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Nuclear Power Plants history and the role

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The views expressed here do not necessarily reflect those of JAEC nor the government

Nuclear Power in the World Today

- **There are over 440 commercial nuclear power reactors operable in 31 countries, with over 390,000 MWe of total capacity. About 60 more reactors are under construction.**
- **They provide over 11% of the world's electricity as continuous, reliable base-load power, without carbon dioxide emissions.**
- **55 countries operate a total of about 245 research reactors, and a further 180 nuclear reactors power some 140 ships and submarines.**

PWR development

PWR was developed based on nuclear submarine reactor technology of US Navy by Westinghouse

Nautilus (1954, north pole voyage 1958)

Shippingport PWR (1957, Westinghouse, demonstration reactor, 60MWe)

Yankee Rowe (1961, 1st commercial plant, 185MWe)

Saxton (1960, testing reactor, 20MWt)

Mihama I (1970, 340MWe, Kansai EPCO, Japan)

Standardization ; 2 loop (600MWe), 3 loop (900MWe), 4 loop (1200MWe): same design of steam generators and coolant pumps

VVER, Konvoi, EPR, KPR1400, AP1000, Hualong1

USS Nautilus (Nuclear submarine)



Source: <http://www.hnsa.org/ships/nautilus.htm>

Shippingport Atomic Power Station



Source: <http://www.mbe.doe.gov/me70/history/photos.htm>

BWR development

BORAX-I; Inherent safety, power excursion test

BORAX-II; Pressurization, instability study

BORAX-III; Power generation test

BORAX-IV; UO₂ fuel, stability, radiolysis, radioactivity in turbine island

BORAX-V; High power density core, nuclear superheat

EBWR (Argonne national lab. 5MWe); Power demonstration, Accumulation of trouble experience

VBWR (GE) ; Economic improvement, natural/forced circulation, direct/indirect cycle, materials testing

Dresden-I (Demonstration reactor, 180MWe,1959, Zircaloy fuel)

JPDR (Japan, JAERI, demonstration reactor, 12.5MWe, 1963)

Dresden-II、Oyster Creek (1st generation of commercial plants, 1965)

Tsuruga 1 (357MWe, 1969, JAPC), Fukushima I (460MWe, 1970, TEPCO

Swedish BWR, German BWR, ABWR

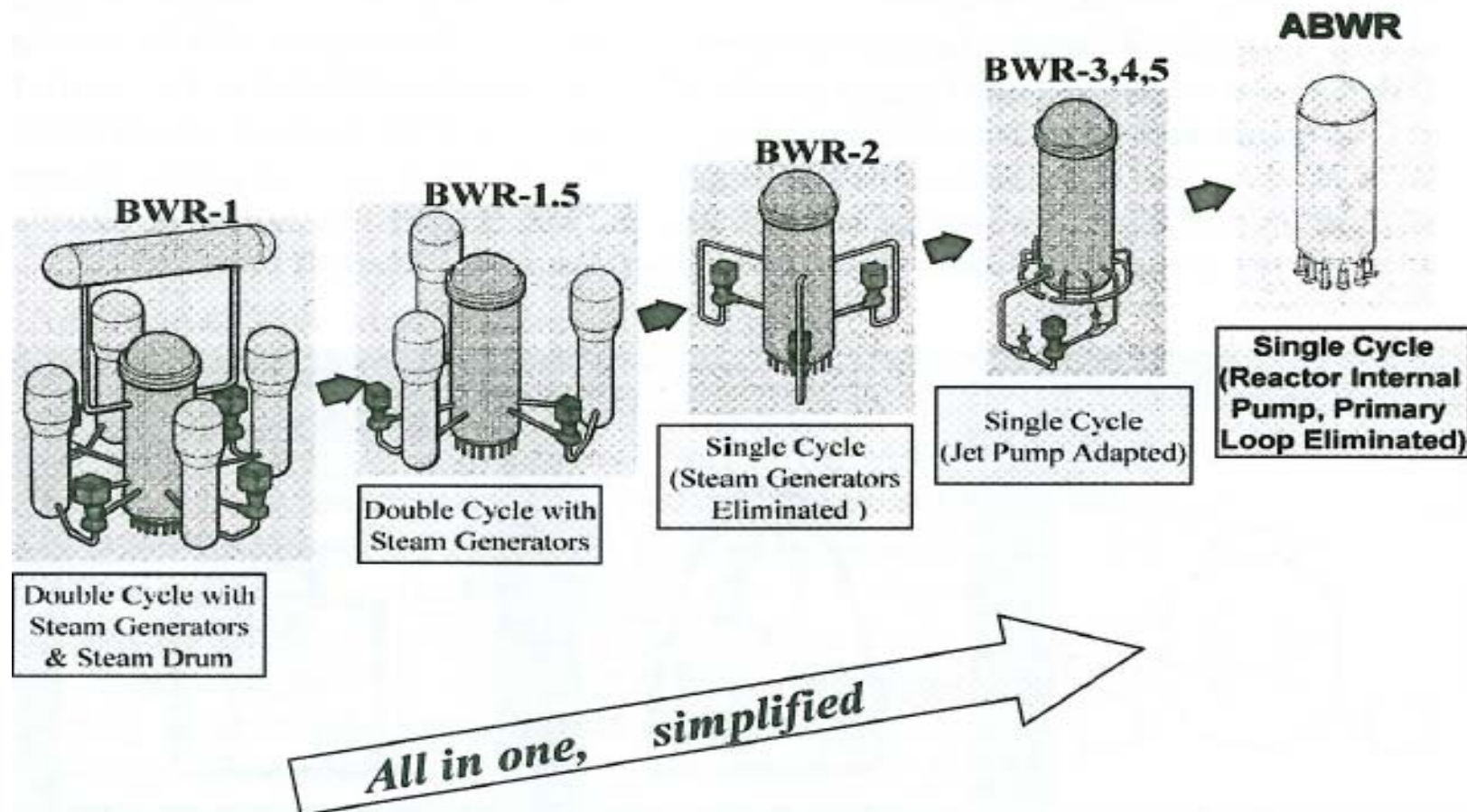


Argonne National Laboratory-West 201-709

BORAX-I, the "runaway" reactor.

