An Assessment of the Power- Generation Sector of China

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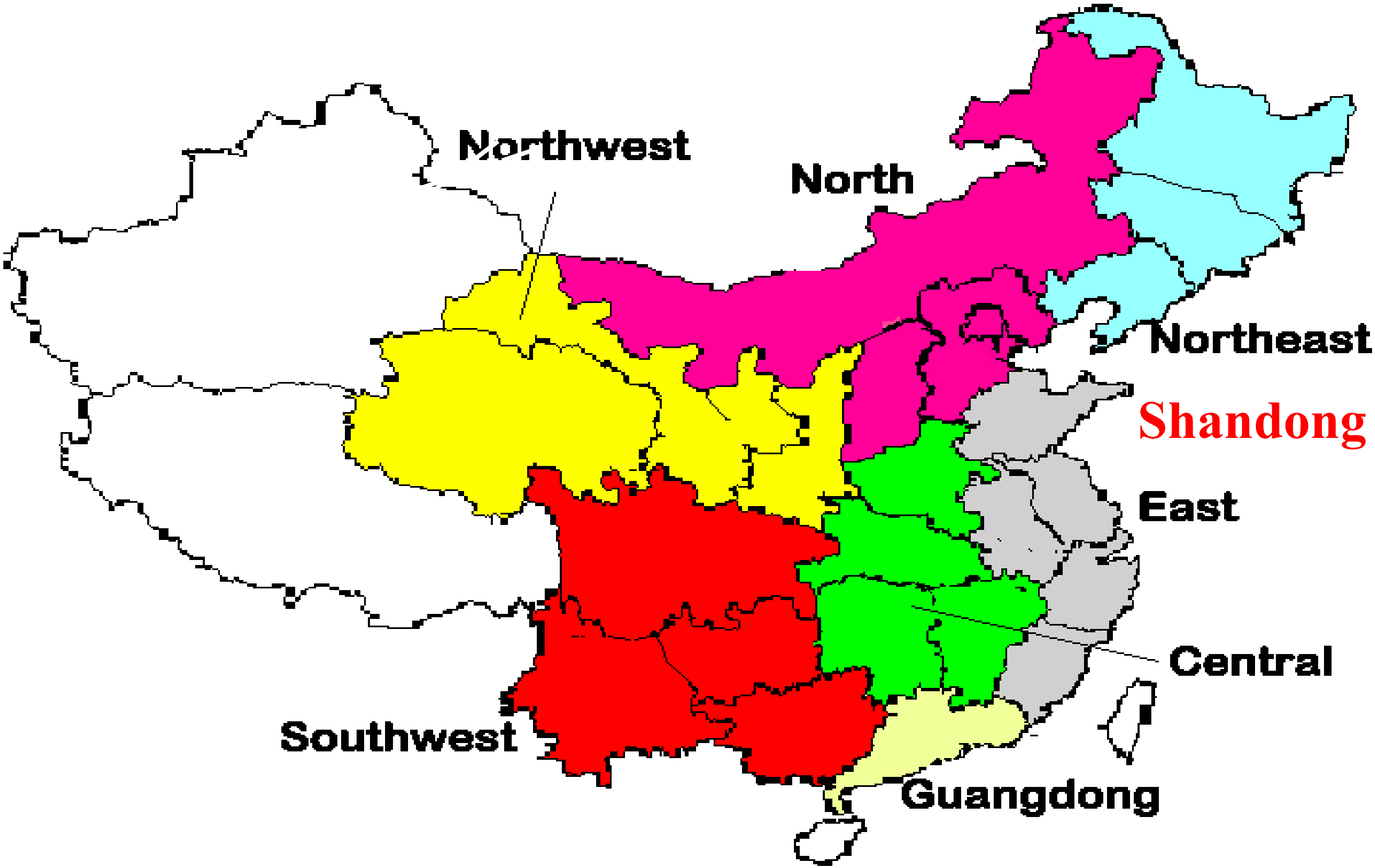


