REPUBLIC OF INDONESIA

MINISTRY OF PUBLIC WORKS AND HOUSING

COLLABORATION PROGRAM WITH THE PRIVATE SECTOR FOR DISSEMINATING JAPANESE TECHNOLOGIES FOR ACTIVATED CARBON FIBERS (ACF) AIR PURIFICATION UNIT IN REPUBLIC OF INDONESIA

FINAL REPORT

March 2020

Japan International Cooperation Agency

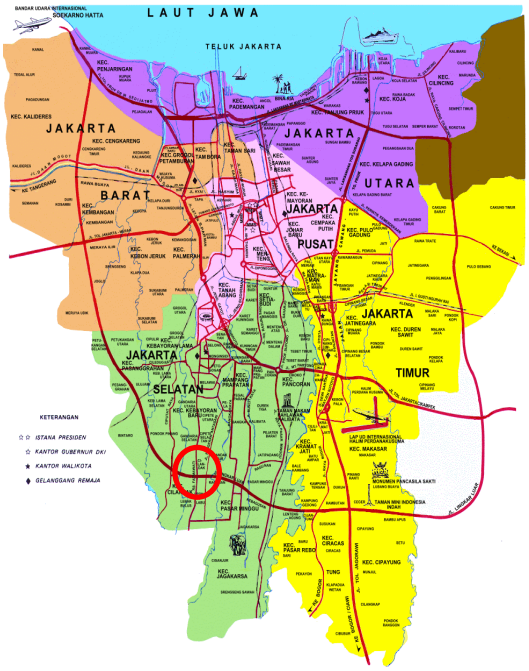
Osaka Gas Engineering Co., LTD.

OS
JR
20-005

Project Map

Special Capital Region of Jakarta, Indonesia

Source: http://www.sekaichizu.jp/



Installation location of ACF air purification unit: JL. Simatupnag, in front of Fatmawati General Hospital

Source: Pemkot DKI Jakarta,2013

1. Executive Summary

- Background of the Project

This business project is targeted at the Special Capital Region of Jakarta in Indonesia. In the region, air pollution caused by severe traffic jams has become serious problem. In 2013, the number of registered vehicles in the capital was more than twice that in Tokyo, including 12,000,000 motorcycles, 3,000,000 passenger cars, 620,000 trucks, and 360,000 buses. Also, due in part to slow road improvements, the capital's air pollution has become serious. As such, in Jakarta, the concentration of nitrogen oxide (NO_x), a cause of respiratory diseases such as lung cancer and asthma, rose to a dangerous level of 74 $\mu g/m^3$ in fiscal 2013, up three-fold from fiscal 2008 (Jakarta Police's Traffic Directorate, BPLHD Jakarta, 2014). In the capital, the incidence rate of child asthma patients at 13 or 14 years of age was 12.6%, 4.5 times higher than the average in Japan (International Study of Asthma and Allergies in Childhood 2012).

Consequently, the medium-term development plan announced by President Joko Widodo who took office in 2014 aimed to reduce air pollutant emissions by 15% during the period from 2014 to 2019, strengthen air monitoring frameworks in 45 cities throughout the country, and meet the ambient air quality standards. However, traffic jams resulted in rapid aggravation of air pollution. The countermeasures have not been effective. Even worse, the air pollution reached the world's worst level. (*Current Situation, and Measures to Counter, Environmental Contamination in Indonesia*, Japanese Ministry of the Environment website; Daily Jakarta Shimbun, Aug 2, 2019; and other sources)

- Technology the Project Aims to Spread

Using its proprietary carbon material technology, Osaka Gas developed Activated Carbon Fiber (ACF) that adsorbs nitrogen oxides (NO_x) contained in the air and remove them with high efficiency. The Company molded ACFs into an ACF unit with a slit structure that allows air to flow through, as an air purification product for installation along roadsides and other similar locations. The ACF unit is a non-energy-consuming product that requires no electric power and removes 80% or more of the NO_2 contained in the air passing through the unit. Moreover, a catalytic function is imparted to the ACFs to oxidize adsorbed NO_x to NO_3^- ions. Simple washing with water is effective for recovering the NO_x purification performance.

- Project Purposes/Goals

The project intends to prove the effectiveness of the ACF unit in reducing local NO_x concentration in the air by placing the units in front of a hospital on a heavily congested highway

in Jakarta. Data acquired with them will be used to conduct a comparative analysis with data acquired from preceding projects in Japan and China to estimate how much NO_x reduction effects in terms of percentage can be attained from ideal installation. Thus, the goal is to provide the Indonesian government with estimation and other material for it to explore anti-air pollution measures. Regarding the business aspects, the achievements of the project will be used as the basis for stimulating demand from road administrators, by spreading information about the achievements to the Indonesian Ministry of Public Works and Housing (PU) and local governments, including the municipality of the Special Capital Region of Jakarta (Daerah Khusus Ibukota; DKI). Local parties concerned with road works and consulting firms will be surveyed to ascertain the size of the market for ACFs. Moreover, by providing engineering workshops and site tours, the project will also aim to help interested parties deepen their understanding of ACFs and consider installation of ACFs by way of public purchase.

