To: Global Environment Partnership Office,
Ministry of Economy, Trade and Industry, Japan

“Study on the enhancement of global greenhouse gas emission reductions through Japan’s technologies”

Final Report

March 2016

Mizuho Information & Research Institute, Inc.

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1. Overview of the study

(1) Background and objective

In November 2013, the Japanese government launched "ACE: Actions for Cool Earth Proactive Diplomatic Strategy for Countering Global Warming," that states, "accelerating the diffusion of such technologies (outstanding existing low-carbon technologies) and verifying the reduction effect by technologies will lead to the strategic creation and diffusion of the next-generation technologies, and will realize the further emission reduction of greenhouse gasses and new economic growth simultaneously.

For the diffusion of such technologies, Japan should continue the development of high-efficiency technologies in the country which reduce the greenhouse gas emissions such as energy-efficient appliances electric/hydrogen vehicles, steelmaking process with hydrogen reduction and so on.

At the same time, Japan should promote the transfer of technologies on energy-efficient manufacturing process, disseminate the technologies on low-carbon products, high-efficiency thermal power generation, nuclear power generation and renewable energies and create the investment environment in which those technologies are properly adopted. To achieve these objectives, it is important to create mechanisms for appropriate technology transfer and further support for the improvement of the market environment.

Under these circumstances, the Study Team examined the way how Japan should enhance her enhancement of the GHG emission reductions in the international arena through Japanese technologies.

(2) Tasks carried out

① Operation of the Study Committee

The Study Committee, composed of experts in the field of global GHG emission reduction, was established with the objective of examining the way of enhancement of Japanese enhancements through technologies for global GHG emission reduction. Through its five meetings, the Study Committee developed recommendations on the topic at the end of the study period. The Study Committee presented the output of the study in the event of GHG emission reductions at Japan Pavilion in COP21.

② Elaboration of the report

This final report was produced based on the result of ①

2. Implementation of Study Committee Meetings

(1) Summary of the Study Committee

The Study Committee, composed of experts in the field of countering global warming, was established with the objective of examining the way of Japan's enhancement of global GHG emission reduction. Five meetings were held and the Study Committee complied recommendations on the topic at the end of the study period.

Table 1 Structure of the Study Committee

	Name, title and organization
Chairperson	• Dr. Ryuji MATSUHASHI, Professor, Department of Electrical Engineering and Information Systems, Graduate School of Engineering, the University of Tokyo.
Members	• Dr. Kanako TANAKA, Research Group Leader, Center for Low Carbon Society Strategy, Japan Science and Technology Agency. • Mr. Hiroyuki TEZUKA, General Manager, Climate Change Policy Group, Technology Planning Dept., JFE Steel Corporation. • Mr. Takashi HONGO, Senior Fellow, Technology Studies Dept. I, Technology & Innovation Studies Division, Mitsui Global Strategic Studies Institute. • Mr. Kazuhiko HOMBU, Visiting Professor, Graduate School of Public Policy, the University of Tokyo. • Ms. Mari YOSHITAKA, Chief Consultant, Clean Energy Finance Division, Mitsubishi UFJ Morgan Stanley Securities Co., Ltd.
Observers	• Mr. Jun ARIMA, Professor, Graduate School of Public Policy, the University of Tokyo. • Mr. Masami Hasegawa, Senior Manager, Environmental Policy Bureau, Keidanren Japan Business Federation • Mr. Masanori KOBAYASHI, Director, JCM/BOCM Group, Kyoto Mechanisms Promotion Department, New Energy and Industrial Technology Development Organization
Secretariat	• Ministry of Economy, Trade and Industry, Global Environment Partnership Office, • Mizuho Information and Research Institute, Environment and Energy Division 2 ➢ Mr. Isao ENDOU, Chief Consultant ➢ Ms. Maiko SUGIMURA, Chief Consultant ➢ Mr. Yusuke NAGAI, Consultant

The meeting schedule was shown on the following table.

Table 2 Meeting Schedule

#	Date and time
1st	23rd October, 2015, 10:00-12:00
2nd	9th November 2015, 10:00-12:00
3rd	27th November 2015, 15:30-17:30
4th	12th February 2016, 13:00-15:00
5th	4th March 2016, 10:00-12:00

(2) Deliverables of this Study Committee

I. Perspectives

1. Importance of the enhancements of developing countries' GHG emission reductions

- The Paris Agreement, which is a fair and effective framework with participation from all countries, was adopted at the 21st Session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (COP 21) held from 30 November to 13 December 2015.
- Currently, more than sixty percent of global greenhouse gas (GHG) emissions are accounted for by developing countries.
- For GHG emission reductions on the global basis, developed countries including but not limited to Japan need to not only execute their own domestic pledges but also actively enhance developing countries' GHG emission reductions.

2. Importance of the result-based quantification of the enhancements

- Although not all of them are intended for offsetting, developed countries have been undertaking various activities to enhance developing countries' GHG emission reductions through e.g. public funding and business.
- A part of such activities have been quantified on input-basis, particularly when the public funding has been mobilized. However, the results of such activities, i.e. amount of GHG emission reductions, have not always been clear.
- Appropriate quantification of the results, i.e. amount of GHG emission

reductions, would allow developed countries to confirm the results of their activities of enhancement.

- Furthermore, such quantification would help developed countries to efficiently allocate the limited amount of resources (e.g. public funding) to maximize the results.
- Developing countries would also be benefitted from such various activities of enhancement in terms not only of domestic reduction of GHG emissions but also of e.g. energy cost saving, energy security, technology-transfer, investment inflow.

3. Scope of this Study Committee

- This Study Committee made recommendations for the Government of Japan on how to enhance developing countries' GHG emission reductions through various activities such as public assistance and private business other than crediting scheme and to promote international collaboration for it.

II. Recommendations

1. Quantification

(1) Result-based quantification of activities of enhancement

- Toward GHG emission reductions on the global basis, Japan should quantify her activities of enhancement on the result-basis, e.g. amount of developing countries' GHG emission reductions, instead of on the input-basis, e.g. public funding mobilized.
- It is necessary to develop common principles for the quantification applicable to various activities of enhancement for developing countries' GHG emission reductions.

(2) Scope of quantification

- Japan should include in the scope of quantification a broad range of her public and industries' activities which enhance developing countries' GHG emission reductions.
- Examples of such activities include, but are not limited to:
  - Assistance to a specific mitigation project whose GHG emission reductions are directly measurable (renewable energy projects such as a geothermal power generation project)

- Assistance to policy reform
- Capacity building
- Provision of low-carbon goods and services

(3) Domestic systems for quantification

- Japan should establish an institution to assist the quantification and aggregation of the results of activities realized especially with public funding.
- In collaboration with the Japanese industries in their follow-up of "the voluntary approaches on the environment," the Government of Japan should further facilitate the quantification of the results of industries' activities through the development of common principles for the quantification on the basis of existing methodologies.

2. International collaboration for the "New Game"

(1) Collaboration with other developed countries, et al

- Japan should propose other developed countries and relevant international organizations to quantify developing countries' emission reductions through their activities of enhancement.
- Japan should explain to other developed countries the importance of the quantification of the results, i.e. the amount of developing countries' emission reductions enhanced by the developed countries, instead of the amount of the public funding mobilized or of the target amount of GHG emission reductions of their own country.
- Japan should explore for collaboration with relevant international organizations including, but not limited to, the International Energy Agency (IEA), the World Bank Group, the Asian Development Bank (ADB) and Asia-Pacific Economic Cooperation (APEC).

(2) Collaboration with developing countries

- Japan should work on the public assistance with the following aspects to enhance developing countries to recognize such assistance as "Japanese activities of enhancement" in their Nationally Determined Contribution (NDC) to be communicated every five years.
  - Eligibility: Japan should provide such assistance for a mitigation project in a developing country with an advanced low-carbon technology whose GHG emission per unit is less than a certain threshold and whose GHG

emission reductions are measurable. The non-exhaustive list of such advanced low-carbon technologies should also be prepared for prioritization.

- Conditionality: Japan should request a recipient country to implement measurement, reporting and verification (MRV) of the GHG emission reductions on the assisted projects and to include the results in their NDCs for a long term.
- Action plan: Japan should work on integrating the above eligibility and conditionality in her existing public funding schemes et al. To complement the existing public and private finance schemes, Japan should additionally consider introducing a performance-based incentive (e.g. interest subsidies linked with the amount of GHG emission reductions).

・ Japan should explain to developing countries that the result-based quantification of the activities of enhancement would encourage developed countries' further enhancement, confirming their results.

・ Japan should work on the quantification on the basis of her experiences of JCM and CDM, facilitating developing countries' understandings on the methodology and environmental integrity through a bilateral agreement, et al.

(3) Collaboration in the UNFCCC

・ In application of the transparency framework in the Paris Agreement, Japan should propose under the UNFCCC to include GHG emission reductions through developed countries' activities of enhancement. Such information should be provided by developed countries and by developing countries.

・ A possible framework could, for example, be the following; developing countries provide information on GHG emission reductions through developed countries' activities of enhancement as a part of their own NDCs; and developed countries should count GHG emission reductions through their activities of enhancement, not as a part of their own NDCs but only as a result of their activities of enhancement.

3. Proactive enhancements for developing countries' self-sustained GHG emission reductions

(1) Cooperation for developing countries' regulatory reform

・ For developing countries' self-sustained GHG emission reductions, Japan

should establish a standing structure to assist regulatory reform of a developing country.

- Non-exhaustive, indicative examples of functions of such structure include, but not limited to:
  - assistance to eliminate inefficient fossil fuel subsidies in collaboration with relevant international organizations, et al;
  - assistance to introduce energy-efficiency standards

(2) Cooperation for additional international frameworks

- For further dissemination and research and development of advanced low-carbon technologies, Japan should be actively engaged in international discussions for international standardization to evaluate technological performances.

III. Summary

- This Study Committee recommends Japan the following:
  - Result-based quantification of the activities of enhancement: To quantify developing countries' emission reductions enhanced through various activities by the Japanese government and industries.
  - International collaboration for the quantification: To facilitate the quantification of the amount of developing countries' GHG emission reductions enhanced through various activities by developed countries and relevant international organizations.
  - Proactive enhancement for developing countries' self-sustained GHG emission reductions: To actively cooperate with developing countries in their regulatory reform for their self-sustaining GHG emission reductions; and work with multiple countries and organizations to develop international frameworks to further facilitate dissemination and research and development of advanced low-carbon technologies.

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(3) Issues discussed in detail

① Quantification of the enhancements

1) Quantification

In general, activities of enhancements of developing countries' GHG emission reductions can be quantified as two types of indicators:

- Input-based indicator (for example, amount of funds from developed to developing countries); or
- Outcome-based indicator (GHG emission reductions).

For the enhancements by developed countries, quantification has been implemented based on input-based indicators: the latest example is the COP 21 under the UNFCCC in December 2015, where parties reached an agreement to mobilize a total of 100 billion US dollars from both public and private sectors from 2020 to 2025, as the target on climate finance.

However, taking into consideration limited resources of developed countries for activities of the enhancements, it will be more beneficial to use the outcome indicator, i.e. GHG emission reductions in ton-CO_2, rather than input indicator, to proceed with GHG emission reductions in a global scale in an effective and efficient manner.

2) Scope of the enhancements

In consideration of global GHG emissions reductions as the goal, there are various types of actions that can be taken by Japan's Government or private sector in developing countries as a part of enhancements.

For example, public assistance to the mitigation projects (e.g. Clean Development Mechanism (CDM), Japan's Joint Crediting Mechanism (JCM)) is an option that should be included in the enhancements as a direct enhancement of developing countries' GHG emission reductions in a measurable manner.

Moreover, there are types of assistance that are not necessarily in the scopes of the CDM or JCM but are enough reasons to be included in the activities of enhancements. For example, providing public assistance for regulatory reforms in developing countries (e.g. introduction of energy-efficiency criteria), human-resource development and project operation with low-carbon products/technologies, etc.

There are various methodologies to quantify emission reductions by such enhancements depending on applications and purposes. The following table outlines classification of enhancements

by their use in the international arena.

Table 1 Classification of the enhancements and quantification methodologies

Use in the international arena	Scope of the enhancements	Methodology for quantification
(1) Developed countries' claim of enhancement of global GHG emission reductions	• Various activities by Japan's Government and companies enhancing developing countries' emission reductions. (E.g. assistance for regulatory reform, providing technologies/facilities, project operation, funding, etc.) * Technologies applied for such assistance may include those with emission intensity lower than mean or regulated value.	• Various methodologies in line with the common principels are accepted. • How to avoid double-counting will be discussed as necessary.
(2) Developing countries' recognition of developed countries' enhancements in their NDCs under the Paris Agreement.	• Activities that can win a global recognition as Japan's enhancements. • E.g., emission reduction projects for which reduction volume is measurable and Japan's advanced technologies and finance are used. * Cannot be used for offsetting.	• Quantification of emission reductions should be conducted in a manner that ensures understanding of developing countries in terms of evaluation approaches and environmental integrity through bilateral agreements and/or international standards, which will be based on experiences in activities under CDM and JCM, * Issues to be discussed include application of a common baseline over countries.
(3) Offseting under the Kyoto Mechanisms, etc.	• Emission reduction projects that meet conditions such as additionality.	• Approved methodologies

Broader

narrower

[Source] Compilation of discussions this Study Committee

3) Domestic arrangements to promote quantification practices

The Study Committee conducted a research on activities of the enhancements by Japan's Government or companies, examining action types and current status of quantification practices.

