# High Efficiency Low Emissions:

# The first way forward for clean coal technology

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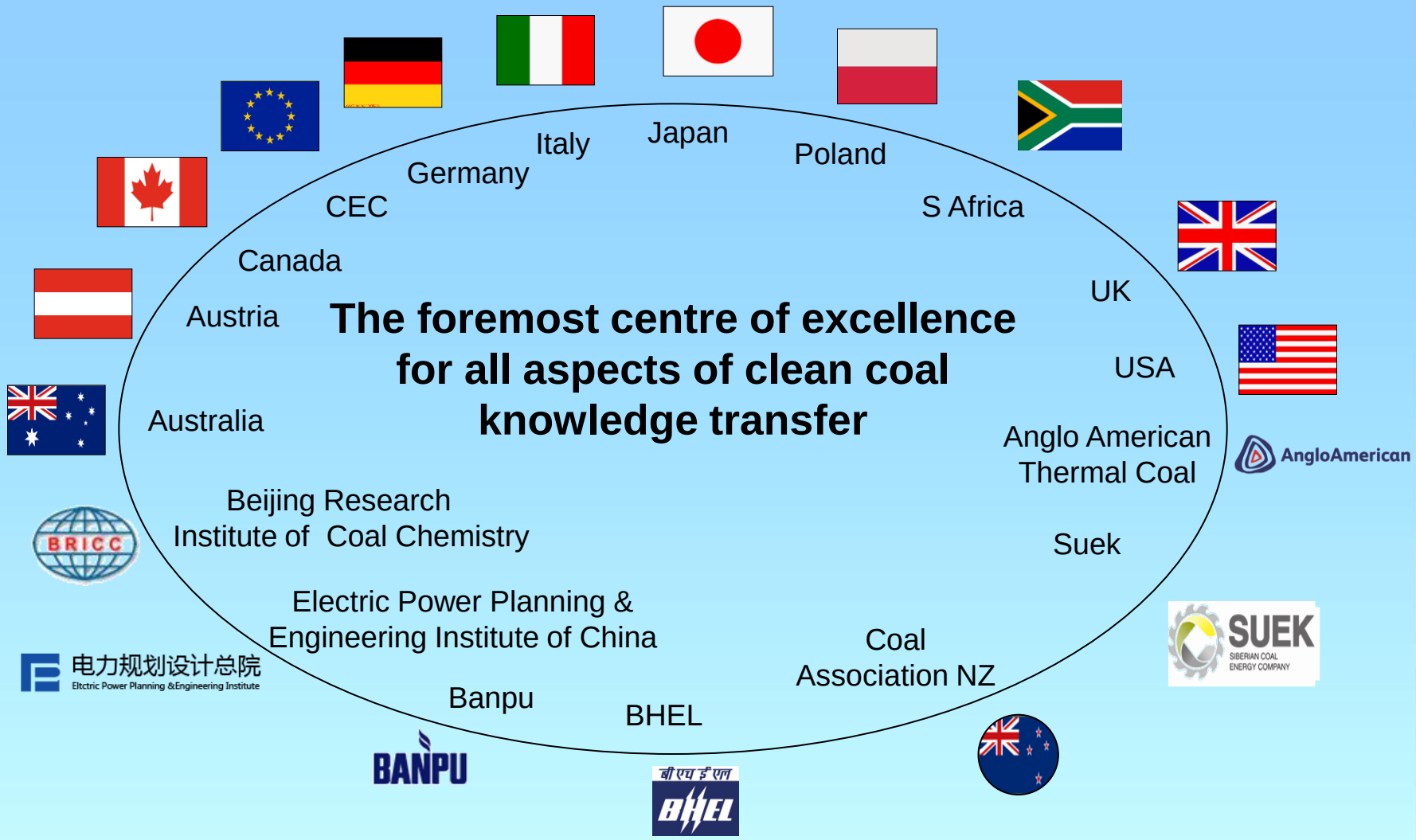
# IEA Clean Coal Centre mission statement

The IEA CCC will disseminate to a wide community objective analysis and information on the efficient, low emissions use of coal worldwide according to a programme agreed by the Membership: In order to achieve this objective, the focus of the IEA CCC activities comprises three broad categories:

- Towards zero emissions – including carbon abatement, emissions and effects, pollution control technology, residues.
- Coal utilisation and analysis – including coal properties, fuel handling, power generation technologies, coal conversion technologies, and industrial uses of coal.
- Economics and markets – including supply, transport and markets development, country studies, capital and operating cost reviews of current and new build technologies, including comparisons with non-coal options.

Services will be delivered through direct advice, review reports, workshops and conferences, facilitation of R&D, provision of networks and web based instruments.

