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Clean Coal Applications:
NICE Perspectives

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China Energy Group Overview

中国国电 CHINA GUODIAN + 神华集团 SHENHUAAGROUP

- **The largest coal supplier (~500MT)**
- **The largest coal-fired power generation company (~190GW)**
- **The largest wind power provider (~33GW)**
- **The largest coal-to-chemical producer (~8MMT)**
- **Vertically integrated businesses**
  - coal mining, transportation, coal-to-chemicals, power generation
- **Diversified energy portfolio**
  - coal, wind, gas, solar

One of **the largest** energy company

transforming to

one of **the best** clean energy companies

NICE Overview

- 3 *R&D locations*
- 600+ *Employees*

North American Technology Center (Silicon Valley, US)

European Technology Center (Schwabich Hall, Germany)

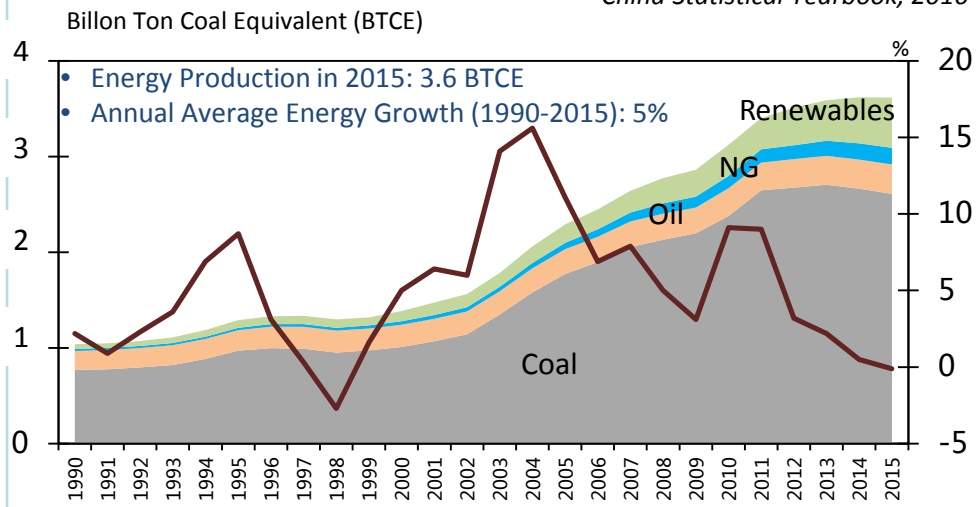
HQ based in Beijing, China

Focusing on Clean Energy Technology Development

Energy Mix in China

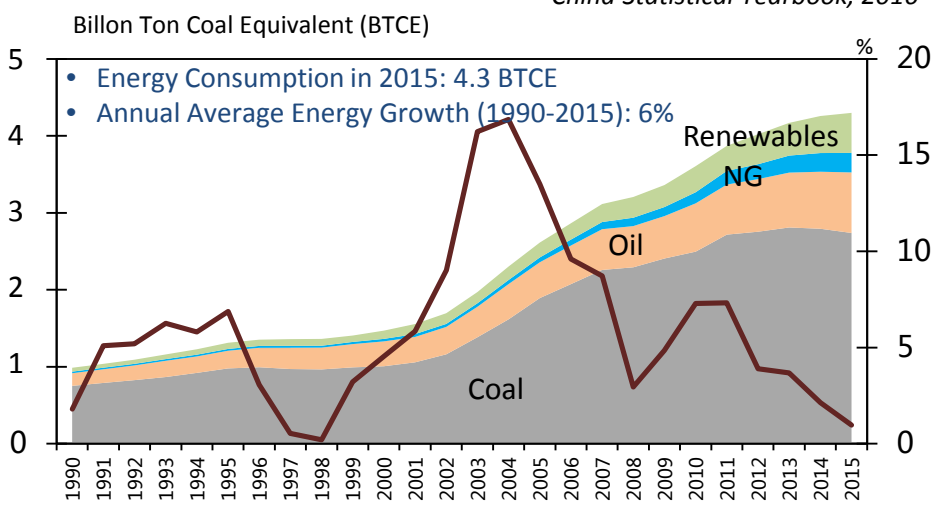
Energy Production in China (1990-2015)

