Evaluating the Effectiveness of Japan’s Climate Change Mitigation and Clean Technology Development Policies

I. Ihara¹, R. Zhao², A. H. Pandyaswargo²*, H. Onoda²

¹Deloitte Tohmatsu Consulting, LLC., 100-8361 Tokyo, Japan
²Graduate School of Environment and Energy Engineering, Waseda University, 169-8555 Tokyo, Japan
Correspondence: E-mail: andante.hadi@aoni.waseda.jp

ABSTRACT
The energy sector has been the highest contributor of greenhouse gases (GHG) emission in Japan. To reduce GHG emissions, the development and applications of cleaner technologies supported by effective policies are required. In this study, the effectiveness of Japanese government policies related to climate change mitigation especially in the technology development sector was analyzed. To do so, two methodologies; 1) results-based approach (RBA) and 2) case-based approach (CBA) will be combined to test the effectiveness of government policies. This combination was conducted to fill the missing data required to conduct the two methodologies. The merging of the two methodologies produced indexes where the proximity of the performance of each policy measured to it would determine its effectiveness. In order to verify the results, the number of projects related to the policy took place over the years was also observed. The results show that the most effective policies were related to the following technologies: 1) Energy management, 2) Biomass energy production, and 3) Electric power storage.

1. INTRODUCTION
Clean technologies play a significant role in achieving both the medium and long-term targets of Greenhouse Gases (GHG) emission mitigation. In Japan, the energy sector accounts for the highest GHG emission with over 88% of the total annual GHG emission in 2016 (MOE, 2018). This strikingly high percentage of GHG emission from the energy sector has not changed much over several decades. The ability of Japan to meet its GHG emission mitigation target under the United Nations Framework Convention on Climate Change (UNFCCC) depends largely on the energy path pursue after the Fu-
kushina nuclear disaster in March 2011 (Kuramochi, 2014).

The policies that support clean technology development projects are the product of assessments in determining how the government uses a systematic methodology to assist GHG emission mitigation (DOE, 2010; GAO, 2016; IEA, 2017). For example, the United States Department of Energy (US - DOE) conducts Technology Readiness Assessment (TRA) for its government technology development acquisition programs (DOE, 2015). In general, TRA helps in identifying development risks and potentials, prioritize subsidy allocation, and accelerate the development of promising clean energy technology. TRA has also been adopted by the Australian Renewable Energy Agency (ARENA) and the European Union (Héder, 2017). Japan has recently adopted and developed the Japanese version of TRA, named J-TRA (Ihara et al., 2019; Ihara et al., 2018; MOE, 2016; Pang et al., 2019).

One way to evaluate the effectiveness of a policy is to use “results-based approach” (RBA). In this approach, the plans and targets are formulated prior the implementation of the policy then compared with the actual results after implementation. In the RBA method, the differences between actual results and targets values in tons of CO₂ from each sector are compared. In this case, the weaknesses of using RBA method are the following: 1) Evaluation cannot be conducted when the target and actual values are not available in the unit amount of CO₂ or other GHG emission chemical compounds; and 2) There is no appropriate verification to check the initial target and actual values.

Another way to evaluate the effectiveness of clean technology development policy is by the “case-based approach” (CBA). In this method, policy effectiveness is not measured quantitatively, but rather by organizing the projects into groups based on their phases and contents. Consequently, the policy can be revised in detail by referring to the evaluation results of the past projects.

Since both approaches have their own advantages and disadvantages, this paper aims to combine RBA and CBA, and develop a “Policy Evaluation Index”. By doing so, all non-emission achievement targets in the Kyoto Protocol Target Achievement Plan (KPTAP) are quantified. The merging process used the least-squares method and Multiple Regression Analysis (MRA). The verification of the output indexes was conducted by plotting the number of the established technology development project in each category against the CO₂ emission mitigation performance of each technology development project categories. Two databases were utilized to serve this merging process: 1) The official report of the KPTAP and 2) Clean Technology Research and Development (R&D) database by Deloitte Tohmatsu Consulting (DTC) company. DTC has been assisting the MOE of Japan in reviewing clean technology R&D projects. The database used in this study is the archive of their assistance work.

