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Research and Development Strategy for Green Innovation

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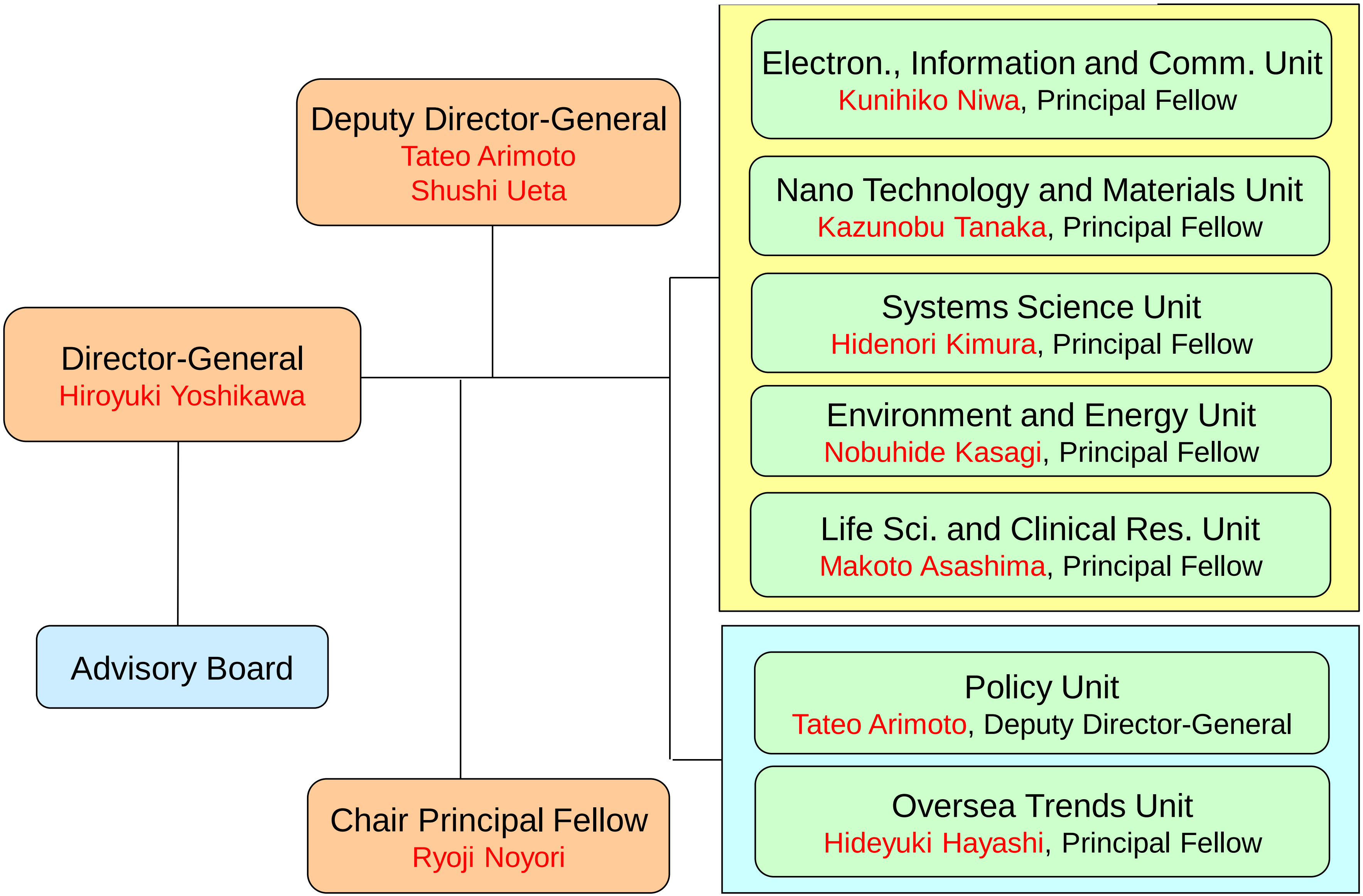
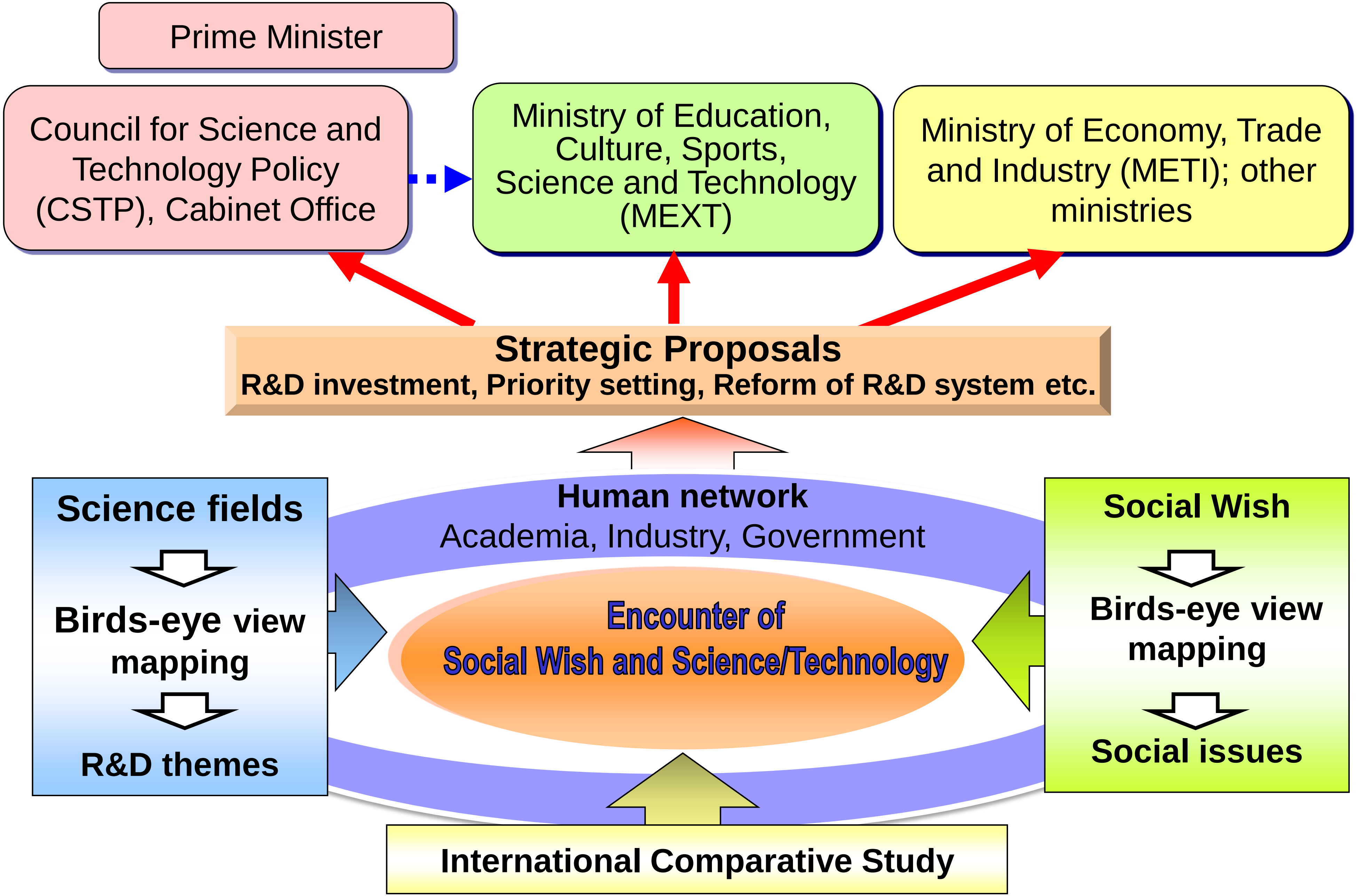
- CRDS and National STI Policy
- Principles of Strategic Proposal Making
- Current CRDS Movement
- Filling Gaps in Innovation Ecosystem

Organization of CRDS



(44 full-time and 19 part-time staffs)

CRDS Strategic Proposal



Convergence of Knowledge for "Science for Society"

(ICSU, Budapest, 1999)

- Basic and applied research designed by knowing social wishes

  Cf. Curiosity-driven basic scientific research independent of social wishes

- Social wish as design specification for research, and need to identify currently latent social wishes

- Issue-driven research for offering solution and measures to society through Collection, Connection and Convergence (3C) of knowledge

Overview of the 4th S&T Basic Plan (Aug 19, 2011)

Sustainable growth and development toward the future

Japan aims for realization of restoration and reconstruction from the disaster and promotion of STI toward sustainable growth and development of society in the future.