- **Project Actions**

The national road in front of Fatmawati General Hospital in the southern part of Jakarta is subject to serious air pollution from exhaust gas due to traffic jams. Combined with an elevated highway over the road, traffic jams has resulted in a stagnant high concentration of NO_x. Installation of ACF units has been found to be urgent for the protection of outpatients susceptible to health damage. As a local activity of the project, ACF units will be installed for a length of 50 m along the roadside in front of the hospital to measure the units' effectiveness in purifying the surrounding air.

Meanwhile, to act as host on the Japanese side, the project invites officials of the counterpart, the Indonesian Ministry of Public Works for tours to an installation location of ACF air-purification facilities and other anti-air pollution facilities in Japan and to engineering workshops held at Osaka Gas. These activities are intended to deepen their understanding of Japan's superb anti-air pollution technology to a level enabling them to develop ambient air policies in Indonesia and build a network of personal contacts.

- **Results/Achievements of the Project**

Regarding the project's activity in Indonesia, in September 2018, ACF units were safely installed for a length of 50 m in JL Simatupang on the National Road in front of Fatmawati General Hospital in Jakarta. The ambient air in the area surrounding the ACF units was measured once before the installation and four times within one year after the installation. The measurements showed an average NO_2 removal rate of approximately 60% as a comparison between the front (roadway side) and rear (sidewalk side) of the ACF units. Before the installation, the surrounding air far exceeded

the Indonesian environmental standard for NO_2. After the installation, the air satisfied the environmental standard enforced in the surrounding area for one year. Unlike Japan, Indonesia remains virtually rainless in the dry season for several months, leading to a lack of cleaning by rain for performance recovery. Therefore, the performance of the installation somewhat decreased in the dry season. However, simple manual washing with water proved to be effective for performance recovery. Although not included in the initial plan, a measurement was conducted in response to PU's request, to measure PM 2.5 perceived as a notable problem recently in Jakarta. The ACF units showed an average removal rate of approximately 40%, meeting the environmental standard in the surrounding area. Based on these results, on November 22, 2019 an ACF engineering workshop was held at the Directorate General of Highways of PU. The achievements of the project were presented to a host of some 50 participants from organizations outside PU, including the Ministry of Environment and Forestry (KLHK), DKI, and the bus transport company Trans Jakarta, as well as from relevant sections of the counterpart the Directorate General of Highways.

In July 2019, to act as host on the Japanese side, the project received two officials from the counterpart in this project, the Directorate General of Highways of the Indonesian Ministry of Public Works. The period of their stay was from July 21 to July 28. Regarding the guests, the initial plan underwent three changes, settling on two people, with one person from the Sub Directorate of Environmental and Road Safety of the Ministry of Public Works and one person from National Road Office 5 (Palembang). During the eight-day period of stay, they toured an ACF installation location and the ACF R&D site, received hands-on training, and had meetings with interested organizations, thus building higher confidence in the ACF technology, deepening their understanding of Japanese environmental techniques and policies, and built a network of personal contacts.

- **Current Business Development Prospects**

  Based on the achievements of the project, the Daigas (Osaka Gas) Group has made a decision on business development at the current stage for the ACF air purification unit.

- **Grounds for Determining the Business Development Prospects**

  The grounds for determining the favorable possibility of business development are the following:

  （1）The ACF air purification unit effectively removed NO_2 in the climate and environment of Jakarta in Indonesia.

  （2）In Indonesia, air pollution has become increasingly serious. The people's interest in the ambient air and needs for anti-air pollution measures are growing, as exemplified by a lawsuit filed by residents against the administration.

（3）The Directorate General of Highways of PU, albeit at the staff member level, expressed their willingness to promote the installation of ACF units with the help of Japanese aid.

- **Remaining Tasks for Business Development and Solutions/Course of Action**

There are several remaining tasks for business development. Notably, one remaining task is budgeting for installing ACF units along roadsides. Currently, the amount required for road improvements is U.S. $134 billion, as indicated in the National Medium-Term Development Plan of Indonesia. The government budget can cover only about 30% of this amount. Therefore, the Indonesian government needs to provide the budget by way of PPP, government aid, and other means (material for the lecture meeting held at the 31st Japan Road Conference). Under these circumstances, it is important to formulate schemes and strategies for assigning a high priority to using the budget for environmental measures. That said, targets for the ambient air are set by the aforementioned KLHK, while road improvement is budgeted by PU. Consequently, it is necessary to ensure that both parties collaborate and share goals. Meanwhile, the road management responsibilities are being transferred from the national government to municipalities in major cities in Indonesia. Policies developed as their own by municipalities, including the Special Capital Region of Jakarta, are of high importance. This was stressed in a meeting with KLHK. They said that the Special Capital Region of Jakarta was going to develop a grand design for anti-air pollution measures, with support from KLHK.

With this being the situation, it is necessary to reach out to Jakarta and other major provincial municipalities (e.g. Bandung, Palembang, Surabaya, and Semarang) which were not directly involved in the project, while continuously pursuing collaboration with, and proposing ACF installation to, PU. For proposals to provincial municipalities, it is necessary to collaborate with the Association of the Indonesia Municipalities (APEKSI) and the Ministry of National Development Planning (BAPPENAS).