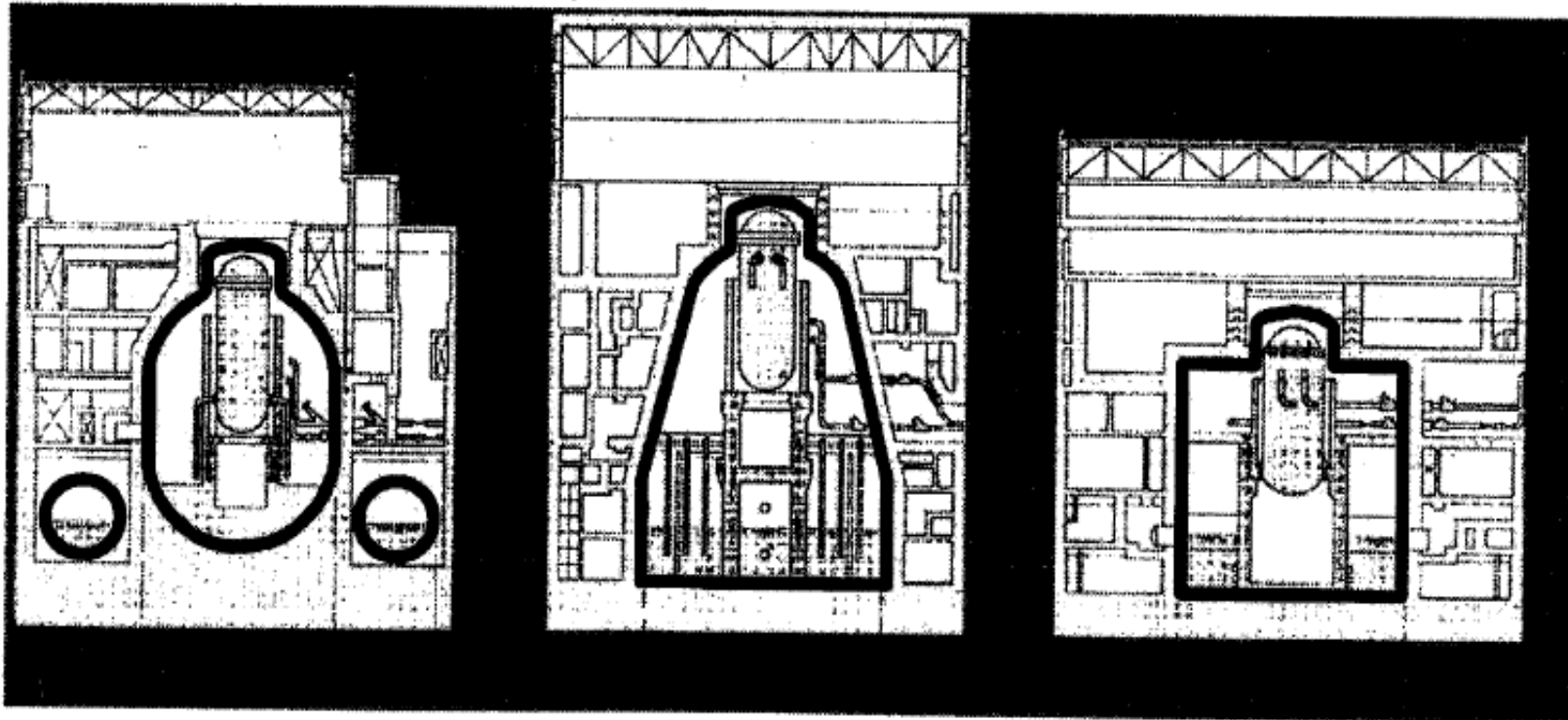
Source: S.M. Stacy "Proving the principle" DOE/ID-10799

Evolution of BWR



Source: Y.Oka (editor) "Advances in light water reactor technologies", Springer 2011

Evolution of BWR containment



Mark-I
(1100 MWe class)

Mark-II
(1100 MWe class)

RCCV
(1350 MWe class)

BWR

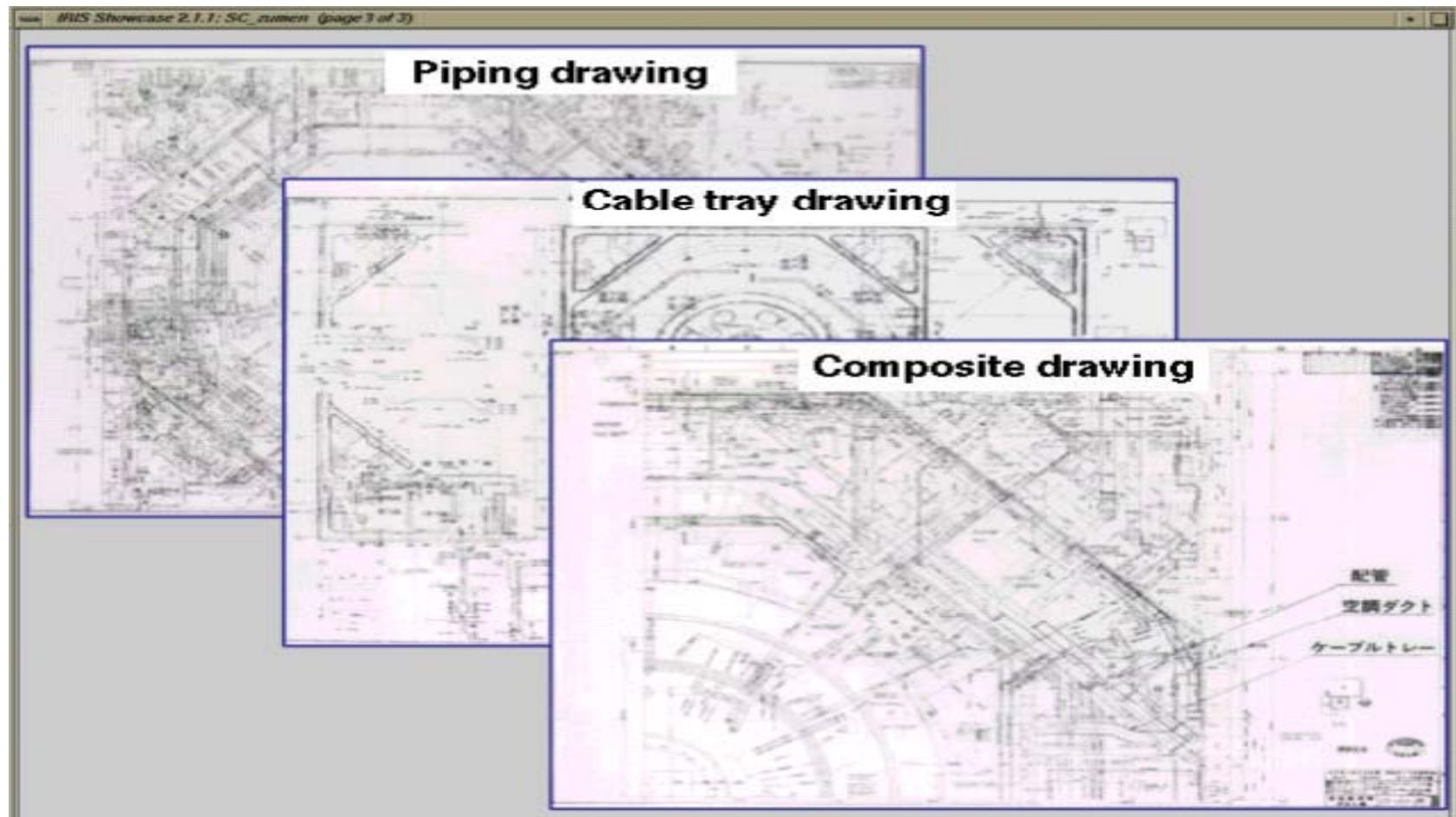
ABWR

Source: Y.Oka (editor) "Advances in light water reactor technologies", Springer 2011