Restoration and reconstruction

To stabilize living of the people in the devastated area and reconstruct business and industries:

1) Restore and reconstruct the industries of the disaster-stricken region.
2) Restore and reconstruct the social infrastructure.
3) Realize safety living of the disaster-stricken region

Green Innovation

Toward low-carbon, circulating and sustainable society co-existing with nature and of good living standards for citizens:

1) Realize stable and low-carbon energy supply
2) Highly efficient and smart use of energy
3) Green the social infrastructure

Life Innovation

Toward health-oriented nation, where the people are vigorous in body and in mind and can feel the affluence and achieve a sense of fulfillment of being alive.

1) Develop innovative preventive care
2) Develop new early diagnostic method
3) Realize safe and highly effective treatment
4) Improve quality of life (QOL) for elderly, people with disabilities and patients

System reforms to promote STI

- ✓ Set up the “Science, Technology and Innovation Strategy Council” (tentative name) for the better collaboration among the industry, academia and government
- ✓ Create “a network of knowledge” among government, industry and academia
- ✓ Establish “an open-innovation platform”
- ✓ Promote intellectual property strategy and international standardization strategy

2013 Action Plan for Green Innovation

(currently under discussion by _Science, Technology and Innovation Strategy Council_)

Vision: Sustainable society of advanced energy utilization co-existing with nature

A) Securement of steady clean energy supply
- Massive introduction of renewable energy by technological renovation

B) Active promotion of distributed energy systems
- R&D on innovative energy production/storage technology
- Smarter energy management

C) Renovation of energy utilization systems
- Drastic reduction energy consumption by technology innovation

D) Green social infrastructure
- Local green community co-existing with nature

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General Strategy of CRDS

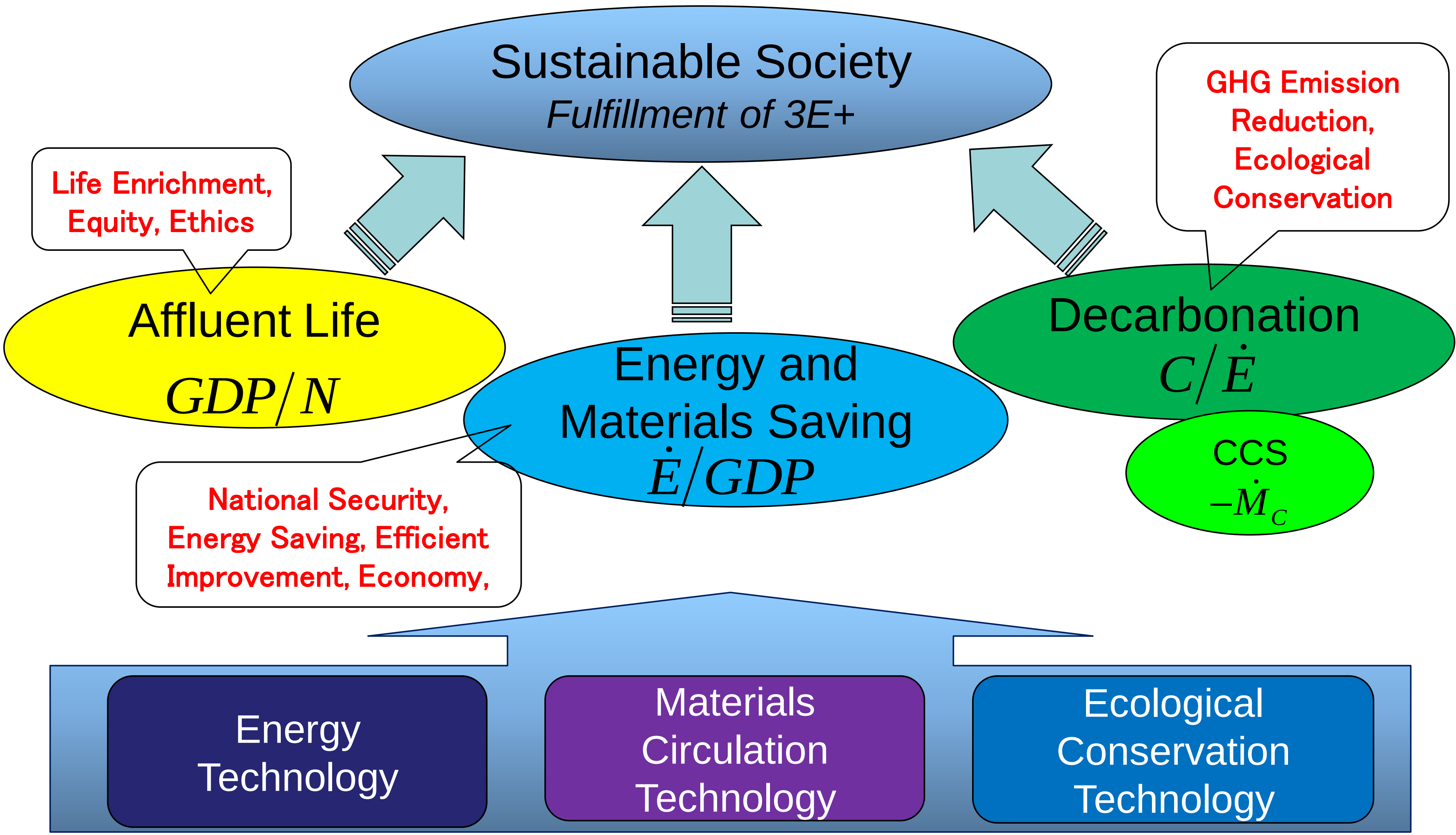
1. Focus on 3E+
2. Short-, mid- and long-term R&D goals
3. Basic scientific rules and principles of energy utilization under the constraints of environment and resources
4. Cross discipline collaboration based on a shared perspective view
5. Network of excellence (cf. COE) and collaboration between industry, academia and government with participation of younger researchers

Strategic Planning of R&D on Advanced Energy Technologies

1. Relevance of Energy Technologies

- Linking science to innovation, economic growth and social welfare
- Common wish to fulfill requirement of “*stable, safe and sustainable energy supply with least cost*”
- Contexts of national security and industrial/economic competitiveness at the nation’s level
- Assessment of energy technology options from three viewpoints of 3E+