# Membership status of the IEA Clean Coal Centre at September 2014

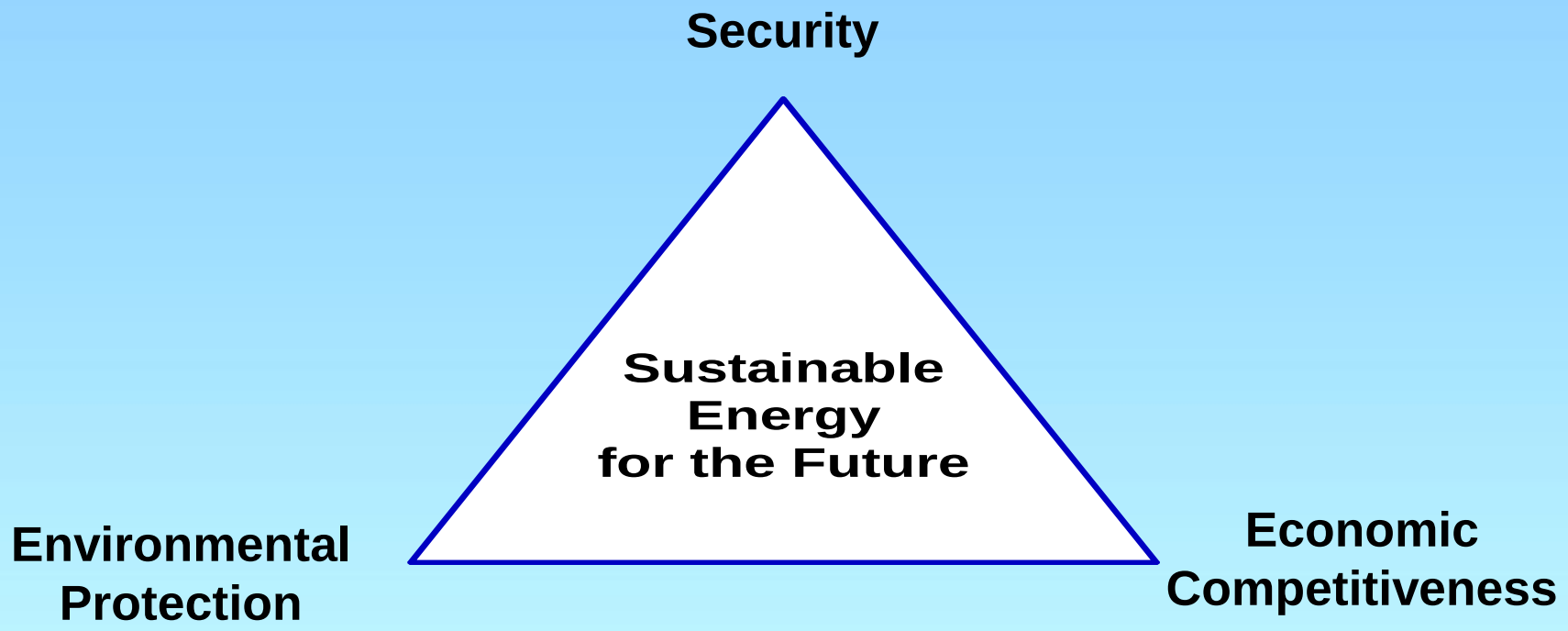


# Scope of the presentation

- Drivers for technology advancement
- Historical improvements in coal power generation technology
- Getting larger and introducing higher efficiency steam cycles
- HELE concept both for CO2 and non-GHG emissions mitigation
- Current examples of HELE coal power plant
- Advanced HELE developments
- Scope to maximise HELE plants in major coal using economies
- Future work for IEACCC

# Coal and sustainability

**Coal can ensure energy security and economic competitiveness. There are environmental challenges but technologies are available to deal with these.**



# Role of clean coal technology

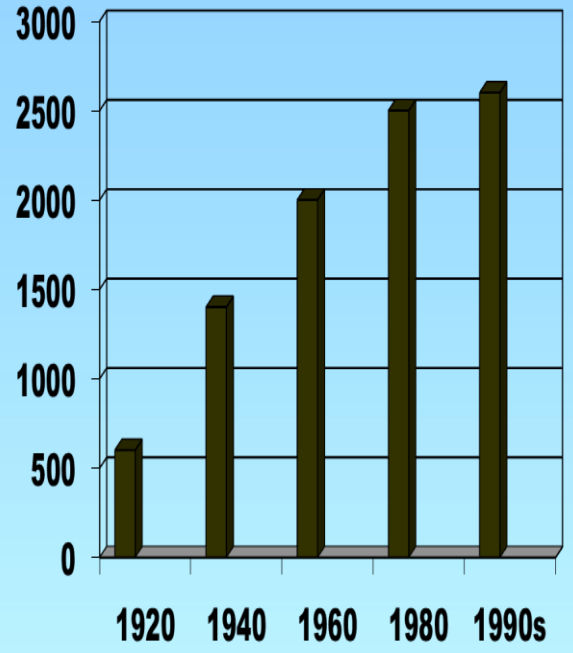
High efficiency low emissions technologies are critical to maintain coal based energy security and as a precursor to the longer term deployment of CCS

Essential to assist developing countries in making this choice as part of their efforts to escape from poverty through access to reliable sources of power

Lending criteria by multi-lateral donors not overly helpful

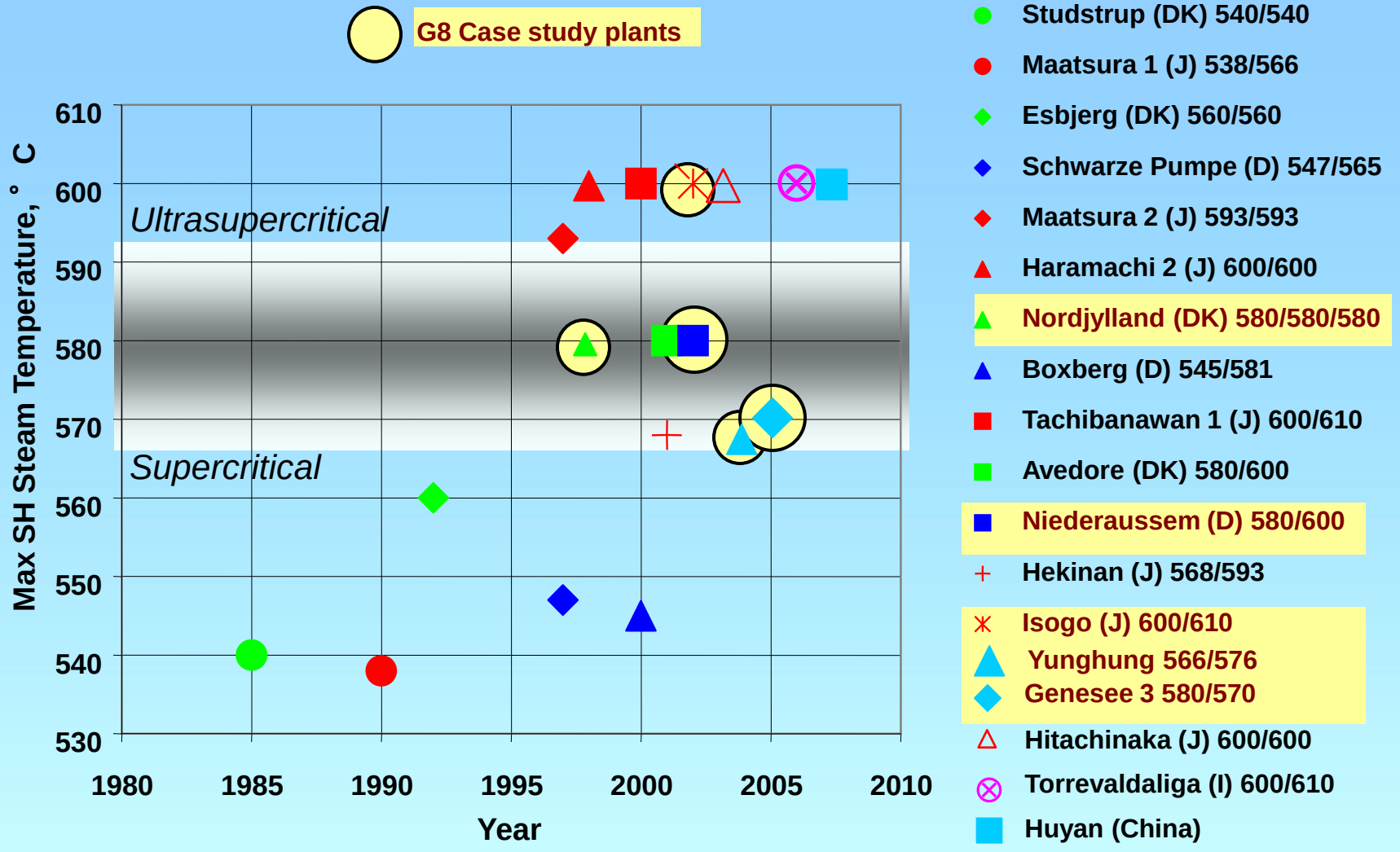
# Historical improvements to power cycle efficiencies