Advances in LWR technologies

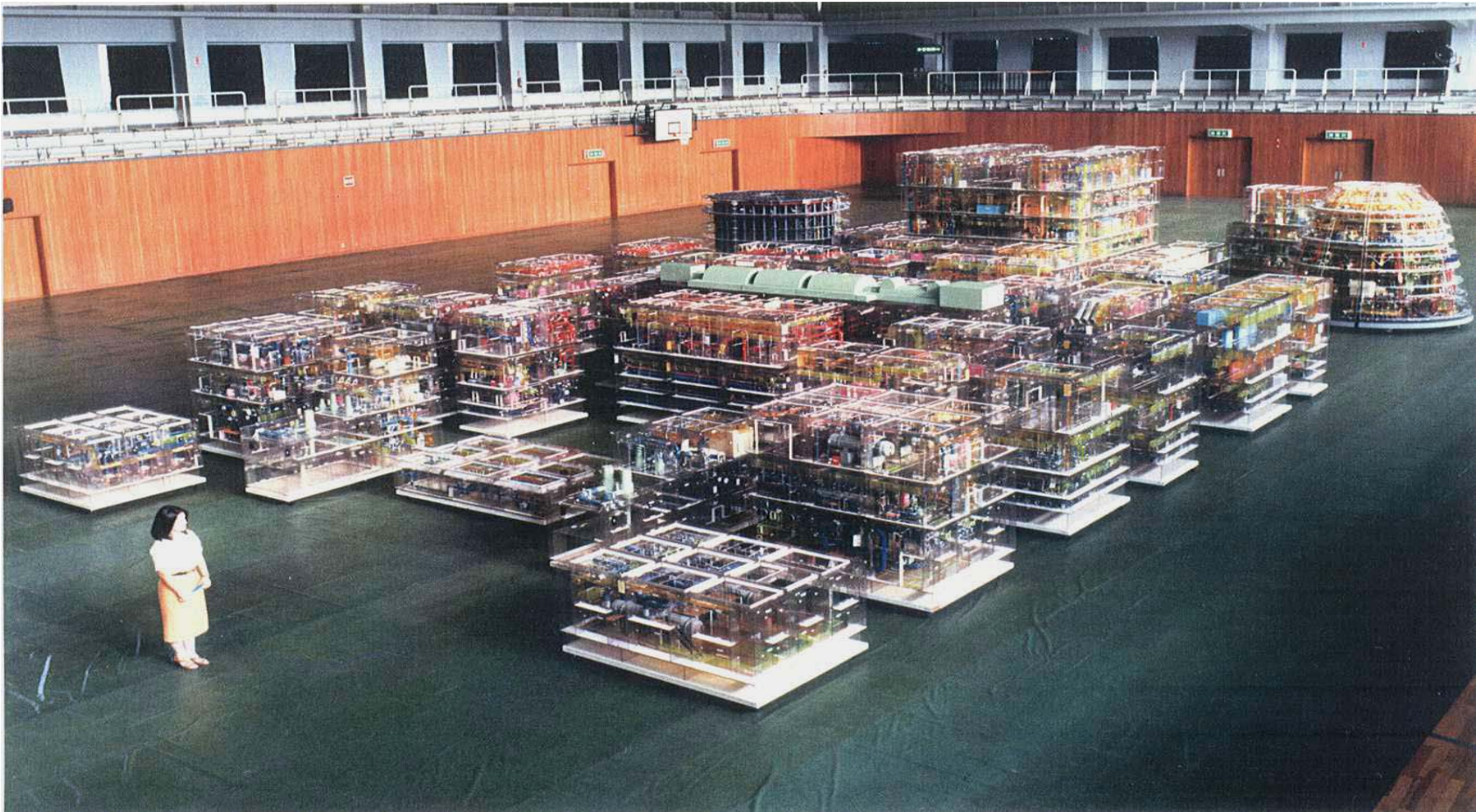
An example,
Computer aided design, engineering
and construction

Design by Hand drawing (1975's)



"Source: Kawahata, Hitachi-GE Nuclear Energy, Ltd., Intn'l Summer School of Nuclear Power Plants, Tokai-mura, Univ. Tokyo 2009"

Design by plastic model (1985's)



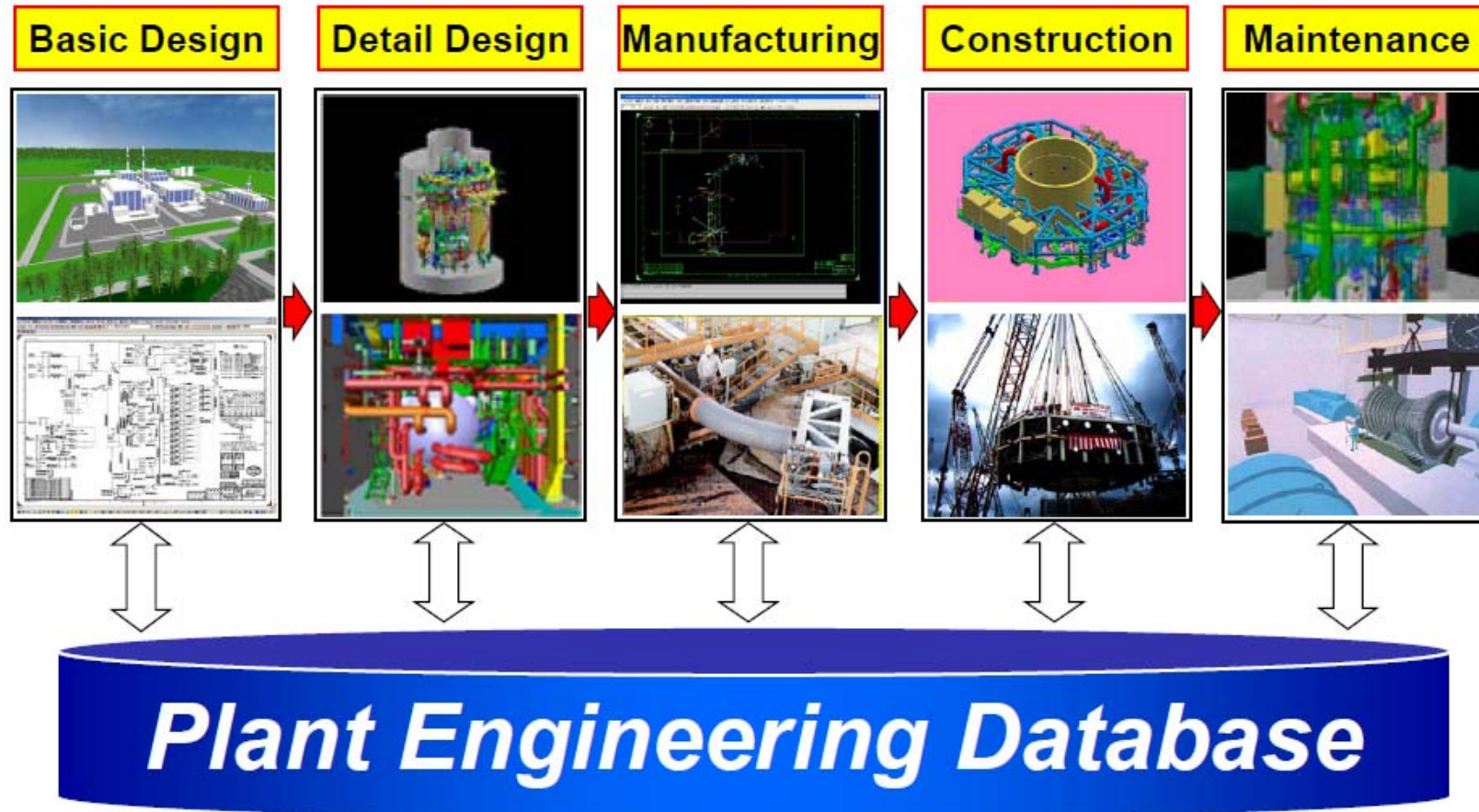
"Source: Kawahata, Hitachi-GE Nuclear Energy, Ltd., Intrn'l Summer School of Nuclear Power Plants, Tokai-mura, Univ. Tokyo 2009"