STI for Society and the Environment



Assessment Indices for Technology Options

Energy Security	Environment (Safety)	Economy (Cost)
• Resource reserve (geophysical/geopolitical distribution), Reserve-production ratio (fossil and nuclear fuels) • Security and stability of resource feedstock (import dependence, independent development) • Stability of international market fuel price • Time-dependent fluctuation, rates of availability and operation (natural energy resources) • Rate of plant operation (periods of inspection and repair) • Response to load fluctuations • Disaster countermeasures and energy supply to isolated areas	• Climate change (GHG) • Radioactive wastes, radioactive contamination (nuclear power) • Atmospheric contamination (NOx, SOx, soot, particulates), Ozone layer destruction (CFC), thermal discharge • Compatibility to food production, Condensation of specific molecules (N, P) (biomass, biofuels) • Impacts on ecology and biodiversity	• LCA, energy profit ratio, energy payback time • Fuel costs (mining, transformation, transportation, storage), material cost, energy price, electric power price • Business continuity stability against fuel price fluctuation • Costs for R&D, equipment, plant construction, land, installation, environmental countermeasures • Length of periods for environmental assessment and construction • Costs for maintenance, waste processing, decommissioning • Costs for countermeasures to terrorism and disaster, recovery cost and time, compensation • Economical impact as energy industry (energy equipment, electric power market, fuel businesses), employment

Social Wish in Different Regional Contexts

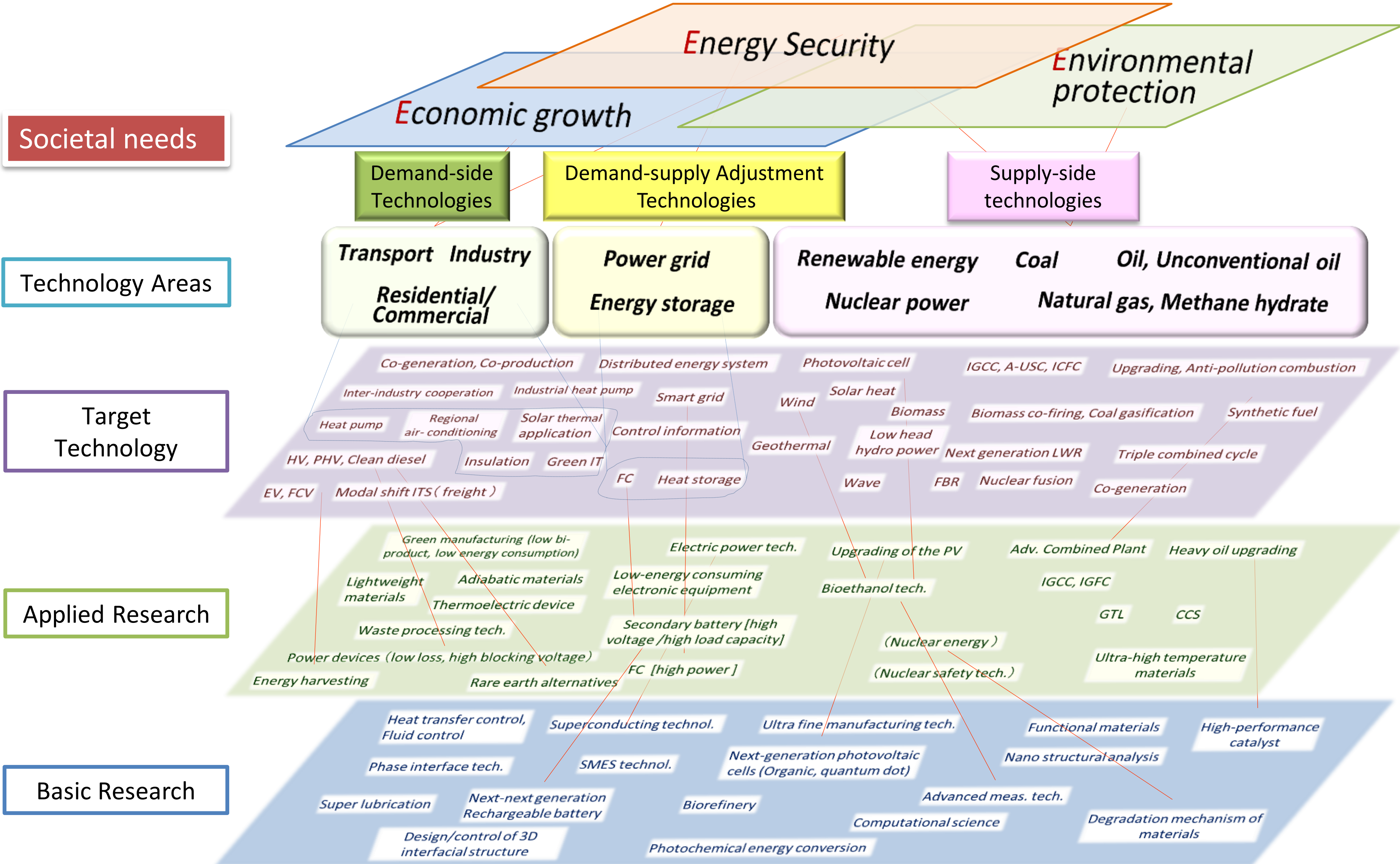
	Japan	East Asia	World
Stable and sustainable supply	National security	Harmonization	Sustainability
Environment[1] (Generalized safety)	Eagerness to safety and security	Technology transfer and environmental conservation	Consensus formation (Climate change prevention)
Growth and prosperity[2] (Competitive economy, better life)	Sustainable prosperity	Economic cooperation	Equity

1. Difference between time scales of climate change and disaster
2. Economic growth (quantitative expansion) vs. social prosperity (qualitative development)

Strategic Planning of R&D on Advanced Energy Technologies

2. Structuring Focal Areas and Research Themes

Perspective View of Social Wishes, Target Technologies and Scientific Research



Strategic Planning of R&D on Advanced Energy Technologies

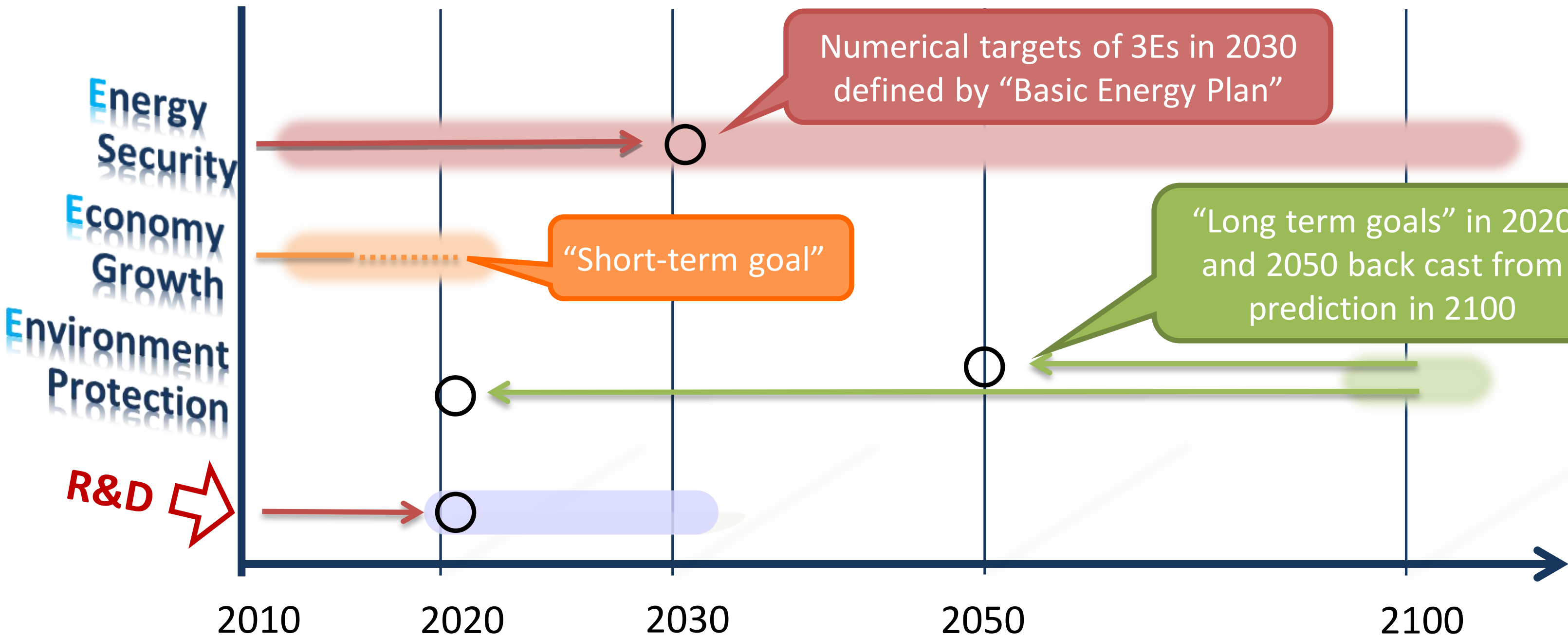
2. Structuring Focal Areas and Research Themes