China Statistical Yearbook, 2016

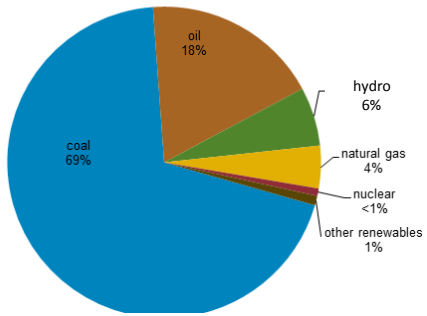


Energy Consumption in China (1990-2015)

China Statistical Yearbook, 2016

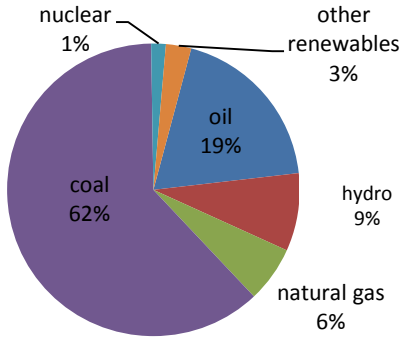


2011 China energy consumption



2016 China energy consumption

Source: BP Statistical Review of World Energy



In China

- Energy Consumption > Energy Production
- Coal contribution over 60% today
- Rapid growth of renewables but still a small presence (3%)

Clean Coal Technologies critical

Clean Coal Technology Strategy

Cleaner Power Generation

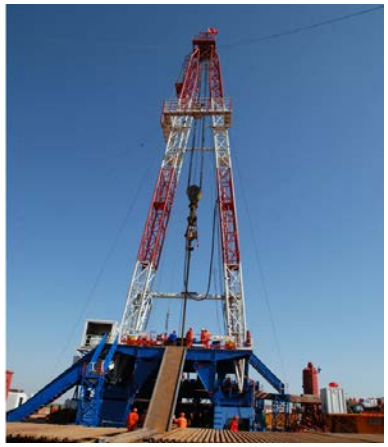
Better Fuel Choice

More Value-added Conversions

Cleaner Power Generations

Emission Control

Ultra-low Emission Power Generation



CO_2 Mitigation

CO_2 Capture, Storage and Utilization

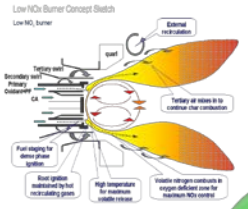
FGD Wastewater Reuse

Zero Liquid Discharge, Saleable Salts

Solid Waste Management

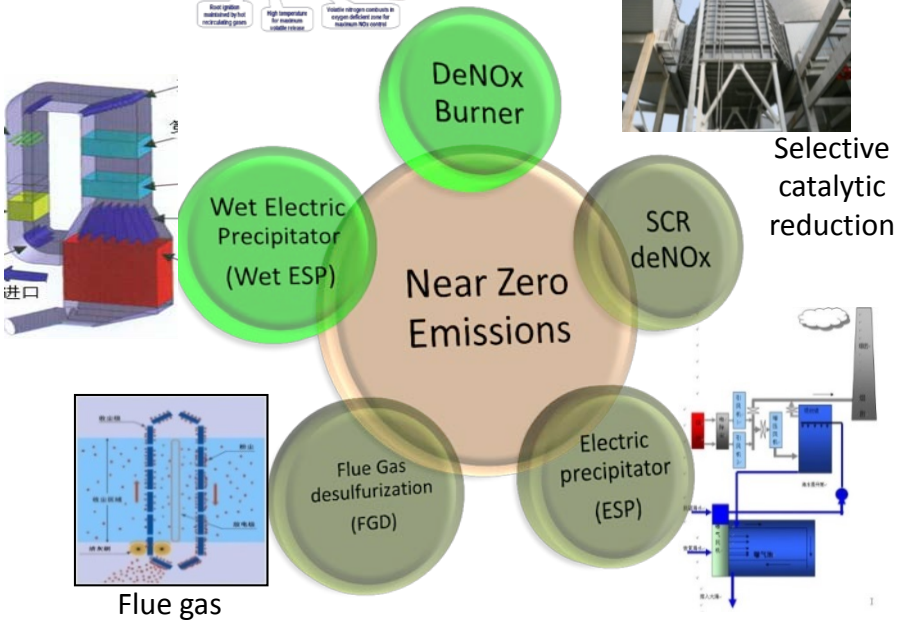
Value-added Products, Minimal Fly Ash Disposal