CHINA and SHANDONG

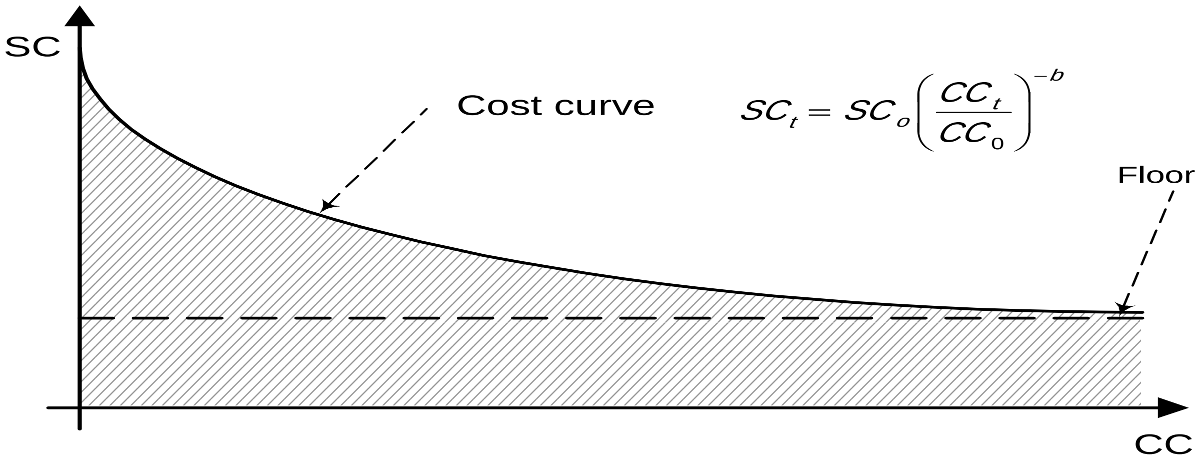
Three Attributes Define our Scenarios

- **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

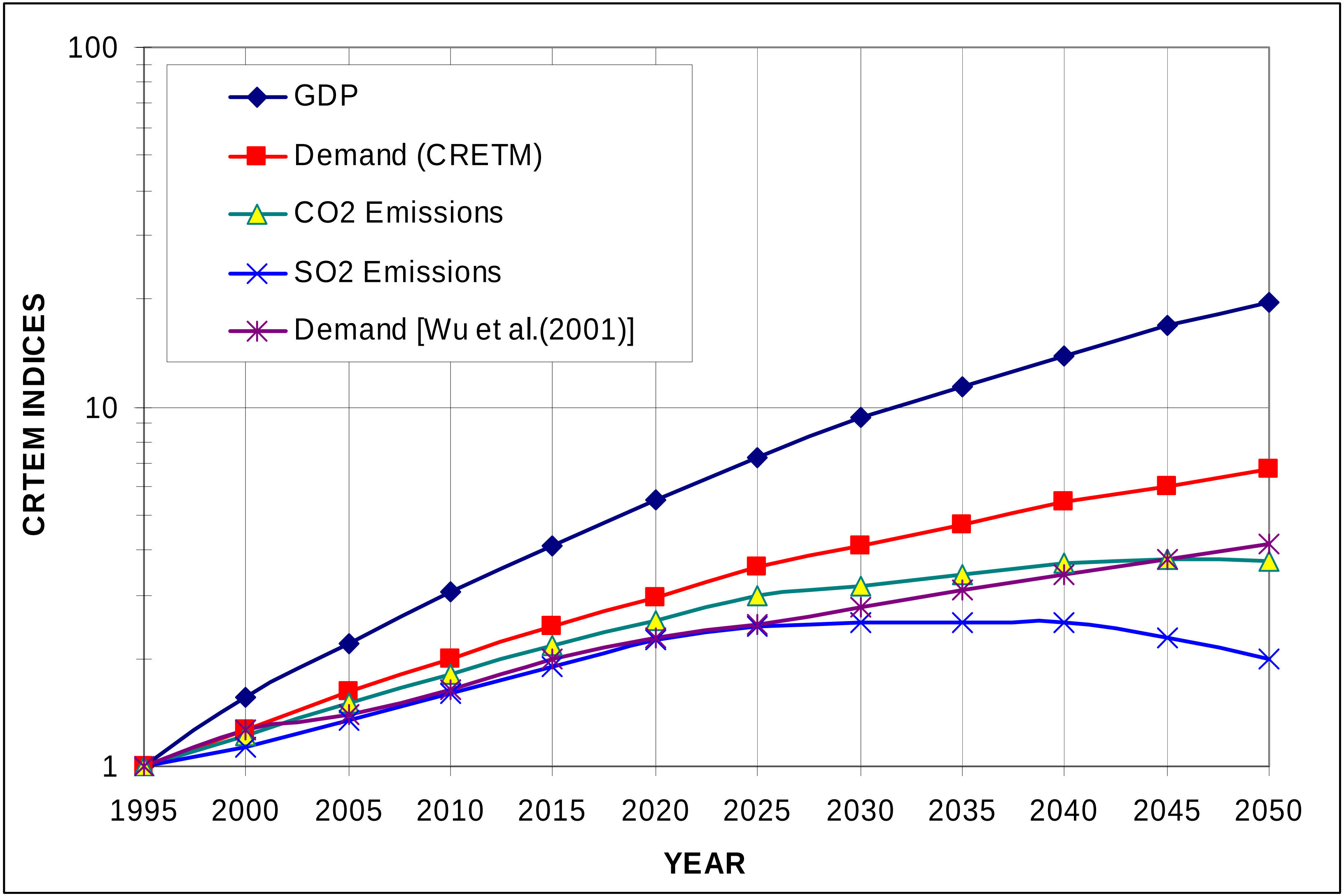
$$\frac{Q_t}{Q_0} = \left(\frac{p_t}{p_0}\right)^{-\varepsilon} \cdot \left(\frac{GDP_t}{GDP_0}\right)^{a}$$

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

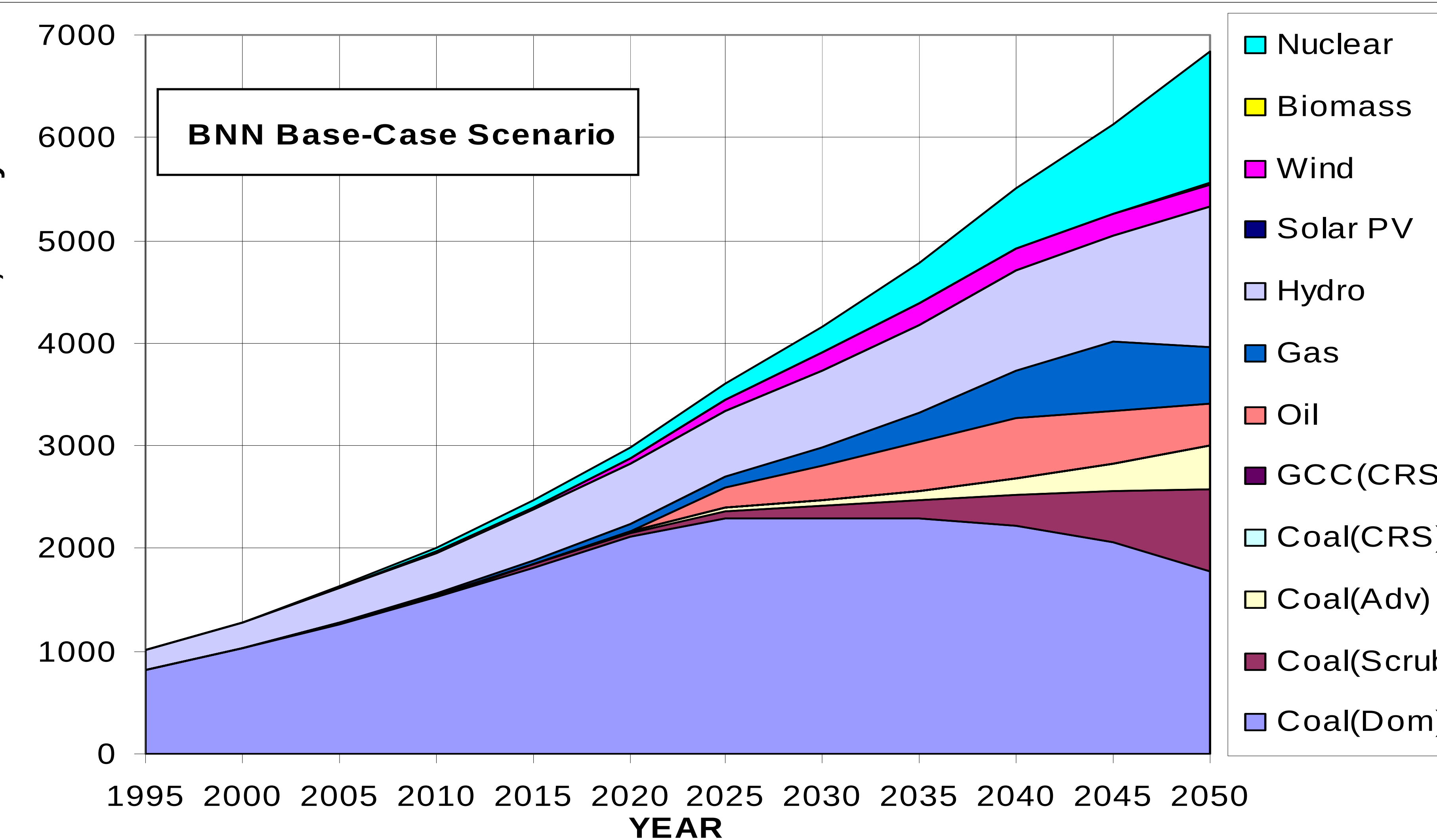
jion ble I)	Population 1000 persons	Area 1000 km^3	Density persons/km^3	Factor relative to Shandong	External Costs, $/tonne, Scaled with Population Density			
					NO_X	SO_2	PM	
O	139910	1572.2	89.0	0.1610	737.0	1135.9	810.0	
E	103850	757.2	172.8	0.3126	1431.3	2205.8	1572.9	
A	268180	638.5	439.9	0.7957	3643.4	5615.1	4003.9	
A [a]	80000	153.0	552.9	1.0000	4579	7057	5032	
C	333990	1007.0	331.7	0.5999	2747.0	4233.6	3018.8	
W	190630	2317.8	82.3	0.1488	681.2	1049.9	748.6	
W	86070	3140.3	27.4	0.0496	227.0	349.9	249.5	
tal	1202630	9586.0	125.5					

andong province serves as the reference (Hirschberg, 2003).

