ENN's Energy Strategy towards a Climate-Neutral World

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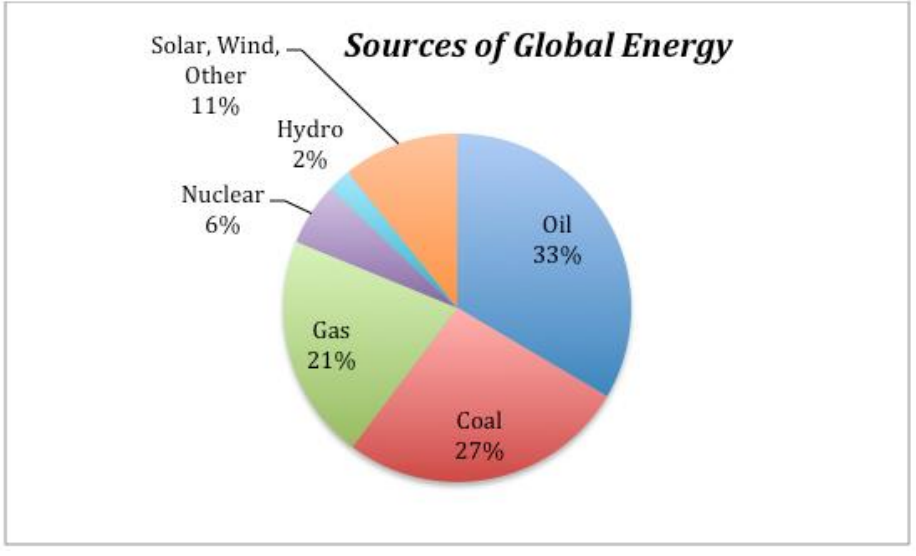
August 16, 2022

Energy Trend

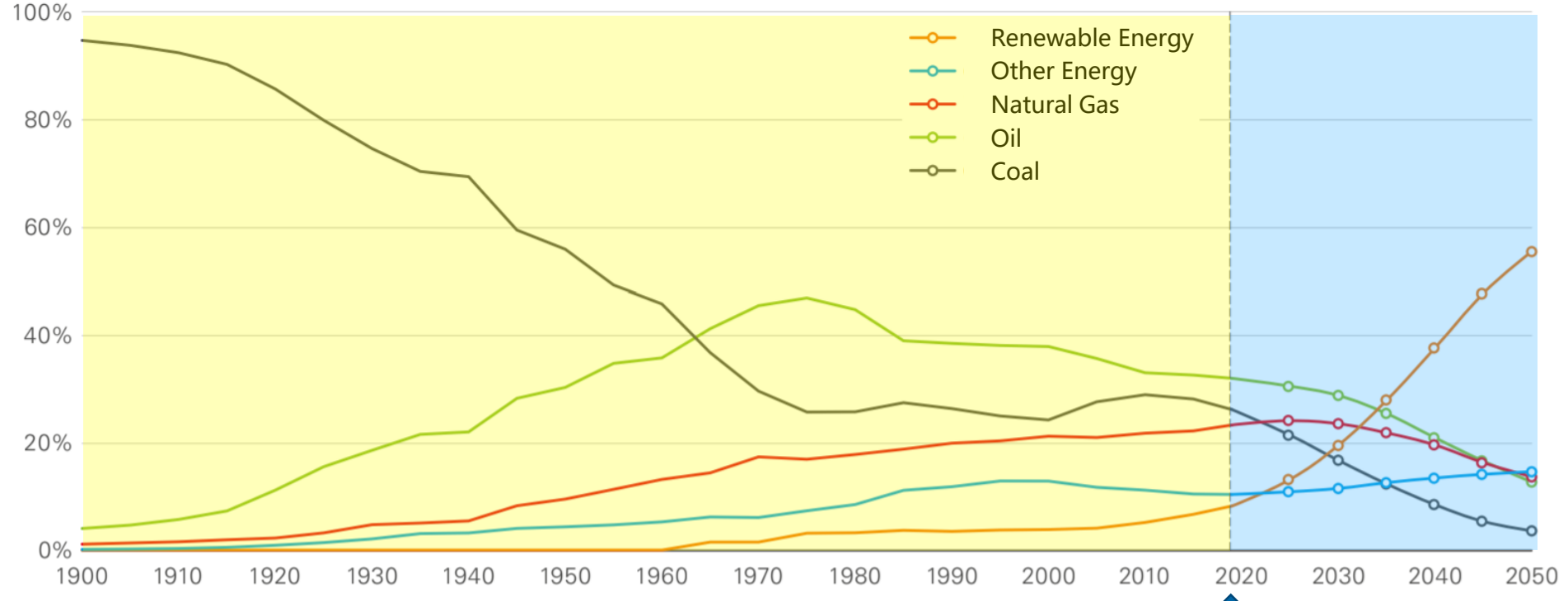
1.5 million years ago
(www.history.com)

21 Century
(International Energy Agency)



Energy Trend

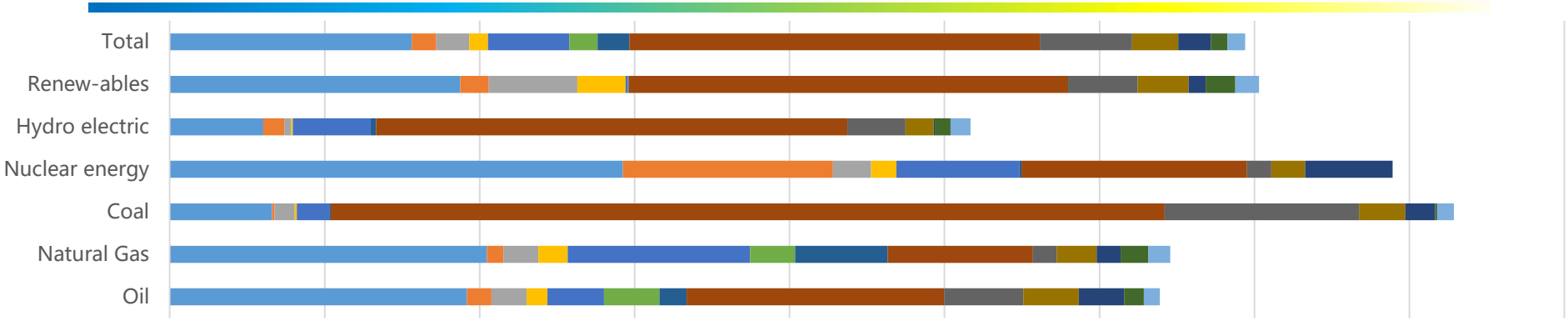
Renewable energy use continues to increase as demand for other fuels declines.



1.5 million years ago
100% timber

today

Energy consumption by major countries in 2021 (percentage)



	Oil	Natural Gas	Coal	Nuclear energy	Hydro electric	Renew-ables	Total
US	19.18%	20.48%	6.60%	29.25%	6.03%	18.74%	15.62%
France	1.58%	1.07%	0.15%	13.55%	1.36%	1.85%	1.58%
Germany	2.27%	2.24%	1.32%	2.46%	0.45%	5.71%	2.12%
United Kingdom	1.35%	1.91%	0.13%	1.64%	0.12%	3.11%	1.21%
Russian Federation	3.64%	11.76%	2.13%	7.94%	5.02%	0.15%	5.26%
Saudi Arabia	3.58%	2.90%	0.00%	0.00%	0.00%	0.02%	1.82%
Iran	1.76%	5.97%	0.05%	0.13%	0.35%	0.04%	2.05%
China	16.61%	9.38%	53.82%	14.55%	30.42%	28.35%	26.49%
India	5.11%	1.54%	12.55%	1.57%	3.75%	4.48%	5.95%
Japan	3.59%	2.57%	3.00%	2.19%	1.82%	3.30%	2.98%
South Korea	2.93%	1.55%	1.90%	5.64%	0.07%	1.10%	2.11%
Italy	1.27%	1.80%	0.14%	0.00%	1.01%	1.91%	1.07%
Turkey	1.03%	1.42%	1.09%	0.00%	1.30%	1.52%	1.15%

NEW ENERGY CHALLENGE

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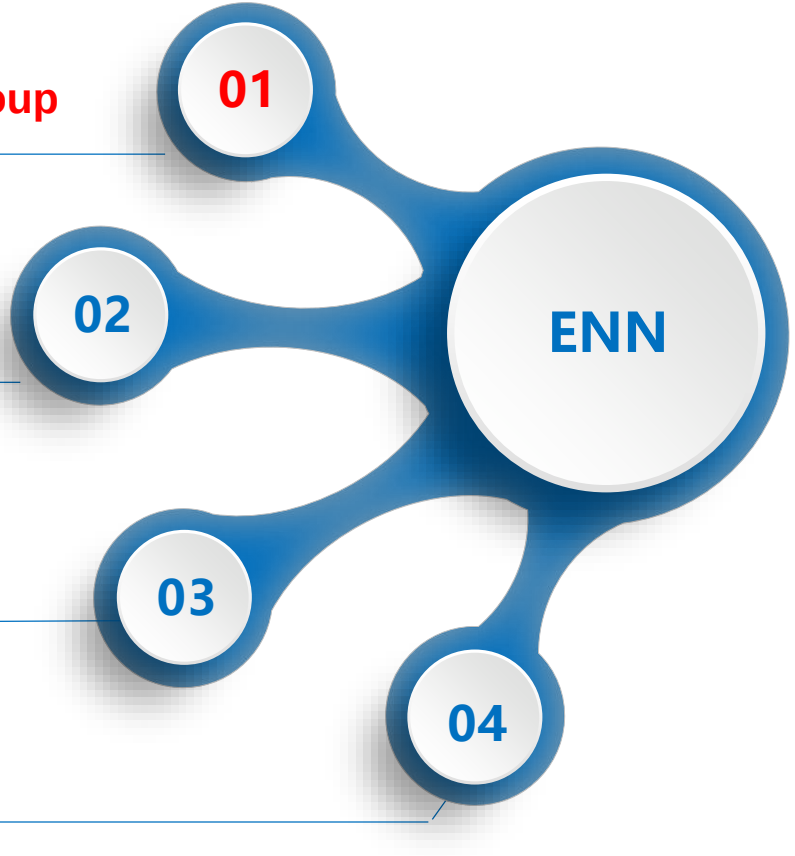


WHO WE ARE

Established in 1989, ENN Group is a Chinese conglomerate committed to establishing modern energy systems and improving quality of life.

