

Fuctional carbon materials

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Application of carbon materials

Electric and Heat Conductions

- Conductor and Semi-conductor

Energy Storage

- Battery anode
- Super capacitor
- Gas storage

Environmental Protection

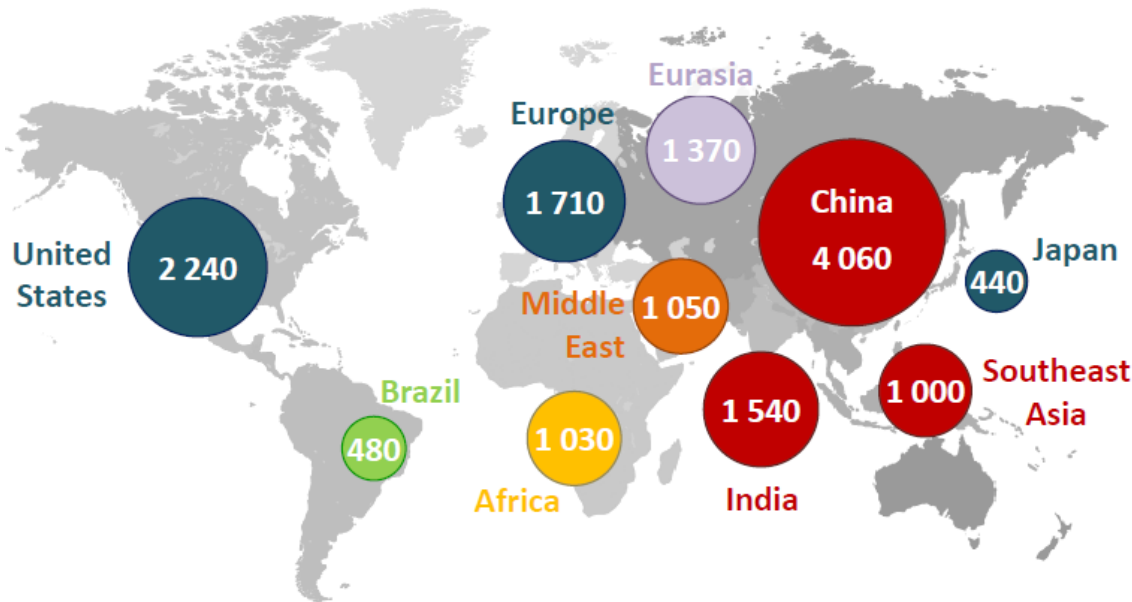
- Activated surface

Mechanical
Reinforcement

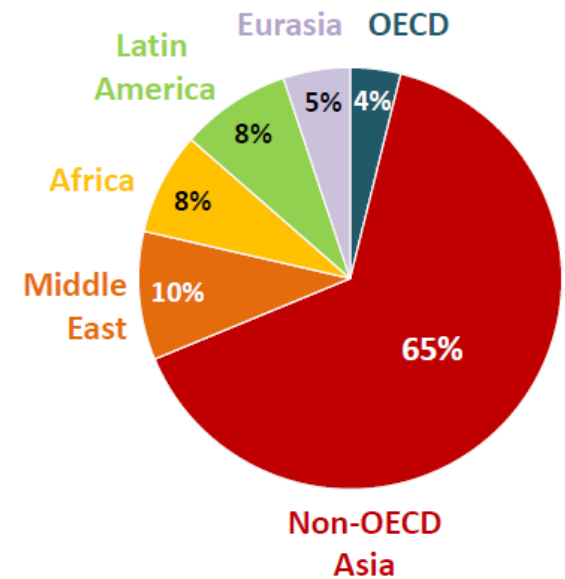
High Temperature
Materials

Forecast of World Energy Demand

Primary energy demand, 2035 (Mtoe)



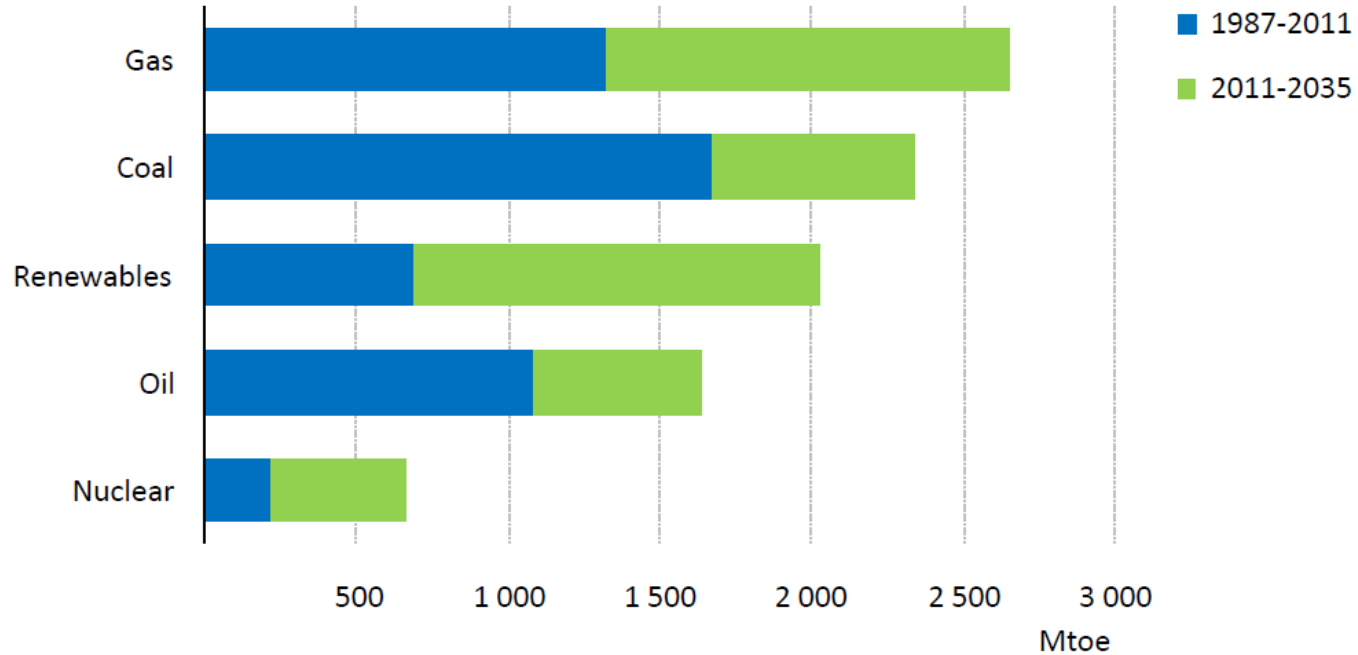
Share of global growth 2012-2035



China is the main driver of increasing energy demand in the current decade, but India takes over in the 2020s as the principal source of growth

Forecast of World Energy Compositions

Growth in total primary energy demand



Today's share of fossil fuels in the global mix, at 82%, is the same as it was 25 years ago; the strong rise of renewables only reduces this to around 75% in 2035

