GHG Inventory on energy sector using mobile application in Surabaya City: some challenges and opportunities

K D M E Handayeni¹, U F Kurniawati¹ and I Hafidz²

¹ Department of Urban and Regional Planning, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia
² Department of Information System, Institut Teknologi Sepuluh Nopember, Surabaya, Indonesia

E-mail: erli.martha@gmail.com

Abstract. Global warming which causes climate change has a significant social economic impact. Indonesia's commitment to protecting the global climate has been a concern since the 1990s. Through Presidential Regulation No.61 of 2011 concerning the National Action Plan (RAN) for Reducing Greenhouse Gas Emission, each region needs to develop climate change mitigation actions through reducing emission or increasing the absorption of Greenhouse Gases (GHGs) from various emission sources. The formulation of climate change mitigation actions needs to be supported by greenhouse gas inventory activities and measurement of emission. Measurement of GHG emission is a cross-sectoral activity. Therefore, an information system through an electronic GHG calculator platform is needed as an instrument for measuring GHG emission that can support districts/cities to formulate the most relevant mitigation actions. This study describes the sources of GHG emission based on energy use and its measurement using GHG calculator. GHG calculator is developed based on the theoretical context and designed in form of mobile application. Using Focus Group Discussion (FGD) technique and Spearman’s correlation analysis, this research aims to evaluate GHG assessment based on the use of mobile platform to predict and calculate GHG emission. It shows that perception on easiness and usability level of mobile calculator are correlated significantly; 2) there are some opportunities and challenges in implementing mobile application for measuring GHG emission in Surabaya City.

1. Introduction
Global warming is causing climate change and increasing the frequency and intensity of extreme weather events. The results of the IPCC study, 2007 (in the Ministry of Environment, 2007) show that 11 of the 12 hottest years since 1850 occurred in the last 12 years. The increase in total temperature from 1850-1899 to 2001-2005 was 0.76°C. Global average sea levels have risen at an average rate of 1.8 mm per year in the period between 1961 and 2003. The increase in total sea level recorded in the 20th century is estimated to be 0.17 m.

Global warming which causes climate change has a significant social economic impact. According to the World Disaster Report, 2001 (in the Ministry of the Environment, 2007) mentioned the current economic losses due to climate disasters at the global level compared to those that occurred in the 1950s had increased 14 times, reaching 50-100 billion USD per year. Therefore, efforts are needed to deal with...
the impacts of climate change through long-term climate risk management. This effort requires a cross-sectoral, cross-regional, and cross-authority approach at the national, regional and local levels.

Indonesia's commitment to protecting the global climate has been a concern since the 1990s. At the national level, various efforts developed in dealing with the impacts of climate change are through the formulation of policies related to national action plans for mitigation and adaptation to climate change. Presidential Regulation No. 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions is an effort to develop climate change mitigation actions through reducing emissions and or increasing the absorption of Greenhouse Gases (GHGs) from various emission sources. The policy for developing the National Action Plan for Reducing GHG Emissions is also based on the commitment of the Government of Indonesia in the G-20 meeting in Pittsburg to reduce greenhouse gas emissions by 26% on its own efforts and reach 41% if it receives international assistance in 2020. There is a national GHG emission reduction target. This is a necessity for the province/city to formulate climate change mitigation actions as outlined in the Regional Action Plan for GHG reduction.

Intergovernmental Panel Climate Change (IPCC), 2006 in the Greenhouse Gas Inventory Guidelines grouping the main sources of greenhouse gas emissions into 4 (four) sectors, namely the energy sector, IPPU (Industrial Processes and Product Use), AFOLU (Agriculture, Forestry and Other Land Use) and waste. Measurement of greenhouse gas emissions is a cross-sectoral activity, various information/data needed in the measurement of greenhouse gas emissions involves various stakeholders/actors. Based on Presidential Regulation No. 71 of 2011 concerning the Implementation of the National Greenhouse Gas Inventory that GHG inventory activities are activities to obtain data and information on the level, status, and trends of changes in GHG emissions periodically from various sources of emissions, absorbers/sinks, and carbon stock. Each district/city has the duty to carry out GHG inventories at the national level. Developing GHG inventory is the beginning for planning climate change mitigation. An inventory enables city to understand the difference of emissions contribution of each activity in community.