Employees:

45,000+

3 In-House Institutes

- ★ Energy Research Institute
- ★ Digital Research Institute
- ★ Institute of Life S&T

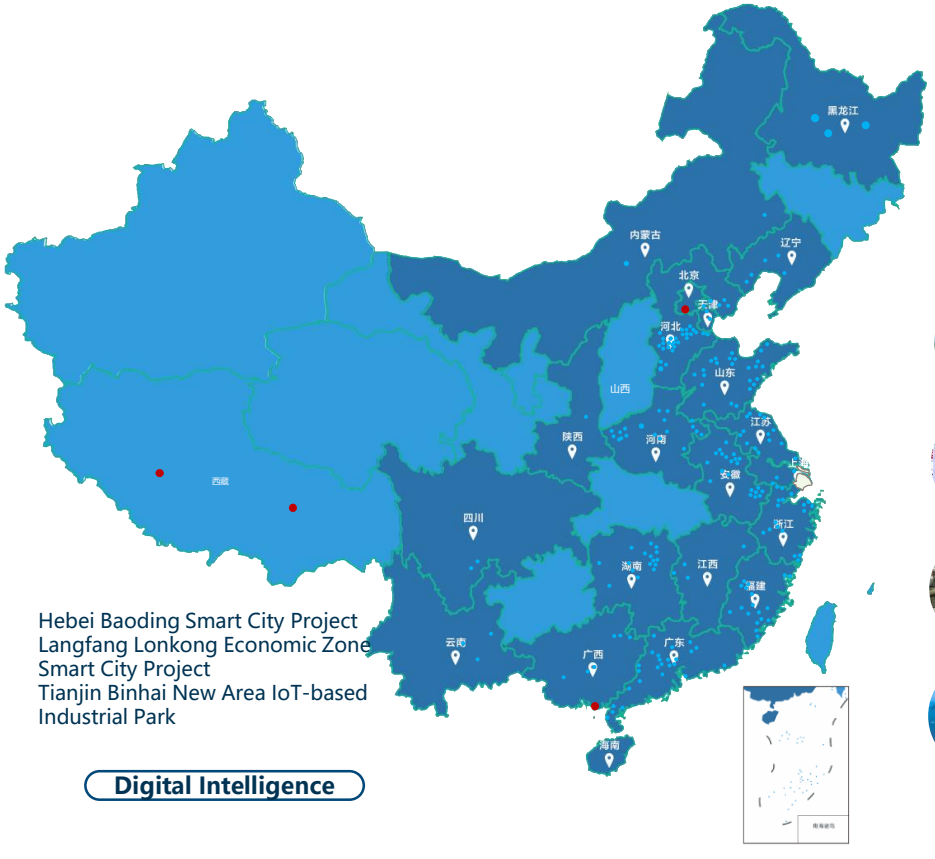
4 Publicly Traded Companies

- ★ ENN Energy Holdings 新奥能源（02688.HK）
- ★ ENN Ecological Holdings 新奥股份（600803.SH）
- ★ ENC Digital Technology 新智认知（603869.SH）
- ★ Tibet Tourism 西藏旅游（600749.SH）

Business Landscape

Focus on the major concerns of all industries-
"safety, energy, carbon, quality"

Business Landscape



Hebei Baoding Smart City Project
Langfang Lonkong Economic Zone Smart City Project
Tianjin Binhai New Area IoT-based Industrial Park

Digital Intelligence

Energy business coverage
21 provinces in China
Urban energy projects 52
Residential users
25.83 million
Industrial users
202,400
Total annual sales of natural gas
37.2 billion cubic meters

Dalad Banner, Inner Mongolia——
Coal Gasification Demo Projects

Langfang, Hebei——
Compact fusion and deep geothermal energy research laboraroties

Shanghai, Langfang——
Micro-combustion engine manufacturing base

Zhoushan, Zhejiang——
LNG receiving station

Clean Energy

Life related business coverage
5 provinces in China
Scenic areas 7
Tourist routes 3
Cruises 24
Real estate projects 12

Langfang, Hebei——
Theaters, Hotels, Real estate projects

Tibet——
Tourism

Beihai, Guangxi——
Tourism

High-quality Life

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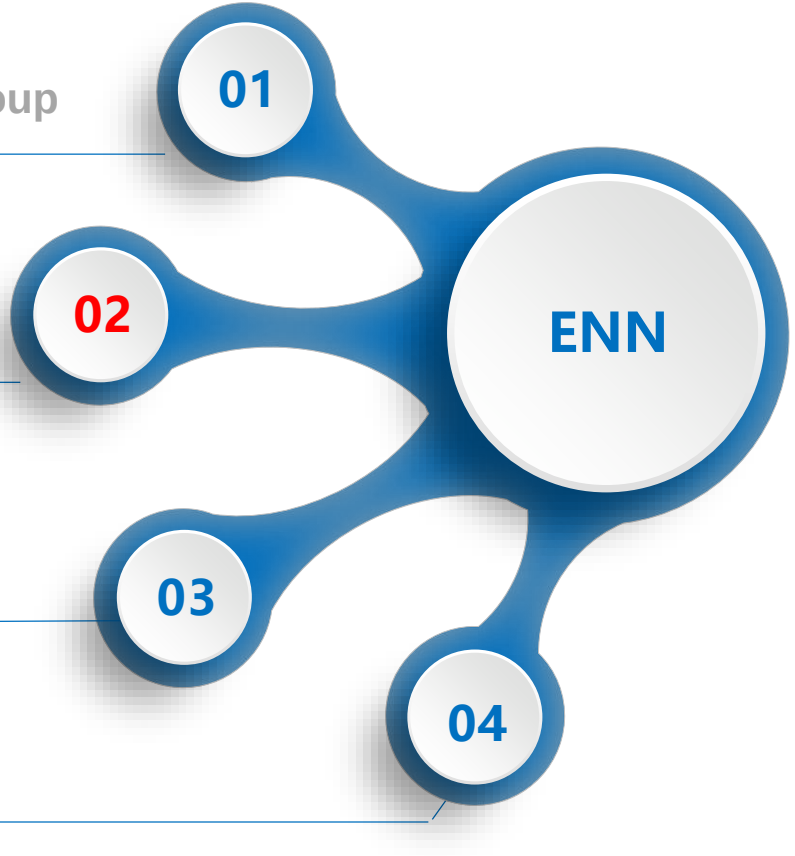


ENN Energy Research Institute (EERI)

- Founded in 2006
- ENN's innovation engine
- Committed to address humanity's energy challenges

Team

500+ Researchers

Partners

MIT
UCLA
NETL
Tsinghua University
Peking University
……

Intellectual Properties

Applied Patents 2200+
Issued patents 1600+

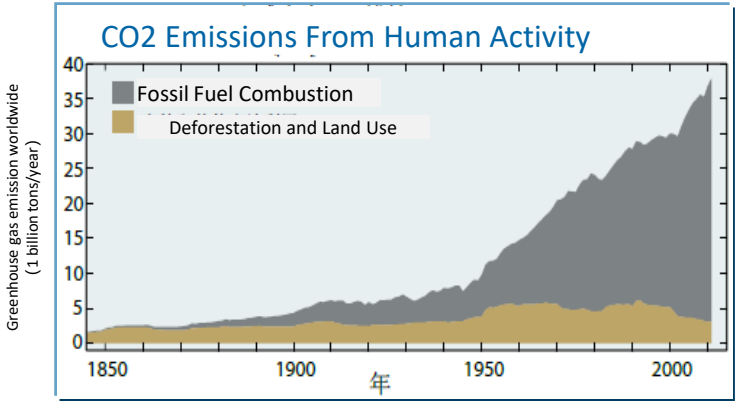
Innovation Platforms

State Key Laboratory for Coal-based Low Carbon Energy
International Scientific and Technological Collaboration Base
Post-Doctoral and Academician Work Station
……

From Low-Carbon to Carbon-Free: Future Energy Trends

Human activities are the primary cause of global warming.

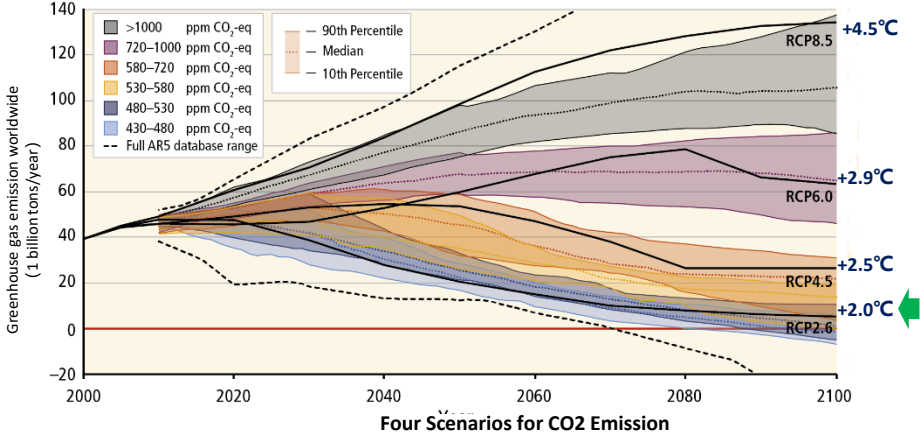
1. From 1850 to 2015, atmospheric CO2 concentrations reached 400 ppm, leading to an average global temperature increase of 1 ℃ and a sea level rise of 12 cm.
2. Since the industrial revolution, CO2 from fossil fuel combustion was the primary contributor to global warming.



