Doosan Heavy Industries & Construction

Doosan's Efforts to develop Power-Gen Technology

Integrated solutions for a better life

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2015 International Forum Korea on Advances in Mechanical Engineering, Sept. 17, 2015, KIMM, Daejeon, Korea

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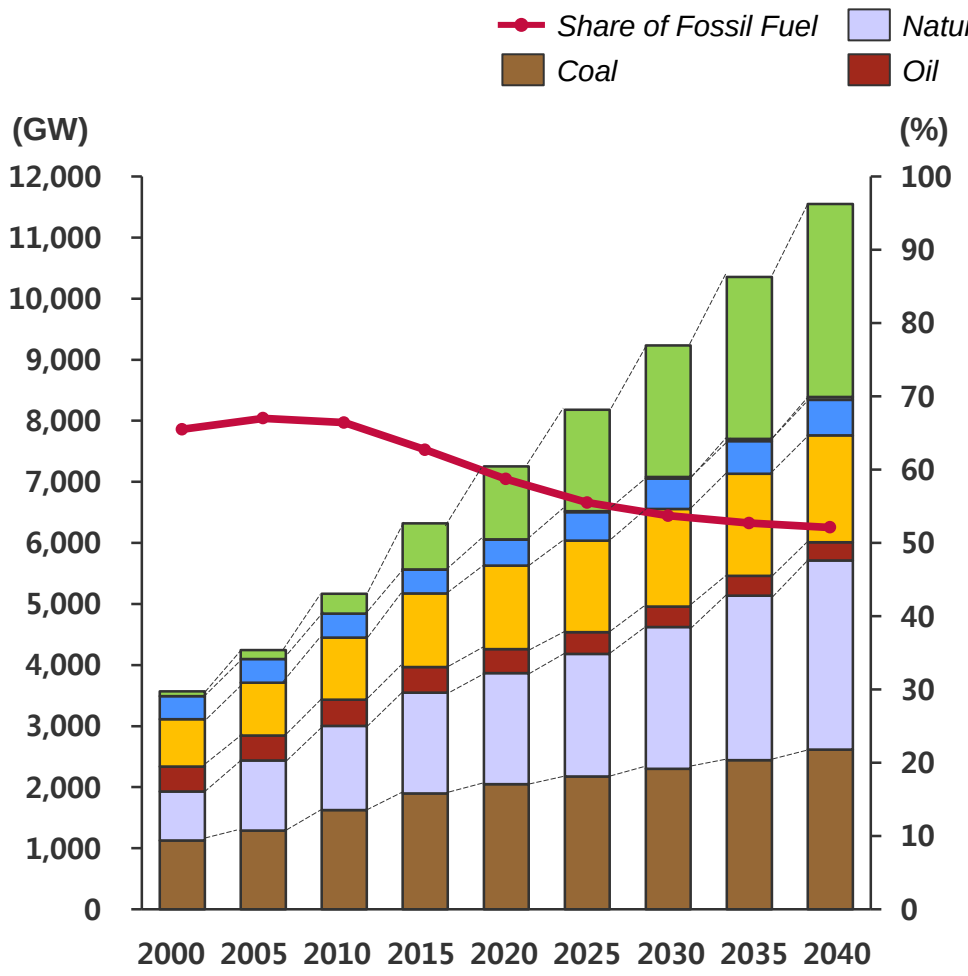
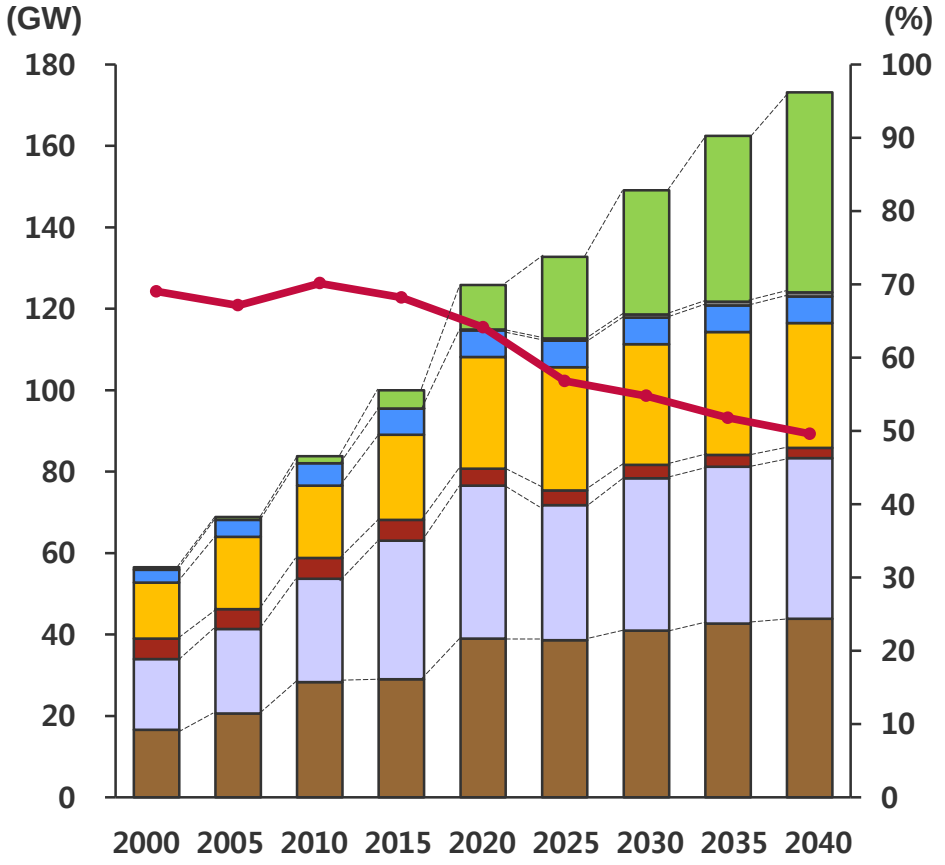
POWER CAPACITY OUTLOOK