- **Future Business Development Plan**

Based on the achievements of the project, we will encourage PU and KLHK to draw up plans to capitalize on government aid. Just recently, we held consultations with them to install ACF units at bus stops of Trans Jakarta under the umbrella of DKI, as proposed in the initial plan of the project. The plan is to install ACF units at a bus stop for testing purposes and monitor the effectiveness of the installation, which will be made open to passengers and other people for public relations. Details are still under discussion. We will improve the ACF units used there to exhibit higher performance than that of the type used in the current project to remove PM 2.5, which is a matter of great concern for local people. It is planned to promote these business

development plans, using PT Osaka Gas Indonesia, a Daigas Group member company founded in 2019, as a sales support center.

- **About Prospects for Coordination with ODA Projects**

As previously described, in Indonesia, road improvements can only be made with the help of PPP or government aid. Many PU staff members expressed their hopes for aid from Japan. It should be noted, however, that PU has no experience in actually designing, conducting feasibility studies, or carrying out construction work of ACF air purification units. As such, projects need to be promoted under guidance provided from the Japanese side. For this purpose, technical cooperation and like schemes appear suitable. We will determine details through consultation with JICA and local interested parties.

2. Background of the Project

- General Political and Economic Aspects of the Target Country, Regions, and Cities

Indonesia is the world's largest island nation consisting of about 13,500 islands, with an approximate land area of 1,890,000 km^2 (about five times larger than Japan). The country has a population of about 255 million (2015), which makes it the world's fourth largest after China, India, and the United States. About 60% of the overall population is concentrated in Java, which is only 7% of the country in terms of land area. Religion-wise, approximately 87% of the population is Muslim, while Christians account for approximately 9.8%. Indonesia has the world's largest Muslim population.

Politically, the nation is a republic, comprising 34 provinces. The head of state is the President (who is also the head of government). The current president is Joko Widodo (since 2014, reelected in 2019). The legislature consists of the People's Representative Council (DPR; legislative function, national budget planning, and monitoring the government) and the Regional Representative Council (DPD; provision of legal suggestions concerning local administration and participation in deliberations). Furthermore, the nation has the People's Consultative Assembly (MPR; establishment and revision of the constitution and removal of the President and Vice President during their tenures) comprising the DPR and DPD members.

Even in 2009 under the influence of the global financial crisis, the Indonesian economy grew at a relatively high growth rate of 4.6%, which was followed consistently by steady economic growth at 5% to 6%. Although in 2015 the growth rate slowed down to 4.8% due to the influences of a decelerating global economy, the Unites States easing its money policy less, and other factors, the Indonesian economy recovered hitting the 5% mark at 5.02% in 2016. The unemployment rate, which was higher than 10% in 2006, dropped to 5.5% in February 2016 (according to figures released by the Central Bureau of Statistics). That said, estimation states that 2.5 million people will newly enter the labor market each year. It has been pointed out that to create jobs for them, the Indonesian economy needs to grow at an annual growth rate of 6% or more. (According to *Latest Situation in Indonesia*, Ministry of Foreign Affairs of Japan website)

The project is targeted at the Special Capital Region of Jakarta, which is located in the northwestern part of Java and faces the Java Sea (map). The region's area is only 0.04% of the land area of Indonesia. However, Jakarta has a population of about 10 million, accounting for 4% of the country's total population, with its population density being 2.4 times that of Tokyo. The so-called Jabodetabek metropolitan region, containing Jakarta and its surrounding areas of Bogor,

Depok, Tangerang, and Bekasi has a population of about 32 million. The region's economy size reaches about 30% of the GDP. Its per capita GDP at $14,000 is far higher than those of other provinces by a factor of four or more. As such, the concentration of economic activities and overpopulation in the Jakarta capital area has become an issue. For this reason in August 2019, current President Joko Widodo after his reelection expressed a policy to move the capital to Kalimantan. (According to JETRO website)

- **Development Challenges Facing the Target Country, Regions, and Cities**

In the Special Capital Region of Jakarta in Indonesia, air pollution caused by severe traffic jams has become an issue as a result of the aforementioned concentration of economic activities and overpopulation. In 2013, the number of registered vehicles in the capital was more than twice that in Tokyo, including 12,000,000 motorcycles, 3,000,000 passenger cars, 620,000 trucks, and 360,000 buses. Also, due in part to slow road improvements, the capital's air pollution has become increasingly serious.