**Electricity Produced per tonne of Coal (kWh/t)**




- **Economies of scale leading to larger units**
- **Higher temperature steam cycles**
- **Better integrated operating procedures**

# Recent plant state of the art conditions

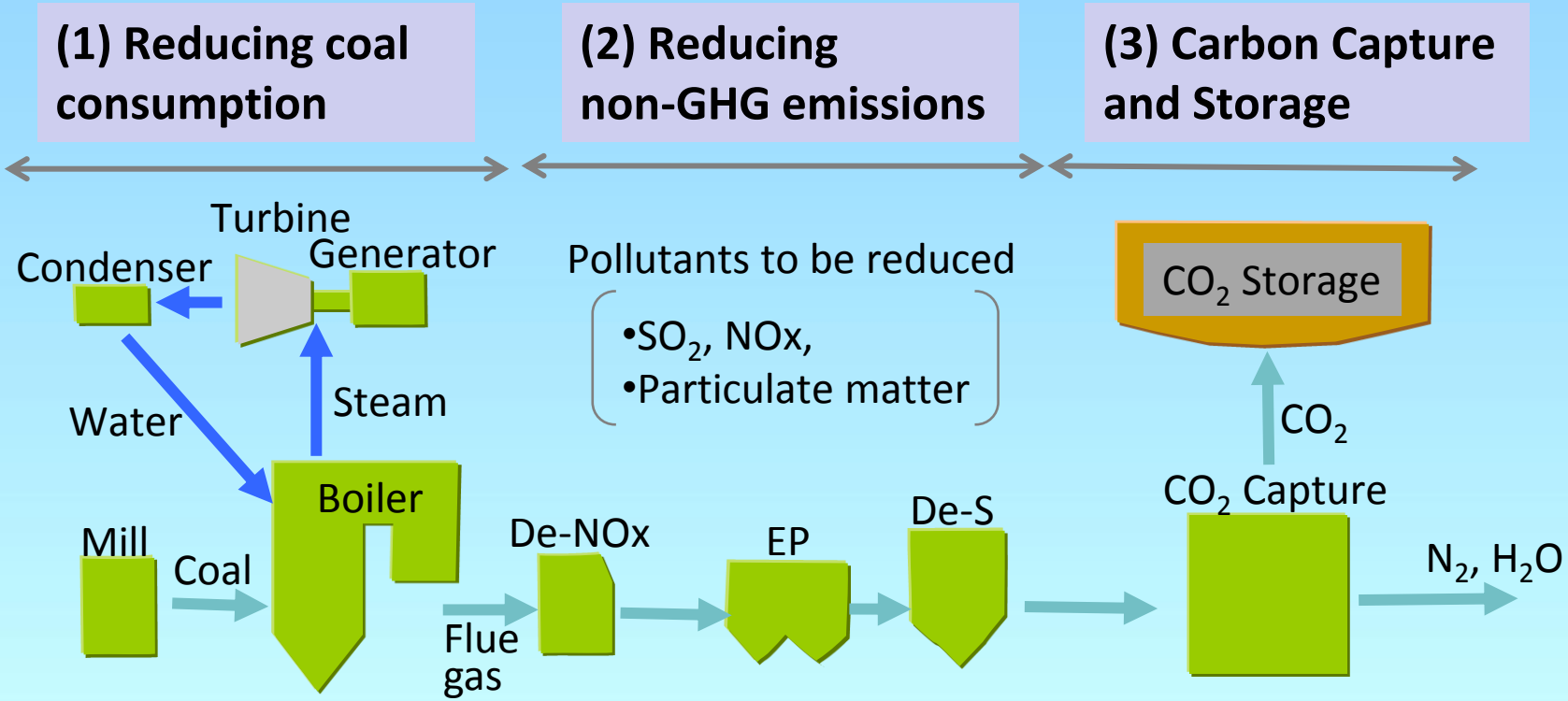


# Application of sc and usc steam cycles

# HELE Technologies

Focus on technologies to reduce both GHG and non-GHG (NOx, $SO_2$, PM) emissions.

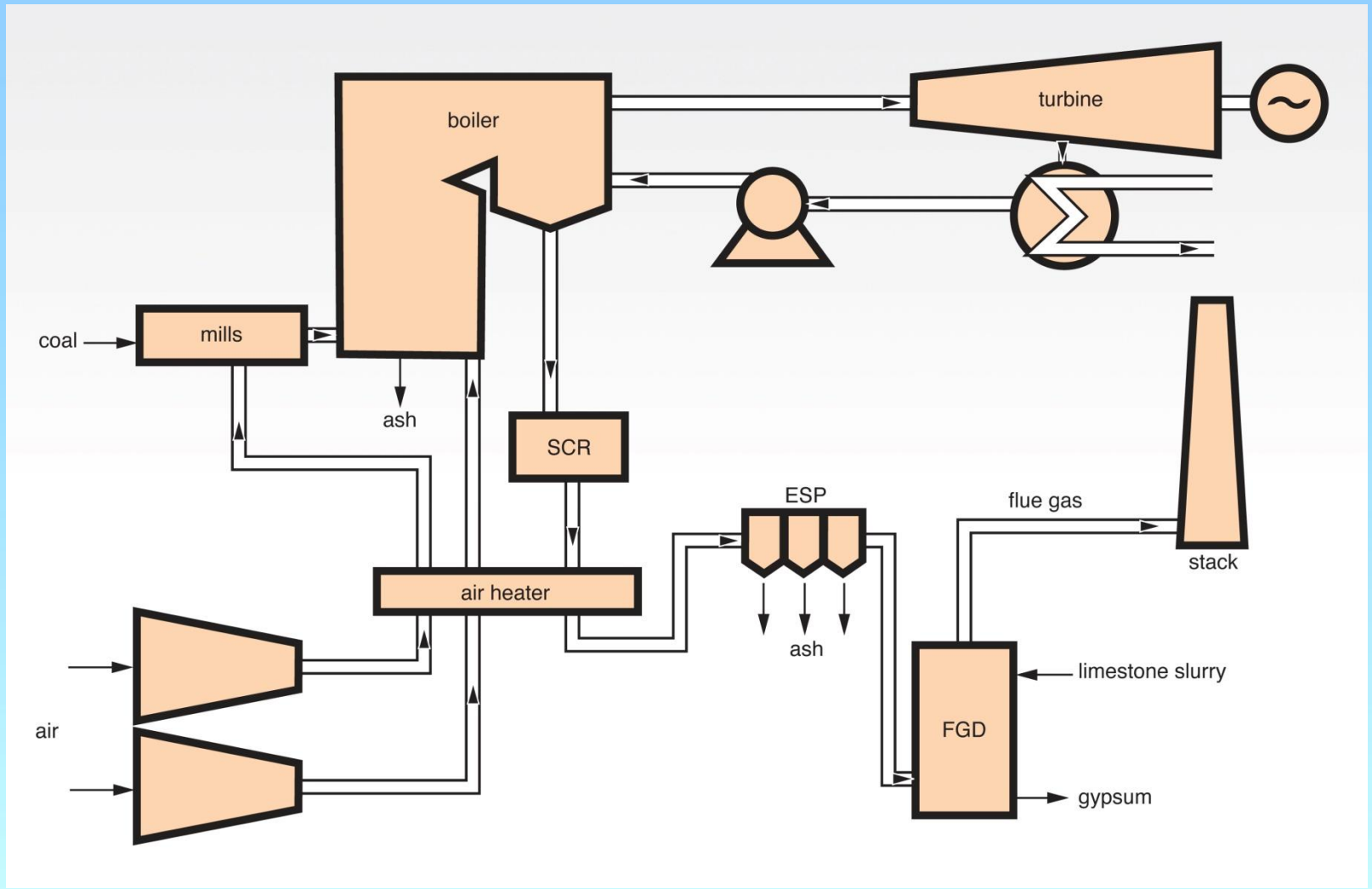
## Technologies for cleaner coal generation



