

# Sustainable Development of Nuclear Reactor Systems for Future Generations

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# The Current State Of Nuclear Power In The World

- At the end of last year there were 440 nuclear power units operating worldwide. Together they supplied 16% of the world's electricity in 2003.
- That percentage has remained relatively steady for some time, meaning that nuclear electricity generation has grown at essentially the same rate as total electricity generation worldwide.



# The Current State Of Nuclear Power In The World

- It is often claimed that this is because world events such as the oil embargoes of the 1970s and the political unrest in the Middle East have influenced energy policy in many countries.
- However, current expansion and growth prospects for nuclear power are weak and centered in Asia. Of the 31 units under construction worldwide, 18 are located in China, Taiwan, India, Japan, and Korea.

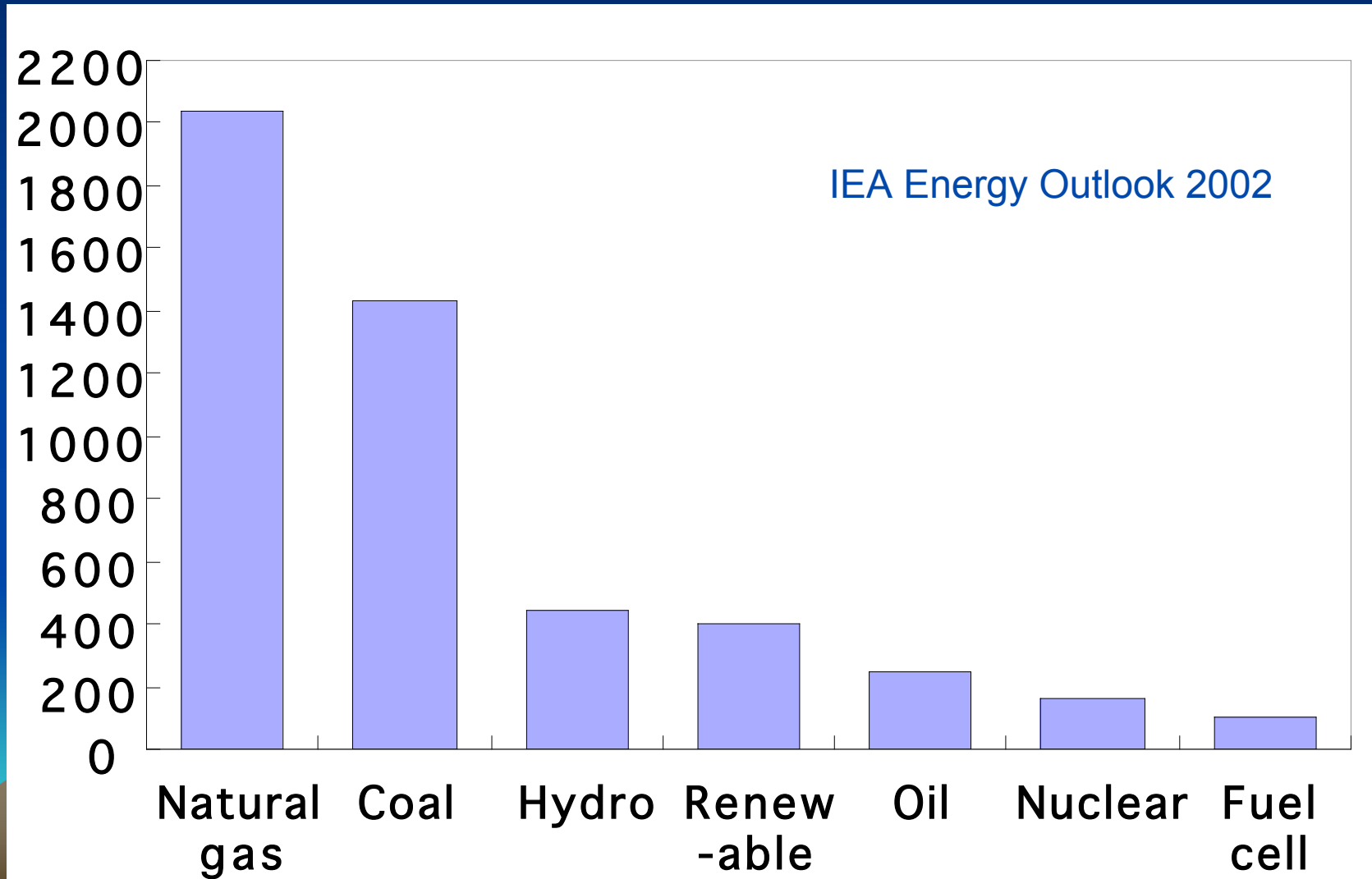


# The Current State Of Nuclear Power In The World

- For Western Europe and North America, no new construction of nuclear power unit has started for some time and only a few constructions is expected to start in 10 years.



# Predicted Power Generation Capacity (GWe) Additions During 2000-2030



# Prediction of Future

- Several important long-term energy demand-supply forecasts like IPCC Special Report on Emission Scenario (SRES) suggest that nuclear energy should be a major component of energy supply mix of the world in the latter half of this century to curve the accumulation of greenhouse gas in the atmosphere.



# Responsibility of Nuclear Community

## Vision:

- Safe, economical, and reliable nuclear energy technology will contribute as a mainstay electricity and heat generation technology to fostering economic growth, providing security and fuel diversity, and enhancing environmental quality in many parts of the world in future.

## Strategy:

- Pursue a well-coordinated mix of near-term, mid-term, and long-term plan, respectively.



## The purpose of my presentation

- to give you my personal thinking on such strategy of the development of nuclear reactor systems for future generation consistent with such vision.





# Near-term Plan

## Observation:

- The existing nuclear power plants based on LWR technology are recognized as a safe, reliable and competitive power source in many countries. This performance should be assured and improved in the long run to maintain high levels of public, investor and regulatory confidence in the nuclear power supply sector.
- It is essential to establish relevant back-end services for LWRs, if not yet, including arrangements for spent fuels storage, the use of the plutonium recovered from them by reprocessing, and radioactive waste management.