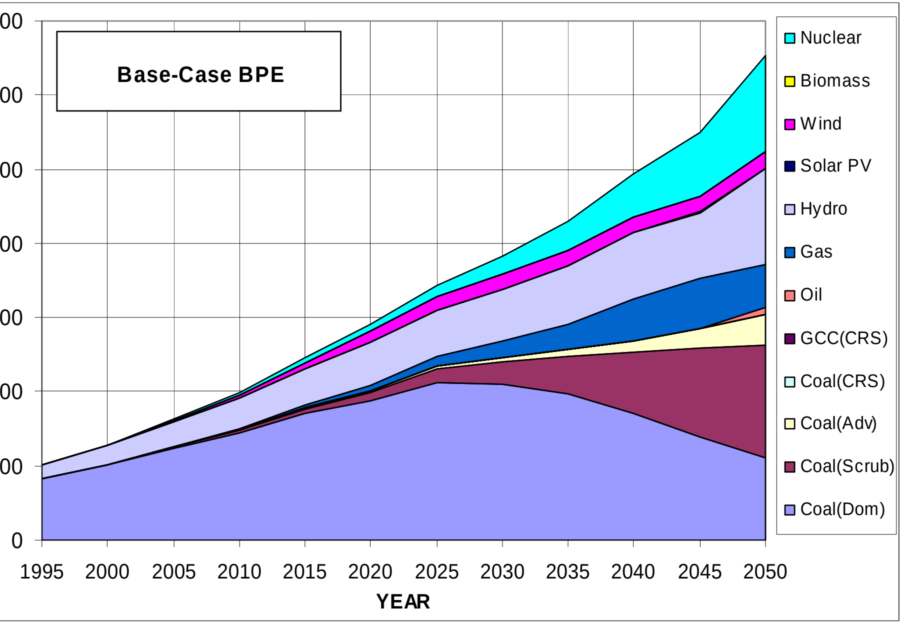
Time-dependence of GDP, electricity demand, and emission rates indexed to the base-year 1995

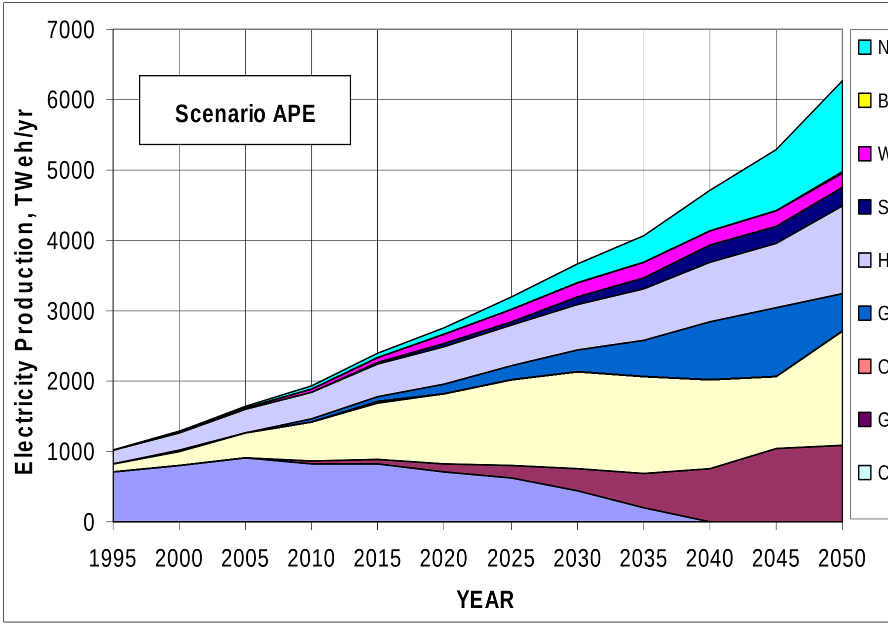


Generation by Technology BNN case; Baseline with present policy



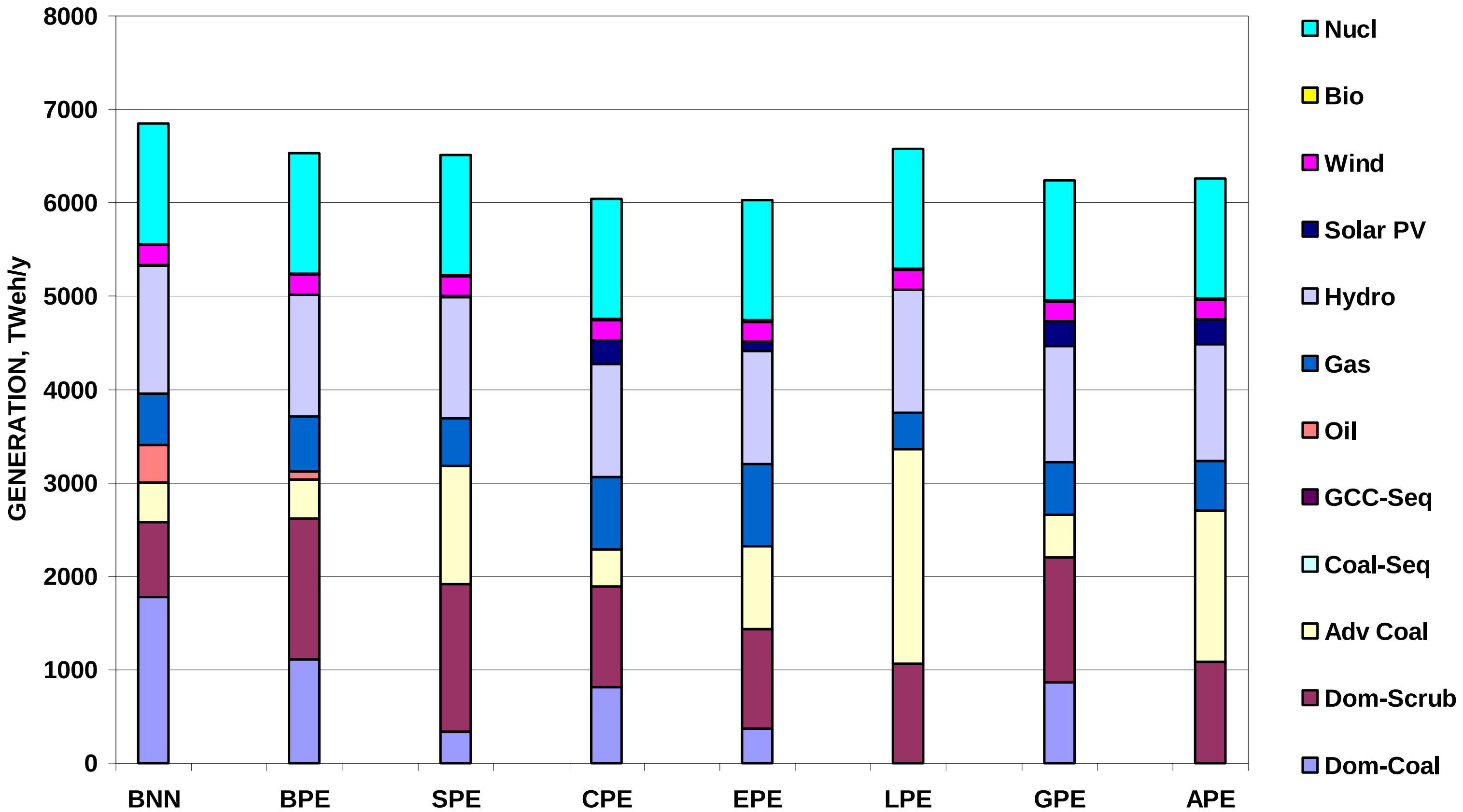
Electricity generation mix without externalities (BPE) and with all externalities charged (APE);