2. METHODOLOGY

2.1. Development Framework

There are three main purposes in designing the policy evaluation index. Those are the following: 1) relevant and usable by the technology sector to create policies/measures in climate change mitigation; 2) appropriate and usable for the local and national government agencies to publish the climate change mitigation strategies information; 3) sufficient to help in creating policies and strategies in technology development.
The information about the CO₂ reduction amount from each technology are taken from the Progress Status of KPTAP report. Then, the information from these databases are screened, classified, and linked as technology categories. Finally, the CO₂ reduction target and the result of each technology category are compared, and the result is identified as Policy Evaluation Index. By reviewing the index, one can recognize what technical sectors must be strengthened in terms of their CO₂ reduction. The expected output of this approach is the knowledge of technology development projects in the actual states. From this output, the right policies can be introduced to support the development of the bottle-neck technical sectors.

2.2. Database Classification and Screening

2.2.1 R&D Database Classification and Screening

There are 42 technology development projects in the Deloitte’s Clean Technology R&D database. These projects are classified into two major categories to reflect the supply side of energy. Projects without direct contribution to the reduction of GHG emission categorized as “others”. The classified projects are sorted further to the following subcategories: 1) new/renewable energy; 2) energy storage and transportation; 3) power electronics; 4) transportation; 5) industry; 6) social system; and 7) consumer. Then, they are sorted into further subcategories based on the type of technology. The result of this third step classification is referred as the 3rd level screening categories. Each of the project is given an ID to identify their categories and subcategories. Among the 42 classified projects, only 37 are used for initial index calculation. The 5 temporarily eliminated projects are the following: 1) Those belonging to the “others” category; 2) The “social system” subcategory as they do not contribute directly to GHG emission reduction; and 3) Two projects overlap with each other with the same subcategories. These 4 projects will be reincluded once the initial indexes are identified.

2.2.2 Progress Status of KTPAP Database Classification and Screening

There are 196 technology categories belonging to a number of climate change mitigation policies that directly or indirectly contributes to the CO₂ reduction listed in the Progress Status of KPTAP database (MOE, 2016). In the preparation of building the Policy Evaluation Index, these categories were filtered out using the following conditions: 1) Those having available actual values of CO₂ reduction information from the year 2010 to 2012; 2) Those with a direct contribution to the promotion or performance improvement of clean technology equipment and systems. Categories met conditions 1 and 2 were eliminated and resulted in 27 remaining categories. The next step is to link these 27 categories with the subcategories in the 3rd classification level of the R&D database.

2.3. Linking the Two Databases

The linking process for most of the 27 technology categories found to be non-problematic as the naming is obvious. However, CO₂ data is only shown as a whole in 4 technology categories belonging to the "Promotion of high-efficiency energy-saving equipment" policy in the KPTAP. Furthermore, there is CO₂ amount from categories belonging to other policies included in the data. To estimate the actual CO₂ emission of each category in the "Promotion of high-efficiency energy-saving equipment" policy, 5 scenarios (CASE) were constructed and multiple regression analysis was conducted. The 5 CASEs are presented in Table 1.
Table 1. Assumptions made to calculate the CO₂ emission reduction improvement rate in CASE 1 to 5 measure with 3rd level classification subcategories in the R&D database

| CASE | CO₂ Emission Reduction Improvement Rate Calculation Assumptions |
|------|---------------------------------------------------------------|
| 1    | Baseline scenario: As presented in the Kyoto database (The sum of CO₂ reduction from projects belonging to 2-7-34 to 2-7-36 subcategories are included together in the 2-7-38 subcategory) |
| 2    | The sum of CO₂ reduction from projects belonging to 2-7-34 to 2-7-36 subcategories are excluded from the baseline CO₂ reduction scenario data for the 2-7-38 subcategory |
| 3    | Amount of CO₂ reduction from projects belonging to 2-7-34 to 2-7-36 subcategories are prorated according to the crude oil reduction ratio in 2010 |
| 4    | The general performance improvement index is incorporated in the calculation of the 2-7-34 to 2-7-36 CO₂ Emission Reduction Improvement Rate |
| 5    | Projects belonging to 2-7-34 to 2-7-36 are managed together as a separate classification category |