World Power Generation Capacity



Korea Power Generation Capacity

Source : IHS Cera Energy Data 2015 relative to the Rivalry Scenario

CHANGING POWER INDUSTRY

Generation | **Transmission & Distribution** | **Utilization**

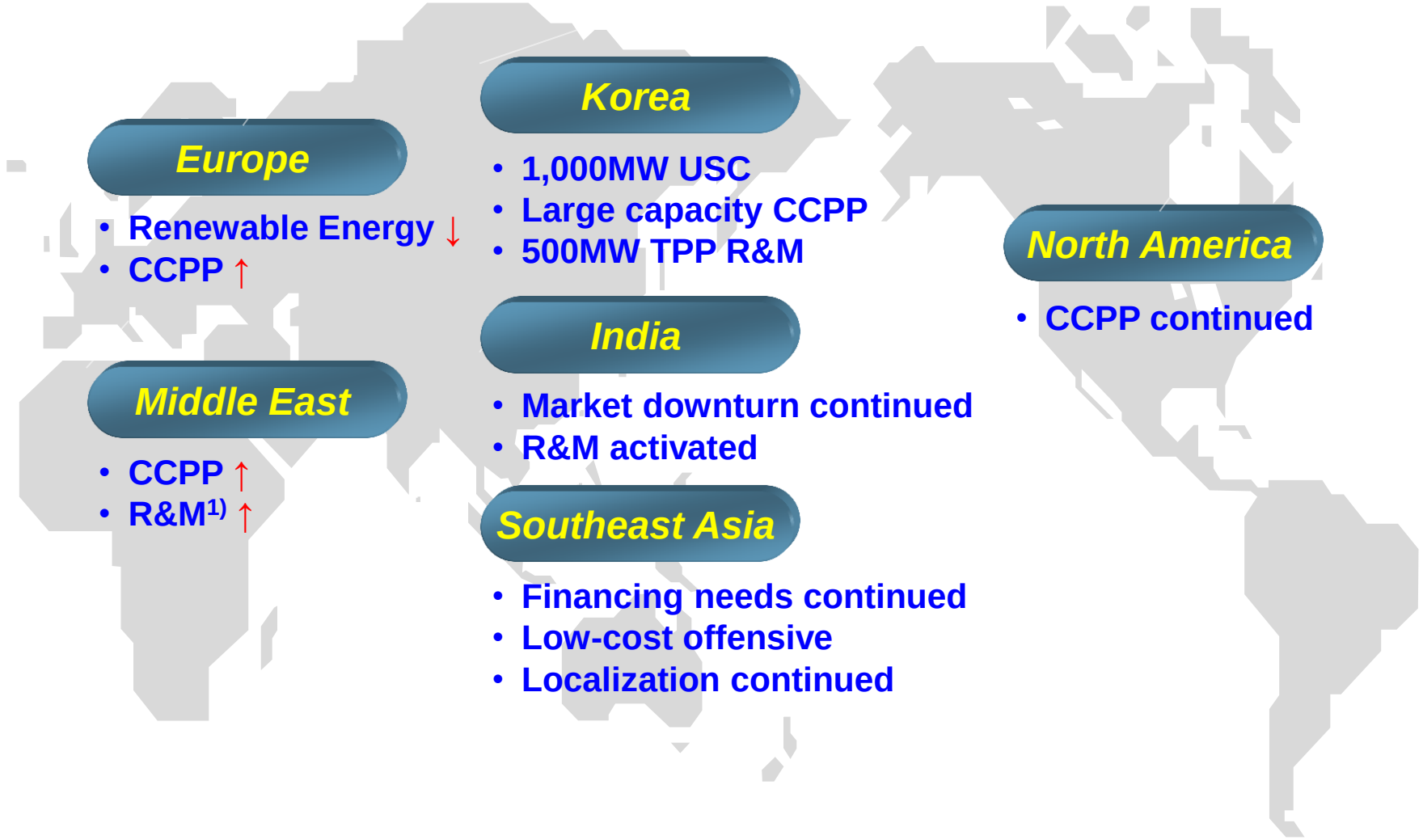
- **Decarbonization**
- **Distributed Generation**
- **Digitalization**

- **Regional Aggregation Systems**
- **Grid of Things**

- **Demand Management**
- **Smart Meter**

Source : Smart Energy: New Applications and Business Models, BCG in collaboration with the Energy Chair of Orkestra, April 2015

GLOBAL MARKET



Europe

- Renewable Energy ↓
- CCPP ↑

Middle East

- CCPP ↑
- R&M[1] ↑

Korea

- 1,000MW USC
- Large capacity CCPP
- 500MW TPP R&M

India

- Market downturn continued
- R&M activated

Southeast Asia

- Financing needs continued
- Low-cost offensive
- Localization continued

North America

- CCPP continued

1) R&M: Retrofit & Modernization Market

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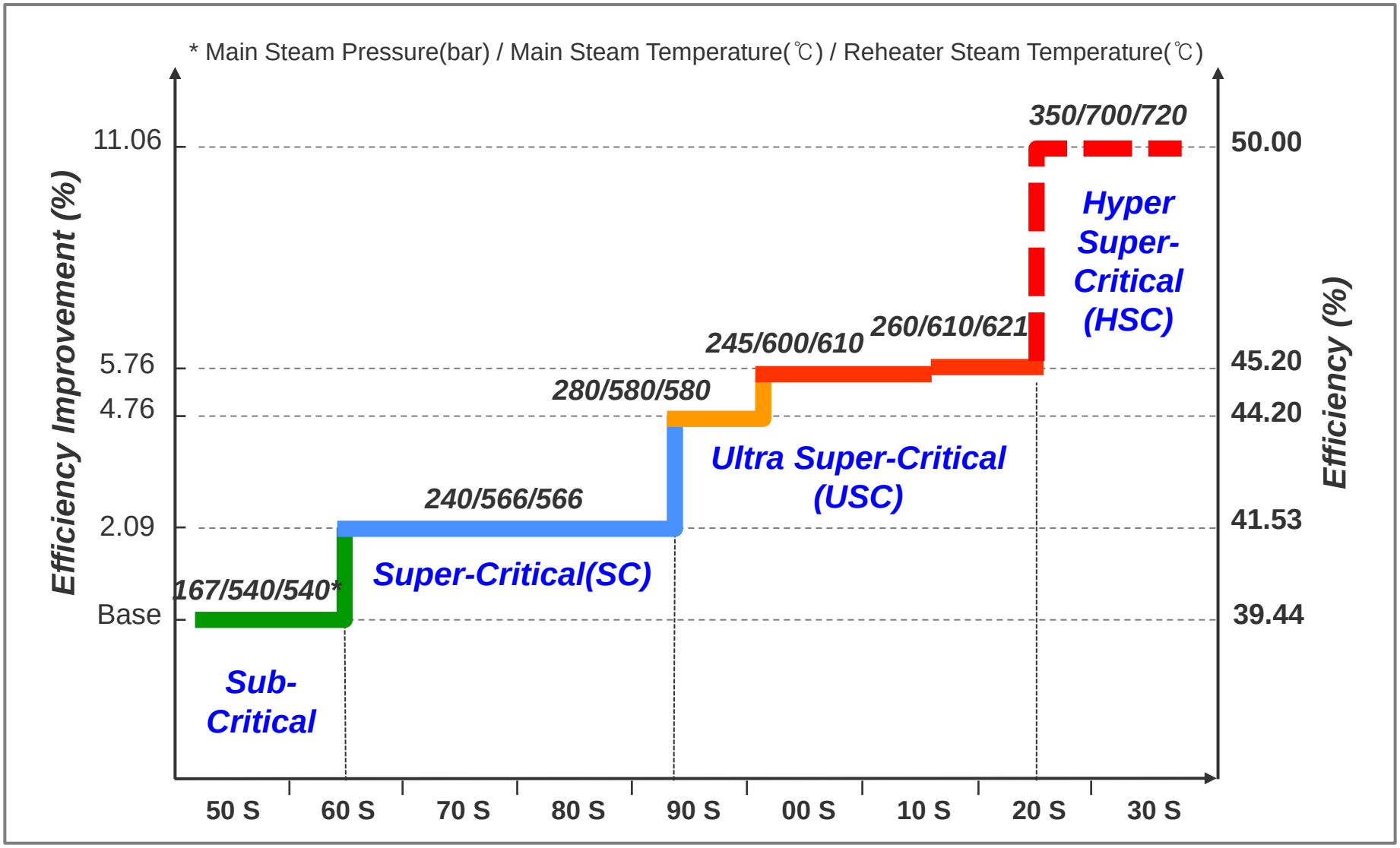
COAL-FIRED POWER PLANT