- Hierarchical structures with different layers of societal needs, target technologies, scientific research and scientific disciplines
- Upper layer R&D more relevant to societal issues (Needs-pull）
- Lower layer R&D driven by technology breakthrough and basic science (Seeds-push)
- Scientific breakthroughs connected to innovative technologies and social needs in many possible ways

Strategic Planning of R&D on Advanced Energy Technologies

3. Time Axes

- Time scale of R&D dependent on assessment indices
- Timely technology identification, optimal target time setting, R&D policy consistent over 10 to 20 years



Prioritization of R&D Themes in 2012

1. Does it meet social wish (national policy)?
   - Contribution to innovation, recovery and restoration, industry competitiveness advocated in the government policy such as 4^{th} Basic Sci. Tech Act and the New Growth Strategy
2. Does it make remarkable quantitative impact to energy issues?
3. Does it challenge to core scientific principle and make disruptive change ? (game changing?)
4. Does it cultivate research incentive of young researchers, train them, and contribute to human resource development?

- Distinguish short-term and mid- to long-term R&D themes
- Watch negative impact of new science and technology
- Be aware that energy issues have deep relationship to social and economical aspects, and a new scientific methodology is necessary to quantitatively predict R&D outcomes' influence

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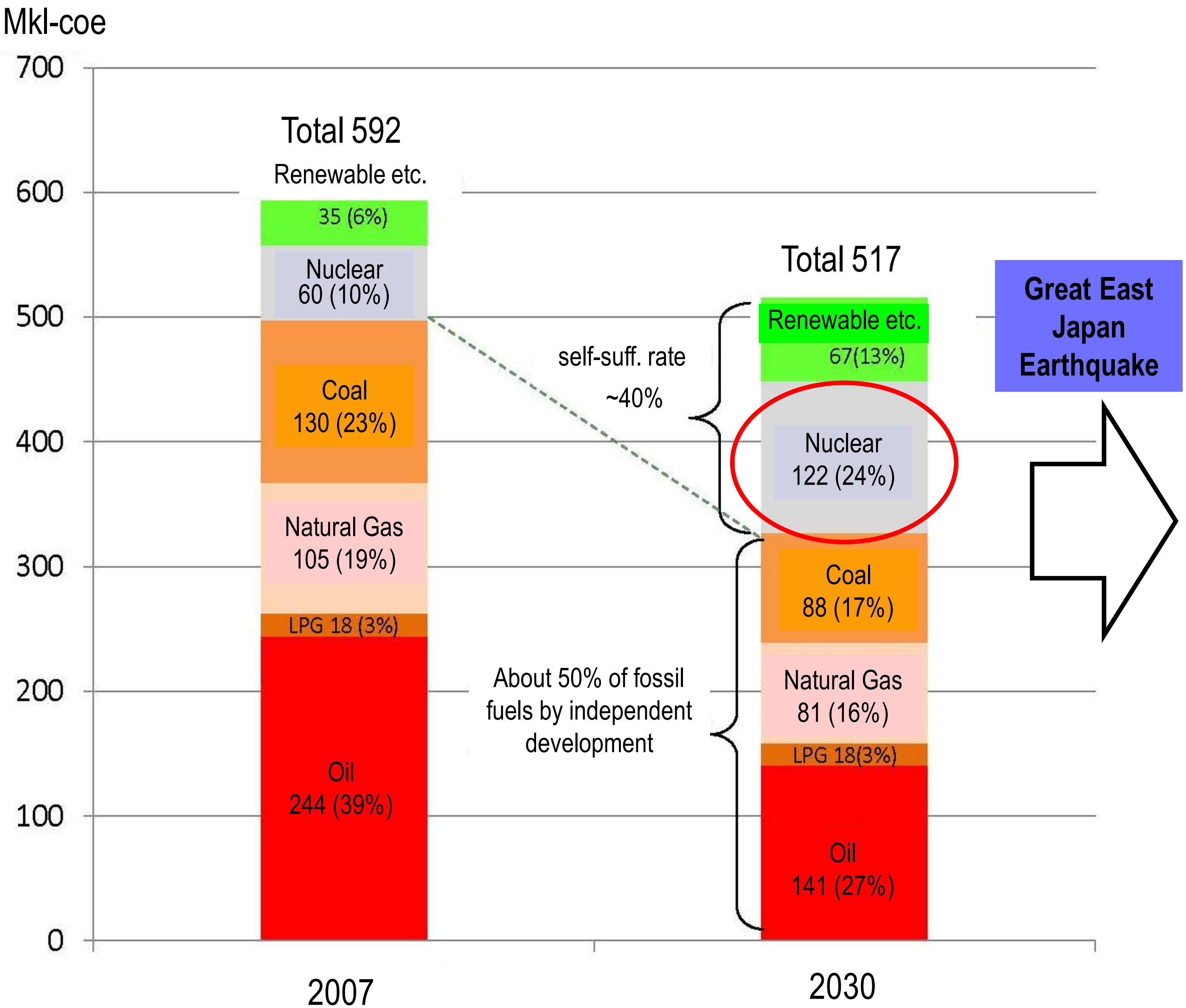
Strategic R&D Themes Focused by CRDS

1. Science for energy policy: Modeling energy technology and economy
2. Phase interface science for efficient energy utilization
3. Energy carriers for transportation, storage and utilization of renewable energy
4. Analysis and control of ions and electrons in buttery electrodes
5. Advanced technology development for medium to low temperature thermal energy
6. Technology and system development for utilization of off-shore natural energy resources
7. Sustainable nitrogen circulation