Data Source: 2014 Climate Change Synthesis Report, Intergovernmental Panel on Climate Change (IPCC)

Low-carbon and carbon-free energy is fundamental to addressing climate change

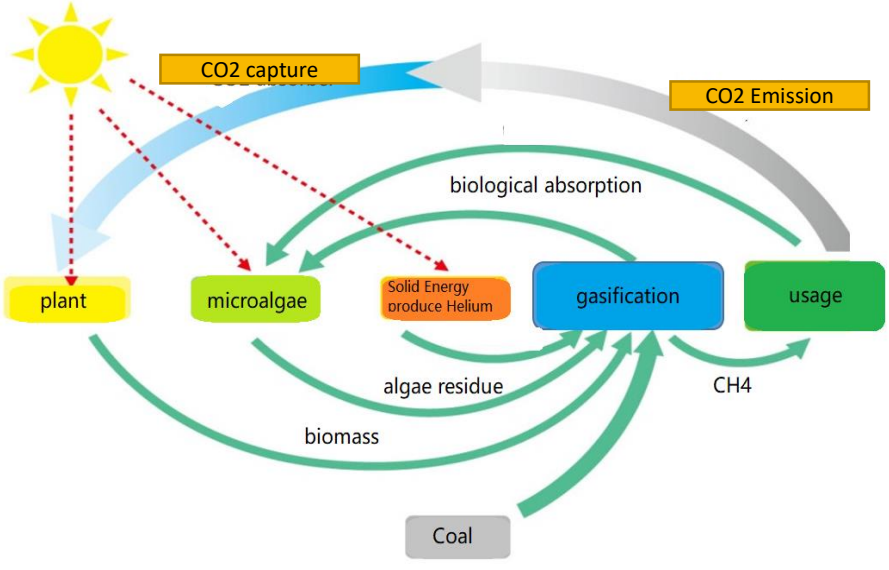
1. A global average temperature increase of 2 ℃ will cause disasters that may significantly impact food and drinking water supplies, threatening human lives.
2. To ensure a temperature increase of less than 2 ℃, greenhouse gas concentration must not exceed **450ppm**, zero emission and carbon-free energy is mandatory. China promises to reach a peak CO2 emission value where non-fossil based energy will take 20% of all power generation.



Four Scenarios for CO2 Emission

Energy 1.0: (2006-2017)

We achieved multiple innovations and scientific breakthroughs in coal-based low-carbon energy systems, the Ubiquitous Energy Internet (UEI) and advanced environmental protection technologies.



Coal-Based Clean Energy Technology:

To optimize energy structure and reduce emissions:

- ✓ **Catalytic Coal Gasification to Methane**
- ✓ **Coal Hydrogasification**
- ✓ **Underground Coal Gasification**
- ✓ **Supercritical Coal Gasification**

Ubiquitous Energy Internet (UEI):

To reduce energy consumption and improve energy efficiency

Clean Coal Gasification

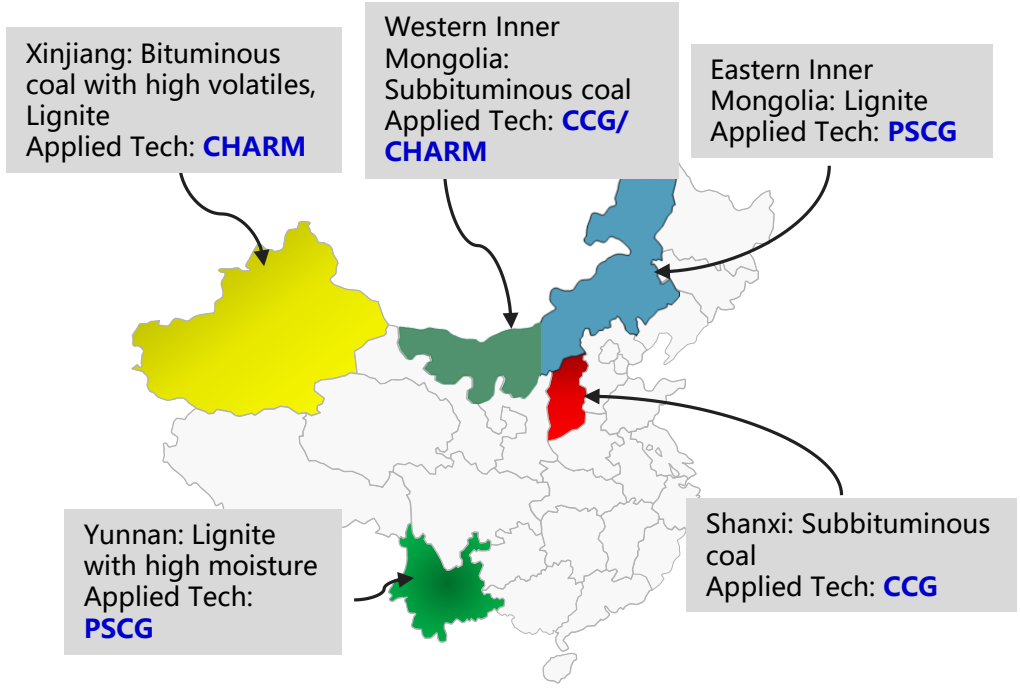
Coal →Natural Gas+ Chemicals+ High Value-added Products

Catalytic Coal Gasification for Methane (CCG)

Coal Hydrogasification for Aromatics and Methane (CHARM)

Pulverized-coal and Slurry Coupled Gasification Technology (PSCG)

Suitable for different types of coal in different regions



Clean Coal Gasification

Catalytic Gasification

0.1 t/d PDU

0.5 t/d PDU

5 t/d pilot demo

1500t/d demo

Key technologies: catalyst development, load and recovery; pressurized fluidized bed stability control; coal selection and catalyst matching; computer simulation and engineering scale-up; indirect condensation heat recovery

Lab Scale 2008-2009 → **Bench Scale 2010-2012** → **Pilot Scale 2013-2014** → **Industrial Scale 2015-2018**

Coal Hydro-gasification

Collaborative research with ICC and THU

10 t/d pilot demo

400t/d demo

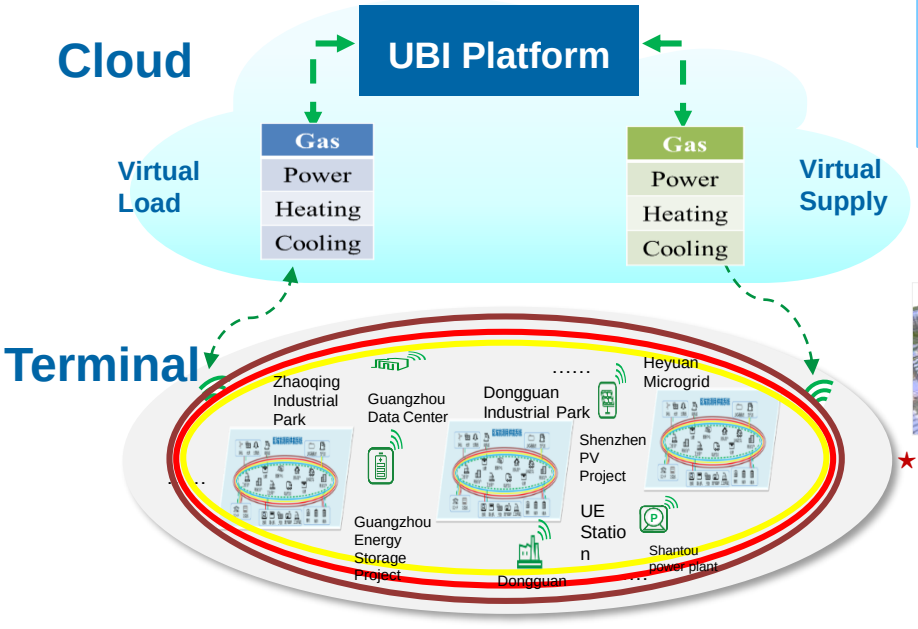
Key technologies: dense phase transport with high pressure H_2; high temperature H_2-O_2 nozzle technology; entrained flow bed gasifier configuration; char dry cooling and transport technology

Sustained Research and Development

1. Catalytic Gasification 2.0
2. Hydro-gasification 2.0
3. Coal to Low-Carbon Alcohols
4. Chemical Looping Gasification

Ubiquitous Energy Network

UE network enables optimal supply and demand matching, efficient energy conversion, low investment capital and low-cost energy utilization.



UE Projects Across China

Economic and Technological Development Zone of Langfang

★ National Demonstration Project of Multiple Energy Integration

Sino-German Ecopark in Qingdao

★ National Demonstration Project of New Energy Microgrid

Economic and Technological Development Zone of Wenzhou

★ The First UEI Demonstration Project in China

Micro-Grid UEI Demonstration Project in Langfang

★ National Green and Ecological Demonstration Area

Economic& technological Development Zone of Zhaoqing

★Data Center Alliance and Green Grid 5A Certified

Cloud Computing Center of Tencent

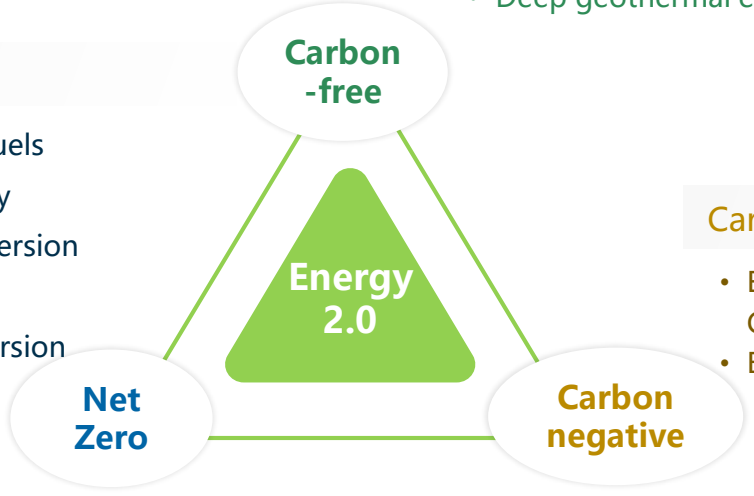
Energy Transition to Carbon Neutrality (Energy 2.0)

Carbon-free technologies

- Compact fusion
- Deep geothermal energy

Net Zero

- Integration of fossil fuels and renewable energy
- Thermocatalytic conversion of CO2
- Electrocatalytic conversion of CO2