NUCLER POWER PLANT

Nuclear Reactor Timeline

Generation I

Early Prototype Reactors

- Shippingport
- Dresden, Fermi I
- Magnox

Generation II

Commercial Power Reactors

- LWR-PWR, BWR
- CANDU
- AGR

Generation III

Advanced LWRs

- ABWR
- System 80+

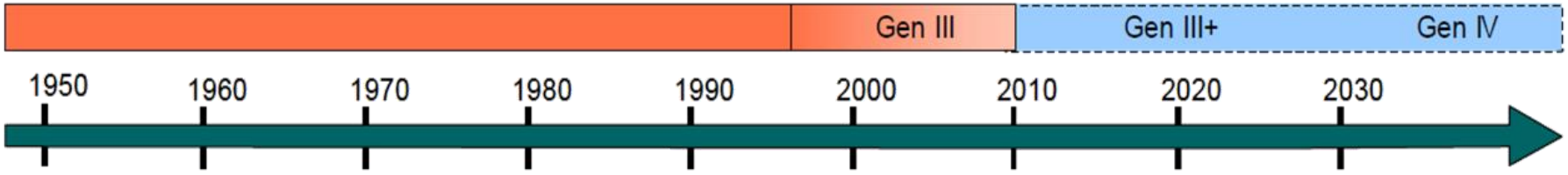
Generation III +

Evolutionary Designs Offering Improved Economics for Near-Term Deployment

- AP1000
- EPR
- ESBWR
- APR1400

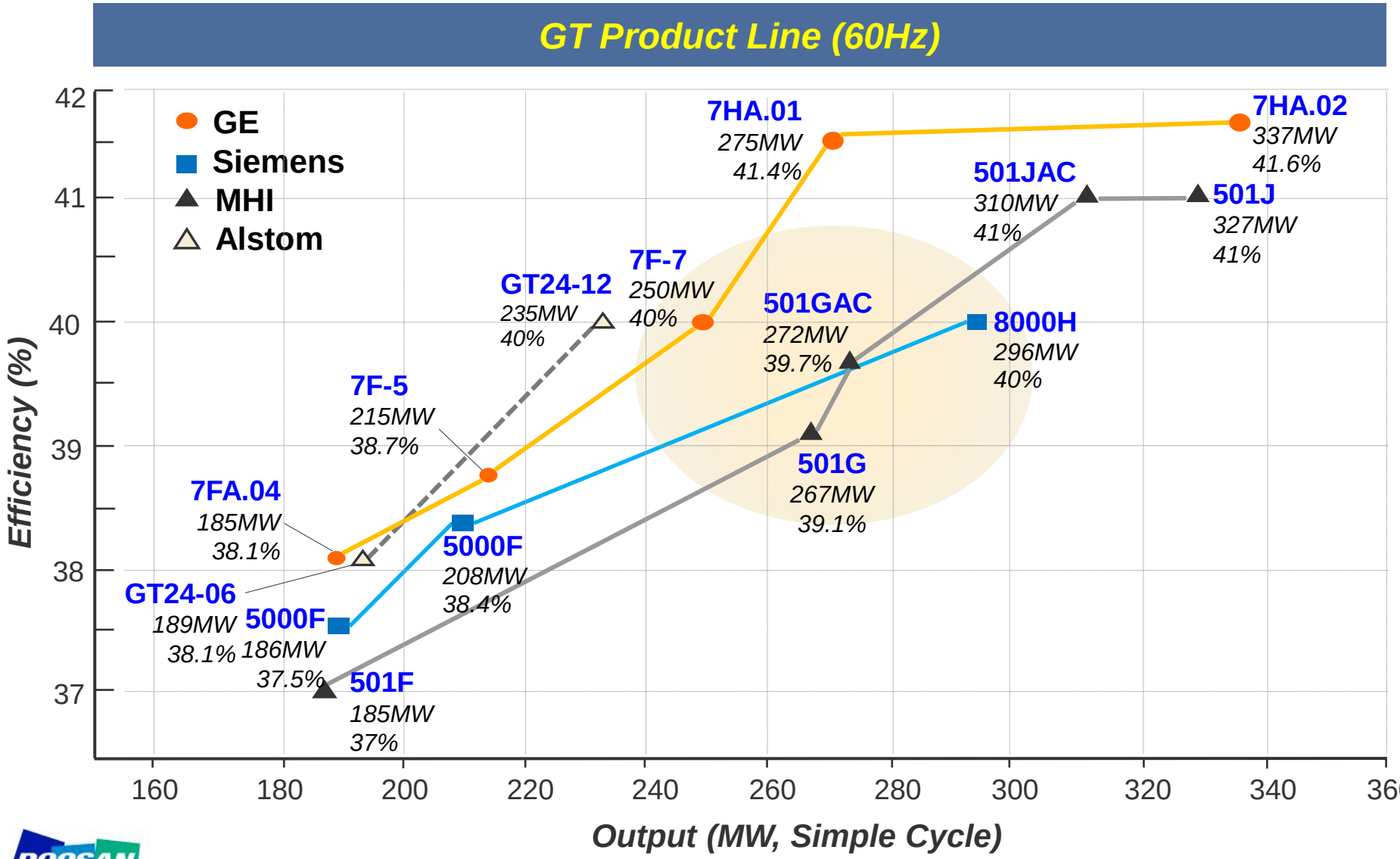
Generation IV

- Highly Economical
- Enhanced Safety