Cleaner Power Generation...Ultra Low Emission (ULE)



Selective catalytic reduction

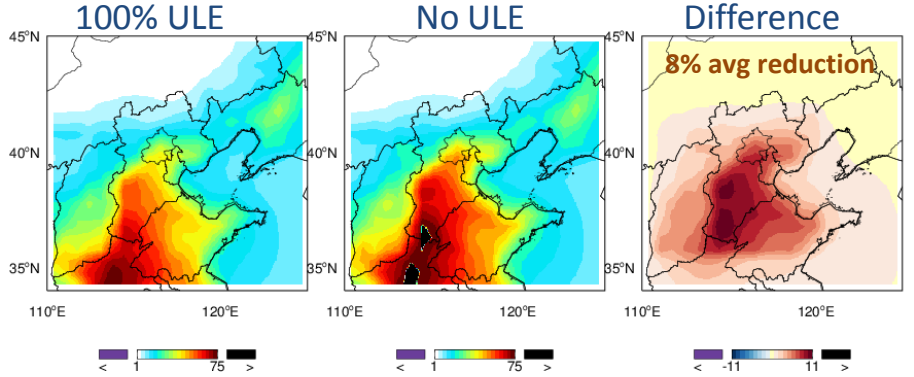
Flue gas desulfuration



Ultra Low Emission: Soot, NOx, SO2

EP indicator	Soot (mg/Nm³)	SO_2 (mg/Nm³)	NOx (mg/Nm³)
National standard (Natural Gas)	≤5	≤35	≤50
Shenhua demo plant	<2	<5	<20

Effects of ULE on haze (Jing-Jin-Ji Area)



Two thirds of power plants implemented with ULE Technologies

Cleaner Power Generation…CO_2 Mitigation

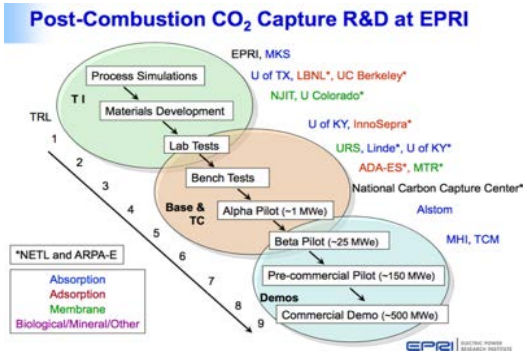
Near-term: Ultra-low Emission

Company-wide Adoption

Without CO_2 capture

Mid-term: Post-combustion capture

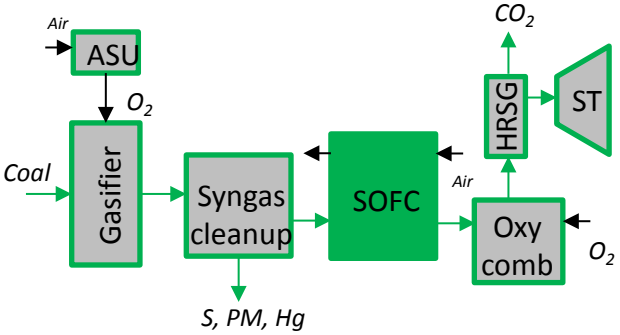
Shenhua Demonstration Project



Partial CO_2 capture

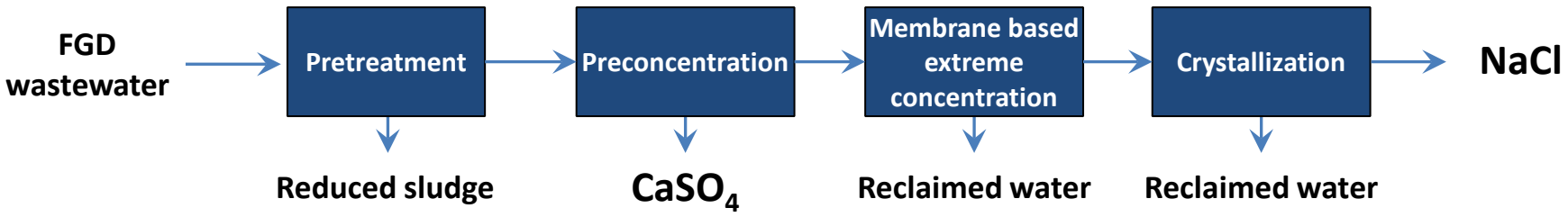
Long-term: Integrated Gasification Fuel Cell Power Generation (IGFC)