As the result, it cleared that a certain progress has been made in quantification of emission reductions by each actor. Such quantification covers enhancements by providing (i) technologies, products and services, or (ii) financial assistance. The figure below shows correlation of actors, types and examples of enhancements.

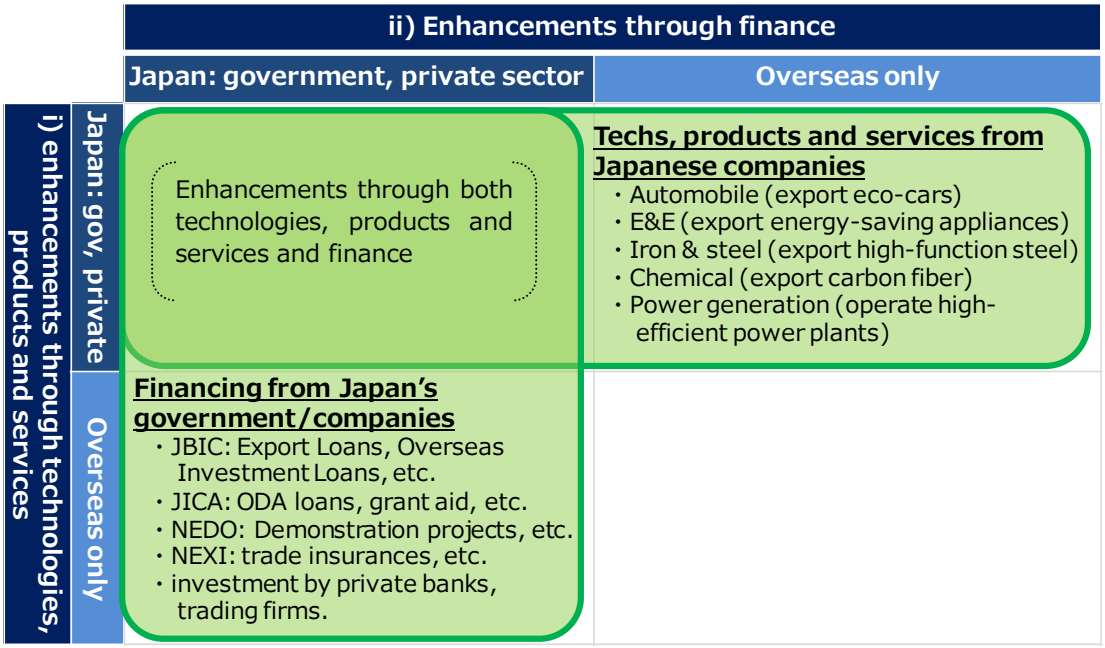


Figure 1 Mapping of the enhancements focusing of providers of finance and technologies, products and services

[Source] Prepared by the Secretariat

[Note 1] ·JBIC: Japan Bank for International Cooperation

[Note 2] JICA: Japan International Cooperation Agency

[Note 3] MOE: Ministry of Environment

[Note 4] NEDO: New Energy and Industrial Technology Development Organization

[Note 5]· NEXI: Nippon Export and Investment Insurance

a. Quantification of the enhancements by Japan's governmental organizations

Figure 2 outlines schemes for the enhancements by Japan's governmental organizations, and the current status of quantification of GHG emission reductions.

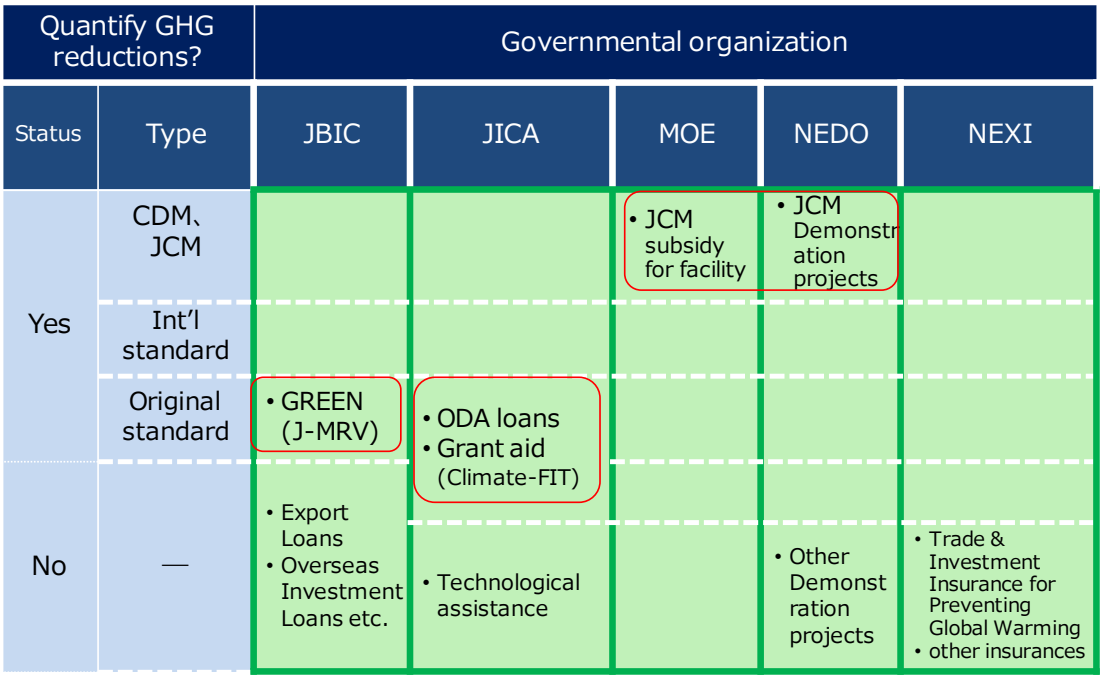


Figure 2 Schemes for the enhancements by Japan's governmental organizations, with quantification status

[Note] Red frames indicate that quantification is applied by each organization.

[Source] Prepared by the Secretariat

Looking into details by organization, firstly, Japan Bank for International Cooperation (JBIC) provides GREEN (Global action for Reconciling Economic growth and ENvironmental preservation), an untied low-interest loan scheme for GHG emission reductions, while offering a good variety of schemes for the enhancements through export financing and investment products.

Specifically, projects that JBIC engages in include but are not limited to gas-fired Independent Water and Power Producer (IWPP) project in Kuwait, geothermal power generation project in Indonesia. Among such schemes, GREEN is the only category for which JBIC conducts quantification of GHG emission reductions, although the result has not yet made public.

Japan International Cooperation Agency (JICA) provides ODA Loan and grant aid schemes to developing countries (see the figure for case examples). JICA actively promotes quantification of GHG emission reductions for any projects under its schemes with mitigation potential, through encouraging consultants who engage in project formulation. For other types of schemes that may contribute emission reductions, besides technological assistance, JICA has not yet conducted quantification because emission reductions through such projects are recognized as indirect effects.

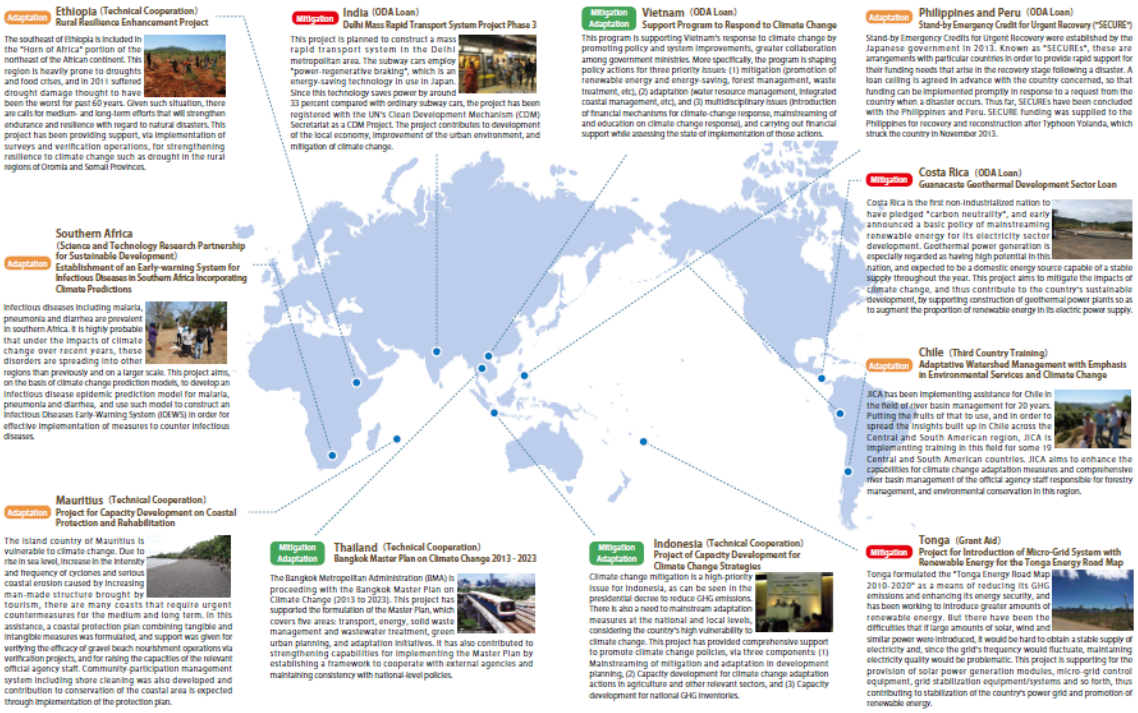


Figure 3 Examples of JICA's assistance activities to tackle climate change

[Source] JICA's Assistance in the Field of Climate Change

[Note] Those activities include both mitigation and adaptation activity.

New Energy and Industrial Technology Development Organization (NEDO) conducts quantification of GHG emission reductions in projects under its initiatives, including feasibility study for JCM Demonstration projects. However, NEDO sees difficulties in disclosure of quantification results due to projects' confidentiality.

The Study Committee calculated the expected reduction amount per year from the projects approved in FY2013 and FY2014 for the schemes by the governmental organizations. (See the figure below.)

In the following figure, values for CDM and JCM indicate prospective volume of emission reductions based on a specific procedure of each scheme, while that for JBIC and NEDO are estimates made by the Secretariat. It should be noted that credit schemes such as CDM and JCM tends to have a relatively stringent baseline than other schemes, as classified in the vertical axis of the following figure.

As the result, it clearly shows that significant volume of GHG emission reductions may exist under non-credited enhancements, despite the difference in baseline emissions depending on schemes.

[Unit: kt-CO2]

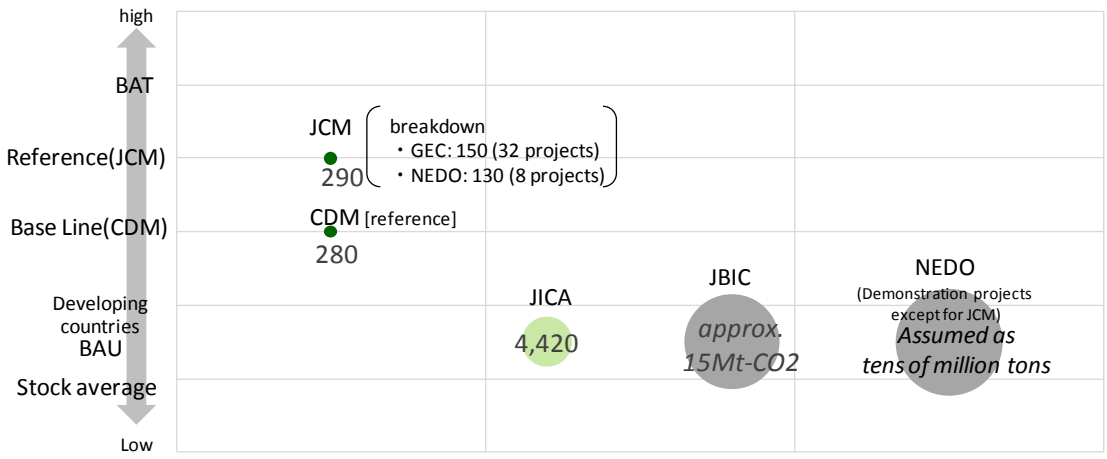


Figure 4 Assumption of GHG emission reductions through Japan's financial assistance through governmental organizations
(Projects approved or launched in FY2013 - FY2014)

[Note 1] Value in green dot indicates calculation result based on publicized data on GHG emission reductions; value in gray dot indicates assumption by the Secretariat based on publicized values.

[Note 2] The value of JBIC is estimated by the Secretariat

[Note 3] The value of NEDO is based on the interview.

[Source] Prepared by the Secretariat based on data provided from each organization, etc.

As for quantification method, JBIC has developed "Guidelines for Measurement, Reporting and Verification of GHG Emission Reductions in JBIC's GREEN (the "J-MRV Guidelines")" as its own standard, which was followed by JICA's Climate Finance Impact Tool for Mitigation (Climate-FIT) developed in reference to this guideline.