In 1988, Indonesia established its first ambient air quality standards, and in 1999, the nation laid down a government ordinance concerning the prevention of air pollution and established, and made it obligatory to observe, emission standards for factories. Moreover, since 1992, the country has been working on the Blue Sky Program to reduce the emissions of air pollutants. Subsequently, the medium-term development plan announced by President Joko Widodo who took office in 2014 aimed to reduce air pollutant emissions by 15% during the period from 2014 to 2019, strengthen air monitoring frameworks in 45 cities throughout the country, and meet the ambient air quality standards. However, traffic jams resulted in a rapid aggravation of air pollution. The countermeasures have not been effective. (Japanese Ministry of the Environment website: *Current Situation, and Measures to Counter, Environmental Contamination in Indonesia*) As such, in Jakarta, the concentration of nitrogen oxide (NO_x), a cause of respiratory diseases such as lung cancer and asthma, rose to a dangerous level of 74 $\mu g/m^3$ in fiscal 2013, up three-fold from fiscal 2008 (Jakarta Police's Traffic Directorate, BPLHD Jakarta, 2014). In the capital, the incidence rate of child asthma patients at 13 or 14 years of age was 12.6%, 4.5 times higher than the average in Japan (International Study of Asthma and Allergies in Childhood 2012).

The Daigas Group has formulated its business strategies centering around three businesses, i.e., longstanding domestic energy business combined with overseas energy business and life &

business solutions (LBS) business, as stated in the Group's Long-Term Management Vision 2030 toward fiscal 2030 and the Medium-Term Management Plan 2020 for four years from fiscal 2017 to 2020. The founding of Osaka Gas Indonesia was based on these management strategies. The Group's Overseas Environmental Solutions and Materials Business, evolving from the achievements of the project, is in line with the above strategies.

Specifics on the Technology to Be Spread

Features of the Technology

Using its proprietary carbon material technology, Osaka Gas developed activated carbon fibers (ACFs) that adsorb nitrogen oxides (NO_x) contained in the air and remove them with high efficiency. The Company molded ACFs into an AFC unit with a slit structure that allows air to flow through, as an air purification product for installation along roadsides and other similar locations. The ACF unit is a non-energy-consuming product that requires no electric power and removes 80% or more of the NO_2 contained in the air passing through the unit (Fig.1). Moreover, a catalytic function is imparted to the ACFs to oxidize adsorbed NO_x to NO_3^- ions. Simple washing with water is effective for recovering the NO_x purification performance (Fig.2).

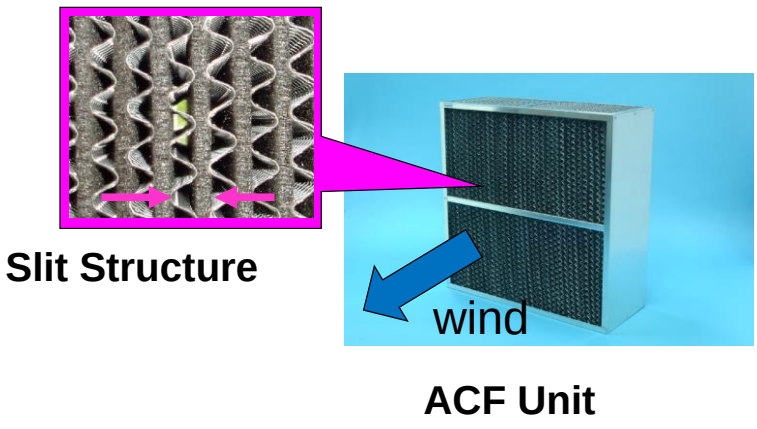


Fig.1 Structure of ACF Unit

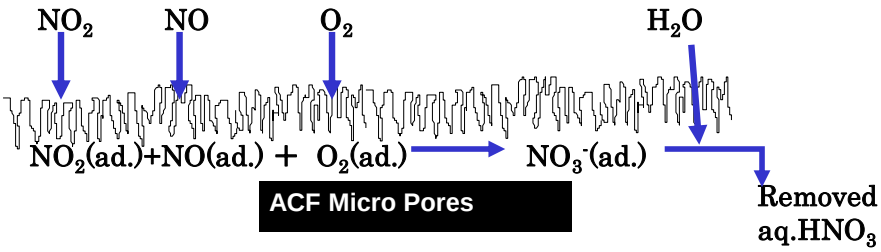


Fig.2 NOx removal mechanism over ACF

- **Domestic and Overseas Sales Performance**

The Daigas Group began industrial production of ACFs in 1985. The product has been in wide use in applications such as household water and air purifiers. The Group holds a 40% domestic market share for general ACF products. For 20 years Osaka Gas has conducted pilot testing many times to use ACFs for air purification in the road sector. It has acquired patents for and commercialized ACF products, which have been adopted by the Ministry of Land, Infrastructure, Transport and Tourism for use at the major air pollution locations shown below and have proved their performance in local ambient air improvement.

• National Highway 3 in Fukuoka Prefecture

• National Highway 43 in Nishi-yodogawa ward, Osaka

• National Highway 43 intersection in Minato ward, Osaka

• Yamato-cho, Itabashi ward, Tokyo

• Sound barriers on National Highway 23 in Minami ward, Nagoya

Outside Japan, the ACF product has been installed in Beijing, China.