• **Marked Increase of Energy Demand in Asia and Africa in 21st Century**

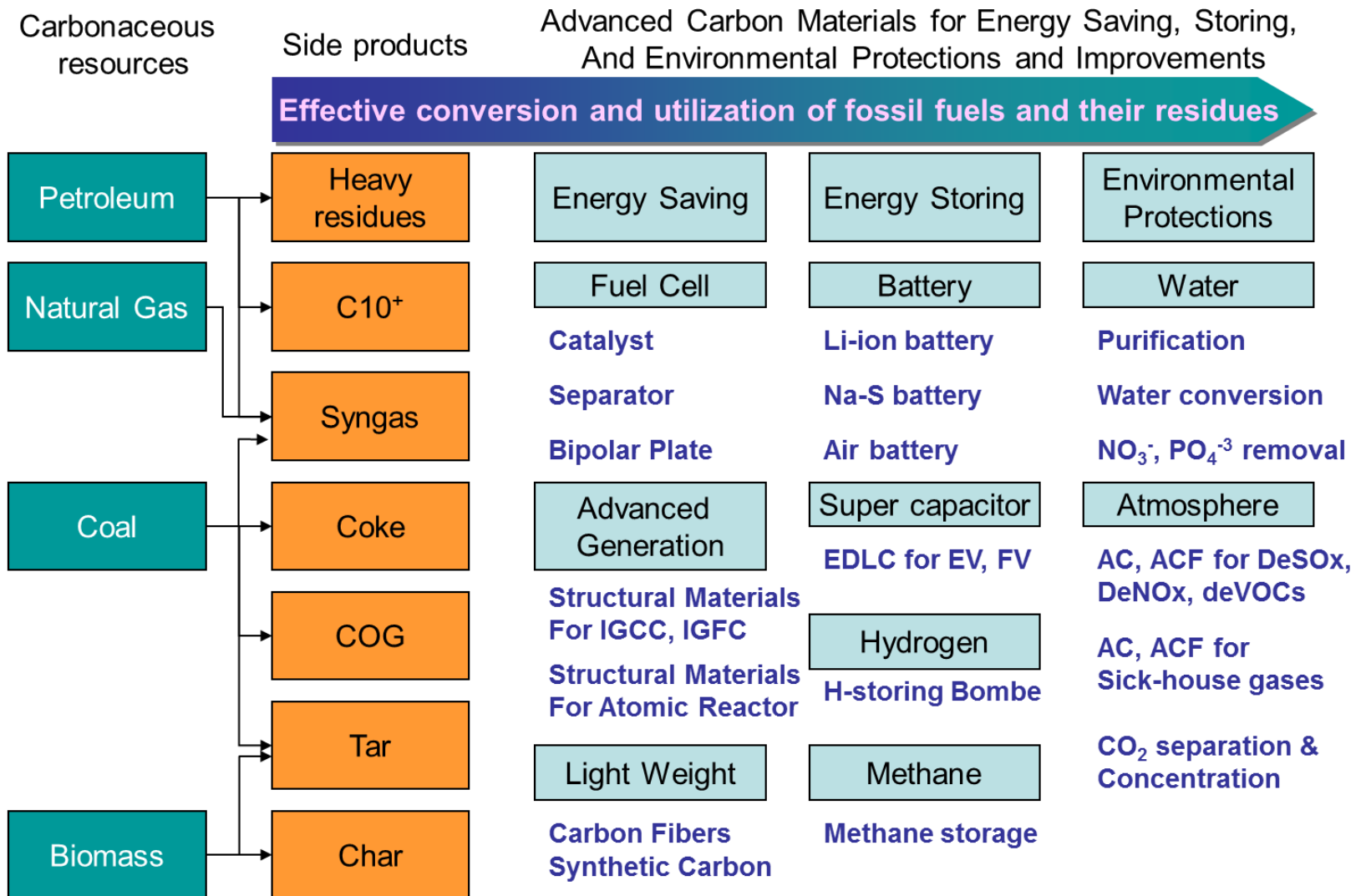
❖ Population x Demand/Head

❖ Three to Four Times of Current Demands of Fossil Fuels ⇒ Increasing By-products of Fossil Fuels

Issues

- ❑ Supply
- ❑ CO₂ Emission Enhances Global Warming
- ❑ **Effective utilization of by-products of fossil fuels**

From fossil fuel to functional carbons



Raw materials and precursors for carbons

Raw materials

Coal tar

Polymer: Thermosetting and thermoplastic

Heavy oil and residues

Biomass

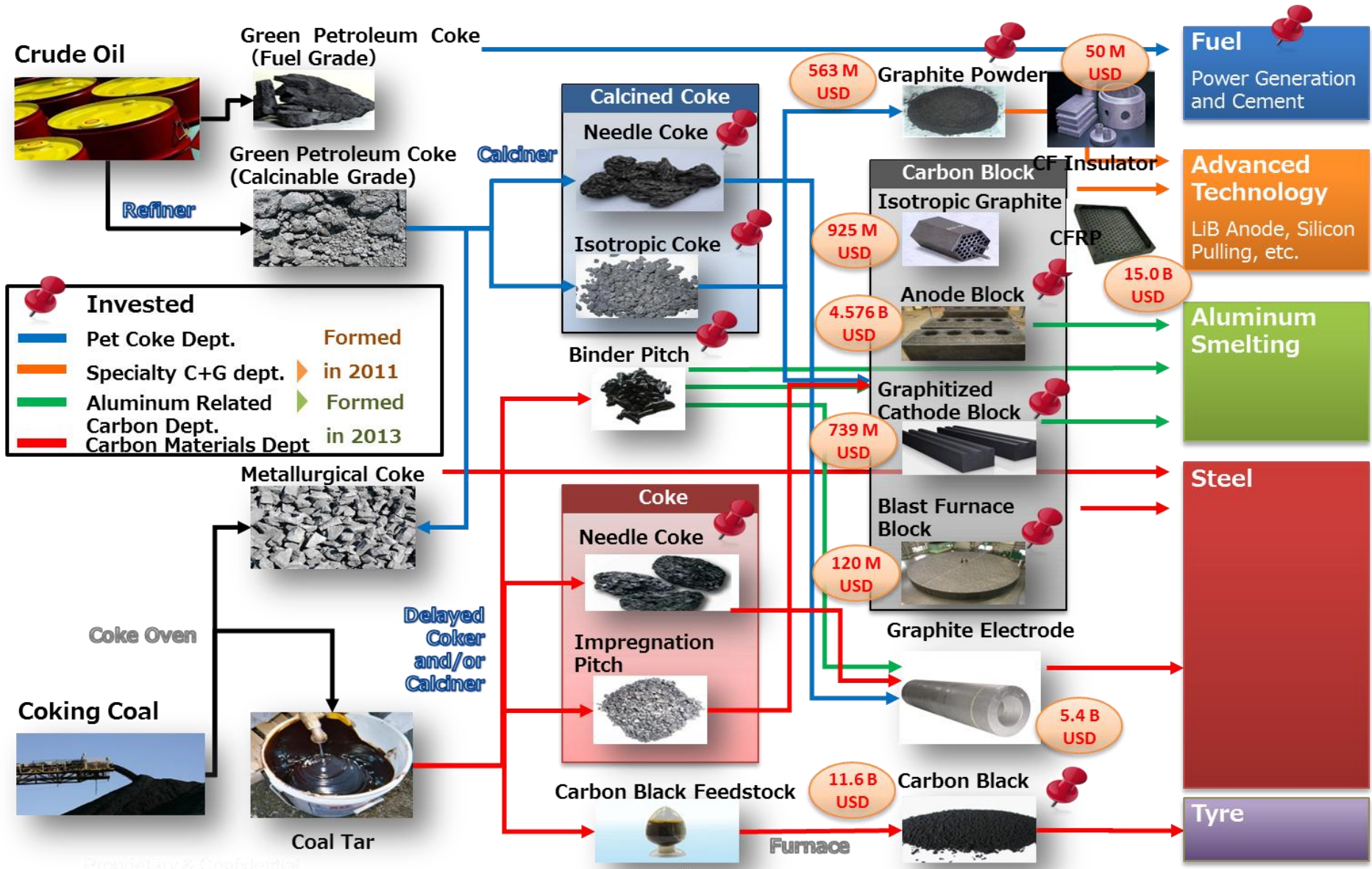
Precursor

- Pitches: CF, ACF, MCMB, Ball type AC, Binder pitch, Additives
- Polymer: AC, ACF, Glassy carbon, CF
- Cokes: Electrode, Capacitor, Battery anode, AC, Additives
- Char: AC, Additives, Reducer for Solar cell

A Historical Development of Carbon



Carbon Industry – Chain Industry



Carbon Industry

Carbon industry is a growth industry.

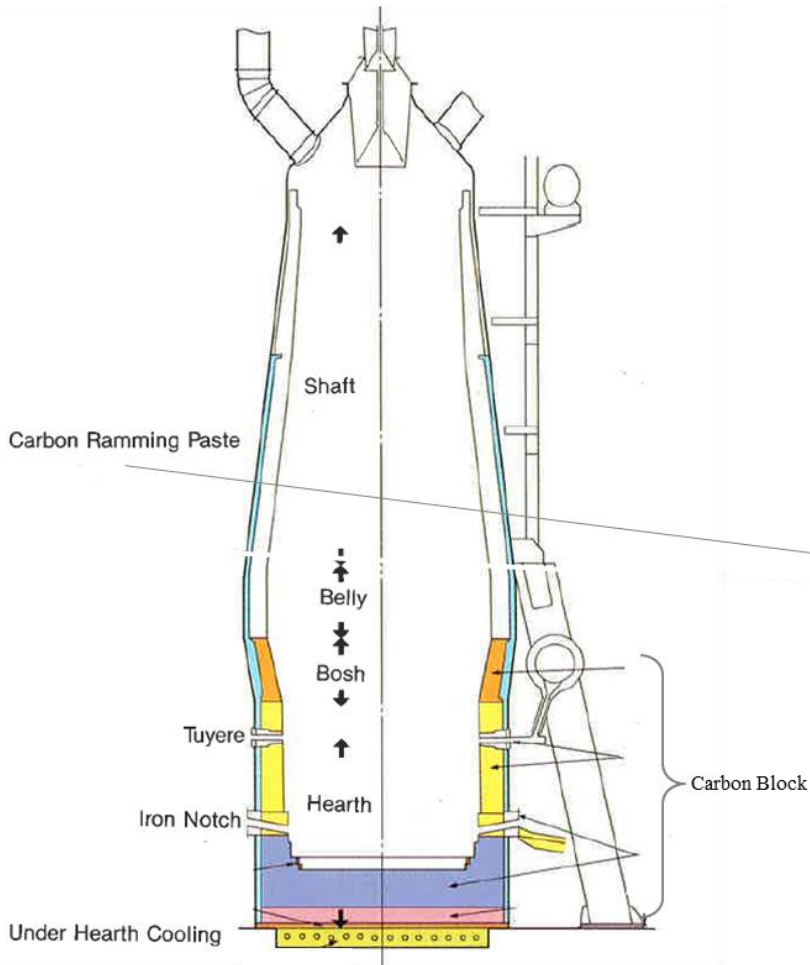
- Energy-saving and environmental protecting are most important in modern society.
- Functional carbons are key materials for the energy-saving and environmental protecting technologies.
- The world markets for functional carbons are still increasing with increasing of energy and environmental related industries.