As observed above, quantification of GHG emission reductions by Japan's governmental

organization has made a certain progress in recent years while remaining room to add values of GHG emission reductions. To do so, institutional systems should be established to promote quantification and aggregation of emission reductions.

b. Quantification of the enhancements by Japan's industrial sector

Quantification practices by private sector have been conducted in the context of enhancements of overseas emission reductions through voluntary actions by industries. Specifically, the follow-up of the Keidanren's Commitment to a Low Carbon Society contains calculated values of CO2 emission reductions for 2013 based on actual performance in "Promotion of Enhancements" section as reported by industrial associations, including iron & steel, electric & electronics, foreign trade and mining.

The table below outlines the current status of quantifying CO2 emission reductions by major industries as contained in the follow-up of the Keidanren's Commitment to a Low Carbon Society.

Table 2 Current status of quantification of enhancements by industrial association

Industry	Calculated value of CO2 emission reductions volume
Japan Iron & Steel Federation	・Total CO2 emissions reductions in overseas countries in FY2012 as avoided emissions by using technologies disseminated through Japanese companies is approx. 470Mt-CO2. (Tentative value. Calculation for FY2013 value underway.) －CDQ (cokes dry quenching): approx. 153.3Mt-CO2 －TRT (top-pressure recovery turbine) generating system : approx. 107.3Mt-CO2 －Other: approx. 245.7Mt-CO2 (by-product gas-firing GTCC, OG gas recovery for converter furnace, OG sensible heat recovery for converter furnace, waste heat recovery from sintering)
Electric & electronics industry	・Power generation －reduction from new installation, production: 6.52Mt-CO2 －accumulated reduction from new installation, use of products: 256.22Mt-CO2 ・Home appliances －reduction from new installation, production: 0.99Mt-CO2 －accumulated reduction from new installation, use of products: 9.86Mt-CO2 [*breakdown of reduction from parts: 3.78Mt-CO2] ・ICT products/solutions －reduction from new installation, production: 4.25Mt-CO2 －accumulated reduction from new installation, use of products: 21.25Mt-CO2 [*breakdown of reduction from parts: 10.34Mt-CO2]
Japan Foreign Trade Council	・Contribution from LCA perspective －Bio-ethanol production in Brazil and the Philippines: reduce CO2 emissions by 60% compared to gasoline －Bio-diesel production in Nebraska, US: reduction of 0.50-0.57Mt-CO2/yr (estimate)
Japan Mining Industry Association	・Hydropower generation in Peru (Construction of 1,000kW hydropower plant underway in Pallca mine, Peru. Operation commencement is scheduled for October 2014) Assumed CO2 emission reductions: approx. 4kt-CO2/yr.

[Source] Prepared based on the Keidanren's follow-up report (2014)

Some industries develop an industry-specific method for quantifying GHG emission reductions, as shown in the following Table.

Table 3 Development of quantification method for GHG emission reductions by industry

Org/industry	Development status
Iron & Steel industry	➢ In 2001, Japan Iron & Steel Federation (JISF) launched its internal committee on LCA Energy Assessment to examine emission reduction potential of high-function steel. ➢ In March 2013, "ISO 14404" was released as calculation methodology for CO2 emissions and intensity in iron mills, as proposed by JISF to International Standardization Organization (ISO).
Chemical industry	➢ In October 2013, International Council of Chemical Associations released a guideline on avoided emissions. ➢ In March 2014, Japan Chemical Industry Association (JCIA) released cLCA case studies (3rd version) (prepared in line with the guideline). ➢ In March 2015, JCIA released a supplement material for cLCA Guideline (for Japanese business operators).
Electric & electronics industry	➢ In August 2014, IEC TR 62726 (Guidance on quantifying greenhouse gas emission reductions from the baseline for electrical and electronic products and systems) was released.
IT industry	➢ In March 2015, European Telecommunications Standards Institute released (ETSI) released ETSI ES 203 199 (Environmental Engineering; Methodology for environmental Life Cycle Assessment of Information and Communication Technology goods, networks and services). ➢ ETSI ES 203 199 has been developed to ensure harmonization between ITU-T's Recommendation L.1410 (by International Telecommunication Union) and ESTI TS 103 199. Revised L.1410 will be released by ITU-T.
The Institute of Life Cycle Assessment, Japan	➢ In March 2015, a guideline for calculation of avoided GHG emissions was released.

[Source] Prepared based on a METI's report (2015a)

For further promotion of quantification practices, a common ground of quantification should be established on the basis of existing approaches, in cooperation with the Keidanren's follow-up of voluntary actions by the sector.

Measurement, Reporting and Verification (MRV) is a technical instrument to confirm GHG emission and GHG emission reduction objectively. Including but not limited to the universal CDM MRVs and the bilateral JCM MRVs, methodologies of MRV are various. Practical way to implement is to accept varieties of MRV when it is considered as reasonable one but is in line with key principles to be agreed by parties and shared by other stakeholders[1]. A good practice we have is

[1] An example of such principles is given in Hongo (2013b) as the Common Principles for Climate Finance:
- Simple, objective and practical;
- Encourage the low carbon investment; and
- Taking into account of the different investment climate and keeping flexibility

“Common approach for environment consideration” by export credit agency (ECA). Each ECA has own environment due diligence guideline under the Common Approach.

Common Principles looks like a compass for navigation. When we worried how we should evaluate the reduction appropriately (“we lose the way”), we should see Common Principles and determine following Common Principles.

② Launch of the “new game” (efforts toward international recognition)

1) Collaboration with developed countries, et al

Developed countries should launch the “new game” in which they pursue not domestic GHG emission reductions but enhancements of developing countries’ GHG emission reductions.

The new game requires the involvement of the main actors who possess the financial resources, knowledge and technologies for international enhancement. Concretely, the developed countries as bilateral donors (ref. the following table) and the international development/financial organizations as multilateral donors should be involved in the new game.

Table 4 Amount of ODA committed by the developed countries in the energy sector (2014)

Rank	Country	Amount（million USD）
1	Germany	3,946.0
2	Japan	2,945.0
3	France	788.9
4	United States	358.1
5	Norway	204.7
6	England	134.3
…		
17	Italy	8.6
…		
24	Canada	0.3
…		
Total		8,782.1

[Source] OECD-DAC database

a. Collaboration with developed countries

Japan should explain to other developed countries that they should pursue not for a target of domestic GHG emission reductions nor an amount of funding amount to the developing countries but for enhancement which can be measured as the amount of developing countries’ GHG emission reductions (see the figure below). G7 can be considered as the proper place to promote the quantification of such activities of international enhancement by the developed countries.

“Leaders’ Declaration G7 Summit” states that “in order to incentivize investments towards low-carbon growth opportunities we commit to the long-term objective of applying effective policies and actions throughout the global economy, including carbon market-based and regulatory

instruments and call on other countries to join us[2]" This part of the Declaration might be interpreted that the developed countries would support the wide approach including the regulatory one for the GHG emission reductions.

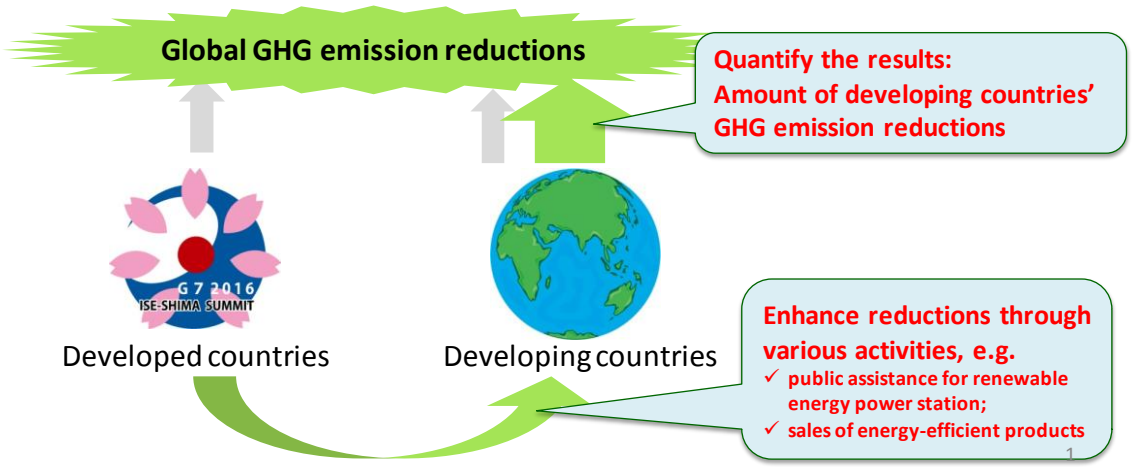


Figure 5 Conceptual model of international enhancement (draft)

[Source] Elaborated by the Study Committee Secretariat

b. International Development/Finance Organizations

Not a few international development/finance organizations quantify the GHG emission reductions of their investment projects based on certain assumptions (see table below). It might be valuable for Japan to collaborate with those organizations in promoting the result-based quantification of the enhancements.

Table 5 Examples of quantification of GHG emission reductions by international development/finance organizations

Entity	What they do for quantification
International Finance Institutions (IFIs)	• Agreed on the IFI Framework which defines the following; ➢ Screening the direct investment projects based on GHG emissions ➢ Implementing the GHG accounting based on the established pre-accounting methodology (including the net emissions comparing to the baseline) ➢ Accounting result is expressed in t-CO_2 • Reporting of at least yearly aggregate value

[2] G-7 Leaders' Declaration, Schloss Elmau, Germany, June 8, 2015

Entity	What they do for quantification
World Bank	• Sequential development of Guidance notes for GHG accountingIn parallel, periodic reporting of annual estimated reductions by specific climate funds in Corporate Scorecard
Asian Development Bank (ADB)	• Annual issue of Clean Energy Investments Project Summaries, including the expected amount of GHG emission reductions of each project • Development of Draft Guidelines for Estimating Climate Change Mitigation Investment and GHGs Emissions Reductions of ADB Projects

[Note] The international organizations such as IFC (International Finance Corporation), EBRD (European Bank for Reconstruction and Development) and so on, which are not included in the table, are also working on their own quantification.

[Source] Elaborated by the secretariat based on each institution's document

2) Collaboration with developing countries

The Paris Agreement states the following:

> The Paris Agreement, Article 4
>
> […]
>
> 9. Each Party shall communicate a nationally determined contribution every five years in accordance with decision 1/CP.21 and any relevant decisions of the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement and be informed by the outcomes of the global stocktake referred to in Article 14.
>
> […]

Based on this article, Japan may consider a possibility of supporting the developing countries on conditions that they recognize the Japanese "enhancement" activities for the GHG emission reductions in the developing countries in their Nationally Determined Contribution (NDC) reported every five year (see the figure below).

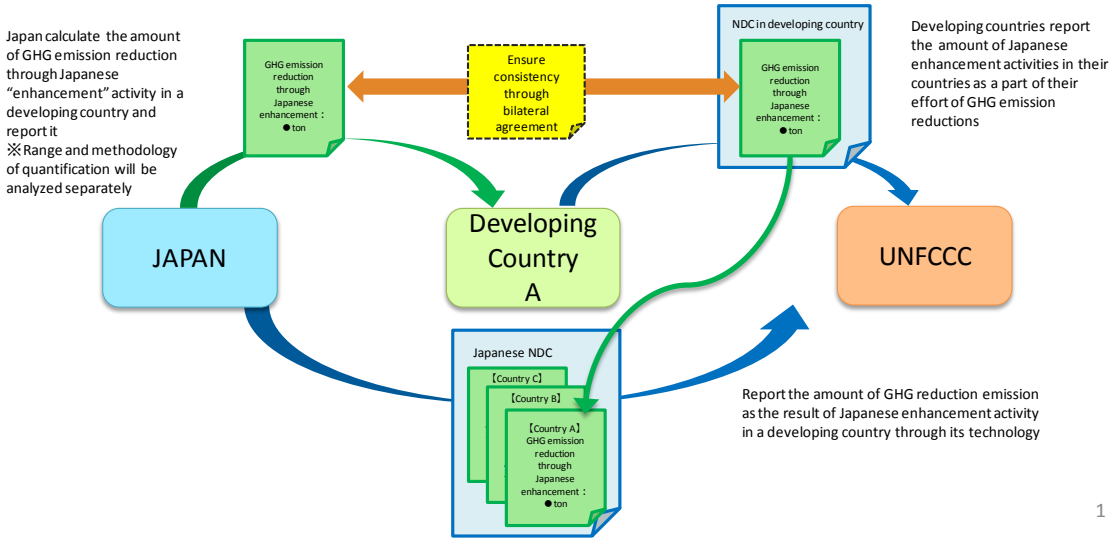


Figure 6 General image of reporting of developed countries' enhancement activities in developing countries' NDC

[Source] Prepared by the Study Committee Secretariat

Such public assistance should have the following aspects:

- Eligibility: Japan should provide such assistance for a mitigation project in a developing country with an advanced low-carbon technology whose GHG emission per unit is less than a certain threshold and whose GHG emission reductions are measurable. The non-exhaustive list of such advanced low-carbon technologies should also be prepared for prioritization.
- Conditionality: Japan should request a recipient country to implement measurement, reporting and verification (MRV) of the GHG emission reductions on the assisted projects and to include the results in their NDCs for a long term.

Japan should work on integrating the above eligibility and conditionality in her existing public funding schemes et al. To complement the existing public and private finance schemes, Japan should additionally consider introducing a performance-based incentive (e.g. interest subsidies linked with the amount of GHG emission reductions).