# Waigaoqiao No. 3 power plant in Shanghai is one of the cleanest in the world

## Seeing is believing

# Coal fired power plant layout showing ESP, FGD and SCR system locations



# Waigaoqiao no. 3 power plant

**Emissions ($mg/m^3$)**

Dust: 11.63

$SO_2$: 17.71

NOx: 27.25

| Year | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| **Net efficiency (%)** | 42.73 | 43.53 | 43.97 | 44.50 | 44.40 |
| **Specific coal consumption (gce/kWh)** | 287.4 | 282.2 | 279.4 | 276.0 | 276.1 |
| **Annual load rate (%)** | 75 | 75 | 74 | 81 | 77 |

# Need to limit capital costs as well as increase steam cycle efficiency

Thermie AD700
325 bar, 700˚ C/700˚ C
η= 50÷55% (Net, LHV)

COST 522
300 bar, 630˚ /650˚ C

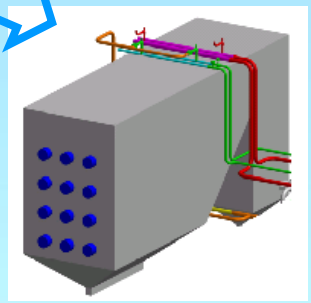
Today

2010-2015

soon

600 MW reference design
300 bar, 600˚ /620˚ C
Achievable η= 45÷47% (Net, LHV)

Reduced capital costs
Novel layouts



Yesterday

Vertical or spiral wound furnace
250 bar, 540˚ /560˚ C
η< 40% (Net, LHV)





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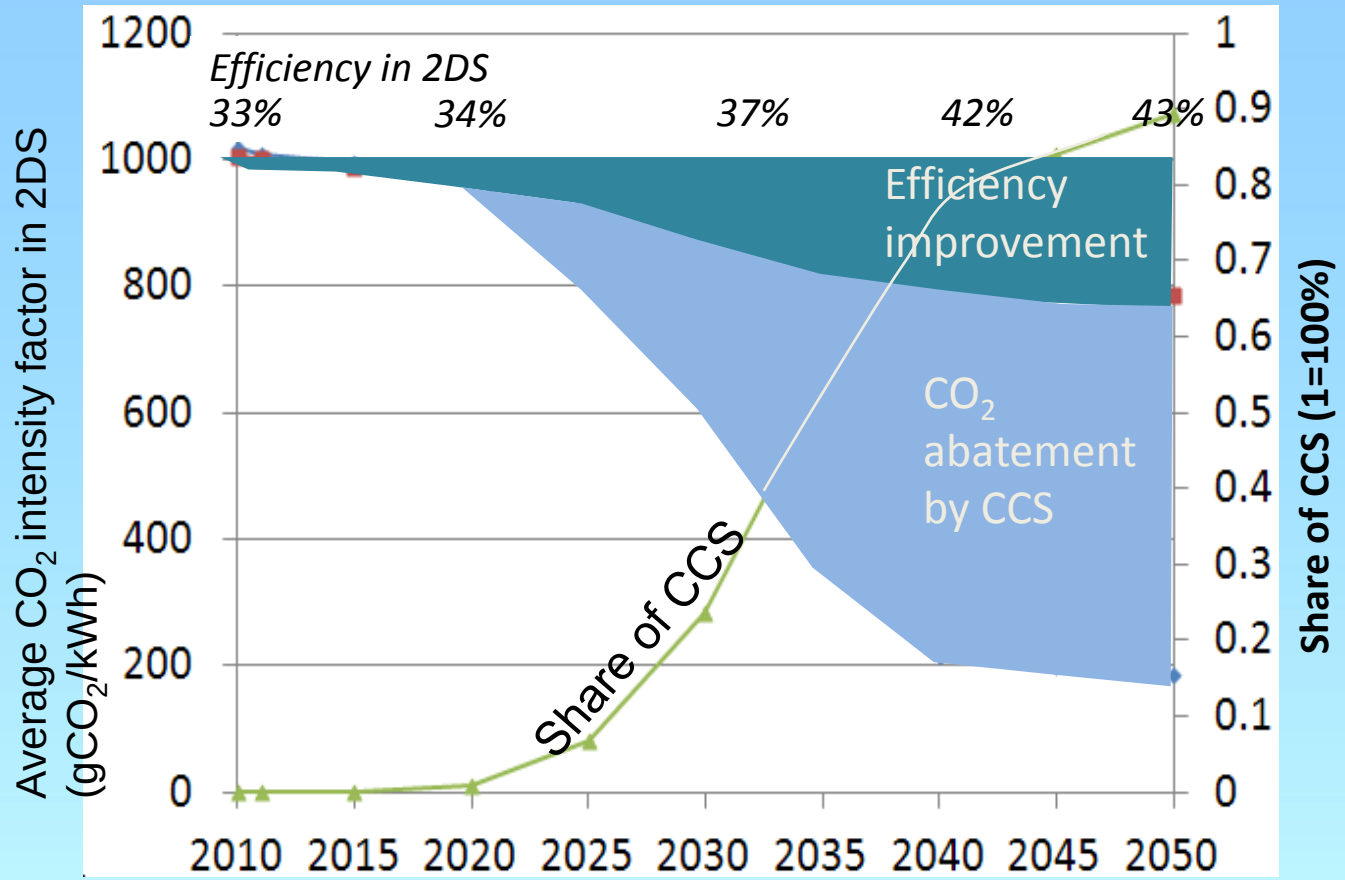
# Towards ≥50% cycle efficiency with advanced USC technology

| National programme | Steam temperature | Efficiency (LHV, net ) | Programme start date | Demonstration plant operational by (size) | Also includes: |
|---|---|---|---|---|---|
| EU | 700°C | >50% | 1998 | 2021 (500 MWe) | Coatings, biomass co-firing, cycling |
| USA | 760°C | 45-47% (HHV, net) | 2000 | 2021 (600 MWe) | Oxyfuel, coatings, high sulphur coal |
| Japan | 700°C | >50% | 2008 | 2021 (600 MW) | Biomass co-firing |
| China | 700°C | 46-50% | 2011 | 2021 (660 MWe) | - |
| India | 700°C | >50% | 2011 | 2017 (800 MWe) | - |