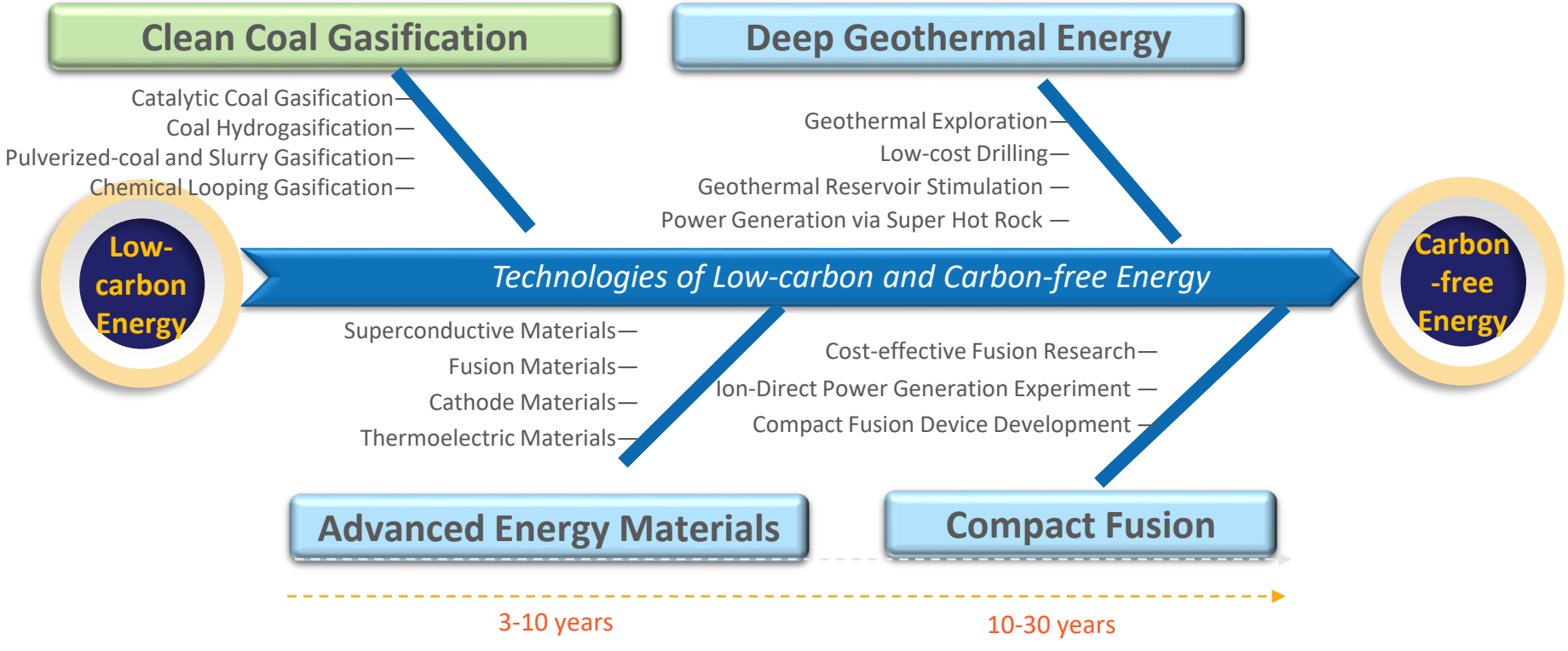


Carbon negative technologies

- Enhanced Geothermal & Carbon-capture System (EGCS)
- Biomass gasification + CCUS

Research Areas

To Embrace a Carbon-free Future with Disruptive Innovations

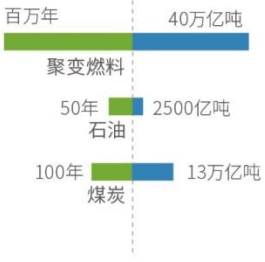


Energy 2.0 —— Fusion

Fusion is a nuclear reaction in which some light nucleus fuse with some other light nucleus, while releasing abundant amounts of energy.

Abundant

从海水中提取

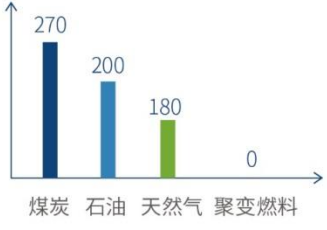


High energy density

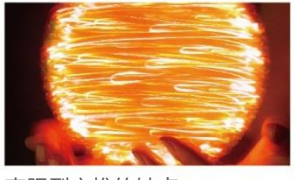
百万人口的市能源消耗

Environmental friendly

单位发电量碳排放

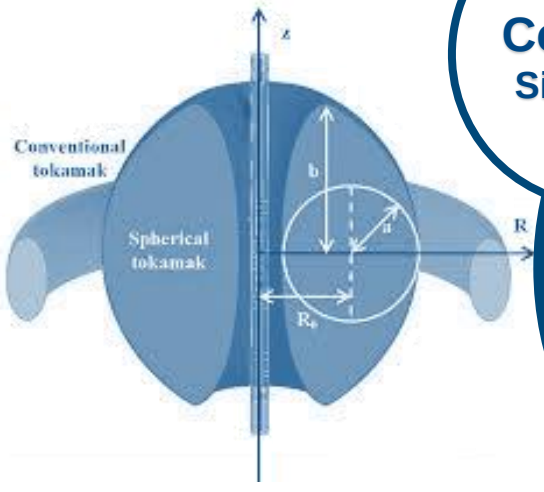


Safe and reliable



克服裂变堆的缺点

Compact Clean Commercial Power, Starting with Spherical Tokamak

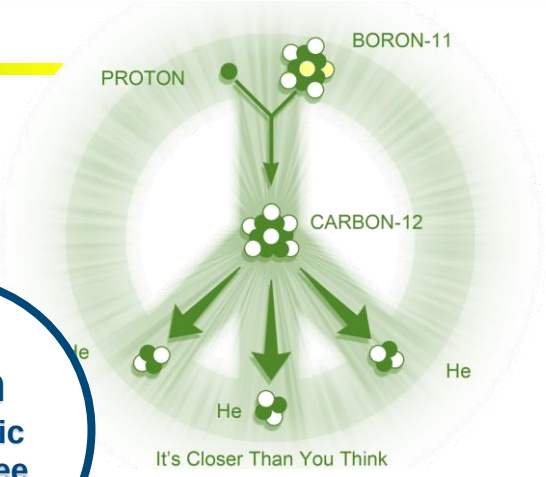


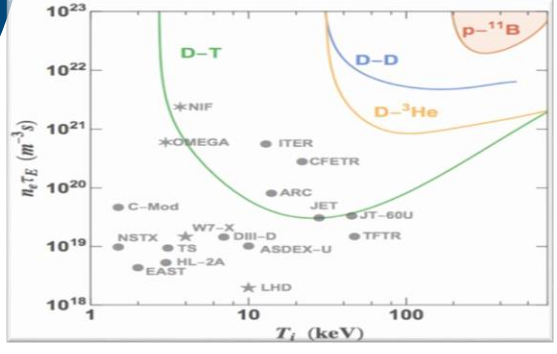
Compact
Simplified

Fusion
ENN

Clean
Aneutronic
Tritium-free

Low Unit Cost
Mass Produced



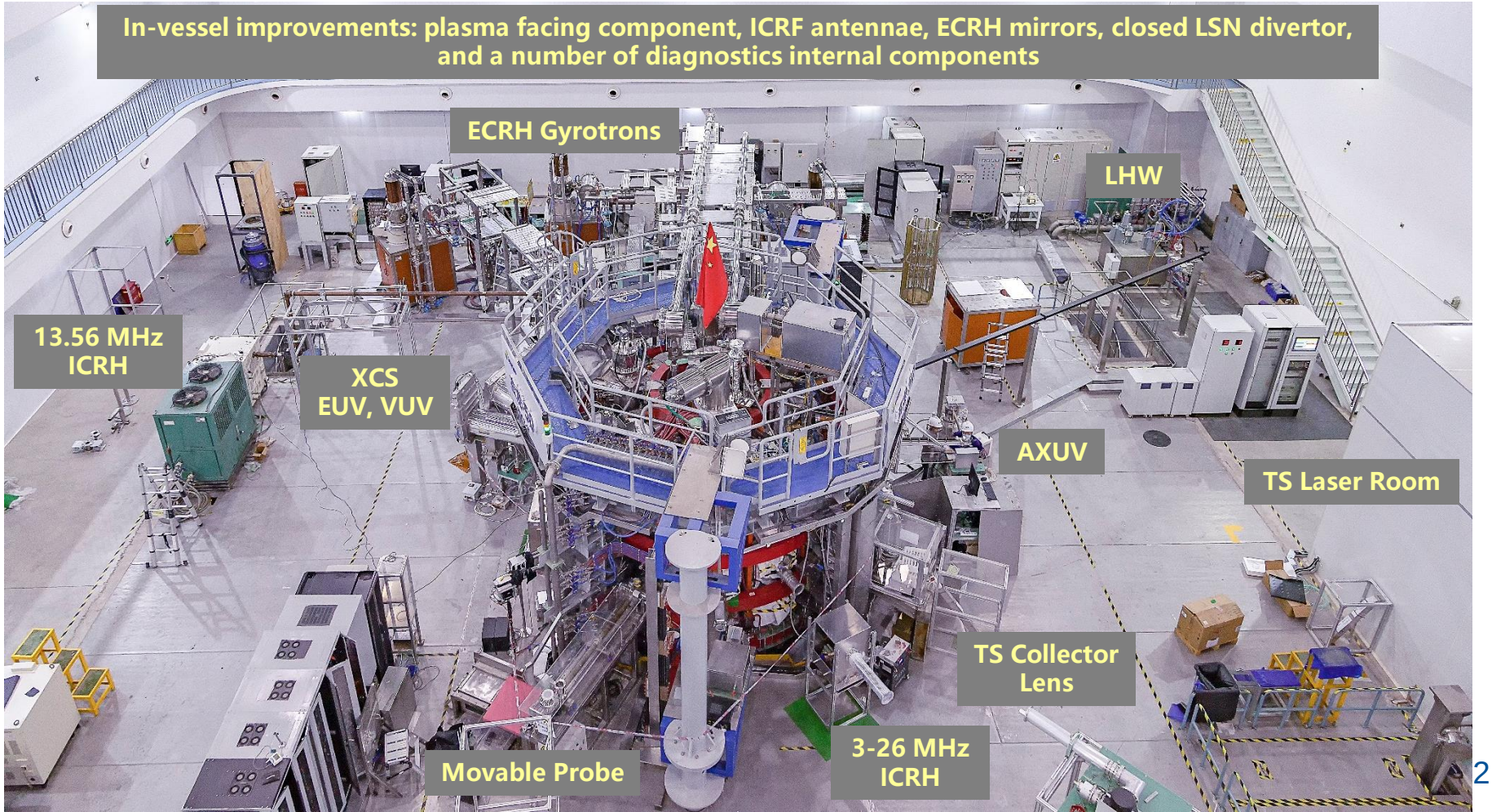


EXL-50 Proof-of –Principle Experimental Platform

Parameters	Technical Goals
Plasma Current I_p	500 kA
Toroidal Field B_T	0.46 T
Major Radius R	0.58 m
Minor Radius a	0.41 m
Elongation k	1.8-2.2
Triangularity δ	0.1-0.4
Plasma Density	10^{19} m^{-3}
Ion Temperature T_i	1 keV
Pulse Length t_d	5 s