Basic Energy Plan: Primary Energy Breakdown in 2030

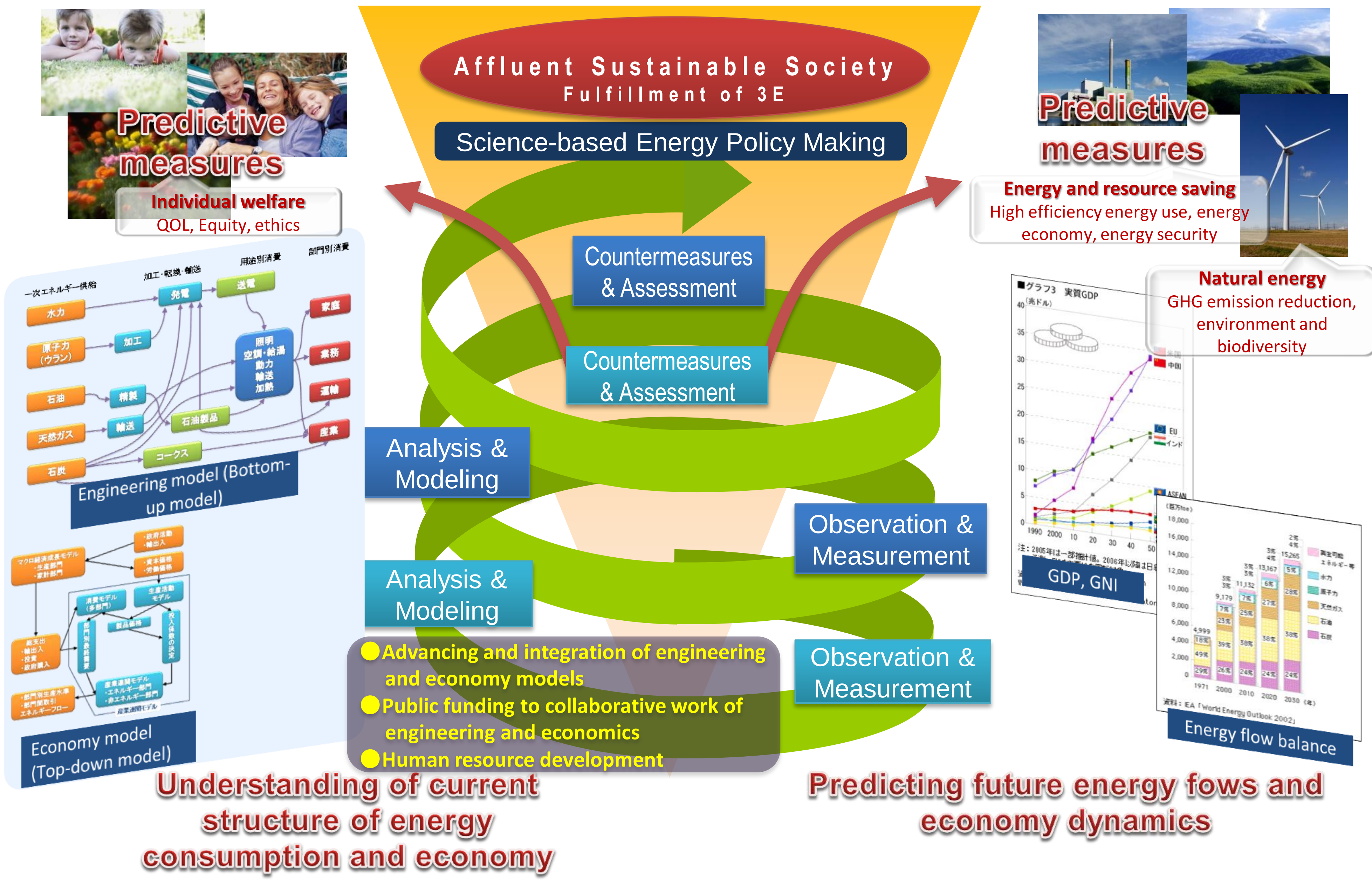


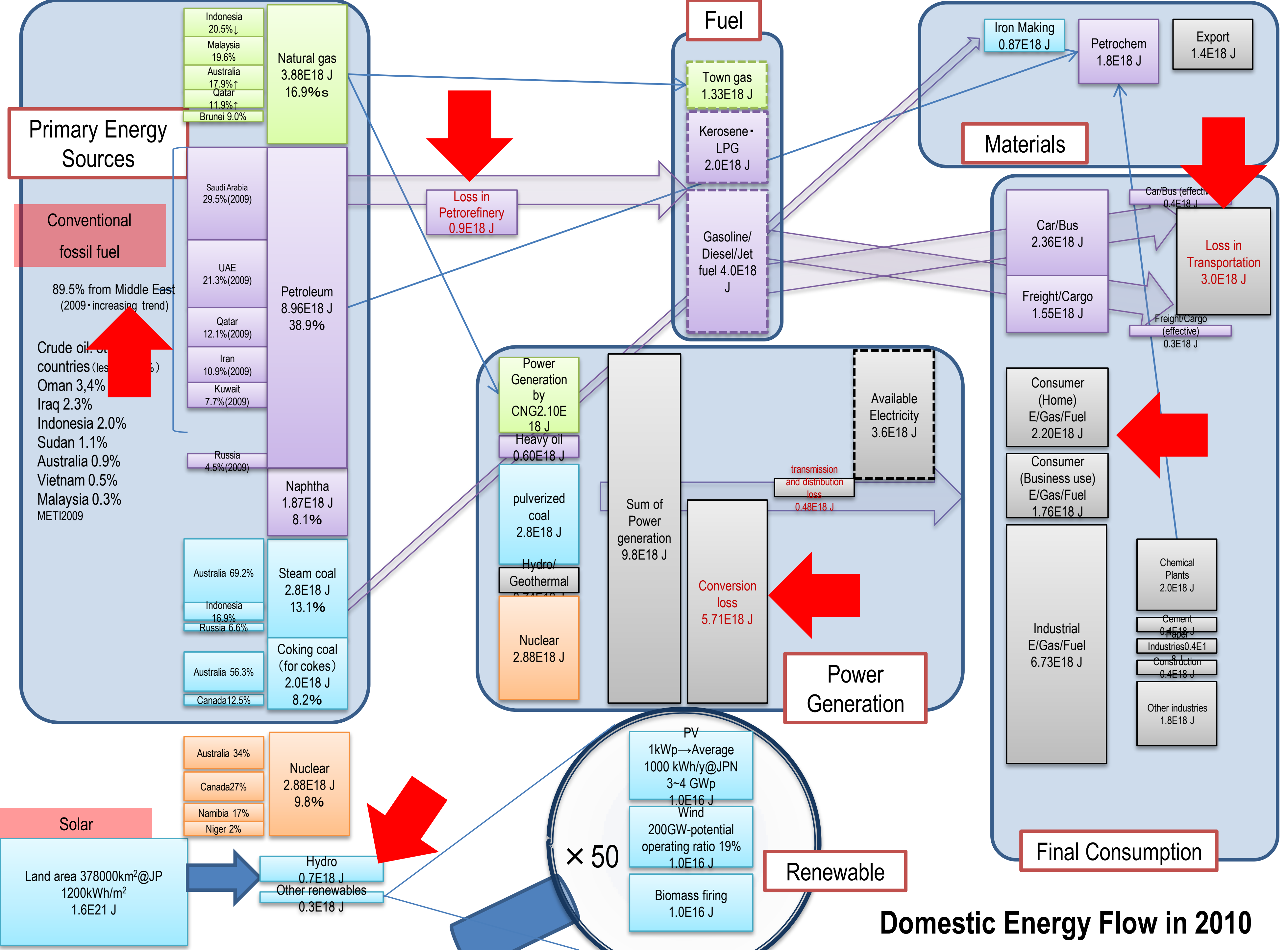
New energy plan options for 2030 with nuclear power fractions of:

