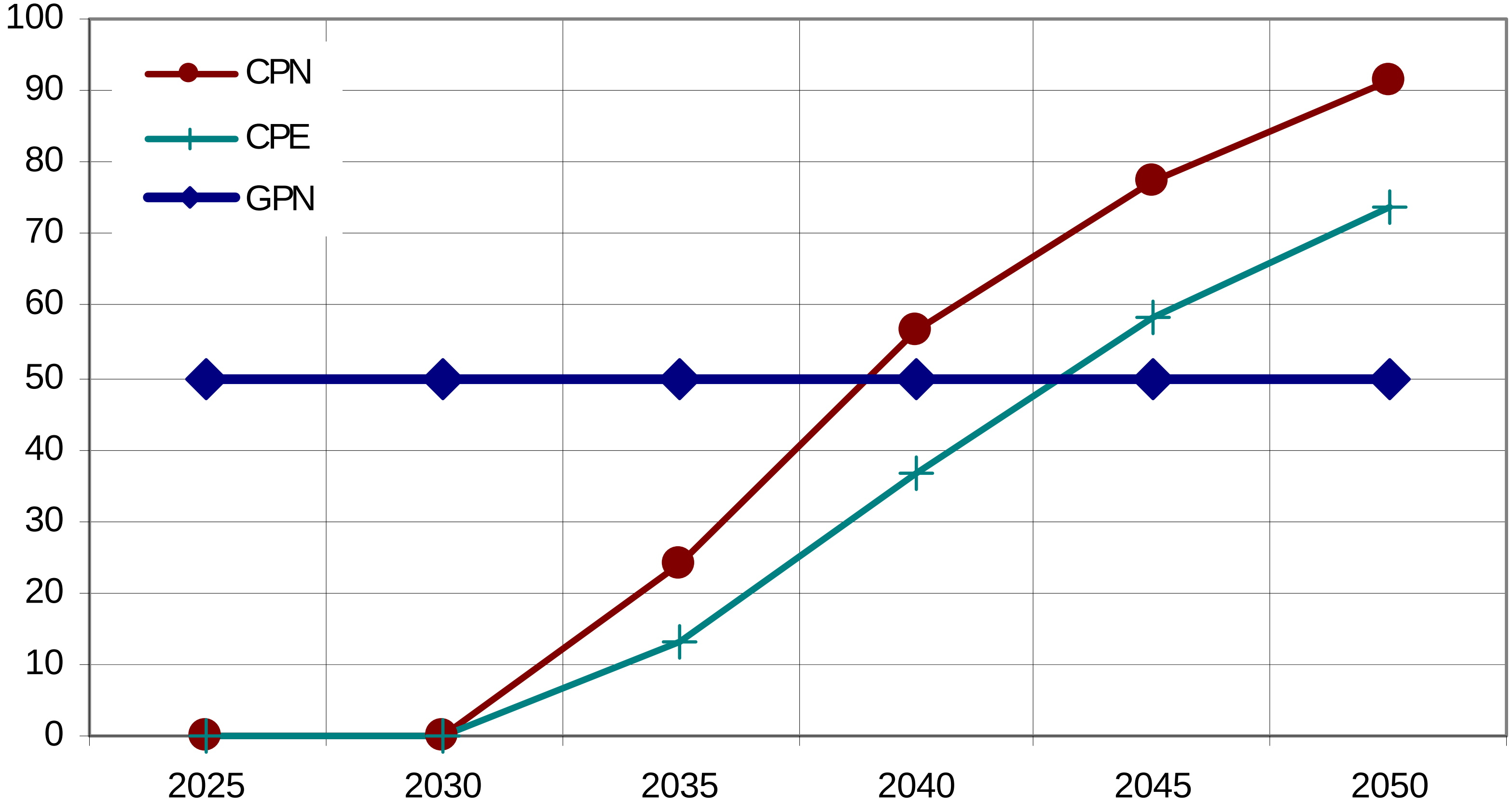
CRETM-CHINA;
SO2 marginal costs or taxes in US$ /tonne SO2