Based on the results of the 2014 Emission Inventory Study in the City of Surabaya conducted by the Center for Settlement and Environmental Studies, Technology Institute of Sepuluh Nopember shows that the industrial and transportation sectors are the main contributors in the production of emissions in the City of Surabaya, particularly in energy use. GHG emission inventory activities collect quantitatively the quantities of human activities that can release and/or absorb GHG. Activities that need to be collected and measured in the energy sector are numerous, for example the use of electricity in government and non-government buildings, the use of energy by industrial activities, the use of energy by transportation activities. These various activities are sourced from various stakeholders and sectors/offices. Therefore, an electronic platform that facilitates the collection of data and measurement of GHG emissions in the energy sector in the city of Surabaya needs to be developed.

By developing a prototype of an electronic platform, an illustration will be obtained on how related data that has been available can be integrated. This platform is able for further processing in making strategic decision to reduce the main source of GHG emissions. The platform will also be able for various stakeholders to access data generated by other relevant agencies. GHG calculator as electronic platform promises a more comprehensive picture of GHG inventory. This study aims to develop the mobile platform in way of measuring GHG emission and evaluate its usefulness, potentials and limitations.

2. GHG Inventory on Energy Sector and Mobile Application Development

2.1 Contributing Activities of GHG Emission from Energy Use

Greenhouse gases or commonly abbreviated as GHG is a collection of gases that are considered capable of increasing the potential for global warming by scientists around the world. It is called GHG because the way the gases work is like a greenhouse that functions to hold heat to get out of the system resulting in changes in the temperature of the Earth. In general, climate change is triggered by increasing concentrations of Greenhouse Gasses (GHG) in the Earth's atmosphere. Based on the Kyoto Protocol amendment proposal (Decision 4/CMp.7), the type of GHG whose emission reduction is regulated in
the framework of the Convention through the Kyoto Protocol (basket of gases) increased to 7 gases (previously 6 gases); namely Carbon Dioxide (CO$_2$), Methane (CH$_4$), Dinitrooxide (N$_2$O), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulfur Hexafluoride (SF$_6$). Following table shows six types of greenhouse gases based on the Kyoto Protocol.

| No | Type of GHG                        | Potential for Global Warming (GWP) |
|----|-----------------------------------|-----------------------------------|
| 1  | Carbon dioxide (CO$_2$)           | 1                                 |
| 2  | Methane (CH$_4$)                  | 21                                |
| 3  | Dinitrooxide (N$_2$O)             | 310                               |
| 4  | Hydrofluorocarbons (HFCs)         | 140-11,700                        |
| 5  | Perfluorocarbons (PFCs)           | 6500-9200                         |
| 6  | Sulfur Hexafluoride (SF$_6$)      | 23900                             |

Source: Intergovernmental Panel for Climate Change (IPCC), 2006

The increase in GHG concentrations is triggered by human economic activities, both micro and macro. In general, human daily activities produce CO$_2$, CH$_4$ and N$_2$O; while the other four GHGs come from industrial processes. Specifically, 5 sectors contribute to GHG emissions into the atmosphere, namely: Energy Sector, Industrial Processes and Products, Agriculture, Forestry, and Other Land Use, and Waste/Waste.

The energy sector is usually the most important sector in greenhouse gas emission inventories, and typically contributes over 90 percent of the CO$_2$ emissions and 75 percent of the total greenhouse gas emissions in developed countries (Eggleston et al., 2006). Based on IPCC Guideline 2006, the energy sector mainly consists of 4 activities, namely 1) exploration and exploitation of primary energy sources; 2) conversion of primary energy sources into more useable energy forms in refineries and power plants; 3) transmission and distribution of fuels; 4) use of fuels in stationary. At local level, GHG emission inventory is usually identified from fuel combustion activities. However, all activities in energy sector are collected for GHG inventory in national level. Fuel combustion activities comprise 5 parts, namely energy industries, manufacture industries and construction, transportation, other sectors (commercial/institutional, residential, agriculture/fishing/forestry) and non-specified activities (stationary, mobile, multilateral operations).