Steel-Making

Graphite electrode → Needle coke + Binder pitch (Impregnation pitch)

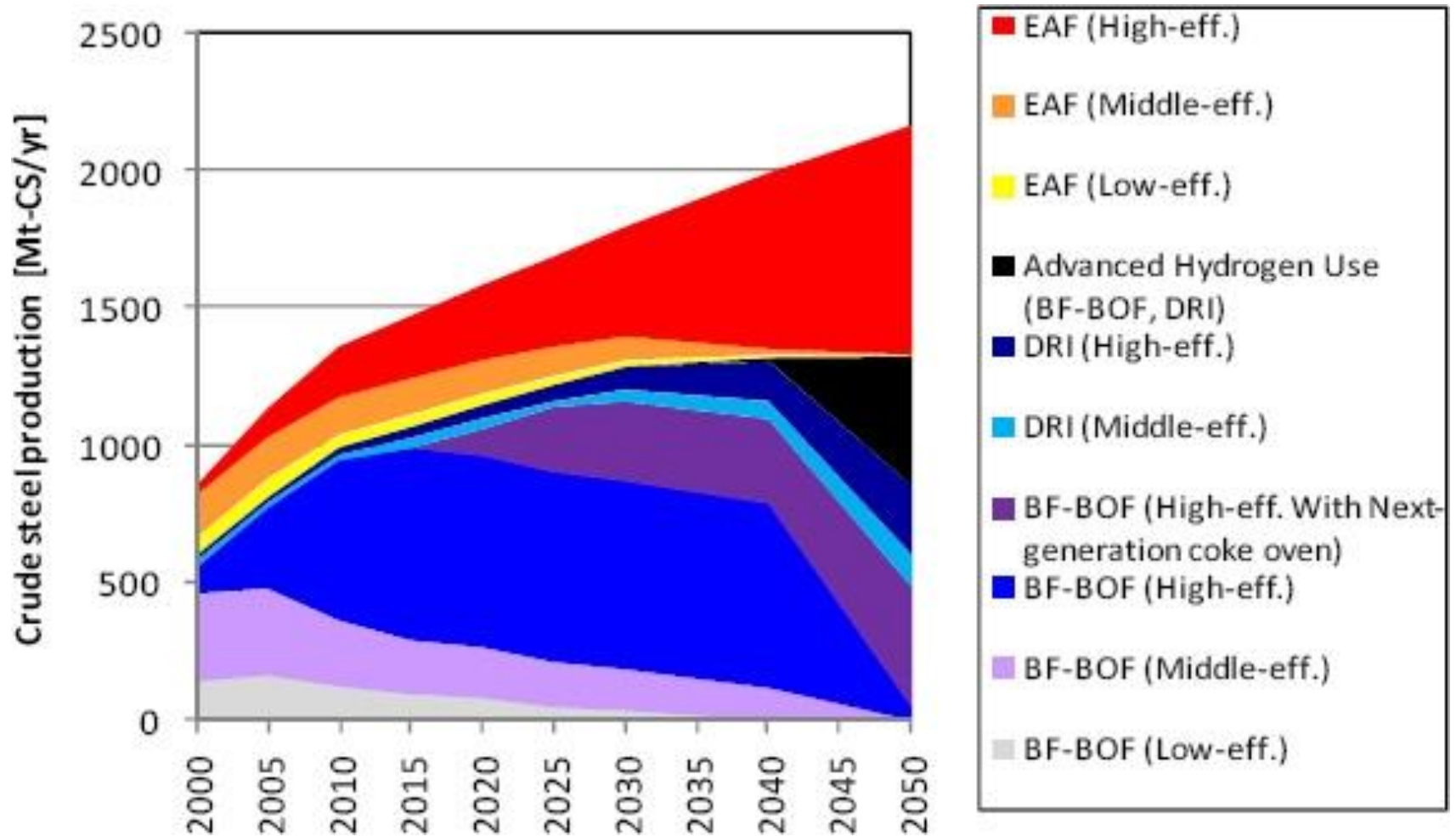
Blast Furnace

Electrical Arc Furnace



Graphite Electrode

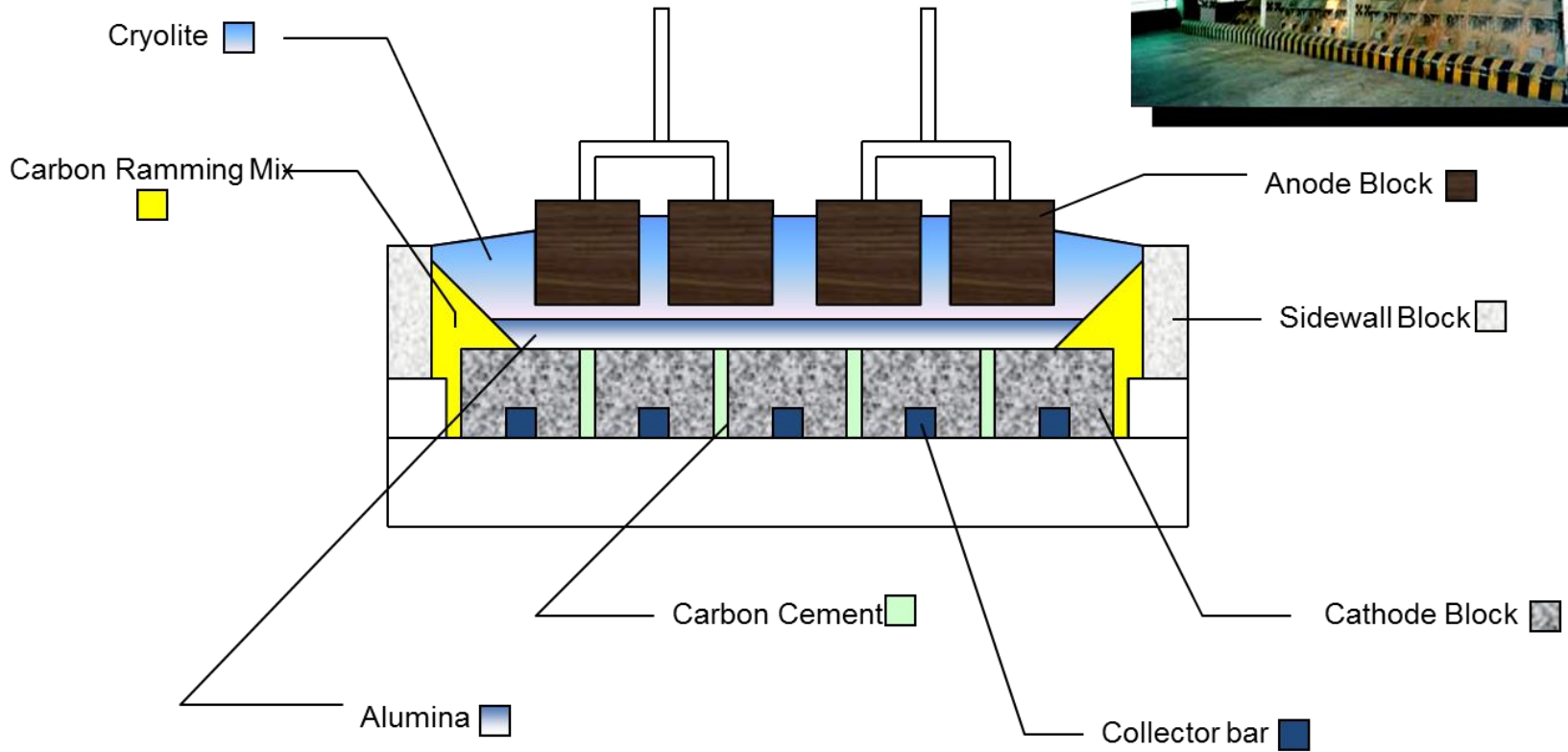
World-wide Record/Outlook for Crude Steel