# Near-term Plan

## Goal:

- Establish, improve, and expand the performance of existing plants and fuel cycle facilities by applying a broad range of technologies that promises to enhance the long-term performance of the plants and related facilities, increase in their capacity, resolve material ageing, and advance and optimize operations of these plants and facilities.



# Objectives of Actions Planned

- Develop and apply advanced technologies for increased output and longer-term operation.
- Develop and implement technologies for high burn-up fuel.
- Implement effective and efficient measures to economically maintain a high level of safety.
- Promote the closed fuel cycle of separating high-level radioactive waste from valuable nuclear material and recycling the latter into fuels.



# Important Notice

- The activities necessary for pursuing these objectives should be promoted with toughness, resolution, and the consideration to details, as they will directly affect the performance of the existing plants and facilities.



# Mid-term Plan

## Observation:

- The competitive operation of current design units and facilities by no means guarantees the adoption of the same type of plants and facilities for replacement of retiring units or for addition of the capacity, as deregulation of electricity market has sharply altered the financial landscape for utilities, who are no longer guaranteed a fixed return on investment.
- Emerging are neighbor-friendly modular power generation technologies such as renewable energy sources and fuel cells hybrids with gas and/or steam turbines for stationary power and more cost competitive advanced energy supply technologies like combined heat and power, etc.



# Mid-term Plan

## The Goal:

- Prepare competitive nuclear power plants and related facilities by making the third generation plants more cost-effective and enhancing their human-consciousness so that they can be choices for replacement of retiring plants and/or new capacity added.



# Objectives of Action Planned

- Reduce capital cost by shortening licensing and construction time through standardization of design, sharing one-time engineering and licensing cost, and developing modular cost-effective construction technologies and associated planning and information management tools that reduce the labor intensity of these complex construction projects.
- Improve robustness in maintaining safety and reliability by adopting passive safety features, enhance easiness of inspection, and minimize environmental impact by reducing volume of radioactive waste from operation and decommissioning of the plants and related essential facilities.