Based on the study conducted by Wang et al. (2019), city-level total carbon accounting can be classified into 3 scopes: Scope 1 –the direct carbon emissions produced by fossil fuel combustion and industrial process occurring within the city boundary; Scope 2 –the indirect carbon emissions related to imported electricity, steam and heating out of the city boundary; Scope 3 –the transferred carbon emissions embodied in imported/exported products and services out of the city boundary. System boundary for carbon account is essential for understanding the production difference in GHG emission at various levels, such as national, regional, or local level (Liu et al., 2015). Calculating direct carbon emission from energy sector within the city boundary is related with stationary fuel combustion and in-boundary transportation (WRI (World Resources Institute), C40 Cities Climate Leadership Group, ICLEI (International Council for Local Environmental Initiatives, 2014). Stationary fuel combustion includes electricity consumption in residential buildings, commercial and institutional buildings/facilities, energy use in manufacture industry and construction, energy industry and forestry, agriculture and fishing activities. Transportation includes fuel consumption in road transportation, railway, aviation and waterway.

2.2 Calculating GHG Emission from Energy Sector
In simple function, GHG emission is multiplication between activities data with emission factor associated with the activity being measured (Ministry of Energy and Mineral Resources, 2017). Activity data is quantitative measure of activity level conducted with the amount of GHG emission
taking place during a given period time (e.g., kilowatt-hours of electricity use, kilograms of gas used, litters per day of fuel use, etc). An emission factor is a coefficient of the mass of HGH emission relative to a unit of activity. For instance, calculating CO$_2$ emission from the use of electricity is multiplying the level of electricity consumption (kilowatt-hours/kWh) with emission factor (kgCO$_2$/kWh) for electricity. GHG emissions calculation is reported as metric tonnes of each GHG as well as CO$_2$ equivalents (CO2e). Mathematically, this calculation of GHG emission is formulated as follows:

\[ \text{GHG Emission} = \text{Activity} \times \text{Emission Factor} \]  

The formula can be used in simple way to estimate GHG emission, especially on energy consumption. Emission factor can be obtained from default value set by IPCC, if local, regional or national emission factors are not available. Based on IPCC Guideline 2006, there are three methods in measuring GHG emission based on tier of accuracy as following (Ministry of Energy and Natural Resource, 2017):

1. Tier 1, estimation of GHG emission uses basic equation, activities data are gained from global source, and uses emission factor default in IPCC Guideline.
2. Tier 2, GHG emission is calculated using more detail equation, activities data are collected from national and/or local source, and uses emission factor default in IPCC Guideline or country specific emission factor.
3. Tier 3, calculation of GHG emission uses modelling approach and sampling technique, activities data are collected directly at local level, and uses country or plant specific emission factor.

Value of Global Warming Potential (GWP) in Table 1 is used to convert non-CO$_2$ GHG emission into CO2 equivalents (CO2e).

This study adopts Tier 1 and Tier 2 to determine the emission factor. Tier 1 is used to estimate GHG emission on source of manufacture industry and transportation activities. For electricity use, Tier 2 is adopted to estimate GHG emission using JAMALI (Java-Madura-Bali Power System) emission factor. The following tables are emission factor described by ICLEI under the cooperation agreement with Gesellschaft für Internationale Zusammenarbeit (GIZ). The emission factors are used to estimate carbon emission in Indonesia cities.