Fig.3 National Highway 23, Nagoya

Fig.4 Tsinghua University in Beijing, China

As an achievement in ambient air improvement, the NO_2 concentration in the surrounding area decreased by 6 ppb at the National Highway 43 intersection in the Minato ward, Osaka. This reduction level is equivalent to reducing the traffic of large vehicles by about 2,000 per day (March 2009 press presentation by Osaka National Highway Office, Ministry of Land, Infrastructure, Transport and Tourism). Moreover, after installation in February 2013 on National Highway 23 in Nagoya, the ACF product exhibited high effectiveness, with the annual 98% figure being 46 ppb, or a 10 ppb reduction from the previous year, as indicated by the results of fiscal 2014 measurements conducted by the Atmospheric observation station (released in June 2015 by the Chubu Regional Development Bureau, Ministry of Land, Infrastructure, Transport and Tourism).

- **Pricing (Unit Price)**

The unit price of the ACF air purification unit is ¥65,000 (excluding installation cost).

- **Cost Efficiency**

Table 1 compares the cost efficiency of this product and those of competitors' technologies.

Table1. Comparison of This Technology and Competitors' Technologies

	This Technology ACF	NO_x Reducing Sound Insulating Wall (Photocatalytic Coating)	EAP (Soil-Based De-NOx)
Product Image	 National Highway 43 in Osaka		 National Highway 43 in Nishinomiya
Launched	2007	1996	1993
Feature	80% NO_2 removal rate achieved using only natural wind without being powered by electricity	Photo catalysts designed to decompose NO_x are coated on the surfaces of sound insulating walls.	EAP draws the air with fans to decompose contaminants by way of microorganisms contained in soil.
Function (1)	NO_x purification rate: 1.4 g/m^2·day	NO_x purification rate: 0.009 g/m^2·day	NO_x purification rate: 80%
Function (2)	Reduces noise	Reduces noise	-
Special Information	Performance recovery by washing with water	Low purification level due to the lack of capability to allow for a draft	Requires a large lot and power

Measurements conducted by the Ministry of Land, Infrastructure, Transport and Tourism proved that the NO_x removal performance of the ACF unit is 1.4 g-NO_x/day·m^2 (installation area). This is 100 times or more effective than the figure of photo catalyst-coated walls (0.009 g/m^2·day). Incidentally, soil-based De-NOx is also known as a means of air purification along roadsides. However, this method requires a huge amount of electric power and a large installation space for the forced passage of contaminated air through a soil layer. The ACF unit requires no fan and its installation space is very small. As the greatest feature, ACFs can be refreshed by washing with water, as described previously. The installed units have been exhibiting this effect continuously for more than eight years after installation in Japan.

- **Safety of the Technology**

ACFs use no electricity or other power. The technology is highly safe, using only natural wind and wind turbulence generated by running vehicles and has been accident-free at all their installation locations. ACFs, made of 100% carbon, are flame-retardant and have been certified under the UL 94 specification. Frames and other supporting materials are all made of aluminum.

- **Environmental Considerations**

As previously described, simple washing with water can refresh the NO_x purification performance of ACFs, with NO_3^- ions contained in the cleaning effluent being 100 ppm or less meeting the general sewage/wastewater standard, as verified by the Minato ward office of Osaka.

- **Comparison with Competing Technologies in the Target Country**

Indonesia has been slow in taking road environment improvement measures. As far as the surveys conducted by Osaka Gas indicate, no competing technology has been found in the country.

Potential to Contribute to Meeting Development Challenges

In Jakarta, according to the 2012 survey conducted by the UN Environment Programme (UNEP), air pollution attributable to severe traffic jams caused an annual amount of economic loss reaching 38.5 trillion rupiahs (about ¥385 billion) spent on respiratory diseases (Daily Jakarta Shimbun dated May 31, 2014). Consequently, implementing local anti-pollution measures at

about 500 locations such as in the surrounding areas of schools in heavily congested districts where NO_x concentration is locally high is expected to be effective in reducing respiratory diseases of 10,000 people or more a year. This would bring about an economic effect equivalent to about several hundreds of million yen to the local economy.

Moreover, by producing ACF units at a local joint venture when the business expandability has been confirmed for the product, and by setting up a production site in Indonesia for ASEAN and South Asia, it will be possible to enlarge the size of the local economy.

3. Project Purposes/Goals

Purposes of the Project

The project deploys the ACF-based air purification technology, with proven performance and in wide use in Japan, along roads in Jakarta in Indonesia. The project's goal is to spread information about the technology's effectiveness widely to the public and authorities by proving the technology's performance in the tropical climate and on roads more heavily congested than in Japan. Notably, the plan is to install ACFs in front of a hospital on a highway measures for which a higher priority should be assigned due to the presence of children, pupils, and patients susceptible to health damage from air pollution.

Project Goal (Contributing to Meeting Development Challenges Facing the Target Country, Regions, and Cities)

The project intends to prove the effectiveness of the ACF unit in reducing local NO_x concentration in the air by placing units in front of a hospital on a heavily congested highway in Jakarta. Data acquired with them will be used to conduct a comparative analysis with data acquired from preceding projects in Japan and China to estimate how much NO_x reduction effects in terms of percentage can be attained from ideal installation. Thus, the goal is to provide the Indonesian government with estimation and other material for it to explore anti-air pollution measures.