Table 2 summarizes the actual number of projects in Japan for each category and the “CO₂ reduction effectiveness improvement rate” for each of the 3rd level classification category. “CO₂ reduction effectiveness improvement rate” (hereinafter referred to as the policy evaluation index or just index) was calculated from the increasing or decreasing trend of the CO₂ reduction amount from 2010 to 2012 using the least squares method. The policy evaluation index is then indicated as the effectiveness of a policy in contributing to the CO₂ emission reduction. Several things to note during the calculation of index are the following: 1) Actual values of CO₂ reduction for solar power generation, wind power generation, high-performance railways, and energy-saving houses and buildings were not available in 2012. Therefore, the actual values from 2010 to 2011 were used to calculate the “CO₂ reduction effectiveness improvement rate” for these categories; 2) Actual values of CO₂ reduction for some policies related to the use of biomass and waste energy were not available in 2012. Therefore, it is calculated using data from 2010 to 2011. In general, there are 11 categories from the 3rd level classification of the R&D database that could not be linked to the categories from the KPTAP. MRA was conducted in order to calculate the policy evaluation index of these 11 categories.

2.4 Completing the Missing Policy Evaluation Index using Multiple Regression Analysis

In order to perform MRA, the unknown policy evaluation index of the 11 categories were set as the target variable. There are 7 explanatory variables from R&D database such as: basic research, applied research, practical research, experimental implementation, initial dissemination and indirect contribution. From the independent variable of each project development phase (basic research, applied research, and others), the observed relationships are: 1) As the number of project increases, the policy evaluation index becomes higher; 2) Correlation with the number of projects is particularly high in the “experimental implementation” phase.
Table 2. CO₂ reduction effectiveness improvement rate (Policy Evaluation Index) for each of the 3rd level classification category