### Table 2. Emission Factors for Manufacture Industry

| Fuel type          | Unit     | Energy (GJ) | CO2 (ton/unit) | CH4 (ton/unit) | N2O (ton/unit) | CO2e (t) / Unit |
|--------------------|----------|-------------|----------------|----------------|----------------|-----------------|
| Biosolar           | (liter)  | 0.0346      | 0              | 0              | 7.00E-09       | 2.19E-06        |
| Biosolar (palm oil)| (liter)  | 0.036       | 0.0026         | 0              | 2.00E-08       | 0.00265         |
| Coal               | (ton)    | 18.9        | 1.7981         | 0.000189       | 3.00E-05       | 1.810885        |
| Solar              | (liter)  | 0.036       | 0.0026         | 1.08E-07       | 2.16E-08       | 0.00265         |
| MFO                | (liter)  | 0.04        | 0.0031         | 1.20E-07       | 2.00E-08       |                 |
| IDO                | (liter)  | 0.038       | 0.0028         | 1.14E-07       | 2.28E-08       |                 |
| Electricity        | (MWh)    | 3.6         |                |                |                | .73             |
| Ethanol            | (litre)  | 0.0234      | 0              | 1.40E-09       | 4.68E-09       | 0.000001        |
| Residual Fuel Oil  | (litre)  | 0.0384      | 0.0029         | 1.15E-07       | 2.30E-08       | 0.002921        |
| Gas                | (M3)     | 0.0385      | 0.0021         | 1.06E-09       | 3.85E-09       | 0.00215         |
| Premium Pertamax   | (litre)  | 0.033       | 0.0023         | 9.90E-08       | 1.98E-08       | 0.002272        |
| Biopertamax        | (litre)  | 0.033       | 0.0022         | 9.90E-08       | 1.98E-08       | 0.00225         |
| Kerosene           | (litre)  | 0.0355      | 0.0025         | 1.07E-07       | 2.13E-08       | 0.002509        |
| LPG                | (kg)     | 0.0473      | 0.003          | 4.73E-08       | 4.73E-09       | 0.002972        |
### Table 3. Emission Factors for Land Transportation Emissions

| Fuel type         | Unit  | Energy (GJ) | CO2 (ton/unit) | CH4 (ton/unit) | N2O (ton/unit) | CO2e (t) / Unit |
|-------------------|-------|-------------|----------------|----------------|----------------|----------------|
| Avgas             | (litre) | 0.031896    | 0.0022         | 1.59E-08       | 6.38E-08       | 0.002209       |
| Avtur             | (litre) | 0.037044    | 0.0026         | 1.85E-08       | 7.41E-08       | 0.002619       |

### Table 4. Emission Factors for Building

| Fuel type | Unit | tons of CO2 | tons of CH4 | Tons of N2O | Tons of CO2e / unit |
|-----------|------|-------------|-------------|-------------|---------------------|
| LPG       | (kg) | 0.003       | 2.40E-07    | 4.70E-09    | 0.002976            |
| Solar     | (litre) | 0.0026     | 3.60E-07    | 2.20E-08    | 0.002563            |
| Gas       | M3    | 0.0021      | 1.90E-07    | 3.90E-09    | 0.002154            |
| Kerosene  | (litre) | 0.0025     | 3.60E-07    | 2.10E-08    | 0.002515            |

2.3. Development of Mobile Application-Based GHG Emission Calculator

The GHG calculator that has been developed by ICLEI-Local Governments for Sustainability is a GHG contribution analysis tool in excel format that is easily designed to be applied to local communities. Based on experience from activity through the Center for Study of Disaster and Climate Change (PSKBPI) work with Gesellschaft für Internationale Zusammenarbeit (GIZ) has carried out an inventory of greenhouse gases and emissions measurement in Probolinggo Regency, the challenge in using this calculator is when the GHG release activity data sourced from various stakeholders and institutions need to be integrated manually and requires long time enough. The use of information and communication technology in GHG inventory activities is very important. The mobile application-based GHG calculator can facilitate the collection of GHG release data and integrate it into one information system that is easily accessed by various specific stakeholders.

In its preparation, the GHG calculator application was developed as a first step in the integration of the data. With an application interface that allows information to be entered and supported by a back-end that allows data to be stored in a more standardized manner, in the future data that has been collected can also be processed to produce deeper insights. This will certainly be very useful in supporting strategic and preventive decision making and policy efforts and having a positive impact in the long run.

Android application "GRK Calculator" is an application that is built on an android / mobile system to carry out an inventory of GHG (Greenhouse Gas) emissions, especially in the energy sector. GHG emission inventory activities collect quantitative quantities of activities or activities that can release GHGs through energy use. Activities that need to be collected and measured in the energy sector include the use of energy by the government, community and industry sectors. In developing GHG emission calculator, some limitations of mobile application are considered as following (Zhang and Adipat, 2005):
1. Connectivity: slow connectivity will impact the performance of mobile applications.
2. Small screen size: mobile devices contain very limited screen size and so the amount of information that can be displayed is limited.
3. Different display resolution: the resolution of mobile devices is reduced from that of desktop computers resulting in lower quality images.
4. Limited processing capability and power: mobile devices often contain less processing capability and power, even though it is portable mobile devices. This will limit the type of applications that are suitable for mobile devices.
5. Data entry methods: there are different input method in mobile device compare with desktop computers. It requires a certain level of proficiency. This limitation increases the likelihood of erroneous input and decreases the rate of data entry.