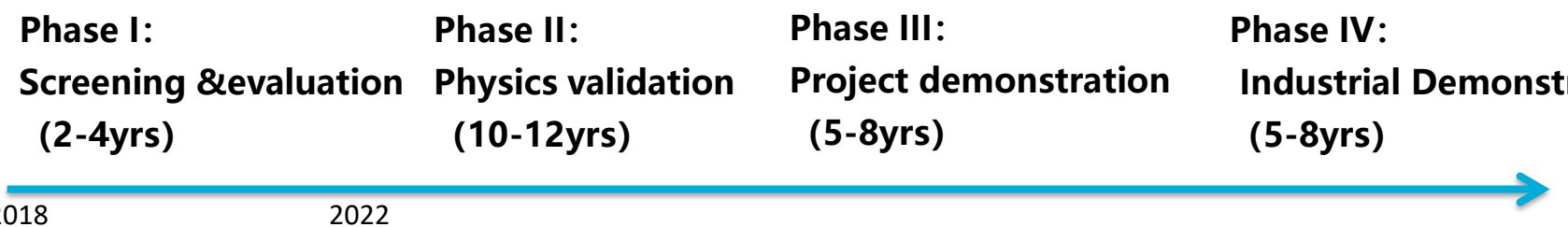
ENN has designed and built the first medium-scale Spherical Tokamak experimental device EXL-50. On August 8, 2019, the first solenoid-free plasma discharge was produced on "EXL-50 ".

EXL-50 Proof-of –Principle Experimental Platform

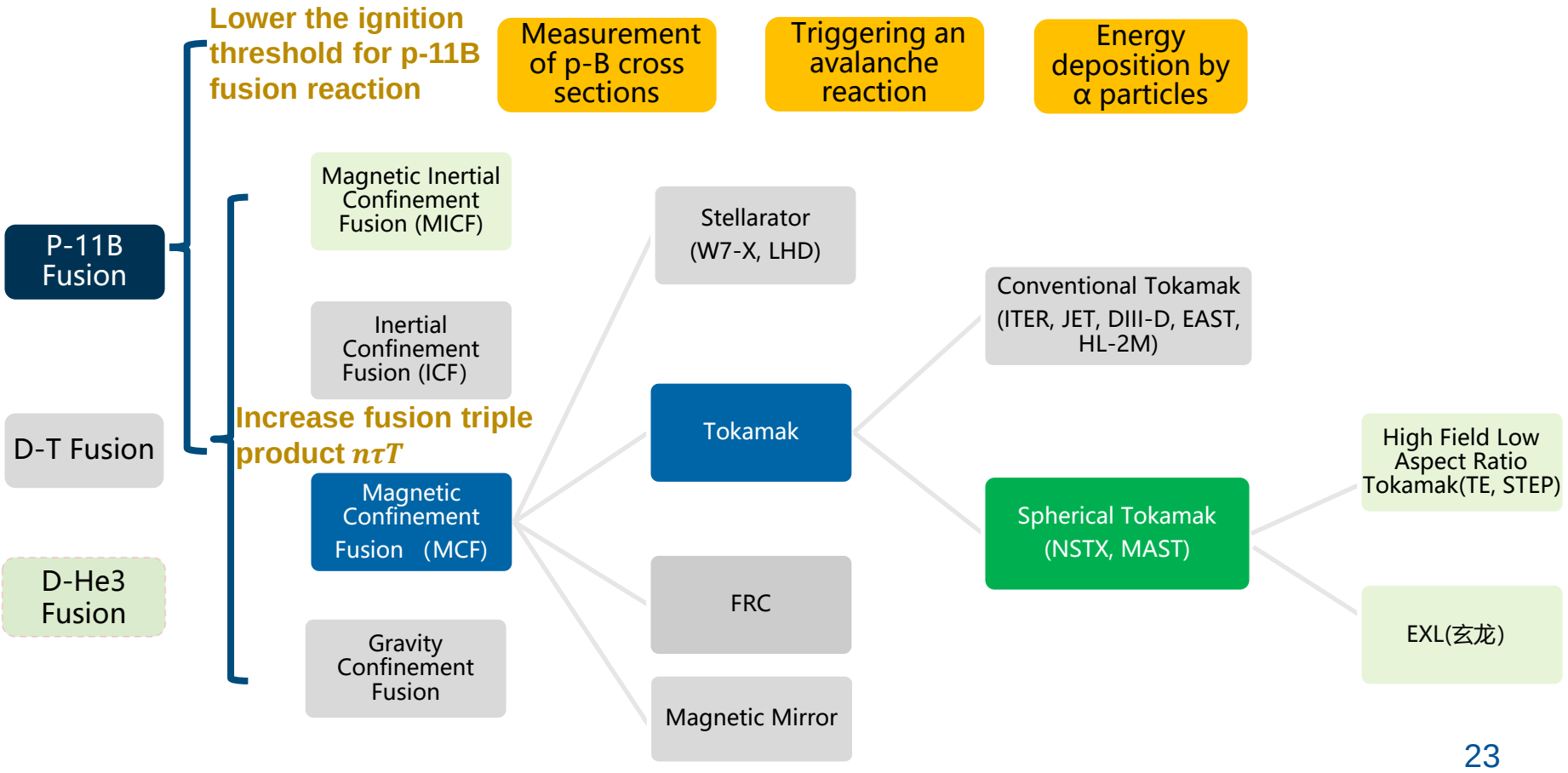


ENN Compact Fusion Timeline

Conduct Scientific Feasibility Study | **Address Engineering Challenges** | **Improve Cost Effectiveness**



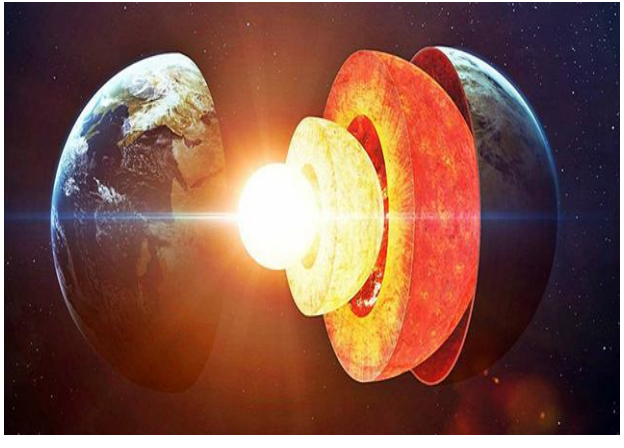
Explore P-11B Fusion based on Spherical Tokamak



Deep Geothermal Energy

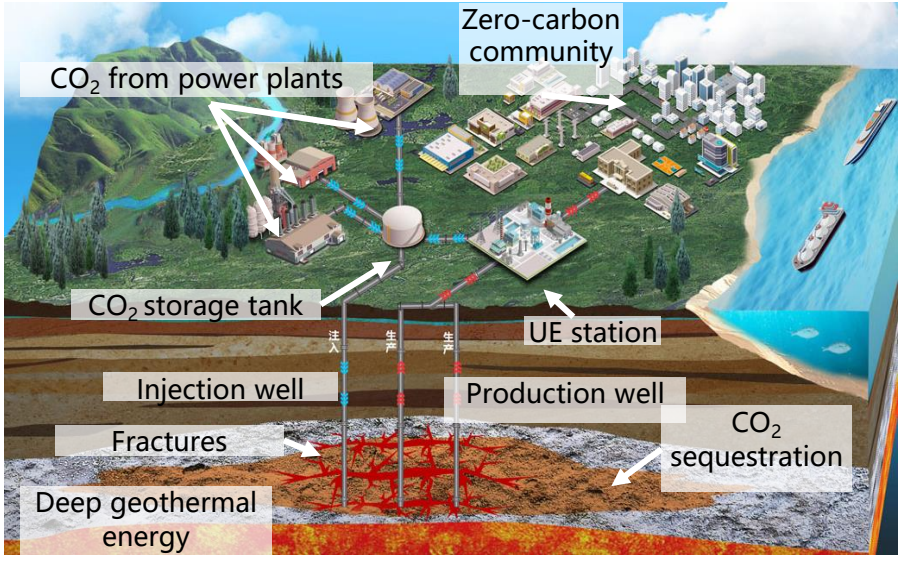
Geothermal heat is a renewable energy resource from deep within the Earth's core caused by radioactive material decay and is transferred by molten magma and intense pressures to crust.