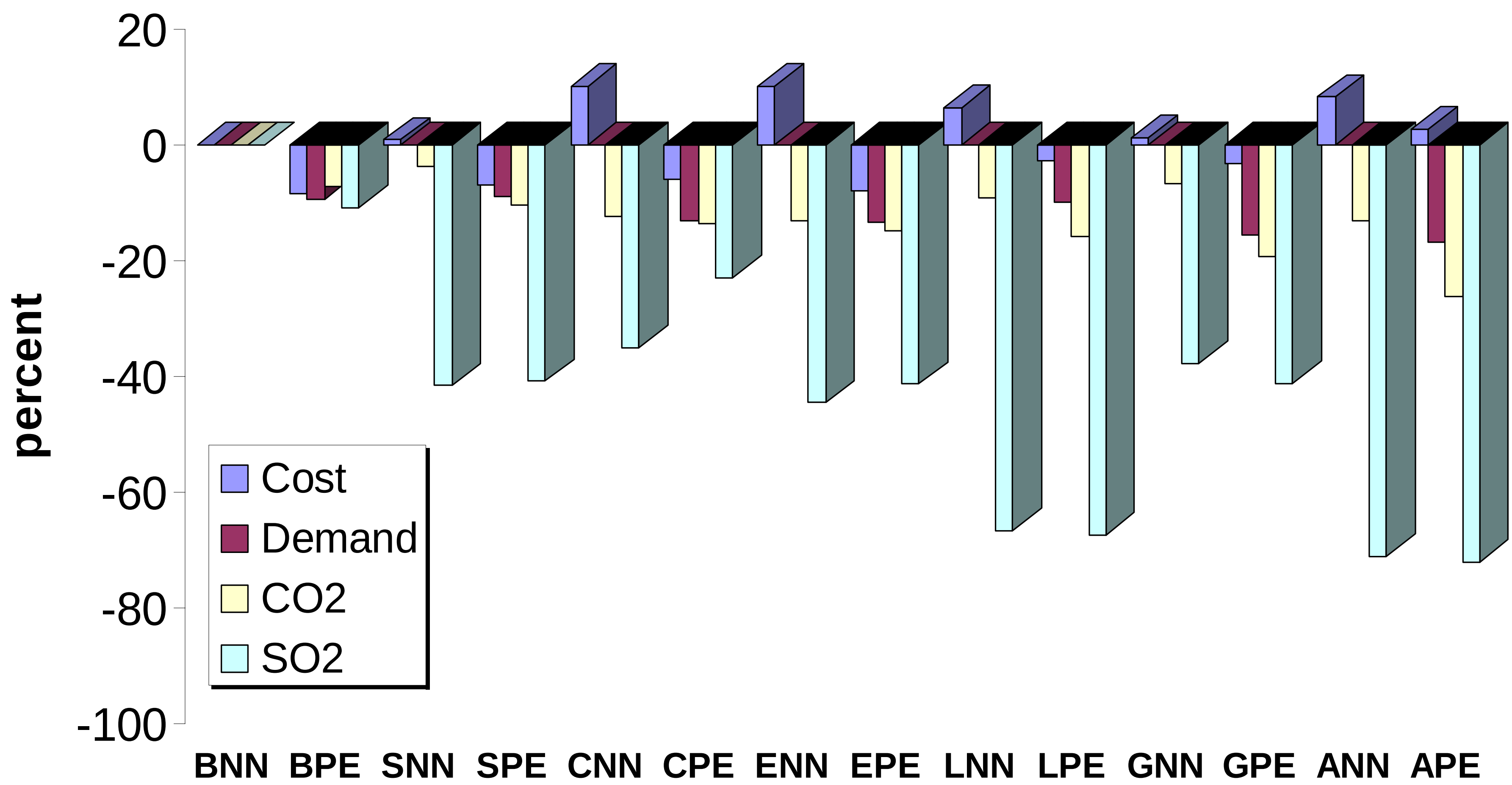
CRETM-CHINA
Carbon Emissions in Power Generation (MtC/yr)