a. 0 %
b. 5 %
c. 20~25 %

and renewables of 25~35%

Science for Energy Policy: R&D on Engineering and Economy Models





Primary Energy Sources
Conventional fossil fuel
Indonesia 20.5%↓
Malaysia 19.6%
Australia 17.9%↑
Qatar 11.9%↑
Brunei 9.0%
Natural gas 3.88E18 J 16.9%s
Saudi Arabia 29.5%(2009)
UAE 21.3%(2009)
Qatar 12.1%(2009)
Iran 10.9%(2009)
Kuwait 7.7%(2009)
Russia 4.5%(2009)
89.5% from Middle East (2009・increasing trend)
Petroleum 8.96E18 J 38.9%
Naphtha 1.87E18 J 8.1%
Oman 3,4%
Iraq 2.3%
Indonesia 2.0%
Sudan 1.1%
Australia 0.9%
Vietnam 0.5%
Malaysia 0.3%
METI2009
Australia 69.2%
Indonesia 16.9%
Russia 6.6%
Steam coal 2.8E18 J 13.1%
Australia 56.3%
Canada12.5%
Coking coal (for cokes) 2.0E18 J 8.2%
Australia 34%
Canada27%
Namibia 17%
Niger 2%
Nuclear 2.88E18 J 9.8%
Solar
Land area 378000km²@JP 1200kWh/m² 1.6E21 J
Hydro 0.7E18 J
Other renewables 0.3E18 J
Loss in Petrorefinery 0.9E18 J
Fuel
Town gas 1.33E18 J
Kerosene・LPG 2.0E18 J
Gasoline/ Diesel/Jet fuel 4.0E18 J
Power Generation by CNG2.10E 18 J
Heavy oil 0.60E18 J
pulverized coal 2.8E18 J
Hydro/ Geothermal
Nuclear 2.88E18 J
Sum of Power generation 9.8E18 J
Conversion loss 5.71E18 J
Available Electricity 3.6E18 J
transmission and distribution loss 0.48E18 J
Power Generation
PV 1kWp→Average 1000 kWh/y@JPN 3~4 GWp 1.0E16 J
Wind 200GW-potential operating ratio 19% 1.0E16 J
Biomass firing 1.0E16 J
× 50
Renewable
Materials
Iron Making 0.87E18 J
Petrochem 1.8E18 J
Export 1.4E18 J
Car/Bus 2.36E18 J
Freight/Cargo 1.55E18 J
Car/Bus (effective) 0.4E18 J
Freight/Cargo (effective) 0.3E18 J
Loss in Transportation 3.0E18 J
Consumer (Home) E/Gas/Fuel 2.20E18 J
Consumer (Business use) E/Gas/Fuel 1.76E18 J
Industrial E/Gas/Fuel 6.73E18 J
Chemical Plants 2.0E18 J
Cement
Paper
Industries0.4E1
Construction 0.4E18 J
Other industries 1.8E18 J
Final Consumption
Domestic Energy Flow in 2010

Emerging S&T Issues

(1) Securement of resources -- including risk-hedge

- Middle east, Australia, Indonesia, Canada and Russia are important countries for Japan's energy security

(2) Improvement of energy efficiency in power generation sector

Fuel consumption: Electricity of only 3.6 EJ/year from fuels of 9.8 EJ/year (6.2 EJ/year is missing)

- IGCC, Ultra Super Critical Steam Turbine, 1700℃ Gas Turbine, SOFC etc.
- How to produce and distribute the electricity?

(3) Increase of energy efficiency in petrochemical division

More than 10% of loss as wasted heat

- Recovery of the wasted heat for high energy efficiency distillation

(4) Reduction of energy loss on board

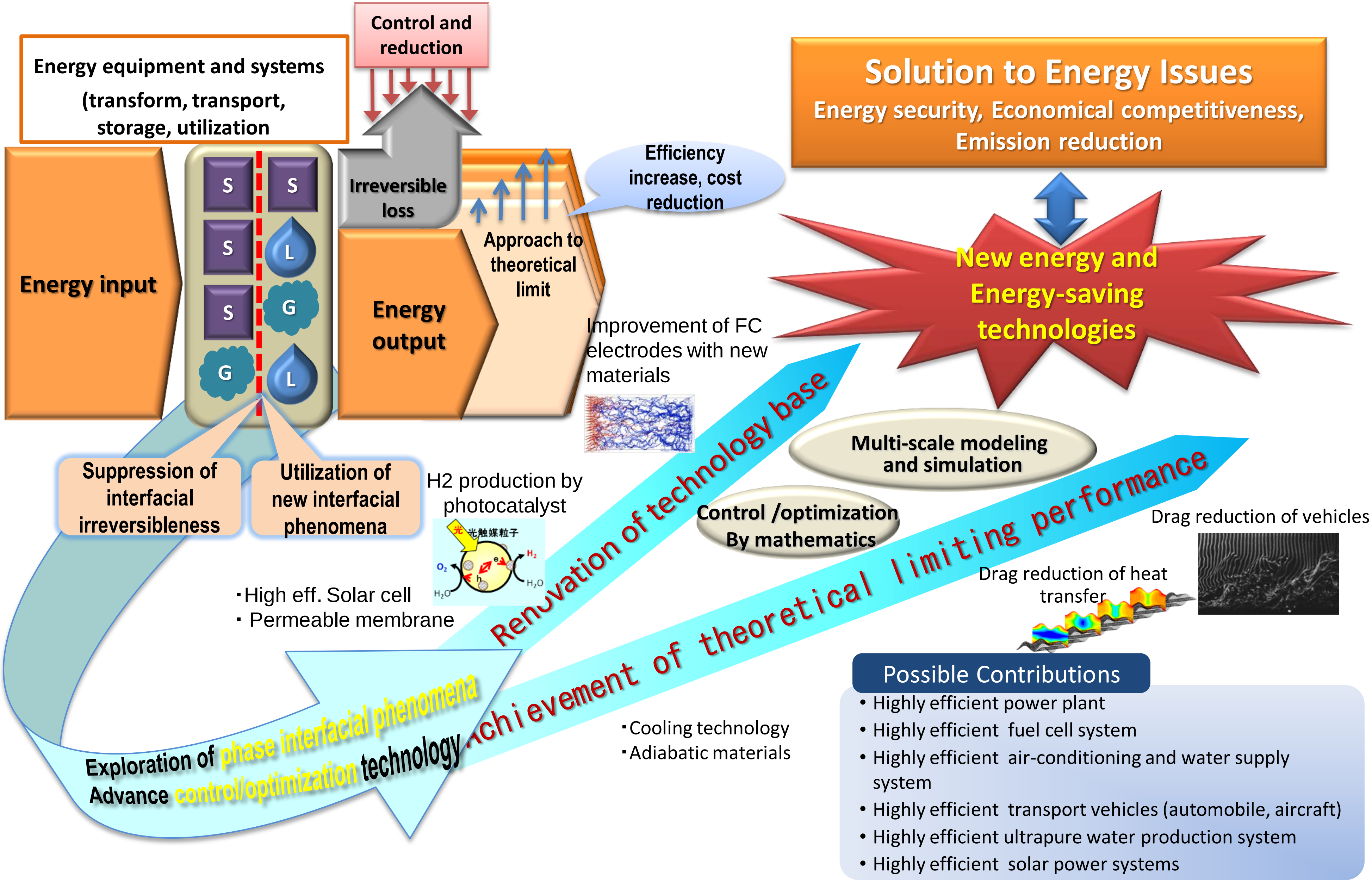
- High efficiency engine, fuel cell, butteries, other technologies including liquid fuel

(5) Efficient heat supply at low temperature

- Heat pumps with high energy efficiency (COP>6), solar heat, thermal energy storage