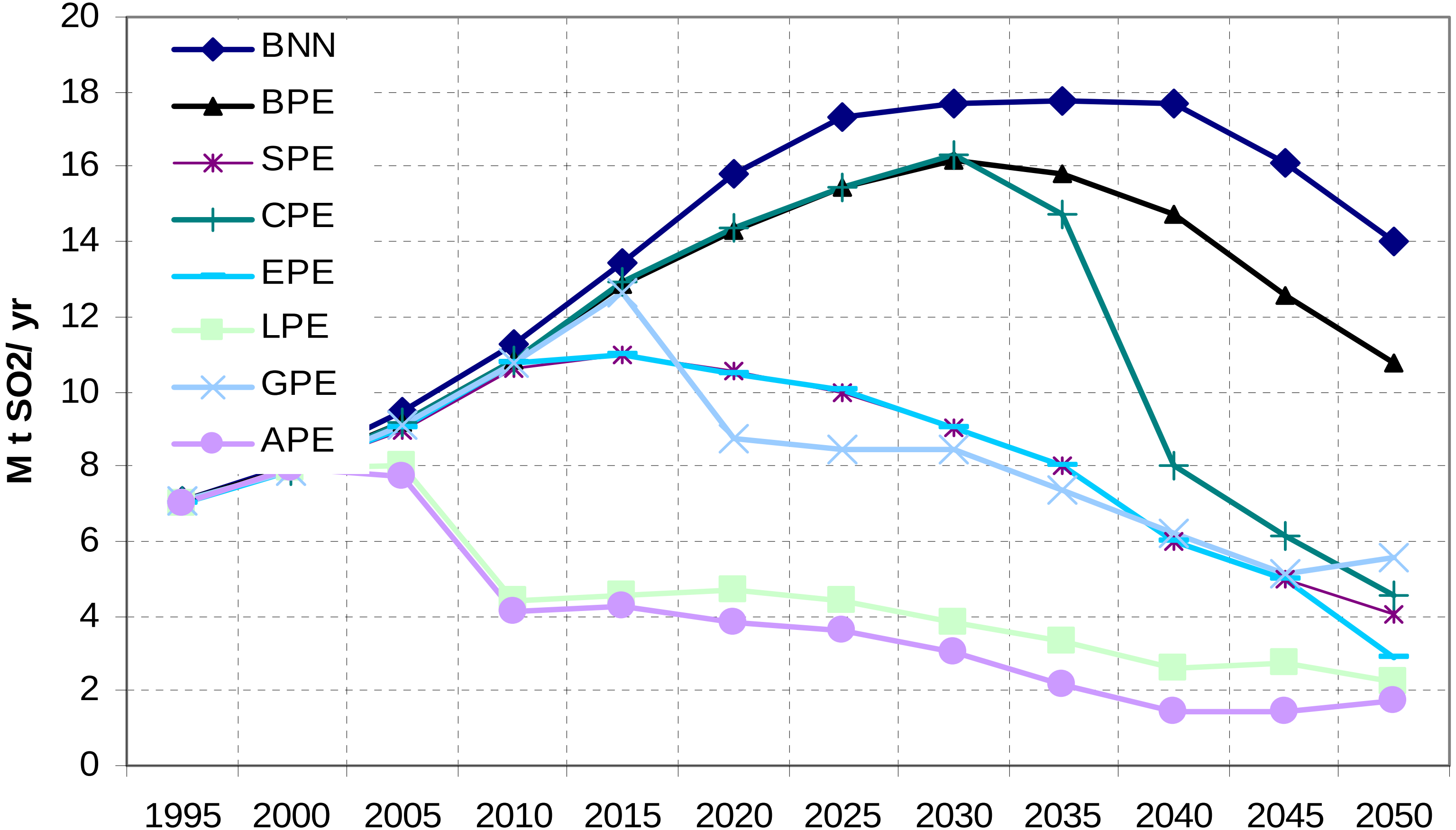
Electricity -generation becomes more diversified when externalities are internalized