Based on Harrison and Duce (2013), in order to overcome the mobile application limitations, six attributes of usability model should be applied in application design as following:
1. Effectiveness. It refers to the ability of a user to complete a task in a specified context.
2. Efficiency. It means the ability of a user to complete a task with speed and accuracy. This attribute describes the productivity of a user while using the application.
3. Satisfaction. It reflects the perceived level of comfort and pleasantness gained through the use of application.
4. Learnability refers to the ease level of user to gain proficiency with an application. It means that how long it takes for a person to understand the use of an application effectively.
5. Memorability is the ability of a user to remember the way of an application used effectively. Sometimes users might not use the application on a regular basis or may only use it sporadically. Therefore, it is necessary for users to remember how to use the application without the need to relearn it after a period of inactivity.
6. Errors means that are made by users while using mobile application. This attribute reflects how well the user can complete the desired tasks without errors. Therefore, identifying the most troublesome areas for users and improving these areas in subsequent iterations of development are critical points to be considered.

3. Research Method
The Android application "GRK Calculator" consists of several components to calculate GHG emissions from the energy sectors. In this application, the energy sector is produced from energy consumption at the government, community and industrial level. In Government Sector consists of (1) energy consumption from electricity used, (2) energy consumption in each building for operational and transportation, (3) energy consumption from street lighting, (4) energy consumption from water treatment system. Community Sector consists of (1) electricity consumption from housing, commercials and institution, (2) energy consumption from transportation and housing. In industrial sector consists of energy consumption for industrial process. For more details explained as follows:

| Sectors                  | Variables                          |
|--------------------------|------------------------------------|
| Government Sectors       |                                    |
| Building Government      | Name of building                   |
|                          | For example: Environmental Agency, Public Works Agency, etc. |
|                          | Total of electricity consumption   |
|                          | In KwH/year                        |
|                          | Total of LPG consumption           |
|                          | In kg/year                         |
|                          | Total of premium consumption       |
|                          | In litre/year                      |
|                          | Total of solar consumption         |
|                          | In litre/year                      |

Table 5. Descriptions of Variables Used in GRK Calculator
The method used in this research to collect the data is Focus Group Discussion (FGD). Focus group discussion is frequently used as a qualitative approach to gain an in-depth understanding of social issues. The method aims to obtain data from a purposely selected group of individuals rather than from a statistically representative sample of a broader population (Nyumba, Wilson, Derrick & Mukherjee, 2017). Even though the application of this method in conservation research has been extensive, there are no critical assessment of the application of the technique. In addition, there are no readily available guidelines for conservation researchers (Focus group discussion requires a team consisting of a skilled facilitator and an assistant (Burrows & Kendall, 1997; Krueger, 1994). The facilitator is central to the discussion not only by managing existing relationships but also by creating a relaxed and comfortable environment for unfamiliar participants. Similarly, the assistant’s role includes observing non-verbal interactions and the impact of the group dynamics, and documenting the general content of the discussion, thereby supplementing the data (Kitzinger, 1994, 1995).

In this study, FGD was designed to gain participant’s response and feedback on mobile application usability. There are 12 participants from Environmental Agency, Surabaya City. They consist of junior and senior staffs, also some of them are head of division of environmental conservation and capacity.
The participants have main task function on emission inventory and reduction. Using Likert scale, participants assess the level of use and ease of mobile application in measuring emissions, as well as providing input on application development. Participant’s perception on easiness and usability of mobile application are correlated using Spearman bivariate analysis.