**Metals used in boiler and turbine hot spots:**

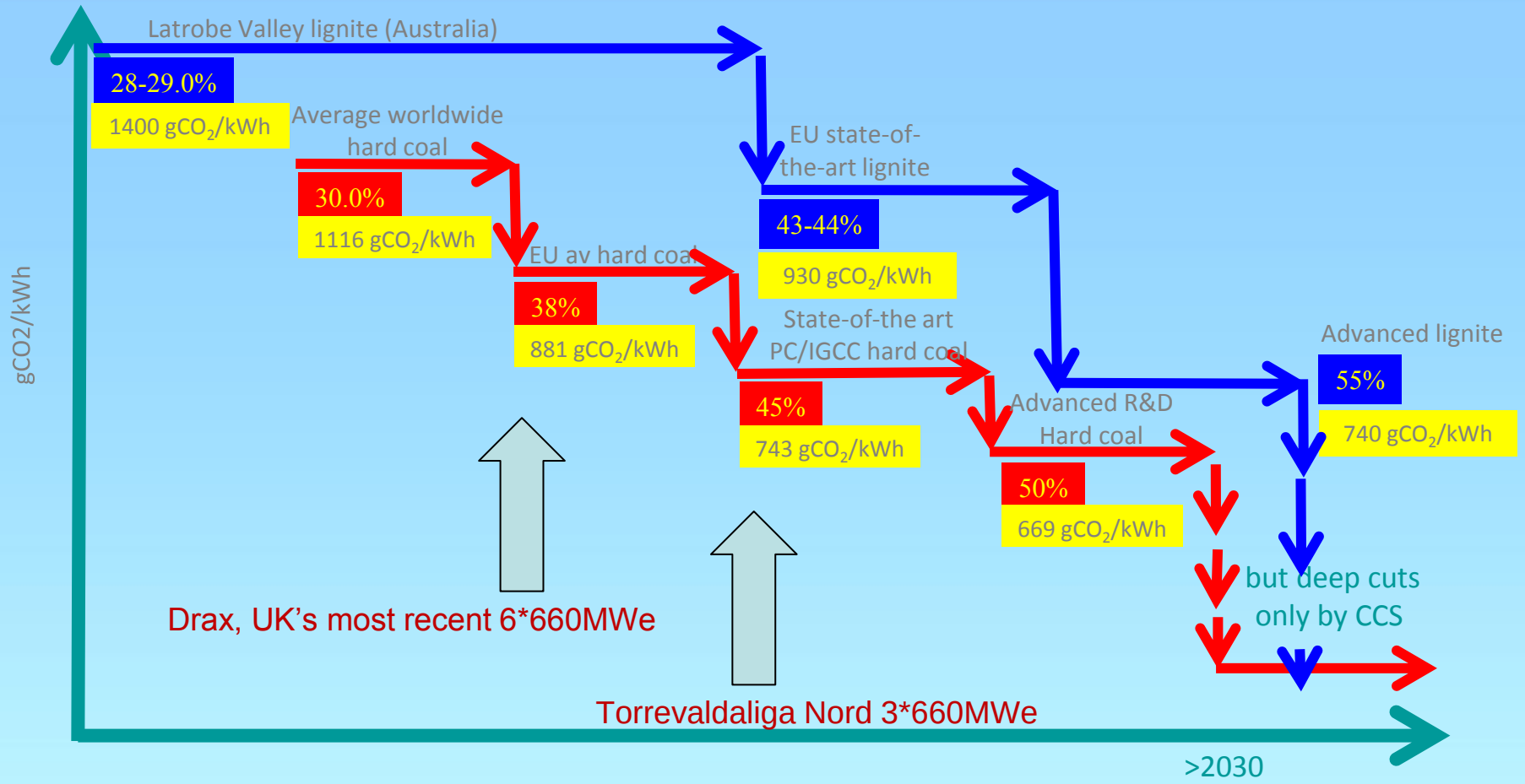
- **Steels well proven in USC at 600°C**
- **Nickel based alloys proving capable in A-USC at 700°C**

# Impact of efficiency improvement on $CO_2$ abatement




**Raising efficiency significantly reduces the $CO_2$/kWh emitted (source: IEA HELE Roadmap, Dec 2012)**

# $CO_2$ emissions reduction by key coal utilisation technologies




Data for hard coal-fired power plants from VGB 2007; data for lignite plants from C Henderson, IEA Clean Coal Centre; efficiencies are LHV,net

***Energy Efficiency makes big change but deep cuts of $CO_2$ emission can be done only by Carbon Capture and Storage (CCS)***

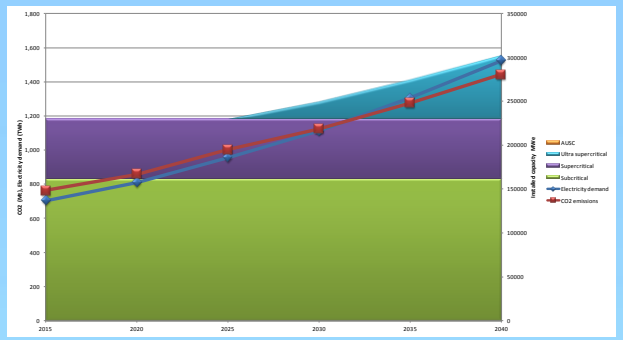
# IEACCC HELE assessment study

- Country specific study on the prospects for implementing High Efficiency Low Emissions (HELE) technologies
- Impact of HELE implementation on emissions of CO2
- Look at Australia, China, Germany, India, Japan, Poland, Russia, S Africa, S Korea, USA
- Determine outline costs of deployment, where possible
- Identification of significant trends

# HELE upgrade path through phased plant retirement

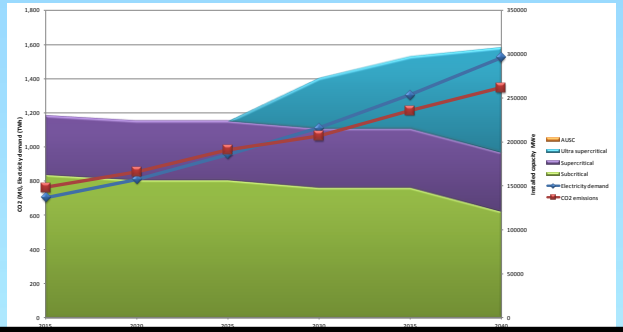
## Base Case

Existing coal fleet with additional USC to meet demand (if required)