Design by 3D CAD (1990's)



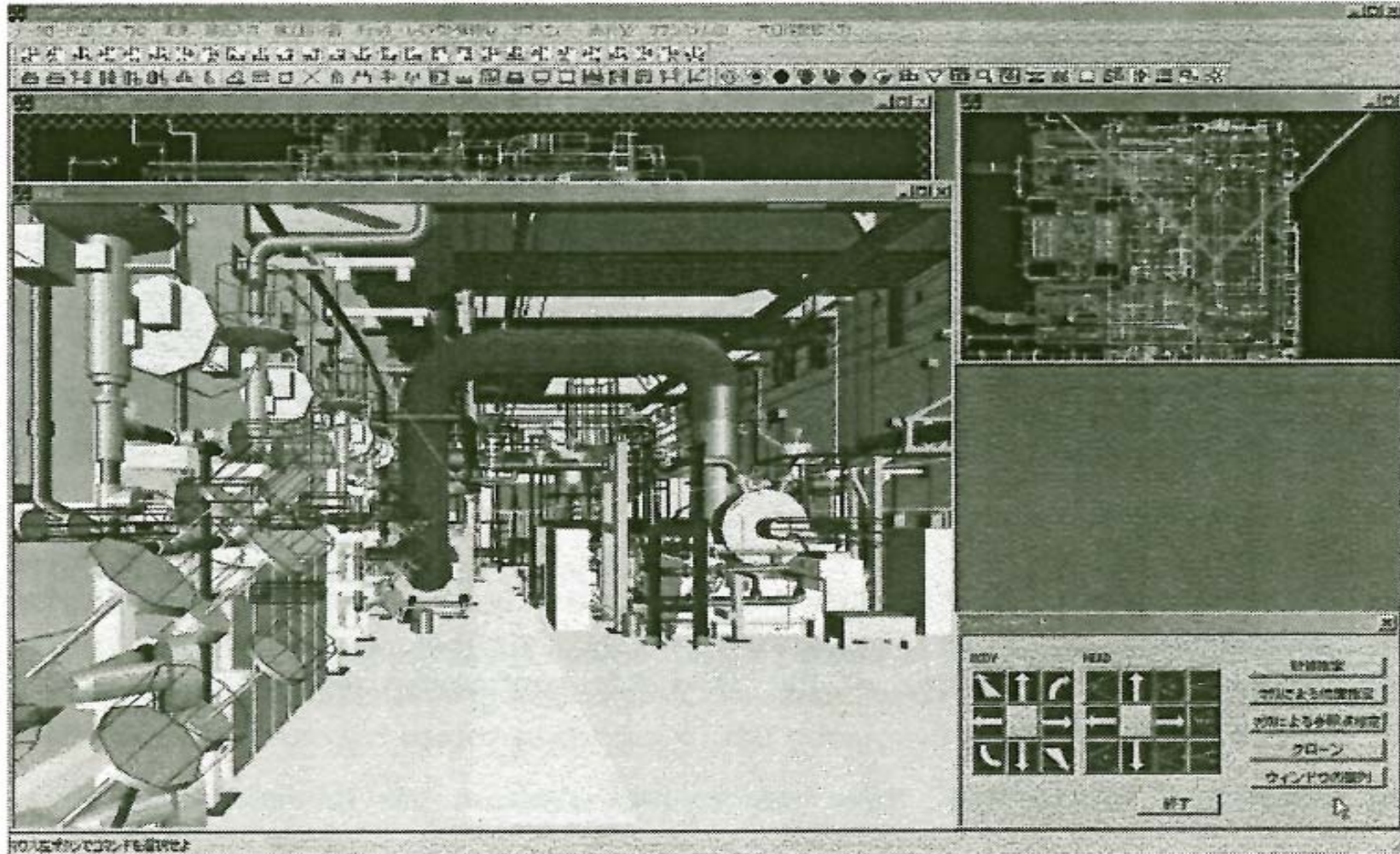
"Source: Kawahata, Hitachi-GE Nuclear Energy, Ltd., Intn'l Summer School of Nuclear Power Plants, Tokai-mura. Univ. Tokyo 2009"

Plant integrated CAE system (present)



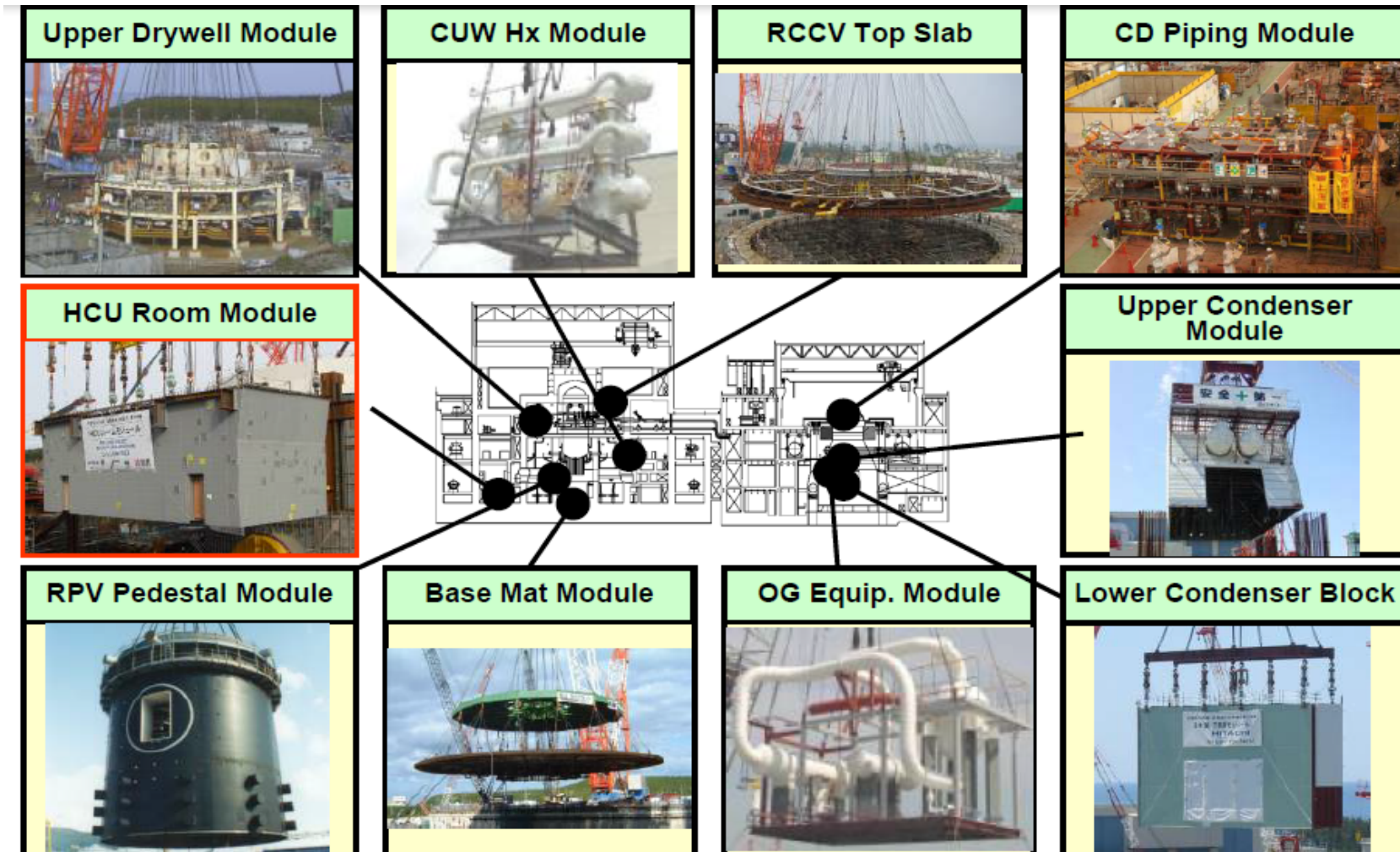
"Source: Kawahata, Hitachi-GE Nuclear Energy, Ltd., Intn'l Summer School of Nuclear Power Plants, Tokai-mura, Univ. Tokyo 2009"