| ID      | 3rd Level Classification Category                          | Number of Projects in Japan | Amount of CO₂ reduction (in ten thousand t·CO₂) | CO₂ reduction effectiveness improvement rate |
|---------|--------------------------------------------------------------|-----------------------------|-----------------------------------------------|---------------------------------------------|
|         |                                                               |                             | 2010 | 2011 | 2012 |                                             |
| 1-1-1   | Solar power generation                                       | 211                         | 112  | 112  | 111  | 0.48                                        |
| 1-1-2   | Solar heat utilization                                       | 34                          | 0    | 0    | 0    |                                             |
| 1-1-3   | Biomass and waste energy utilization                        | 44                          | 1428 | 1428 | 1405 | 23.43                                       |
| 1-1-4   | Biomass fuel production                                     | 223                         | 0    | 0    | 0    |                                             |
| 1-1-5   | Bio-utilization technology                                  | 20                          | 0    | 0    | 0    |                                             |
| 1-1-6   | Ocean energy power generation                               | 22                          | 0    | 0    | 0    |                                             |
| 1-1-7   | Hydrogen production                                         | 35                          | 0    | 0    | 0    |                                             |
| 1-1-8   | Hydropower generation                                       | 45                          | 0    | 0    | 0    |                                             |
| 1-1-9   | Coal utilization                                            | 11                          | 0    | 0    | 0    |                                             |
| 1-1-10  | Geothermal power generation                                 | 45                          | 0    | 0    | 0    |                                             |
| 1-1-11  | Natural gas utilization technology                           | 3                           | 0    | 0    | 0    |                                             |
| 1-1-12  | Wind power generation                                       | 51                          | 142  | 142  | 145  | 0.61                                        |
| 1-1-13  | Unutilized energy                                            | 103                         | 0    | 0    | 0    |                                             |
| 2-2-14  | High-efficiency power transmission                          | 8                           | 0    | 0    | 0    |                                             |
| 2-2-15  | Hydrogen storage                                            | 27                          | 0    | 0    | 0    |                                             |
| 2-2-16  | Hydrogen transportation and supply                          | 41                          | 0    | 0    | 0    |                                             |
| 2-2-17  | Heat storage                                                | 5                           | 0    | 0    | 0    |                                             |
| 2-2-18  | Electric power storage                                      | 128                         | 0    | 0    | 0    |                                             |
| 2-2-19  | Heat transportation                                         | 6                           | 0    | 0    | 0    |                                             |
| 2-3-20  | High-performance devices                                    | 89                          | 0    | 0    | 0    |                                             |
| 2-3-21  | High-performance power electronics                          | 6                           | 0    | 0    | 0    |                                             |
| 2-4-22  | Clean energy vehicles                                       | 87                          | 2626 | 2994 | 3389 | 381.50                                      |
| 2-4-23  | High-efficiency internal combustion engine vehicles         | 37                          | 0    | 0    | 0    |                                             |
| 2-4-24  | High-performance aircrafts                                 | 13                          | 215  | 202  | 236  | 10.50                                       |
| 2-4-25  | High-performance ships                                     | 45                          | 132  | 111  | 177  | 22.50                                       |
| 2-4-26  | High-performance railways                                   | 27                          | 94   | 107  | -    | 13.00                                       |
| 2-5-27  | Coproduction                                                | 2                           | 0    | 0    | 0    |                                             |
| 2-5-28  | High-efficiency industrial furnaces and boilers             | 3                           | 0    | 0    | 0    |                                             |
| 2-5-29  | Solar power generation                                      | 95                          | 0    | 0    | 0    |                                             |
| 2-6-30  | Solar heat utilization                                      | 392                         | 540  | 620  | 680  | 70.00                                       |
| 2-6-31  | Biomass and waste energy utilization                        | 41                          | 0    | 0    | 0    |                                             |
| 2-6-32  | Biomass fuel production                                     | 50                          | 0    | 0    | 0    |                                             |
| 2-7-33  | Bio-utilization technology                                  | 14                          | 1288 | 1335 | 1459 | 85.50                                       |
| 2-7-34  | Ocean energy power generation                               | 2                           | 0    | 0    | 0    |                                             |
| 2-7-35  | Hydrogen production                                         | 46                          | 0    | 0    | 0    |                                             |
| 2-7-36  | Hydropower generation                                       | 25                          | 0    | 0    | 0    |                                             |
| 2-7-37  | Coal utilization                                            | 4                           | 0    | 0    | 0    |                                             |
| 2-7-38  | Geothermal power generation                                 | 67                          | 3932 | 4293 | 4828 | 448.15                                      |
| 2-7-39  | Natural gas utilization technology                           | 6                           | 0    | 0    | 0    |                                             |
| 2-7-40  | Wind power generation                                       | 62                          | 3430 | 3930 | -    | 500.00                                      |
| 2-7-41  | Unutilized energy                                            | 85                          | 0    | 0    | 0    |                                             |

In other words, the greater the number of relevant policies/measures included in the category, the higher the policy evaluation index. The policy evaluation index for each category can be calculated with the multiple regression equation, the 5 initially eliminated 3rd level categories from the R&D databases are also included back in the analysis. The completed list of policy evaluation index is shown in Table 3 with the exception of coal utilization, natural gas utilization, and co-production because these project types are not available in the R&D database. From this point on, since the two databases have been fully merged, “the 3rd level classification categories” from the R&D database is referred to just “technology category”.
3. RESULTS AND DISCUSSION