## 50 year retirement scenario

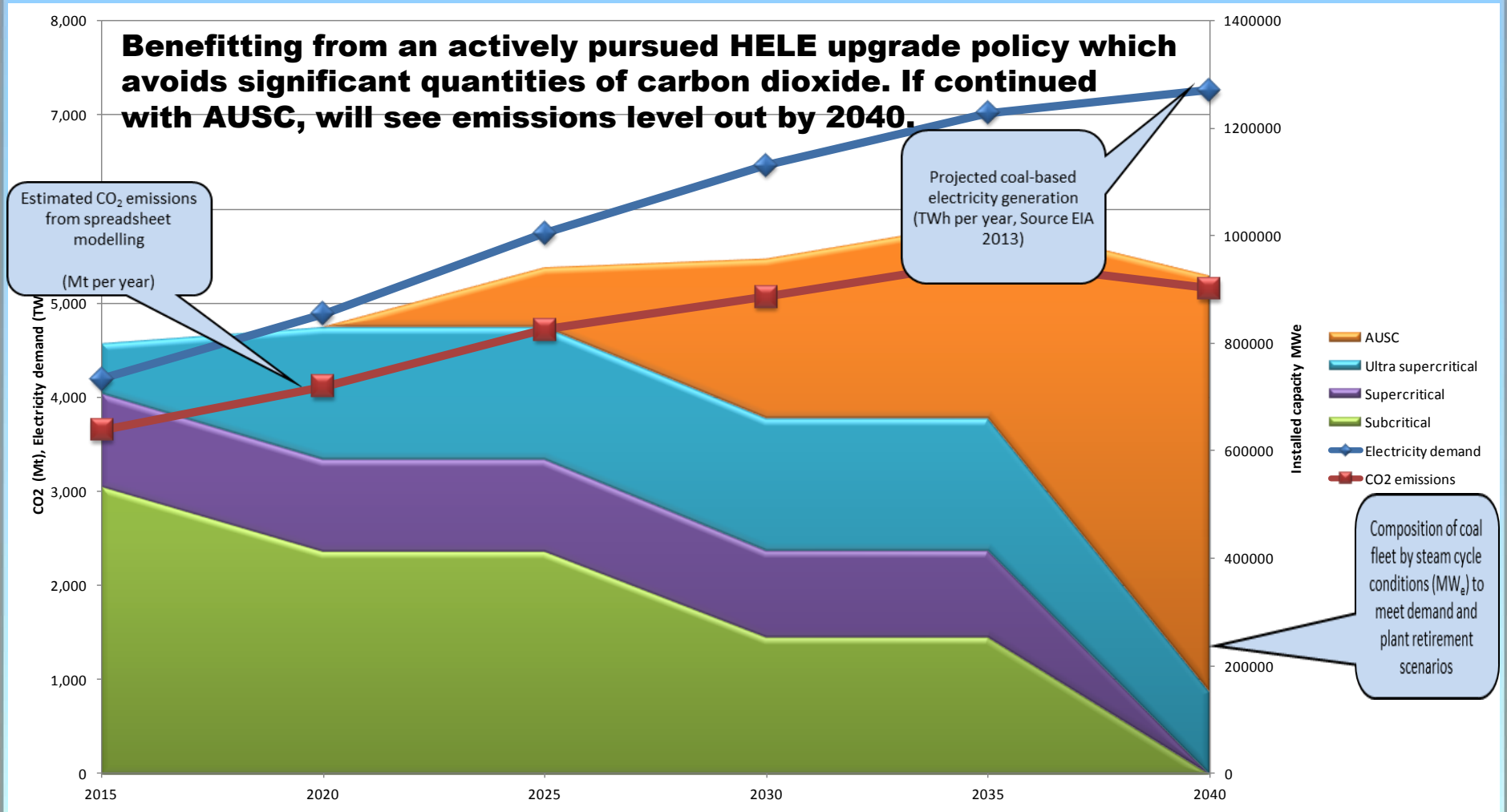
Review in 2020, 2030 and 2040. Retire capacity over 50 years old and replace with USC