Walk – through simulation with CAE



Source: Y.Oka (editor) “Advances in light water reactor technologies”, Springer 2011

Modular construction



"Source: Kawahata, Hitachi-GE Nuclear Energy, Ltd., Intn'l Summer School of Nuclear Power Plants, Tokai-mura, Univ. Tokyo 2009"

Nuclear Power Utilization in Japan

43 LWR plants; BWR and PWR

9 utilities (TEPCO, Kansai, Chubu etc.) by region and
JAPC and J-Power(EPDC)

First LWR demo (JPDR, 12MWe BWR) in 1959

First commercial plant (GCR) in 1965, LWR in 1970

Developed ABWR and APWR

3 Manufacturers; Toshiba/WH, Hitachi/GE and MHI

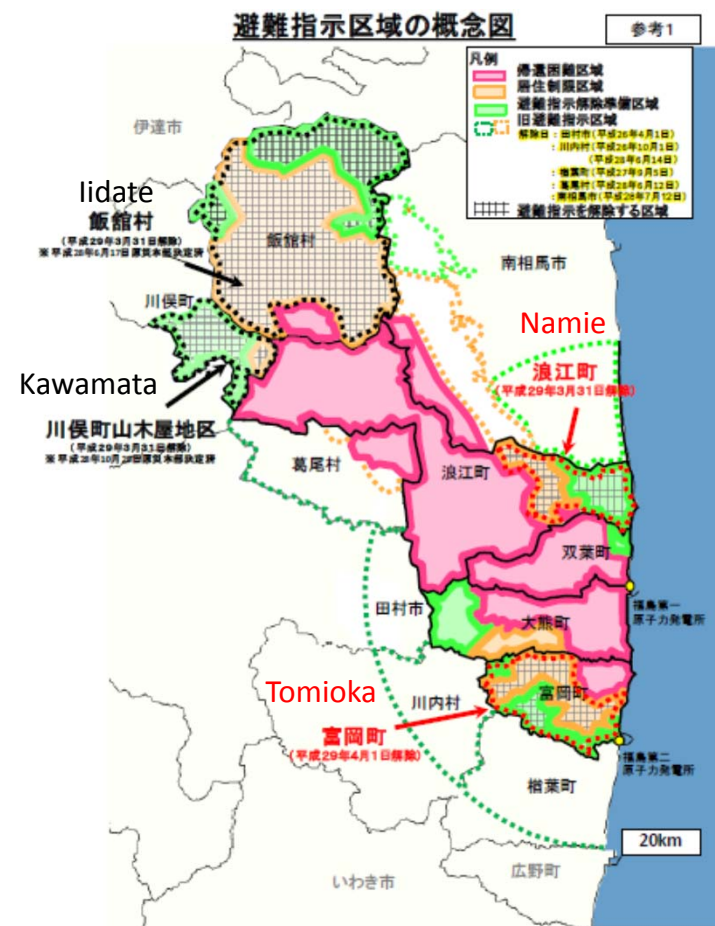
3 nuclear fuel manufacturers; GNF, Mitsubishi NF, NFI

Commercial nuclear fuel cycle program by JNFL
(enrichment, spent fuel reprocessing and low level
radioactive waste disposal) in Rokkasho-mura

Only for peaceful use, no nuclear weapon by law

Follow-up of Fukushima Nuclear Accident (off-site)

Evacuation Orders were Lifted in Most of the Restricted Areas
【Iidate, Kawamata, Namie, Tomioka】 (April 2017)




Evacuees of Fukushima : 164,865 (May 2012) → 77,283 (March 2017)

□ Difficult-to-Return Zone

The area that needs physical protective measures such as barricades and seek evacuation because the radiation dose is at a very high level,

 Restricted Residence Zone

The area that aims to enable the residents to return home and rebuild the community in the future by decontaminating and restoring the infrastructure for early recovery.

 Zone in Preparation for the Lifting of the Evacuation Order

The area that aims to improve the environment for residents to return home by prompt support measures for restoration and reconstruction.

Inspections of All Bags of Rice in Fukushima Prefecture

- Radioactive inspections have been carried out on all bags of rice since 2012.
- Results in 2016 show that all bags of rice were within the limit (100Bq/kg).