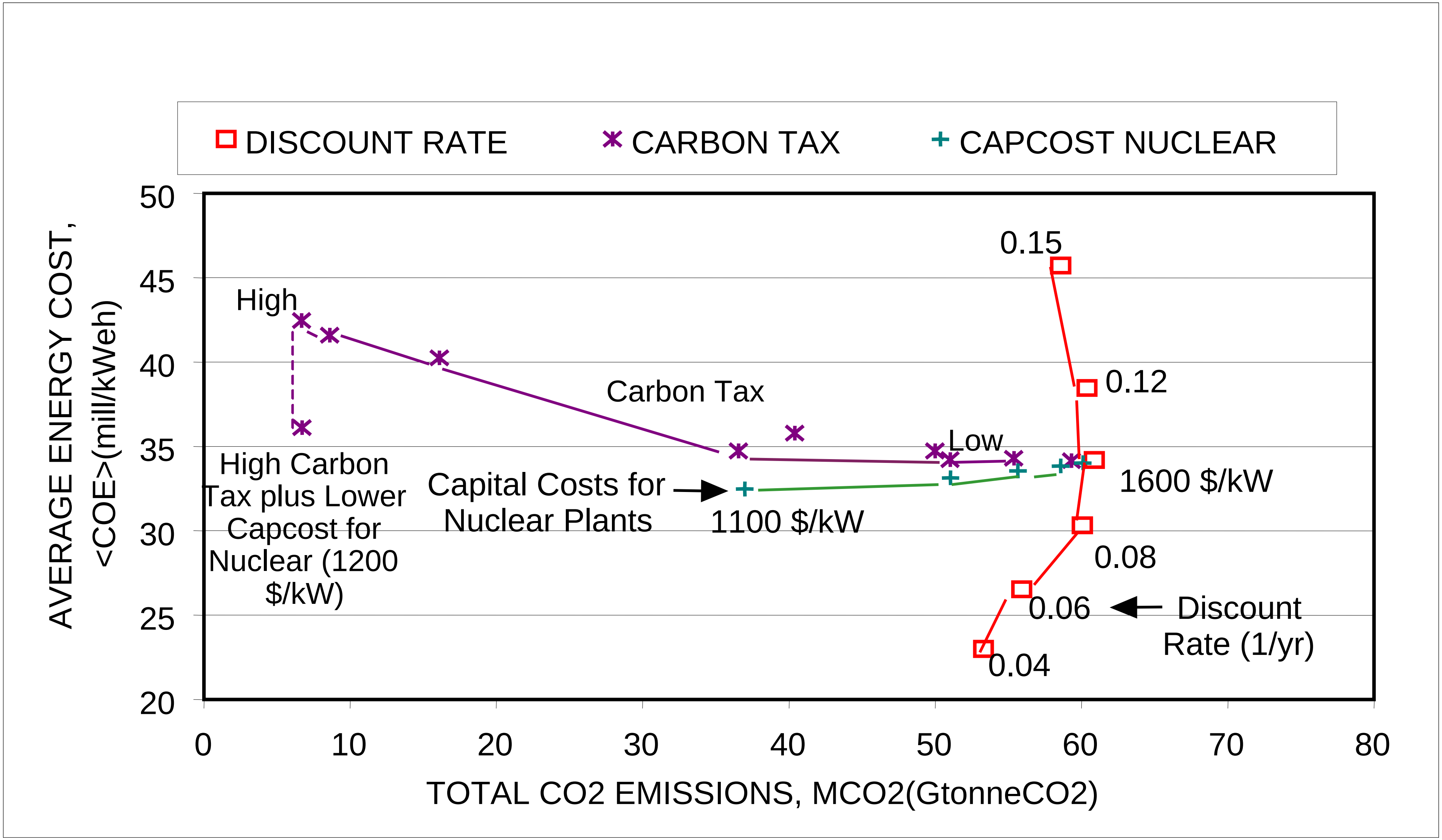
CO_2 marginal costs or taxes in US$ /tC



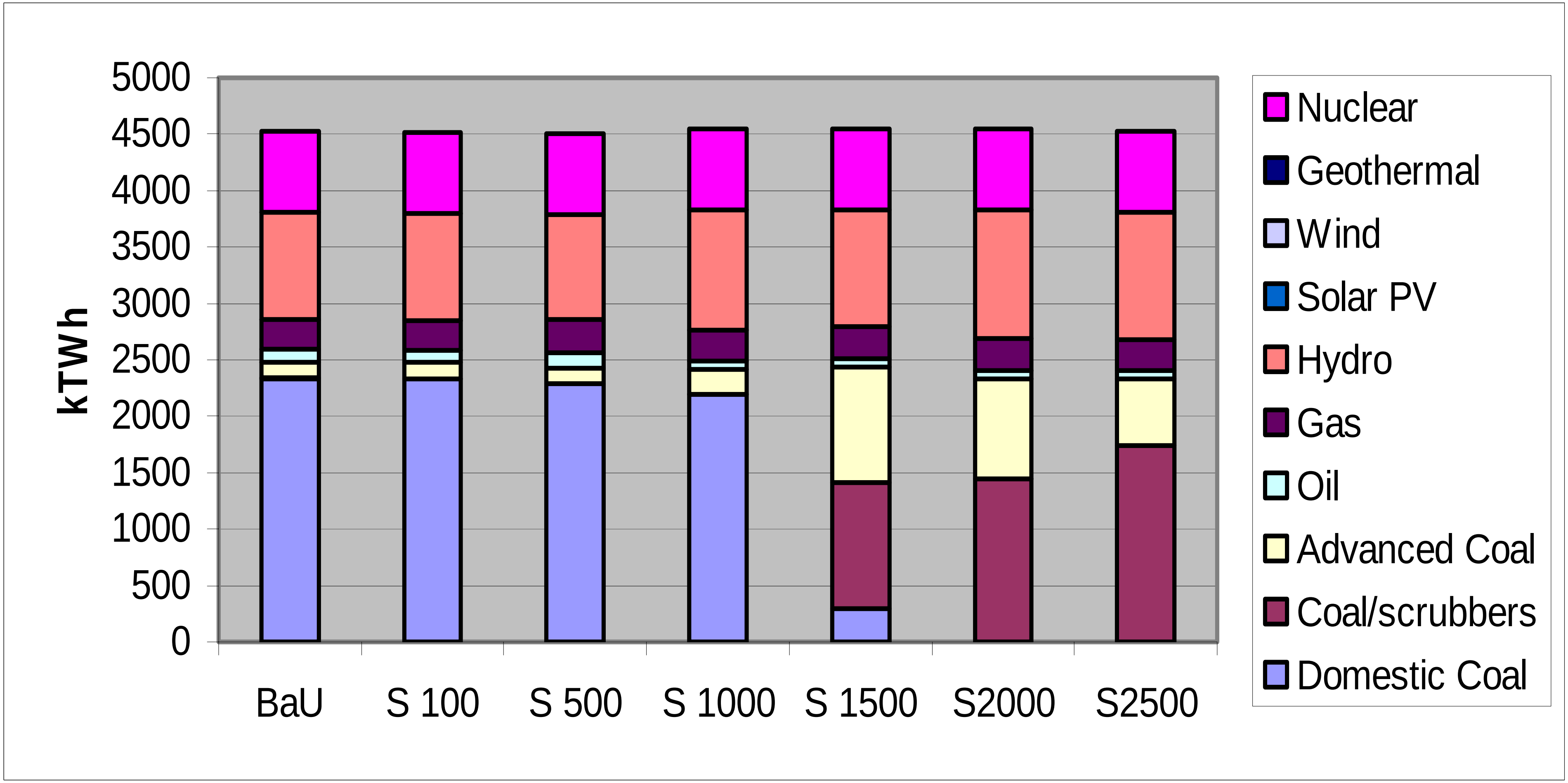
Cumulative reduction in Demand, CO2, SO2 and Cost relative to BNN



CRETM-Energy Cost Vs CO2 emissions in China



MARKAL-CHINA 2050: Electricity Production Vs SO2 Tax



Conclusions

Coal is King: China will rely always on coal for electricity production

RD&D for advanced generation technology can improve economics and the environment.

Sulfur Reductions Affordable: Pollution related to SO2 emissions can be reduced for moderate investments by introducing scrubbers and/or advanced-coal technology.

Carbon Reductions Not Cheap: Carbon-emission reduction will also improve local environments through reduced SO2 emissions, which is an important secondary benefit.

Generation Cost Increases but Demand Responds to Price Changes

Increased Power Demand: The demand for electrical power in China is projected to increase six-fold by 2050.