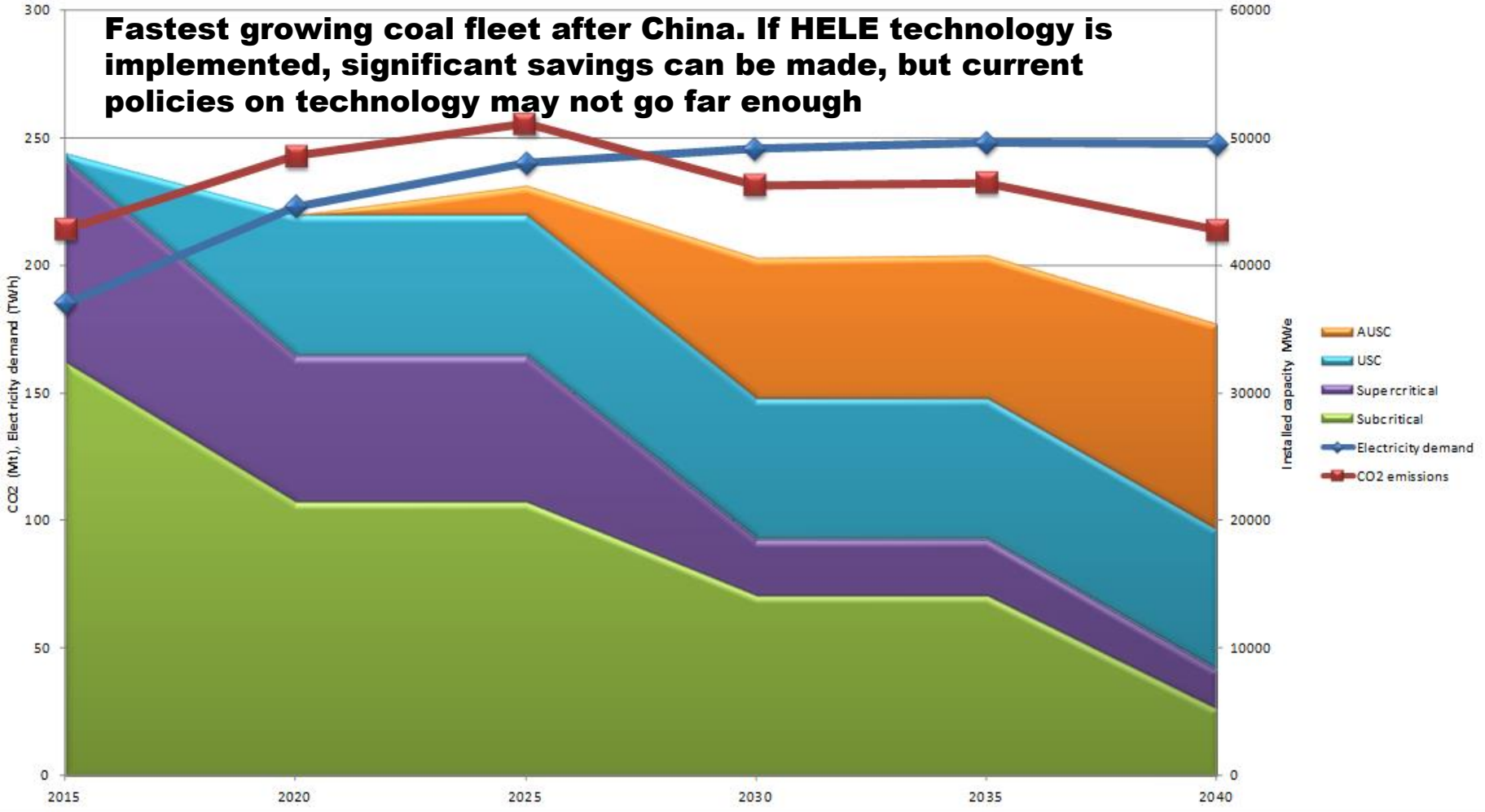
## 25 year retirement scenario

Review in 2020, 2030 and 2040. Retire capacity over 25 years old and replace with USC in 2020, AUSC in 2030 and 2040

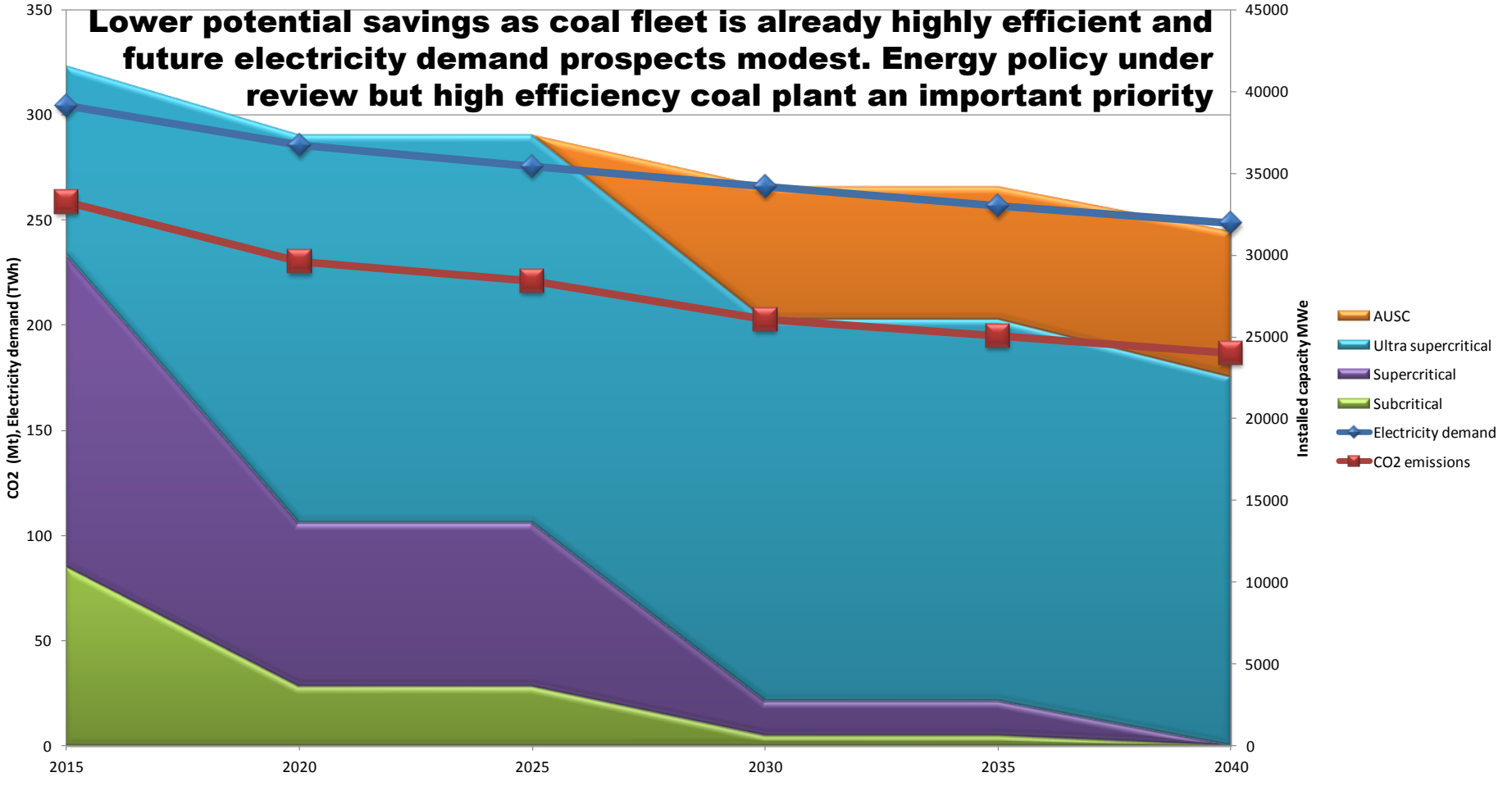
# China – 25 year retirement scenario 2015 - 2040