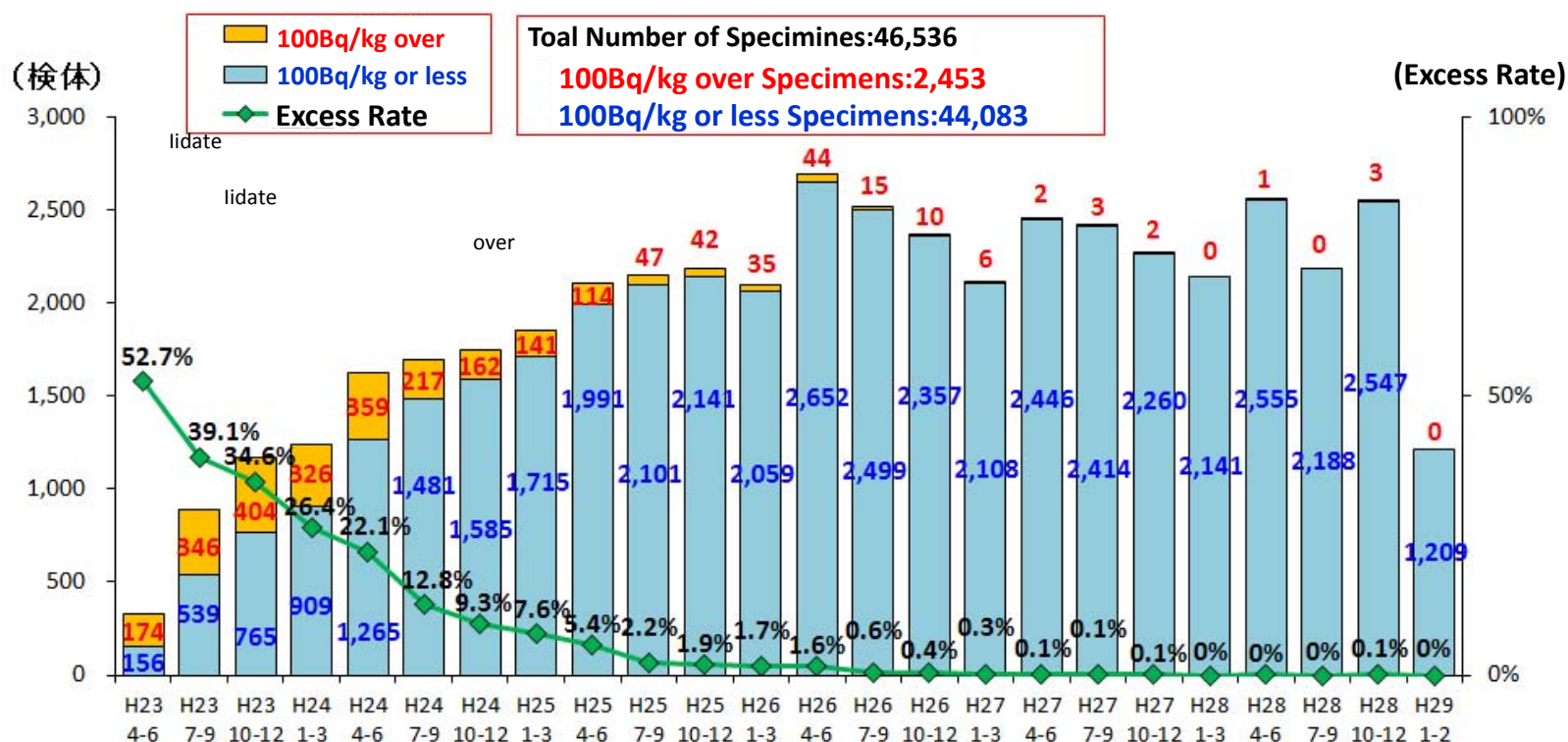


Evaluation of monitoring, etc. by IAEA (Excerpts from IAEA report (November 2015))

- According to the information provided, although many food restrictions remain in force, it has not been necessary to implement new food restrictions over the reporting period and several such restrictions have been lifted where extensive testing confirms that food collected no longer exceeds the regulatory limit.
- The IAEA continues to acknowledge that systems are in place and are being implemented to prevent food and agricultural products with levels of caesium radionuclides in excess of the national regulatory limits from entering the food supply chain.
- The Joint IAEA / FAO Division understands that the measures taken to monitor and respond to issues regarding radionuclide contamination of food are appropriate, and that the food supply chain is under control.

Results of Surveys of Marine Fishery Products in Fukushima Prefecture

Between April and June 2011 immediately after the disaster, the percentage of marine fishery products in Fukushima Prefecture that exceeded the standard limit (100Bq/kg) was 52.7%. This percentage has continued to decline, and has fallen to 0% since April 2015.



Source: Fisheries Agency HP "Results of radioactive material survey of marine products" - Update on 24th March - <http://www.jfa.maff.go.jp/j/housyanou/kekka.html>

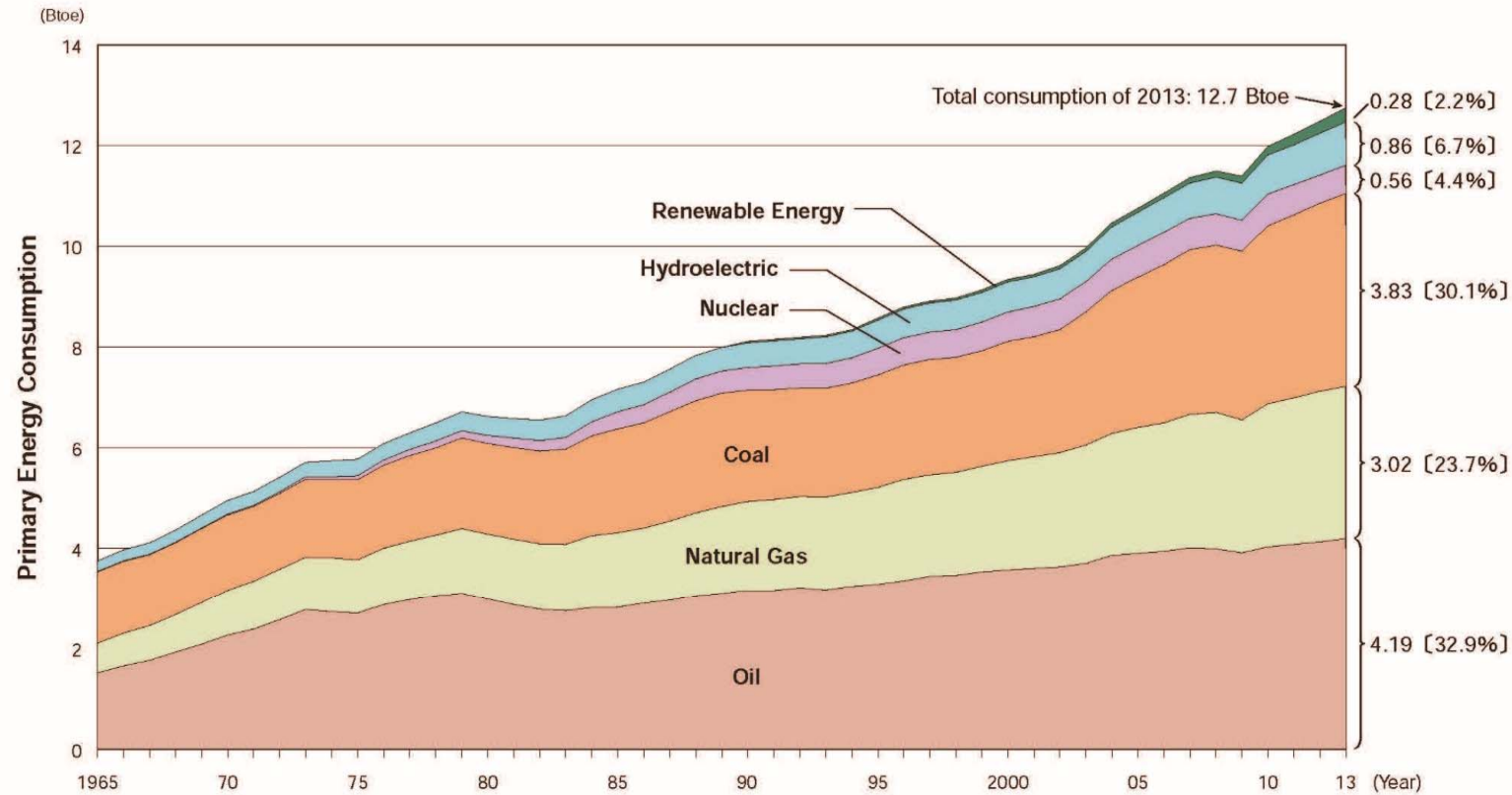
Thorough monitoring inspections are conducted for agricultural, forestry and fishery products prior to shipment

The foods exceeding the standard limit (100 Bq/kg) have decreased sharply in recent years . Those exceeding the standard are restricted from shipping.