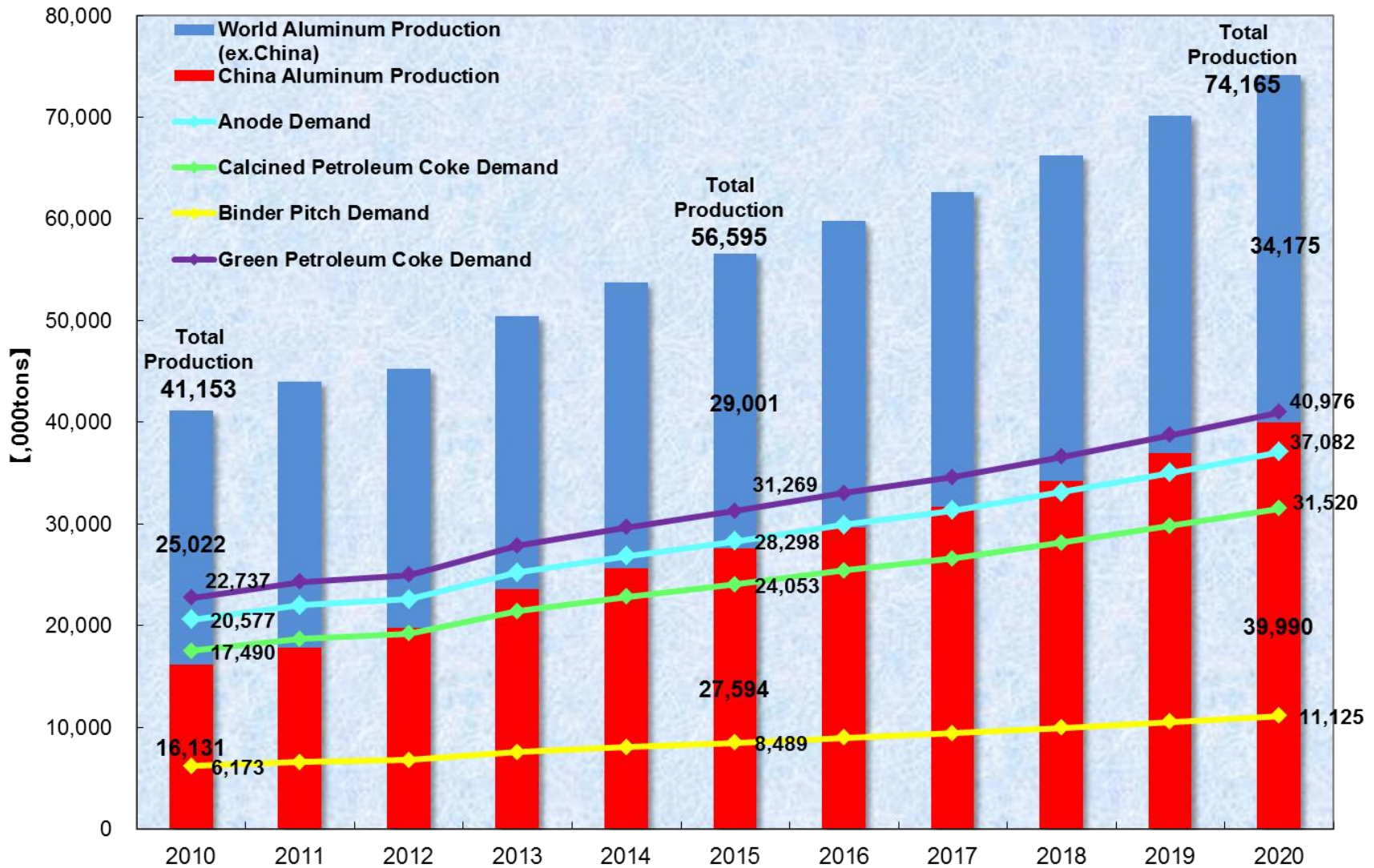
(Data :RITE, 2009)

Aluminum Smelting Cell Configuration

Graphite electrode → Pitch coke + Binder pitch (Impregnation pitch)

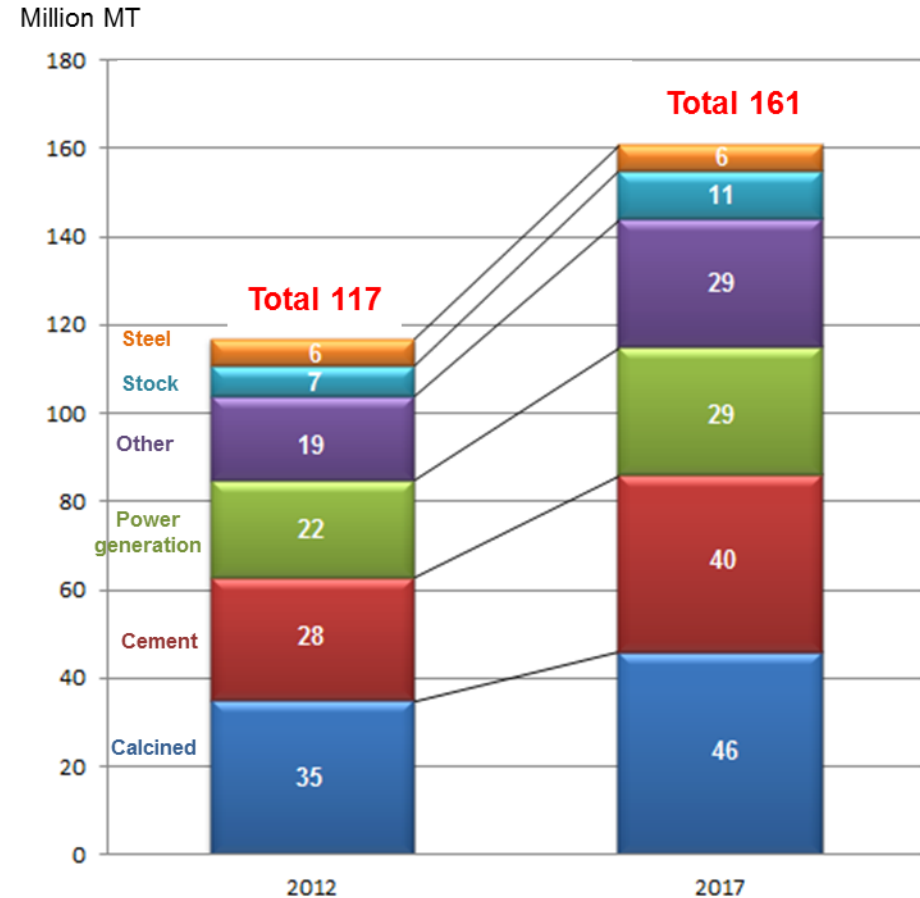
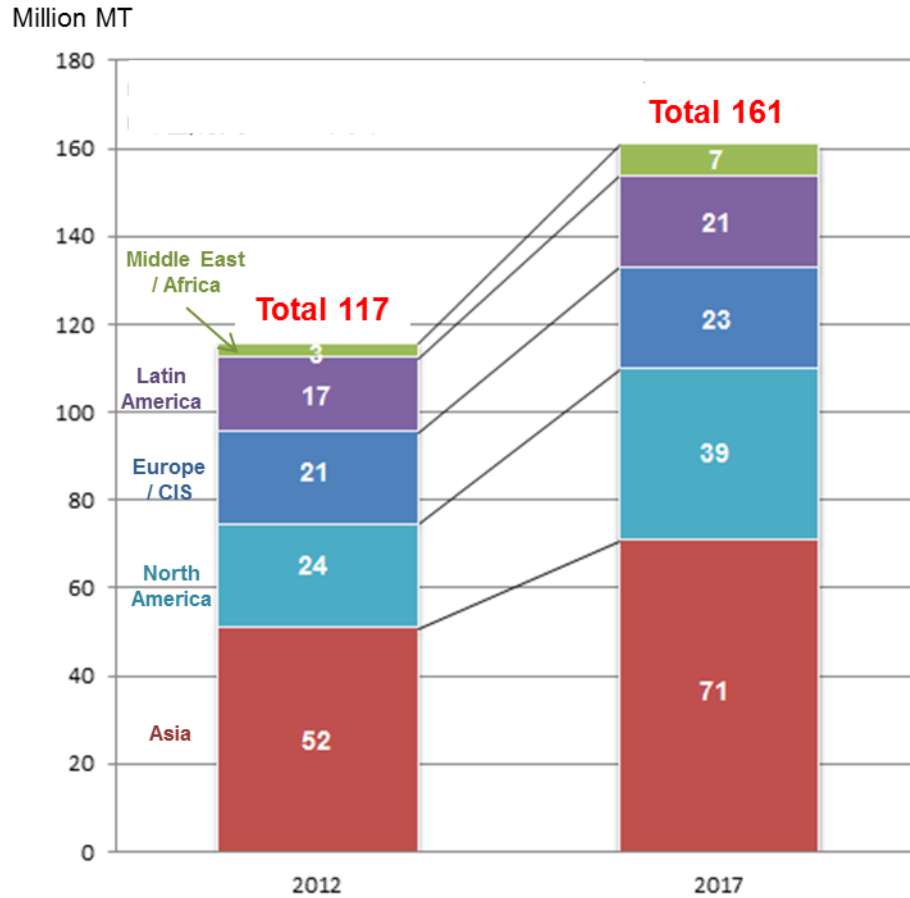


World-wide Record/Outlook for Aluminum



(Data : CRU The Five Year Outlook for Carbon Products 2012 Edition)

World-wide Record/Outlook for Petroleum Coke



(Data :Mitsubishi Corporation)

Carbon is key element for Batteries !!