3.1 Verification

To verify the developed policy evaluation index reflections in the reality, the values are plotted against the number of all-Japan-project belonging to each technological category. A positive correlation can be seen from the scatterplot with an $R^2$ value of 0.70 (Figure 1). However, there are anomalies identified. The following project categories either deviate significantly from the approximate straight line, has really high policy evaluation index, or has really low policy evaluation index: 1) energy management; 2) biomass fuel production; 3) electric power storage; 4) solar power generation; and 5) wind power generation. It is understood that projects such as energy-saving home appliances and commercial equipment, and clean energy vehicles are among the higher policy evaluation indexes.

Table 3. Policy Evaluation Index for each Technology Category

| Technology Category | From Kyoto database | Calculated from multiple regression equation |
|---------------------|---------------------|-----------------------------------------------|
| Solar power generation | 1.0                | 1.0                                           |
| Solar heat utilization | -                  | 235.3                                         |
| Biomass and waste energy utilization | -69.2            | -69.2                                         |
| Biomass fuel production | -                 | 1,716.8                                       |
| Bio-utilization technology | -            | 15.9                                          |
| Ocean energy power generation | -            | 233.3                                         |
| Hydrogen production | -                  | 44.7                                          |
| Hydropower generation | -                 | 300.3                                         |
| Coal utilization | -                  | -                                             |
| Geothermal power generation | -              | 1.7                                           |
| Natural gas utilization technology | -              | -                                             |
| Wind power generation | 6.5                | 6.5                                           |
| Unutilized energy | -                  | 543.5                                         |
| High-efficiency power transmission | -          | 13.7                                          |
| Hydrogen storage | -                  | -32.9                                         |
| Hydrogen transportation and supply | -            | 87.6                                          |
| Heat storage | -                  | 8.3                                           |
| Electric power storage | -                 | 1,398.6                                       |
| Heat transportation | -                 | 44.1                                          |
| High-performance devices | -               | 427.2                                         |
| High-performance power electronics | -           | -30.3                                         |
| Clean energy vehicles | 379.7             | 379.7                                         |
| High-efficiency internal combustion engine vehicles | -         | 51.0                                          |
| High-performance aircrafts | 27.4         | 27.4                                          |
| High-performance ships | 143.1            | 143.1                                         |
| High-performance railways | 45.7           | 45.7                                          |
| Coproduction | -                  | -                                             |
| High-efficiency industrial furnaces and boilers | -            | 1.7                                           |
| Energy-saving industrial processes | -         | 200.0                                         |
| Energy management | -                  | 2,990.4                                       |
| New power supply systems | -             | 223.5                                         |
| Advanced transportation systems | -            | 298.0                                         |
| High-efficiency cogeneration | 65.7        | 65.7                                          |
| High-efficiency water heaters | 281.4       | 79.8                                          |
| High-efficiency air conditioners | 281.4       | 1,027.1                                       |
| High-efficiency lighting | 281.4           | 345.5                                         |
| High-efficiency heating equipment | -         | 15.8                                          |
| Energy-saving home appliances and commercial equipment | 281.4       | 281.4                                         |
| Energy-saving houses and buildings | 466.9       | 466.9                                         |
| Fuel cells | -                  | 149.7                                         |
3.2 Interpretation and Discussion

In general, higher index correlates with a larger number of projects in different technology categories. However, there is an uncountable number of factors may influence the growth of technology development projects. For example, the number of technologies on solar power generation has increased with the introduction of Feed-In-Tariff in the field of renewable energy usage in 2012. In contrast, the technology is also considered to be already mature to a certain extent, this resulted in a low index. Another example is the biomass and waste energy utilization and bio-utilization technology categories. A lot of investments have been made for the technology development in these categories.