Food categories	Number of types	Number of Tested Items	Number of Items Exceeding the Standard Limits(100Bq/kg)	Number of Items at/below the Standard Limits(100Bq/kg)
Brown Rice	0	0	0	0
Grain (excluding Brown rice)	14	705	0	705
Vegetables	233	2,870	0	2,870
Fruit	42	923	0	923
Raw Milk	1	415	0	415
Meat	5	3,791	0	3,791
Chicken Eggs	1	143	0	143
Honey	1	35	0	35
Grass/Feed Crops	—	922	0	922
Seafood (Marine Seafood)	154	8,766	0	8,766
Seafood (River Fish/Lake Fish)	16	621	4	617
Seafood (Fish Farmed in Fresh Water)	4	118	0	118
Mountain Herbs(Wild)	15	737	2	735
Mountain Herbs (Cultivation)	1	299	0	299
Mushrooms(Wild)	17	46	0	46
Mushrooms (Cultivation)	25	750	0	750
Tree Nuts	2	39	0	39
Total	530	21,180	6	21,174

Source: Monitoring inspection results of agricultural, forestry and fishery products in FY2008 (as of March 31)
<http://www.pref.fukushima.lg.jp/site/portal/89-4.html>

The World's Primary Energy Consumption



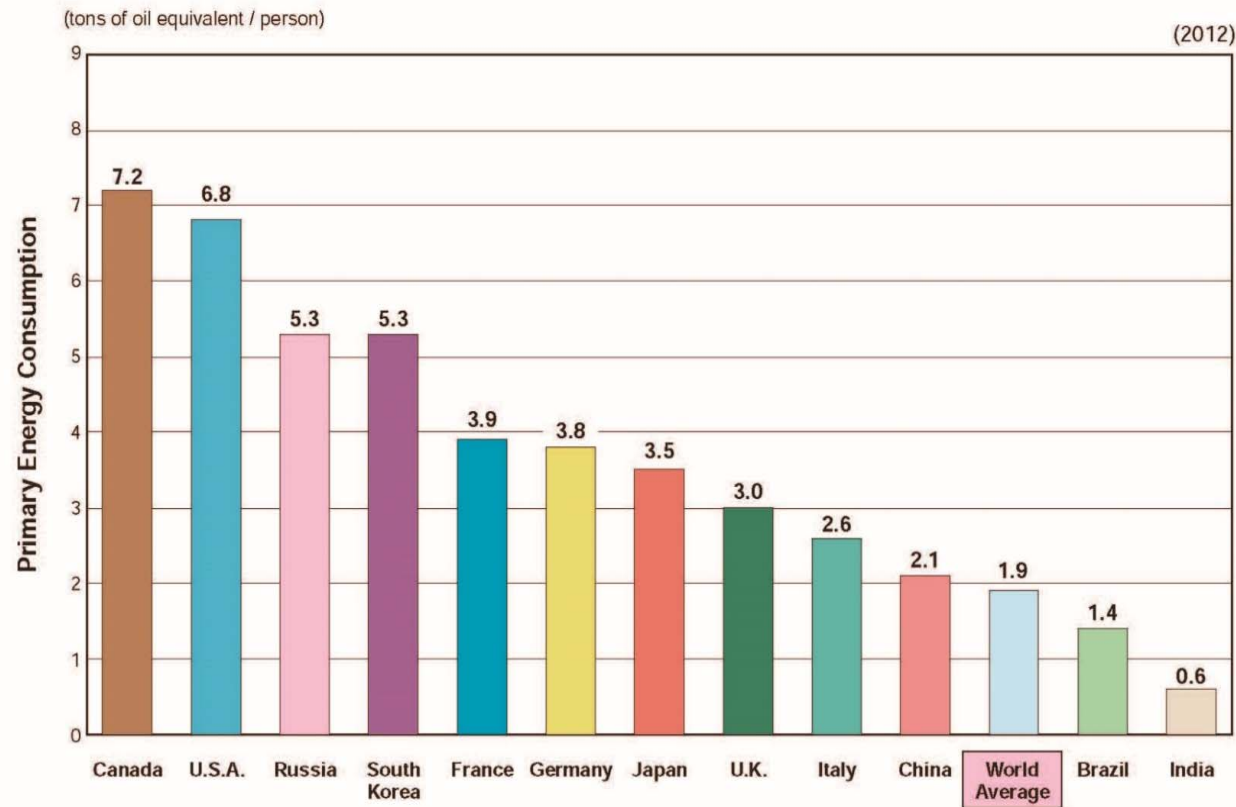
(Note) Figures may not add up to the totals due to rounding. The figures in parentheses are share of total.
Btoe: billion tons of oil equivalent