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

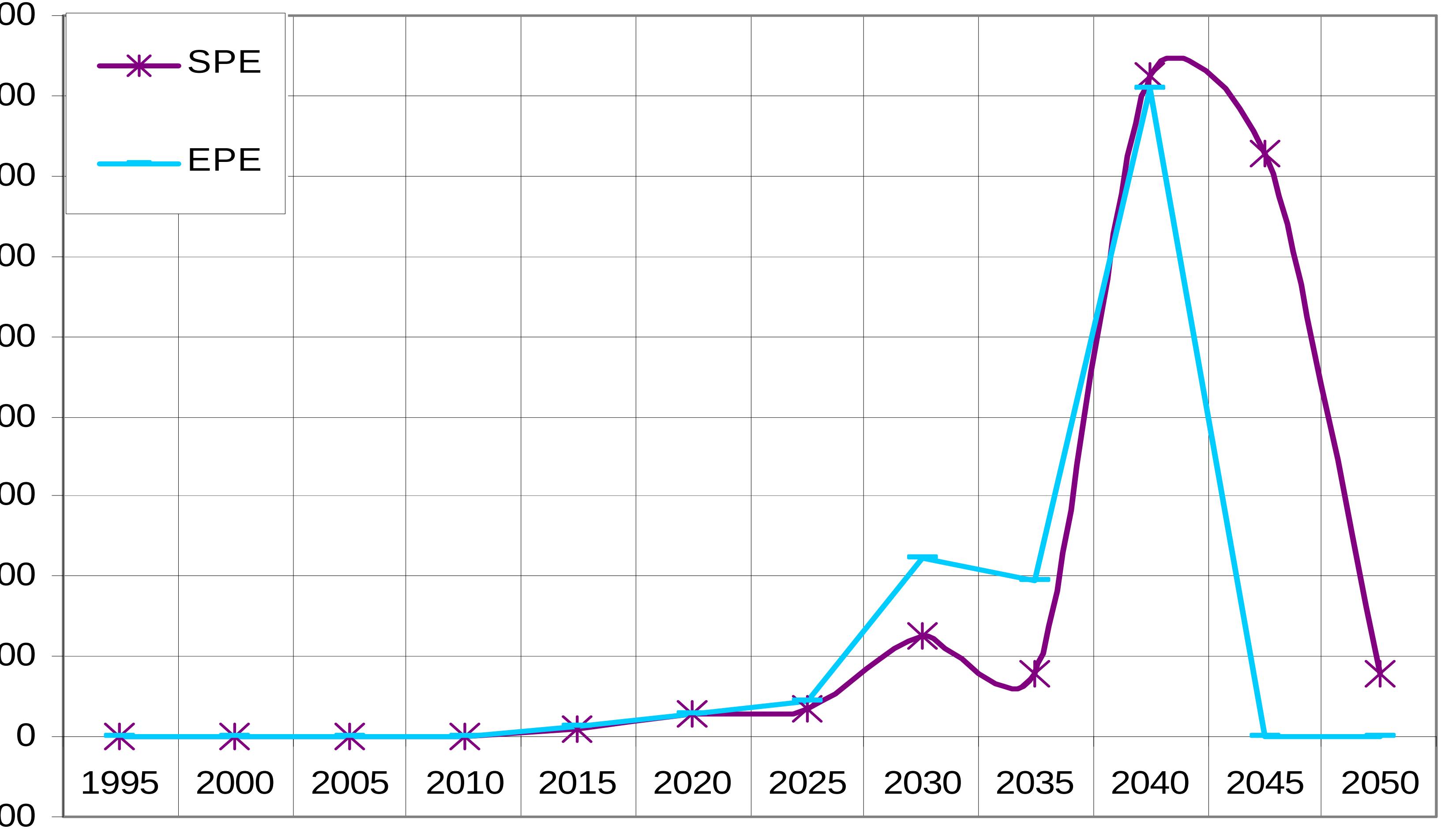


Electricity -generation becomes diversified when externalities are internalized

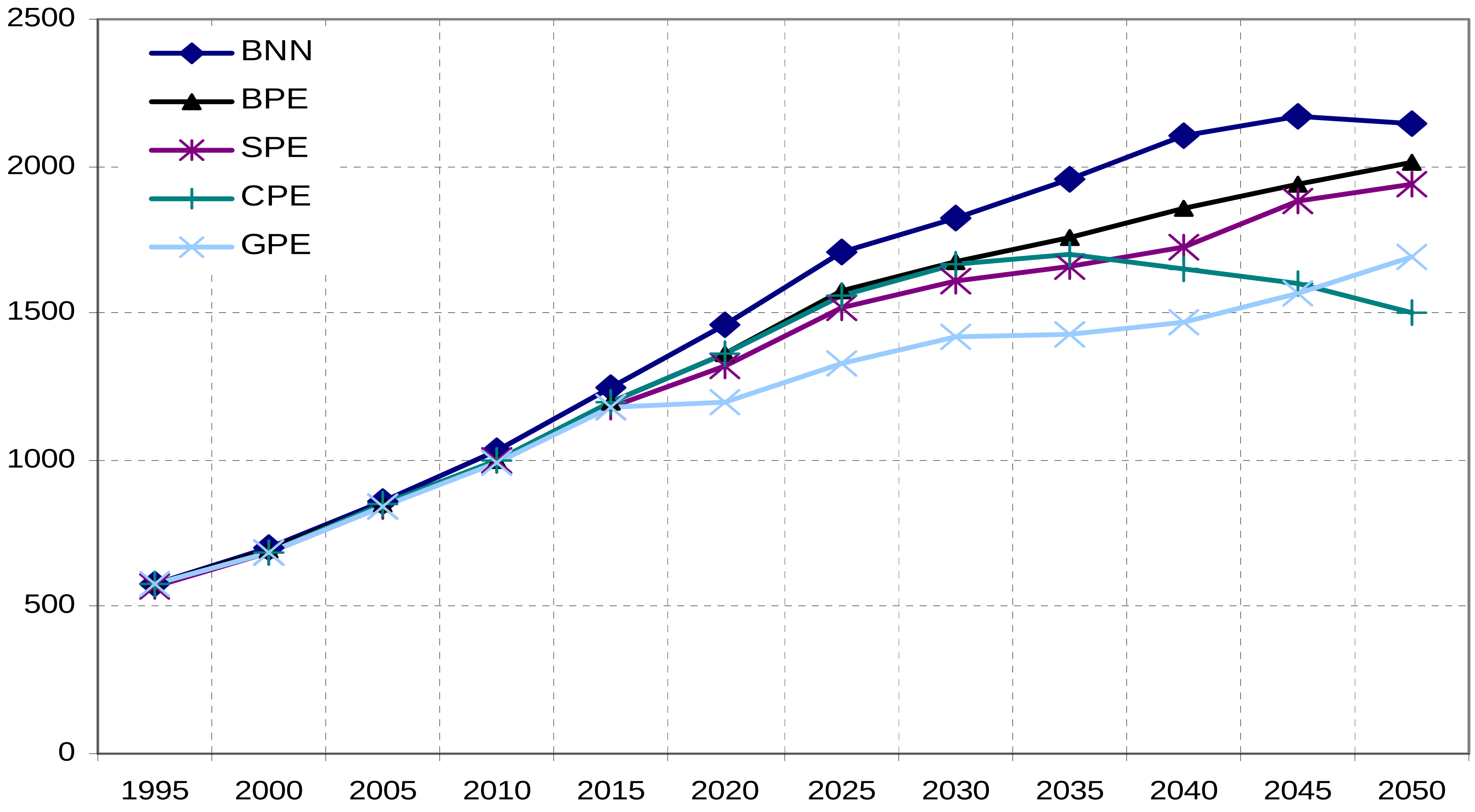
CRETM-CHINA; Sulphur Emissions (Mt SO2/yr)