A performance-based incentive system is very cost-effective. Performance-based incentive schemes using MRV can determine the amount of incentives objectively and scientifically when the unit incentive amount is fixed under the incentive scheme. For instance, "one ton of CO_2 emission is equivalent to a fixed US dollar price, which will be determined prior to delivery." A performance-based incentive system could reduce the economic burden of adopting advanced technology by investors[3].

3

3) Negotiation in the UNFCCC

The Paris Agreement includes the following description of "Transparency framework".

The Paris Agreement, Article 13

1. In order to build mutual trust and confidence and to promote effective implementation, an enhanced transparency framework for action and support, with built-in flexibility which takes into account Parties' different capacities and builds upon collective experience is hereby established.

[…]

9. Developed country Parties shall, and other Parties that provide support should, provide information on financial, technology transfer and capacity-building support provided to developing country Parties under Article 9, 10 and 11.
10. Developing country Parties should provide information on financial, technology transfer and capacity-building support needed and received under Articles 9, 10 and 11.
11. Information submitted by each Party under paragraphs 7 and 9 of this Article shall undergo a technical expert review, in accordance with decision 1/CP.21. For those developing country Parties that need it in the light of their capacities, the review process shall include assistance in identifying capacity-building needs. In addition, each Party shall participate in a facilitative, multilateral consideration of progress with respect to efforts under Article 9, and its respective implementation and achievement of its nationally determined contribution.

[…]

Based on this article, Japan might propose in the future negotiations in the United Nations Framework Convention on Climate Change (UNFCCC) that the amount of GHG emission reductions in the developing countries achieved through the enhancement activities by the developed countries should be recognized in the NDCs of both developed and developing countries in the transparency framework.

Concretely, apart from the existing scheme of transferring the GHG emission reductions credits from the developing countries to the developed countries, the special scheme to measure the amount of GHG emission reductions in the developing countries through the enhancement activities by the developed countries should be introduced.

Under this scheme, it is assumed that, when the developed and developing countries corporate in the GHG emission reduction activities in the developing country through the technology of the

developed country, the amount of emission reduction is recognized as the amount of "reduction" in the NDC of the developing country while it is counted as the amount of "enhancement" (not "reduction") in the NDC of the developed country.

Among the amount of emission reduction under this scheme, the whole or part of such amount which is not counted to achieve the country target for reduction and is recognized by both of the developed and developing countries can be the object of "crediting." In addition, this scheme and its consequential amount of reduction and transfer can be managed by the UNFCCC secretariat.

③ Proactive enhancements

To facilitate developing countries' self-sustaining GHG emission reductions, this Study Committee discussed Japan's additional measures for enhancements to complement conventional ones (e.g. mitigation projects under CDM or JCM). This Study Committee recommended two types of additional measures, i.e. bilateral policy assistance to a developing countries; and multilateral collaboration to develop international standards.

1) Cooperation for developing countries' regulatory reform

It is pointed out that the current regulatory frameworks in developing countries often constitute barriers to introduce advanced low-carbon technologies. Improved regulatory frameworks would serve as a strong backbone to disseminate advanced low-carbon technologies.

Among such regulatory frameworks are fossil fuel subsidies. G7 leaders' declaration of Elmau Summit reads: "We remain committed to the elimination of inefficient fossil fuel subsidies and encourage all countries to follow and we remain committed to continued progress in the OECD discussions on how export credits can contribute to our common goal to address climate change."
Energy subsidies damage the environment, causing more premature deaths through local air pollution, exacerbating congestion and other adverse side effects of vehicle use, and increasing atmospheric greenhouse gas concentrations.

Energy subsidies impose large fiscal costs, which need to be financed by some combination of higher public debt, higher tax burdens, and crowding out of potentially productive public spending (for example, on health, education, and infrastructure), all of which can be a drag on economic growth.

Energy subsidies discourage needed investments in energy efficiency, renewables, and energy infrastructure, and increase the vulnerability of countries to volatile international energy prices.
Energy subsidies are a highly inefficient way to provide support to low-income households since most of the benefits from energy subsidies are typically captured by rich households.

(US$ billions on top axis; percent regional GDP on bottom axis)

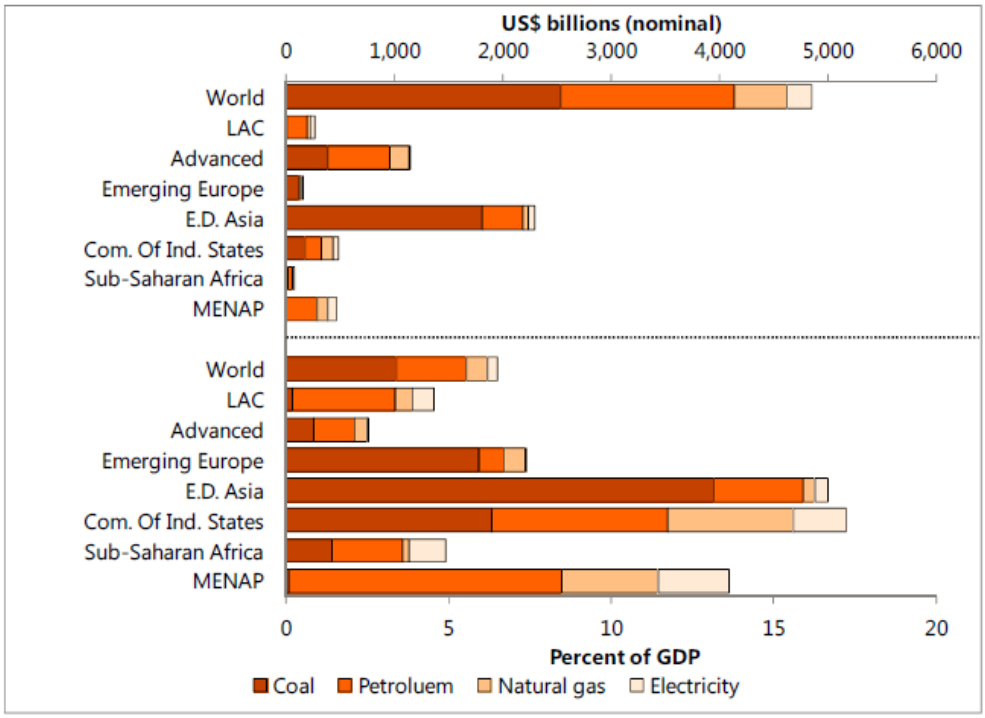


Figure 7 Energy subsidies by regions, 2013

[Source] Coady, D. et al (2015) "IMF Working Paper: How Large Are Global Energy Subsidies?"

As IMF illustrates, the net gain from reform, after subtracting the cost of higher energy prices to consumers from the fiscal and environmental gains, is projected at US$1.8 trillion (2.2 percent of global GDP) and could be much larger if the fiscal gain is used for growth-enhancing tax cuts on labor and capital or badly needed investments in education, health, and infrastructure (for details, see the figure below).

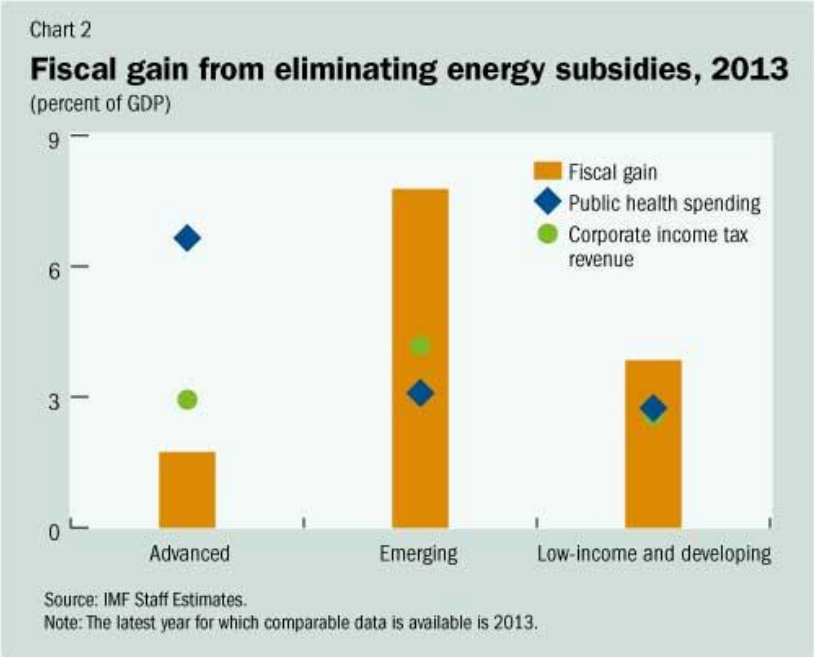


Figure 8 Fiscal gain from eliminating energy subsidies

[Source] IMF (2015) "Counting the Cost of Energy Subsidies"

Therefore, this Study Committee recommends the Japanese government to increasingly assist developing countries to improve (For details, see the figure below).

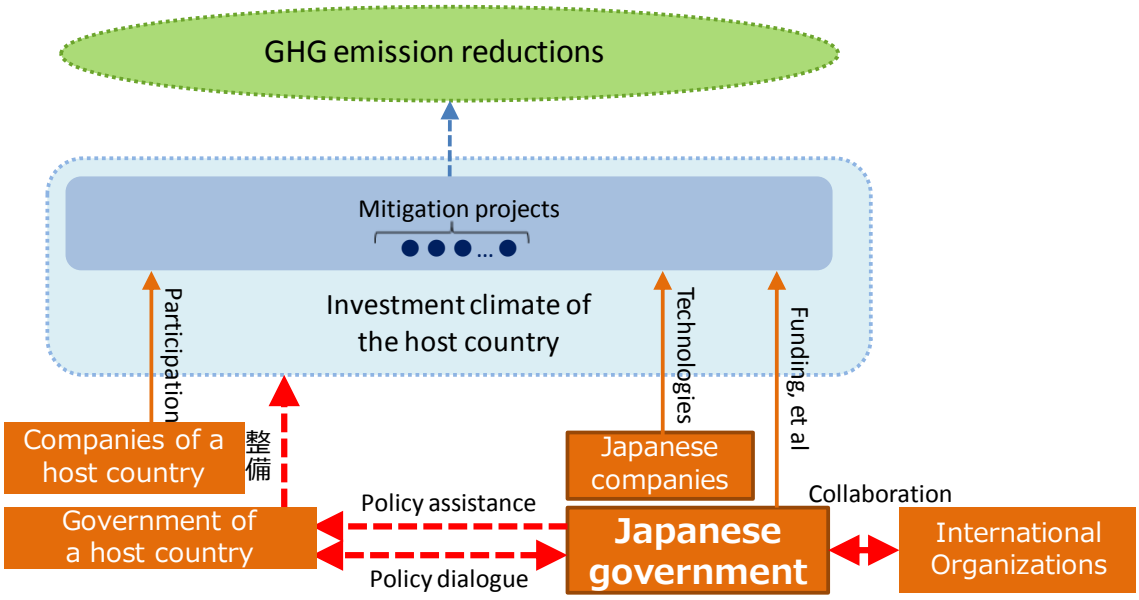


Figure 9 Abstract of the proactive enhancement

[Note] Dotted red lines outline elements of the proactive enhancement

[Source] This Study Committee

Non-exhaustive, indicative examples of functions of such structure include, but not limited to:

- assistance to eliminate inefficient fossil fuel subsidies in collaboration with relevant international organizations, et al;
- assistance to introduce energy-efficiency standards

2) Cooperation for additional international frameworks

A standard is a document that provides requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose[4]. International Standards reflect agreements on the technical description of the characteristics to be fulfilled by the product, system, service or object in question[5].

For developing countries, International Standards are an important source of technological know-how. Developing countries can use International Standards to access knowledge in areas where they may lack expertise and/or resources[6].

For further dissemination and research and development of advanced low-carbon technologies, Japan should be actively engaged in international discussions for international standardization to evaluate technological performances.

Column: Example of an International Standard enhancing global GHG emission reductions

World Steel Association praises new ISO standard

21.03.2013 Brussels

Brussels, 21 March 2013 – The World Steel Association (worldsteel) welcomes the publication of an ISO standard that defines a calculation method of carbon dioxide emission intensity from iron and steel production. The standard is based on the CO_2 data collection methodology that has been used for the past five years in the steel industry.

Launched in 2007, worldsteel's CO_2 data collection aims to provide steel producers with a reliable benchmark for their CO2 emissions. The number of participating organisations has steadily increased since the launch, from 38 companies in 2007 to 51 in 2011, representing more than 200 steel plants worldwide. Of these, 33 steel organisations have reported their CO_2 emissions data using

[4] http://www.iso.org/iso/home/standards.htm

[5] http://www.iec.ch/about/activities/standards.htm

[6] http://www.iso.org/iso/home/about/iso-and-developing-countries.htm

this methodology for five consecutive years as part of worldsteel's Climate Action programme.

Edwin Basson, Director General of worldsteel, said: "We are very pleased with the published standard as it confirms the validity and relevance of our methodology. This globally developed and supported standard will drive the continued uptake of this methodology by the industry. Steel is essential to the modern world and the use of steel is critical in enabling man to move towards a sustainable future. As steel plants actively monitor CO_2 emissions, focus is sharpened onto those activities that ensure the role of steel in a sustainable modern society.

The standard is available for two categories of steel-making processes; Part 1 (ISO 14404-1) for steel plants with blast furnaces and Part 2 (ISO 14404-2) for steel plants with electric arc furnaces. They are now available for purchase at the ISO website: http://www.iso.org

To learn more about steel's contribution to a low carbon future, click here. Attached is a list of accredited steel organisations for the 2012-2013 Climate Action programme.