① Li-ion



[High capacity]

(+) : LiCoO_2

(-) : **Carbon(Graphite)**

Conductor : **Carbon**

② Dry Battery



[Cheap]

[Easy Available]

(+) : MnO_2

(-) : Zn

Conductor : **Carbon**

③ Ni-MH



[High power]

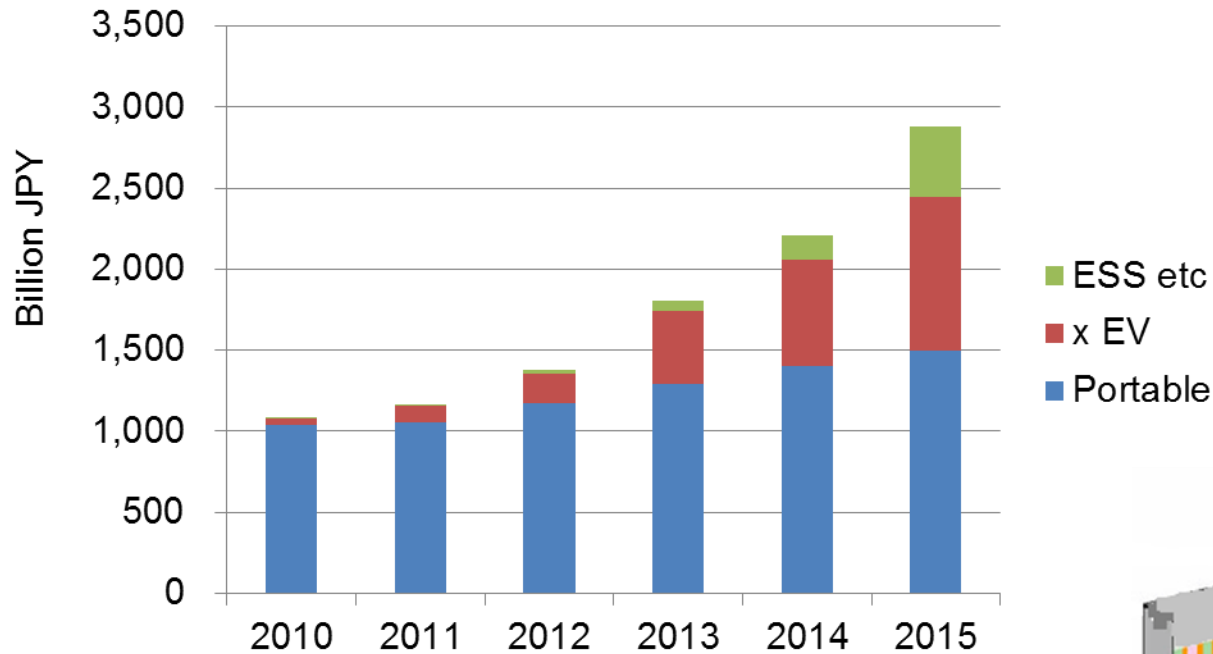
[Total balance]

(+) : $(\text{Ni-Co})(\text{OH})_2$

(-) : $\text{Mm}(\text{Ni-Mn-Al-Co})_5$

substrate: Nickel and **Carbon**

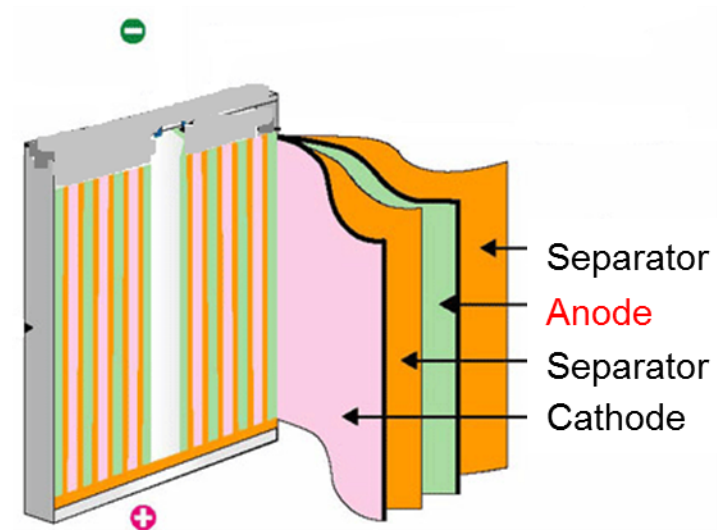
World-wide Record/Outlook for Lithium-ion Battery



(Data :Yano Research Institute. Mar, 2013)

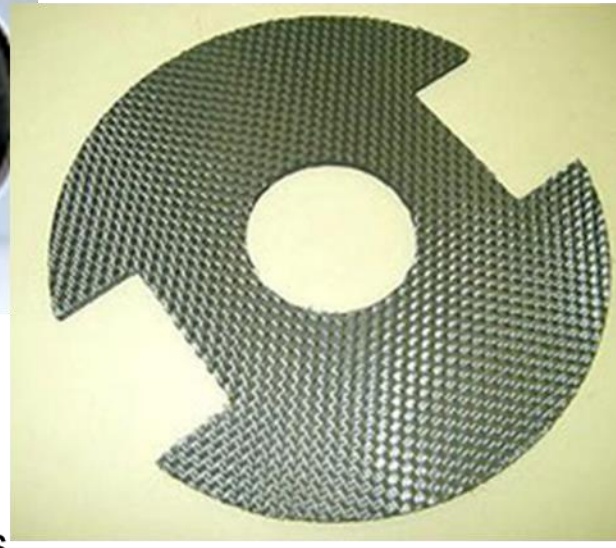
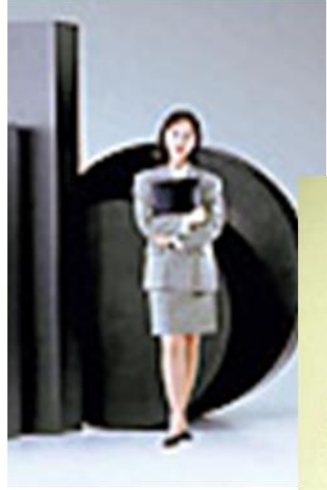
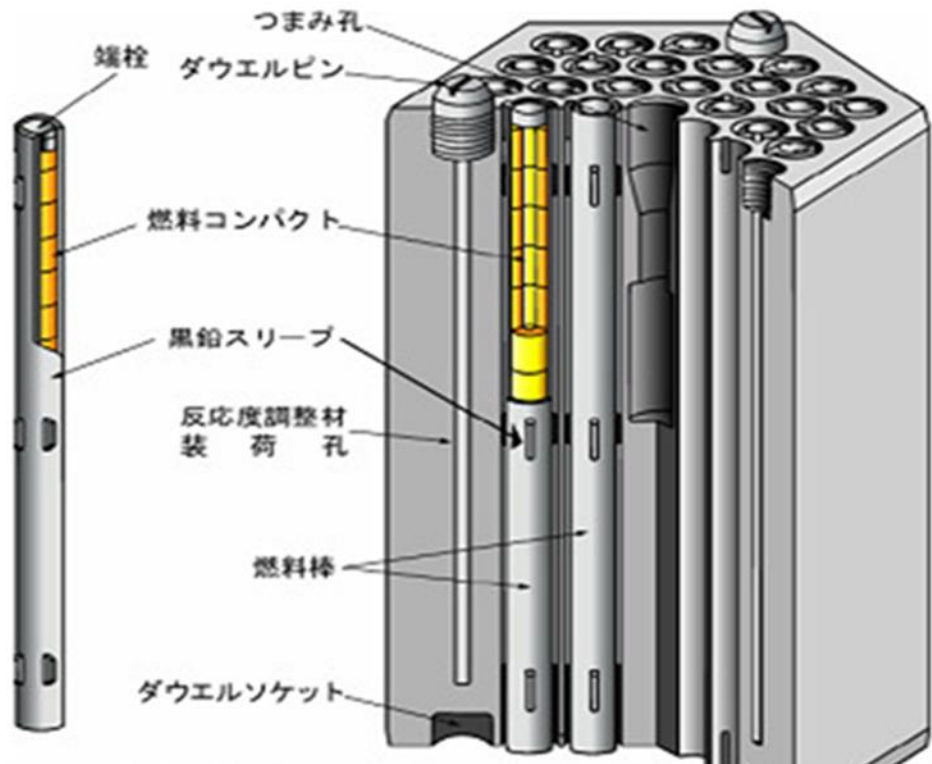
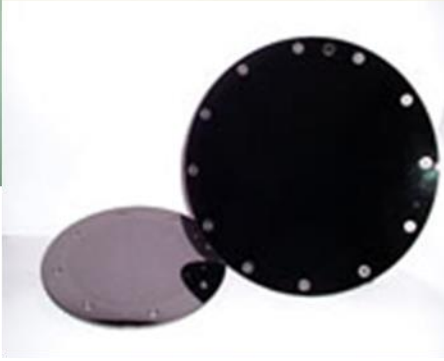
Battery Strategy (METI, 2012)

Target for 50% share of storage battery market(2,000 billion JPY, including LiB, NiMH battery, Lead-acid battery, NAS battery, etc) at 2020.