Conclusions-2

The best substitutes for coal are advanced gas combined cycle systems followed by nuclear energy, and renewable energy sources (e.g., wind and small hydro)

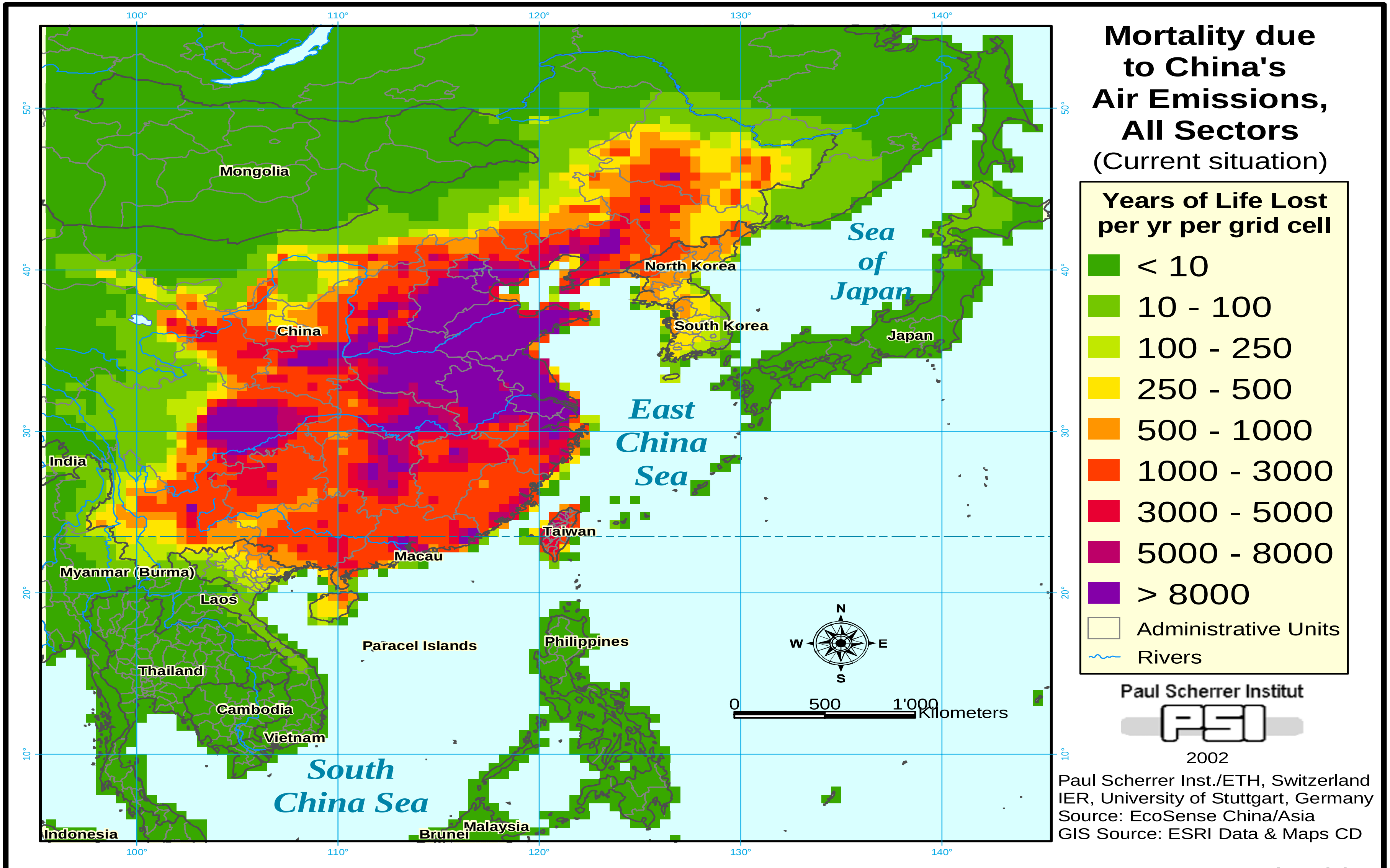
Pollution Costs Must be Reduced: Annual outdoor air pollution costs the Chinese economy anywhere from 6-7% of GDP (Hirschberg, 2003); RD&D support and international cooperation for technology diffusion can reduce the cost of pollution control significantly.

Nuclear* energy *can be competitive if

- reactors have a cost below 1,800 $/kW and construction time is below 5 years,
- or at higher capital cost when local or global externalities are addressed

Electricity transmission across regions makes economic sense and reduces local pollution.

Mortality in China - Emissions from all Sectors



Source: Hirschberg et al.

Proposal;

Link regional MARKAL models with ECOSENSE/RAINS to perform:

- *A gradual internalization of external cost and imposition of critical loads*
- *Map results and discuss costs and benefits with stakeholders*
- *Define a technology portfolio to address resource availability, costs and pollution issues in ASIA*
- *Identify benefits of cooperation in terms of resource management, environmental concerns and technology development*

Thanks for your attention