Predicted by BP， geo-thermal will weight 3rd of all energy consumptions globally in 2050



Enhanced Geothermal & Carbon-capture System (EGCS):

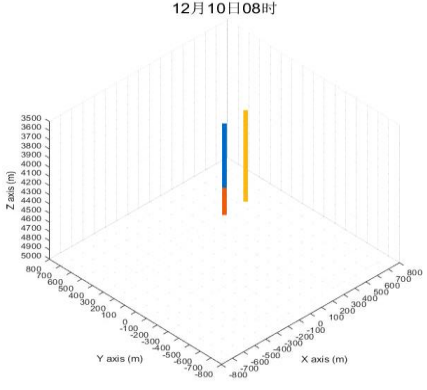
- ✓ Deep geothermal energy （300℃-450℃）
- ✓ At depth of 3km-10km
- ✓ Medium: supercritical CO_2



Deep Geothermal Energy

Resource exploration and site selection

- Developed fractures monitoring and imaging technology
- Site selection and evaluation techniques for the formation of hot dry rocks
- Regional tectonics and geothermal geology;
- High temperature geothermal geophysical exploration



Micro-seismic monitoring

Advanced energy drilling

- The first energy drilling laboratory in China
- 9 types of steam plasma torch prototype
- Steam plasma torch 50KW, 200hours

Deep Geothermal Energy

High temperature rock true-triaxial lab

- 300℃×100MPa (up to 400℃)
- Rock mechanical characteristics, fracturing mechanism, tools, materials and CO2 geological storage under high temperature and pressure

- To increase the complexity of the fracture system, fractures are generally segmented.
- ENN is the first company capable of offering **high temperature temporary blocking agent** (150℃, 180℃, 200℃, 250℃, 300℃)

200℃ 250℃ 300℃

Advanced Energy Materials

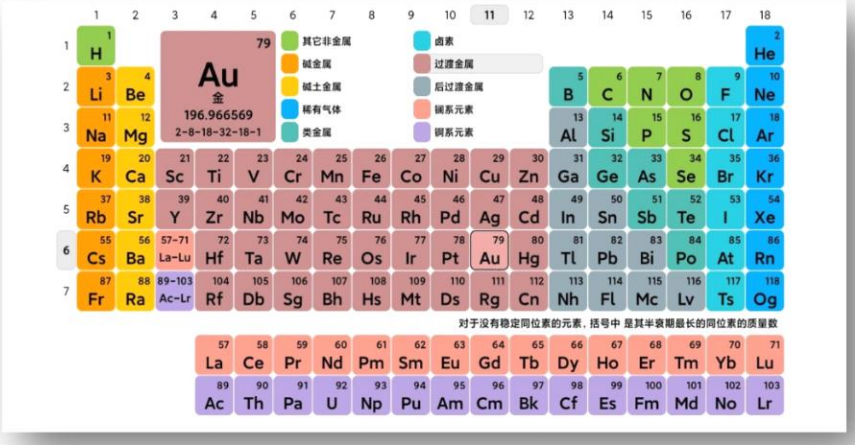
Main research areas:

High Temperature Superconducting Technology

Thermoelectric Materials

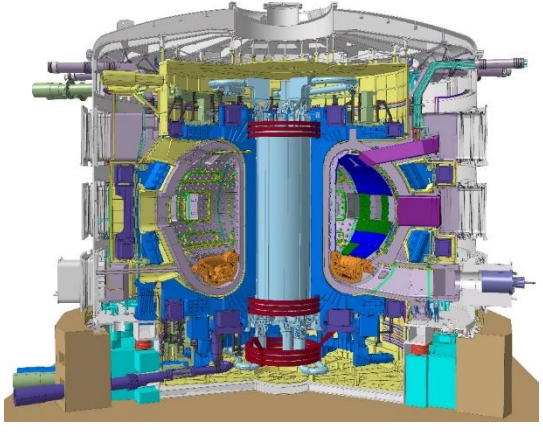
Fusion Materials

Cathode Materials



High Temperature Superconducting Technology

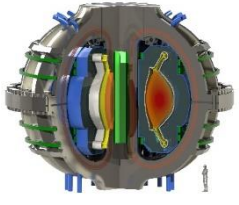
ENN focuses on the research of high-temperature superconducting magnet technology for fusion, including large-scale high-temperature superconducting magnet coil technology, compact central solenoid technology, cable and conductor technology, coil internal and inter-cable joint technology, quench detection and protection technology, etc.



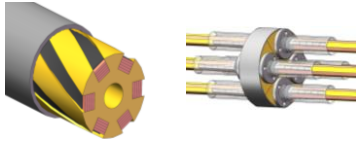
LTS fusion device

Advantage:

With the same fusion power, the volume of the HTS device is significantly smaller than that of the LTS device.

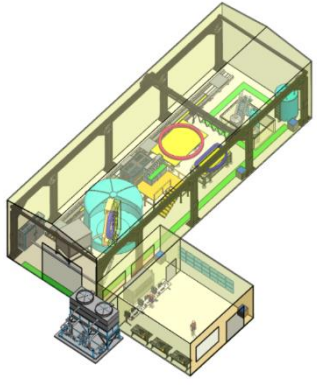


HTS fusion device

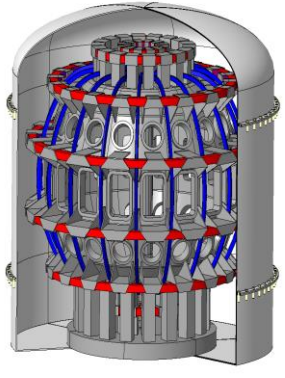


HTS conductor, joint

HTS coil



HTS magnet test platform



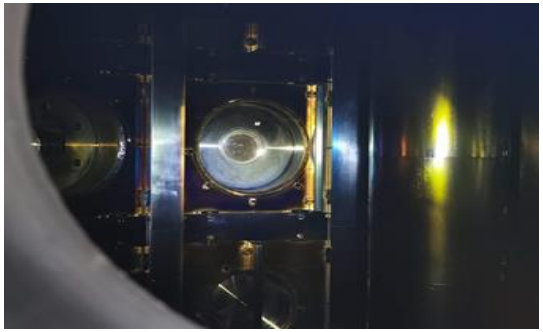
HTS fusion device

Fusion Materials

Wall conditioning and fueling technique

We focus on suppression of impurity and recycling reduction, while explore fueling technology for Hydrogen-Boron reaction.

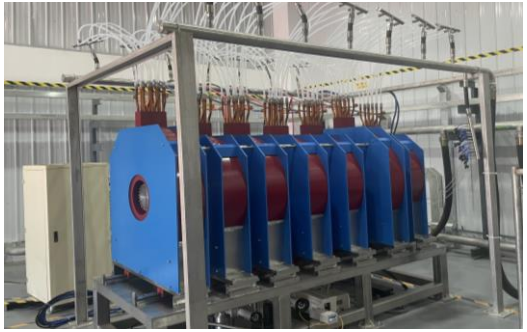
Our boronization technology provides a guarantee for EXL-50 experiments, while boron particles injection technique fosters the promotion of plasma parameters



EXL-50 wall after boronization

Plasma-facing material

The mechanism of plasma-wall interaction process is key to solve the fusion materials issue. We conduct research on PWI and develop new materials for fusion reaction based on the Plasma linear device.



PWI equipment

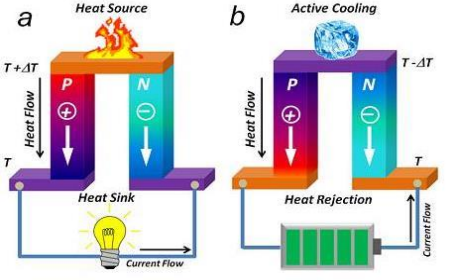
Boron nuclear target

We use magnetron sputtering method in PVD and CVD equipment to prepare nano-scale to micro-scale self-supporting boron targets, which has been used in hydrogen-boron fusion physics verification experiment.

Boron target fabrication equipment

Thermoelectric Materials

ENN is the first enterprise in China to develop thermoelectric technology at medium/high temperature (400~600 ℃).



Advantages

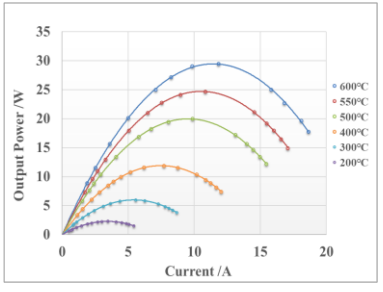
- Direct conversion of thermal energy and electric energy
- All solid, no noise, fast response, no moving parts and harmful working medium , multiple heat sources

Ability

- Full process preparation and test
- Customers include energy, vehicle and other scientific research institutes

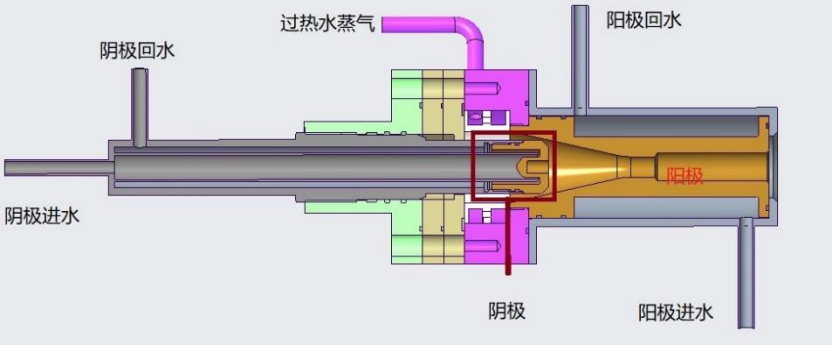
Application

- Space probe power
- Deep sea exploration power
- Industrial waste heat power generation
- Automobile exhaust power generation
- Island power
- Refrigeration



Cathode Materials

The service life of cathode materials used in high-temperature steam plasma torches(at 200 kW) has reached 370 hours.



3D model of plasma torch

Characteristics

- Heat and hot electron emission obtained
- Low electron work function, high oxidation resistance, low evaporation, good thermal conductivity and conductivity.