A Major R&D Program



Close to 100% CO_2 capture

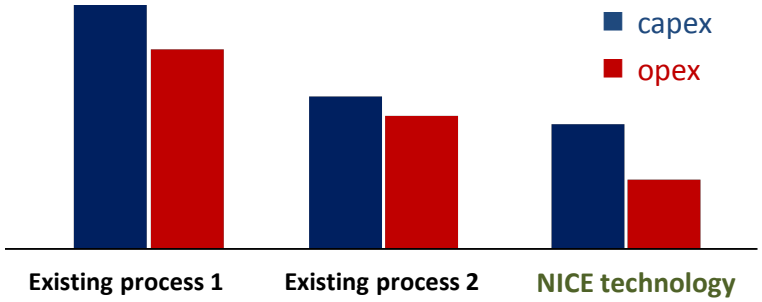
Cleaner Power Generation…Wastewater Reuse



Technology Features

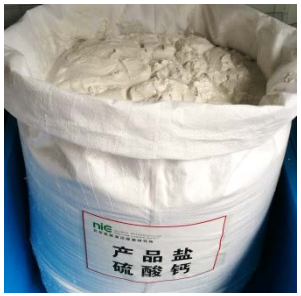
- Only partial softening in pretreatment
  → *50-70% lower chemical cost*
- Membrane concentration up to 18-20% in TDS
  → *80-90% less evaporation*
- Saleable salts…minimal solid waste

Capex & Opex comparison



Technology Status

- Pilot Projects Completed
- Commercial launch underway



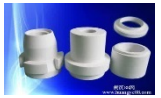
Cleaner Power Generation...Fly Ash Utilization Technologies

Coal combustion solid waste: fly ash

NICE classification and utilization technology

- Green cement 
- Low carbon mortar (fly ash loading 30%-45%) 
- Insulation and fire-resistant Foam 
- Functional filler for polymers 
- High strength proppants 