(Data : Battery Association of Japan)

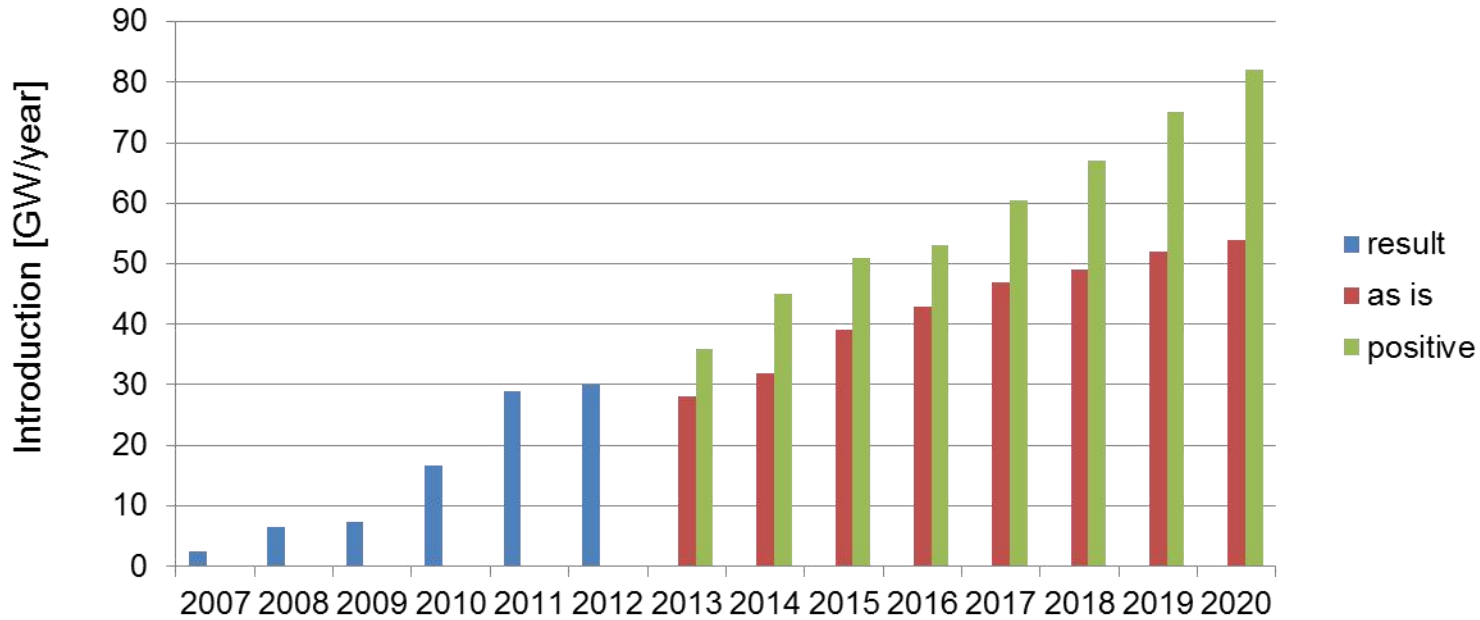
Synthetic graphites



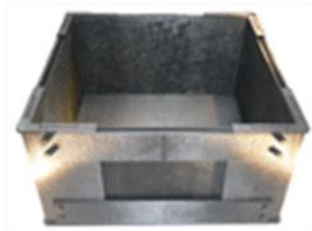
ated Carbons

Carbons for Nuclear

World-wide Record/Outlook for Photovoltaic



(Data :RTS Corporation. July, 2013)



Crucible for polycrystalline silicon manufacturing



CZ Furnace for single crystal silicon manufacturing



PV Panel

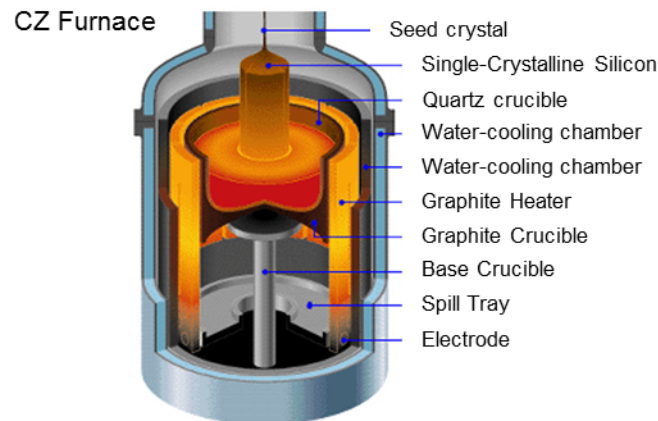
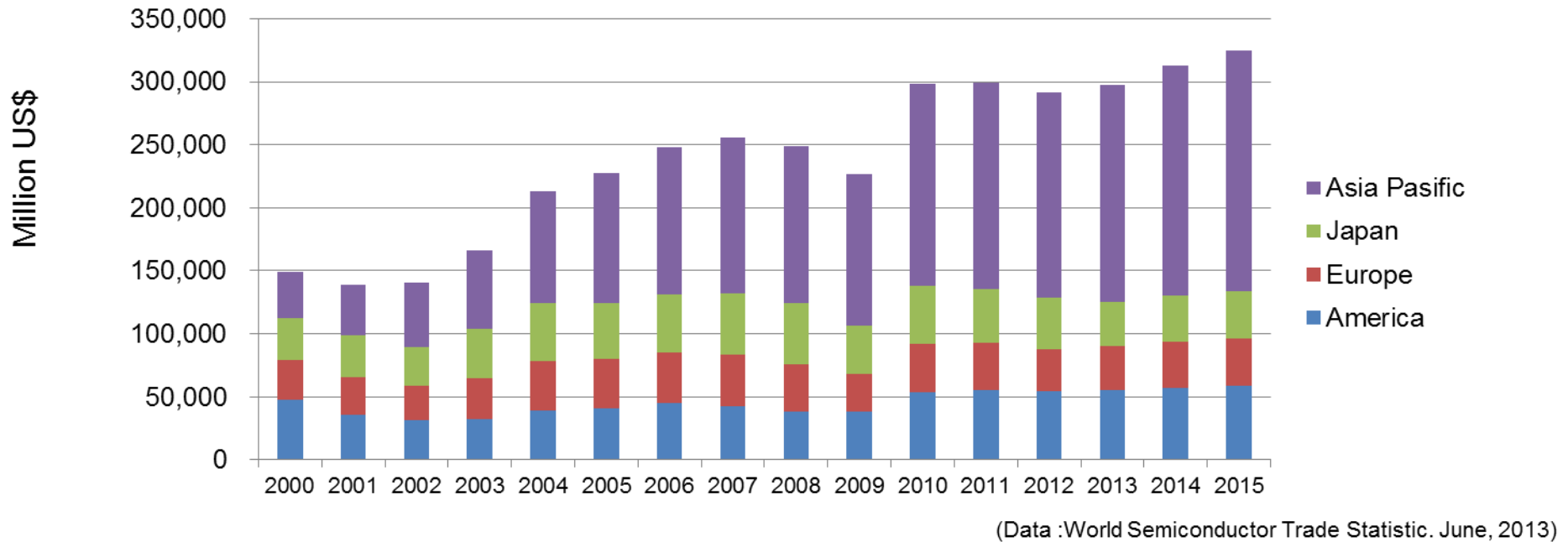
Synthetic graphites for semi-conductors