[Source] Website of the World Steel Association

(http://www.worldsteel.org/media-centre/press-releases/2013/New-ISO-Standard.html)

(4) Presentation of a deliverable of this Study Committee

The Director of the Global Environment Partnership Office, Ministry of Economy, Trade and Industry (METI), Japan made a presentation "How to Innovate Environment Friendly Socio-Systems for Multi-Benefit Climate Actions" at the Japan Pavillion at the COP21/CMP11 jointly hosted by the NEDO and the United Nations Industrial Development Organization (UNIDO) on 9th December 2015.

As an input of this Study Committee, the presentation included a slide to outline "Integrated Contribution Approach" proposed by Dr. Kanako Tanaka, a member of this Study Committee, et al (See the figure below).

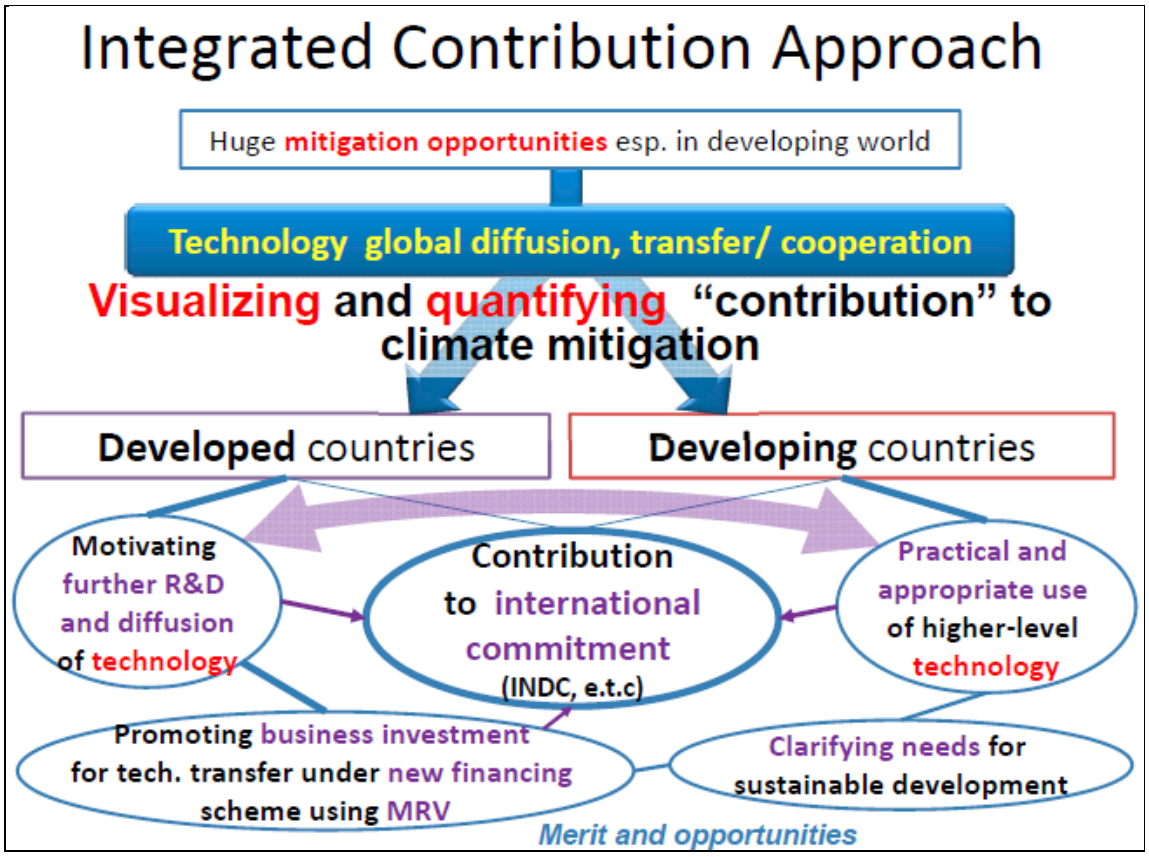


Figure 10 Presentation of the deliverable of this Study Committee

[Source] Elaborated by the METI based on the Japan Science and Technology Agency, Center for Low Carbon Society Strategy (2014)

3. Reference materials

This chapter contains figures and tables on data related to global warming as background information, aggregated for implementation of this project.