However, the market environment to utilize the technology is not ready due to the limited usage. These aspects such as the level of technology and market maturity may influence the progress of technology development. However, the index can be used as a pointer to technology categories that require further attention and as approximation tool to show how the development of a certain technology category is positioned relative to the others.

Some technology categories have exceptionally high and exceptionally low values. The first one is energy management which is exceptionally high with an index value of 2,990.4 points. Factors that might have contributed to the high values are: 1) The number of projects in this category is quite high; 2) The popularization of “smart community” project in Japan; 3) Reconstruction of the Fukushima nuclear disaster affected area that adopts a number of more sustainable strategies. The second one with exceptionally high is biomass fuel production category with 1,716.8 index point. Some explanation of this high performance are the following: 1) The number of projects in this category is quite high with 113 projects; 2) From July 2010, the use of non-fossil energy resources by operators of electricity, oil, and gas as well as the effective use of fossil energy resources were mandated by the “Advancing Energy Supply Structure Act” (This act has resulted in the increase of biomass fuels mixed in gasoline to more than 3%). Following the increased demand for biofuels, projects related to the
production of biomass fuels had increased significantly.

The third highest index technology category is electric power storage with 1,398.6 points. Some factors that might have influenced are: 1) The number of projects in this category is quite high with 97 projects; 2) There was a technology that has been dormant for a decade and suddenly came into use. This was the new type of battery power storage that was developed in 1991 under a national project called the "Moonlight Plan". Another project called the "Sunshine Project" distributed this technology between 1992 to 2002 but the popularity of this technology did not happen until suddenly in 2010 the number of projects related to this technology skyrocketed. There were 48 projects and half of them (24 projects) belong to the development project of Japan's New Energy and Industrial Technology Development Organization (NEDO) on complex electricity storage systems. The objective of this technology is to be used in smart communities. The development of this technology became active at the same time with the popularization of a smart community.

The fourth highest index technology category is the high-efficiency air conditioner with 1,027.1 points. Factors that have contributed to the high index value are: 1) Although the total number of projects throughout Japan is not so high with 44 projects, as many as 28 of them are in the practical research phase and so it has bigger impact in the CO₂ reduction; 2) In 2010, the revised "Energy Conservation Act" was released and within the act, the standard values for commercial air conditioners were improved. The majority of technology categories with small indexes (meaning, a small effect on CO₂ reduction), are either due to the small number of projects, having projects started outside the calculation period, or having projects that are in early development stages.

3.3 Policy re-organization and re-classification

Policies can be categorized to understand the nature, performance, and urgency after policy evaluation indexes for each of the categories are known and discussed. The technology categories belonging to various policies from the Kyoto database are sorted into 4 levels of effectiveness based on their performance on the CO₂ emission reduction (Table 4). Among the low performing policies are: 1) Promoting the installation of equipment and machinery with high energy-saving performance; 2) Implementation of thorough energy management; and 3) Introduction of the optimal use of renewable energy.

In the real world of policy implementation, some policies are cross-sectoral, while others are sectoral. The Japanese climate change mitigation policies (not only those from the Kyoto database) are summarized and categorized based on their sectors (industrial, business, housing, transport, energy conversion, and adsorption of GHG). Furthermore, to assist technical stakeholders to quickly identify whether policies in each sector includes technical measures and whether there is positive progress in the sector, the information is provided using the knowledge gained from the analysis and discussions in this study (Table 5). Policies that have no, or little progress are the “promotion of carbon logistics”, “reduction of carbon dioxide emission level in the power sector”, “promotion of Energy-saving measures in the petroleum products manufacturing sector”, “measures for forest sinks”, “measures for carbon sinks of farmland soil”, and “promotion of urban afforestation”.
Table 4. Range of index for each greenhouse gases emission mitigation policy