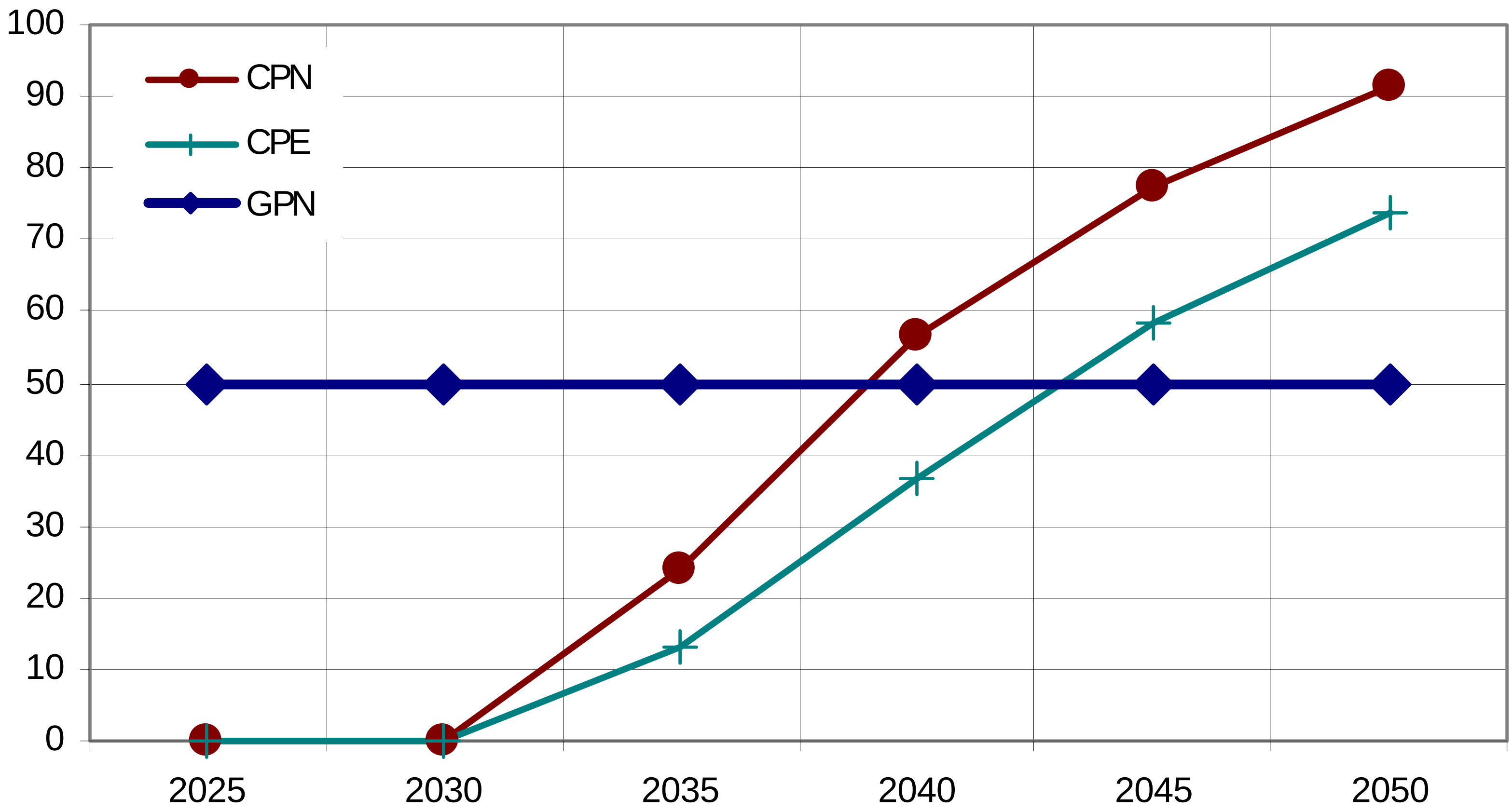
CRETM-CHINA;
SO2 marginal costs or taxes in US$ /tonne SO2



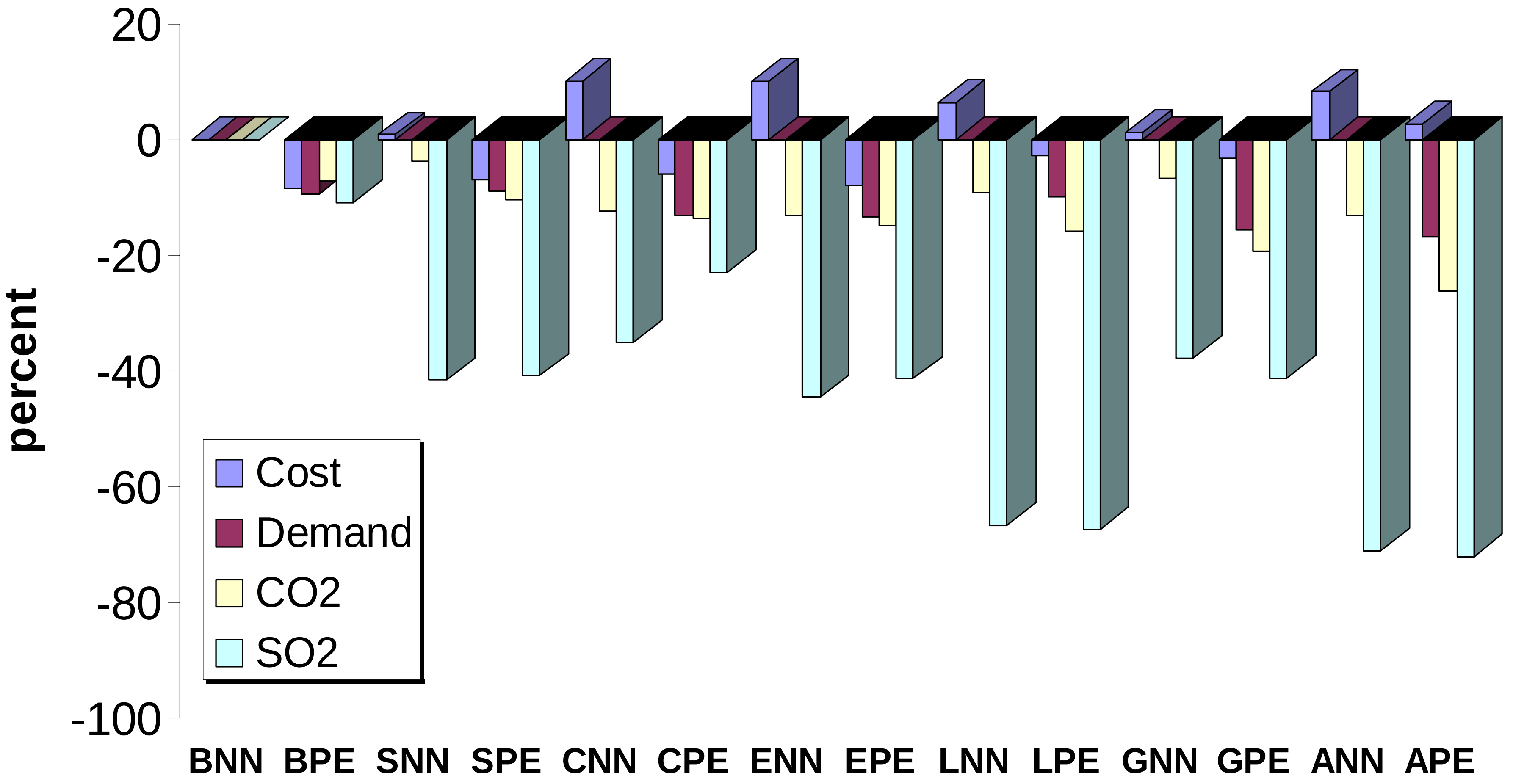
CRETM-CHINA
Carbon Emissions in Power Generation (MtC/yr)