- Minimal Waste
- Proliferation Resistant

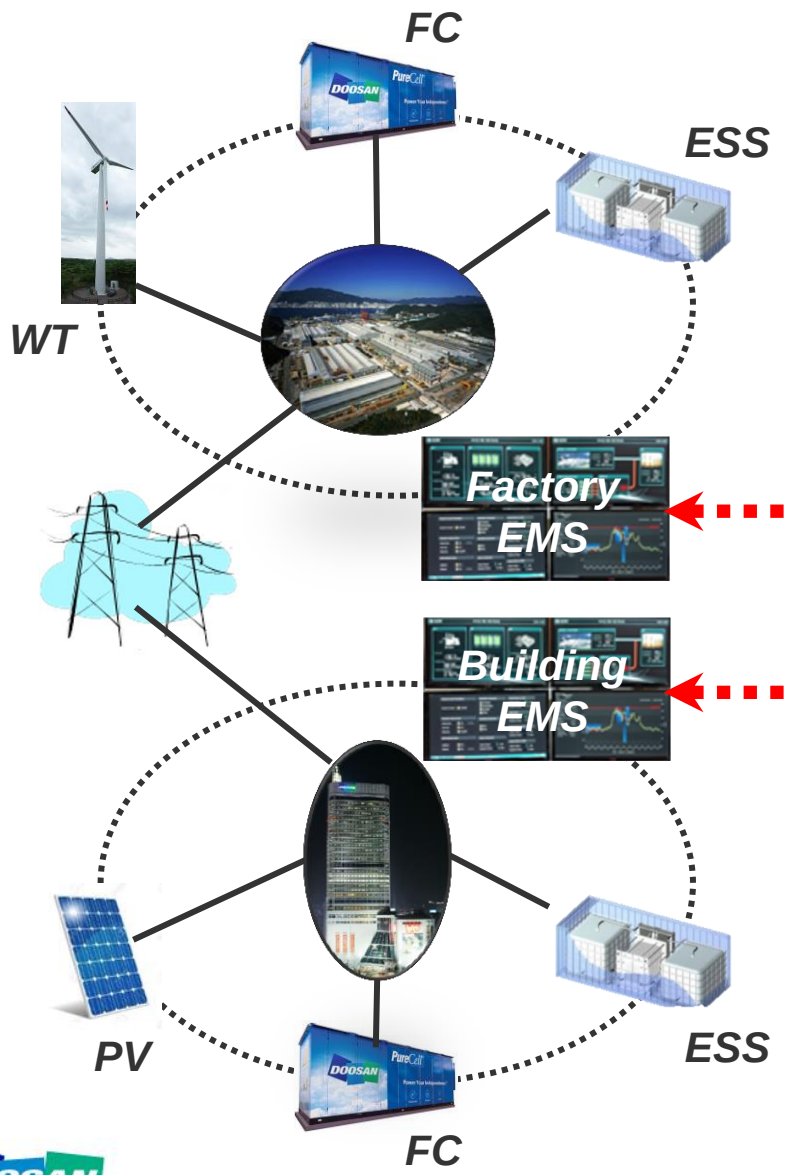


Source : Advanced LWRs(MIT OpenCourseWare), Jacopo Buongiorno, Associate professor of Nuclear Science and Engineering, MIT

COMBINED CYCLE POWER PLANT



RENEWABLE ENERGY



VPP EMS

- Market & Resources Analysis
- Forecast
- Market Trading
- Distributed Resources Management
- Schedule & Power Feeding
- Charging

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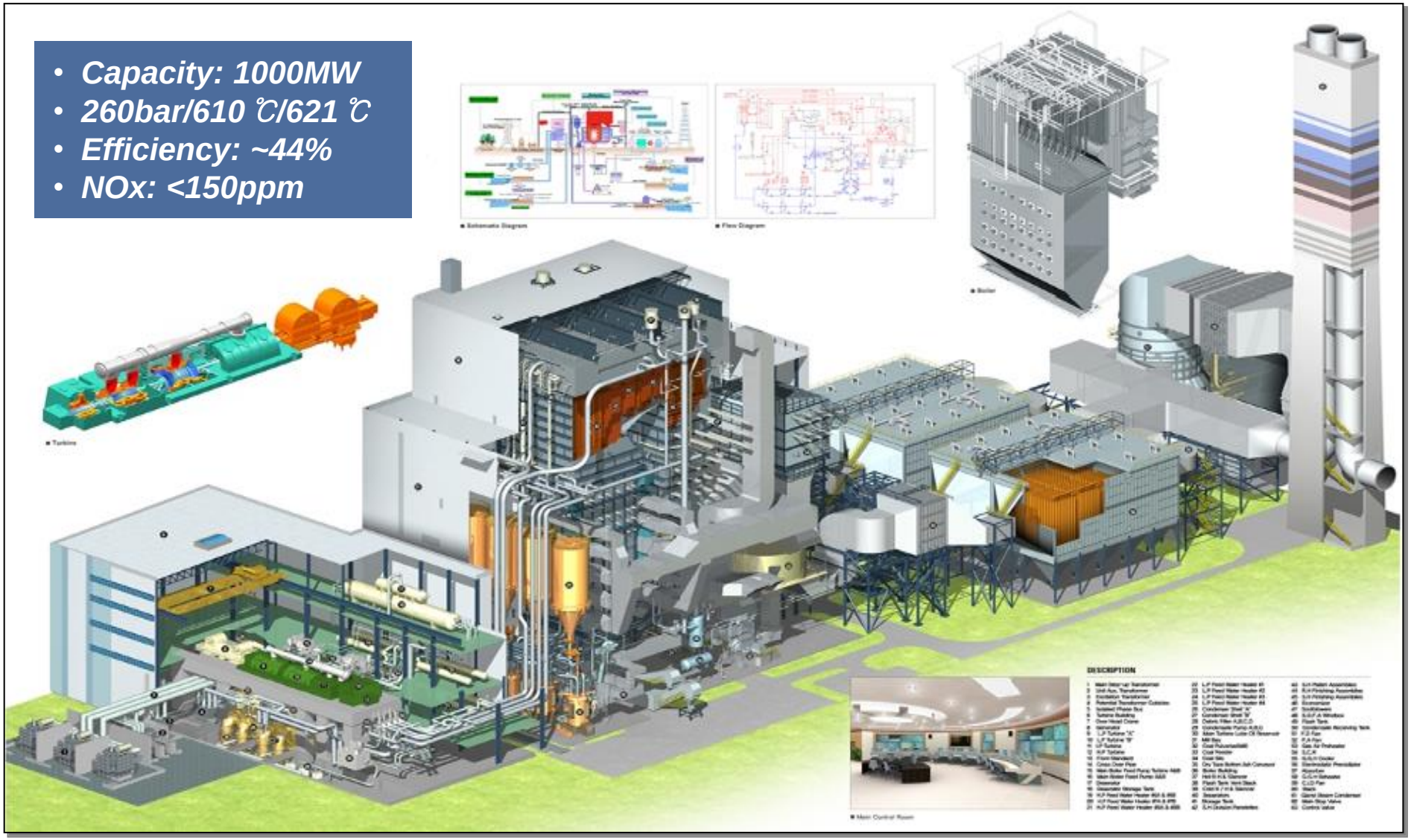
DOOSAN USC MODEL(1/4)