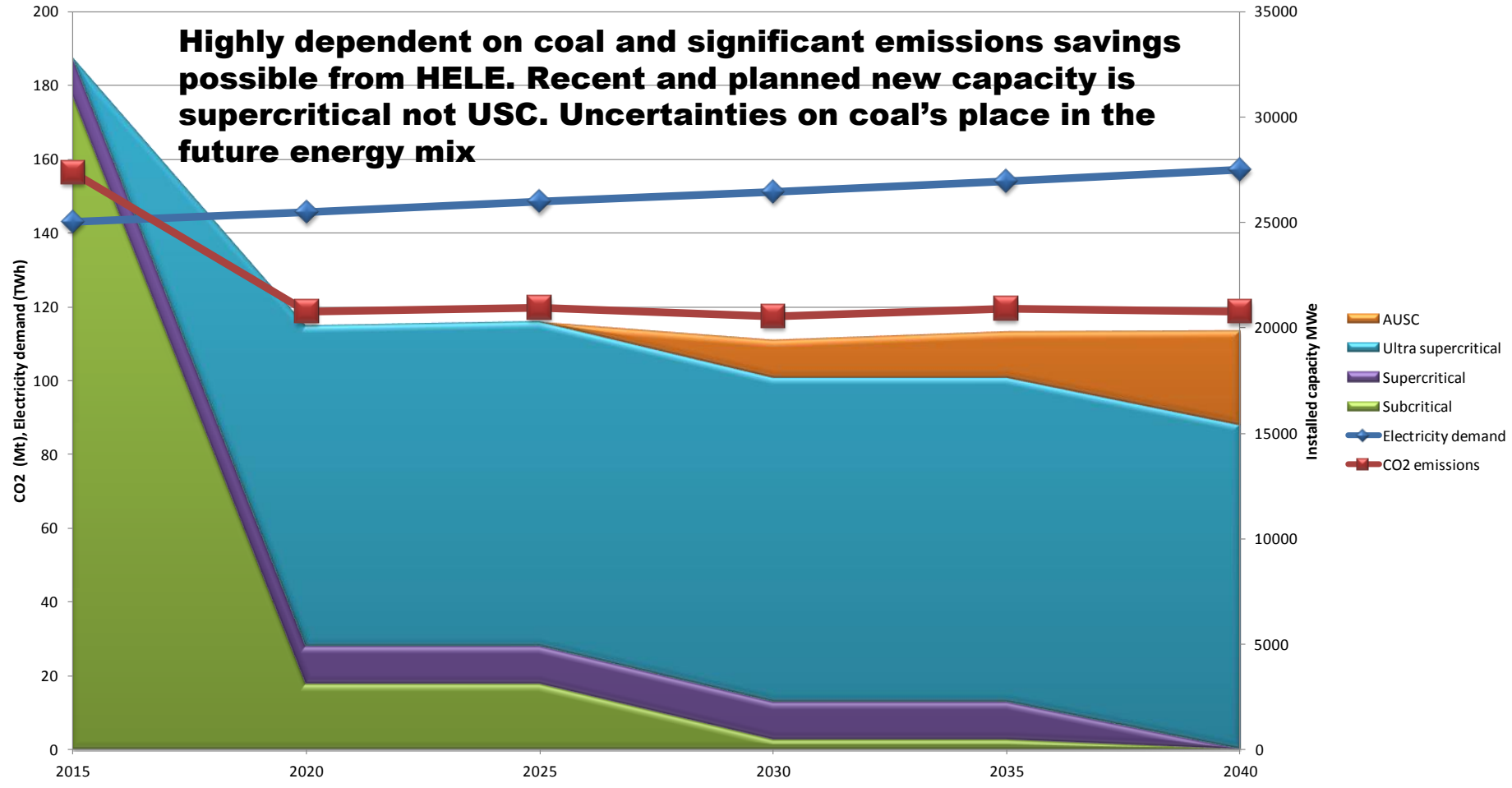
# India – 25 year retirement scenario 2015 – 2040



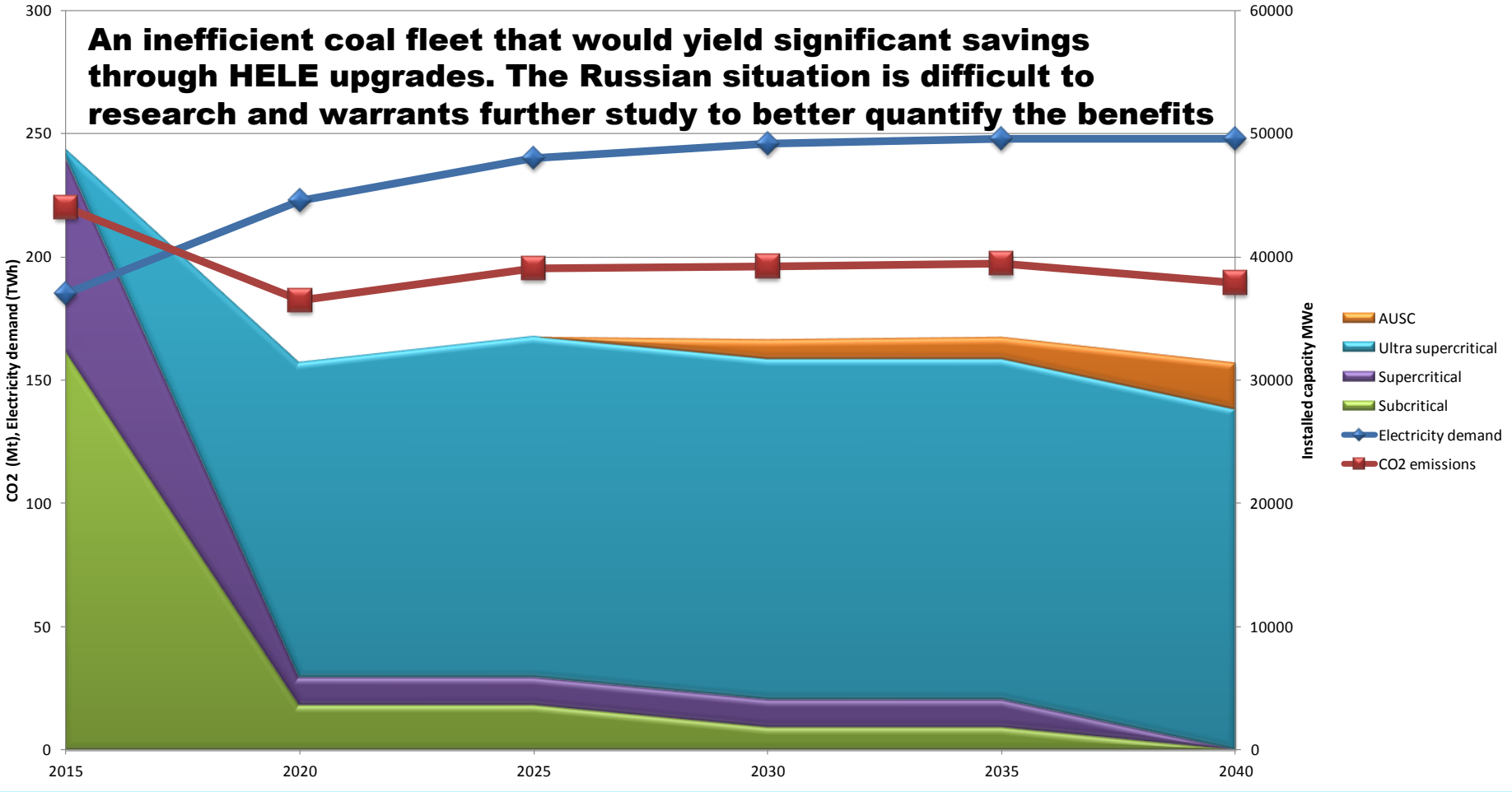
# Japan – 25 year retirement scenario 2015 - 2040



# Poland – 25 year retirement scenario 2015 - 2040



# Russia – 25 year retirement scenario 2015 - 2040



# IEACCC intended further research

- This study has provided a valuable insight into country-specific HELE possibilities but deeper analysis for all countries is recommended.
- Priority areas for further study are considered to be: India, South Africa, Poland and Russia.
- Other coal users need to be researched to complete the world view. A further overview study on HELE prospects is recommended for the “Asian Tiger” economies as a first step.
- Plant improvements are significant to achieving efficiency gains and a review of the current best practices is recommended leading to knowledge transfer opportunities.

# Dissemination and outreach

- **IEACCC information is available to all its members and, in due course, non-members**
- **Webinars are given on key studies, which include the HELE assessment work; all can be accessed via our website**
- **The Centre is keen to meet with potential stakeholders to discuss the work and to consider specific issues**
- **You can reach us via www.iea-coal.org**

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