(1) Current situation of global GHG emissions

① Trend in global GHG emissions

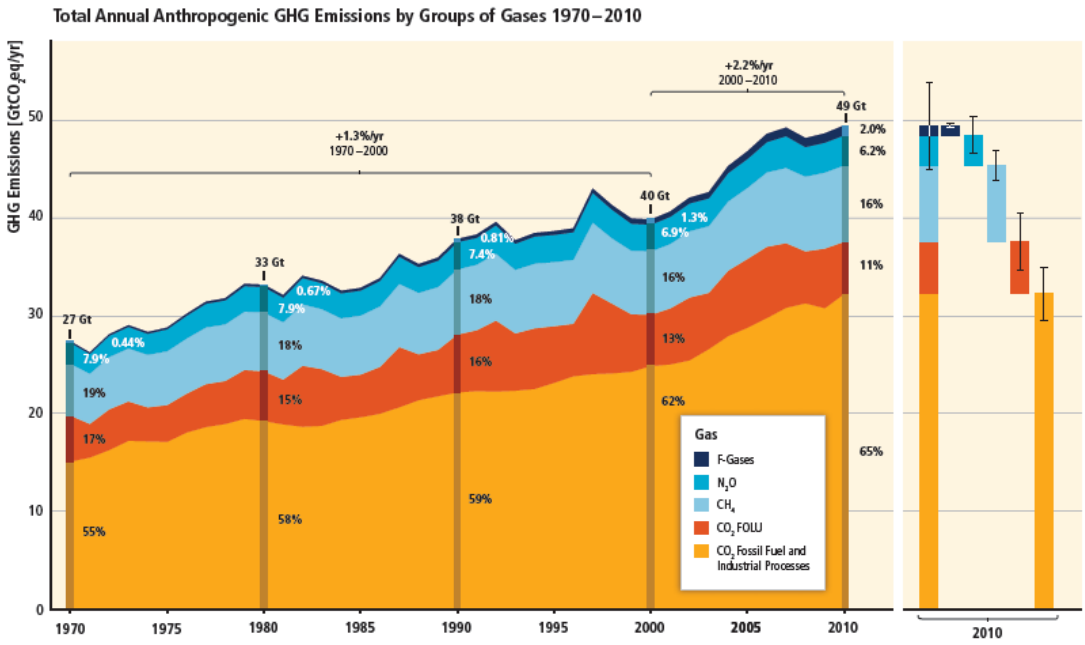


Figure 11 Trend in global GHG emissions

[Source] IPCC "The Fifth Assessment Report" of the WG3, Summary for Policymakers

② Trend in GHG emissions by selected country

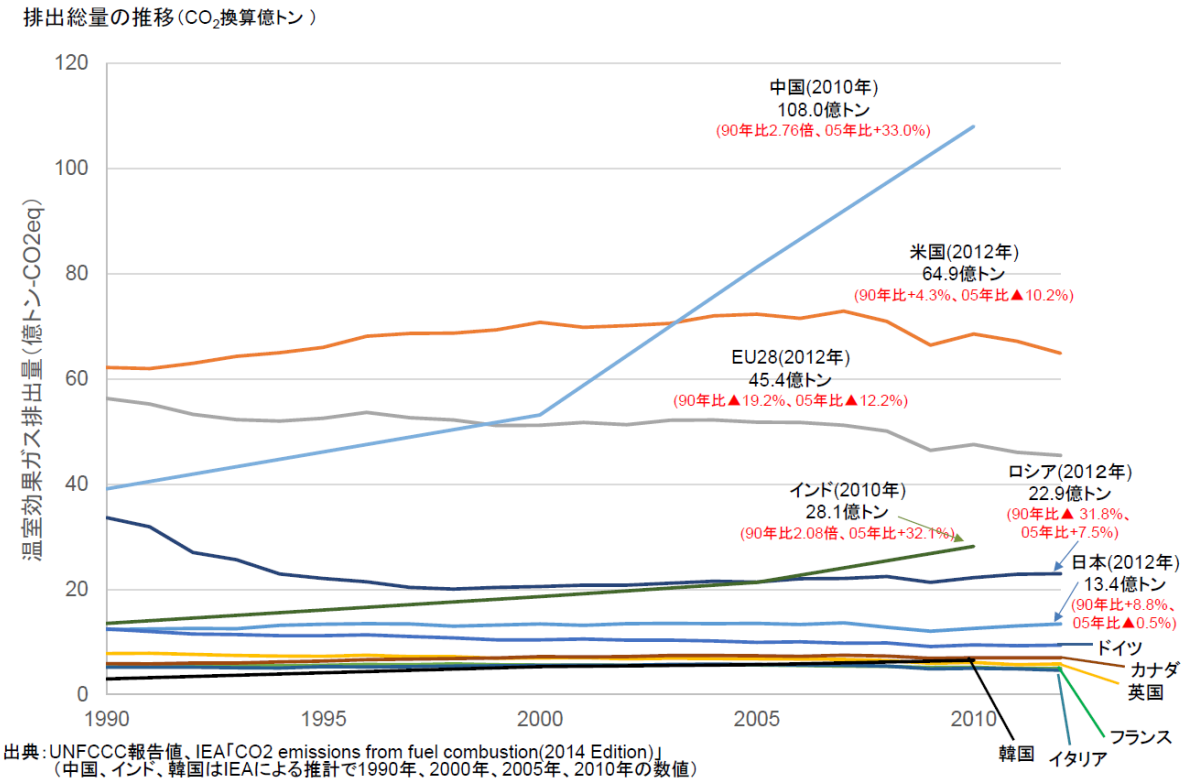


Figure 12 Trend in GHG emissions by selected country

[Source] Ministry of Economy, Trade and Industry

③ GHG emissions per capita by selected country

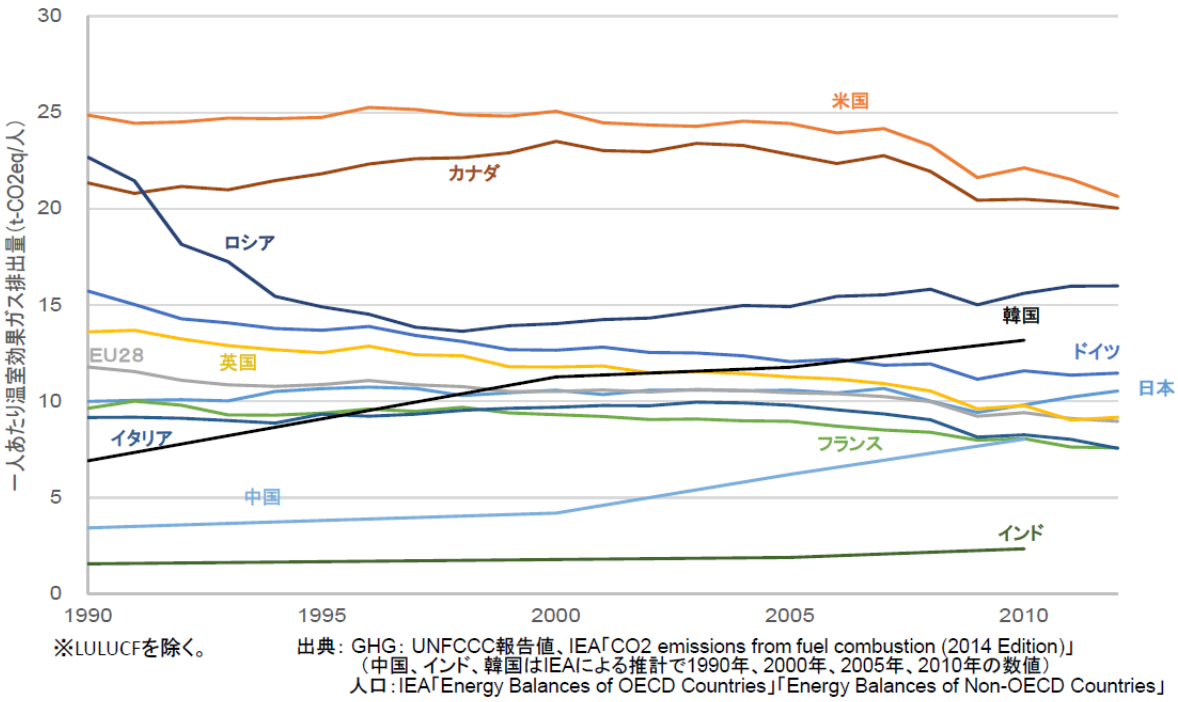


Figure 13 Trend in GHG emissions per capita by selected country

[Source] Ministry of Economy, Trade and Industry

④ Global GHG emissions by sector

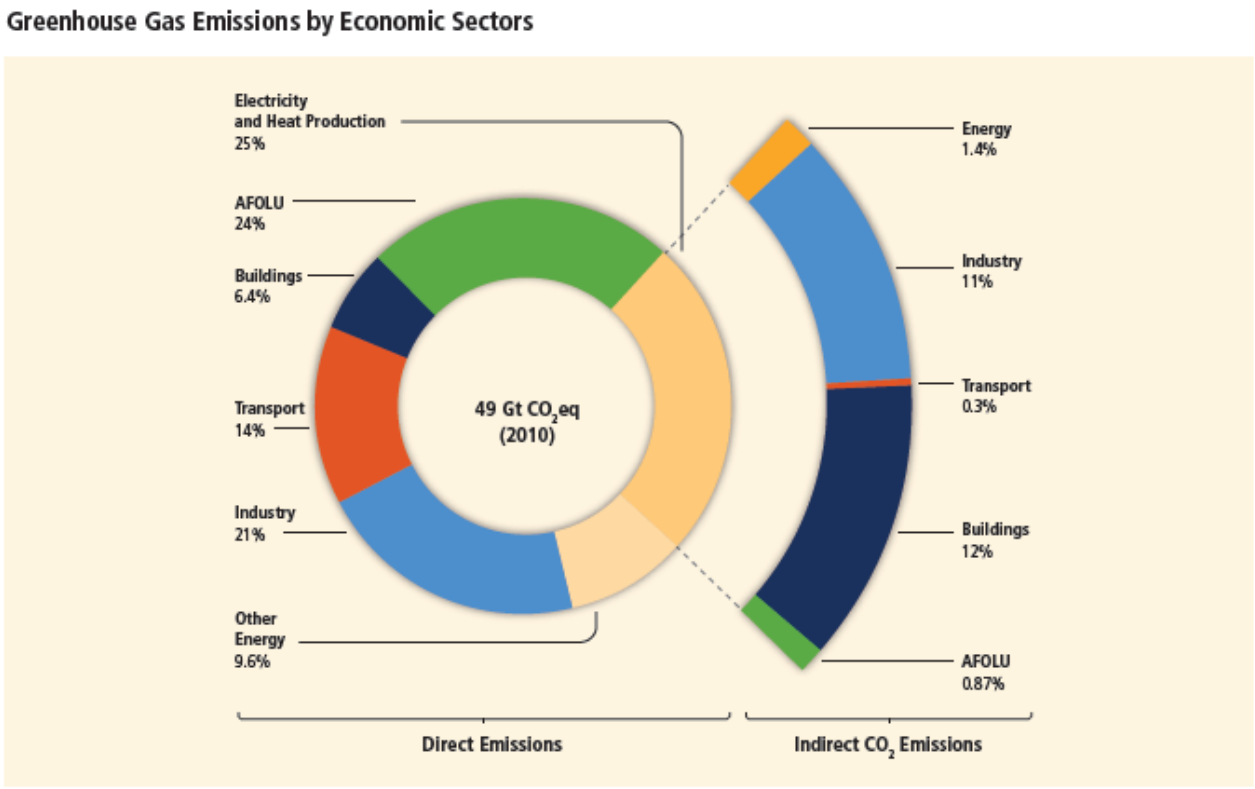


Figure 14 Global GHG emissions by sector

[Source] IPCC "The Fifth Assessment Report" of the WG3, Summary for Policymakers

(2) Reduction potential in global GHG emissions

① Reduction potential in GHG emissions by country

1) Reduction potential in GHG emissions by selected country

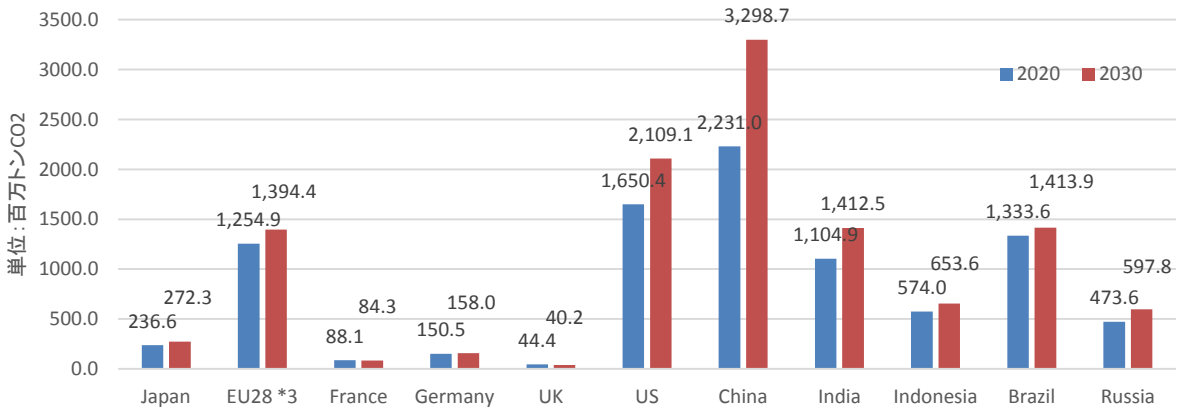


Figure 15 Reduction potential in GHG emissions by selected country

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

Table 6 Reduction potential in GHG emissions by selected countries by sector

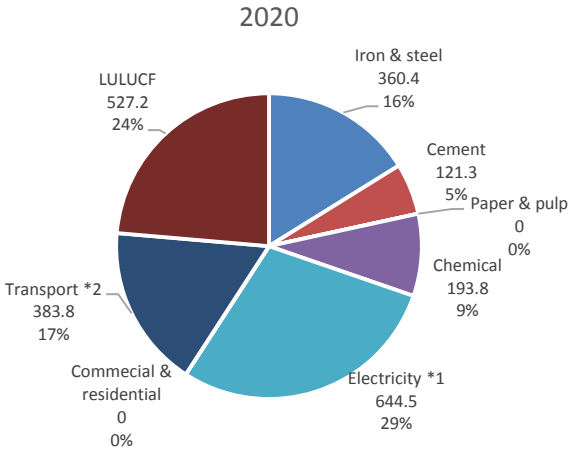
Unit: million ton

		Japan	EU 28 *3	France	Germany	UK	US	China	India	Indonesia	Brazil	Russia	Total
Iron & steel	2020	8.4	16.8				7.7	360.4	66.9		9.0	17.8	487.0
	2030	8.2	19.8				9.0	378.5	95.6		11.6	21.5	544.2
Cement	2020	2.0	9.1				7.8	121.3	13.6		1.7	6.4	161.9
	2030	1.9	9.2				9.3	106.6	20.5		2.0	7.0	156.5
Paper & pulp	2020					15.9			27.6			3.7	47.2
	2030					16.2			66.1			5.5	87.8
Chemical	2020	15.0	7.2	14.5			53.8	193.8	34.5		6.9		325.7
	2030	14.9	8.4	17.0			54.6	279.4	48.1		8.4		430.8
Electricity *1	2020	29.3	71.8	8.5	17.2	9.0	132.5	644.5	348.4	43.8	6.5	53.7	1330.6
	2030	34.6	113.7	3.5	22.2	4.5	194.2	1020.8	423.0	60.5	15.9	92.7	1955.3
Commercial & residential	2020												0.0
	2030	25.8	62.5				187.8	369.7	31.1	4.8	1.2	65.0	747.9
Transport *2	2020	65.7	527.1				672.2	383.8	127.9	79.7	132.7	84.0	2073.1
	2030	70.7	559.1				877.8	616.5	242.0	137.9	198.1	98.2	2800.3
LULUCF	2020	116.2	630.1	72.4	118.8	19.5	776.4	527.2	486.0	450.5	1176.8	308.0	4471.2
	2030												
Total	2020	236.6	1254.9	88.1	150.5	44.4	1650.4	2231.0	1104.9	574.0	1333.6	473.6	8896.7
	2030	272.3	1394.4	84.3	158.0	40.2	2109.1	3298.7	1412.5	653.6	1413.9	597.8	11194.0

* 1 Assuming growth in BAU; BAT replacement rate at 1/4.
* 2 Fixed case
* 3 Data of EU 27 for Iron & steel, cement and transport.