- *Capacity: 1000MW*
- *260bar/610 ℃/621 ℃*
- *Efficiency: ~44%*
- *NOx: <150ppm*



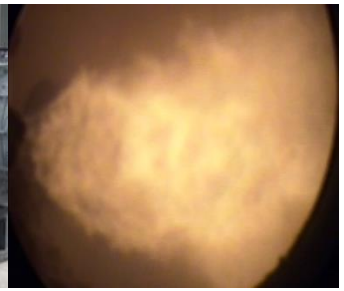
DOOSAN USC MODEL(2/4)

Doosan USC's First Delivery Site

Source: KOMIPO(KOREA MIDLAND POWER CO., LTD)

DOOSAN USC MODEL(3/4)

D-NOx™ Burner



Burner concept and basic design

Burner Development and Plant Demonstration

Commercialisation

1 Define Burner Concept and Development Targets *(Sept 2007 – Feb 2008)*

2 2.2MWt Burner Testing *(Mar-Apr 2008)*

3 Scale-up Rule and 63MWt Burner Testing *(Oct-Dec 2008)*

4 40MWt CCTF Testing (Isothermal & Combustion) *(Sept-Nov 2009)*

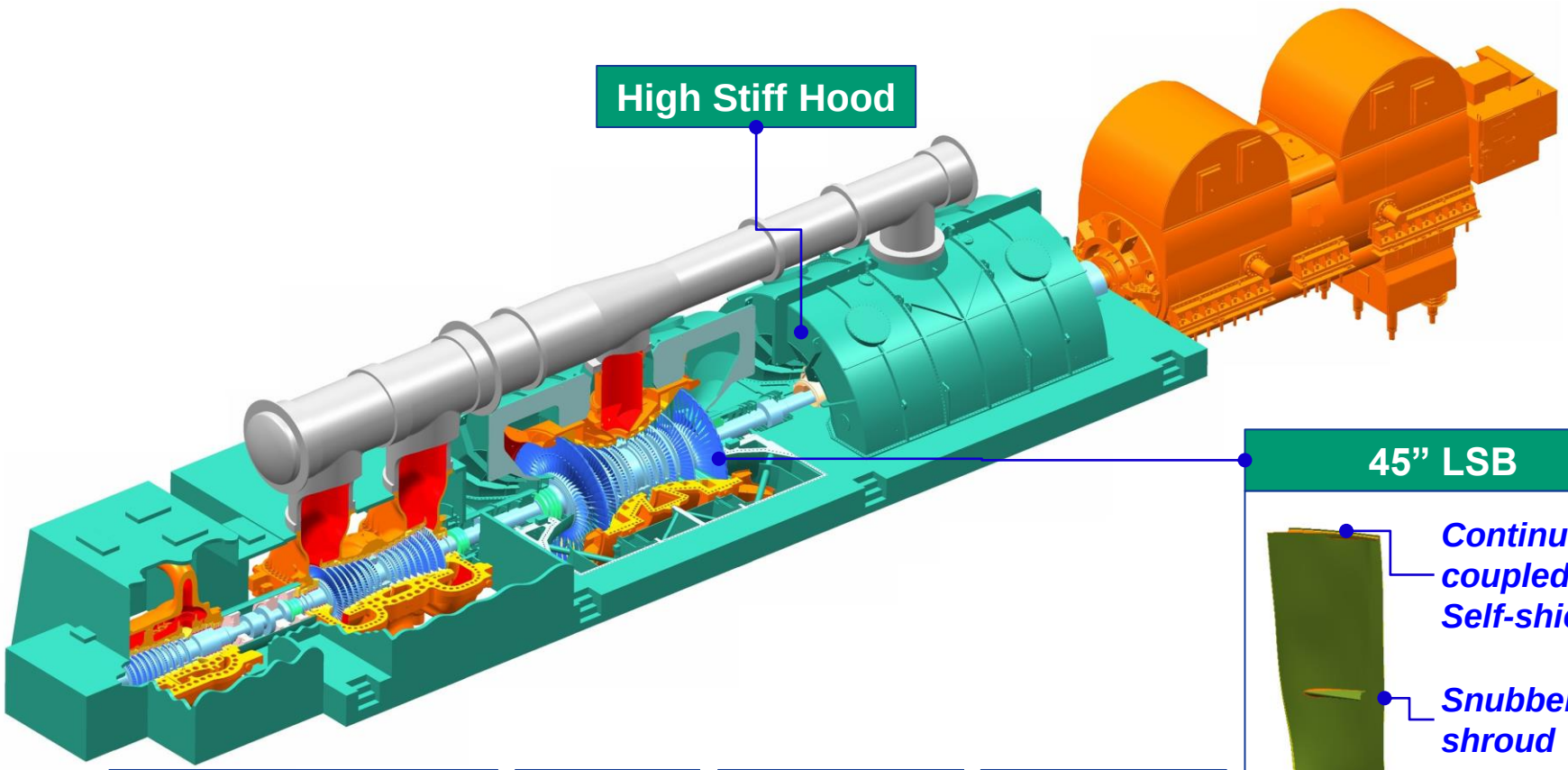
5 40MWt Burner Integrity and Performance Demonstration on Plant *(Jun 2010)*

6 **62MWt Commercialisation** ***(NOx 136ppm, CIA 3%)***

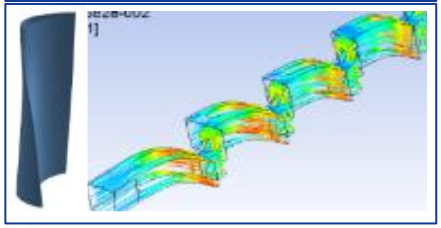
7 90MWt High Capacity

1-1 **D-NOx 2** Development Started ***(NOx 110 ppm, CIA≤ 0.5%, 2018)***

DOOSAN USC MODEL(4/4)