Spearman’s correlation analysis is non-parametric statistic and so can be used when data have violated parametric assumptions such as non-normally distributed data (Field A., 2009). This study is dealing with non-parametric test. The test work on principle of ranking the data. Spearman correlation is suitable for two variables which are measured by ordinal scale. In this study, variable of easiness and usability level are ranked/ordinal data. The test result Spearman’s rho correlation coefficient ($r_s$) which means direction and strength of correlation. Positive value of correlation coefficient means that there is positive relationship between variables. Range of correlation coefficient is $0 - 1$. Coefficient value close to one means the relationship between the two variables is very strong, and lower relationship if the value close to zero. The correlation between easiness and usability of mobile application based on participant’s perception and also some feedbacks give overview on potentials and constraints of GHG inventory using mobile platform-based calculator in Surabaya City.

4. Result and Discussion

GHG calculator was designed in android / mobile system to carry out an inventory of GHG emissions, especially in energy sector. The activity of GHG inventory collect quantitatively the amount of activities that can release GHG through the use of energy. Activities that need to be collected and measured in the energy sector include the use of energy by the government, community and industry sectors.

There are three main parts of the platform as seen on figure 1. First is a part to input data related with energy consumption. In this part, user can choose the sector that will be calculated, such as government, private, and community/household. The use of energy for building, public street lighting, transportation and clean water treatment are field of government. In private field, user can input the amount of energy used for transportation and electricity are inputs for household level. Second part, user can find the result of calculation for each field. The result is based on formula (1) using method of 2-tier. The output will be displayed and stored in the application as historical. Then, user can recall the data or delete as user needs in future. Final is summary part. Users can see a summary of the entire calculation of the data stored. The platform has advantage of converting data into excel format and users can get soft file from a calculator.
The use of platform was simulated by government actors of Environment Agency, Surabaya City. Using FGD technique, participants were grouped by division of work field. Then, each group discussed how useful the platform to support their main task function. Each participant also gave assessment on easiness and usability level of mobile calculator. Based on the graph in figure 2 and 3 shows that most of all participants gave positive feedbacks for application development.
Regarding to the participant’s perception on easiness and usability level of mobile calculator, correlation analysis aimed to investigate significant relationship between two variables. Using Spearman bivariate correlation technique, the study results that easiness level correlate significantly with usability level. Based on table 5, Spearman’s correlate coefficient ($r_s$) is 0.573 at significance level of 0.051. It means that there is positive and strong enough correlation between perception on easiness and usability level. Public acceptance of GHG measurement tools is important needs for making GHG inventory easy and helpful.

**Table 6. Spearman’s Correlation Coefficient**

| Level of the mobile application usability | Correlation Coefficient | Level of ease to use mobile application | Sig. (2-tailed) | N  |
|-----------------------------------------|-------------------------|----------------------------------------|----------------|----|
| Spearman’s rho                         | 1.000                   | 0.573                                  | 0.051          | 12 |
| Sig (2-tailed)                         |                         |                                        |                |    |
| N                                      | 12                      | 12                                     |                |    |
GHG mobile calculator focuses on collecting data of energy consumption. Using mobile platform, there are some benefits as following:

1. Rapid assessment of GHG emissions to predict which sector have high contribution
2. Doing self-assessment at household and industrial level is possible by mobile calculator. It promises for GHG reduction by doing self-control in using energy.
3. Inventory activities using mobile calculator can save resource and time efficiency

However, based on participant’s experience in using the mobile calculator, there are needed some improvements of application development as following:

1. The application does not work on android version 5.0 (Lollipop), so the application should be designed to suitable for all version of mobile devices
2. Data of electricity consumption at household level is usually measured by unit of Kilowatt Hours (KwH), but input process in GHG Calculator is measured by unit of Megawatt Hour (MwH). Unit conversion needs to be provided in calculator platform
3. Mobile calculator needs to provide additional features for understanding the way of GHG reduction at household and industrial level based on which source of energy consumption contributing high to GHG emission
4. The use of 2-tier method in mobile application can be considered to use another option of 1-tier
5. Development at large scale is needed to support GHG emission calculation at city level

GHG inventory needs to provide projection method in forecasting emission growth and preparing mitigation plan (Nagar, Pavan K. et al, 20019). Therefore, features of forecasting and mitigation options are needed for further development of mobile application based GHG calculator.