Project Goal (Business Aspects)

The achievements of the project will be used as a basis for stimulating demand from road administrators, by spreading information about the achievements to the Indonesian Ministry of Public Works and local governments, including the municipality of the Special Capital Region of Jakarta. Local parties concerned with roadworks and consultation firms will be surveyed to ascertain the size of the market for ACFs. Moreover, by providing engineering workshops and site tours, the project will also aim to help the interested parties deepen their understanding of ACFs and consider installation of ACFs by way of public purchase. Moreover, to provide material for exploring local production, a cost-benefit analysis will be conducted in collaboration with the Jakarta Representative Office of Osaka Gas Singapore Pte. Ltd., founded in 2016, of the Daigas Group (the representative office becoming PT Osaka Gas Indonesia in 2019).

Through these activities, the project aims to serve as the impetus for incorporating, in the road environment improvement in Indonesia, measures for reducing residents' health damage caused by air pollution, which had not been considered by PU.

Project Actions

Project Schedule

The project will be implemented in the period from June 2018 to January 2020, during which six local activity programs and one program for acting as host on the Japanese side are planned.

Project Framework

Yoshikawa of the Energy & Environment Business Division of Osaka Gas Engineering Co., Ltd., who is the proposing legal person, will be chief in charge of operation management and practices. General Manager Masuda and Kato of the division will take responsibility for planning and safety management. Yamaguchi of the division will assist field surveys and construction management. As a support framework for ACF quality control and measurements on site, the Energy Technology Laboratories of Osaka Gas Co., Ltd. and the Frontier Materials Laboratories of Osaka Gas Chemicals Co., Ltd., which are members of the Daigas Group, will provide study, data analysis, and other support services. As for outside personnel, Toshihiro Kitada, Professor Emeritus at Toyohashi University of Technology will provide support. He has years of experience and knowledge in the analysis of the structure of, and air purification by, ACFs and in research cooperation in Indonesia. Moreover, as outside personnel, Katahira & Engineers International with a wealth of experience and expertise in road construction in Indonesia will provide assistance. Furthermore, as a local partner, Bandung Institute of Technology will provide assistance and overall cooperation in on-site measurements, analyses, questionnaires, and workshops.

Project Actions

The results of a preliminary field survey showed that the national road in front of Fatmawati General Hospital in the south part of Jakarta is subject to serious air pollution by exhaust gas due to traffic jams. Combined with an elevated highway over the road, traffic jams has resulted in a stagnant high concentration of NO_x. Installation of ACF units has been found to be urgent for the protection of outpatients susceptible to health damage. ACF units will be installed for a length of 50 m along the roadside in front of the hospital to measure the units' effectiveness in purifying the surrounding air.

4. Summary of the Project (Assessment of the Project Results)

Achievements of the Project (Contributing to the Target Country, Regions, and Cities)

The achievements of the project are summarized into the following two aspects and are thought as successful attainment of the goal.

（1） One hundred ACF units were installed safely in front of a hospital along a heavily trafficked highway in Jakarta (Fig.5). Environmental measurements were carried out five times. The measurements proved an NO_2 removal rate of approximately 60%, meeting the ambient air standard for the surrounding area (Fig.6). It also proved the effectiveness for reducing the level of PM 2.5.

（2） Based on environmental measurement data obtained in the surrounding areas of ACFs, the air purification effect of ACFs was verified on a more heavily trafficked road than in Japan, in the tropical climate of Indonesia. Maintenance methods were also ascertained in the dry season by testing washing with water. These results were presented at an ACF workshop to provide material for the Indonesian government to explore anti-air pollution measures.

Fig.5 Completion of ACF unit installation in Jakarta and on-site visit (September 2018)