Adv. Reaction Blade



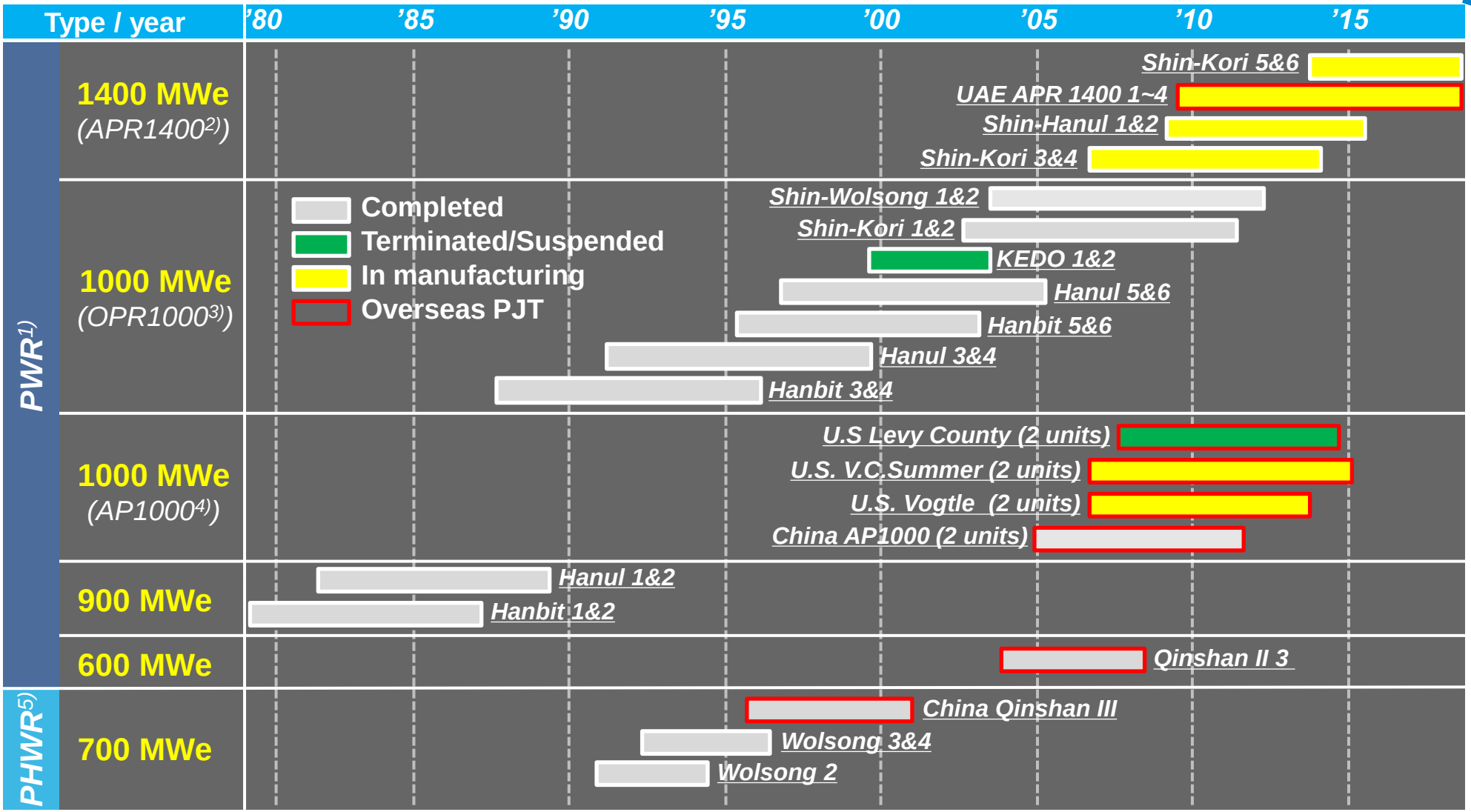
CCB[1)]

Brush Seal

Swirl Break

1) Continuous Coupled Blade

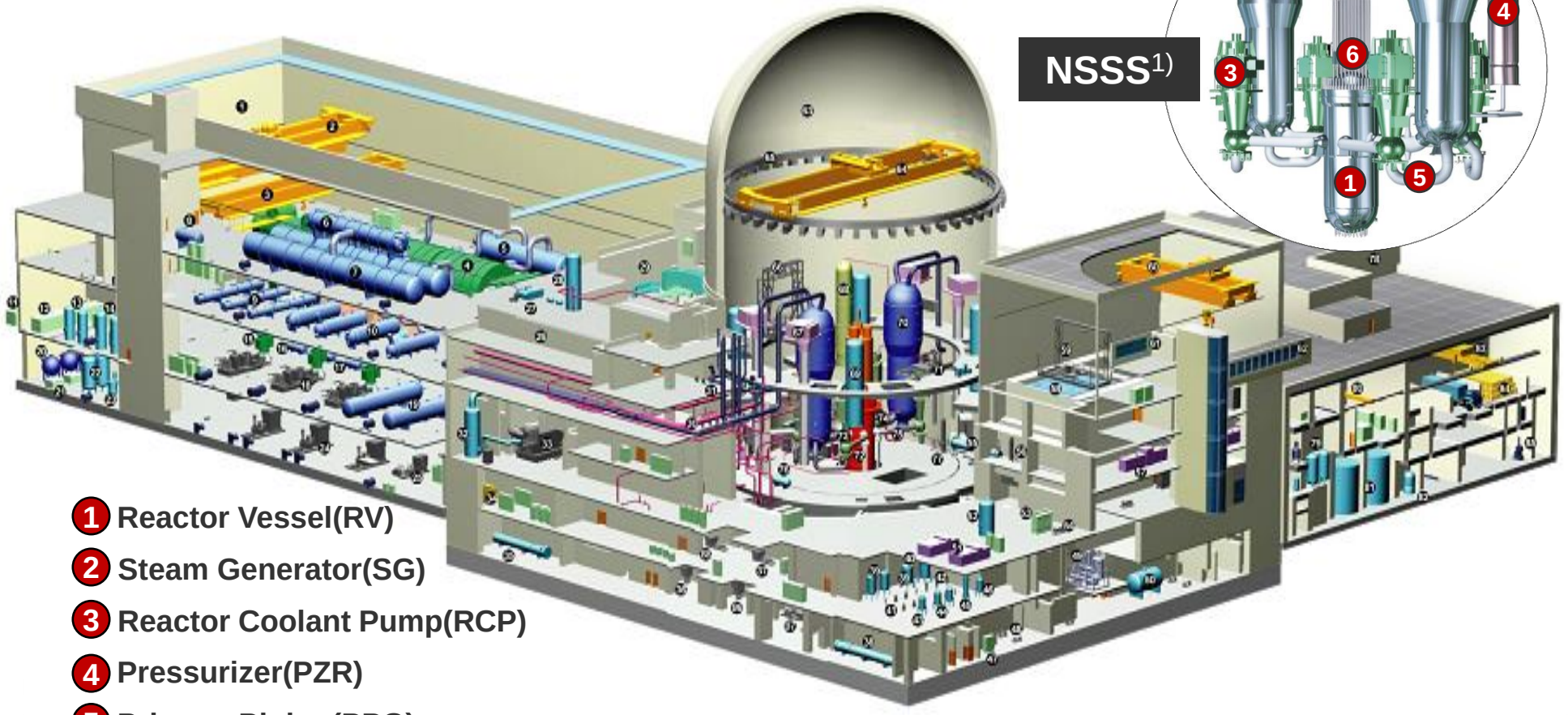
DOOSAN NUCLEAR POWER PLANT(1/5)