Structural ceramic technology

- High-end industrial ceramics 

Al rich fly ash

Alumina extraction technology

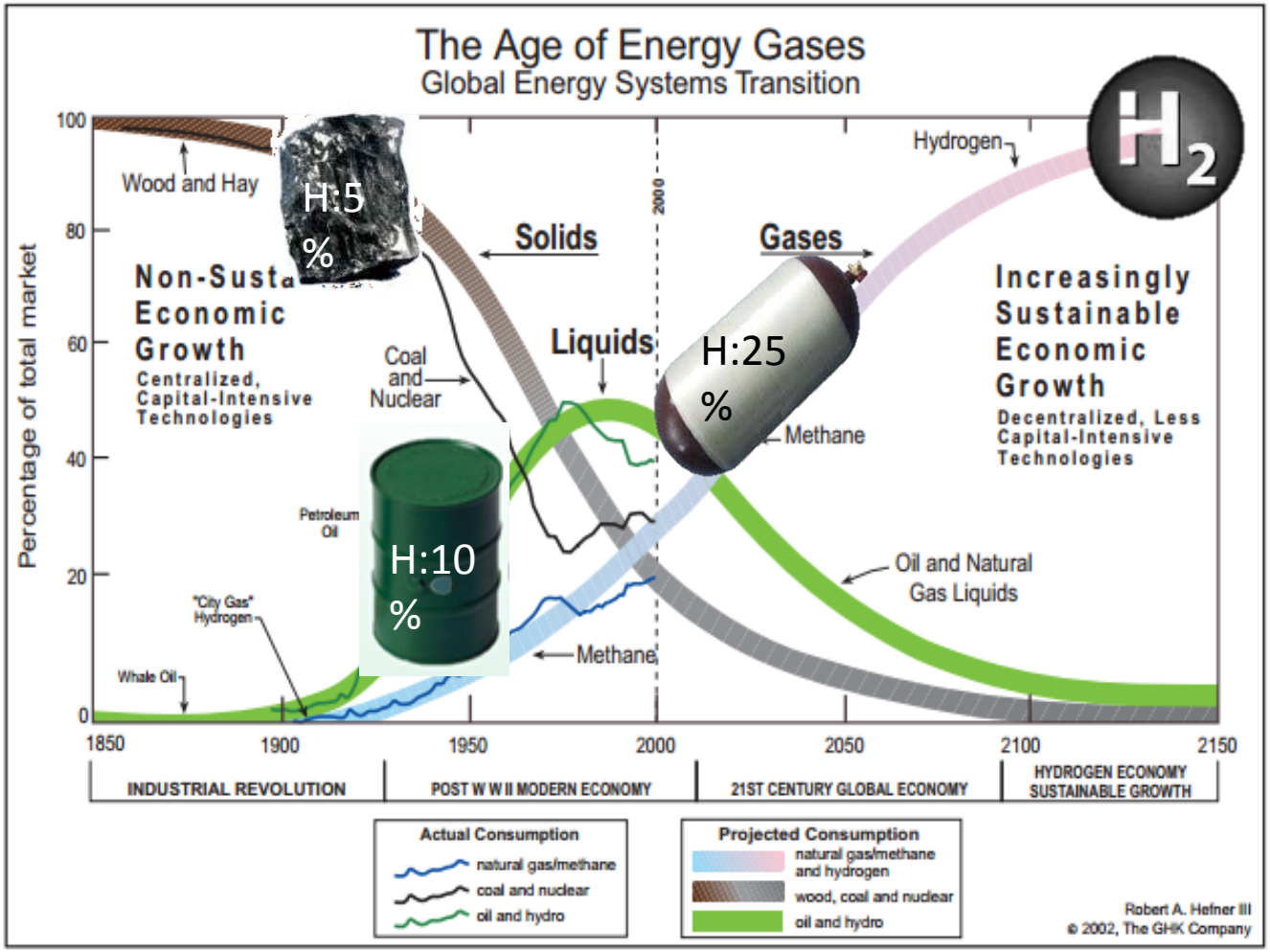
- Aluminium and by-products 

High volume

High value

~100% Fly Ash Utilization

Better Fuel Choice: Coal as A Secondary Energy Source



Global energy trend: increasing H/C ratio

Hydrogen Energy Value Chain

Production

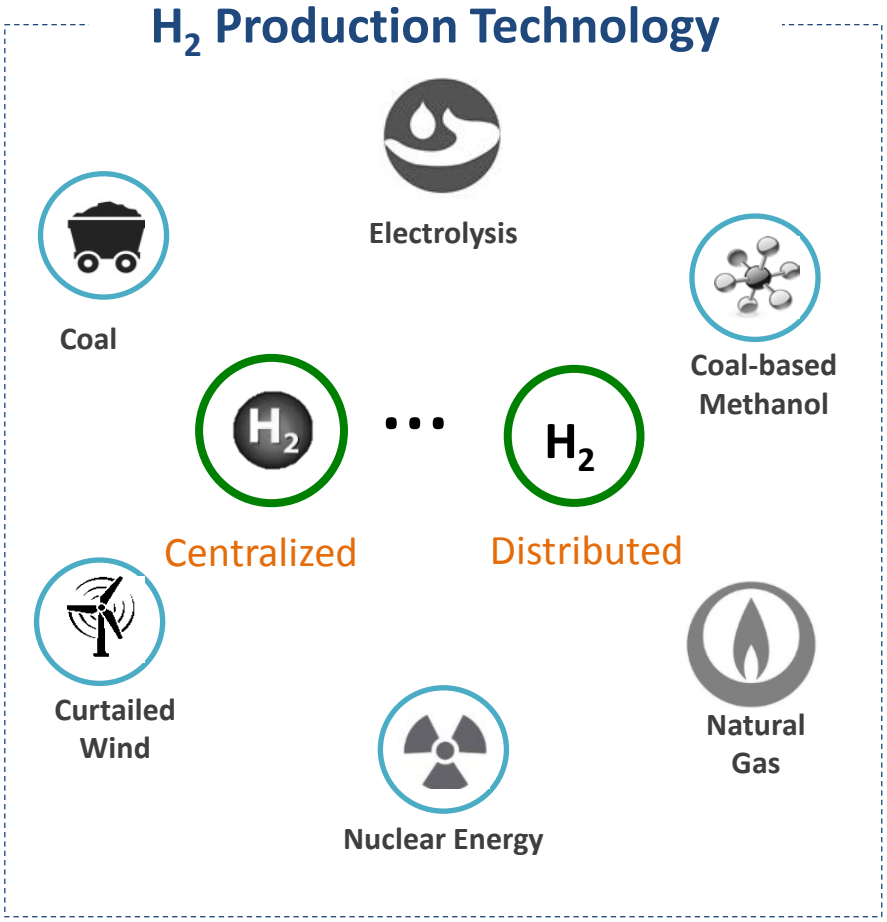
Shipping

Storage & Charging

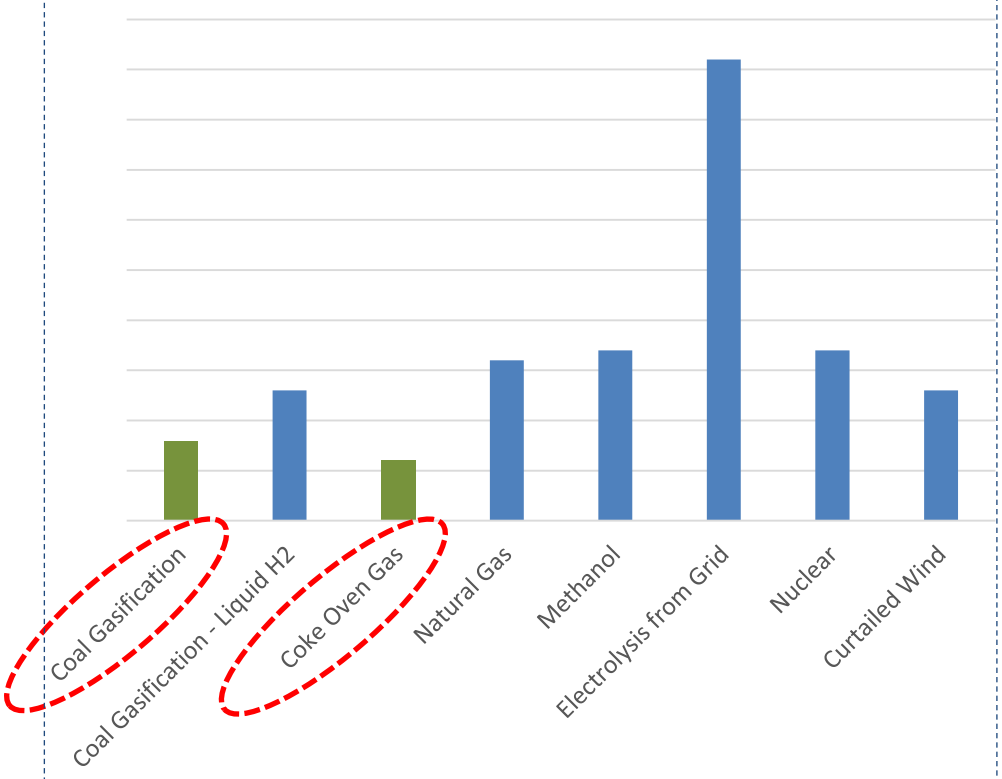
Consumption

Hydrogen Production…Cost Comparison

H_2 Production Technology



H_2 Production Cost



Coal to H_2…low cost route

Hydrogen Energy…China Energy Group Strategy

神华集团 SHENHUA GROUP

Production

- Drive low-cost production with coal and curtailed wind

Storage & transport

- Leverage Shenhua transportation network

H_2 refueling station

- Focus on investment and ownership