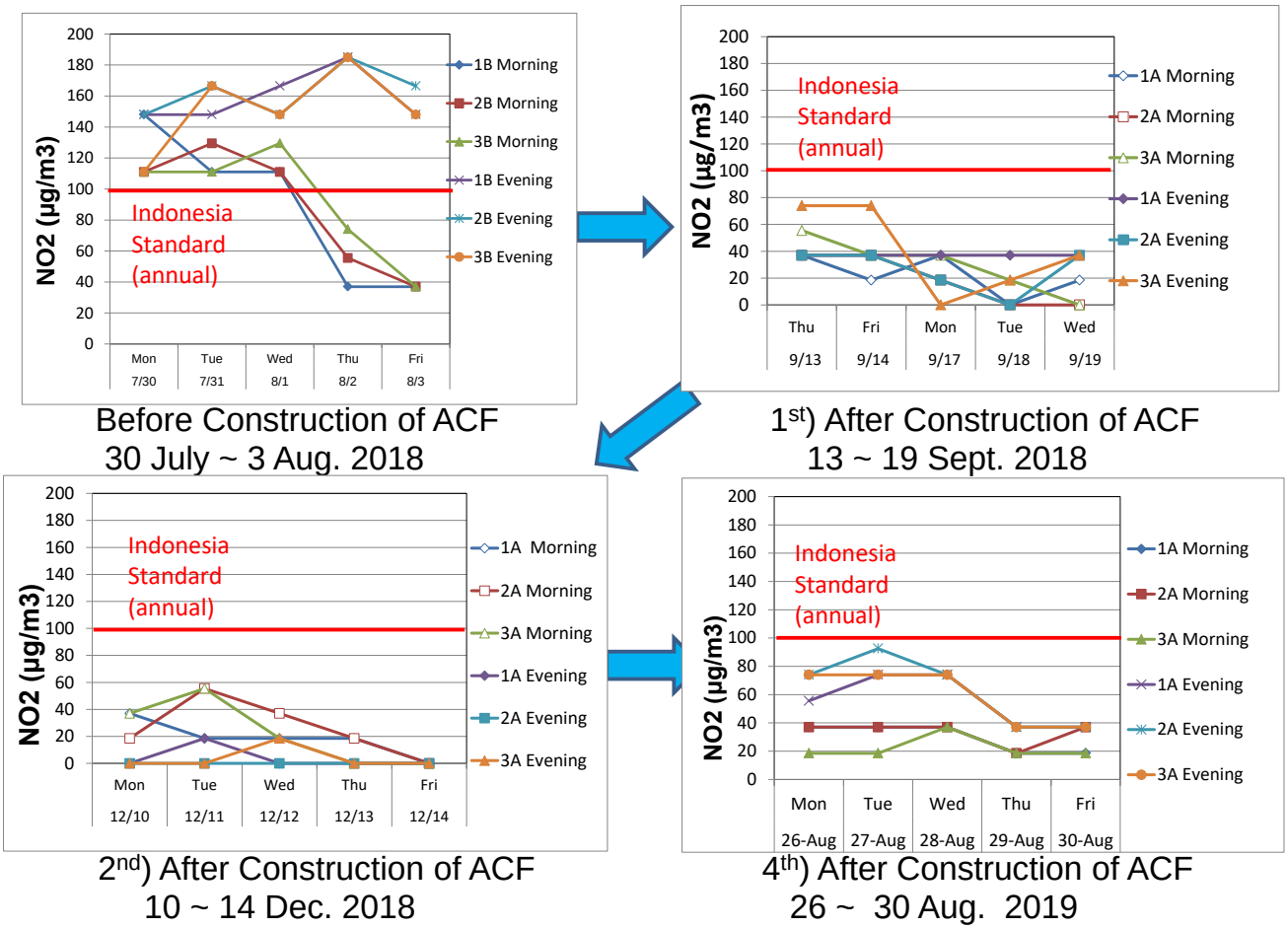


Fig.6 NO2 measurement results surrounding ACF for 1 year

Achievements of the Project (Business Aspects)

Through the local activities, the marketability of and local needs for the ACF technology were thought of as very high. Through the two-year activities, the understanding of PU about the ACF technology advanced very much relative to that before the project. Human resources who are able to correctly understand the effects of ACFs and maintenance and other techniques have been trained successfully through the program of receiving them in Japan. For export to and installation work in Indonesia, a partner relationship has been established with a locally licensed firm for future business cooperation. Regarding the business route, Osaka Gas has built a cooperation framework with a local partner and Osaka Gas Indonesia, a member of the Daigas Group. For profitability, one challenge is difficulty in budget allocation at PU, although there is no competition at present. Therefore, as a future task, it is necessary to plan to use ODA through consultation with JICA.

Table2. Project item, results, remaining issues and solution policy

Task	Item	Results and Evaluation	Remaining issues and solutions policy
1	Verification of the ACF unit construction plan	Consultations with PU, and meeting with the local cooperators and contractor were completed.	
2	Installation of ACF units and verification of local understanding	ACF on the national highway was completed safely. On-site visit are held.	
3	Development of Operational Personnel for Air Environmental Technology	Trained in ACF environmental technology through activities in Japan	
4	Demonstration of performance of ACF units in the local area, on-site tours and seminars	ACF performance was demonstrated by the measurement of 5 times. Seminars were held and communicated to the PU and other stakeholders.	
5	Inspection and delivery of ACF	Completed the inspection for 1 year and proceeded with the delivery procedure.	
6	Establishment of a commercial stream	ACF unit is delivered through a local license provider. General marketing support is supported by OG Indonesia	Establishment of direct sales system at the site. We will consider a joint venture with the local companies at the stage of business expanded.
7	Ensuring profitability	No current competitive products exist. Indonesian government's budget plans are not available. Private sector-based deals started	Propose and acquire the road construction budget. Plan of ODA, etc. shall be established in consultation with PU and JICA within these 3 years.

5. Business development plan after implementation of this project

Anticipated Achievements through Business (Business Aspects)

Regarding the amount of sales of the ACF technology on a business basis, a higher priority will be assigned to heavily trafficked roads in Jakarta's urban areas during the business startup period, specifically to the surrounding areas of schools and hospitals. The market size has been estimated as follows. Central, East, and South Jakarta have public and private primary, middle, and high schools numbering 1,615, 764, and 341, respectively. Of these schools, about 500 are located in highly trafficked, heavily air-polluted areas. The ACF installation size is estimated at between ¥500,000 and ¥1,000,000 per location (excluding construction cost), with the sum being somewhere between ¥250 million and ¥500 million. Public hospitals number 13. An estimated ACF installation size for these is about between ¥1,000,000 and ¥5,000,000 per location. In the next phase, ACF installation will extend to locations that require measures to counter exhaust gas pollution, such as bus stations located amid heavily trafficked roads and parking lots of large shopping malls. Furthermore, in the phase after the next, ACF installation can be extended to general roads. In Jakarta, the total length of heavily trafficked roads is estimated at 150 km. On the assumption that ACF units will be installed along roadsides for 30 km, or 20% of the total length, the market is estimated at ¥3 billion. Moreover, there will be demand for replacing ACFs seven to ten years after installation, which will be around ¥300 million a year. If in addition to Jakarta, megalopolises in the ASEAN countries are taken into account, the market size is expected to be several times larger.