1) PWR: Pressurized Water Reactor
2) APR1400: Advanced Power Reactor for 1400MWe
3) OPR1000: Optimized Power Reactor for 1000MWe
4) AP1000: Westinghouse Nuclear Power Plant Model
5) PHWR: Pressurized Heavy Water Reactor

DOOSAN NUCLEAR POWER PLANT(2/5)

Advanced Power Reactor 1400



1. Reactor Vessel(RV)
2. Steam Generator(SG)
3. Reactor Coolant Pump(RCP)
4. Pressurizer(PZR)
5. Primary Piping(PPG)
6. Integrated Head Assembly/Control Element Drive Mechanism

1) NSSS: Nuclear Steam Supply System
Source: KHNP(KOREA HYDRO & NUCLEAR POWER CO., LTD)

DOOSAN NUCLEAR POWER PLANT(3/5)

Reactor Vessel

Height	***14.8 m***
Thickness	***29.2cm***
O.D	***5.5m***
Weight	***553 ton***

Steam Generator

Height	***23 m***
Thickness (Upper Shell)	***14.3 cm***
O.D (Upper Shell)	***5.89 m***
Weight	***775 ton***

DOOSAN NUCLEAR POWER PLANT(4/5)

Integral Heads Manufacturing Technology

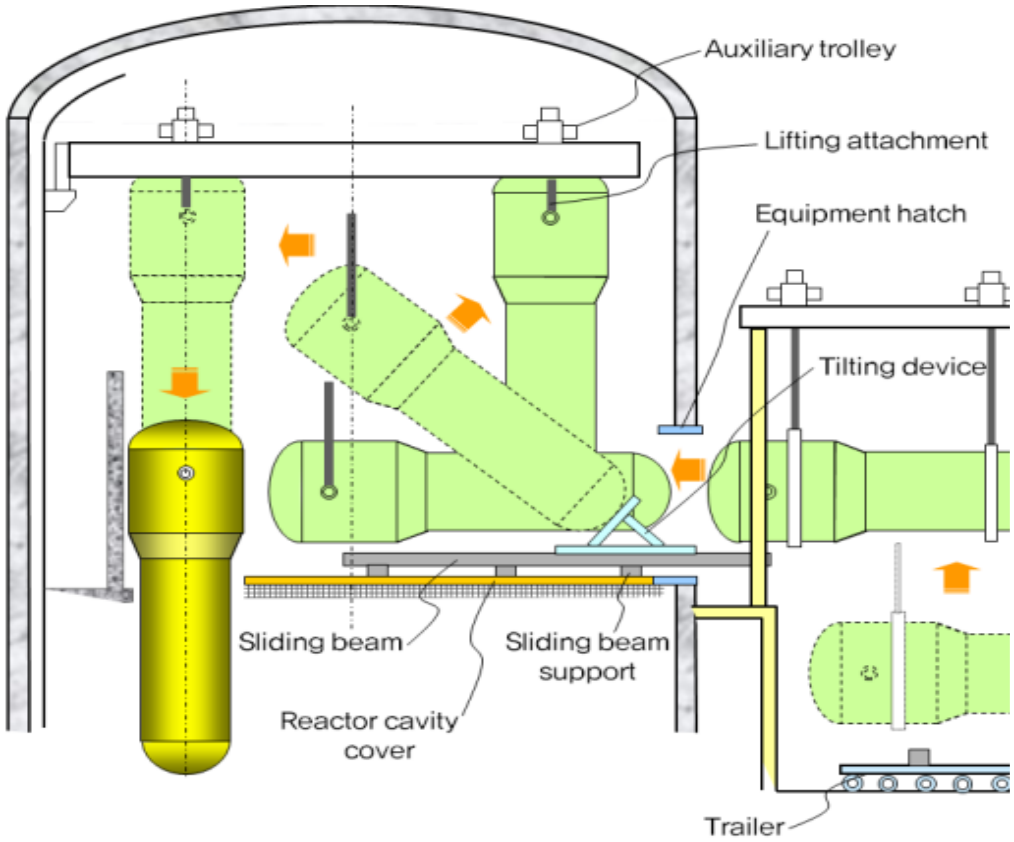
Steam Generator

O.D 4,488mm x H2,470 mm (61 Ton)

DOOSAN NUCLEAR POWER PLANT(5/5)

Steam Generator Replacement

- *Preparation*
- *Templating / Clamping & Supporting*
- *Pipe cutting & Removal*
- ***Rigging & Handling***
- *Beveling / Templating*
- *SG set up & Fit up*
- *Narrow gap Welding & FOSAR[1)]*
- *Testing*



Rigging & Handling

1) FOSAR: Foreign Object Search And Retrieval

DOOSAN IGCC TECHNOLOGY(1/2)

DOOSAN IGCC TECHNOLOGY(2/2)

IGCC Plant

- **EPC for Gasification Plant**
- **Development of Basic Design Technology**
- **Manufacturing Key Equipment**
- **Development of Engineering Technology**

Progress 95%
(completion in 2015.12)

Wind Turbine(1/3)

Power regulation Pitch regulated with variable speed

Operating data

Rated power	3,000 kW
Wind class – IEC	Ia / IIa
Rated wind speed	13 / 12.5 m/s

Rotor

Number of blade	3
Rotor diameter	91.3 / 100 m
Rotor speed (rated)	8 ~ 20.4 (15.71) / 7.26 ~ 16.92 (15.4) rpm

Gearbox

Type	2 planetary + 1 parallel
Gear ratio	92.92 / 94.93

Tower

Type	Tubular steel tower
Height	77.78 m

Wind Turbine(2/3)

Onshore Demo-Plant
(R&D Operation)