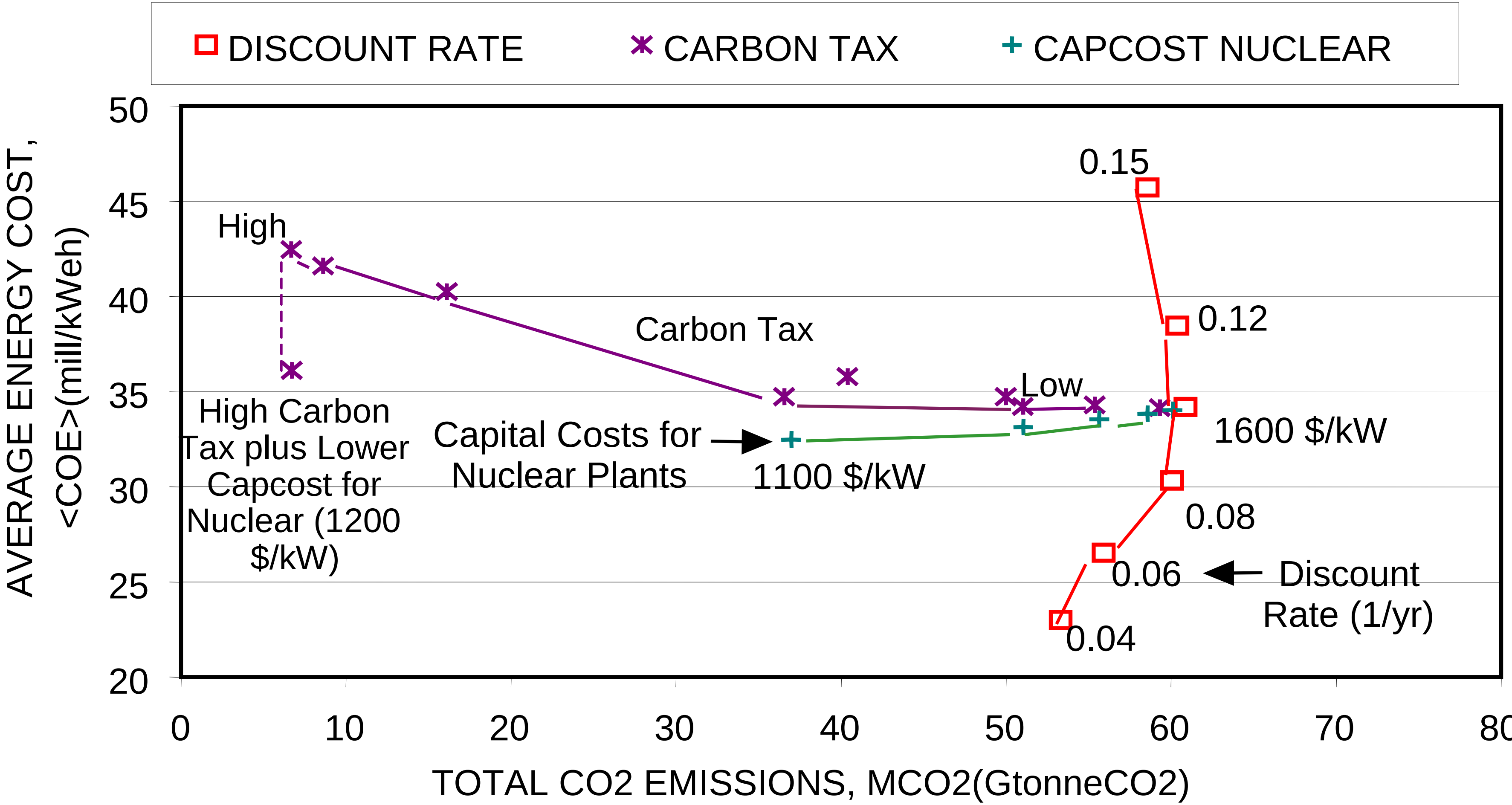
CO2 marginal costs or taxes in US$ /tC



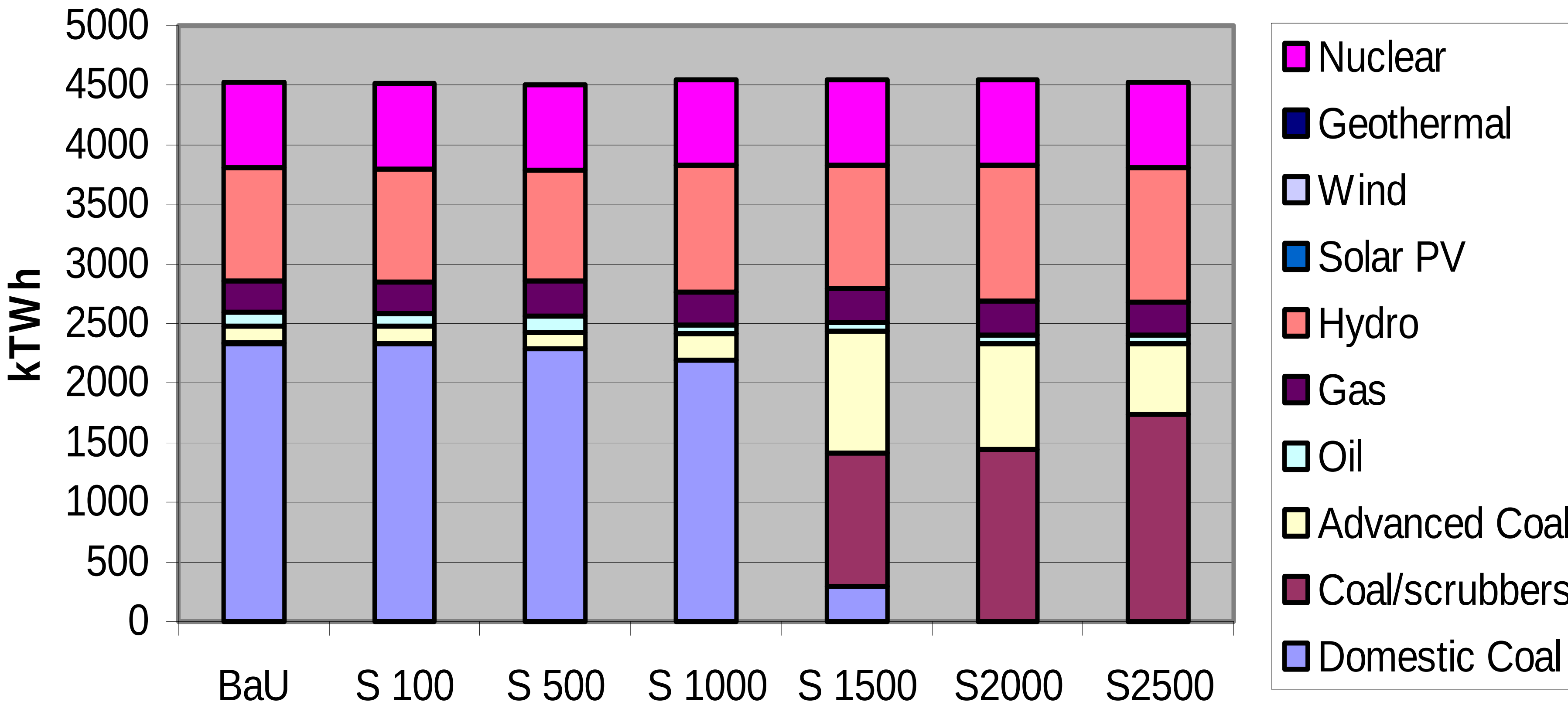
umulative reduction in Demand, CO2, SO2 and Cost relative to B



RETM-Energy Cost Vs CO2 emissions in Chi



MARKAL-CHINA 2050: Electricity Production Vs SO2 Tax



Conclusions

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

D&D for advanced generation technology can improve economics and the environm

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

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

eneration Cost Increases but Demand Responds to Price Changes

ncreased Power Demand: The demand for electrical power in China is projected crease six-fold by 2050.