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

2) Reduction potential in China's GHG emissions



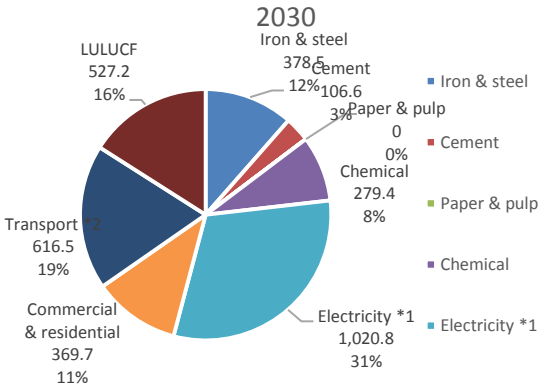


Figure 16 Reduction potential in China's GHG emissions by sector

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

3) Reduction potential in India's GHG emissions

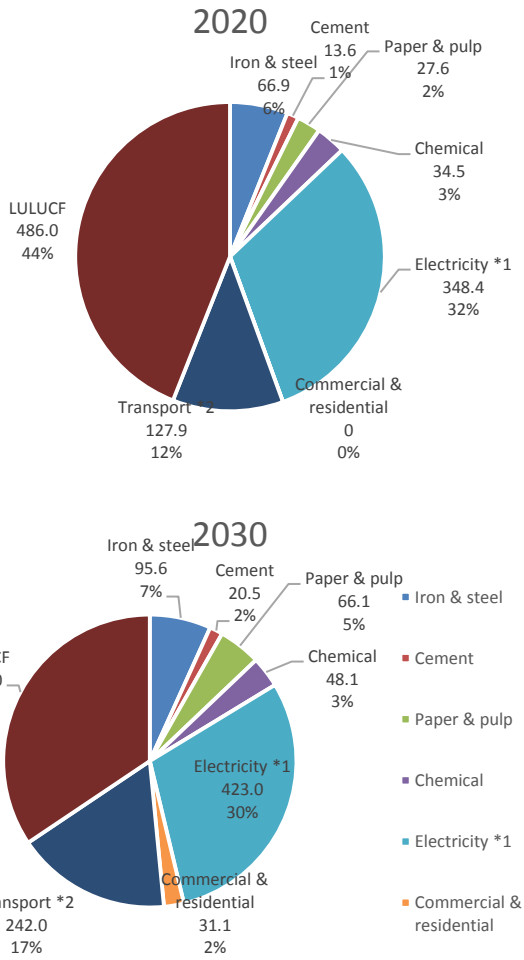


Figure 17 Reduction potential in India's GHG emissions by sector

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

② GHG emission reduction potential in selected countries by sector

1) Iron & steel

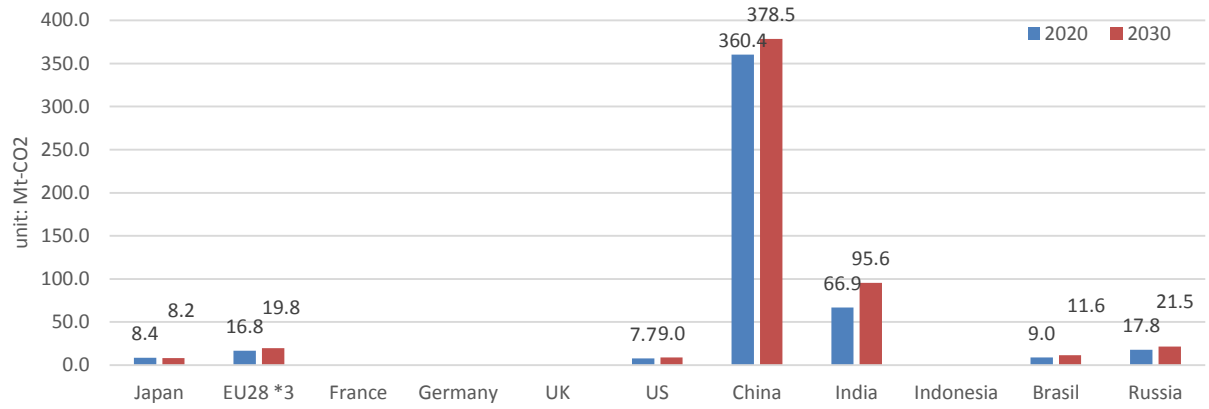


Figure 18 GHG emission reduction potential in iron & steel sector by country

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

2) Cement

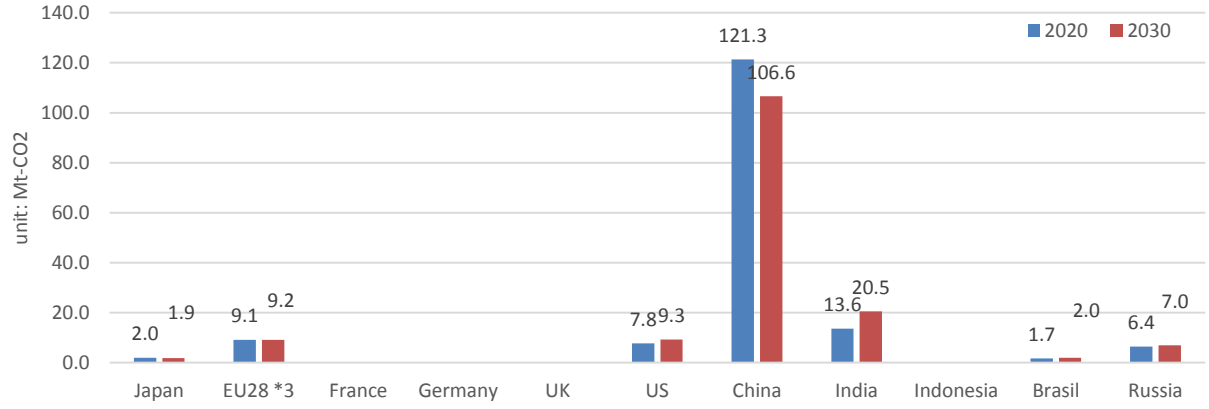


Figure 19 GHG emission reduction potential in cement sector by country

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

3) Chemical

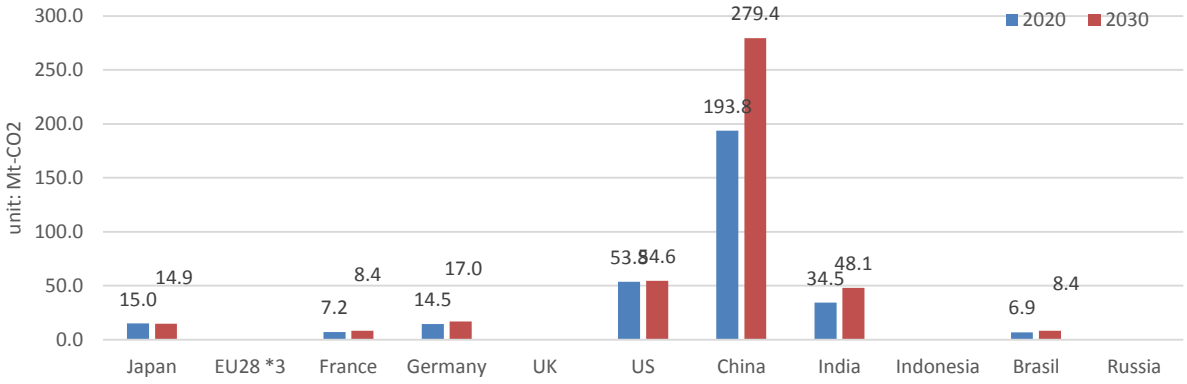


Figure 20 GHG emission reduction potential in chemical sector by country

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

4) Electricity

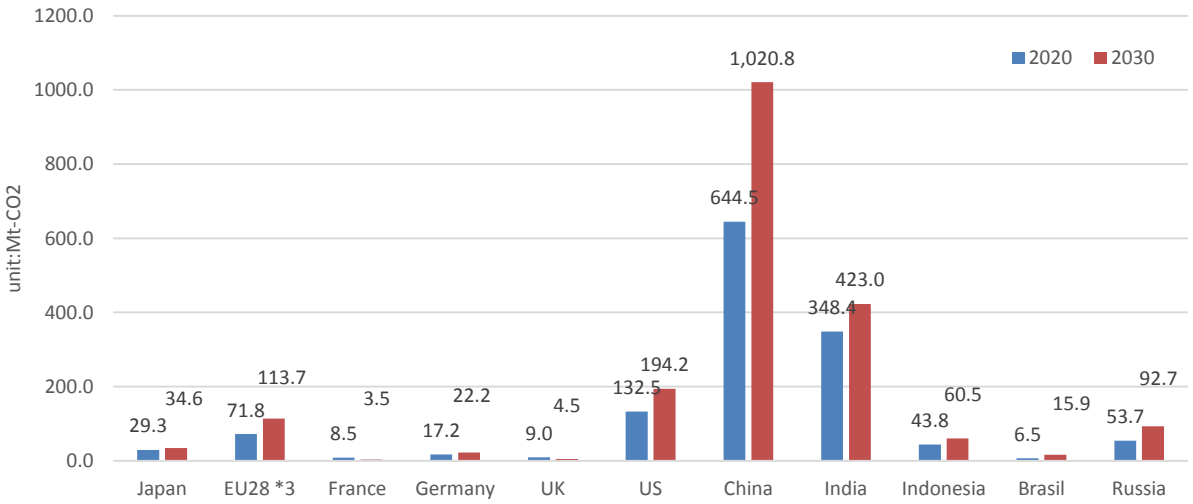
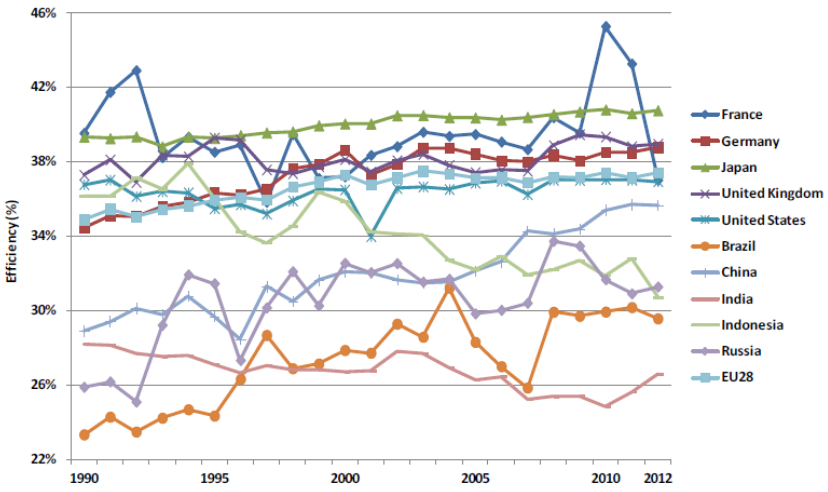


Figure 21 GHG emission reduction potential in electricity sector by country

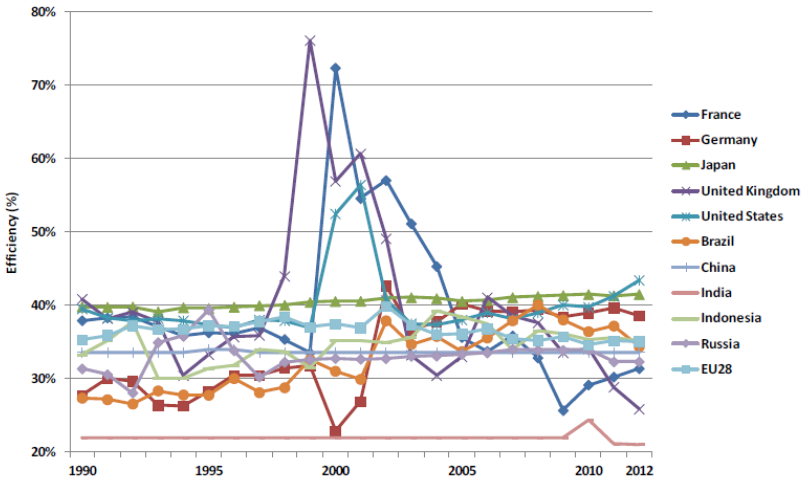
[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

③ Trend in efficiency of electricity generation by country

Coal-fired



Petrol-fired



Gas-fired

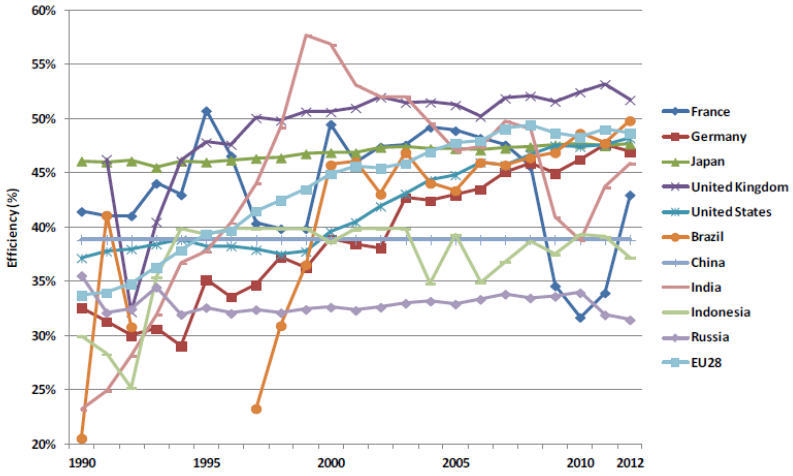


Figure 22 Trend in efficiency of electricity generation by fuel type by country

[Source] Prepared based on a report of Ministry of Economy, Trade and Industry (2015b)

(3) Status of advanced electric power generation technologies

① Solar power generation

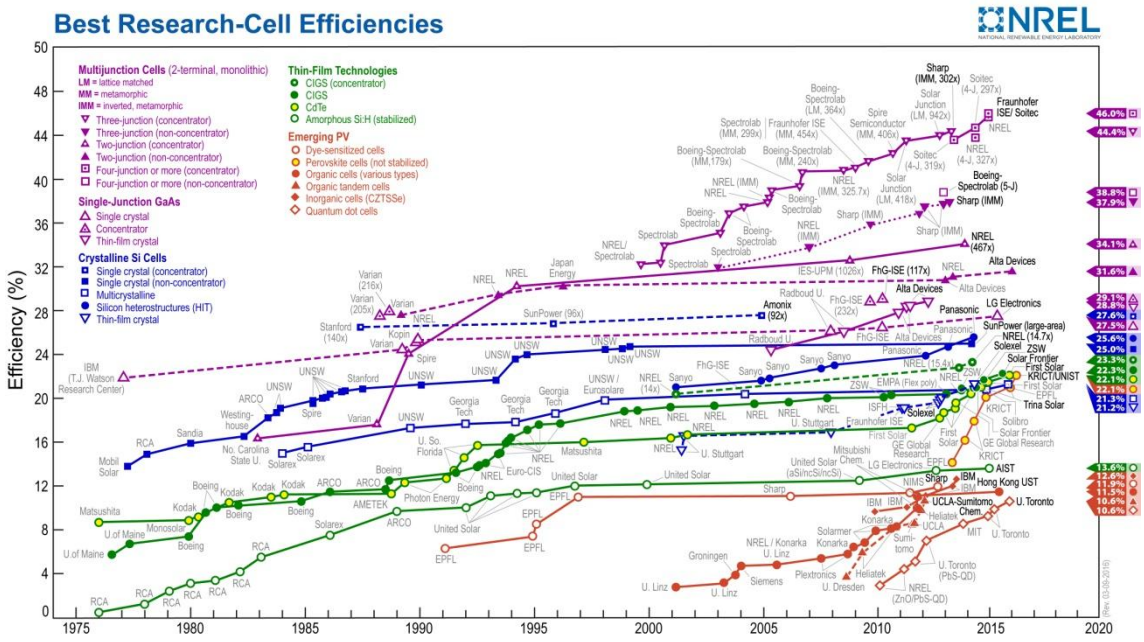


Figure 23 Conversion efficiency of solar cells at laboratory level

[Source] National Renewable Energy Laboratory

② Wind power generation

Table 7 Large-scale wind power generation: 5MW or above (at practice or FS stages)

(at practical use stage)

Wind-mill manufacturer	Type	Rated capacity (MW)	Roter diameter (m)	Note
Repower (Germany)	6M	6.2	126	Gearbox and secondary winding type induction generator
Siemens (Germany)	SWT-6.0-154	6.0	154	Gearless synchronous type generator (permanent magnet)
Gamesa (Spain)	G128-5.0	5.0/5,5	128	Gearbox and synchronous type generator (permanent magnet)
AREVA (France)	M5000-135	5.0	135	Gearbox and synchronous type generator (permanent magnet)
BARD (Germany)	BARD5.0	5.0	122	Gearbox and secondary winding type induction generator
Sinovel (China)	SL5000	5.0	—	Gearbox and secondary winding type induction generator
…				
[Reference] Hitachi (Japan)	HTW2.0-86	2.0	86	Downwind system

[Source] Prepared based on NEDO (2015) and hearing surveys for companies

(at feasibility study)

Wind-mill manufacturer	Type	Rated capacity	Roter diameter (m)	Power train
Upwind system				
Vestas (Denmark)	V164-7	8.0	164	Gearbox and synchronous type generator (permanent magnet)
ENERCON (Germany)	E126	7.5	127	Gearless multipolar synchronous type generator
Mitsubishi Heavy	MWT167/7.0 (SEA	7.0	167	Hydraulic pressure and synchronous type generator

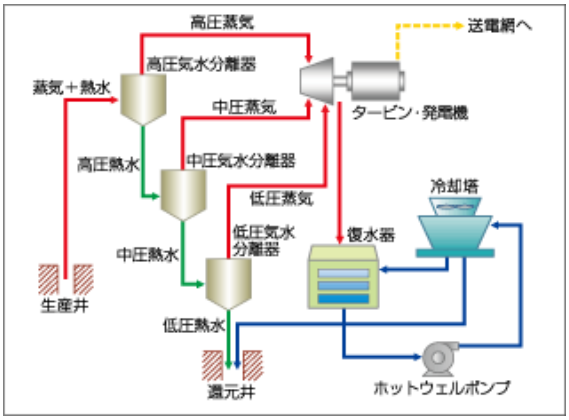
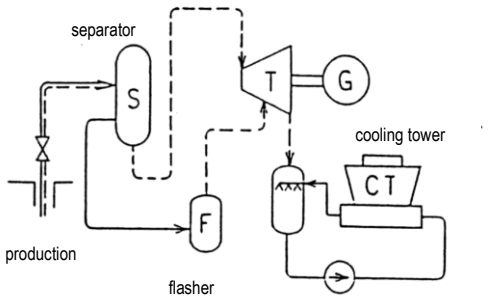
Wind-mill manufacturer	Type	Rated capacity	Roter diameter (m)	Power train
Industries (Japan)	ANGEL)			
SAMSUNG (Korea)	S-7.0-171	7.0	171	Gearbox and synchronous type generator (permanent magnet)
BARD (Germany)	Bard6.5	6.5	122	Gearless synchronous type generator (permanent magnet)
Alstom (France)	Haliade150	6.0	150	Gearless synchronous type generator (permanent magnet)
Nordex (Germany)	N150/6000	6.0	160	Gearless synchronous type generator (permanent magnet)
Goldwind (China)	GW6.0M	6.0	150	Gearless synchronous type generator (permanent magnet)
Gamesa (Spain)	G132-5.0	5.0/5,5	132	Gearbox and synchronous type generator (permanent magnet)
Hitachi (Japan)	HWT5.0-126	5.0	126	Gearbox and synchronous type generator (permanent magnet) Downwind system