Tray for Wafer : CFRP composites



World-wide Record/Outlook for Semi-Conductor



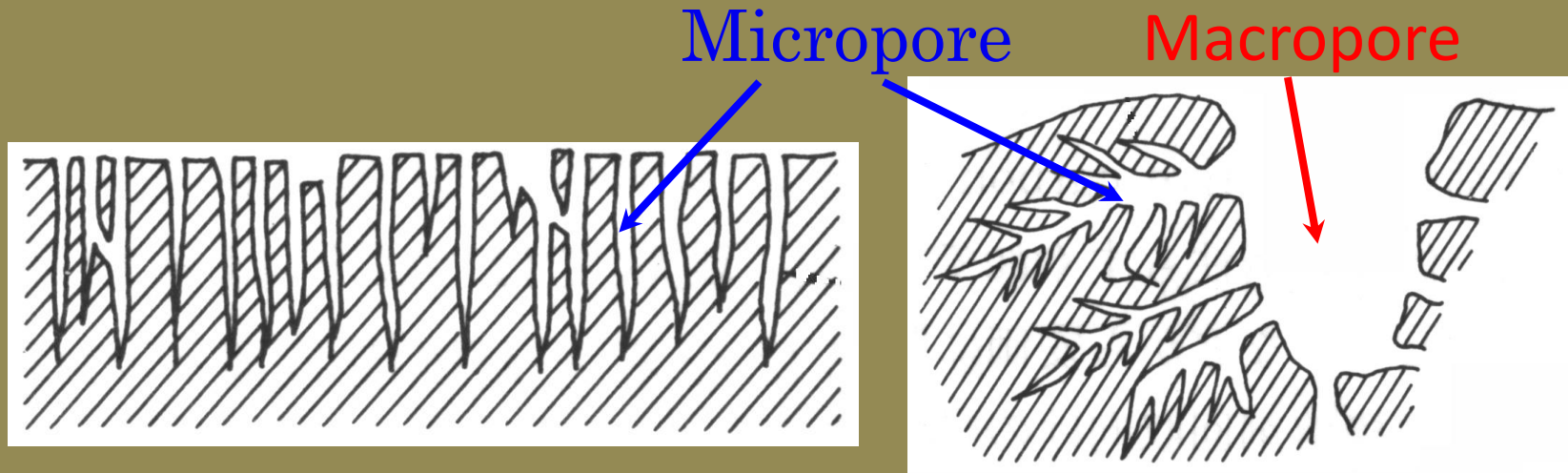
Activated Carbons

Activated carbon fiber

Large surface area
(Large micropore volume)
Adsorption-desorption

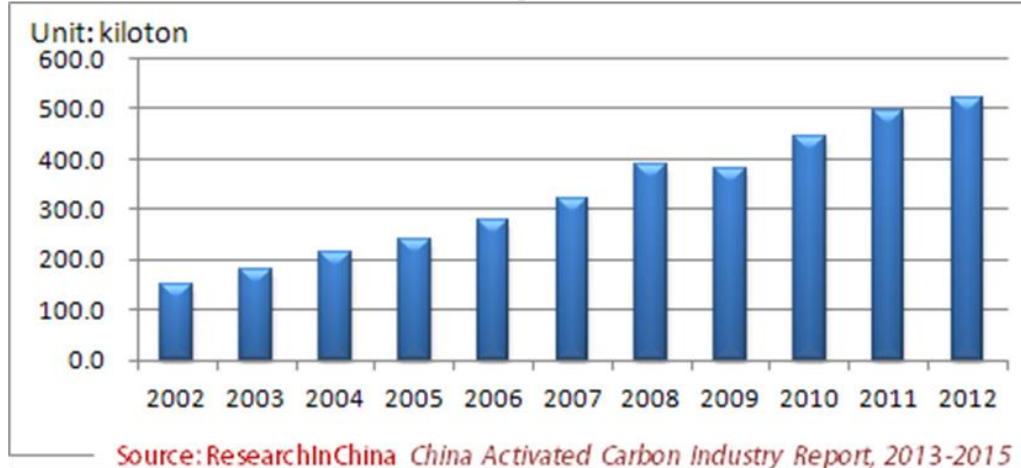
Activated carbon

Small surface area
(Large macropore volume)
Mainly adsorption

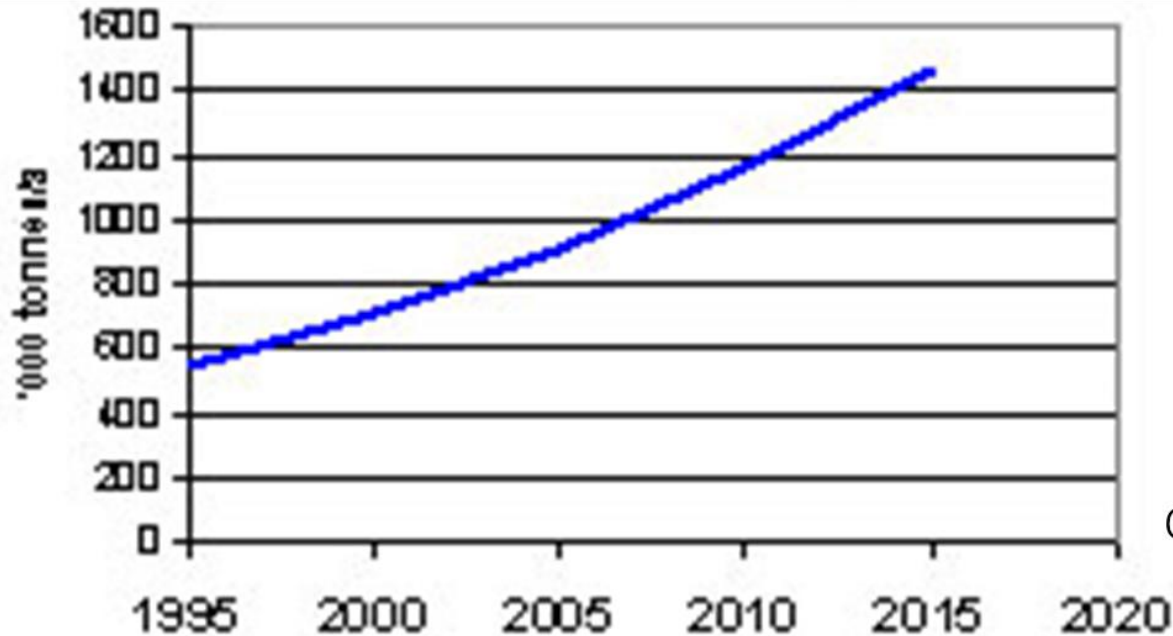


World market trend of activated carbon

Activated Carbon Output in China, 2002-2012

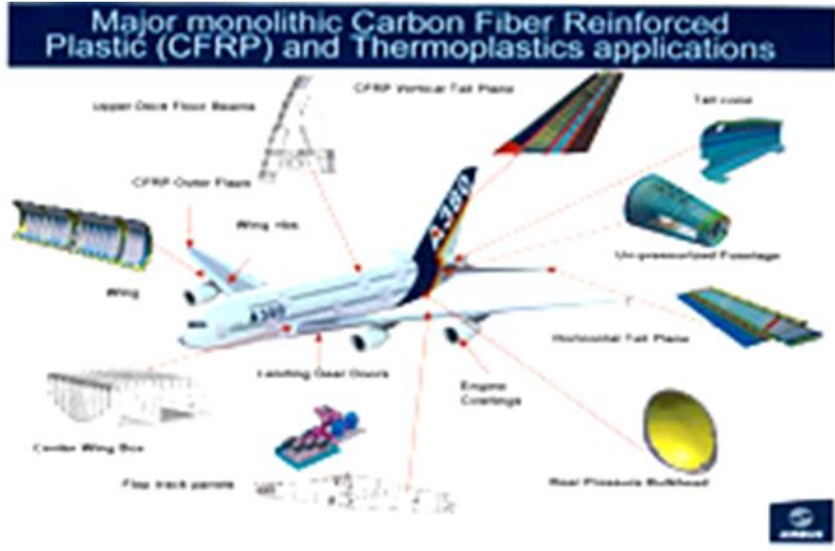


World market of activated carbon, 1995-2012

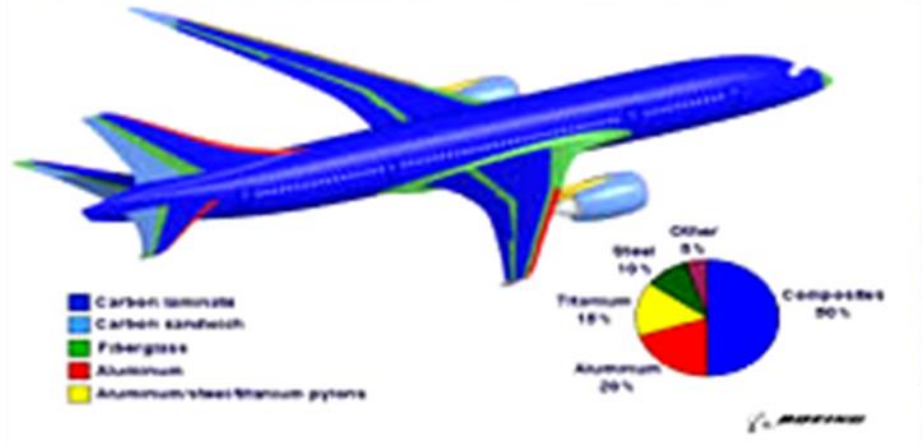


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Carbon Fiber



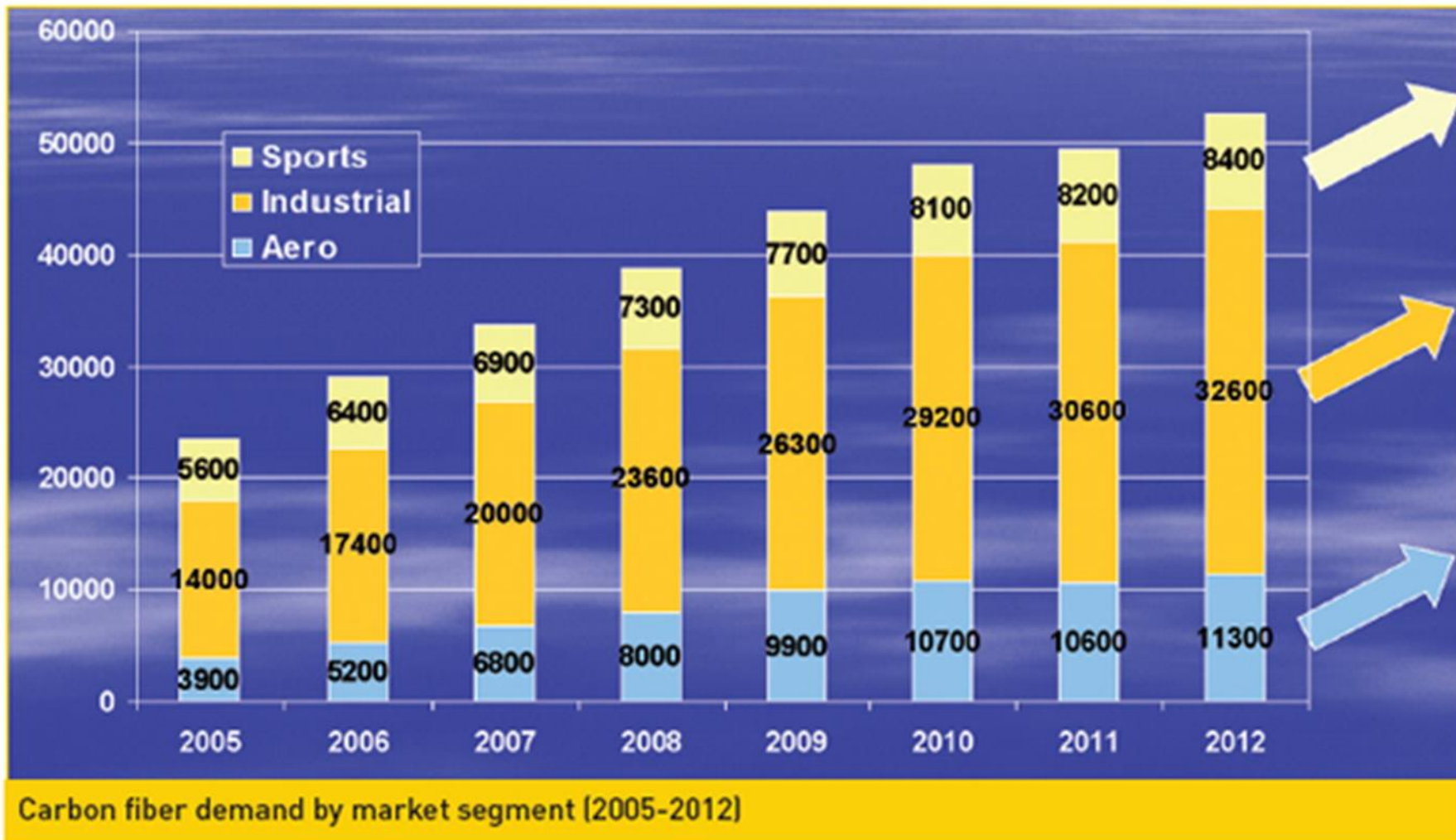
787 Composite Solutions Applied Throughout the 787



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World market trend of carbon fiber



Carbons **until now**

Precursors come from good raw materials such as coal tar and FCC-DO

No designed technology. Only experience is Know-how.



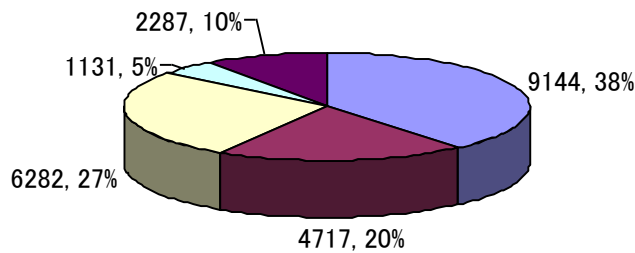
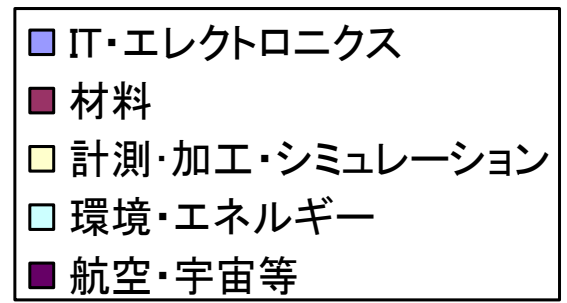
Developed countries who have long history of development only get chance to produce the advanced carbons such as T-800 and premium class needle coke.

Carbons of general performances are only produced in under-developed countries

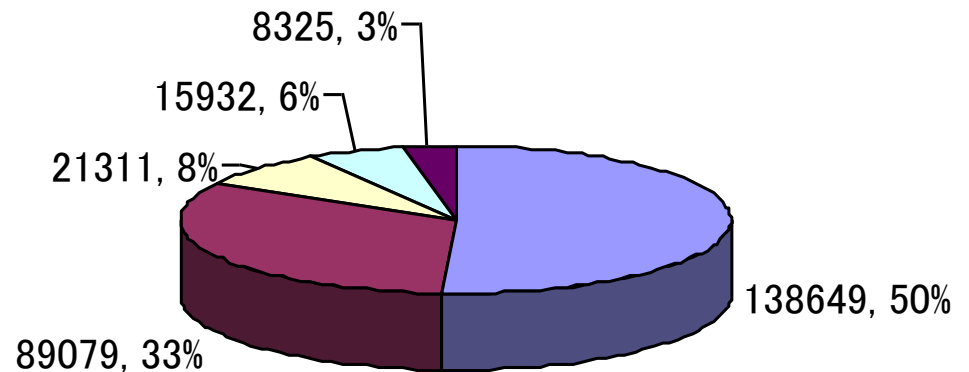
Pitch and coke based carbon technology only get a markets for applications