| Policy                                                                 | Technology Categories based on the Range of their Policy Evaluation Index |
|-----------------------------------------------------------------------|--------------------------------------------------------------------------|
| Promoting the installation of equipment and machinery with high energy-saving performance | ≤10: High-performance power electronics  | 11 to 100: High-efficiency water heaters, High-efficiency cogeneration, High-efficiency heating equipment | 101 to 1000: High-efficiency lighting, High-performance devices | ≥1000: High-efficiency air conditioners |
| Implementation of thorough energy management                          |                                                                          |                                                                          | Energy management |
| Energy-saving of buildings                                             |                                                                          |                                                                          |                                                                  |
| Increasing the areas of energy utilization                            | Heat storage                                                              | New power supply systems                                                  |                                                                  |
| Energy-saving for houses                                              |                                                                          | Energy-saving houses and buildings                                         |                                                                  |
| Measures for individual automobiles                                   | High-efficiency internal combustion engine vehicles                      | Clean energy vehicles                                                      |                                                                  |
| Greening of the automobile transportation business by promoting the use automobiles that are environmentally friendly |                                                                          | Advanced transportation systems                                            |                                                                  |
| Measures for railroads, ships, and aircrafts                          | High-performance aircrafts                                               | High-performance ships                                                     |                                                                  |
| Promotion of low-carbon logistics                                     | Renewable energy generation                                              | Solar power generation                                                     | Ocean energy power generation                                    |
| Introduction of the optimal use of renewable energy                   | Renewable energy heat                                                     | Biomass and waste energy utilization                                      | Hydropower generation                                            |
| Maximum utilization of electricity, heat and unutilized heat derived from renewable energy within the region | Bio-utilization technology                                               | Heat transportation                                                        | Solar heat utilization                                           |
| Reduction of carbon dioxide emission level in the power sector        | Highly efficient thermal power generation                                | Technology category exists but the number of projects is zero              | Fuel cells                                                       |
| Promotion of Energy-saving measures in the petroleum products manufacturing sector | Utilization of nuclear power generation that is confirmed as safe       |                                                                    | Biomass fuel production Electric power storage |
| Realization of the hydrogen society                                   | Introduction of renewable energy to the maximum                          | Hydrogen storage                                                          | Hydrogen production Hydrogen transportation and supply |
| Greenhouse effect gas measures and policies for carbon sinks          | Measures for forest sinks                                                | Hydrogen production                                                        |                                                                  |
|                                                                        | Measures for carbon sinks of farmland soil                               | Hydrogen transportation                                                    |                                                                  |
|                                                                        | Promotion of urban afforestation                                         | and supply                                                                |                                                                  |
### Table 5. Organization and progress situation of the climate change mitigation policies

| Cross-Sectoral Policies | Sectoral Policies | Technical measures | Progress situation |
|------------------------|-------------------|--------------------|--------------------|
|                        |                   | √                  | √                  |
| Promotion of the J credit system | Industrial sector | Promotion of voluntary initiatives in the industrial world |                  |
| Development of national movement | Business and other sectors | Promotion of voluntary initiatives in the industrial world |                  |
| Formation of low carbon cities, regional structure, and socio-economic system | Business and other sectors | Energy-saving of buildings | √  
Promoting the installation of equipment and machinery with high energy-saving performance implementation through energy management | √  
Increasing the areas of energy utilization, other measures, and policies | √  
Development of citizen movement, and initiatives by the public agencies |
| Realization of the hydrogen society | Housing sector | Development of citizen movement |                  |
| Initiatives based on the guidelines for controlling the greenhouse gas emission effects | Transportation sector | Promote the installation of equipment and machinery with high energy-saving performance |                  |
| Promotion of environmental business activities | Energy conversion sector | Measures for railway, ships, and aircraft and other measures and policies |                  |
| Support for greening the tax system and making effective use of taxes to counter global warming | Energy conversion sector | Measures for railway, ships, and aircraft and other measures and policies |                  |
| Greening of finances | Energy conversion sector | Measures for railway, ships, and aircraft and other measures and policies |                  |
| Emissions trading system within Japan | Energy conversion sector | Measures for carbon sinks of farmland soil |                  |