Ability

- Full process preparation and research of cathode materials, good at powder metallurgy and refractory metal smelting
- Strong process stability, long service life, strong electron emission ability and high arc stability

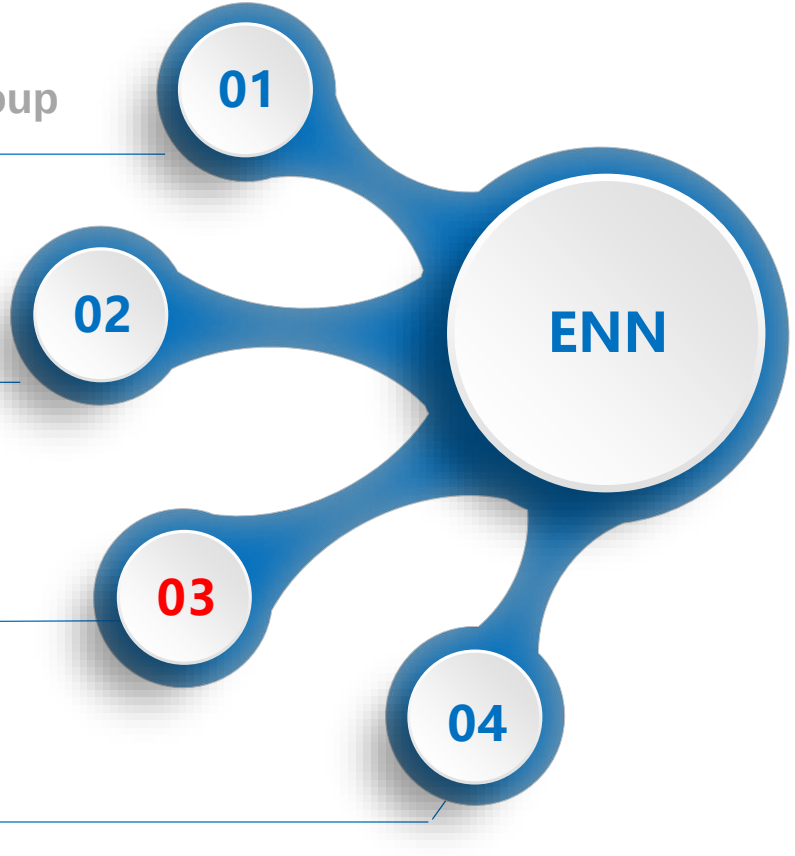
Application

- Deep geothermal drilling
- Hazardous waste treatment
- Plasma cutting
- Plasma spraying
- Refractory metal smelting
- Preparation of nanomaterials

EPT00

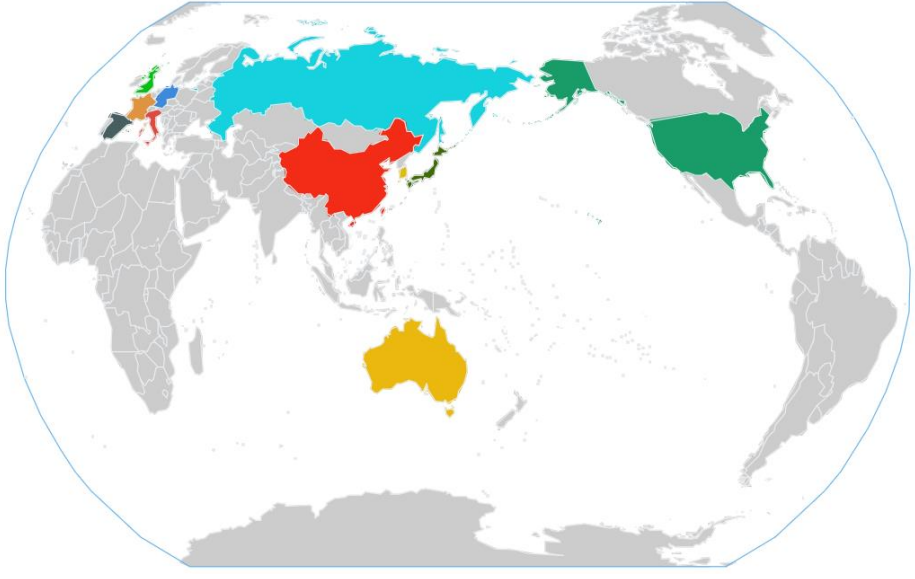
EPT04F

CONTENTS



Open Innovation

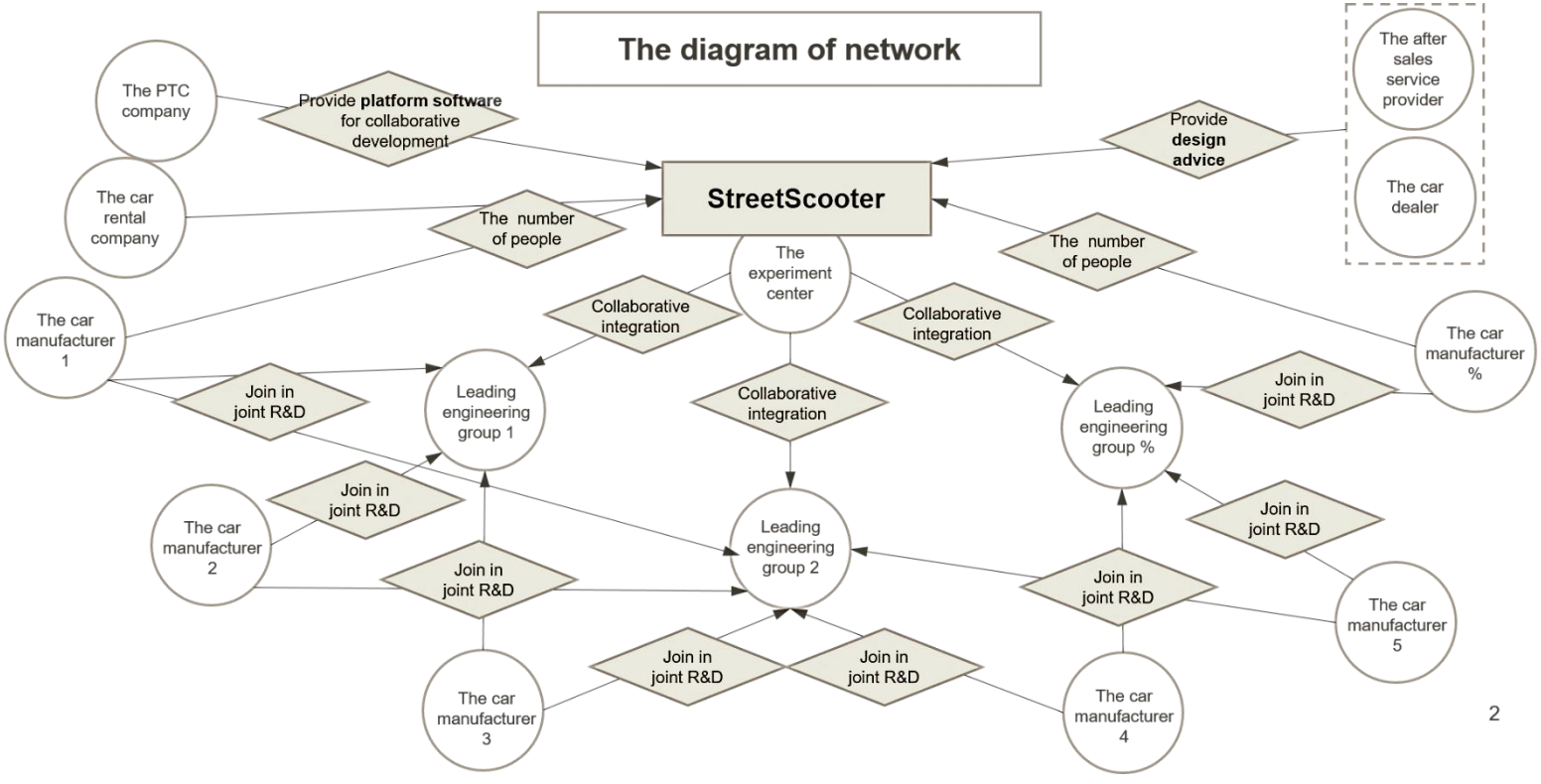
- Innovation and collaboration is in our DNA. In partnership with preeminent universities, research institutes, governments and companies, we proactively seek ways to make a significant and sustainable impact.



Peking University
Zhejiang University
Xi'an Jiaotong University
北京大学 PEKING UNIVERSITY
ASIPP
Tsinghua University
Tianjin University (Peiyang University)
Massachusetts Institute of Technology
University of Science and Technology of China
TECHNISCHE UNIVERSITÄT DRESDEN
中国科学院近代物理研究所
Institute of Modern Physics, Chinese Academy of Sciences