# Objectives of Action Planned

- Improve human consciousness of the design by pursuing low occupational exposure; low work load in operation, maintenance, and emergency situations; low man power need for inspection and maintenance; and neighbor-friendly features.





# Important Notice

- These mid-term R&D activities should primarily be sponsored by private sector as in the case of near-term actions.
- However, it is important for government to participate in the R&D of long-term nature and/or generic nature, so as to ensure that a broad range of technologies is applied that promises to enhance the long-term performance of plants and facilities to be added to the existing fleet.




# Long-term Plan

## P. Drucker:

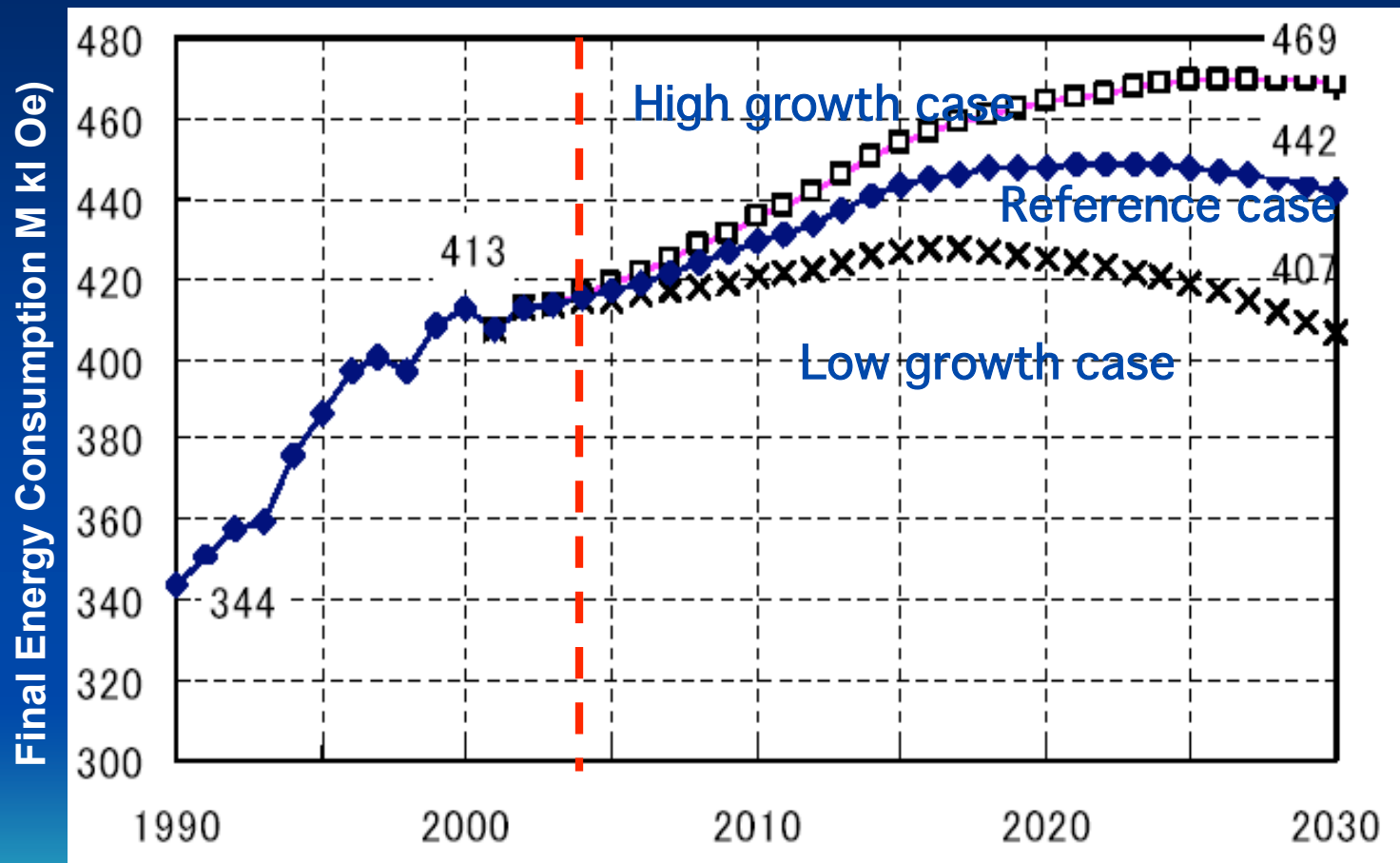
- The period we are living in is one of "PROFOUND TRANSITION" and the changes in this period are perhaps more radical than even the structural changes triggered by the Great Depression and the Second World War.
- In the midst of all this change, there are five social and political certainties that will shape business strategy in the not-too-distant future:
  - the collapsing birth-rate in the developed world;
  - shifts in distribution of disposable income;
  - a redefinition of corporate performance;
  - increased requirement of global competitiveness;
  - the growing incongruence between economic and political reality.