1-1-7

Source: BP Statistical Review of World Energy 2014

Source: http://www.fepec.or.jp/library/pamphlet/zumenshu/pdf/all_english.pdf

Primary Energy Consumption per Capita

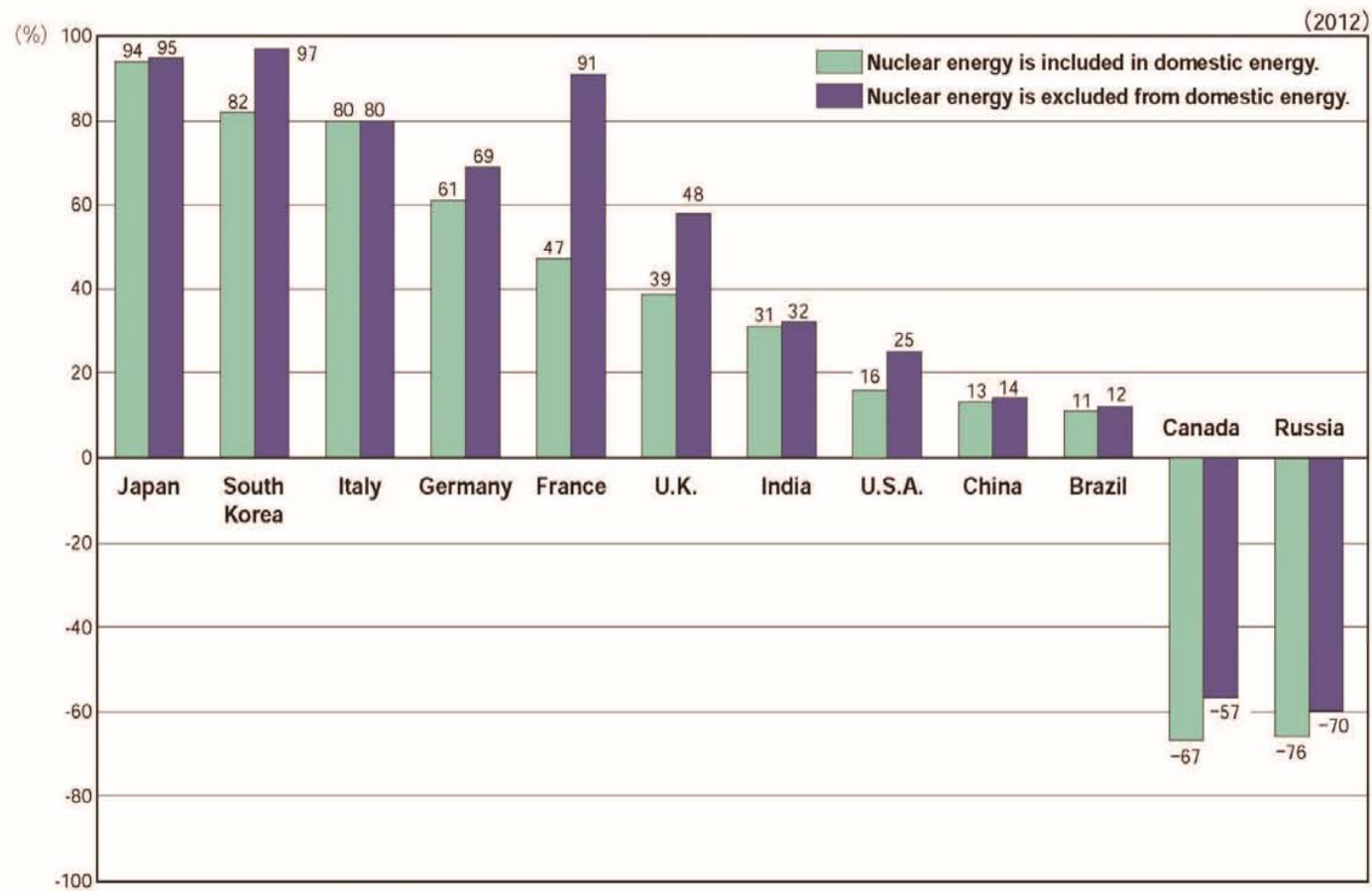


1-1-4

Source: IEA "ENERGY BALANCES OF OECD COUNTRIES (2014 Edition)" / "ENERGY BALANCES OF NON-OECD COUNTRIES (2014 Edition)"

Source: http://www.fepec.or.jp/library/pamphlet/zumenshu/pdf/all_english.pdf

Dependence on Imported Energy Sources in Major Countries



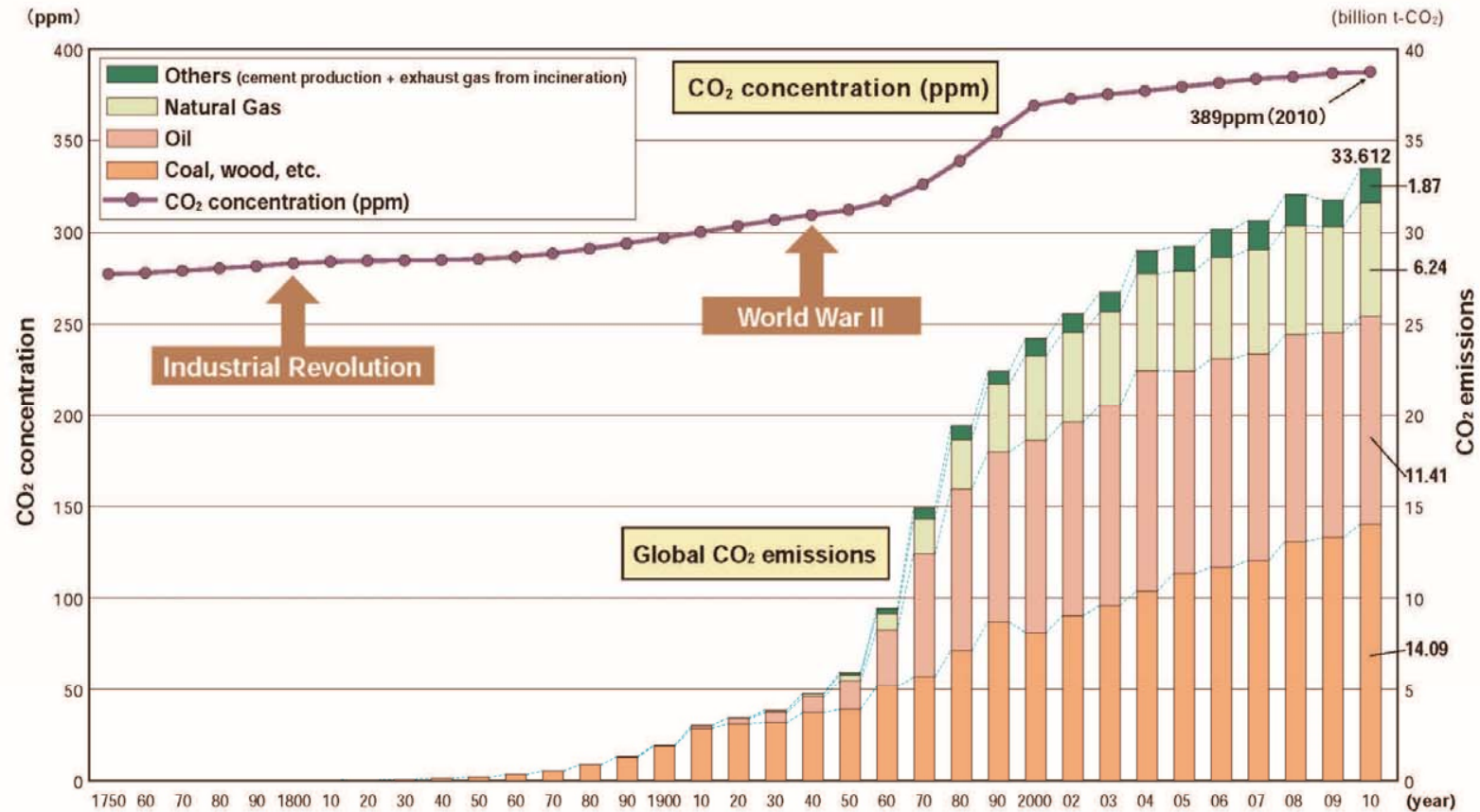
(Note) Canada and Russia are net-exporting countries.

1-1-11

Source: IEA "ENERGY BALANCES OF OECD COUNTRIES (2014 Edition)" / "ENERGY BALANCES OF NON-OECD COUNTRIES (2014 Edition)".

Source; <http://www.fepec.or.jp/library/publication/pamphlet/nuclear/zumenshu/index.html>

Changes in CO₂ Emissions from Fossil Fuels and Atmospheric CO₂ Concentration in Japan



(Note) Figures may not add up to the totals due to rounding.

2-1-3

Source: CDIAC "Global Fossil-Fuel Carbon Emissions" etc.

Source: http://www.fepc.or.jp/library/pamphlet/zumenshu/pdf/all_english.pdf

Role of nuclear power

- **The world will need greatly increased energy supply in the future, especially cleanly-generated electricity.**
- **Electricity demand is increasing twice as fast as overall energy use and is likely to rise by more than two-thirds 2011 to 2035. In 2012, 42% of primary energy used was converted into electricity.**
- **Nuclear power should meet the needs of an environmentally benign way of producing electricity on a large scale.**

G7 Leaders' Declaration

Ise-Shima Summit, 26-27 May 2016, pp.29

- In those countries that opt to use nuclear energy, it substantially contributes to the reduction of future GHG emissions and works as a base load energy source.
- In those countries it is also crucially important to engage the public in science-based dialogue and transparency to inform policymaking.
- We call upon all countries that opt to use nuclear power to ensure the highest standards of safety, security and non-proliferation including an independent and effective regulator, and to exchange their expertise and experiences.

Thank you for your attention