During last decade, we recognized carbon materials are the best key materials for energy-saving and environmental protections.

Market forecast of nanocarbons



2005
(2.4 Trillion ¥)



2010
(27.3 Trillion ¥)

Trends of carbon products

High performance

→ High prices

Ton → Kg → g

10000 ¥ /Kg

1000 ¥ /Kg

100 ¥ /Kg

10 ¥ /Kg

Market

5 Billion ¥

50 Billion ¥

200 Billion ¥

Char

NG

NG

Pet

3兆円

Electrode

Green Petro coke

Foundary co

De

Carbon black

Carbon for Al smelting

Needle coke

Carbon for 2nd ba

Activated carbon

Cathode blick

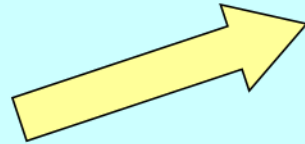
Coke for iron smelting

Carbon specialties

Pitch based LP carbon fiber

ed carbon fiber

Fullerene, nanotube



Processing degree

2013

Nano-carbons

- Fullerenes, carbon nano-cages, carbon onions, ...
- Carbon nanotubes, carbon nanofibers, carbon nanowires
- Graphene oxides, graphenes

Nano-carbons have been intensively studied during last 30 years.

Industry for large consumption was failed to achieve.

Successful in the science level but failed to attain to engineering one

No target specifications

Nano-carbons made us recognize that carbons are key materials for energy-savings and environmental protections.

Nano-carbon science informed to us many specific properties of carbon materials and possible routes for design.

Is it possible to design the carbon materials using conventional raw materials or precursors? What we have to do for it?