5. Conclusion
GHG inventory on energy sector is an activity of GHG emissions measurement based on energy consumption in the government, community and industry sectors. This inventory activity involves multi-stakeholders so that the development of an electronic platform for measuring GHG emissions is important. Measurement of GHG emissions on energy sector in the city of Surabaya has been done through the Agency of Environment using a manual calculation instrument. Simulation on the use of mobile devices to calculate GHG emission digitally give positive feedbacks showed from significant correlation between perception of easiness and usability level of GHG mobile calculator. The calculation of GHG emissions using mobile application provides several opportunities, such as the ease of rapid inventory or rapid self-assessment, easy calculation of GHG emissions because the application design is user-friendly, can be an educational media for the industrial communities related to emissions mitigation GHG in the industrial sector, and active involvement of the public and private community in the GHG inventory of the energy sector. However, some challenges faced in measuring GHG emissions through this mobile application are the development of mobile applications that can be accessed from various android versions, the application of emission factor coefficients with the 2-tier method that affects the results of GHG emission calculations, and the need for a support system for developing this mobile application for measurement GHG emissions on a large scale.

Opportunities and challenges in GHG inventory on the energy sector using this electronic platform can be considered by other regencies / cities to develop effective and efficient instruments for measuring GHG emissions. Inventory activities supported by an electronic calculator will make it easy for districts / cities to develop GHG emission mitigation action plans quickly and accurately. Projection tool and mitigation options features are important to be added for future development of mobile application based GHG calculator.

6. References
[1] Burrows, D., & Kendall, S. (1997). Focus groups: What are they and how can they be used in nursing and health care research? Social Sciences in Health, 3, 244–253.
[2] Eggleston, H S, Buendia, L, Miwa, K, Ngara, T, & Tanabe, K. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Japan.

[3] Field, Andy. (2009). Discovering Statistic Using SPSS, Third Edition. Sage Publication Ltd.

[4] Harrison, R., Flood, D. & Duce, D. Usability of mobile applications: literature review and rationale for a new usability model. *J Interact Sci* 1, 1 (2013). https://doi.org/10.1186/2194-0827-1-1

[5] Intergovernmental Panel for Climate Change (IPCC), 2006 IPCC Guideline for National Greenhouse Gas Inventories, the Institute for Global Environmental Strategies (IGES), Japan. https://www.ipcc-nggip.iges.or.jp/public/2006gl/ (accessed on April 19, 2019)

[6] Krueger, R. A. (1994). Focus groups: A practical guide for applied research. Thousand Oaks, CA: Sage Publications Inc.

[7] Kitzinger, J. (1994). The methodology of Focus Groups: The importance of interaction between research participants. *Sociology of Health and Illness*, 16, 103–121

[8] Liu, Z., Feng, K., Hubacek, K., Liang, S., Anadon, L. D., Zhang, C., & Guan, D. (2015). Four system boundaries for carbon accounts. *Ecological modelling*, 318, 118-125.

[9] Ministry of Energy and Natural Resource. 2017. The Study of Local Emission Factor Use (2-Tier) in GHG Inventory on Energy Sector. First Edition, Desember 2017. Kementerian ESDM: Jakarta

[10] Nagar, Pavan K. Sharma, M. Gupta, S. Singh, D. A framework for developing and projecting GHG emission inventory and preparing mitigation plan: A case study of Delhi City, India, Urban Climate 28 (2019)

[11] WRI (World Resources Institute), C40 Cities Climate Leadership Group, ICLEI (International Council for Local Environmental Initiatives). Global Protocol for Community-Scale Greenhouse Gas Emission Inventories: An Accounting and Reporting Standard for Cities. December 2014. https://www.wri.org/publication/global-protocol-community-scale-greenhouse-gas-emission-inventories (accessed on April 19, 2019)

[12] Zhang D, Adipat B: Challenges, methodologies, and issues in the usability testing of mobile applications. International Journal of Human-Computer Interaction 2005,18(3):293–308. 10.1207/s15327590ijhc1803_3

**Acknowledgement**

This research was fully supported by the Institution of Research and Community Service, Technology Institute of Sepuluh Nopember, the Ministry of Research, Technology and Higher Education through funding agreement of research-based community service scheme “Pengabdian kepada Masyarakat berbasis Penelitian”, 2019.