



Analysis of regional reallocation of zero-carbon ammonia production in China with carbon neutrality targets

carbon neutrality targets

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Introduction

This study focused on the regional level, adopted the transportation cost tandem to link the zero-carbon transition technology routes for the ammonia industry in each region, strengthened the regional coordinated development, analyzed the regional reallocation of zero-carbon ammonia production from the perspective of feasible regional solar resource costs.

Methodology

- In this study, the traditional technologies were classified as Fixed-bed Intermittent Gasification (FIG), Fixed-bed Pure Oxygen Gasification (FOG), Pulverized Coal Gasification (PCG), Coal Water Slurry Gasification (CWSG), Circulating Fluidized-bed Gasification (CFG), Steam Methane Reforming (SMR), Coke Oven Gas Reforming (COGR) and Residual oil to ammonia (RO_A).
- The production sites of ammonia in inland China were divided into 12 regions(as shown in Table 1) according to regional development clusters, PV, and fossil fuel resource endowment and supply conditions.
- The PV electricity costs for the 12 regions for 2020-2050 were calculated as shown in Table 1.

Table 1 Photovoltaic power cost setting by region (yuan/kWh)

Region	2020	2025	2030	2035	2050
Beijing-Tianjin-Hebei	0.281	0.240	0.225	0.190	0.149
Three Northeastern Provinces	0.258	0.217	0.165	0.136	0.103
Shandong	0.308	0.267	0.252	0.217	0.176
Yangtze River Delta	0.344	0.290	0.270	0.223	0.169
Henan	0.317	0.271	0.254	0.214	0.169
Triangle of Central China	0.360	0.303	0.282	0.233	0.177
Southern China	0.292	0.249	0.232	0.194	0.151
The Northwestern District	0.210	0.177	0.165	0.136	0.103
Xinjiang	0.213	0.180	0.168	0.139	0.107
Southwest China	0.291	0.245	0.228	0.188	0.143
Shanxi	0.301	0.257	0.241	0.203	0.160
Inner Mongolia	0.214	0.181	0.168	0.140	0.107

- This study considered the impacts of electrolysis technology (ET), nuclear technology-high temperature gas cooled to ammonia (HTGC), and carbon prices respectively when analyzing the supply-demand balance of ammonia and ammonia industry development in each region.
- Carbon price setting is shown in Table 3.

Table 2 Scenarios parameter settings

Scenario	explain
reference scenario (REF)	Without nuclear technology;
nuclear technology promote scenario (NPS)	With nuclear technology;
carbon price promote scenario (CPS)	Based on REF, consider carbon price;
carbon price and nuclear technology promote scenario (CNPS)	Based on NPS, consider carbon price.

Table 3 Carbon price assumptions.