FC vehicles

- Build external partnership

More Value-added Conversions: Coal as Raw Materials

Coal

Liquefaction

Gasification

Coal-based Intermediates

FT/Oil Hydrotreating

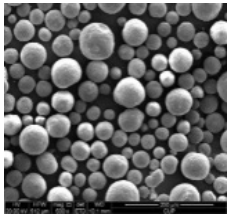
MeOH

MTO/MTPB

Liquid Fuels

Commodity Chemicals

Specialty Materials



Coal as Raw Materials…Commodity Materials

Coal to Liquid: ~5MMT/year

Coal to Olefins: ~3MMT/year

Value-added Materials

Cross-linkable polymer with high impact resistance

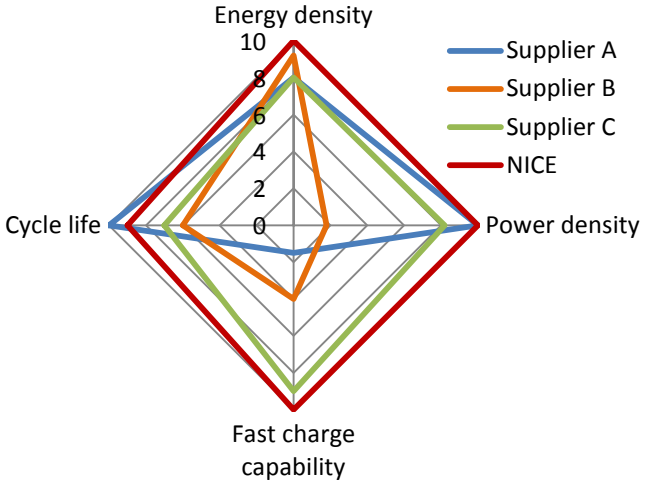
"Breakless" grade material with flame retardant properties

Start-up Company

Coal as Raw Materials...High Power Lithium Battery Material

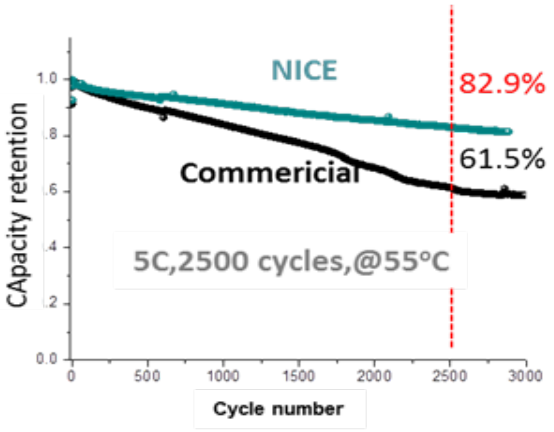
Coal

High power LIB



Technical Advantages

- Fast charge Capability (5 min to 80%)
- Long cycle life (>5000 cycles at 5C)
- Superior low temperature performance (5X better at -40°C)