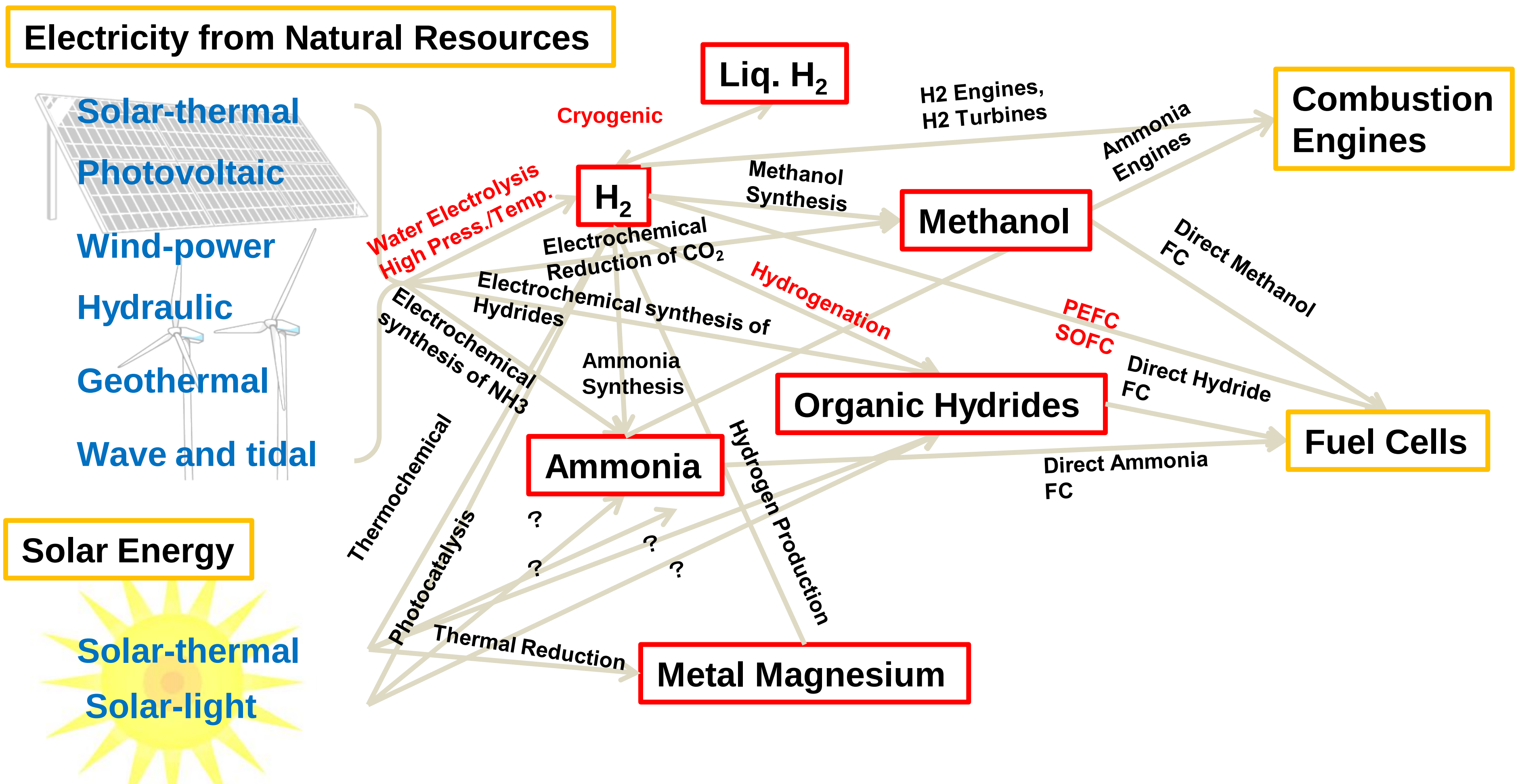
(6) Increase the use of renewable resources

Phase Interface Science for Energy Efficient Society



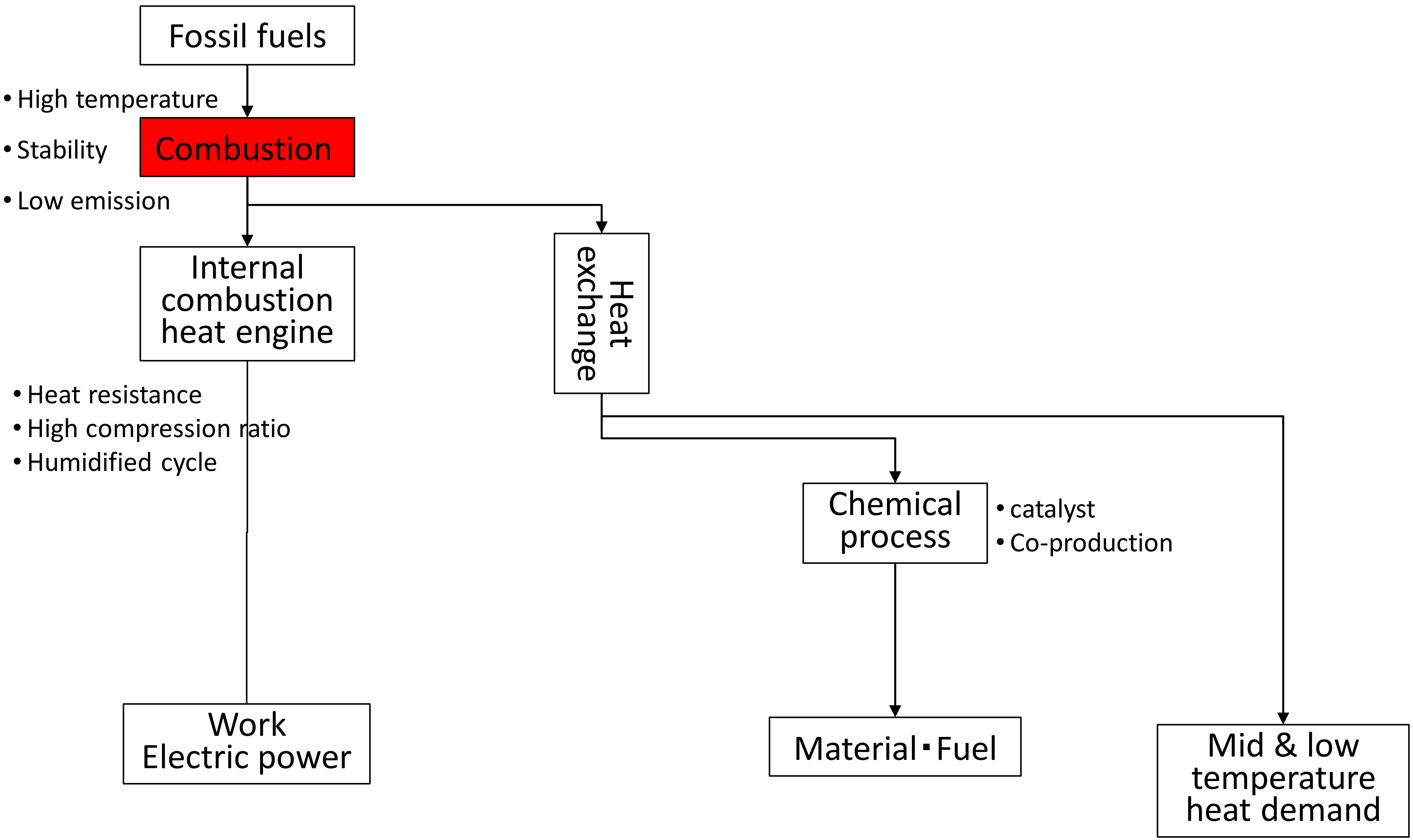
Renewable Energy Carriers for Transportations, Storages, and Utilizations

1. For international and intercontinental transportations
2. For leveling of natural energy in local regions
3. For house energy systems