Year	2020	2025	2030	2040	2050
Carbon price (yuan/tCO ₂)	55	68	104	287	751

Results and Discussion

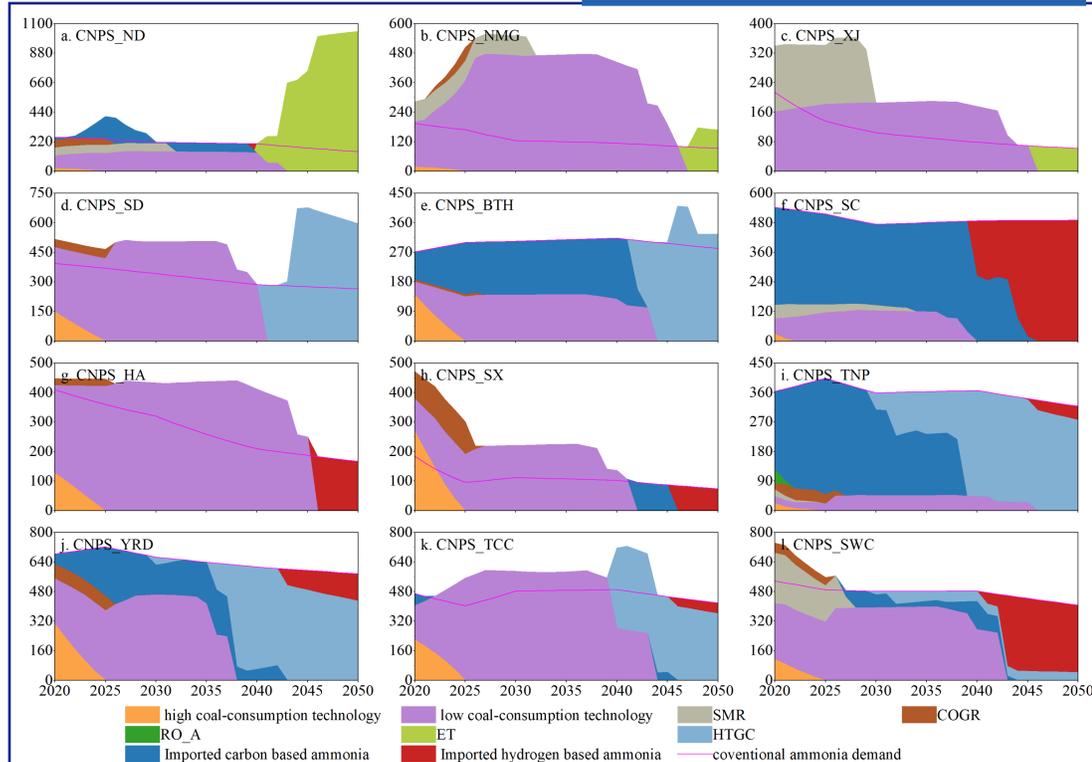


Fig. 1 ammonia supply mix (10⁴ ton) in 12 regions from 2020 to 2050 in CNPS scenario.

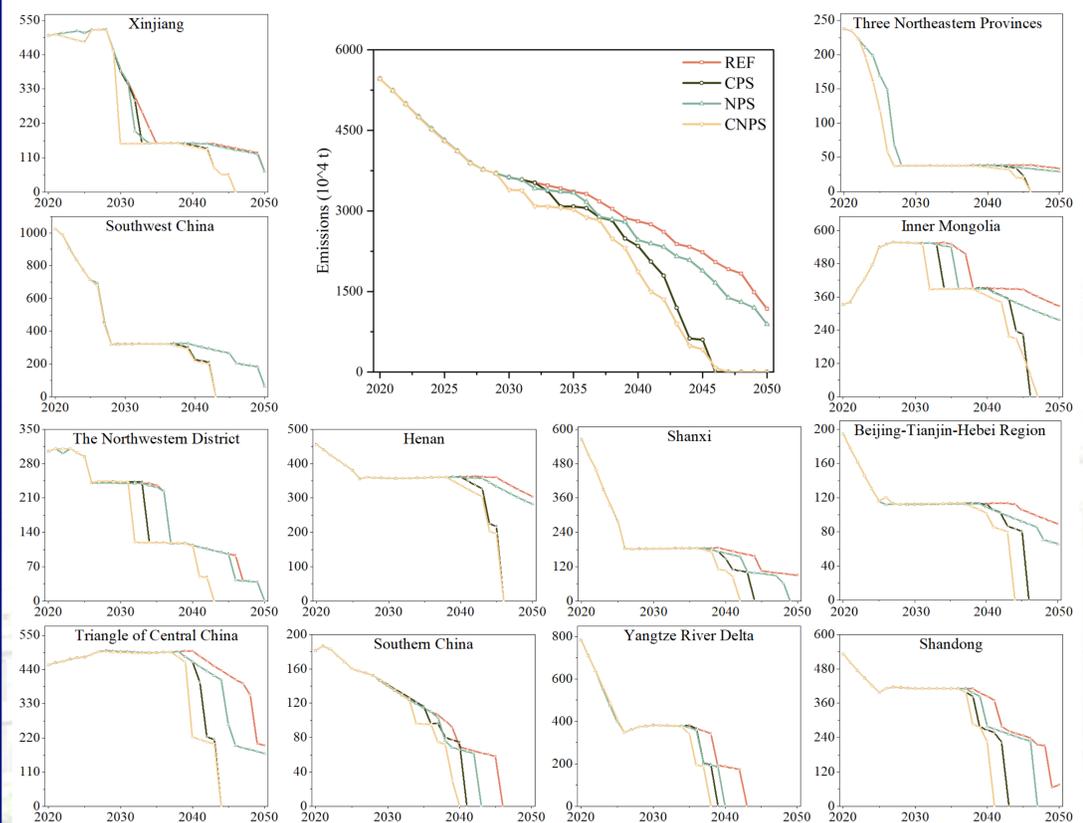


Fig. 2 CO₂ emissions pathways under different scenarios across regions and nationally (10⁴ tons).

- The electrolysis technology priority group, primarily composed of Xinjiang, Inner Mongolia, and The Northwestern District, depended on native abundant solar resource to achieve zero emissions
- In the nuclear technology priority group, Beijing-Tianjin-Hebei Region and Shandong could reach zero-carbon emissions with HTGC, while ET was the least economical technology
- Southern China, Henan, and Shanxi were completely phased out ammonia production, because they had poor PV resources, and it was more difficult to rely on their solar resource conditions to realize zero-carbon technology transformation.
- The national annual total CO₂ emissions showed an overall rapid downward trend, finally achieving zero carbon emissions with carbon prices promote, and the no-carbon price scenarios still maintaining a specific amount of CO₂ emissions by 2050.
- The development of the ammonia industry in Xinjiang, Inner Mongolia, and Triangle Central of China would impose pressure on the local carbon targets, with their carbon emissions rising before falling.
- Southern China, Yangtze River Delta, and the Northwestern District could achieve zero CO₂ emissions in all scenarios, with their earliest zero-emission years occurring in 2040, 2038, and 2043, and their latest zero-emission years occurring in 2046, 2043, and 2050, respectively.