Commercial Operation

Commercial Operation

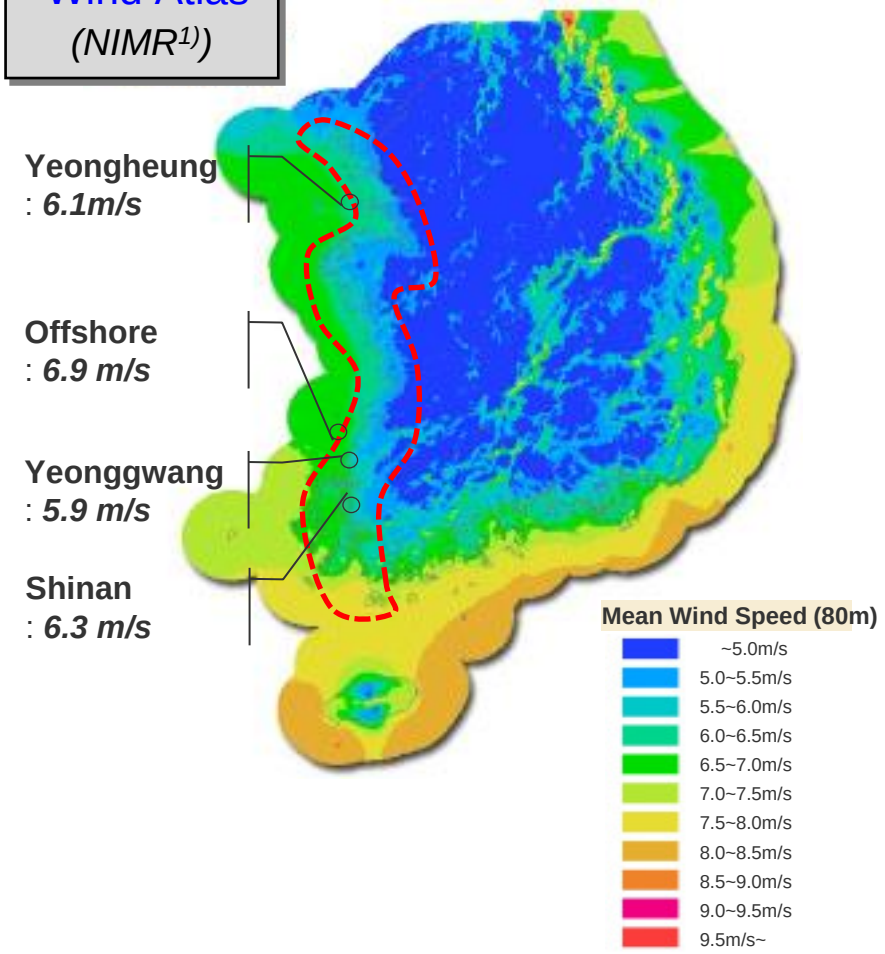
Under construction

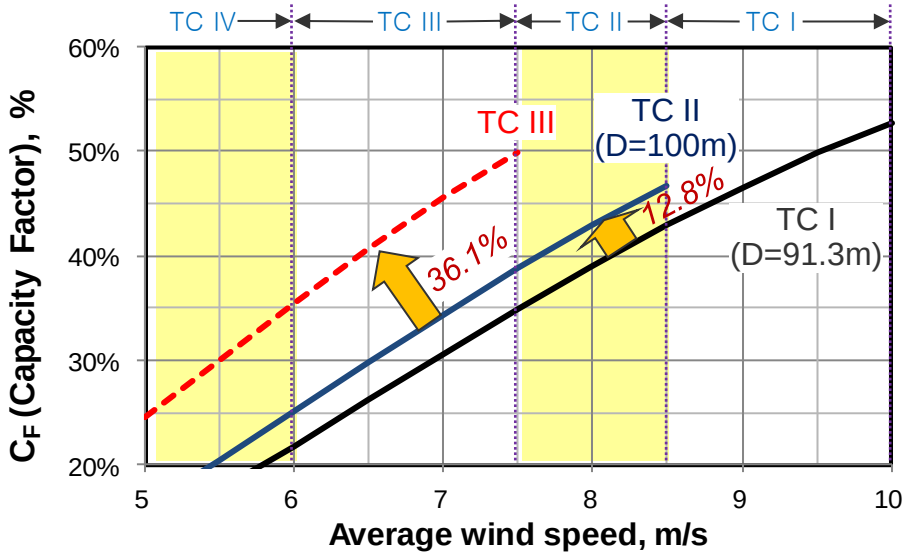
Offshore Demo-Plant
(R&D Operation)

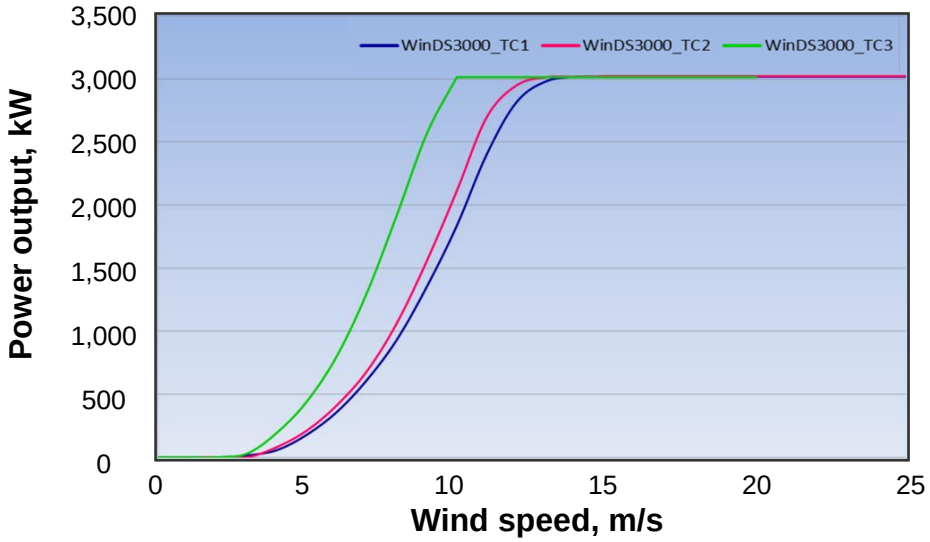
Under construction

Wind Turbine(3/3)

Wind Atlas
(NIMR[1])







1) National Institute of Meteorological Research

Creating a world of opportunities

As we continue our quest to become one of the world's top 200 companies by 2020, our focus will remain on core technologies that will give us a competitive edge and allow us to continue to transform our company to meet whatever challenges and opportunities lie ahead to create a better world for us all.

By a 'better world' we mean a world of opportunity where each of us has the tools and facilities to reach our full potential. For some, opportunity may mean having fresh water to enjoy fuller harvests. For others, it may mean having power to light the family home, or the tools to make machines to advance in business. Whatever may be needed to meet to challenges of the future, we are ready to play our part.

That's what '*Building your tomorrow today*' means to all of us at Doosan.

DOOSAN

Building your tomorrow today