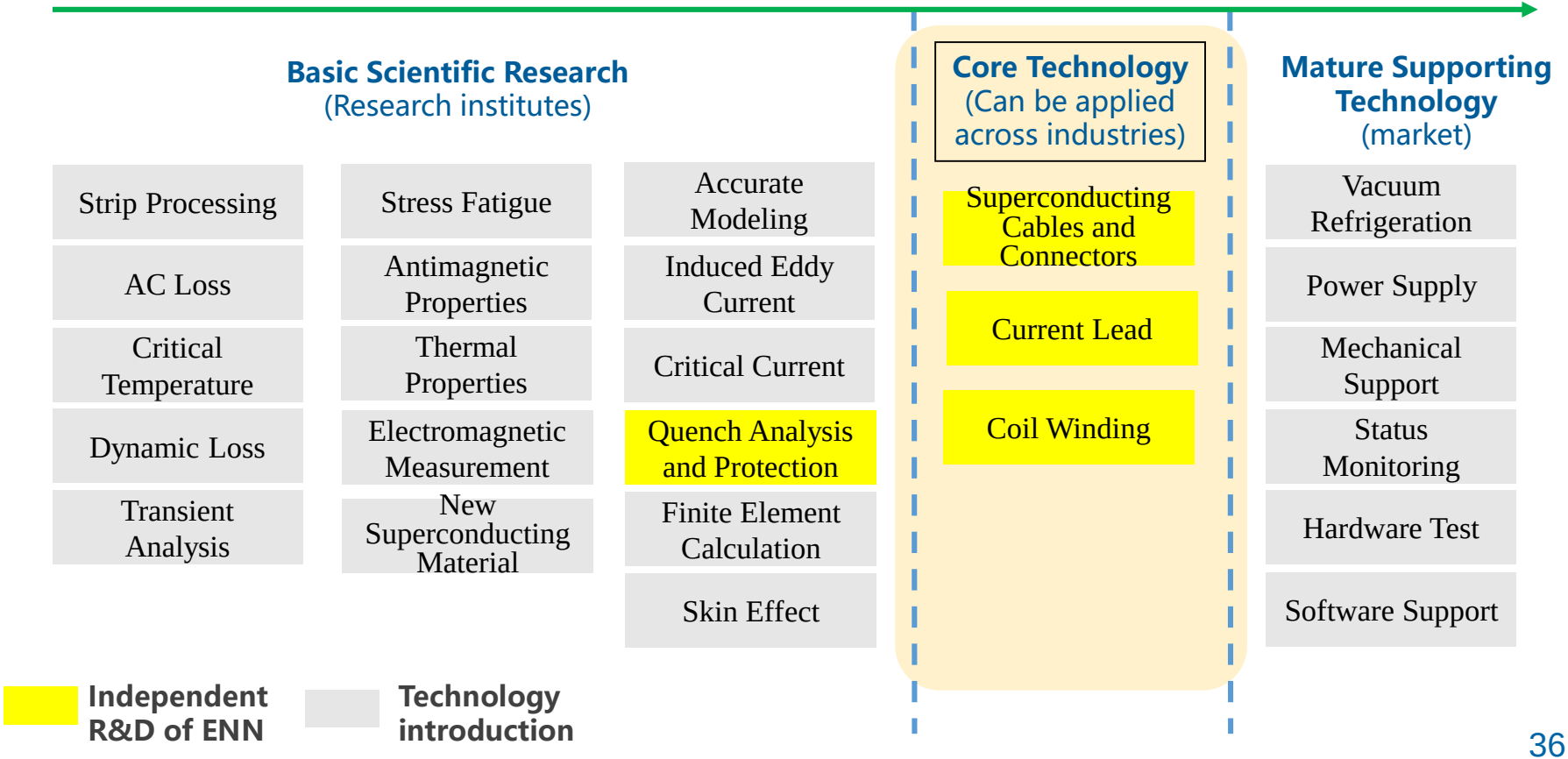
Global R&D Trends - Openness and Innovation

Taking the StreetScooter company as an example



Key Technologies Readiness Assessment

TRL of high temperature superconducting magnets

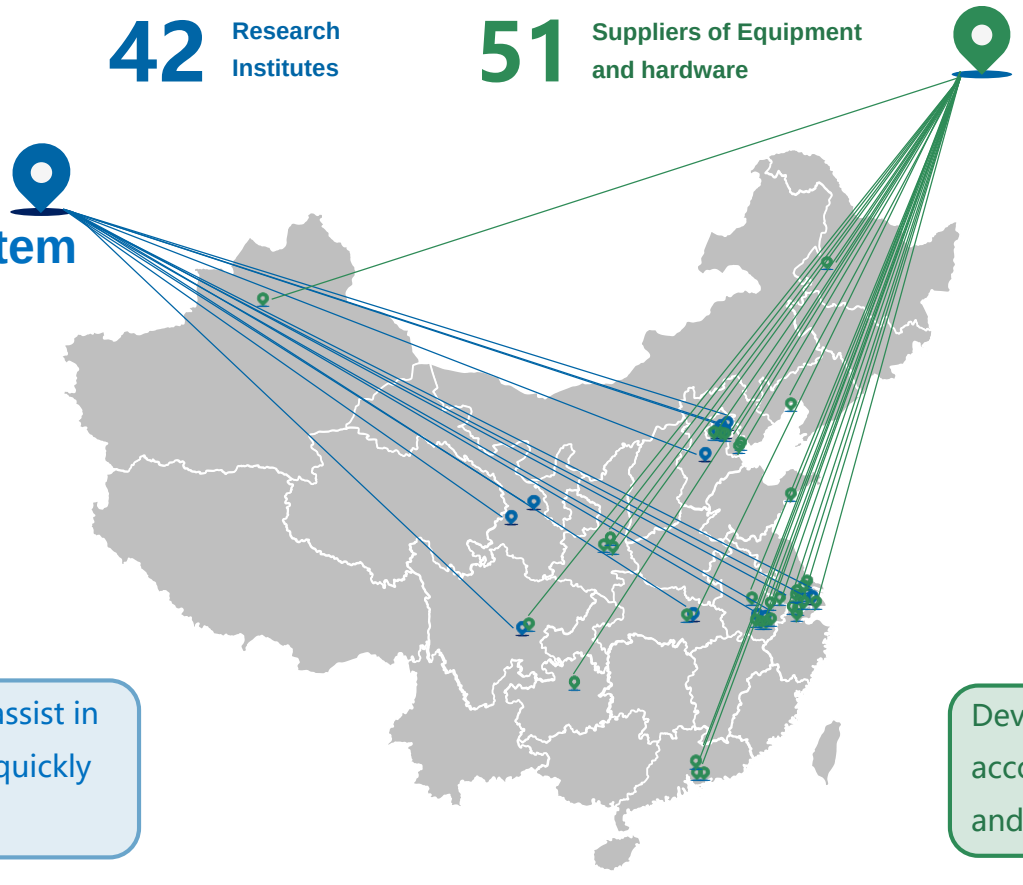


Build a Resource Ecosystem

147 Technical experts, leading scholars

42 Research Institutes

51 Suppliers of Equipment and hardware



R&D Ecosystem

- Cable/Conductor
- Coils
- Quench Analysis and Protection

Carry out cooperation, assist in technical research, and quickly replenish capabilities

Manufacturing Ecosystem

- Strip
- Cable
- Conductor/connector
- Feeder
- Low temperature
- Vacuum/pump
- Power Supply
- Screen/Dewar
- Support system

Develop procurement plans according to demand time and integrate systems

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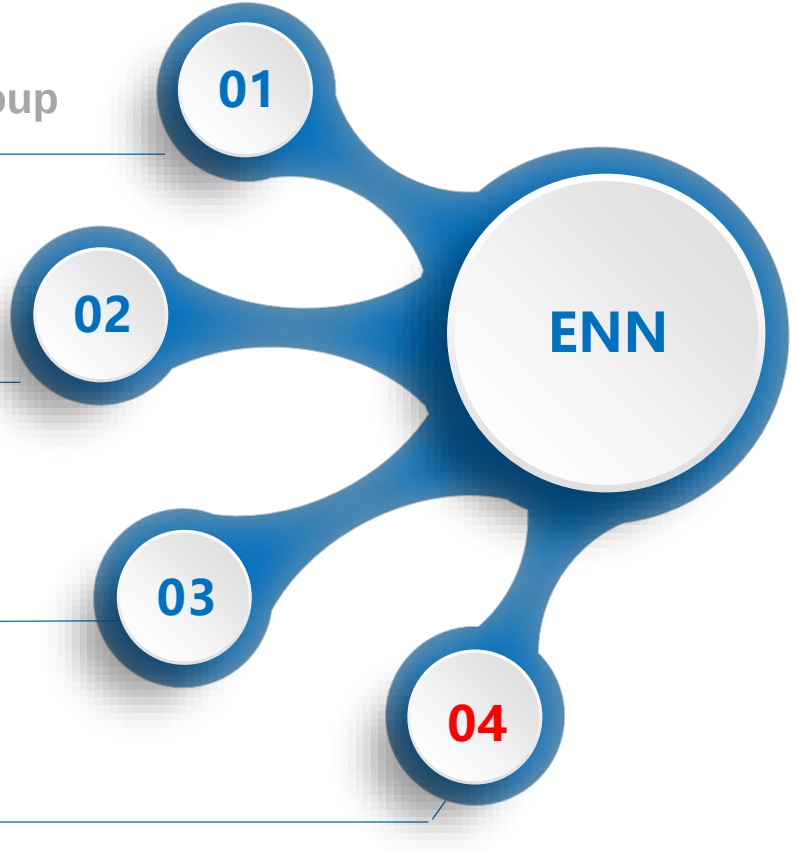
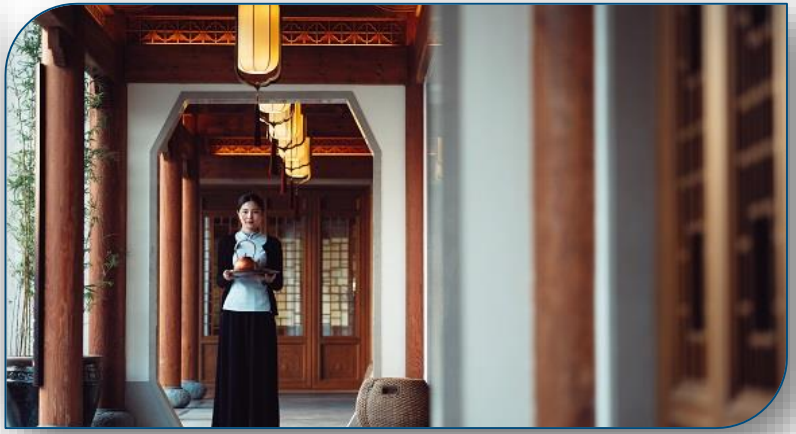


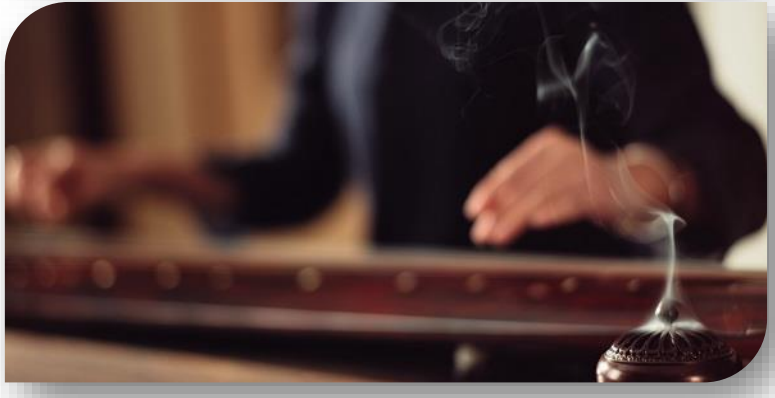
ENN at a Glance

ENN at a Glance



ENN at a Glance

ENN at a Glance



Conferences& Events

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