Business Development Plan

Business Overview

Roughly summarized, in the early phase of the business, the Daigas Group and its subcontractors in Japan will manufacture ACFs, assemble them into units, and place them in frames, followed by exporting. A local partner company will import them and install them on site. In the next phase after the business expands, the goal is that while ACFs will be manufactured in Japan and exported, a joint venture set up by the Daigas Group and the local company will carry out unit assembly and the subsequent processes. In this phase, the business will hopefully encompass additional services such as ACF unit maintenance (e.g. washing with water and replacement) and environmental measurement (Fig.7).

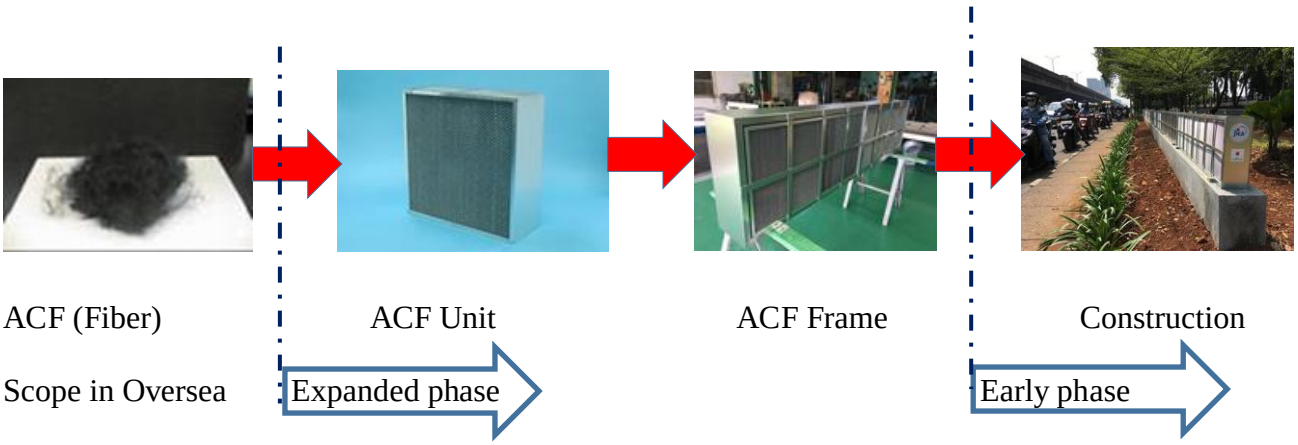


Fig.7 Business flow of ACF products

Tasks for Business Development and Solutions/Course of Action

Among the tasks for business development, a notable one is budgeting for installing ACF units along roadsides. Currently, the Indonesian government is planning a tight budget for road improvements. The amount required for road improvements is U.S. $134 billion, as indicated in the National Medium-Term Development Plan of Indonesia. The government budget can cover only about 30% of this amount. Therefore, the Indonesian government needs to provide the budget by way of PPP, government aid, and other means (material for the lecture meeting held at the 31st Japan Road Conference). Under these circumstances, it is important to formulate schemes and strategies for assigning a higher priority to using the budget for environmental measures. That said, targets for the ambient air are set by KLHK, while the road improvement is budgeted by PU. Consequently, it is necessary to ensure that both parties collaborate and share goals.

Prospects for Coordination with ODA Projects

Necessity of Coordinated Projects

In Indonesia, road improvements can only be made with the help of PPP or government aid due to lack of funds. Many PU staff members expressed their hopes for aid from Japan. In this business field, a synergistic effect is expected between the mitigation of air pollution that has become an issue in Indonesia and the business expansion of Osaka Gas. Therefore, it is thought necessary to coordinate with ODA projects.

Envisioned Project Scheme

PU has no experience in actually designing, conducting feasibility studies, or carrying out construction work of ACF air purification units. As such, projects need to be promoted under guidance provided from the Japanese side. For this purpose, technical cooperation and similar schemes appear suitable. It is necessary to determine the details through consultation with JICA and local interested parties.

Specifics of Coordinated Projects

A conceivable specific program in a project coordinated with ODA is to install ACF units in surrounding areas of schools and hospitals on heavily trafficked roads in Jakarta's urban areas where urgent needs exist specifically for taking measures. Installation for about 500 schools and 13 public hospitals is a high priority. An effective way is to install ACF units along roads in the surrounding areas of these locations or on the fences at road boundaries of these facilities. It is also valid to use simple measurement devices for displaying monitored values so as to enable the interested parties to recognize the effectiveness.