### 4. CONCLUSION

Policies have been evaluated by comparing the quantitative results, known as the RBA approach and by reviewing the achievement and progress status according to the type and nature of the policies or the CBA approach. A database of clean technology R&D belonging to the consultant of Japan's Ministry of Environment was screened and linked to the Kyoto database in order to fill the gap information from the Kyoto database, and to include the benefits from the CBA approach. The
policy evaluation index for each technology category in the Kyoto database policy was successfully developed using the least-squares method and multiple regression analysis. The developed index was useful in pointing which technology category requires further attention. One finding was that there is a number of technology categories had a significant number of projects which stands out among the other technology development projects. These technology project categories are: 1) energy management; 2) biomass fuel production; and 3) electric power storage. Levels of indexes were found to be not only influenced by the number of projects in each technology category but also the stage of technology development and whether there are large incidental events such as the Fukushima nuclear disaster and sudden change in the market. Finally, the policies were classified according to their index levels and categorized them according to their sectors. From these classifications, the progress situation of each policy in terms of promoting development projects was able to be identified. Even though the effectiveness of each policy in different clean technology development categories have been identified, it is up to the government to decide on kind of changes and implementation actions will be taken to make real changes on the field.

REFERENCES

DOE. (2010). Standard review plan (SRP): Technology readiness assessment report. Retrieved from https://www.energy.gov/sites/prod/files/em/Volume_I/O_SRP.pdf

DOE. (2015). Technology readiness assessment guide. Retrieved from www.directives.doe.gov

GAO. (2016). Technology readiness assessment guide: Best practices for evaluating the readiness of technology for use in acquisition programs and projects. Retrieved from https://www.gao.gov/assets/680/679006.pdf

Héder, M. (2017). From NASA to EU: The evolution of the TRL scale in public sector innovation. The Innovation Journal: The Public Sector Innovation Journal, 22(2), 1–23. Retrieved from https://core.ac.uk/download/pdf/94310086.pdf

IEA. (2017). Energy technology perspectives 2017. Retrieved from https://webstore.iea.org/energy-technology-perspectives-2017

Ihara, I., Pandyaswargo, A. H., Pang, D., & Onoda, H. (2019). Technology readiness assessment of biomass energy projects using J-TRA method: Application on Southeast Asian countries. E212. Nago, Okinawa: International Workshop on Environmental Engineering 2019.

Ihara, I., Pandyaswargo, A. H., & Onoda, H. (2018). Development and the effectiveness of the J-TRA: A methodology to assess energy technology R&D programs in Japan. EcoDePS 2018 Proceedings, 109–117. Retrieved from https://researchmap.jp/?action=cv_download_main&upload_id=219915

Kuramochi, T. (2014). GHG mitigation in Japan: An overview of the current policy landscape. Retrieved from https://pub.iges.or.jp/system/files/publication_documents/pub/policyreport/4259/WRI_WorkingPaper_Japan_Final.pdf

MOE. (2016). TRL calculator manual: Third edition. Retrieved from https://www.env.go.jp/earth/ondanka/biz_local/29_a01/7_trlmanual.pdf

MOE. (2018). National greenhouse gas inventory report of JAPAN 2018. Retrieved from
Ihara, et al. Evaluating the Effectiveness of Japan’s Climate Change Mitigation and Clean Tech. | 12

http://www-gio.nies.go.jp/aboutghg/nir/2018/NIR-JPN-2018-v4.1_web.pdf

Pang, D., Pandyawargo, A. H., Onoda, H., & Ihara, I. (2019). Application of J-TRA (Japanese version of technology readiness assessment) to biomass utilization projects: With focus biomass energy conversion technologies in Southeast Asia. The 14th Meeting of the Institute of Life Cycle Assessment, Japan. Retrieved from https://www.env.go.jp/earth/ondanka/biz_local/29_a01/7_trlmanual.pdf