# A Few Example of “PROFOUND TRANSITION” in Japan

- Several studies have predicted that the final energy consumption in Japan will start decreasing before 2030 and most likely at around 2020, after a period of very low growth-rate at around 0.1%/year.
  - The enactment of Basic Law for Establishing a Recycling-based Society gave momentum to the pursuance of “zero emission society” through Reduce, Reuse, Recycle and Refuse Campaign.
  - The sale of hybrid cars is steadily expanding.
  - Distributed electricity generations have successfully found slots of window in market.
  - The local governments that locate nuclear power plants are increasing the tax rate on nuclear fuel, claiming that the cost of administration related to the plants have increased significantly.
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# Forecast of Final Energy Consumption in Japan



# Long-term Plan

## Wise Assumption for Setting the Goal:

- Over the long-term, radical new energy technologies will appear and address effectively the challenges of air pollution, climate change and energy supply insecurity while expanding energy service availability to all on the globe.
- Even during the second quarter of this century technologies like photovoltaic power, fuel cell cars, hydrogen derived from fossil fuels with sequestration of carbon dioxide in geological reservoirs, and di-methyl ether or similar synthetic fuel derived from biomass become as commonplace as gasoline cars and coal-fired power plants are today.



# Long-term Plan

## GOAL:

- Explore, through R&D, innovative nuclear energy system concepts which can compete with new and radical non-nuclear energy technologies in the long run with a view to making nuclear energy system sustainable in terms of social acceptability as well as safety, economy and environmental protection.



# Long-term Plan

## Objectives of Actions Planned

- Explore nuclear reactor systems which are consistent with 3R or reduce-reuse-and-recycle campaign, burning not only most of U-238 excavated but also minor actinides generated during operation to minimize the amount of high-level radioactive waste to be disposed of.



# Long-term Plan

## Objectives of Actions Planned

- Explore future reactor systems not only from technology base but also from better marketing plans and better support networks and all the kind of things essential to their use, taking into consideration the prediction that distributed grid and hydrogen economy will be prevailing in the center of this century and a significant niche market will be open for modular nuclear heat source reactors synergistically coexisting with industrial facilities to generate hydrogen from hydro-carbon resources.



# CONCLUSION

- The R&D of advanced reactor systems should be a part of strategic plan for maintaining nuclear energy as an important energy technologies in the world where people use energy wisely and cleanly, protecting our environment.
- The plan should be a thoughtful mix of Near-term, Mid-term and Long-term actions for sustainable development of nuclear energy utilization, having a common objective of pursuing the establishment of from-cradle-to-grave infrastructure for nuclear technology utilization adapted to the needs of the society of coming age.
- Nuclear community should be flexible to adapt advanced nuclear reactor systems to a new societal paradigm to be emerged in future.



Our knowledge on feasibility and costs of future technologies is limited. What is sure, though, is that the technologies survived is provided with new societal paradigm.