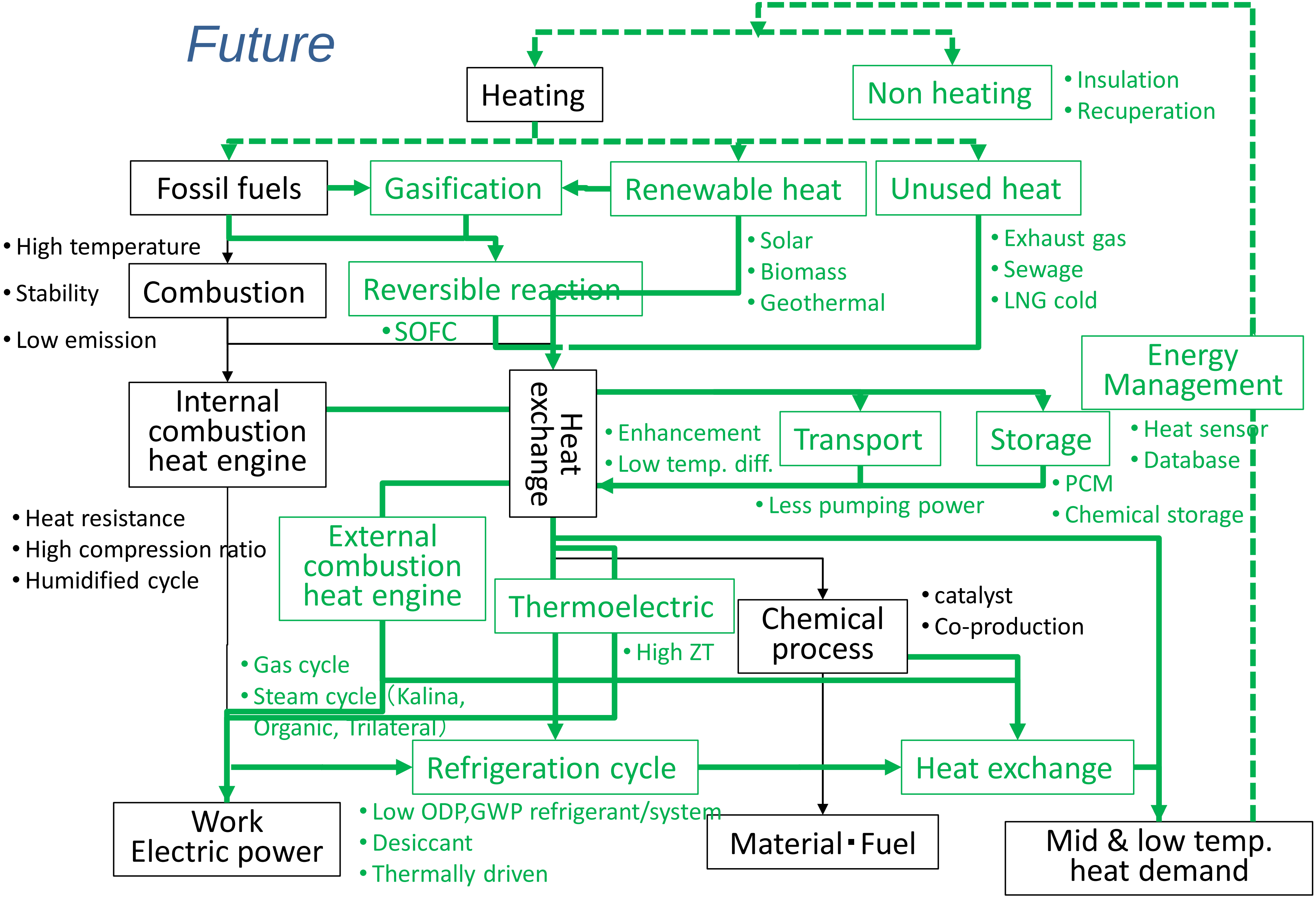


Thermal Energy Utilization

Present



Thermal Energy Utilization



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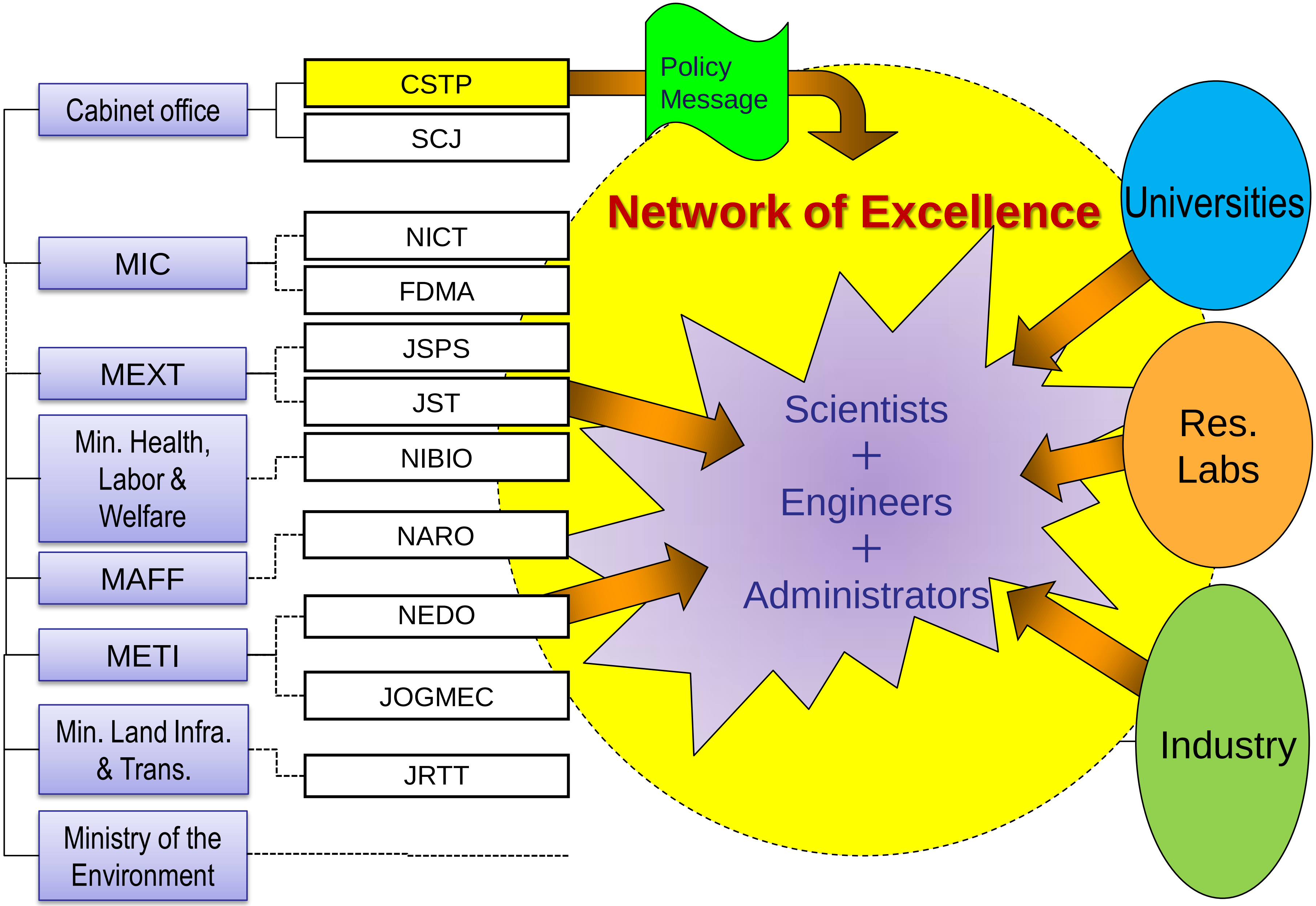
Gaps to be Filled

Between:

- Basic and applied research
- Scientific disciplines
- Industry/business, research laboratories and universities
- Government ministries and funding agencies
- Scientists/engineers/administrators and society

Consolidated Funding Schemes



World Premier International Research Center Initiative by MEXT

International Institute for Carbon-neutral Energy Research

Kyushu University
Best-equipped and best-funded laboratory on hydrogen research

I²CNER

University of Illinois
Prominent research record on hydrogen/materials compatibility

President of Kyushu University

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Research Teams