- Balanced energy density and power rating

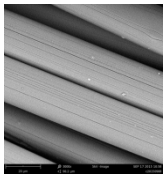


Coal as Raw Materials...Thermal Management Materials

Coal based intermediate product

Carbon block

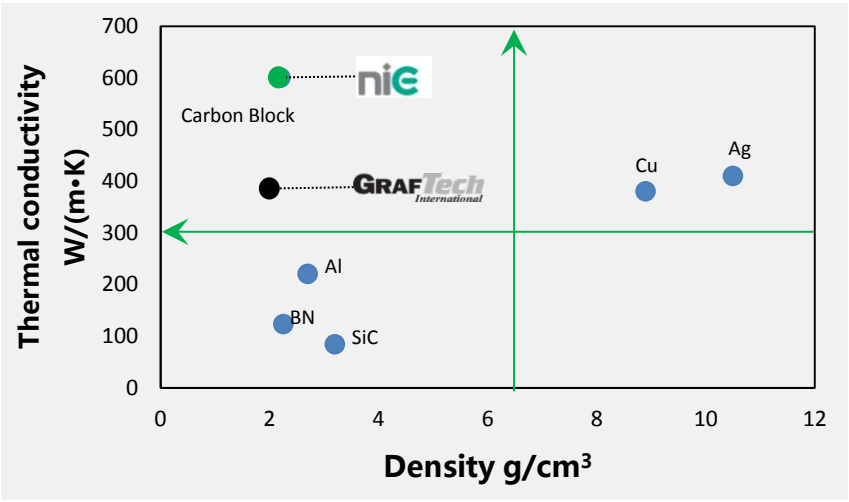
Carbon foam



Carbon fiber

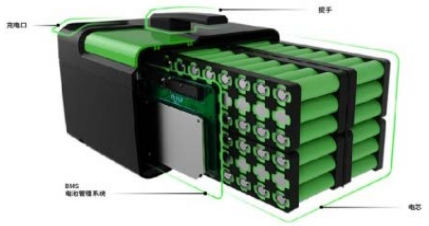
Technical Advantages

- High thermal conductivity - Block/Fiber: 300-680W/(m•K); Foam: 100W/(m•K)
- Light weight, Density: 0.5–0.2g/cm^3
- Excellent processability and high-temperature stability
- Low cost



Applications

- Heat dissipation of electronic devices
- Heat storage
- Fillers for thermally conductive composites
- Intelligent thermostatic devices



Summary

- Coal is a major energy source today
- Coal will continue to be an important energy component in the foreseeable future
- Coal applications need to be clean and can be cleaner
- Technology innovation will drive economics