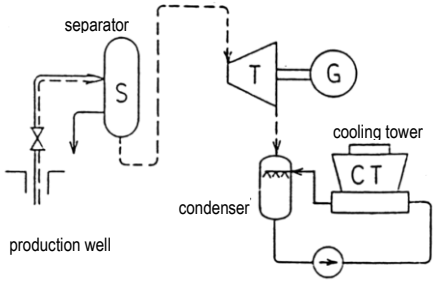
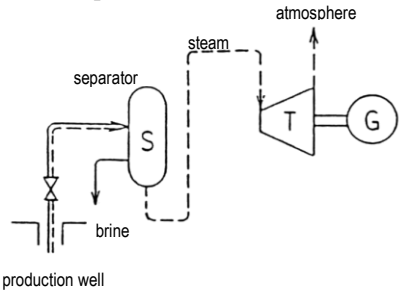
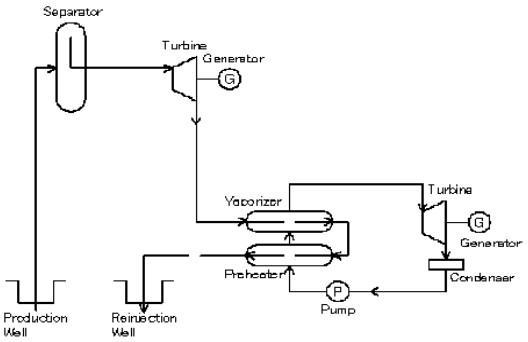
[Source] Prepared based on NEDO (2015) and hearing surveys for companies

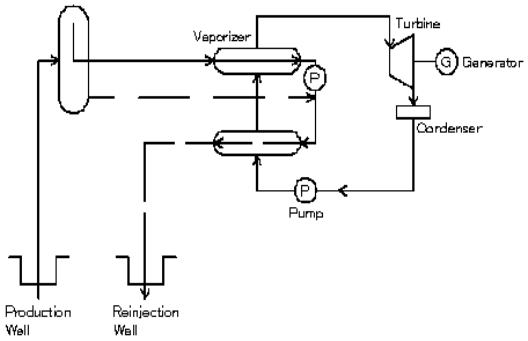
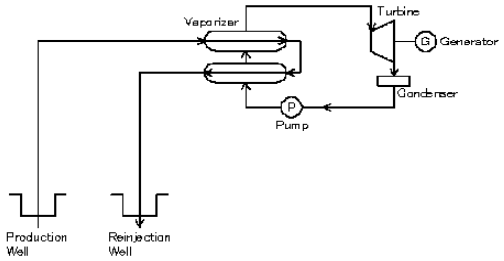
③ Geothermal Power Generation

Two types of geothermal power generation system are in practical use; “Flash Cycle”, which is widely known and “Binary Cycle,” which has been commercialized recently. In addition, “HDR (Hot Dry Rock) geothermal system,” which is also called “ EGS (Enhanced Geothermal Systems)” including a series of technologies of utilization of geothermal resources, is in the experimental stage. Efficiency of geothermal power plants depends on not only the type of generation but also the characteristics of geothermal fluids (see table below). For example, for the geothermal steam and brine with low temperature, only the binary cycle is applicable.

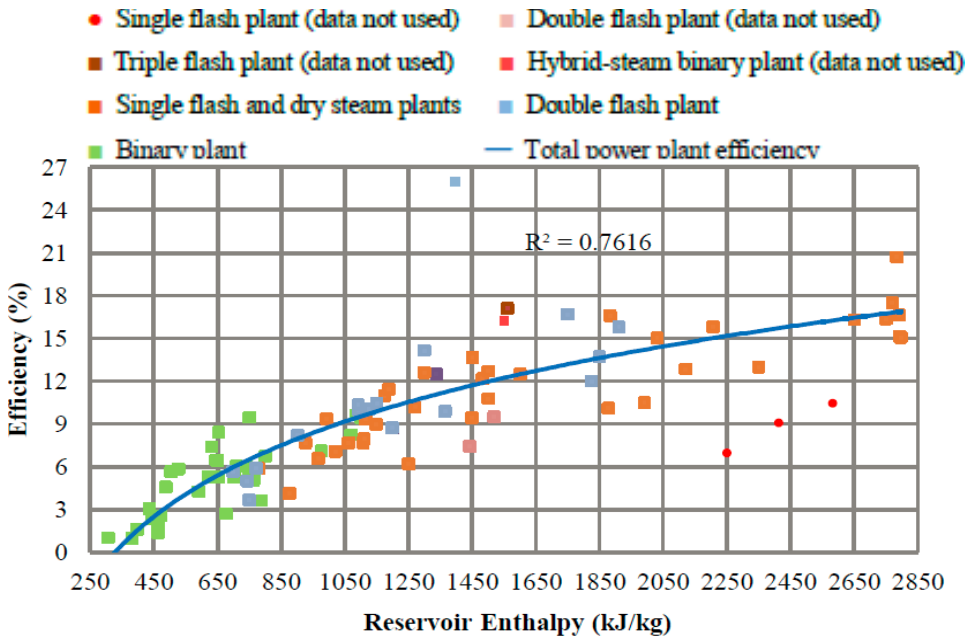
Table 8 Examples of geothermal power generation technologies

Type	Type of generation	Characteristics
Flash cycle	Triple flash condensing* 	・ Applicable to wells with very high pressure. ・ Three stages of “flashes” (vaporization of the liquid dominated brine steam in a separator) to obtain the higher rate of steam utilization ・ Nga Awa Purua geothermal power plant (Fuji Electric) in New Zealand has the largest capacity per unit in the world (147 MW/unit).
	Double flash condensing 	・ Applicable to wells with water-dominated geothermal fluid containing few NCGs. ・ High capacity power generation is possible. ・ When hot water can be secured, this method has more output by 15 to 25 percent than for the single flash method. ・ The construction cost is higher by approximately 6 percent than for the single flash method. ・ The volume of rejoined water is smaller than for the single flash method.

Type	Type of generation	Characteristics
	Single flash condensing 	・ Applicable to wells with water-dominated geothermal fluid containing few NCGs. ・ High capacity power generation is possible. ・ When much hot water is used, geothermal energy use efficiency is low. ・ Due to high-temperature and high-pressure reinjection, this method may be more advantageous in silica scale prevention in reinjection wells and for reducing the number of reinjection wells or reducing the power cost for reinjection pumps than the double flash method
	Single flash back pressure 	・ Applicable to wells with water-dominated geothermal fluid containing a great amount of NCGs. ・ This is well-head power generation, which is generally low capacity. ・ Geothermal energy use efficiency is lower than for the condensing method. ・ Construction cost is low while specific steam consumption is high. ・ Exhaust noise control measures are required.
Binary cycle, et al	Combined cycle 	・ Applicable to high-pressure, middle to high enthalpy wells. ・ Use of high-capacity gas extractors (vacuum pumps) is not required. ・ All NCGs have been reinjected before. ・ Using hot water in addition to steam as a heat source is possible. ・ The system consists of a back pressure turbine and several binary units. ・ High capacity power generation is possible.

Type	Type of generation	Characteristics
	Steam and hot water combination 	・ Applicable to low to middle enthalpy wells with water-dominated geothermal fluid. ・ Use of high-capacity gas extractors (vacuum pumps) is not required. ・ There is a possibility that all NCGs can be reinjected. ・ Since this method uses both steam and hot water as heat sources, the use efficiency of geothermal energy is high. ・ The output of a single unit is several megawatts. ・ The facility structure is relatively simple and applicable to medium-scale power plants through the use of many units.
	Simple binary 	・ Heat from hot water is transported to a heat exchanger (vaporizer), where a working fluid with a low boiling point is vaporized to generate steam, which drives a turbine. ・ Applicable to low enthalpy wells that are not suitable for the flash cycle method. ・ Generally low-capacity package type. ・ The structure of facilities is simple and they can easily operate without human operators.

[Source] METI (2015c) *Report of the Joint Credit Mechanism Feasibility Study on Introduction of Small-scale Geothermal Power Generation Unit to the Republic of Kenya*, MOE (2014), et al


Single flash plant (data not used)
Double flash plant (data not used)
Triple flash plant (data not used)
Hybrid-steam binary plant (data not used)
Single flash and dry steam plants
Double flash plant
Binary plant
Total power plant efficiency
R² = 0.7616
Efficiency (%)
0
3
6
9
12
15
18
21
24
27
250
450
650
850
1050
1250
1450
1650
1850
2050
2250
2450
2650
2850
Reservoir Enthalpy (kJ/kg)

④ Gas-fired electric power generation

Table 9 Advanced gas-fired electric power generation technologies in commercial operation with good economic efficiency and reliability

Scale of power generation	Applied technology [combustion temperature, etc.]	Fuel	Current phase	Designed heat efficiency (power generation end) [%: HHV] (Unit for parenthesis is %: LHV)	Designed heat efficiency (transmission-end) [%: HHV] (Unit for parenthesis is %: LHV)
<Eastern Japan (50Hz)> *					
800,000 kW level	Gas-turbine combined cycle (GTCC) [1,450 degree-C level] [multiaxial]	LNG	Commercial operation	50.5 (56)	49 (55)
500,000 kW level	Gas-turbine combined cycle (GTCC) [1,500 degree-C level] [uniaxial]	LNG	Commercial operation	53 (59)	52 (58)
400,000 kW level	Gas-turbine combined cycle (GTCC) [1,400 degree-C level] [uniaxial]	LNG	Commercial operation	52 (58)	51 (57)
<Western Japan (60Hz)> *					
600,000 kW level	Gas-turbine combined cycle (GTCC) [1,300 degree-C level] [multiaxial]	LNG	Commercial operation	52 (58)	51 (57)
400,000 kW level	Gas-turbine combined cycle (GTCC) [1,500 degree-C level] [uniaxial]	LNG	Commercial operation	52 (58)	51 (57)
300,000 kW level	Gas-turbine combined cycle (GTCC) [1,400 degree-C level] [uniaxial]	LNG	Commercial operation	51 (57)	50 (56)
200,000 kW level	Gas-turbine combined cycle (GTCC) [1,200 degree-C level] [uniaxial]	LNG	Commercial operation	51.5 (57)	50.5 (56)

* Classified into Eastern Japan (50Hz area) and Western Japan (60Hz area), considering generalized property of gas turbines with product lineup to suit each frequency.

[Source] METI's Agency for Natural Resources and Energy, Ministry of the Environment (2014)

Table 10 Gas-fired technologies for which commercial plants are under construction (incl. test operation) or in the process of environmental assessment

Scale of power generation	Applied technology [combustion temperature, etc.]	Fuel	Current phase	Designed heat efficiency (power generation end) [%: HHV] (Unit for parenthesis is %: LHV)	Designed heat efficiency (transmission-end) [%: HHV] (Unit for parenthesis is %: LHV)
<Eastern Japan (50Hz)> *					
700,000 kW level	Gas-turbine combined cycle (GTCC) [1,600 degree-C level] [uniaxial]	LNG	Under construction	54.5 (61)	53 (59.5)
500,000 kW level	Gas-turbine combined cycle (GTCC) [1,600 degree-C level] [uniaxial]	LNG	In the process of environmental assessment	56 (62)	55 (61)
<Western Japan (60Hz)> *					
1,100,000 kW level	Gas-turbine combined cycle (GTCC) [1,600 degree-C level] [multiaxial]	LNG	Under construction	55.5 (62)	54 (60.5)
500,000 kW level	Gas-turbine combined cycle (GTCC) [1,600 degree-C level] [uniaxial]	LNG	Operation launched in August 2013	54 (60)	52.5 (58.5)

* Classified into Eastern Japan (50Hz area) and Western Japan (60Hz area), considering generalized property of gas turbines with product lineup tailored to each frequency.

[Source] METI's Agency for Natural Resources and Energy, Ministry of the Environment (2014)

Table 11 Other gas-fired power generation technologies under development

Scale of power generation	Applied technology [combustion temperature, etc.]	Fuel	Current phase	Designed heat efficiency (power generation end) [%: HHV] (Unit for parenthesis is %: LHV)	Designed heat efficiency (transmission-end) [%: HHV] (Unit for parenthesis is %: LHV)
600,000 kW level	Gas-turbine combined cycle (GTCC) [1,700 degree-C level]	LNG	Feasibility study	-	57 (63)
100,000 - 200,000 kW level	Advanced humid air turbine (AHAT)	LNG	Feasibility study	-	51 (56.7)

[Source] METI's Agency for Natural Resources and Energy, Ministry of the Environment (2014)

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The Ministry of Economy, Trade and Industry, Japan

"Study on the enhancement of global greenhouse gas emissions reduction through Japan's technologies"

Final Report

28th March 2016

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