Conclusions-2

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

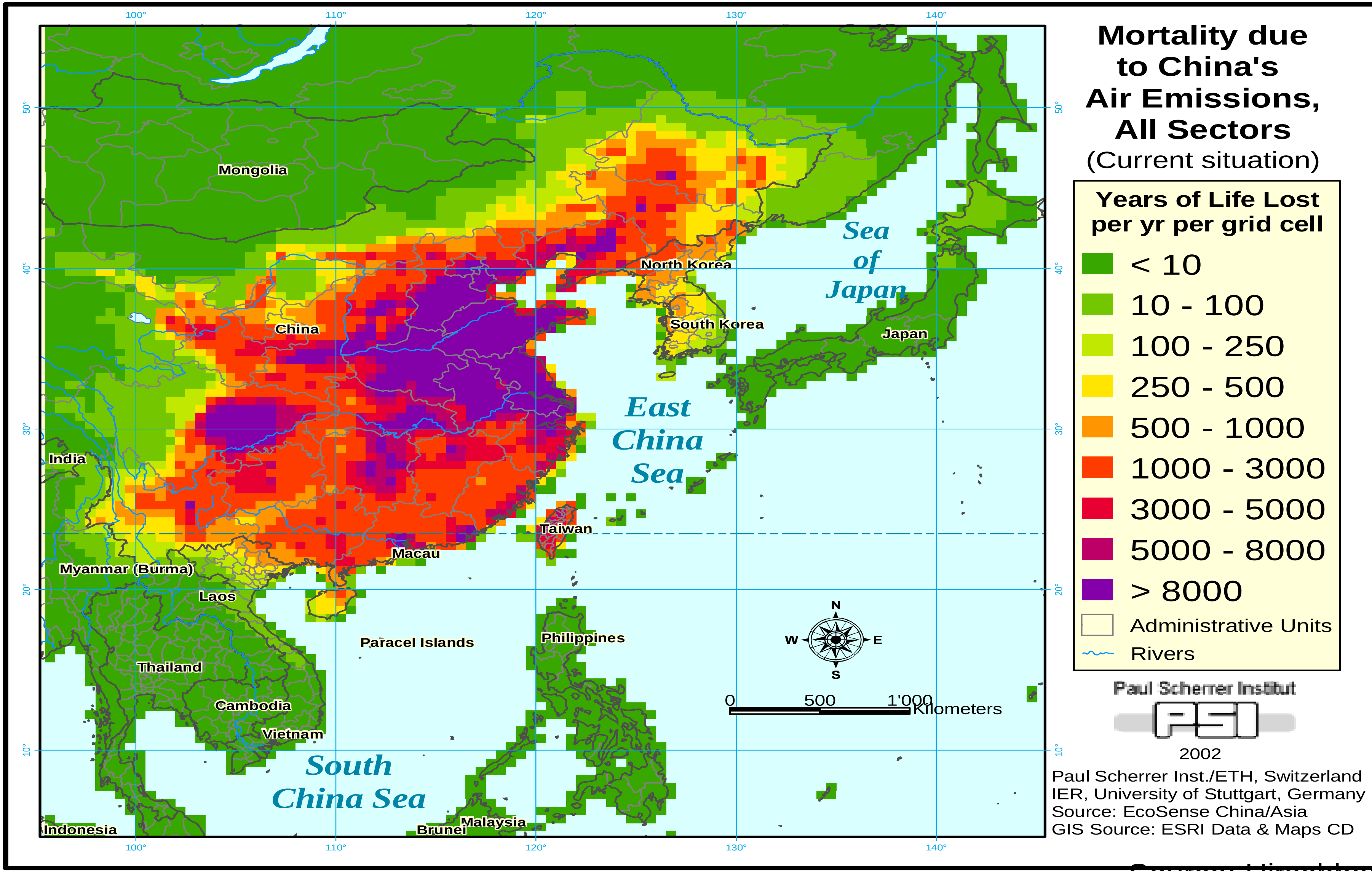
ollution Costs Must be Reduced: Annual outdoor air pollution costs the Chinese onomy anywhere from 6-7% of GDP (Hirschberg, 2003); RD&D support and international operation for technology diffusion can reduce the cost of pollution control significantly.

uclear* 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

lectricity transmission across regions makes economic sense and reduces local pollutio

Mortality in China - Emissions from all Sectors



Source: Hirschber

Proposal;

nk regional MARKAL models with ECOSENSE/RAINS to perfor

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